DETERMINING THE CAUSES OF STRUCTURAL FIRE DUE TO ELECTRICAL FAULT IN DWELLING

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EXAMINERS APPROVAL

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DEDICATION

“TO MY BELOVED SON, AQIL LUQMAN BIN AHMAD FAIZ AND MY PARENTS; NORKIAH BINTI MUHAMAD AND ZAINUDDIN @ THARIMA BIN YAAKOB”

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ABSTRACT

Among natural disasters, fires seem to be impossible to deal with, as they bring misery to human life, incur losses of property as well as giving the worst impact to the national economic stability. Electrical home fire is commonly caused by either wiring system or electrical appliances. This study was carried out to assess the level of practice on electrical appliances and wiring system among fire victims as well as to study the factors related to overload. A total of 77 respondents from 3 states (Negeri Sembilan, Pahang and Terengganu) were involved in this study. The respondents were chosen through universal sampling. A survey through telephone calls among fire victims in the dwelling houses was conducted to obtain information on their practice which could lead to electrical fault. Results showed that the most common type of dwelling involved in residential fire was typical kampong houses (35.1%). In addition, the most commonly used electrical appliances by the fire victims were television (93.5%), fluorescent lamp (90.9%), washing machine (88.4%), rice cooker (88.3%), iron (77.9%) and ceiling fan (74%). Descriptive analysis showed that 54.5% of fire victims obtained less than 59.4 of mean scores, indicating that they had poor practices toward electrical appliances failure. In comparison, the T-Test revealed that there was a significant difference in practice scores between those who performed good practices and poor practices on electrical appliances failure ($p<0.001$). Most of the respondents (>50%) performed poor practice in all domains (poor connection, short circuit, aging and lightning) except for overload. Multiple linear regression analysis showed that there was a significant relationship between overload and factors such as poor connection ($\beta = 0.318$; $p = 0.002$), aging ($\beta = 0.300$; $p = 0.003$), appliances failure ($\beta = 0.233$; $p = 0.022$) and portable cooking ($\beta = 0.277$; $p = 0.015$). In conclusion, the level of practice on wiring system among fire victims towards warning signs of danger and experience is considered below the satisfactory level. According to the coefficient values order, wiring systems (poor connection, aging, appliances failure) and electrical appliances (portable cooking) were the common causes to overload before leading to electrical fire in dwelling.

ABSTRAK

Di antara bencana alam yang sedia ada, bencana kebakaran tampak mustahil untuk ditangani daripada terus berlaku selain boleh menyebabkan kerugian yang besar kepada harta benda, kehidupan manusia dan juga kestabilan ekonomi negara umumnya. Kebakaran rumah lazimnya disebabkan oleh faktor sama ada sistem pendawaian mahupun peralatan elektrik. Kajian ini dilakukan untuk menilai tahap amalan di kalangan mangsa kebakaran terhadap peralatan elektrik dan sistem pendawaian rumah selain mengkaji hubungan antara faktor lebihan beban arus dan faktor-faktor penyebabnya. Seramai 77 orang mangsa kebakaran telah dipilih dari tiga buah negeri (Negeri Sembilan, Pahang dan Terengganu) melaui kaedah persampelan universal sebagai responden. Survei melalui panggilan telefon kepada mangsa-mangsa kebakaran telah dilakukan untuk mendapatkan maklumat tentang amalan mereka yang menyebabkan berlakunya kebakaran elektrik. Hasil kajian menunjukkan bahawa jenis rumah yang paling banyak terlibat dalam kebakaran adalah rumah-rumah kampung (35.1%). Sementara itu, peralatan elektrik yang paling kerap digunakan oleh mangsa kebakaran adalah televisyen (93.5%), lampu kalimantang (90.9%), mesin basuh (88.4%), periuk elektrik (88.3%), seterika (77.9%) dan kipas siling (74%). Analisis deskriptif menunjukkan bahawa sebanyak 54.5% mangsa kebakaran memperolehi skor min kurang daripada 59.4, menunjukkan mereka mempunyai tahap amalan yang tidak memuaskan terhadap kegagalan peralatan elektrik. Secara perbandingan,Ujian-T mendedahkan bahawa terdapat perbezaan skor amalan yang signifikan di antara mereka yang mempunyai tahap amalan yang memuaskan dan yang tidak memuaskan terhadap kegagalan peralatan elektrik ($p<0.001$). Sebahagian besar responden (>50%) mempunyai tahap amalan yang tidak memuaskan terhadap semua domain (penyambungan yang longgar, litar pintas, penuaan dan kilat) kecuali lebihan beban arus. Ujian regresi berganda pula menunjukkan bahawa terdapat hubungan yang signifikan antara lebihan beban arus dan faktor-faktor seperti penyambungan yang longgar ($\beta = 0.318$; $p = 0.002$), penuaan ($\beta = 0.300$; $p = 0.003$),faktor kegagalan peralatan elektrik ($\beta = 0.233$; $p = 0.022$) dan peralatan memasak elektrik mudah alih ($\beta = 0.277$; $p = 0.015$). Kesimpulannya, tahap amalan terhadap sistem pendawaian elektrik melalui pengalaman dan tanda amaran dianggap berada di bawah tahap yang tidak memuaskan. Menurut susunan nilai pekali (β), sistem pendawaian (penyambungan yang longgar, penuaan, kegagalan peralatan elektrik dan peralatan memasak elektrik mudah alih) adalah penyebab utama berlakunya lebihan beban arus seterusnya menyebabkan kebakaran elektrik di rumah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

V	Voltage
I	Ampere
R	Resistance
α	Alpha
P	Probability value
β	Standardize regression coefficient
R^2	Coefficient of determination

LIST OF ABBREVIATIONS

FRDM	Fire and Rescue Department Malaysia
SIRIM	Standards and Industrial Research Institute of Malaysia
ESFI	Electrical Safety Foundation International
USFA	United States Fire Administration
NFPA	National Fire Protection Association
AES	Auger Electron Spectroscopy
SIMS	Secondary Ion Mass Spectrometry
TDR	Time Domain Reflectometry
STDR	Spread Spectrum Time Domain Reflectrometry
CPSC	United States Consumer Product Safety Commision
LHC	Large Hadron Collider
KAP	Knowledge, Attitude and Practice
SPSS	Statistical Package of Social Science
ANOVA	Analysis of variance
KS	Kolmogorov-Smirnov

CHAPTER 1

1.1 INTRODUCTION

There are various incidents or disasters that create misery to human life as well as bringing the worst impact to the national economic stability. Floods, fires, hurricanes, earthquakes, bombs, riots, chemical spills, and air pollution; these events seem to be impossible to deal with (Miller, 2010). Sandercock (2008) conceded that next to natural disasters, fires cause some of the greatest losses to property and human life around the world. However, there are no possible outline as such incidents to prevent the occurence of fires.

Fire is a chemical reaction process which involves three elements: fuel, oxygen and heat. When the concentration of fuel and oxygen achieves lower flammability limit and with the introduction of heat, fire ignites. The rule of fire triangle is the heat must exceed the ignition point of fuel or flammable material in order to cause blazing. Flaming or burning will only be self-extinguished whenever the fuel comes to the end or if there is extinguishment effort made. At the same time, the heat reduces simultaneously in the absence of adequate oxygen.

Among the reasons fire might occur are households have low practices and awareness towards fire safety. Most people lack awareness of fire even though many fire cases are broadcasted in the media almost every day. The number of victims who died and injured steadily increases from year to year, and brings fear to anyone. Surprisingly, all of these cases were recorded in structural fire.

In view of that, structure means something that is made of several parts, especially a building (Hornby, 2005). Normally, structure is constructed by several foundations, columns, beams, slabs, walls and the like. In this context, structure is referred to the building such as shops, warehouses, factories, residential houses, squatters, hostels, entertainment centres, shopping malls and the like. According to the Fire and Rescue Department Malaysia (2006) structural fire refers to the ignition of flames which are out of control and are able to destroy buildings and all the things/properties inside them.

Many related literatures have exemplified that fire occurrences mostly occurred in residential areas. For example, 75.5% of 4758 structural fires t between 1988 and 2007 in British Columbia, occurred in residential areas (McCormick, 2009). Figure 1.1 proves the similar problems of fires that caught the world attention. The Figure 1.1 shows the top four types of fire and types of structural fires in United Kingdom, Jordan, China, United States, Jordan and even Malaysia. As can be seen, the fire cases mainly involved residential or dwelling and, the top four causes of fire were mostly ignited from electrical failure. Similarly, the electrical problem not only affected dwelling but also storage in the United Kingdom in 2005. Equally, according to U.S Fire Administration Center (2008), the electrical fires in residential building occurred over three times more than non-residential building. From the several instances stated, it shows that the issue with fires in the dwelling needs to be sorted out.

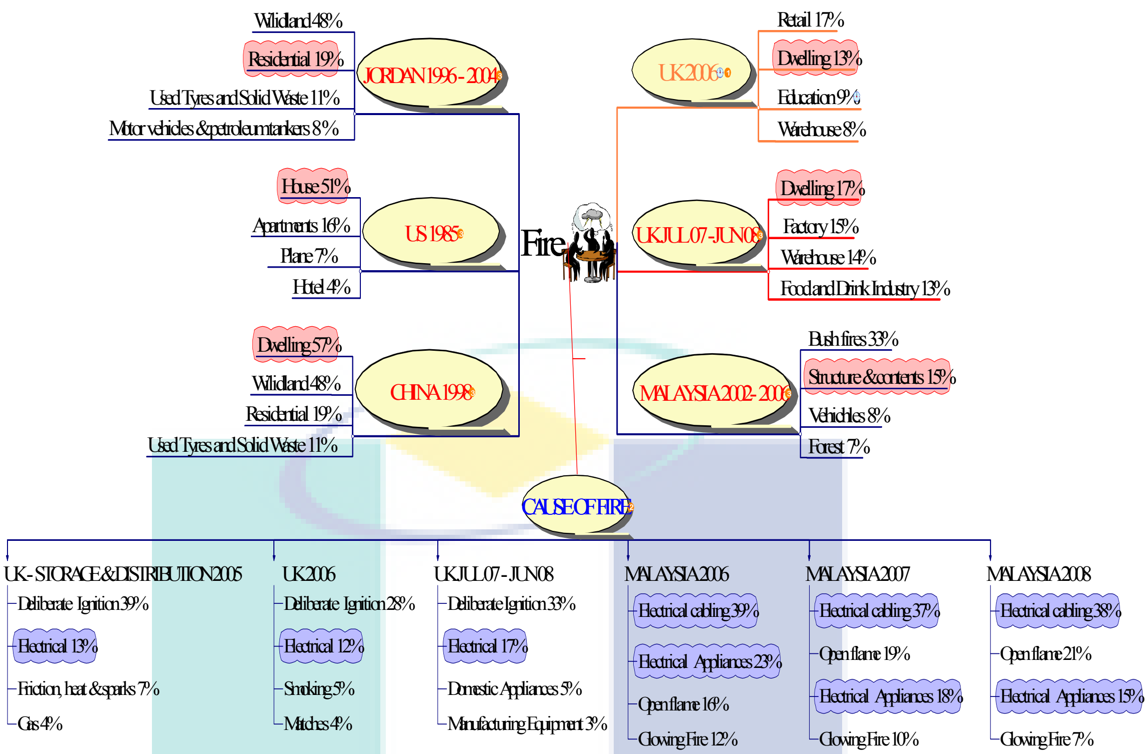

Figure 1.1: The percentage order in top four ranks pertaining to types of fire, types of structural fires and causes of fire in several countries

Source: Fawaz, 2006; Copeland, 1985; Yang et al., 2002; Helm, 2007; Fire Risk Management, 2009; Fire & Rescue Department Malaysia, 2006; Fire & Rescue Department Malaysia, 2007; Fire & Rescue Department Malaysia, 2008

Fire has always been a risk to human safety. More injuries and death were reported in buildings. Zhang et al. (2006) and Roberts and Diguiseppi (1999) stated that about 300,000 deaths in the world was due to fire and most of these occurred at home. For example, a mother and her baby were scorched in a fire mishap in Kuala Lumpur in 2009. The fire also affected 57 people and 21 families. In another case a fire dashed a feast in Kota Bharu Kelantan in 2009 and the loss was approximately RM100, 000.

In order to show that fire significantly contributes to in structural fire generally and dwelling specifically as well as electrical problems as a source of fire, the following

Table 1.1 shows that these problems are not only urgent and important but they also need national and even worldwide concern and action.

Table 1.1: Fire cases broadcasted in several world news showing fire causing structural fire and electrical problem as the ignition sources.

NO.	DATE /PLACE	TYPE	TOPIC	CAUSE	LOSS	SOURCE
1	NEW YORK Sept. 20, 2010	Bridge	Bridge fire shuts down New York commuter rail	Electrical transformer	-	Trotta, D and Gralla, J. 2010.
2	TOKYO Aug. 23, 2007		Two killed in fire caused by Sanyo electric fan	Fire broke out from the fan	-	Two killed in fire caused by Sanyo electric fan .2007.
3	MALACCA: Jan. 7, 2007	TNB Main Station	Fire causes blackout in Malacca	Overloading or a faulty circuit breaker	RM20mil	Fire causes blackout in Malacca.2007.
4	SAUDI ARABIA, Apr. 29, 2010	Shop/Office	Parkway Pharmacy Fire Cause Determined	An electrical short in the circuit.	Not stated	Parkway pharmacy fire cause determined.2010.
5	NEW BLOOMFIELD Jan. 4, 2010	A Mobile Home	Trailer home fire caused by electrical problem	Electrical problem	Not stated	Trailer home fire caused by electrical problem. 2010..
6	KEOKUK Feb. 1, 2010	Roquette America Plant	Fire cause investigated	Equipment failure	-	Mangalonzo, J.2010.
7	SANTA MARIA May 10, 2010	House	House fire causes $350,000 damage	An improperly discarded cigarette	$350,000 damage	House fire causes $350,000 damage. 2010..
8	CHICHESTER August 25, 2009	House	House fire causes heavy damage	Electrical	$20,000 worth of damage	Augustine, A. 2010.
9	SPARTA Apr. 05, 2009	Medical Services Building	Fire caused $350,000 in damage	Electrical fire started inside a wall		Clodfelter, T.2009.
10	SIOUX CITY Dec 24, 2009	Apartment	Apartment Fire Cause Determined	An electrical malfunction	-	Apartment Fire Cause Determined. 2009.
11	BANGKOK, January 2, 2009	Night Club	Cause of deadly Thailand club fire disputed	A fireworks ignition	-	Cause of deadly Thailand club fire disputed. 2009.
12	PATTAYA, 26 August 2010	Shopping Complex	Blazing Fire Causes Evacuation of North Pattaya Big C	A suspected electrical fire,	-	Blazing Fire Causes Evacuation of North Pattaya Big C. 2010
13	SINGAPORE Mar 8, 2010	Bus	6 SBS buses wrecked in fire	Someone deliberately set fire to the vehicles	worth about $3 million	Spykerman, K. 2010.
14	GEORGE TOWN, Sept 11 2010	Bridge	High-voltage cable fire causes massive jam on Penang Bridge	Three 132KW cables under the bridge		High-voltage cable fire causes massive jam on Penang Bridge. 2010.
15	PORTLAND, May 10, 2010	Three-Story Building	Fire Causes $240K In Damage In NW Portland	Undetermined	$730,000	Fire Causes $240K In Damage In NW Portland. 2010

Table 1.1: Continued

NO.	DATE /PLACE	TYPE	TOPIC	CAUSE	LOSS	SOURCE
16	WESTERN BRANCH, March 27, 2006:	Brush Fire	Brush Fire Causes the Evacuation of Six Homes	A small pile of burning debris spread out of control.		Brush Fire Causes the Evacuation of Six Homes.2006.
17	BATON ROUGE, LA Jan 06, 2010	Home	Electrical short causes another house fire	An electrical short in an outlet	$45,000 worth of damage	Electrical short causes another house fire.2010.
18	CEBU CITY, Philippines 02/28/2010	Homes	Misuse of electricity tagged main fire cause	Of 533 fires in the region last year, 183 were caused by electrical misuse	destroyed P145 million worth of property	Aragon, C.O. 2010.

When fire occurs, a lot of complications and crisis might happen depending on the various types of fire. Besides injuries and death, structural fire also causes great loss associated with environmental damage, business losses, medical expenses and psychological damage. As the nation is developing, so are the number of fire disasters which keeps increasing from year to year. It is now alarming and gaining nationwide attention as well as the world's.

The Centers for Deases Control (CDC) and the National Fire Protection Association (NFPA), cited by Jingzhen et al. (2006) indicated injuries and death in fire cases occur from households having a low practice towards the fire escape plan. It could be that they have knowledge through education but the lack of training may cause them to have low practical knowledge. Therefore, they could not take reasonable action when they faced fire. In the end, the fire causes injuries and fatality.

Another reason that might cause fires in structures was carelessness (Killalea, 1999). They/Victims did not know that combustible materials were too close to the electrical source. Sometimes, they went to sleep with the ignition source on. Moreover, they left ignition source unattended such as electrical source or cooking appliances which were on when talking to their friends. On the other hand, fires cases in Australia and other countries occurred when victims were unconscious due to alcohol or drugs, and careless when disposing smoking materials. Those were the dominant factors leading to dwelling fire (Killalea, 1999).

1.2 PROBLEM STATEMENT

According to the Fire and Rescue Department Malaysia (2007), dwelling fire contributed to the highest cause of fire losses and shows significant impact over a total of structural fire. The difference between total structural fire (19357) and dwelling houses (9585) can be explained as 49.52% or approximately 2:1 ratio. Therefore it may indicate that fire event in dwelling has the same dangerous pattern within year by year starting from a decade ago.

Figure 1.2 shows the amount of fire losses in 2006 and 2007 in Malaysia. Most of the fire mainly occurred at factories followed by shops and dwelling. The country lost approximately RM617 million in 2006 and it increased by RM15 million to become RM632 million in 2007. These losses would have been even higher without the efforts of the local fire-fighters. The Fire & Rescue Department managed to save property losses amounting to about RM 3.2 million and RM 4.0 million in 2006 and 2007 respectively (Fire & Rescue Department Malaysia, 2006;2007).

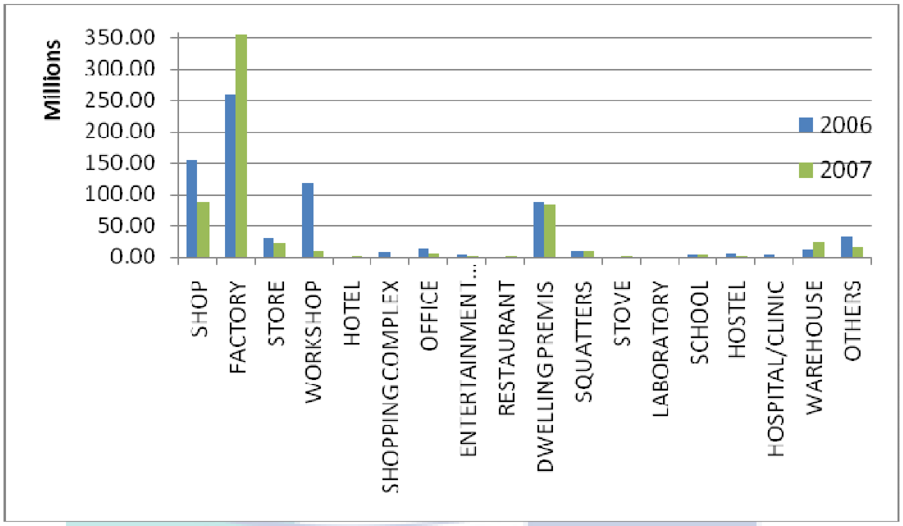

Figure 1.2: Fire amount losses in 2006 and 2007

Source: Fire & Rescue Department Malaysia 2008

Additionally, Figure 1.3 shows the number of death and wounded recorded from 1990 to 2008. The number of death resulting from fire event is always more than 50 victims while the number of wounded victims always look like to be double the amount. Hence, most of the fatalities happen in residential areas or dwelling houses.

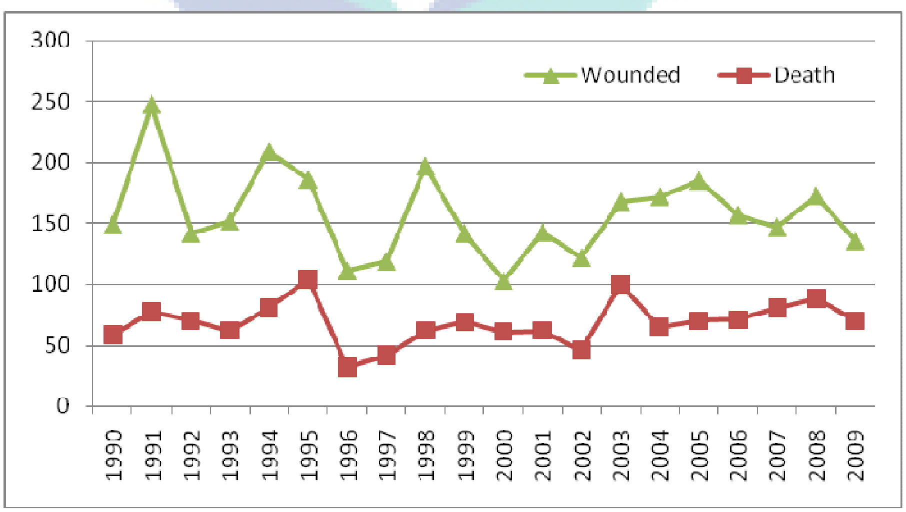

Figure 1.3: Numbers of fire death and wounded between 1990 and 2008

Source: Fire & Rescue Department Malaysia 2009

Table 1.2 shows the statistics of fire investigation division. There is a proof that fire from dwelling contributed the highest fatalities in 2008. Generally, electrical cabling (SN3) and appliances failure (SN4) were found to be the main causes of casualty while cabling failure numbered double compared to electrical appliances failure in total sum and dwelling houses specifically.

Table 1.2: Type of structure and cause of fires in 2008

TYPES OF PREMISES	Cause of Fire Classification																				Undetermined	Total Investigation
	Natural		Accidental									Arson / Incendiary										
	Source of Ignition																					
	SN1	SN2	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10	SN11	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10	SN11		
FACTORY	0	11	99	39	14	20	15	3	7	41	20	0	0	0	15	1	0	0	1	10	59	355
OFFICE	1	0	49	19	1	14	10	0	0	1	4	0	0	0	5	0	0	1	0	3	8	116
DWELLING PREMISES	14	21	449	163	10	357	87	2	1	19	147	3	0	1	83	9	1	2	1	55	153	1578
SHOP	3	6	123	49	1	46	16	1	0	2	26	2	0	0	24	1	0	1	0	11	38	350
SCHOOL	6	1	19	8	0	4	8	0	0	0	3	0	0	0	10	1	0	0	0	2	4	66
SHOPPING COMPLEX	0	0	11	1	0	4	1	0	0	1	3	0	0	0	1	0	2	0	0	0	5	29
STORE/WAREHOUSE	0	2	27	10	0	7	9	0	2	0	5	0	0	0	4	1	0	0	0	9	12	88
ASSEMBLY	0	0	10	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13
HOSPITAL / CLINIC	1	0	4	4	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	1	1	15
HOSTEL / HOTEL	1	0	17	7	0	6	5	0	1	0	3	0	0	0	4	1	0	0	0	0	3	48
PETROL STATION	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
SPECIAL STRUCTURE	1	0	11	6	1	2	2	1	0	1	1	0	0	0	0	1	0	0	0	2	3	32
OTHERS	3	7	36	17	1	9	8	1	0	12	14	0	1	1	4	3	0	0	2	3	15	137
TOTAL	30	48	856	323	28	471	163	8	11	77	228	5	1	2	151	18	3	4	4	96	302	2829

Legend : Source of Ignition

SN 1	Flash / Sunrise lightning
SN2	Auto Ignition
SN 3	Electrical cabling system failure
SN 4	Electrical appliances
SN 5	Friction effect /hit
SN 6	Open flame
SN7	Glowing fire
SN8	Combustion
SN9	Chemical Reaction
SN10	Hot surface material
SN11	Others

Source: Fire & Rescue Department Malaysia (2008)

Moreover, Table 1.3 indicates high electricity disturbance in 1998 and 2007. It was found that the appliances failure caused the electricity disturbance instead of overload (Energy Commission Malaysia, 2009). Moreover, the risks of structural fire increase with the continuous development of housing constructions with the likelihood of loss of life, property and resulting environmental damage.

Table 1.3: Causes of electricity disturbance in Peninsular Malaysia between 1998 and 2007

CAUSE OF ELECTRICITY DISTURBANCE	**NO. OF ELECTRICITY DISTURBANCE**									
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Mishap/Disaster	31264	1468	1826	1391	7953	8575	1891	2114	166	3950
Over Load	13478	4372	5106	4243	4953	4429	4706	9644	675	2201
Interior	5305	5429	6198	5038	3192	-	-	-	-	-
Operations Fault	345	128	91	72	26	-	-	-	-	-
Appliances Failure	16299	5265	8582	5798	2312	2626	1098	1918	118	2295
Third Party Fault	5474	2670	4050	3045	2754	3199	4536	5380	699	4129
Others	12159	5210	6271	4021	3770	7246	1175	1537	996	4050

Source: Energy Commission Malaysia (2009)

Studies on the causes of electrical fire have been summarized into faulty electrical outlet, old wiring, cord or plug problem, electrical cord misuse, appliances misuse, overloading circuit, poor maintenance, running the cord under rug/high traffic areas, appliances defect and also wrongly installed wiring. Those were among the dominant factors contributing to the fire incidents (United States Consumer Product Safety Commision, undated; Electrical Safety Foundation International, undated). However, other analysis proved that short circuit (67.4%) accounted the highest electrical ignition in Korea than overload (8.8%), leakage (4.4%) and poor contact (4.1%) (Choi et al., 2006). Even wide varieties of physical or chemical testing methods have been proposed to differentiate "caused a fire" or "caused by the fire itself". However, none of the proposed methods are promising (Babrauskas, 2003). From this gap of the findings it is important to further this research.

In particular, the number of houses being approved to be built from January to November in 2009 was 88, 015 units. Similarly, about 240, 014 units housing projects have been observed within the same period (National Housing Authority, 2009). In fact, the development of houses in One Government Transformation Programme were announced by the Prime Minister to improve rural basic infrastructure and the plan will provide 50,000 new and restored houses to the rural poor and extreme poor by 2012 (Najib, 2010). In line with continuing development of housing construction, there will be more risk in terms of life, property and environment. Due to this matter, it is vital to do the research on electrical failure that causes a fire.

1.3 STUDY JUSTIFICATION

There are various types, structure and location of fire that have been categorized according to each country. Some countries list concisely while the others register in detail. For example, only seven types of fire are listed in Jordan (Table 1.4) from 1996 to 2004. It includes wild land, residential homes, vehicles and petroleum tankers, stores, plants and others. On the contrary, Republic of China registered 17 categories of types of structure in 2002 with additional categories such as ancient building, dancing place and museum (Table 1.5). The trend is almost similar to the United States with 14 types of structures which was recorded in 1985 (Table 1.6).

Structure and its content was the common type of fire hazard for the entire world as shown in Table 1.4, Table 1.5 and Table 1.6. From 1996 to 2004, the number of fire occurrences in residential home (18.6%) in Jordan is the second highest. The pattern shows similarity in China in 1998 with 56.9% of contribution to residential fire. The pattern is almost similar in the United States with 50.9% recorded for housing.

Table 1.4: The types of fire in Jordan between 1996-2004

Type	**Number of occurrences**	**Percentage of contribution**
Wild land	28,663	47.6
Residential homes	11,196	18.6
Used tyres and solid waste	6760	11.2
Motor vehicles and petroleum	5044	8.4
Commercial stores	1947	3.2
Industrial plants and storages	1812	3.0
Others	4838	8.0
Total	**60,260**	**100**

Source: Fawaz (2006)

Table 1.5: The types of structural fire in China in 1998

Structure	**Number of occurrences**	**Percentage of contribution**
Dwelling house	33,522	56.9
Workshop	6651	11.3
Deposit	5723	9.7
Hotel	2998	5.1
Shopping center	2674	4.5
Warehouse	2494	4.2
Office building	1951	3.3
Dancing place	774	1.3
School	732	1.2
Market	503	0.9
Gas Station	421	0.7
Hospital	227	0.4
Cinema	85	0.14
Station, dock, airport	69	0.1
Post Office	62	0.1
Museum	29	0.1
Ancient building	24	0.04
Total	58,939	100

Source: Yang et al. (2002)

Table 1.6: The types of structural fire in United States in 1985

Structure	Number of occurrences	Percentage of contribution
House	54	50.9
Apartment	17	16.0
Plane	8	7.6
Hotel	5	4.7
Job site	5	4.7
Trailer	4	3.8
Boat	4	3.8
Shack	2	1.9
Bar/club/lounge	2	1.9
Yard	1	0.9
Abandoned car	1	0.9
Car	1	0.9
Grocery store	1	0.9
Store	1	0.9
Total	106	100

Source: Copeland (1985)

Table 1.7: Statistic types of fire from 2002 – 2006

TYPES OF FIRE	2002	2003	2004	2005	2006	Total
Bushfire	10926	6395	9158	1350	6248	34077
Others	5692	4742	5732	7344	5011	28521
Structure & Content	2887	3059	3154	3458	3353	15911
Vehicles	1301	1432	1544	1755	1811	7843
Forest	2368	719	1085	2150	497	6819
Equipment	559	682	691	731	759	3422
Plantations	1013	276	467	1190	288	3234
Gas	546	581	554	636	607	2924
Machinery	256	240	256	228	209	1189
Stalls	120	109	94	92	82	497
Vessels	16	24	15	23	20	98
Petroleum	27	16	14	17	16	90
Chemicals	13	14	12	11	12	62
Aircraft	2	1	3	1	0	7
Total	25726	18290	22779	31138	18913	116846

Source: Fire & Rescue Department of Malaysia (2006)

Referring to Table 1.7, there are 14 categories in the types of fire from 2002 until 2006 in Malaysia. The number in this category is always high in bushfire with 34,077 (29.2%) cases from 2002 until 2006. It is followed by structural fire and its content and which contributes 15,911 cases (13.6%). Even though other fires related to vehicle, forest, equipment and other categories of fires were also reported among the top in occurrences but they are not considered in this study.

However, in Malaysia, the types of structural fire have been divided into 18 types as shown in Table 1.8. In line with that, the highest cases involved dwelling houses (9,595) followed by shops (2,171), others (1,930), factory (1,452) and stores (1,134) within the six years period. In average, about 48% of fires took place in dwelling houses. Meanwhile hospital and clinic are the lowest of the total structural fire reported.

Table 1.8: Statistic Types of Structural fire in Malaysia from 2002 – 2007

TYPES OF STRUCTURE	2002	2003	2004	2005	2006	2007	TOTAL
Dwelling Premise	1445	1478	1497	1689	1741	1735	**9585**
Shop	326	378	347	379	376	365	**2171**
Factory	261	232	252	242	232	233	**1452**
Store	158	156	206	209	192	213	**1134**
Stove	91	121	127	127	111	128	705
Workshop	54	378	50	79	48	74	683
Squatters	83	90	109	109	97	75	563
Office	74	91	85	100	103	96	549
School/Institute	33	42	46	43	50	45	259
Restaurant	15	18	25	36	23	31	148
Hostel	19	20	32	20	25	27	143
Entertainment Outlet	8	13	15	31	25	30	122
Hotel	8	12	10	14	22	22	88
Shopping Complex	9	2	15	10	8	10	54
Laboratory	3	4	12	8	4	9	40
Warehouse	1	10	7	6	7	8	39
Hospital/Clinic	3	6	4	7	5	6	31
Others	296	324	315	360	295	340	1930
Total	2987	3059	3154	3457	3353	3447	19357

Source: Fire & Rescue Department Malaysia (2007)

Furthermore, Table 1.9 shows that electrical fire is the most significant cause of fire compared to other ignition based on increasing number of fire causes in year 2002 until 2006. Even though the highest cause of fire is recorded in non-incendiary fire as well as unknown fire, the overall number of electrical ignition increased slightly from year 2002 to 2006. Specifically, electrical ignition in structural fire was stated as the highest number in year 2005 (35.2%) and 2006 (37.9%) compared to the other sources of ignition.

Table 1.9: Statistics of Overall Causes of Fires from 2002 to 2006

CAUSE OF FIRE	2002	2004	2005		2006	
	Overall	**Overall**	**Overall**	**Structure**	**Overall**	**Structure**
Electrical	2274	3100	3418	**1217**	3625	**1272**
Unknown	6838	4700	5879	677	3341	614
Gas/Gasoline Stove	794	980	1159	357	996	286
Mosquito Coils/Smouldering	295	350	408	235	349	217
Incendiary	1357	1200	2052	124	1088	146
Matches	376	300	334	110	243	106
Cigarette Butts	3037	2000	3349	106	1482	95
Fire Spark	959	600	773	74	584	90
Non-Incendiary	6286	6439	9620	95	4660	86
Spontaneous Combustion	656	400	483	33	324	50
Firecrackers /Fireworks	69	15	139	34	85	28
Chemical Reaction	34	5	27	6	34	13
Others	2751	2800	3497	389	2102	350
Total	25726	22,889	31138	**3457**	18,913	**3353**

Source: Fire & Rescue Department Malaysia (2006)

Therefore, this research was aimed to highlight the problem of structural fire and to propose this study to the policy maker or the administrators before it becomes worse in the future and to gain attention to look into electrical fire cases. For example, there are some proposals worth looking into such as introducing and enforcing fire preventing system at least with the installation of smoke or heat detector in each dwelling houses other than to require rewiring housing electrical circuit within 40 years period of time (Yereance, 1995) and to resolve the incompetence person doing electrical works (Rasdall, 2005) and also other relevant factors that can cause dwelling fire.

In addition, this research was carried out to create safety awareness among the households especially on electrical fire safety. In order to realize that, this research was aimed at the fire victims as respondents to give input on fire safety and particularly electrical fire safety. The results would help the public to determine the safety features during selecting and purchasing of the electrical appliances, particularly their capability to cause or to avoid electrical fire. Moreover, a database related to electrical fire safety can be developed and would be beneficial for the enforcement purposes by Fire & Rescue Department Malaysia, SIRIM or Energy Commission. Subsequently, the results of this research would be elaborated and discussed later in Chapter 4.

1.4 CONCEPTUAL FRAMEWORK

The researcher has decided to choose those factors that influence electrical home fires to be the research variables. The variables are electrical equipment failures, overloading, loose connection, and insulation break down which may be separated into short circuit and aging, and finally lightning. The following Figure 1.4 may give better explanation to solid understanding that is used as research conceptual framework which contains both dependent and independent variables. The figure also represents the wiring circuit that allows the current to flow within the circuit. The theoretical framework can be converted into the graphical model and used for further research purposes when it is proved that there are significant relationships between variables.

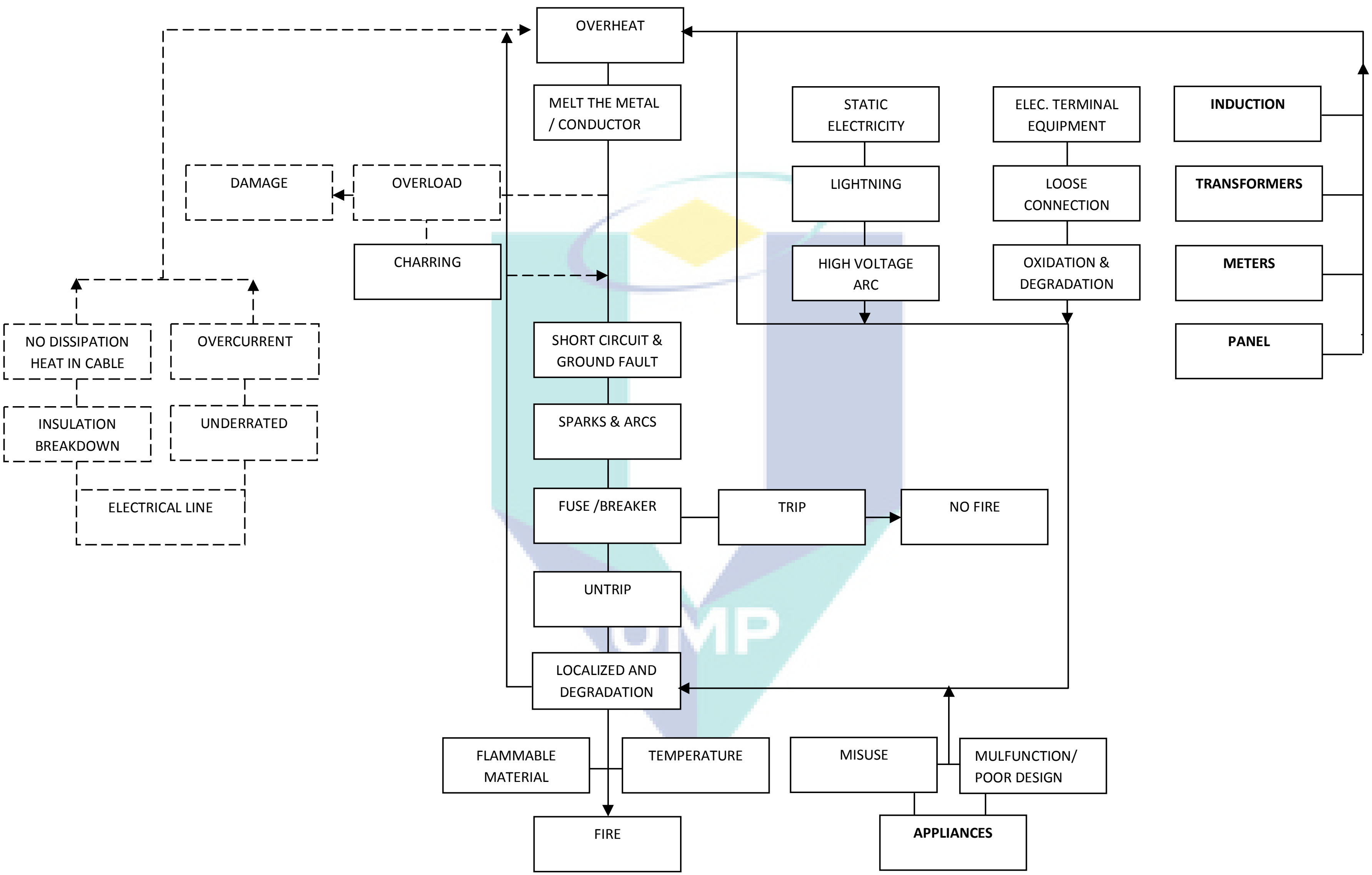

Figure 1.4: Conceptual Framework of Electrical Fire Causation

1.5 DEFINITIONS OF VARIABLES

The following paragraphs should be referred to for definitions of variables that were used throughout the study. It is important to refer to these definitions in order to relate the title of this research.

i) Electrical Appliances Failure means a situation in which an electrical gadget that carries electricity stops working and creates a fire due to overheating, fault causing sudden high temperatures, bad contact and insulation failure (Harrison, 2007). Meanwhile National Fire Protection Association (2001) signifies this as only under specific set of conditions can sufficient heat be generated by electricity as a result of an overload or fault within or by any appliances and subsequently cause ignition.

ii) Overloading means operation of equipment in excess of normal, full-load rating or of a conductor in excess of rated ampacity, which, when it persists for a sufficient length of time, would cause damage or dangerous overheating (National Fire Protection Association, 2001). According to Nagoya City Fire Bureu (undated), overload occurs when the electric wire and appliances are used at the values exceeding these allowable current, rated voltage, current, time and etc.

iii) Loose connection means a circuit has a loose connection such as a loose screw at terminal, increases a resistance causing increased heating at the contact, which promotes formation of an oxide interface (National Fire Protection Association, 2001) whereas Kennedy and Kennedy (1985) indicates if the wires are connected to loose terminals in the receptacles (wire loose under the screw) heat can develop at the terminal and result in hazardous condition

iv) Aging means the changing of the characteristic of a device due to its use or operation of a product before shipment to stabilize characteristic or detect early failure (Licker, 2004) but Rasdall (2005) concluded that cumulative effects of a variety of environmental stresses and the wear and tear of daily electrical uses impact life expectancy of residential wiring. The severity of aging of wiring depends on a variety of factors. Moreover, Basara (2003) dictates the insulation damage due to a variety of reasons such as vibration, friction, moisture and etc with the passage of time.

v) Lightning is a form of static electricity in which the charge builds up on and in clouds and on the earth below. Movement of water droplets, dust and ice particles in the violent winds and updraft of a thunderstorm build up polarized electrostatics charge in the clouds. When sufficient charge builds up, a discharge occurs in the form of lightning stroke between the charged cloud and object of different potential (National Fire Protection Association, 2001).

vi) Short Circuit is a low resistance connection across a voltage source or between both sides of a circuit or line, usually accidental and usually resulting in excessive current flow that might cause damage (Hill, 2004).

An abnormal connection of low resistance between normal circuits conductors where the resistance is normally much greater; this is an over current situation but not an overload (National Fire Protection Association, 2001).

Short circuits are cases when insulating coating of cable are damaged and cooper wires come in direct contact , or when cooper wires are connected via metal such as a nail, etc and also called bridging (Nagoya City Fire Bureau, undated).

A short circuit is an electrical contact between two different potential of conductors. The point of contact will generate heat and melt the conductors and spattered out with generation of arc. The insulator might be damaged due to overloading of cable and melting the conductor (Twibell, 2004).

1.6 AWARENESS CONCEPT

An awareness concept has been widely used in research methodology approach. It is divided into three parts which are:

i) knowledge,

ii) attitude and

iii) practice (KAP).

Kaliyaperumal (2004) stated that practice refers to the way in which they demonstrated their knowledge and attitude through action. Indeed, due to that, this research focused on practice behavior in order to get information from respondents. The research has focused on practice particularly in the use of electrical appliances and other future potential variables. The details on awareness concept will be explained in Chapter 2.

1.7 RESEARCH OBJECTIVES

Generally, this study was carried out to determine the causes of structural fire by electrical failure in dwelling. The specific objectives of the study are as the following:

1.7.1 To describe the fire victims' demographic characteristics associated with residential fire cases;

1.7.2 To assess the level of practice on electrical appliances among fire victims;

1.7.3 To assess the level of practice on wiring system among fire victims towards warning signs of danger and experience;

1.7.4 To identify the correlation variables in the theoretical model (electrical appliances types and failure, overloading, poor connection, short circuit, aging and lightning); and

1.7.5 To determine the relationship between overloading and factors such as electrical appliances types and failure, poor connection, short circuit, aging and lightning.

1.8 RESEARCH QUESTIONS

Based on the problem statement, the researcher has outlined following research questions that needed to be studied:

1.8.1 What are the fire victims' demographic characteristics associated with residential fire cases?

1.8.2 What is the level of practice on electrical appliances among fire victims?

1.8.3 What is the level of practice on wiring system among fire victims towards warning signs of danger and experience?

1.8.4 What are the correlation variables in the theoretical model (electrical appliances types and failure, overloading, poor connection, short circuit, aging and lightning)?

1.8.5 What is the relationship between overloading and factors such as electrical appliances types and failure, poor connection, short circuit, aging and lightning.

1.9 STUDY HYPHOTHESIS

The following hypotheses have been developed based on research objectives:

H_{A1}: The level of practice on electrical appliances among fire victim is considered low.

H_{A2}: The level of practice on wiring system among fire victims towards warning signs of danger and experience is considered low.

H_{A3}: There is a significant correlation between overload and influencing factors such as electrical appliances types, electrical appliances failure, poor connection, aging, short circuit and lightning.

H_{A4}: There is a significant relationship between overload and electrical appliances types such as heating equipment, lamp/ bulb/ lighting, portable cooking devices and other equipment.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The determination of cause of fire in any structural fire or even any type of fire is not an easy mission to be accomplished. The process of fire investigation and determination of the cause of fire require specific procedures and techniques to be followed. For example, the preliminary information prior to the incident is very important to be explored before further investigation. The information could be obtained from witnesses who experience a fire and those who have observed the fire particularly in the preliminary stage.

This information not only can be a proof as cause of fire but it helps investigators to decide on a plan on how the investigation should be directed. In all condition, the electrical ignition has never been neglected by any investigator especially when fire is suspected, engaged or dealt with electrical source. If the cause of fire has not yet been determined once the investigation is over, the sample from the excavation work during investigation still needs to be further analysed in a laboratory. The results of the laboratory analysis require more interpretation by investigator before a conclusion can be made. However, the most difficult task is interpreting the results due to the variety in the identification cause of fire or result of a fire according to electrical marks or beads. For instance, a lot of previous information due to electrical sources which was collected were not used to correlate the current finding and the previous sources. Most of the investigation records were not used in another part of the exploration to look at the trend on electrical fire in the structure. It is expected that by identifying the records of electrical fire will assist this research to close the gap between experimental and statistical analysis.

In addition, there were various studies that have been conducted on electrical failure basis particularly via experimental studies. Previous researchers examined the expect conductors to identify the default causing a fire (cause beads) or resulting of fire (victim beads). Commonly, the electrical conductor is heated by a passing through multi level of current and direct flame. By using tools such as Microscopy, Raman Spectroscopy, X-ray Microanalysis, Auger Electron Spectroscopy (AES) and Secondary Ion Mass Spectrometry (SIMS), there were varieties of determination in concluding their findings. For example, oxidation, discoloration, blisters, melt, number of voids and size, carbon and oxygen concentration as a bench mark for identifying between cause and victim beads. Research on electrical ignition was mostly explored and carried out in Japan. However, these researches were performed by experimental method where it is not quite promising (Babraukas, 2003). Therefore it is recommended that the research is performed through a statistical evaluation method. With these gaps of knowledge, this study attempted to investigate the problem with statistical approach. Therefore, the overview of studies on previous methodology would be acknowledged in the following literature.

2.2 OVERVIEW OF ELECTRICAL FIRE

Throughout the world and specifically in Malaysia, electrical fire has been identified as a common cause of fire. This is mainly contributed by the wiring system instead of electrical equipment as shown by the Fire and Rescue Department (2007 & 2008) information. A variety of ignition sources had been discussed by fire investigators in every fire incident. A short circuit and over current were the ordinary terms used by them. Fire investigators must look into several circumstances and gather evidence before a conclusion can be made. However, there is still something lacking in the investigation to make an accurate conclusion. There were many studies that had been conducted by several researchers on this related matter but they have yet to confirm their findings/conclusion.

For example, Ettling (1978) has identified the way to distinguish a fire characteristic of an electrical cable origin either due a short circuit or over current prior to the fire or causing the fire. The experiment used stranded and copper wire ranging from 20 to 14 AWG (standardized wire gauge system used since 1857) and 20 to 18 AWG respectively by passing through multi level of current and also direct flame. Some wires were bare and some had rubber insulation.

Melted copper fire exhibits oxidation and discolouration. During the melting process, the gases are released and blisters on the surfaced are formed. When the heating continues, melted cooper produces beads and the core areas in between the beads. Usually the beads show rough surfaces. In the same way, during the process of melting the stranded wire changes into solid wire with distorted surfaces. The melting identification is still difficult to recognize due to a short circuit or over current that ensues prior to the fire or causing the fire.

On the contrary, effects from stranded wire were not highlighted by author to distinguish between over current or short circuit. Notwithstanding, there are guidelines proposed by Ettling (1978) to distinguish fire melting from over current and from short circuit as follows:

1. Over current- blisters formed at early stage, rounded with pronounced bead at the ends, entire circuit overheated, flexing few times made stiffer, rough and porous surfaces when looked through the microscope, leaves the core unmelted.
2. Short circuit (only at point of contact)– no partial melting or blistering, the ends may be smooth and fairly flat, rounded or have some size of bead, melting point of contact, with large holes in the back of panel.

On the other hand, Babrauskas (2003) also reviewed some approaches done by several researchers to differentiate between electric arc causing fire and arcs caused due to fire. Arc beads which are originated by electrical fault are called 'cause beads' while ‘victim beads’ are generated due to heat from fire. Most of the instrumental analysis techniques used Microscopy rather than Raman Spectroscopy and X-ray Microanalysis, and Auger Electron Spectroscopy (AES) and Secondary Ion Mass Spectrometry (SIMS).

2.2.1 Microscopy Method

Most of the instrumental analysis techniques created a short circuit which passes excessive current through the cords and exposes the wire to a fire. The beads were examined under a microscope and six differentiations through Microscopy method were revealed and the result is presented in Table 2.1.

Table 2.1: Cause and victim beads indication

Microscopy Method	**Cause bead**	**Victim bead**	**Source**
Square or rectangular pock marks	Yes	less	Gray et al.,1983
Small surface-deposite particles	No	yes	Erlandsson and Strand, 1984/1985
Voids	Small	large	Tokyo Fire Department, 1992
Number of voids or total cross-sectional are	Vary	vary	Babrauskas, 2003
Dendrite-arm spacing	Small	large	Lee et al., 1999/2000
Recrystallization	Uniform	Not uniform	Levinson, 1977

2.2.2 Raman Spectroscopy and X-ray Microanalysis Methods

These methods analysed the existence of carbonize material before and after the fire as a yardstick. In fact, carbonized material produced before the fire refers to electrical fault by over current (cause beads). In contrast, the carbonise material developed after a fire refers to fire heating the conductive material (victim beads). Lee et al. (2002) used Raman Spectroscopy and SEM-EDX to distinguish between primary and secondary molten (arc) marks. The marks were investigated by the examination of the carbon residue remaining on molten marks caused by the short circuit of PVC-coated wire. Moreover, in 2006 Hagimoto and Yamamoto used X-ray analysis to analyze a bead of tin– lead solder from a wire recovered from a large fire. In fact, both analyses targeted to justify cause or victim beads.

A research was done by the Tokyo Fire Department (1992) in which series-arc failure was created in a cord by first charring the wire insulation with a burner flamer, then causing series-arc. Unfortunately, the carbonaceous material was found inside *victim beads* and not in *cause beads* though the experiment was not tested in many experiments. However, Masui (1992) showed that the amount of carbon test by causing electrical series arc was negligible as well as the insulation was charred by burner as using x-ray microanalysis. Besides that, Lee et al. (2002) used Raman Spectroscopy to differentiate the amorphous and graphitic carbon. Unfortunately, that method has low probability in identifying *cause beads* which then could not differentiate the circumstances.

2.2.3 Auger Electron Spectroscopy (AES) and Secondary Ion Mass Spectrometry (SIMS)

Chen et al. in 2003 determined whether a primary or secondary short using Secondary Ion Mass Spectrometry (SIMS) -circuit had occurred through arc beads. Besides, an auger electron spectroscopy (AES) was used by Erlandsson and Strand (1985) to verify the presence of chlorine at surface attached to the beads was not associated with victim beads but equally present in cause beads when tested by creating short circuit. Mac Cleary and Thaman (1980) created short circuit between two conductors for 15 seconds, short the cable by a small fire and produced a current with limited overload which heated the cable for some time to distinguish cause bead, victim bead and overload bead. Those tested were referred to oxygen concentration as a function of depth below the surface of the bead for identifying between cause and victim beads. But the schemes proposed to identify were still limited for re-melt and a bead must be cut in half. Even though oxygen was used as benchmark but Babrauskas (2003) stated that Robertson et al. (1988) refused that because it could not be used to distinguish cause from victim beads. Apart from oxygen, Babrauskas (2003) repeated that Anderson (1989) also used carbon, chlorine, sulphur, calcium, zinc, iron, phosphorus and chromium atom profiles but still could not propose any quantitative criteria for distinguishing cause and victim beads.

Nevertheless, Babrauskas (2001) had reviewed many papers (Hagimoto, 1999; NFPA 921, 1998; Hotta, 1994; Kawase, 1977, Hagimoto, 1988; IEC 1984; Sandia National Laboratories, 1986; Hagimoto, 2000; Nagata, 1983) regarding the same issue. He stated various findings have been promoted by each authors but the fixed theory is still not promising. Moreover, Braunovic (2001) used Contact Resistance Measurement, Micro Hardness and SEM Surface Analysis to determine the causes for overheating and failure of flexible tinned cooper connectors.

Similarly, in 2001, the similar experiment was repeatedly carried out by Hoffman et al. (2001) using 712 power cords under six conditions series test. The series test was constructed in a test station where different appliances power cords were exposed to radiant heat and direct flame impingement. The results did not show any significant difference between damage appearance of electrical conductor and fire conditions. For example, a variety of damage of the cords could not be used to verify which circumstances trip a circuit breaker.

Another test was carried out by Kuhn et al. in 2006 to locate faults in wiring system using Sequence Time Domain Reflectometry (STDR) and Spread Spectrum Time Domain Reflectrometry (SSTDR). The faults can be detected even when they are hidden behind the panel on live wires. The reflectometer can locate intermittent and detect the location of arc-faults on live wires with arc-fault breakers in position to shutdown the circuit and prevent fires. Thus, this technology could not be applied to determine the characteristics of electrical failure.

In 2007, Harrison assessed a risk of fire due to faulty electrical equipment in a both qualitative and quantitative ways. The research implied in the tunnel by collecting the material data of equipments installed. In the same way, the possibility of electrical equipment which can cause a hazard was recorded. However, the location of potential ignition and combustibles material were analysed to predict the fire to be developed.

However, it was hard to accomplish the failure probabilities hence the author suggested to conduct through statistical evaluation. Specifically, those ideas came from Babrauskas in 2003 during the stage of distinguishing beads whether it resulted from fire or caused the fire. Even multi researches had been conducted previously but none of proposed method is promising. Furthermore the evolution in electrical fire is not just one but involved a chain of events (Babrauskas, 2001). According to findings given by the several authors, the researcher decided to further the ideas by statistical approach.

2.3 ELECTRICAL GENERATED FIRE

The philosophy of fire by electrical ignition is similar to the fire triangle rule. The fire triangle consists of fuel, heat and oxygen. Without one of the elements, no fire would take place. However, in electrical fire, the fuel originates from wiring system or appliances' material itself plus adjacent combustible material. In fact, the heat generated from electrical circuit or path must exceed the temperature of the fuel ignition limit and the fire will ensue accordingly.

There are several progressions to meet the ignition level. As noted earlier in the fire triangle, the fire will only be developed by sufficient heat and also adjacent material. Similarly, the conductive material will be overheated when the current flow is limited due to the resistance. Also, over the certain period of time or taking into account of other circumstance, the resistance in the electrical circuit will be automatically heated instead of reaching high level temperature and this phenomenon is called resistance heating. Resistance should be low enough to current-carrying parts and connections should not overheat (National Fire Protection Association, 2001).

2.3.1 Electrical Wiring

Overheating may cause melting of conductive material and a spark begins. A melting process will cause the conductor to be separated. Because the air is a semiconductor, the current will flow in between the conductor and finally an arc will be produced. Within this condition, the high temperature is generated. With the existence of nearby material and also enough heat, the fire will ignite.

Similarly, there are several standpoints as to how electrical energy can ignite the fire. In table 2.2, Kennedy and Kennedy (1985) listed seven forms as the cause to electrical fires. There are electrical appliances, electrical lines, electrical terminal equipment, and the electrical transformers, panel, meters and also lightning. On the other hand, Dehaan (2002) listed eight conditions that can cause electrical fire that are conduction heating, arcs & sparks, aluminum wiring, electric motors & transformers, fixed heaters, appliances, extension cord and heat tape.

Moreover, the researchers from Nagoya Fire Bureau in Japan revealed three factors which are wiring and apparatus, electrical leak and electrostatics sparks. Choi et al. (2006) in his journal titled *The Analysis of Fire Characteristics of Tumbler Switches due to Deterioration Contacts* found that the electrical fire mostly due to short circuit followed by overload, current leakage and finally poor contact.

Similarly, National Fire Protection Association (2001) has summarised five factors which yield electrical ignition. Again, resistance heating is the first aspect being highlighted followed by over-current and overload. Like Dehaan (2002), standing points are arcs and sparks. However arcs have been elaborated more as high voltage arcs, static electricity, parting arcs and arc tracking even as the last point is high resistance fault.

From the above point of view, there are similarities in factors resulting electrical fires. Even though each author used different terms or wording but the ideas are almost the same. For this reason, the researcher has summarized the ideas to define the most significant factor to influence electrical fire in dwellings in Table 2.2.

Table 2.2: Various Analysis Generated by Electrical Ignition

	IGNITION BY ELECTRICITY					
No.	**Chung-Seog Choi & Dong-Woo Kim , 2006**	**John. Kennedy & Patrick M. Kennedy, 1985**	**Nagoya Fire Bureau**	**John D. Dehaan, 2002**	**John J. Lentinni, 2005**	**National Fire Protection Association, 2001**
1	Short circuit	Electric Appliance	Wiring & Apparatus	Conduction Heating	Energized Neutral	Resistance Heating
2	Overload	Electric Line	Electric leak	Overheating by Excessive Current	Worn Out Outlet	Heat Producing Device
3	Leakage	Electric Terminal Equipment	Electrostatics sparks	Overheating By Poor Connection	Make Shift Extension Cord	Poor Connection
4	Poor Contact	Electric Transformers		Insulation Breakdown	A failed Transformers	Over current & Overload
5		Lightning		Arcs & Sparks	An Overdrive Staple	Arcs
6		Electric Panel		Aluminum Wiring		High Voltage Arcs
7		Electric Meters		Electric Motors & Transformers		Static Electricity
8				Fixed Heaters		Parting Arcs
9				Appliances		Arc Tracking
10				Extension Cord		Sparks
11				Heat Tape		High Resistance Fault

Source: Choi *et al*. (2006); Kennedy and Kennedy (1985); Nagoya Fire Bureau; Dehaan (2002); Lentinni (2005) and National Fire Protection Association (2001)

2.3.2 Electrical Appliances

Regarding to the list of ignition source, Kennedy and Kennedy (1985), Dehaan (2002) and National Fire Protection Association (2001) have pointed out that electrical appliances could be among the dominant factors. Kennedy and Kennedy (1985) listed electrical appliances into two groups; motor and heated appliances. Other than that, several technical reports and papers grouped them by some classification. For example, Hall (2009) grouped portable cooking or warming equipment such as coffee maker, food warmer, kettle, pressure cooker, toaster and etc as one group. Halogen light, fluorescent light, lamp-tabletop, floor or desk were sorted into lamp, bulb or lighting group, or the second group.

A research on home fire hazard in Alberta, Canada by Wijayasinghe and Makey (1997) showed that cooking equipment recorded the highest cases from year 1988 to 1992. It was followed by electrical distribution-equipment, heating equipment, smoker's material; matches and lighters. However, heating equipment meant by Kennedy and Kennedy (1985) were irons, heating tools and appliances, television set, neon sign, radio receiving set, electrical welders, toy trains and motion picture projectors. In the same way, stove, fixed space heater, fixed wiring, clothes dryer oven, central heating unit, chimney, light fixture, fireplace, water heater and so on were arranged according to priority of cases recorded by United States Local Fire Departments between 1993 and 1997 (Hall, 2002).

2.3.3 Electrical Line

Another ignition source cited by Kennedy and Kennedy (1985) is electrical line. Electrical line consists internal and external wires, cords, cable and also Christmas tree wiring. Conversely, Dehaan (2002) has separated electrical line into overheating by excessive current and also insulation breakdown while Choi et al. (2006) categorised it as short circuit and leakage. Likewise, Lentini (2006) shared the same view but elaborated it by incident due to worn out outlet and overdriven staple to the electrical line. All the points above having association to overheating phenomenon. In any circumstances, overheating must be converted into heat (Kennedy and Kennedy, 1985) as consequence to fire triangle concept.

2.4 FACTORS CAUSING ELECTRICAL IGNITION

As noted earlier, overheating is the first stage when the mentioned variables face failure. It also is defined as pre–pyrolysis process for the fire incident. Many literatures elaborate on how fire occurs. In consideration of that the resistance must ensue at first as well as Ohm's Law, V = IR, where **V** is voltage, **I** equal to current and **R** means resistance. As the temperature and the resistance increase, the voltage must also increase to maintain a constant **I**. In turn, this causes the amount of power being consumed to increase linearly (Noon, 2001). Dehaan (2002) has summarised the overheating factors. Those factors are excessive current, insulation break down, poor connection and also induction which rarely happens. However, there are other reasons to contribute resistance to heating such as electric appliances, lightning, electrical transformers, electric meters, and also electric panel (Kennedy and Kennedy, 1985).

2.4.1 Insulation Breakdown

Insulation breakdown is initiated by various ways. According to Kennedy and Kennedy (1985), insulation breakdown normally involves electrical lines such asinternal and exterior wire cords and also cables. The insulation fails with underrated cable and when there is no dissipation heat at particular point of circuit. This often occurs over an extended time and at such low rate that is not readily detectable until the conductive part creates so much current causing massive heating (Dehaan, 2002). In other words, that phenomenon can also be called as as aging wiring.

Referring to Licker (2004) aging is known as the changing of the characteristic of a device due to its use or operation of a product before shipment to stabilize characteristic or detect early failure. Whereas, Basara (2003) indicates with the passage of time, the insulation might be damaged due to a variety of reasons such as vibration, friction and moisture. In fact, Rasdall (2005) indicates that aging increases as the number of housing over the age of 40 increases. In addition, historic preservation and restoration also increases, while old wiring falls further behind with regards to improvement in the National Electric Code. He also has same point of view on the respective wiring specialist that aging could be 20, 30, 40, 50, or 60 years old.

Figure 2.1 elaborates the flow of insulation break down which generates fire. Specifically the way how insulation may be damaged is when the current flows in conductor exceed the conductor capacity or also known as underrated. The material of insulation itself may become charred and decomposed. With the frequent occurrence and extension of time the insulation could deteriorate and carbonization being created slowly and physically changed to become semiconductor. Afterwards, the current path flows being switched whether through the insulation material itself or across the surfaces of the insulation materials or even through the air. When it occurs in a limited area between conductors, it is often called arc tracking, arching through char or carbon tracking (Dehaan, 2002). The carbon formed causes it to localize heating which then results in a fire unless a circuit breaker or fuse is functioning. Another instance of aging wiring system is by using the over lamp light fixture. The heat from over lamp causes deterioration process to insulation (Rasdall, 2005) and when it is bundled in cable application while it is coiled or looped (National Fire Protection Association, 2001). The same fundamental also apply to the overheating by excessive current mechanism.

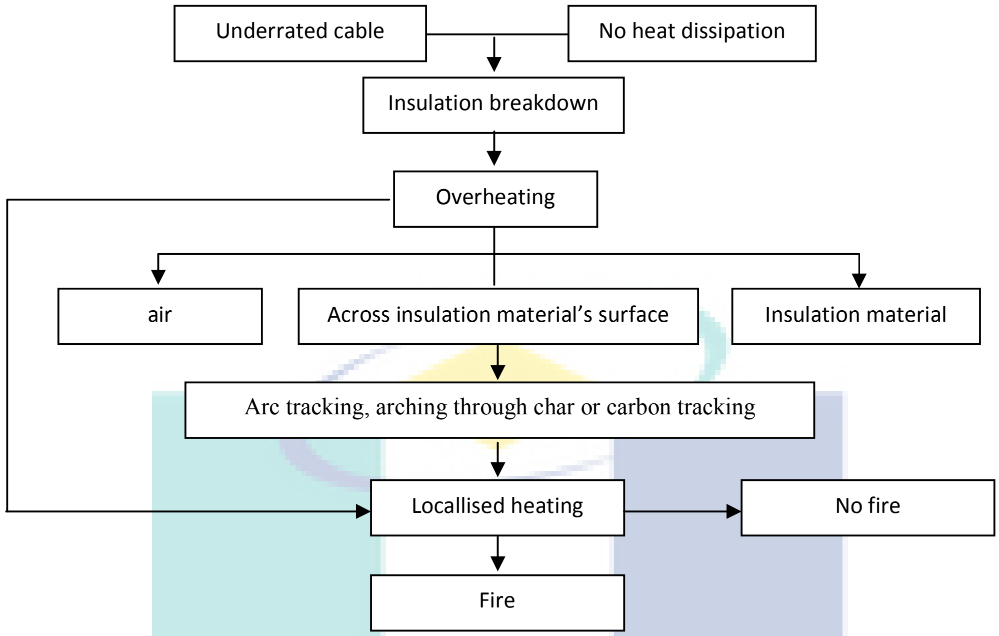

Figure 2.1: Flow of insulation breakdown generates fire

2.4.2 Loose Connection

Electric terminal equipment is usually engaged with a loose connection. Normally it can be found at fixture, outlet, switch, lamp, receptacles and also sockets (Kennedy and Kennedy, 1985). In other words, loose connection could be derived at connection between two cords, a wire connected to appliances as well as power source. The flow of loose connection generating fire is shown in Figure 2.2. Two of the more common reasons for a lug or terminal to lose its ability to safely carry current are looseness and corrosion (Noon, 2001). These mechanisms will form overheating which promotes an oxide interface (National Fire Protection Association, 2001) and creates parting arcs, gases and vapors simultaneously.

Poor contact is caused by various reasons such as vibrations, impacts to the panel box, temperature effects, material creep, chemical attack, and a host of other less obvious causes (Noon, 2001). However, according to Rasdall (2005) the other reasons are as follow:

i) expansion and contraction due to temperature changes seasonally and daily;

ii) vibration from trains, sonic boom from jet aircraft, other noisy vehicles, high decibel level music/radio equipment, and thunder;

iii) wind and air pressure; and

iv) the frequency and or unnecessary use of the switch.

For example, the houses located near to heavy road traffic or train pathways are in the high risk for vibration. Likewise, the geographical and weather factors which may lead to lightning strike could also shake home wiring system. However, there is an indication of warning signs of danger in home wiring system when the home lighting is flickering and dimming every time the switches are turned on. Other than that, by turning off a switch and pulling a plug may cause brief electricity discharge (National Fire Protection Association, 2001). It is due to the affect of arcing activity for a length of time in that equipment. The indication of that is discoloration at the faceplate outlet (National Fire Protection Association, 2009). Therefore, sparks can be seen when the cord is pulled out without turning off the switch or when turning on the switch and also when improperly fitting plug of the cord. The connection repaired between two cords using electrical tape may also contribute to loose connection.

On the other hand, corrosion at a lug or terminal equipment usually causes problems in two ways. First, the products of corrosion are often not good conductors of electrical current. Secondly, corrosion may cause material damage to the connection. It may result in material loss, weakening of the material, or even dimensional distortion (Noon, 2001).

These mechanisms will form overheating which promotes an oxide interface (National Fire Protection Association, 2001) and creates parting arcs, gases and vapors simultaneously. Gas and vapors can be the initial fuel because the point of ignition can be some distance away from where sustained fire starts in the structure or furnishings (National Fire Protection Association, 2001).

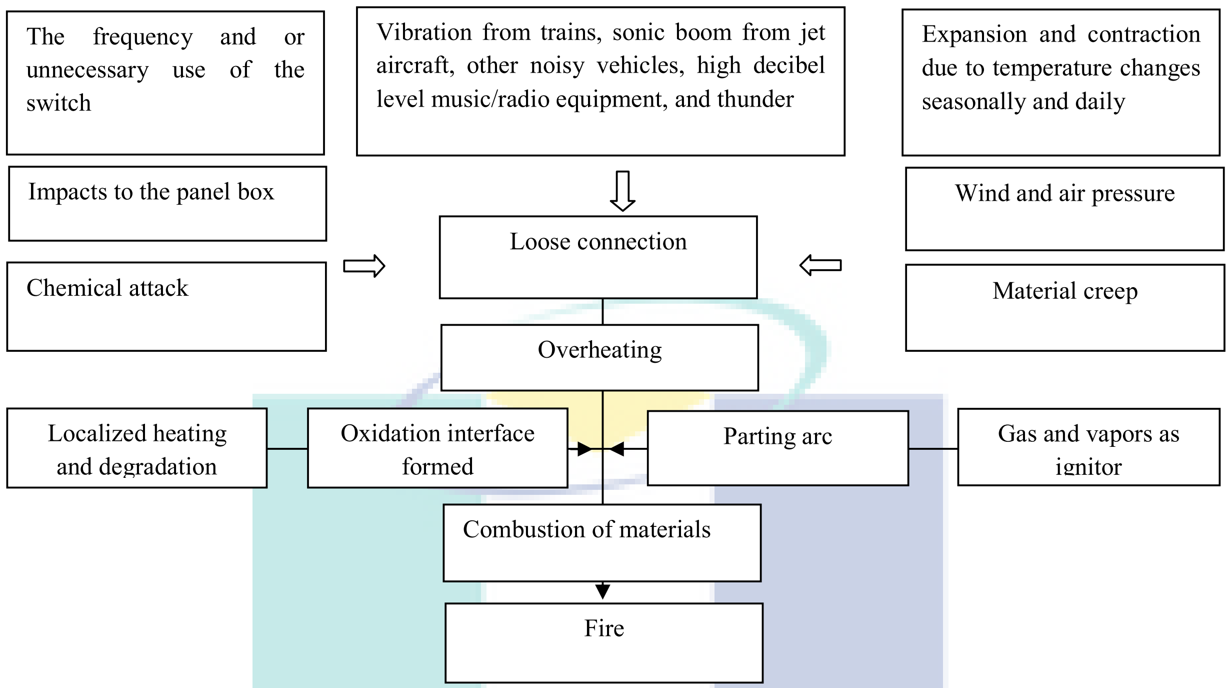

Figure 2.2: Flow of loose connection generate fire

2.4.3 Electrical Appliances

According to Dehaan (2002), the electrical appliances are divided into two categories. The first category is the fixed conductors, switches of protective devices and outlet of the distribution system while the second category is grouping of all portable, moveable lamps, tools and appliances that can be connected into first category. Based on Figure 2.3, there are four factors causing electrical failure or equipment before ignition starts including overheating, faults sudden high temperatures, poor contacts and finally insulation failure (Harrison, 2007). A fault tree analysis was developed by using a Boolean algebra; computing program to detect undetected fire in Large Hadron Collider (LHC) underground - a housed in a circular tunnel. The main purpose of that research was to assess the risk of fire due to faulty electrical equipment in both qualitative and quantitative way. This fault tree analysis has been used to compare the result from the electrical equipment installed and combustibles materials list which may be due to potential factors that develop a fire. Even though it was in the tunnel, an electrical current is a worldwide purpose.

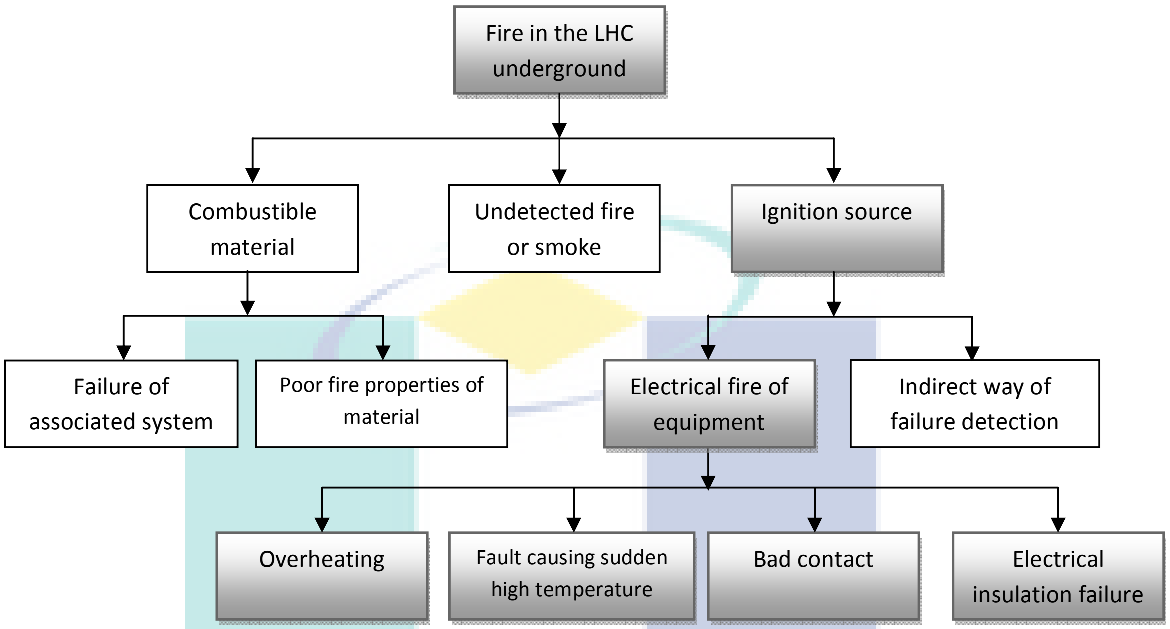

Figure 2.3: Fault tree analysis – Top event "Fire in the LHC underground"

Source: Harrison 2007

The electrical appliances fail to operate properly because of various conditions. First, the consumers misuse the gadget for different purposes and add together to pose all manner of risk (Dehan, 2002). For example, consumers change the bedroom light bulb from ordinary to halogen type without taking into account the total of the power required. Moreover, many houseowners are unaware of the electrical wiring phase during extension or renovation of their houses. As a result, there is an over current passing through circuit and the probability that the fire could originate is very high due to the location of combustible materials such as window curtain near the store.

Next, electrical devices might fail due to malfunction due to poor design as well as being counterfeit product. Such counterfeit electrical products can cause fires, shock and electrocution or even explosion. By looking at certification marks, name and contact name of manufacturer, checking the warning label and do a testing before purchasing defective products might help to avoid potential dangerous. Over the time, houseowners need to check the plug and the body of extension cord while the cord is in use as well as overall house wiring systems (United States Consumer Product Safety Commission, 1999 and Rasdall, 2005). Other than that, it is better to consult a competent person to examine whole wiring system (United States Consumer Product Safety Commission, 2007).

Next, the material of electrical devices is also to be considered as a possible source of ignition. A fuel by itself or an ignition itself does not create a fire unless it is resulted from the combination of fuel and an ignition source (National Fire Protection Association, 2001).

Lastly, the carelessness of using electrical device especially heating devices are among main factors to generate the fire if the switch is not turned off when leaving the house for an extended period of time (Killalea, 1999). Furthermore, the arrangement of electrical appliances near flammable and combustible material is the main factor for fire expansion.

2.4.4 Short Circuit

Normally, a short circuit is a common cause of fire reported in fire investigation report. Choi et al. (2006) revealed causes among electrical fire in Korea in 2004 were short-circuit with 67.4%, overload (8.8%), leakage (4.4%) and poor contact (4.10%). However, there are also other various points of view to elaborate on how short circuit might occur.

According to Licker (2004), short circuit is defined as a low resistance connection across a voltage source or between both sides of a circuit or line, usually accidental and usually resulting in excessive current flow that might cause damage. Similarly, National Fire Protection Association (2001), indicates it as an abnormal connection of low resistance between normal circuits conductors where the resistance is normally much greater; this is an over current situation but not an overload. Besides that, Nagoya City Fire Bureau concluded short circuit are cases when insulating coating of cable are damaged and copper wires come in direct contact , or when copper wires are connected via metal such as a nail, etc and also called bridging. In addition, Twibell (2004) also meant it as an electrical contact between two different potential of conductors. Indeed, it is among the final sequence before the fire occurrence.

In general, short circuit occurs when electric conductor is scratched by melting then creating a gap. The insulator might be damaged due to overloading of cable before the conductor is melted and separated to produce a gap. If the over current protection is defeated or defective, then a short circuit may become the ignition source (National Fire Protection Association, 2001) and create parting arc produced by short circuit and loose connection. Sparks then throw a particle and try to flow the current between the gaps. Importantly, the point of contact will generate heat and melt the conductors and they will be spattered out with generation of arc. Furthermore, melting conductor will cause bridging (Nagoya City Fire Bureau, undated) in between stranded wire. As a result, the ground fault is produced and an electrical shock is the main effect from that circumstances. Due to extension of time, localised heating degrades the conductor assisted by sufficient temperature and nearby material, the fire will eventually start.

Indeed, the difference between loose connection and short circuit is the circumstances of fire initiation. Short circuit should melt the conductive material first before fires propagate while only the combustible material such as dust, gases and vapours can ignite appliances devices itself in accordance to loose connection. The sequence of short circuit can be explained in the following Figure 2. 4.

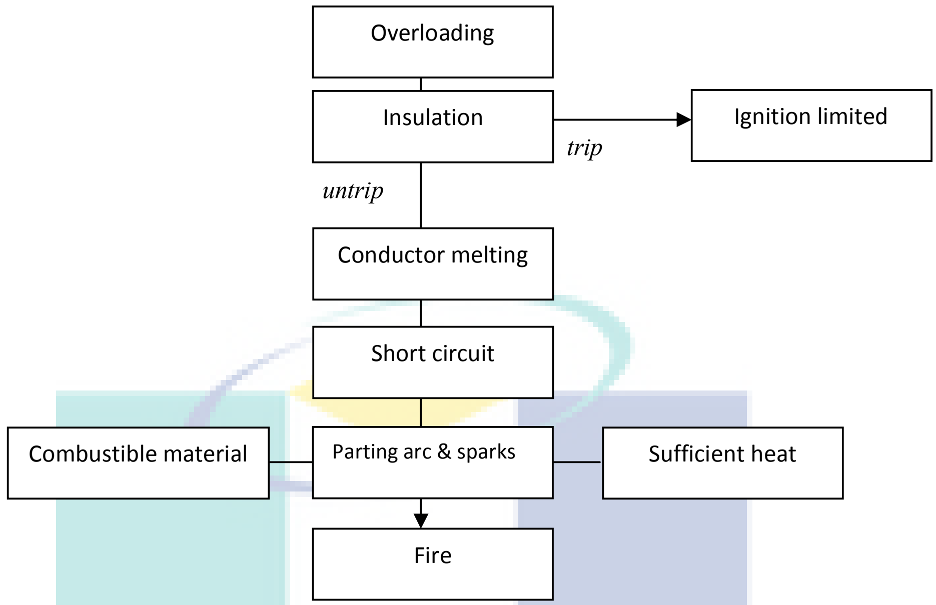

Figure 2.4: Flow of overloading generate fire

2.4.5 Overload

According to National Fire Protection Association (2001) overload may be defined as an operation of equipment in excess of normal, full-load rating or of a conductor in excess of rated ampacity. When it persists for a sufficient length of time, it would cause damage or dangerous overheating. It is similar to Twibble (2004) who suggested that the cable had been overloaded and it must have burnt out or shorted at the damage location. Instead of short circuit and ground fault, overload could also cause excess of the rated current of equipment or the ampacity of the conductor where it is also known as over current. As a result, the sustaining of over current will result in overload if the protection devices malfunctions (National Fire Protection Association, 2001). For example, the same heating effect along the entire of the cable is known as overload even though it is far in distance from the cause of ignition. Fortunately, there is minimal damage to its insulation if overload occurs (Twibble, 2004).

In general, a condition of excessive current flow in electrical line or wiring system which then causes the overheating circumstance before resulting in the fire is defined as overload. In order to trigger the fire, the amperes and sufficient length time are obligatory. Usually, misuse of electrical cords size enables the flow of current in large amounts. It is also called underrated. Subsequently, extension cord is prohibited in long term period of usage as well as when more extension plug is plugged. Hence, it draws a total of more watts than the rating of the cord (U.S Fire Administration, 2000). Meanwhile, Bangert and Hartford (1973) verified that the excess current which was so long active in the circuit will not trip protective devices because the current that passes through it does not exceed 15 amperes. With time, the conductor melts then is separated to produce a gap. Eventually, it may become ignition source creating parting arc (National Fire Protection Association, 2001). In order to enlighten such cases of overloading, the following example can be used.

i) Warm electrical cord. If an electrical cord is warm to the touch, the cord is under rated or defective. (U.S Fire Administration. 2000)

ii) Extension cords should never be used as a long term solution to the need for another receptacle. (United States Consumer Product Safety Commission, 2003).

iii) Never overload an extension cord. If any part of the cord feels warm to the touch, the cord is drawing too much power and could present a fire or shock hazard. (Electrical Safety Foundation International, undated).

iv) The instance of overloading is when the lighting frequently break down; it is also an indicator of overloading condition. (U.S Fire Administration, 2000).

v) If too much current is drawn from the circuit, the circuit breaker trips or the fuse blows, breaking the circuit to prevent an overload (Josh, 2007).

2.4.6 Lightning

Lightning is an electric current. It is generated within or between clouds. There are two different charges with positive at the upper side and negative charges at the underside. The electrical current is generated when the two charges are adequate to cause contact. Lightning causes fire when sufficient heat is created to ignite combustion nearby and cause damage to potential object (Lentini, 2006).

Lightning can enter the building structure with normally four ways. First, lightning strikes the metallic object such as antenna and outside from building roof. If there is a flat roof or parapet, lightning normally attacks at the edge of the roof. Secondly lightning strikes directly the building structure. Next, it also hits the nearby tree or tall structure. Finally, it strikes the conductor of the power line to the building along the normal conductor. Consequently, the fire will occur if sufficient heat is supplied together with combustible material (Kennedy and Kennedy, 1985 and National Fire Protection Association, 2001). Furthermore, lightning damage can be categorized into two characteristics; concentrated explosive damage and localized heating.

2.5 IMPACT OF THE FACTORS CAUSING ELECTRICAL FAULT

Based on the factors, the researcher has decided to choose those factors that influence electrical home fires to be the research variables. The variables are electrical equipment failures, overloading, poor connection, insulation break down which may separate to short circuit and aging, and finally lightning. Nevertheless, the residual of ignition points is not examined in this research because the measurement of variables are put aside from the limitation of the study. To summarize, this research implies a graphical model to upgrade the ideas and variety of point of views, research opportunities and findings in structural fire particularly in residential house. Figure 2.5 simplifies this idea.

Figure 2.5 can be used as research theoretical framework which contains both dependent and independent variables. The figure is presumed as a wiring circuit and assumes that the current is flowing within the circuit. For example, the poor connection mechanism might induce overheating first before igniting the fire through several progressions or even may directly localize heating and ignite fire load nearby. The conceptual framework can be converted into the graphical model and be used for further research purposes when it is proved that there are significant relationships between variables.

As a summary, the conceptual framework is digested to make understanding more clear as drawn in Figure 2.6. The overloading is influenced by electrical equipment failure, poor connection, short circuit, aging and lightning. Due to overloading, fires not also affect structural fire generally but also cause the largest fatality in residential houses particularly. Hence, property loss, electrical shock and even death are also consequences of overloading.

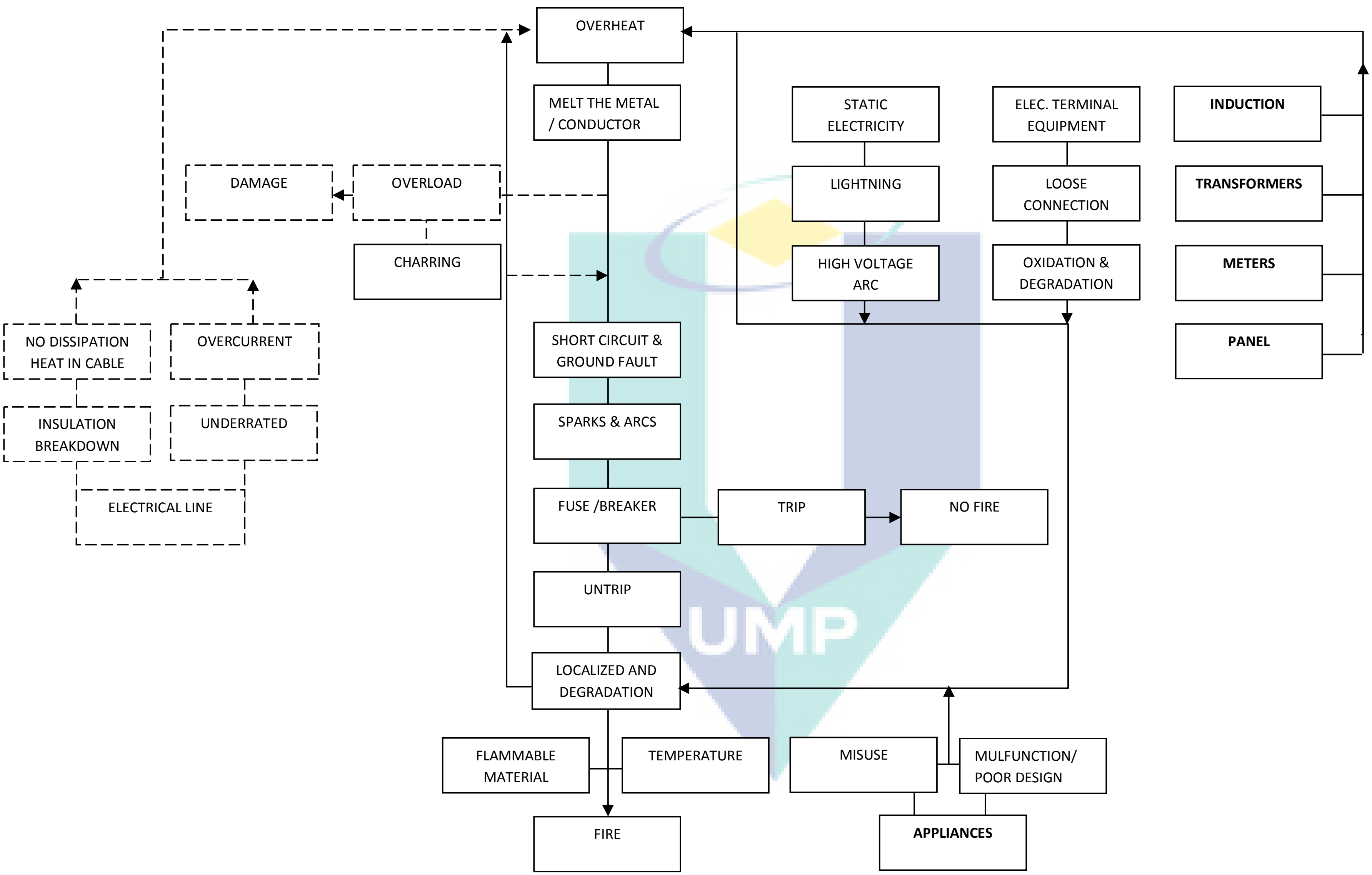

Figure 2.5: Conceptual Framework of Electrical Fire Causation

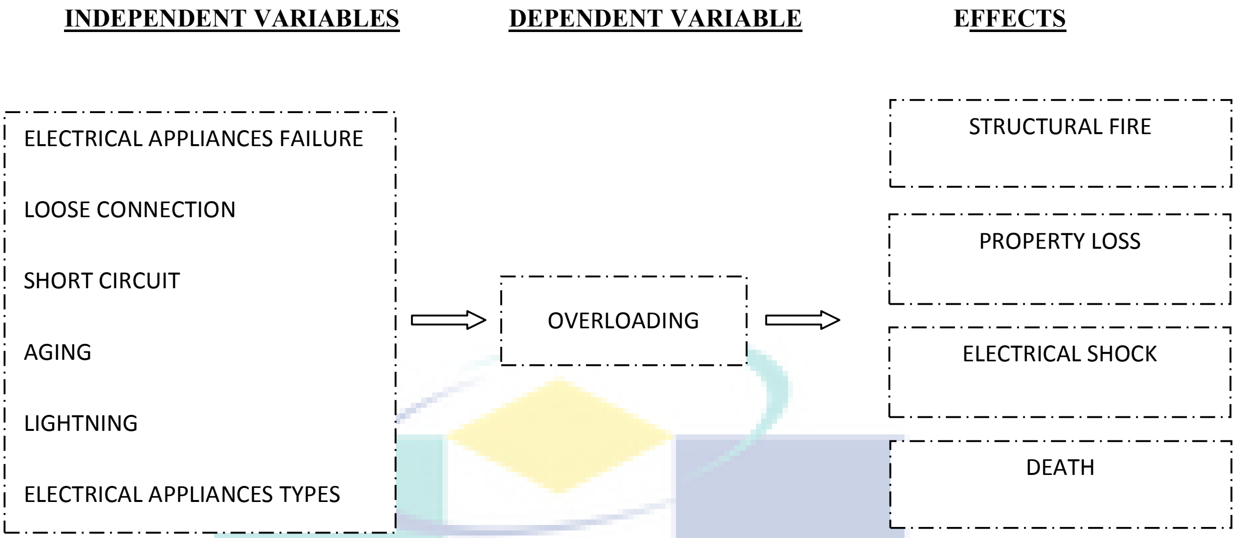

Figure 2.6: The electrical wiring and equipment failure influences huge impacts in above summary research conceptual framework

2.6 KNOWLEDGE, ATTITUDE AND PRACTICE (KAP) APPROACH AS RESEARCH APPROACH

An awareness concept has been widely applied in research methodology. It is divided into three parts which are knowledge, attitude and practice (KAP). Similarly, knowledge, attitude, and behavior (KAB) also has been addressed in various fields such as AIDS prevention and campus safety (Jones, 2000). Knowledge is defined by the information; understanding and skills gained through education and experience while attitude is the way that you think and feel about something or represents an individual's degree of like or dislike for an item. Practice is a way of doing something in the usual or expected way in a particular organization or situation or the act of rehearsing a behavior over and over (Hornby, 2005).

KAP concept has been used to represent population information based on what is known, believed and done (World Health Organization. 2008). Most research using KAP is discovered in medical field, safety and health industry as well as education. In order to get the information, a survey is used to collect a data from the individuals of interest through various mechanisms such as via telephone, internet, face-to-face interview and also mailing surveys (Czaja and Blair, 2005). A set of questionnaire is normally used to document the data obtained.

A variety of measurement is conducted during the design of the questionnaires. Normally researchers employed previous questionnaires instead of self-design. There is no finite rule to design the questionnaires. For instance, Kaliyaperumal (2004) used open-ended question to measure knowledge and practice, and agree statement for attitude to explore changes in knowledge, attitude and practices of the community, paramedical personnel and medical practitioners on diabetes and diabetic retinopathy. However, Askarian and Assadian (2009) used different measurement to assess the level of knowledge, attitude, and practice among Iranian dental healthcare professionals towards standard isolation precautions in Shiraz, Iran. Knowledge was questioned by three possible answers (yes, no, don't know), attitude was measured by five responses (very high, high, intermediate, low and no importance) and practice is evaluated also by five possible answers (always, often, sometimes, seldom and never) (Askarian and Assadian, 2009). According to Wiersma and Jurs (2005), there are a number of possible set of Likert responses and it does not require five options. They may have any reasonable number. For that reason, there are no arguments related to this subject.

In another instance, a five-point Likert scale (five for strongly agree and one for being strongly disagree) was used by Chandrakantan (2004) to determine the current fire safety conditions of residential colleges in a local Malaysian university. In addition to that, Yang et al. (2006) used different measurement to examine their variables. From the four variables, the first questioned on having a smoke detector, second was measured by discussing and practicing the fire escape plan, third was used to gauge respondents' belief if there would be a fire in their home in the future using five Likert scale (very high to very low) and finally actual risk of home fire was calculated by summing up four binary variables; households that reported a previous fire, households using wood as the primary source of heat, households using a wood fireplace and/or wood stove during the past winter and households in which at least one member is a current smoker.

Previous research which had similar meaning of KAP concept was done by Chandrakantan (2004) to determine fire safety condition in local Malaysia university colleges. He found that knowledge about fire safety was in the third place followed by attitude. The first factor was belief and second was perception. However, his belief that perception is out of this research prospective. On the contrary, Jingzhen et al. (2006) revealed that practicing the fire plan was less than one fourth (23.7%) of overall respondents (288) study household. All of above findings complied with World Health Organization (2008) guideline which used KAP survey to identify knowledge gaps, cultural belief or behavioral pattern that may facilitate understanding and action. Moreover, by using that concept researcher may identify the cause and how people practice behaviors from their attitudes and also influencing factors. Furthermore, Kaliyaperumal (2004) stated that a practice refers to the way in which they demonstrated their knowledge and attitude through action. Indeed, due to that, this research focused on practice behavior in order to get information from respondents. The research had also focused to practice variables particularly in electrical appliances and other future potential variables.

The above approach is also similar to Williamson and Feyer (1998) theory regarding electrical fatalities in the Work Related Fatalities Study (WRFS) in Australia. They had positioned the sequence on how electrical/electricity may lead to fatalities. There are environmental events, equipment events, medical events and lastly behavioral events. Behavioral events are also resulted from human involvement. For that reason, the focus of the current research is related to human practice as people who not do have adequate knowledge and have a bad or poor practice unless they attend training (Huseyin and Satyen, 2006). So, the research concentrates on practice rather than knowledge or attitude. As far as practice is concerned, anything from the intangible can be realized to take place. However, it is not possible to do in the future as suggested Huseyin and Satyen (2006) such as to investigate the relationship between fire safety knowledge and peoples' actual response in a fire.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Two methodologies have been elaborated in previous chapter to examine the causes of a fire (cause beads) or result of fire (victim beads or post fire) in structural fire due electrical ignition. Thus, the statistical approach was chosen compared to experimental methodology to accomplish the objectives of the study. Accordingly, several steps should be well arranged such as population identification, study of location, accurate conceptualization of knowledge, attitude and practice (KAP), questionnaire design, variables measurement, data collection, data analysis and until the results can be concluded. Therefore, the outline of the methodology is acknowledged in the following section.

3.2 STUDY LOCATION

The research area involved three states; Terengganu, Pahang and Negeri Sembilan including both rural and urban areas. The research area was scattered according to respondent's residential and fire accidents. The types of houses involved were typical kampong (built using timber and concrete base), terrace, traditional Malay (constructed 100% by timber), semi detached, bungalow, flat, condominium and apartment.

3.3 POPULATION AND SAMPLING

The population of the research was the fire victims in the dwelling houses and the sampling frame was taken from the list of fire victims in Negeri Sembilan, Pahang and Terengganu. The sampling frame was identified from Fire and Rescue Department of Malaysia, in Negeri Sembilan, Pahang and Terengganu based on the monthly report of fire statistics obtained from Fire Investigation Division. Only respondents who had experienced home fire were involved in this research. The samples which represented the research population were the fire victims in dwelling houses caused by either electrical failure due to wiring system or electrical appliances.

A total of 225 fire victims were chosen from the 3 states by universal sampling as respondents, based on 225 dwelling fire cases due to electrical failure in 2008 and 2009. However, only 142 of them were available to be contacted. Unfortunately, only 77 of them (54.2%) participated in this research because some of them were not contactable due to incomplete record changed contact numbers, as well as unwillingness to give cooperation. Table 3.1 shows the distribution of fire victims from the three states.

Table 3.1: Fire victim records in Negeri Sembilan, Pahang and Terengganu (2008-2009)

Description	Negeri Sembilan	Pahang	Terengganu	Total
Dwelling Fire	164	196	210	570
Dwelling Fire Caused By Electrical	50	96	79	225
Able To Contact	47	54	41	142
Respond	31	22	24	77

Source: Fire & Rescue Department state of Negeri Sembilan, Pahang and Terengganu

Even though only three states are chosen, the population has covered the whole Malaysia. In actual fact, fire investigation task is responsible to the Fire and Rescue Department Malaysia under Fire Service Act 1988. The Fire Investigation Division has monitored all over the Fire Investigation team activity in every states by practicing the same procedure, attending the same investigation training course and monitoring the statistics.

3.4 MEASUREMENT OF VARIABLES

Most previous research carried out the same method via experimental on conductors as well as systematically reviewed electrical component-by-component basis (Harrison, 2007). This research emphasized the level of practice on electrical equipment usage and wiring system. It was measured based on respondent's experienced–based indication and warning sign of fire hazard.

One of dependent variables for this research is overloading, which is one of the wiring system variables. However, the remaining wiring systems that are also defined as independent variables are loose connection, short circuit, aging and also lightning. In spite of this, electrical appliances failure is indicated as independent variables. The degree of each variable is measured based on the certainty of respondent's experienced based indicator and warning signs of danger prior to fire event according to the following Likert-scale answer:

1	2	3
Yes	Don't Know	No

1	2	3	4
Very Not Sure	Not Sure	Sure	Very Sure

3.4.1 Dependent Variables

In this research, dependent variable which is overload refers to the degree of certainty to which respondents experienced overload in their residence. Judgments about the extent of overloading were gauged using five questions. The items were adopted from the following literatures; United States Fire Administration (2000) and Josh (2007). One example of the questions used is "you have touched on the ubiquitous cable and felt hot." Respondents were asked to indicate the level of certainly for each statement, using a scale 4-point Likert scale ranging from "Very sure" (4), "Sure" (3), "Not sure" (2) to "Very not sure" (1).

3.4.2 Independent Variables

Independent variables are the factors which influence the dependent variable. The independent variables have been successfully identified from the intensive literature in Chapter 2. The operational definitions of the independent variables are divided by the following:

a) Electrical Equipment Failures
b) Loose Connection
c) Short Circuit
d) Aging
e) Lightning

a) **Electrical Equipment Failures** –The degree of certainty to which respondents experienced poor design, counterfeit product or devices' material as well as misuse which they experienced in their home. The evaluation was measured using 3-point Likert scale which was "yes", "don't know" and "no". The literatures for this section were taken from Electrical Safety Foundation International (2010), United States Consumer Product Safety Commission (2007), Electrical Safety Foundation International (undated), How Stuff Works (2009), Rasdall (2005) and National Fire Protection Association (2001).

b) **Loose Connection** –The degree of certainty to which respondents experienced bad contact at connection at electric terminal equipment such as fixture, outlet, switch, lamp, receptacles and sockets due to vibration from vehicles and thunder instead of flickering light cues and discoloration sign at receptacles. Judgements about the extent of poor connection were gauged using eight questions. The items were cited from National Fire Protection Association (2009), Electrical Safety Foundation International (undated), United States Fire Administration (2000), Electrical Safety Foundation International (2010) and Rasdall (2005). One example of the items used is "you have seen the discoloration on the socket or switch outlet in your house". Respondent were asked to confirm the level of certainly for each statements, using 4-point Likert scale ranging from "Very Sure" (4), "Sure" (3), "Not sure" (2) to "Very Not sure" (1).

c) **Short Circuit** –The degree of certainty to which respondents experienced short circuit in their residence. The extent of respondent experience was measured using two questions. The items were quoted form Rasdall (2005) and How Stuff Works (2009). One example of the item is "you have seen damage to the cable insulation in your home, such as frayed or worn. Respondents were asked to confirm the level of certainly for each statements, using 4-point Likert scale ranging from "Very Sure" (4), "Sure" (3), "Not sure" (2) to "Very Not sure" (1).

d) **Aging** –The degree of certainty to which respondents experienced aging in their dwelling. The extent of respondents' experience was measured by using two questions. Respondents were asked to confirm the level of certainty for each statement, using 4-point Likert scale ranging from "Very Sure" (4), "Sure" (3), "Not sure" (2) to "Very Not sure" (1). One example of the items is "in order to look your wiring system neater, you have coiled or looped it". The questionnaires were modified from Rasdall (2005), United States Consumer Product Safety Commission (2003) and National Fire Protection Association (2001).

e) **Lightning** –The degree of certainty to which respondents experienced in their house. Two parameters were weighted by lightning entering structure or dwelling through power line or causing damage to the electrical appliances. The parameters measure 4-point Likert scale ranging from "Very Sure" (4), "Sure" (3), "Not sure" (2) to "Very Not sure" (1). The illustration of that is referred to Kennedy and Kennedy (1985) and National Fire Protection Association (2001).

3.5 DATA COLLECTION

Data was collected from May 2009 until March 2010 mainly through a survey using a questionnaire as a tool to obtain the information. In line with the advancement in technology, the survey was carried out via telephone calls. In fact, this method could save much time and and it is even much faster than getting the information compared to other methods (Czaja and Blair, 2005).

The questionnaire was administered among the respondents via interview by the researcher and trained interviewer. Another approach used was to collect the data online as requested by respondents because some of them had limited time to be interviewed. The data collection details are given in Chapter 4.

3.6 QUESTIONNAIRE DESIGN

The questionnaire was designed using two-folded A4 paper. The questionnaire was divided into seven sections and it consists of 41 questions with three and four-Likert scale options. The questionnaire was designed in the following six phases:

i) Literature review
ii) Pilot test
iii) Defence proposal review
iv) Expert panel review
v) Re-pilot test
vi) Field study

In **phase 1**, the questionnaire was developed using intensive literature review from journals, books and also established online web mail such as National Fire Protection Association (NFPA), Electrical Safety Foundation International (ESFI), United State Fire Administration (USFA), U.S Consumer Product Safety Commission (CPCS) and How Stuff Works. As mentioned earlier, KAP concept particularly in practice had been instrumented to design the questionnaire for measuring fire victims' practice towards electrical wiring and appliances failure. Questions were coded based on three Likert-scale measuring variables on electrical appliances failure and five Likert-scale measuring variables on overload, poor connection, short circuit, aging and lightning. The response options for the three Likert scale were "Yes" (1), "Do not know" (2) and "No" (3) while the five Likert-scale was '"Very sure" (5), "Quite sure" (4), "Sure" (3), "Not sure" (2) to "Very not sure" (1). Demographic information was also questioned in the open-ended forms at the beginning of the question form in order to evaluate fire victim characteristics. The total number of items was 46. Before running the pilot test, the questionnaire was revised by the main supervisor and co-supervisor.

In **phase 2**, to pilot test the questionnaire, it was distributed to masters' students at Universiti Malaysia Pahang and households surrounding Kuantan district/town/province. The questionnaire was self-administrated by respondents. About 25 questionnaires were successfully collected. The cronbach alpha scores ranged from 0.52 to 0.78. Of these questions, five items were dropped to attain the reliability. Accordingly, most of the respondents reported that they confused with one of the optional answers of "Quite sure". The detail of the results is shown in the following table.

Table 3.2: Pilot test 1 results

Variables	Pilot Test 1 – 5 Likert-Scale – 25 respondents	
	Cronbach's alpha, α	**If Item Deleted**
Appliances Failure	0.71	S7, S8, S9, S11
Overload	0.78	-
Loose Connection	0.76	-
Short Circuit	0.73	-
Aging	0.77	-
Lightning	0.52	SH1

Then, in **phase 3**, the result was presented and evaluated during research proposal defense session. The panel review did not agree with the five Likert-scale. The panel asked the researcher to distribute the questionnaire again before real field study take place. According to Wiersma and Jurs (2005), there are a number of possible set of Likert responses and it does not necessarily require five option; they may have any reasonable number.

In **phase 4**, the questionnaire was further revised due to panel review during defense proposal and feedback from the first pilot test. In this phase, the questionnaire was evaluated by expert panel consisting of two lecturers, two postgraduate students and technical staff with electrical background from Universiti Malaysia Pahang. Furthermore, the questionnaire was also revised by Head of Advance and Quantitative Programme from National Institute of Public Administration (INTAN), Bukit Kiara. The expert panel also helped to verify the content validity and to test the face validity of the questionnaire. As a result, several questions had been corrected such as; "have you forgotten switch off any electrical appliances after use or before you leave home or bed?", "you have seen the discoloration on the socket or switch outlet in your house", "you repair the cable that is damaged or disconnected by using electrical tape", "you see sparks in the socket when you switch off the switch or pull the plug from the socket before switching off the switch", "you have experienced interference lights in your house such as lights dim" and "wiring systems in your homes has been starting over after 40 years". Other than that, new questions were also added such as "have you ever checked your house circuit breaker every six months by pressing the "TEST" button?"

In the **phase 5**, the questionnaire was disseminated again as a pilot test. The respondents were among Negeri Sembilan households and the questionnaire was self-distributed by researcher. About 37 respondents successfully participated. However, the cronbach alphas view a similar scores ranging from 0.51 to 0.80. In addition, three questions were dropped in order to meet the reliability. The items were dropped from each from short circuit, aging and lightning variables. However, the three items remained in the questionnaire for real study. The detail of the results is shown in the following Table.3.3:

Table 3.3: Pilot test 2 results

Variables	**Pilot Test 2 – 4 Likert-Scale – 37 respondents**	
	Cronbach's alpha, α	**If Item Deleted**
Appliances Failure	0.73	-
Overload	0.59	-
Loose Connection	0.80	-
Short Circuit	0.68	SF1
Aging	0.51	SG1
Lightning	0.59	SH1

In **phase 6**, the questionnaire was further evaluated in real field study. The survey was carried out via telephone calls by using the items in the questionnaire as a tool. The respondents were chosen as a universal sampling from the list of fire victims in dwelling in Negeri Sembilan, Pahang and Terengganu. The responses of the questionnaires were recorded by researcher according to the optional scales given by respondents. The questionnaire administration took place during work hours. However, there was also sessions which took place after work hours as requested by the respondents due to their permission and availability. The duration of the interview for each respondent was approximately 45 minutes.

3.7 RELIABILITY ANALYSIS AND VALIDITY

The reliability test was initially done to ensure the consistency of variables. It was determined using item analysis with reference to the cronbach alpha. The commonly cronbach alpha used threshold value for acceptable reliability is 0.70. However, this is not an absolute standard. Values below 0.70 have been deemed acceptable if the research is exploratory in nature (Hair et al., 1998).

Table 3.4 shows the reliability analysis for six domains namely electrical failure, overloading, loose connection, short circuit, aging and lightning. For the pilot study, the cronbach alphas for the six items were from 0.51 to 0.80, while the cronbach alpha values for the actual study were 0.55 to 0.87. Even though the cronbach alpha for aging is 0.51, the questionnaire was considered reliable since Ary et al. (2006) alleged if the measurement results are to be used for making a decision about a group or research purposes, or if an erroneous initial decision can be easily corrected, scores with modest reliability (coefficient in the range of 0.5 to 0.6) may be acceptable. Furthermore, Wiersma and Jurs (2005) quoted Jane Close Conoley and James C. Impara from the Twelfth Mental Year book that reliability coefficient for personality assessment inventory about 22 subscales specifically for normative sample is between 0.45 and 0.90 to be considered reliable.

Table 3.4: Reliability analysis

Variables	Number of items	Cronbach's alpha	Item Deleted
Appliances failure	12	0.69	1
Overloading	5	0.60	1
Loose connection	8	0.55	-
Short circuit	2	0.87	1
Aging	2	0.61	1
Lightning	2	0.63	1

Therefore, the reliability of the questionnaire has been confirmed in one of the Factor Analysis assumption. Although Factor Analysis was not performed in this study-due to smaller sample size, however the assumption can verify the inter –items correlations among independent variables and dependent variable (Hair et al., 1998). Table 3.5 shows the factor ability of the factor loadings indicating a good correlation between the items and factor when correlation coefficient shows 0.3 and above (Tabachnick and Fidell, 2001). The individual items were also consistent in the measurement. Moreover, the eigen value shows that the components meet the criterion when the value is 1 and above, Bartlett's test is statistically significant at $p<0.05$ and Kaiser-Meyer-Olkin value is more than 0.5 (Hair et al., 1998).

Table 3.5: Factorability of the correlation matrix

Variables	**Factor loading;**	**Eigen value**	**KMO**	**Bartlett**
Equipment failure	0.338 - 0.890	3.62	0.74	0.000
Overloading	0.531 – 0.624	1.94	0.57	0.000
Loose connection	0.348 - 0.585	2.20	0.48	0.000
Short circuit	0.5	1.79	0.50	0.000
Aging	0.5	1.44	0.50	0.000
Lightning	0.5	1.46	0.50	0.000

After completing the survey, the data were then edited into SPSS database. These responses were then converted into scores. Total score was calculated for each variable domain. Then, each total raw score was transformed into 'percent score' by dividing the score with the possible maximum score, and multiplied by 100. Moreover, the questionnaire designed and developed is outlined as follows and the details can be referred at appendix.

3.5.1 Section I Demographic - sex, age, status, qualification, house type and also types of electrical appliances they used.

3.5.2 Section II Electrical appliances failure - The equipment's design, certification label, devices material and also product usage (Table 3.4).

3.5.3 Section III Overloading

3.5.4	Section IV	Loose connection
3.5.5	Section V	Short circuit
3.5.6	Section VII	Aging
3.5.7	Section VIII	Lightning

3.8 DATA ANALYSIS

Data was analyzed using a software namely Statistical Package for Social Science (SPSS) version 16.0 (Chua, 2009; and Lay and Khoo, 2009). Kolmogorov-Smirnove (Hair et al. 1998) was performed to access the normality of data. The parametric test was used to analyze the normal data. Therefore, the data has been analyzed using the following statistical test:

a) Reliability test,
b) Descriptive test,
c) One sample t-Test,
d) Correlation test
e) Multiple linear regression test

3.8.1 Reliability Test

The reliability test was initially done to ensure the consistency of variables. It was determined using item analysis with reference to the cronbach alpha. A commonly used threshold value for acceptable reliability is 0.70 (Hair et al., 1998). However, this is not an absolute standard, and values below 0.70 have been deemed acceptable if the research is exploratory in nature (Robinson et al., 1991). In this study, the reliability analysis was performed for six domains namely electrical failure, overloading, poor connection, short circuit, aging and lightning.

3.8.2 Descriptive Test

Descriptive test was used to describe the demographic characteristics such as types of house, electrical equipment usage, respondent qualification, sex, status, and age in percentage and frequency.

3.8.3 One Sample T-Test

One sample T-Test was used to compare the level of practice on electrical appliances as well as wiring system among fire victim based on warning signs of danger and experience.

3.8.4 Correlation Test

Correlation test was performed to see the association between variables such as electrical appliances types and failure, overloading, poor connection, short circuit, aging and lightning to determine the correlation between variables.

3.8.5 Multiple Regressions Test

Multiple linear regression test was performed to study the relationship between overload and factors such as appliances types and failure, loose connection, short circuit, aging and lightning. The regression model was evaluated through coefficient of determination (R^2), F-ratio and significance test of regression coefficient. The higher R^2 value, the higher independent variables influence dependent variables whereas t-value indicates significant relationship between independent variable and dependent variables. The P value less than 0.05 indicates t-value is significant. Consequently, the alternatives hypothesis should be accepted. Moreover, standardize regression coefficient (β) was used to classify the highest influence rank between independent and dependent variable.

In order to run regression analysis, there are several assumptions to be met. According to Chua (2009), it must meet linearity, multicollinearity and singularity, absence of outliers, and also adequate sample size assumption. However, the other assumption; normality and hetrodecasticity which are recommended by Hair et al. (1998) and Tabachnick and Fidell (2001) should also be fulfilled.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

A total of 77 fire victims from Negeri Sembilan, Pahang and Terengganu have participated as respondent. Approximately 54.2% of residential fire victims caused by electrical source has been successfully interviewed via telephone calls. Meanwhile, 45.8% of them were not contactable due to wrong number, unanswered or keep in mailbox voice, incomplete record such as mistaken in recorded, inappropriate respondents and unwillingness to give cooperation.

Even though only three states were chosen, the population has covered for whole Malaysia. In actual fact, fire investigation task is responsible to the Fire and Rescue Department Malaysia under Fire Service Act 1988. Indeed, the Fire Investigation Division has monitored all over the Fire Investigation team activity in every state by practicing the same procedure, attending the same investigation training course and monitoring the statistics.

Kolmogorov-Smirnov (KS) statistics test was conducted to access the normal distribution of the data and the results as in Table 4.1: The value of 0.496 greater than p value 0.05 indicated that the sample is in normal distribution (Hasnah et al., 2006). Similarly, the data is mathematically distributed normal if the sampling size is greater than 30 (Petrie and Watson, 1999).

Table 4.1: Kolmogorov Smirnov – Normality (One-Sample Kolmogorov-Smirnov Test)

		Unstandardized Residual
N		77
Normal Parameters[a]	Mean	.000
	Std. Deviation	18.134
Most Extreme Differences	Absolute	.095
	Positive	.095
	Negative	-.086
Kolmogorov-Smirnov Z		.830
Asymp. Sig. (2-tailed)		.496

4.2 RESPONDENT DEMOGRAPHIC BACKGROUND

The respondents were among the dwelling fire witnesses and have been interviewed by fire investigators during investigation process caused by electrical sources. The witnesses were fire victims, civilians or neighbours and firemen who saw the fire or arrived earlier at the location. Since this study concentrated on warning signs of danger and experience, therefore the fire victims of fire caused by electrical sources were the best respondents.

Table 4.2 shows the background characteristics of the respondents. A total of 77 of fire victims aged between 20 to 70 years were recruited as respondents. In order to study the level of awareness and practices, age is not a significant factor influencing the results as proven by the previous research. For example, a study among the workers in a bottling plant showed that there was no significant difference of awareness and practice levels between those above 40 years and less than 40 years ($p<0.05$) (Kamat et al., 2004). Huseyin and Satyen (2006) also found that age did not significantly influence the level of fire safety knowledge and response. However, the age was statistically significant on the accuracy of response in a fire that paralleled with the research target to focusing on only respondent's practices (Huseyin and Satyen, 2006).

Most of respondents were male (64.9%) and married (93.5%). In addition, most of the fire victims's (48.7 %) level of education was secondary school. Conversely, only 25% of them only finished primary school education.

Table 4.2: Background characteristics of respondent

Demographic Factors		**Frequencies**	**Percentage (%)**
Gender			
	Male	50	64.9
	Female	27	35.1
Age			
	20 – 30	7	9.2
	31 – 40	23	30.3
	41 – 50	26	34.2
	51 – 60	15	19.7
	61 - 70	5	6.6
Marital			
	Status Single	5	6.5
	Married	72	93.5
Qualification			
	Primary	19	25
	PMR / SRP	11	14.5
	SPM / MCE	37	48.7
	Diploma	4	5.3
	Bachelor	3	3.9
	Master	2	2.6

For the residential profile as shown in Table 4.3, 27 (35.1%) respondents live in typical kampong houses and 24 respondents (31.2%) live in terrace houses. On the other hand, only one (1.3%) respondent live in flat houses. As the highest frequency of fire accident occurs in typical kampong houses, therefore it can be summarized that typical kampong house was the common house involved in residential fire. Basically, there are 13 types of houses excluding typical kampong and traditional Malay (Department of Statistics Malaysia, 2010; National Housing Authority, 2009). However, both typical kampong and traditional Malay houses were included in this study since it was reported that there was a number of fire occurred in both types of houses. Therefore, it is recommended to evaluate the association between types of houses, rural area, and level of education towards fire incidents. Moreover, it was reported that electrical fires were more common in areas of lower socioeconomic status due to the older nature of the homes (Duncanson et al., 2002).

Table 4.3: Residential profile of respondent

Residential Profile		**Frequencies**	**Percentage (%)**
Houses Type			
	Typical kampong	27	35.1
	Terrace	24	31.2
	Traditional Malay	15	19.5
	Semidetached	5	6.5
	Bungalow	3	3.9
	Flat	1	1.3
	Others	2	2.6
Heating Equipment			
	Iron	60	77.9
	Water Heater	18	23.4
	Oven	13	16.9
	Stove	10	13
	Cloth Dryer	3	3.9
Lamp/ Bulb/ Lighting			
	Fluorescent	70	90.9
	Wall Light	16	20.8
	Desk Lamp	5	6.5
	Downlight	4	5.2
Portable Cooking			
	Rice Cooker	68	88.3
	Kettle	34	44.2
	Toaster	28	36.4

Table 4.3 continued

Residential Profile		Frequencies	Percentage (%)
Others Equipment			
	Television	72	93.5
	Washing Machine	65	84.4
	Ceiling Fan	57	74
	Radio	54	70.1
	Air conditioner	13	16.9
	Hair Dryer	8	10.4
	Mosquito repelling	7	9.1

* Typical kampong is built using timber and concrete while traditional Malay is constructed only by timber

Based on Table 4.3, electrical appliances were divided into 4 categories including heating equipment, lamp/ bulb/ lighting, portable cooking and other equipments. This category was done according to the previous research. For example, Mansouri (1996) grouped electrical appliances to space-heating and water heating appliances, cooking appliances, refrigeration appliances, television set and video records and; wet appliances. Meanwhile, several studies categorized the appliances into cooking, smoking cigarettes, heating equipment, or electrical malfunction (Ahrens, 2007; Diekman, 2008; Ballesteros, 2008; Berger, 2008; Caraballo, 2008; Kegler, 2008; Duncanson, 2001; Hall, 2008; Leistikow, Martin, & Milano, 2000; Miller, 2005). From this study, the appliances were recorded due to availability in fire victim's houses and the researcher assumed that appliances were all being used. It can be seen that the most commonly used appliances were television (93.5%), fluorescent lamp (90.9%), washing machine (88.4%), rice cooker (88.3%), iron (77.9%) and ceiling fan (74%). There were several references regarding the ranking of appliances involved in electrical fire highlighted at international level. For example, U.S Fire Administration National Data Center (2008) ranked lamp and lighting at the highest order followed by heating equipment while cooking and heating equipment were dominant fault in Canada from 1988 to 1992 (Wijayasinghe and Makey, 1997). Other electrical appliances such as television and radio were also included in a study done by Kennedy and Kennedy (1985).

4.3 LEVEL OF PRACTICE

The second and third objective of this research was:

i) To assess the level of practices on electrical appliances failure and
ii) To assess the level of practice on wiring system among fire victims towards warning signs of fire hazard and experience.

The level of practices on electrical appliances was assessed based on several electrical failures due to counterfeit product, appliances misuse, appliances poor design, and inappropriate appliances material. The wiring systems were evaluated based on overloading, loose connection, short circuit, aging and lightning. Both levels of practices were determined using descriptive analysis and also t-Test as shown in Table 4.4.

Table 4.4: Comparison of practice scores for all domains among the fire victims

Variables		**Frequency**	**Percent**	**Mean (SD)**	**t**	**Sig.**
Appliances	poor	42	54.5	59.38(0.14)	-.001	p<0.001***
	good	35	45.5			
Overload	poor	31	40.3	53.96(0.18)	-930.8	p<0.001***
	good	46	59.7			
Loose Connection	poor	39	50.6	48.38(0.13)	-817.5	p<0.001***
	good	38	49.4			
Short Circuit	poor	58	75.3	38.96(0.24)	-762.6	p<0.001***
	good	19	24.7			
Aging	poor	42	54.5	44.48(0.20)	-752.2	p<0.001***
	good	35	45.5			
Lightning	poor	59	76.6	33.93(0.18)	-673.4	p<0.001***
	good	18	23.4			

***Significant at p < 0.001

4.3.1 Appliances Failure

Kolmogorov test showed that practice's scores of respondents were normally distributed. Therefore, means can be utilized as the benchmark to determine the level of practice among fire victims. Those who noted the scores above the mean value are considered as having good practice, while below the mean are considered as having poor practice. Good practice indicates that fire victims applied proper usage on their hose wiring system and also appliances whereas poor practice means that they carried out bad practice in term of usage.

Based on Table 4.4, descriptive analysis showed that 54.5% of fire victims obtained less than 59.38 of mean scores indicating they have poor practices towards electrical appliances failure. In addition, the t-Test revealed that there was a significant difference in practice scores between those who perform good practices and poor practices on electrical appliances failure.

These electrical failures caused by counterfeit product, appliances misuse, appliances poor design, and inappropriate appliances material that can be related to human interference. Other studies found that residential fire was mainly caused by human error such as playing with fire or a heat source, misuse of products, leaving equipment turned on and or unattended, and failing to clean equipment (McCormick, 2009). Similarly, studies at the workplace also revealed that human factors and equipment malfunction contributed to the unexpected release of explosive electrical energy which eventually results in fire and also fatalities (Jones et al., 2000; Williamson and Feyer 1998).

According to Fire and Rescue Department of Malaysia (2008), the electrical wiring systems recorded double cases in dwelling fire compared to appliances failure problem; there were enough cases to justify some attention. Because of that, there are several ways to resolve the problem such as giving education on fire safety knowledge, changing the product regulation and transforming the manufacturing practices (Hoffman et al. 2001 and Hall, 2002).

The knowledge will enable them to understand the characteristics of fire generally and electrical hazard specifically as well as the consequences of a fire breakout. Besides, the household may able to differentiate the substandard product and also the product materials. With regards to change the product regulation and transforming the manufacturing practices, it should be altered together. If the regulation changes but the manufacturing does not change or the customer purchasing decision does not follow manufacturing change then again the problem will still prevail (Hall, 2002). In terms of the national level, for example, Energy Commission Department and SIRIM should play a significant role to resolve the matter of regulation and also manufacturing.

The idea on how electrical appliances failure having poor practices due to counterfeit product, appliances misuse, appliances poor design, and inappropriate appliances material is shown in the following Figure 4.1.

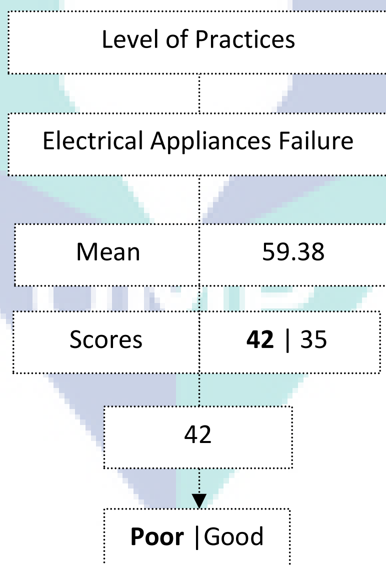

Figure 4.1: 42% of score from respondent indicating that the fire victim having poor practice towards electrical appliances failure

4.3.2 Wiring Systems

According to Fire and Rescue Department of Malaysia (2008), it has been reported that the ignition source from electrical wiring system recorded double cases in dwelling fire compared to electrical appliances failure. On the other hand, the highest number of cases in Korea accounted for short circuit (67.4%), overload (8.8%), leakage (4.4%), and poor contact (4.1%) (Choi et al., 2006).

In comparison, in this study, the level of practice on wiring system was measured based on five domains namely overload, loose connection, short circuit, aging and lightning. Specific variables that are found to be weak in practice were loose connection (50.6%), short circuit (75.3%), aging (54.5%) and lightning (76.6%). However overload was found to be satisfactory as 59.7% was above the mean value (53.96). Thus, most of the respondents (>50%) perform weak practice in all domains except for overload (Table 4.6). In addition, these results have been strengthened by statistical analysis using One Sample t-Test. The results from the same Table 4.6 also shows that there was a significant difference in the practice's scores between those who have good practice and poor practice ($p<0.001$). These results indicate that the level of practice on wiring system among fire victims towards warning sign of danger and experience is considered below the satisfaction level. Figure 4.2 also indicates the support for showing the level of practice among fire victims of this study of having good practice on overload but poor practice on loose connection, short circuit, aging and lightning.

The idea on how wiring systems having poor practices is illustrated in the following Figure 4.2. For example, as short circuit mean (38.96) can be utilized as the benchmark to determine the level of practice among fire victims. Those who either have poor or good scores above the mean value is considered satisfactory. In turn, having poor or good scores below the mean value is considered weak.

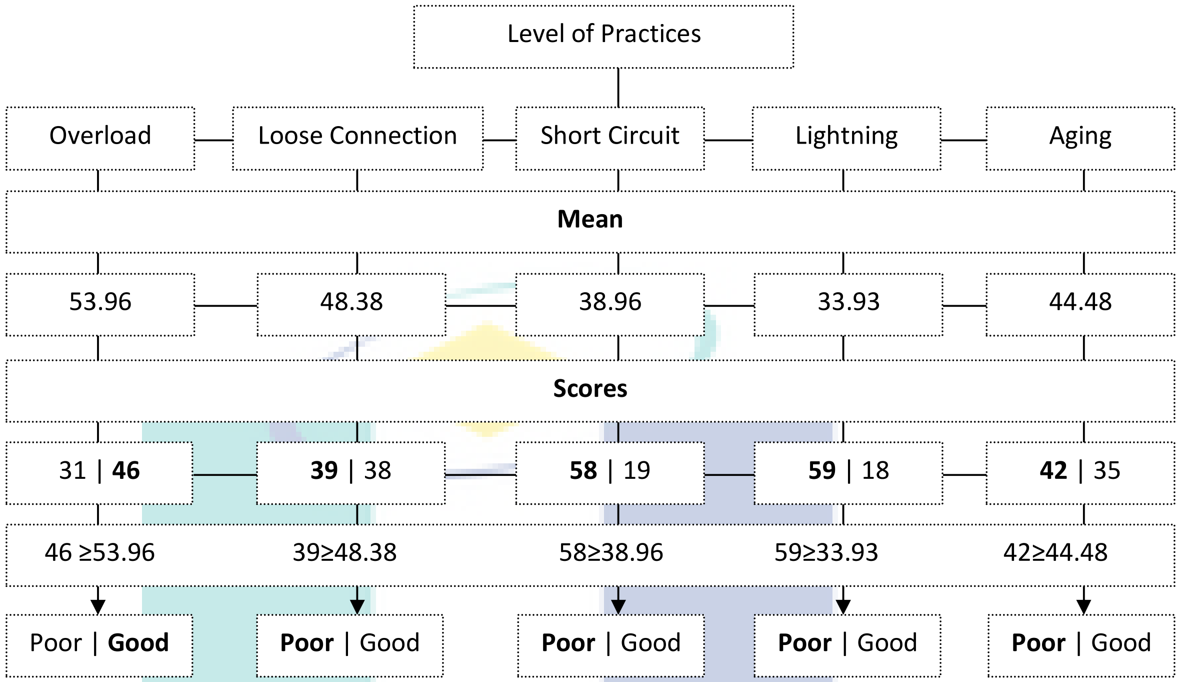

Figure 4.2: Poor or good scores by respondents compared to means may indicate that practice among fire victim were considered satisfactory or weak.

In other context of human practice related to fire safety, it was found that only 17% (Harvey et al., 1998), 37%, (Jaslow et al., 2005) and 23.7% (Jingzhen et al., 2006) of households had practiced their escape fire plan. From this finding, it can be seen that the level of practice towards fire response over the world was almost below the satisfaction level. In fact, the highest 37% who practice their escape plan were assisted-living facility population. It indicates that the assisted-people performed more responses to fire compared to normal people.

4.4 ASSOCIATION BETWEEN VARIABLES

Correlation test was carried out to see association between appliances failure and wiring system, as well as the type of appliances towards overload as mentioned in the fourth objective.

Table 4.5 shows the results of Pearson's correlation test between appliances failure and wiring system among 77 respondents. The correlation matrix shows that there were significant correlations between appliances failure and overload (r=0.305, p=0.007), loose connection (r=0.378, p=0.001), aging (r=0.346, p=0.002) and portable cooking devices (r=0.277, p=0.015). There was also a significant correlation between aging and short circuit (r=0.254, p=0.026). Meanwhile, there was no correlation between short circuit and lightning (p =0 .863, r = -0.020); heating equipments (p= 0.225, r = 0.140); lamp, bulb or lighting (p =0 .840, r = 0.023), other equipments (p = 0.495, r = 0.79) and overload.

Table 4.5: Correlation matrix of all variables

		Overlo	Applia	Loose	Short	Aging	Lightni	Heating	Lamp	Cookin	Other
Overload	Pearson Correlation	1									
	Sig. (2-tailed)										
Appliances	Pearson Correlation	**.305****	1								
	Sig. (2-tailed)	.007									
Loose	Pearson Correlation	**.378****	.148	1							
	Sig. (2-tailed)	.001	.198								
Short	Pearson Correlation	.159	.072	.160	1						
	Sig. (2-tailed)	.167	.532	.164							
Aging	Pearson Correlation	**.346****	.080	.086	**.254***	1					
	Sig. (2-tailed)	.002	.487	.455	.026						
Lightning	Pearson Correlation	-.036	.033	-.092	-.020	.045	1				
	Sig. (2-tailed)	.757	.775	.425	.863	.699					
Heating	Pearson Correlation	.140	-.045	.142	.005	.277*	.113	1			
	Sig. (2-tailed)	.225	.701	.219	.963	.015	.330				
Lamp	Pearson Correlation	.023	.071	.010	-.156	.069	.113	.434**	1		
	Sig. (2-tailed)	.840	.540	.931	.175	.551	.329	.000			
Cooking	Pearson Correlation	**.277***	-.034	.085	.059	.238*	-.066	.430**	.280*	1	
	Sig. (2-tailed)	.015	.767	.465	.612	.037	.570	.000	.014		
Other	Pearson Correlation	.079	-.011	.072	.081	.217	.167	.648**	.346**	.367**	1
	Sig. (2-tailed)	.495	.925	.535	.482	.058	.146	.000	.002	.001	

r ≤ ±0.24 (no correlation);, ± 0.25 ≤ r ≤ ± 0.5 (weak or low correlation); ± 0.5≤ r ≤± 0.7 (moderate correlation), r ≥ ±0.7, (high/strong correlation), *. Correlation is significant at p< 0.05 (2-tailed). **. Correlation is significant at p< 0.01 (2-tailed).

For the evolution of an electrical failure, it usually occurs due to chain of events and can occur in almost any sequence (Harrison, 2007). The result of significant correlation between aging and short circuit was similar to Harrison (2007) that revealed an electrical arcing was resulted by faulty cable insulation leading to short circuit. On the other hand, a faulty insulation may also lead to overload and eventually short circuit but the finding only showed significant correlation between aging and overload and yet to produce a significant correlation between overload and short circuit. On the other hand, Hoffman et al. (2001) tested electrical power cord damage due to radiant heat and fire exposure but the findings did not show any significant correlation among types of power cord, electrical activity and fire conditions. In fact, there were various results. Then, the proposed research framework has been designed thoroughly and can be used to infer the electrical fault of electrical failure flow. Furthermore, as the failure probabilities method was hard to be conducted, Harrison (2007) has suggested carrying it out via statistical evaluation. Surprisingly, this research has proved that statistical estimation was successful and shows significant correlation among the variables as shown in Table 4.5.

Even only portable cooking equipment shows a significant correlation to overload even though the expected result was heating equipment. The mechanisms factors before the fire generated were subjective to be discussed, but should also be considered. For example, fault in handling the appliances, failure or malfunction by controllers or even places close to the fire caused by ordinary fire were among the subjects highlighted by Nagoya Fire City Bureau.

4.5 FACTORS INFLUENCING OVERLOAD

As the correlation analysis shows significant correlation between variables, therefore an examination on the relationship between independent variables and dependent variable can be performed. To illustrate that, the following figure may give more understanding on how relationship test would be analysed.

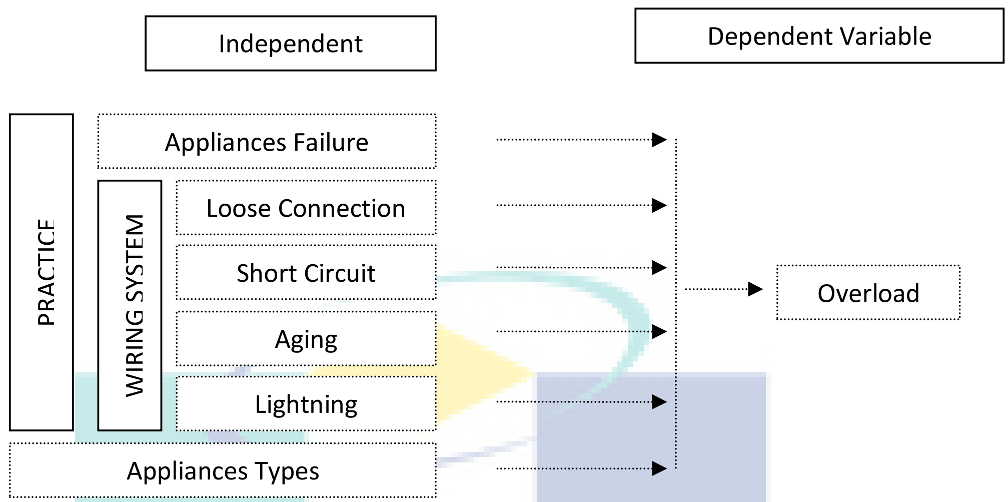

Figure 4.3: Every independent variable analysed to examine the relationship between overload

Multiple linear regression analysis was performed in order to study the relationship between overload and factors such as appliances failure, loose connection, short circuit, aging and lightning. According to Hair et al (1998), multiple linear regression requires the assumptions underlying the statistical techniques being tested to ensure the proven data to be adequate. These assumptions are:

i) normality

ii) linearity

iii) autocorrelation among variables

iv) multicollinearity

v) heteroscedasticity

vi) absence of outliers and also

vii) adequate sample size.

The first assumption on normality has been discussed in the earlier sub-chapter **4.1**. For linearity, there was a linear relationship between overload and independent variables (electrical appliances failure, poor connection, short circuit, aging and lightning). Even though the model was expected to have a significant relationship with dependent variables, yet, this analysis proved three variables (poor connection, aging and appliances failure) were linear to dependent variables. Hair et al. (1998) stated that linear model predict value which fall in straight line may indicate a constant unit change of the dependent variable for a constant unit change of the independent variable.

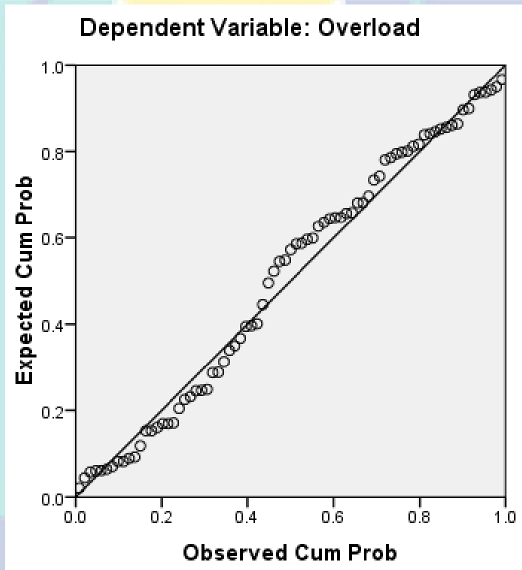

Figure 4.4: A straight line (linearity) indicate that independent variables correlate to dependent variable

In addition to the third assumption was an absence of auto correlation among variables. By referring to Table 4.6 to detect the auto correlation, Durbin Test value of 1.916 was picked and the ratio was between 1.5<D<2.5, meaning that there was no autocorrelation (Hair et al., 1998).

Table 4.6: The Durbin-Watson value of 1.916 shows the ratio between 1.5<D<2.5 were free from auto correlation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.378[a]	.143	.132	17.58415	
2	.492[b]	.242	.222	16.64741	
3	.543[c]	.295	.266	16.16491	
4	.577[d]	.332	.295	15.84139	**1.790**

The next assumption to be fulfilled was multicollinearity. Table 4.7 shows the tolerance value was higher than 0.1 while Variance Inflation Factor (VIF) value was less than 10. It indicated that the data did not face multicollinearity problems. Furthermore, the coefficient value also did not exceed 0.9 (refer to the Table 4.5). Therefore, it can be seen that the data do not have the high correlation among the independent variables (Hasnah et al., 2006).

Table 4.7: Collinearity Matrix

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics	
						Tolerance	VIF
4	Short	.018[d]	.179	.858	.021	**.915**	**1.093**
	Light	-.015[d]	-.149	.882	-.018	**.982**	**1.018**
	Heating	-.062[d]	-.561	.577	-.066	**.771**	**1.298**
	Lamp	-.077[d]	-.761	.449	-.090	**.914**	**1.094**
	Other	-.081[d]	-.770	.444	-.091	**.846**	**1.182**

Another assumption that needs to be considered is heteroscedasticity. It was detected by scatter plot as shown in Figure 4.5. The points were spreading randomly between 0 in the Y-axis and they do not form any regular pattern, showing that the assumption of heterocedasticity has been met (Hasnah et al., 2006).

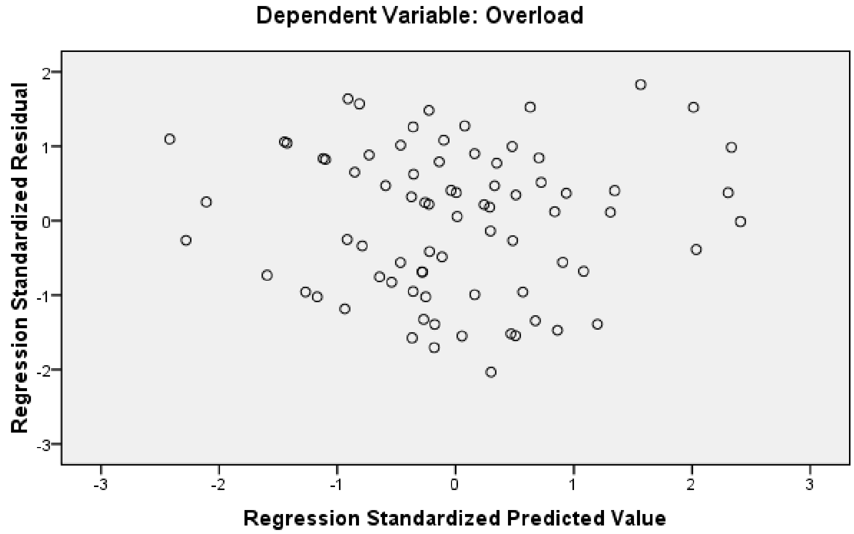

Figure 4.5: The distribution of points scatters randomly and does not form any regular pattern assuming heterocedasticity exist

Besides that, the existence of outliers may mean that the data face a problem. This assumption also needs to be considered and results are free from outliers whenever the standardized residual value in the Residual Statistics presented in Table (4.8) was between +3 to -3 (Chua, 2009). The results indicate that residual value is between 1.83 and -2.04. Therefore, the data is free from outliers.

Table 4.8: Residual Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	27.63	80.19	53.96	10.88	77
Residual	-3.22E1	28.99	.00	15.42	77
Std. Predicted Value	-2.42	2.41	.00	1.00	77
Std. Residual	**-2.04**	**1.83**	.00	.97	77

The last assumption was drawn by Lay and Khoo (2009) that sample size must be at least five times the number of independent variables. So, in this research this assumption also had been accomplished by having 77 respondent or N > 5*9=45 respondents.

After fulfilling all the assumptions, further analysis using Multiple Linear Regression can be done to examine any relationship between variables. Table 4.9 shows that overload was significantly influenced by four factors namely loose connection (p=0.003, t=3.097), aging (p=0.013, t=2.536), appliances failure (p=0.014, t=2.515) and portable cooking (p=0.049, t=2.003).

Table 4.9: Multiple Linear Regression Analysis; Overload as dependent variable

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
4 (Constant)	-3.423	10.306		-.332	.741
Loose	.418	.135	.303	3.097	.003
Aging	.237	.093	.253	2.536	.013
Appliances	.330	.131	.246	2.515	.014
Cooking	4.150	2.072	.199	2.003	.049

R^2 = .332, F = 8.964, Sig. F= 0.001

Additionally, the coefficient of determination (R^2) of 0.332 indicates that 33.2% of the variation in the overload can be explained by three independent variables namely loose connection, aging and appliances failure. Meanwhile, the residual of 66.8% is explained by other variables out of the model. In order to use multiple regression, the sample size in this research has met the appropriateness of statistical power of multiple regression. With the significant α level of 0.05, sample sizes of 77 respondents and number of the independent variables, the minimum R^2 can be found statistically significant with a power of 0.80. By using interpolation, the minimum R^2 = 13.80 in this analysis was adequate (Hair et al., 1998). Therefore, the probability of detecting significant R^2 for this study actually existed.

As a consequence, ANOVA test showed F value of 8.964 with p value of 0.001 or p less than 0.05 ($p < 0.05$). Hence, the regression model can be used for predicting dependent variable (overload) with its independent variables (loose connection, aging, appliances and failure portable cooking). The coefficient values revealed that overload ranking is influenced by loose connection (β=0.303), followed by aging (β=0.253) appliances failure (β=0.246) and also portable cooking (β=0.199). The relationship can be presented by the following linear Eq. (4.1);

$$Y = 0.418X_1 + 0.237X_2 + 0.330X_3 + 4.150\,X_4 - 3.423 \quad (4.1)$$

Y = overloading;

X_1 = loose connection;

X_2 = aging cable;

X_3 = appliances failure

X_4 = portable cooking

It is predicted that for 1% increase in each loose connection, aging cable, appliances failure and portable cooking; the overloading score will increase for 0.418%, 0.237%, 0.33% and 4.150% respectively. Meanwhile the constant value still survives if there is no increment in dependent variables. The constant value indicates that arcing activity has affected wiring connection for a length time is true (National Fire Protection Association, 2009).

With the assumption that the excessive current was flowing in the theoretical framework, an arching might be terminated to cause localize heating when a breaker or fuse was functioning (Dehaan, 2002). Furthermore, the continuous current flow through carbonized material could be sufficient to lead again to a sizeable current flow instead of being placed far from combustible material for fire to be ignited (Babrauskas, 2001). For that reason, this research selected overload as dependent variable to support Dehan (2002) and Babrauskas (2001). In fact, Sandercock (2007) also found that the heat generated degraded the polyvinyl chloride (PVC) plug insulating material which decreased the arch tracking resistance of the plug (i.e. arcs through char), eventually resulting in fire. He added that Goodson, et al. (2002) also found that the inhibition of heat transfer from household electrical wiring when it is surrounded by polyurethane ‘‘sprayin’’ foam insulation and the resulting lack of heat transfer from a loaded circuit may raise the temperature of the wire to the point of ignition. Therefore, there is another reason for overload being studied as it could affect both wiring and appliances to cause a fire.

The **loose connection** items listed in the questionnaire such as switch plates that are discoloured, connecting breaks cable with the electrical tape, sparks appear when insert or remove a plug, loose connections in electrical outlets, switches, light fixtures, and the like due to vibrations from trains, noisy vehicles and thunder, flickering or dimming lights and shrink at television screen can be considered as the causes of electrical fire due to the most significant effect to cause a fire.

Moreover, **aging** as the second significant factor due to wiring system in housing unit over age 40 increase, light bulb usage and bundle wire in practice incline to cause overload. The example of overload indications are electrical cord is warm to be touch, extension cords used as a long term solution, overload extension cords by plugging in appliances, frequent bulb burnout and the circuit breaker trips or the fuse blows. The results also correspond with Hassanain (2008) as speculated by Dailey in 2000. He outlined the reasons to intense localized heating to cause a fire were the usage of light bulb which greater the allowable wattage and use of flickering fluorescent light tubes. He also stated the process to enhance sparking to be lighted was due to damaged or worn electrical cords. These sparks can reach extremely high temperatures, which are more than enough to start a fire.

The third significant factor that was **electrical appliances failure is** also related to several researchers findings. For example, Ahrens (2007) and Patel (2005) claimed that electrical sources include fires that originated from lighting equipment, over fused power supply or outlets, meters, power switch gear or current overload protection devices, or malfunctioning cords or plugs. Other than that, Bangert and Hartford (1973) has justified that the large percentage of fires in homes, commercial buildings and others which due to electrical causes are caused by misuse, abuse, or damage to electrical conductors, and especially to flexible electrical cord. All of these factors were highly correlated to appliances failure questionnaire items surveyed to respondents consisting appliance misuse, appliances poor design despite counterfeit product and inappropriate appliances material. Similarly, this research has found that there is a significant relationship between overload and factors influencing electrical failure such as poor connection, aging, electrical appliances failure and portable cooking (Table

4.12). In other words, the electrical factors listed by previous research (Table 2.2) had related under poor connection, aging and electrical appliances features.

Despite from that, cooking equipment was also a consequence to Wijayasinghe and Makey (1997) which revealed that it caused fire losses and injuries in Canada. In addition this may be due to the larger percentage (88.3%) of electric cooking appliances usage in Malaysia compared to other equipment as well as having good awareness on heating appliances than others. Other possible reasons are sample size, science basis measurement instead of engineering-based approach and questions related to variables. Therefore, further refinement needs to be carried out such as increasing the sampling size, comparing both experimental and statistical approach and adding more questions on existing variables as well as other variables which are outside the conceptual framework.

On the contrary, the result of cooking equipment that showed significance was in line with Australian and United States' reports. In the early 1990, it was reported that the source of ignition by electrical appliances types was approximately 31% in all American residential areas (Baker and Adam, 1993). In contrast, currently the percentage has increased slightly higher to 50.5% incident in Newton and about 30.9% in Cloverdale. In the same way, residential fire incidents in Australian were reported as having similar pattern either in America or in the current research. It was found that heating and cooking equipment were the dominant factors to cause a fire (Runyan et al. 1992; Killalea, 1999). The other factors were faulty electrical appliances and wiring or inappropriate discarded smoking materials. However, this research could not find any relationship between overload and heating equipment, lamp/bulb/lighting and others equipment, but only showed a significant relationship with the portable cooking devices. Consequently there is a significant relationship between overload and portable cooking devices.

In conclusion, from both regression analyses interpretation, Figure 4.6 redraws the actual results after the multiple regression test revealed the finding of poor connection, aging, appliances failure and appliances type (portable cooking) showing the sequence which of the most causes of fire that lead to ignite a fire.

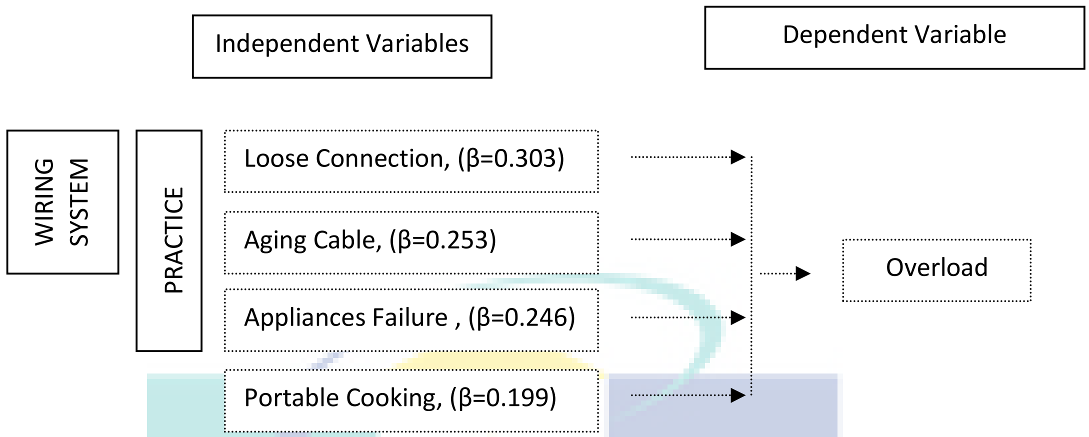

Figure 4.6: The sequence of factor lead to overload before igniting the fire

CHAPTER 5

CONCLUSION & RECOMMENDATION

5.1 CONCLUSION

In general, this research is related to the fire investigation process. Briefly, the investigation processes follow the sequence steps such as collecting the preliminary information through witnesses, excavating and determining fire origin, determining the cause of fire and determining the source of ignition (Figure 5.1). In order to realise that, the fire debris or sample taken from the field brought to the laboratory for further analysis. The experimental results are vital to assist the investigators in interpreting the preliminary information.

In addition, most researchers still do not have a solid theory to be reference when structural fires occur. This is because, to determine the electrical source whether it causes a fire or results in a fire is still not implemented due to various benchmarks/limitations/barriers. In comparison, this study focused on examining human practice particularly by fire victims which may cause to lead the fire ignition in electrical fire. To realise the idea, the conceptual framework has been developed in Chapter 2 with the assumption that the electrical current is flowing in the circuit before the fire occurs. Furthermore, the KAP conceptualisation in Chapter 3 was applied in this research to measure the practice level prior the fire accidents. As the results, it can be concluded that the electrical defaults which lead to ignition parallel with this research finding which occurs prior to the fire event. This research has supported the idea to determine the cause of fire in structural fire specifically in dwelling as a brilliant idea to enhance further exploration of this study.

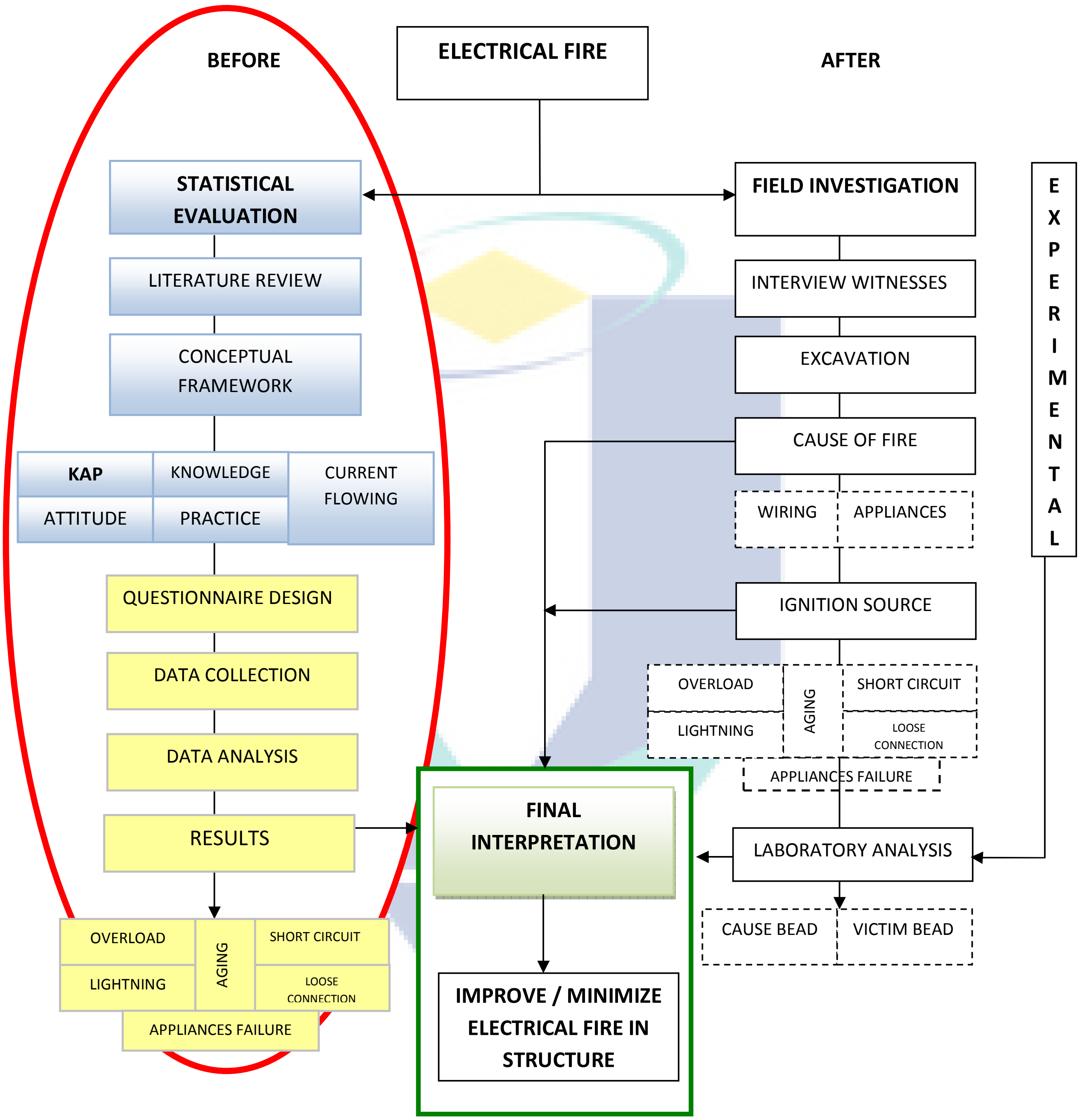

Figure 5.1: The overall illustrations of the study

Referring to the earlier hypothesis in Chapter 1, the alternative hypothesis **(H_{A1})** has accepted as the level of practice on electrical appliances among fire victims was agreed as low. In addition, the fire victims did not perform good practice on wiring system towards warning signs of danger and experience since their practices' scores were below the satisfaction level. Therefore, the second alternative hypothesis **(H_{A2})** has also been supported. On the contrary, this study has proven the applicability of graphical model as a tool to investigate the causes of dwelling fire due to electrical failure. The third hypothesis **(H_{A3})** has also been confirmed with the alternative hypothesis as three of five influence factors show significant relationship between overload, loose connection, aging cable and appliances failure. From the sequence of unstandardized coefficient (B), loose connection can be categorised as the main ignition source to cause dwelling fire instead of aging cable and appliances failure due to factors such as malfunction and substandard appliances. In addition, loose connection, aging and appliances failure which can normally be found at internal and exterior wire cords or cables, fixture, lamp, receptacles, sockets, fixed conductors, switches protective devices and outlet of the distribution system as well as all portable and moveable lamps. Moreover, the last hypothesis is also accepted the alternative hypothesis **(H_{A4})** which mentioned that there is a significant relationship between overload and electrical appliances types. However, only one of the appliances type that is portable cooking indicated a significant relationship between overload compared to heating equipment, lamp/ bulb/ lighting and other equipment which did not show any relationship.

For other risk factors associated with fire occurrence, it is strongly recommended to study the relationship of socio-economic factors such as the types of houses, household income and education level in both rural and urban areas since the previous research was mainly carried out in the lower socio-economic area.

Results of this study can be applied by Fire and Rescue Department to itemize the cause of fire to wiring system and specify the causes via loose connection, insulation breakdown and short circuit besides appliances failures. By utilizing the questionnaires to the fire victims and examining the fire sample via experimental approach, the results of investigation can be made more precise.

Other than that, it is strongly recommended to study other important issues and factors in electrical fire that the theoretical framework was not able to investigate such as induction, panel, meters and transformers. Further research is needed to complete the remaining investigation issues of electrical fire in the theoretical framework so that it can be a relevant reference to be applied in our country.

5.2 RECOMMENDATION

Fire cases keep increasing every year and caused by electrical source of ignition particularly, thus the transformation on regulation, manufacturing practice and enforcement should be done immediately. Based on the findings of this research, it can be seen that the improvement can be done through administrative level and technical level to prevent the occurrence of fire especially in dwelling area. In the context of awareness on fire safety, specifically for the practice domain, an effective fire campaign should be organized to increase awareness among individuals. Therefore, they would enhance their understanding on fire hazard, risk factors of fire electrical hazard and the consequences of a fire breakout. Besides that, they would also be able to identify the substandard products and other product materials that may cause a fire. Towards this end, a continuous education through training and re-training should be implemented and sustained over the country via both electronic and non-electronic media.

For the technical aspect, the authorities should also take relevant action to prevent electrical fire since it is the most significant cause in building structural fire as well as dwelling fatalities. For example, Energy Commission Department and SIRIM should play a role to enforce strictly the procedures of getting certificate of approval (COA) before the product is available in the market. This effort can successfully be implemented with support and cooperation from other related agencies such as the Ministry of Domestic Trade and Consumer Affairs. Other than that, apart from the wiring circuit, houses must be inspected by competent personnels at least once inevery five years. In order to make the idea relevant, Tenaga Nasional Berhad (TNB) is the best agency to accomplish since they do the billing every month. It can be done using appropriate devices and technology such as Sequence Time Domain Reflectrometry (STDR) and Spread Spectrum Time Domain Reflectrometry (SSTDR) as proposed by the previous researchers to detect the wiring fault that occur in home wiring system. Within this early prevention stage, it can prevent the occurrence of the electrical fire.

Since the results showed correspondence at significant correlation and relationship, it is indicated that the overload was caused due to loose connection, aging, appliances failure and portable cooking. Unfortunately, the other two variables; short circuit and lightning are expected to demonstrate the same result. Possible reasons are the sample size, science basis measurement instead of engineering-based approach and questions related to variables. Therefore, further refinements need to be carried out such as increasing a sampling size, comparing both experimental and statistical approach and adding more questions on existing variables as well as other variables which are outside of conceptual framework.

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APPENDIX A

FAKULTI KEJURUTERAAN PEMBUATAN & PENGURUSAN TEKNOLOGI

NAMA PROGRAM	SARJANA PENGURUSAN TEKNOLOGI (KESELAMATAN & KESIHATAN INDUSTRI)
TAJUK KAJIAN	PENILAIAN KE ATAS KEBAKARAN STRUKTUR YANG BERPUNCA DARI KEGAGALAN ELEKTRIKAL DI RUMAH KEDIAMAN

Kaji selidik ini dijalankan untuk mendapatkan maklum balas mengenai tahap keselamatan kebakaran di rumah kediaman. Maklum balas yang diperolehi akan digunakan dalam kajian ini untuk memahami tahap kesedaran keselamatan kebakaran elektrik di rumah khususnya yang melibatkan pendawaian elektrik mahupun peralatan elektrik.

Adalah diharapkan agar reponden dapat mengisi borang kaji selidik ini dengan sejujur mungkin. Segala kerjasama yang diberikan amat-amatlah dihargai dan didahului dengan ucapan terima kasih.Maklumbalas yang diberikan adalah sulit dan hasil kaji selidik ini hanya akan digunakan untuk mencapai objektif penilaian program ini sahaja.

Contoh Panduan Mengisi Borang Kaji Selidik

1. Ya
2. Tidak Tahu
3. Tidak

1	**2**	**3**
.....	.../..	.....

1. Sangat Tidak Pasti
2. Tidak Pasti
3. Pasti
4. Amat Pasti

1	**2**	**3**	**4**
....	.../..	....	....

A. MAKLUMAT RESPONDEN			
1. JANTINA		2. UMUR	
3. TARAF PERKAHWINAN			
BUJANG		BERKAHWIN	
LAIN-LAIN			
4. KELULUSAN			
PMR/SRP		SPM/MCE	
DIPLOMA		SARJANA MUDA	
SARJANA		PHD	
TIADA			
5. JENIS RUMAH			
TERES		SESEBUAH	
BERKEMBAR		PANGSA	
APARTMENT		KONDOMINIUM	
KAYU		SEPARA KAYU DAN KONKRIT	
LAIN-LAIN			
B. PERALATAN ELEKTRIK DI RUMAH			
LAMPU KALIMANTANG		PENGHAWA DINGIN	
LAMPU DOWNLIGHT		SETERIKA	
LAMPU DINDING		DAPUR ELEKTRIK	
LAMPU MEJA		OVEN	
UBAT NYAMUK ELEKTRIK		MESIN BASUH	
PERIUK NASI ELEKTRIK		PENGERING RAMBUT	
CEREK ELEKTRIK		RADIO	
PEMBAKAR ROTI		TELEVISYEN	
PENGERING PAKAIAN		KIPAS SILING	
LAIN-LAIN			

C.	**KEGAGALAN PERALATAN ELEKTRIK**	**1**	**2**	**3**
1	Adakah sistem pendawaian elektrik di rumah anda pernah di ubah suai dengan menambah bilangan plag atau membuat penambahan peralatan elektrik seperti penghawa dingin dan sebagainya?	....	.....	.....
2	Adakah anda memeriksa terlebih dahulu label SIRIM atau Suruhanjaya Tenaga (ST) pada suatu peralatan elektrik sebelum anda membelinya?	....	.....	.....
3	Pernahkah anda memeriksa nama syarikat, pengeluar atau nombor telefon pada kotak peralatan elektrik tersebut?	....	.....	.....
4	Walaupun anda membeli peralatan elektrik bersaiz kecil, adakah telah diluluskan oleh SIRIM atau Suruhanjaya Tenaga (ST)?	....	.....	.....
5	Pernahkah anda memeriksa label amaran di antara peralatan elektrik dan kotak / bungkusannya?	....	.....	.....
6	Adakah anda pernah menguji dahulu peralatan elektrik tersebut sebelum membeli?	....	.....	.....
7	Adakah anda terlupa mematikan mana-mana suis peralatan elektrik selepas digunakan atau sebelum anda keluar rumah atau tidur?	....	.....	.....
8	Adakah pemasangan sistem pendawaian dirumah anda dilakukan oleh orang yang berkelayakan?	....	.....	.....
9	Adakah anda pernah memastikan kabel penyambung (*extension cord*) di antara peralatan elektrik dan soket suis berada dalam keadaan baik dan bebas kecederaan?	....	.....	.....
10	Adakah anda pernah meletakkan bahan-bahan mudah bakar seperti pakaian berhampiran peralatan elektrik yang mengeluarkan haba seperti lampu dinding/meja yang menggunakan lampu mentol halogen?	....	.....	.....
11	Adakah anda pernah memeriksa keseluruhan sistem pendawaian elektrik di rumah anda?	....	.....	.....
12	Adakah bahan peralatan elektrik yang anda beli diperbuat daripada bahan yang tidak mudah terbakar?	....	.....	.....

D.	**LEBIHAN ARUS**	**1**	**2**	**3**	**4**
1	Anda pernah tersentuh pada mana-mana kabel dan terasa panas.	.....	....	.....	....
2	Akibat kekurangan plag di rumah, anda menggunakan plag tambahan (*extension plug*) secara kekal dan tidak membuat sistem pendawaian yang kekal.	.....	....	.....	....
3	Anda membuat sambungan pada plag tambahan melebihi daripada satu plag.	.....	....	.....	....
4	Anda pernah mengalami mentol lampu di rumah anda sering terbakar.	.....	....	.....	....
5	Fius di rumah anda kerap terbakar dan pemutus litar (*circuit breaker*) selalu tertendang (*trip*).	.....	....	.....	....

E.	**PENYAMBUNGAN LONGGAR**	**1**	**2**	**3**	**4**
1	Anda melihat perubahan warna (*discoloration*) pada soket suis di rumah anda?	.....	....	.....	....
2	Anda menyambungkan kabel yang rosak atau terputus dengan menggunakan *electrical tape.*	.....	....	.....	....
3	Anda terlihat percikan api (*spark)* di dalam soket suis semasa anda mematikan suis atau menarik plag daripada soket suis sebelum mematikan suis.	.....	....	.....	....
4	Rumah anda berhampiran dengan laluan kereta api atau lalulintas trafik yang berat.	.....	....	.....	....
5	Kawasan kediaman anda sering mengalami pancaran kilat, guruh dan juga petir.	.....	....	.....	....
6	Anda mengalami gangguan cahaya lampu di rumah anda malap / tidak terang.	.....	....	.....	....
7	Pada keadaan normal lampu di rumah anda dinyalakan, anda pernah alami cahaya lampu di rumah anda berkelip-kelip.	.....	....	.....	....
8	Ketika anda sedang menonton televisyen, anda pernah alami tiba-tiba paparan skrin televisyen anda menjadi mengecil.	.....	....	.....	....

F.	**LITAR PINTAS**	**1**	**2**	**3**	**4**
1	Sistem pendawaian di rumah anda tidak menggunakan konduit plastik atau seumpamanya.	.....	....	.....	....
2	Anda pernah terlihat kesan gigitan tikus pada mana-mana kabel di rumah anda.	.....	....	.....	....
3	Anda pernah terlihat kerosakan pada penebat kabel di rumah anda seperti luka, berbulu-bulu atau terkoyak.	.....	....	.....	....

G.	**PENUAAN**	**1**	**2**	**3**	**4**
1	Sistem pendawaian rumah di buat semula selepas 40 tahun.	.....	....	.....	....
2	Anda menggunakan lampu berkuasa tinggi seperti lampu halogen di rumah anda.	.....	....	.....	....
3	Bagi menampakkan sistem pendawaian tampak lebih kemas, anda menggulung/ melipatkannya.	.....	....	.....	....

H.	**KILAT**	**1**	**2**	**3**	**4**
1	Antena televisyen rumah anda dilengkapi dengan pengalir kilat (*lightning arrester*)?	.....	....	.....	....
2	Kabel utama yang membawa arus ke rumah anda pernah di panah petir.	.....	....	.....	....
3	Peralatan –peralatan elektrik rumah anda pernah rosak akibat kabel utama di luar rumah anda di panah petir.	.....	....	.....	....

APPENDIX B

Questionnaire Development

A.	ELECTRICAL EQUIPMENT'S FAILURE	CITATION	REFERENCES
1	Is the electrical wiring system in your home tampered such as the addition number of the plug or electrical equipment such as air conditioners and so on??	Will electrical inspection by a competent electrical inspector be completed during initial wiring of a new home or rewiring during home improvements and added on space both for interiors and exteriors? (Rasdall, 2005)	Rasdall, 2005.
2	Did you check the SIRIM or the Energy Commission (EC) label on electric equipment before you buy it?	CPCS offers the following tips to help avoid counterfeit hazards-scrutinize the product, the packaging and the labeling. Look for certification mark from an independent testing organization such as Underwriters Laboratories (UL), and the manufacturer label. Trademarked logos that look different than usual may signal a counterfeit.	U.S. Consumer Product Safety Commission, 2007.
3	Have you checked the name of the company, a manufacturer or a phone number on the electrical box?	In addition to looking for labels like these, Electrical Fire Safety Foundation International suggests that you steer clear of buying things like extension cords and circuit breakers from deep-discount stores. Also, look for name brands that you recognize and thrust when buying product like these. Checking labels can also help. Look for spelling errors and bad grammar as sure sign that product you're considering buying was produced by disreputable company.	How Stuff Works, 2009.
4	Are the electrical appliances you bought approved by SIRIM or Energy Commission (EC), even when you buy a small electric appliance?	CPCS offers the following tips to help avoid counterfeit hazards-scrutinize the product, the packaging and the labeling. Look for certification mark from an independent testing organization such as Underwriters Laboratories (UL), and the manufacturer label. Trademarked logos that look different than usual may signal a counterfeit.	U.S. Consumer Product Safety Commission, 2007.
5	Have you checked the label warning on the electrical appliances boxes or packaging?	In addition to looking for labels like these, Electrical Fire Safety Foundation International suggest that you steer clear of buying things like extension cords and circuit breakers from deep-discount stores. Also, look for name brands that you recognize and trust when buying product like these. Checking labels can also help. Look for spelling errors and bad grammar as sure sign that product you're considering buying is produced by disreputable company.	How Stuff Works, 2009.

A.	ELECTRICAL EQUIPMENT'S FAILURE	CITATION	REFERENCES
6	Have you ever tried first before buying the electrical appliances?	CPCS offers the following tips to help avoid counterfeit hazards-scrutinize the product, the packaging and the labeling. Look for certification mark from an independent testing organization such as Underwriters Laboratories (UL), and the manufacturer label. Trademarked logos that look different than usual may signal a counterfeit.	U.S. Consumer Product Safety Commission, 2007.
7	Have you forgotten to switch off any electrical appliances after use or before you leave home or go to bed?	The Electrical Safety Foundation International suggests you keep these simple safety tips in mind-Turn the lamp off whenever you leave the room for an extended period of time	Electrical Safety Foundation International, undated.
8	Is your home wiring system installed by a qualified person?	Will electrical inspection by a competent electrical inspector be completed during initial wiring of a new home or rewiring during home improvements and added on space both for interiors and exteriors?	Rasdall, 2005.
9	Have you ever ensured that the extension cord between the electrical switches and sockets are in good condition and are not worn?	Check the plug and the body of the extension cord while the cord is in use. Noticeable warming of these plastics parts is expected when the cords are being used at the frequently. However, if the cord feels hot or if there is a softening of the plastics, this is a warning that the plug wires or connection are failing and that extension cord should be discarded and replaced.	U.S. Consumer Product Safety Commission, undated.
10	Have you ever put flammable materials such as clothing near heating appliances such as lamps wall, desk lamps that use halogen bulbs?	Never place a halogen floor lamps where it could come in contact with draperies, clothing or other combustible materials,	Electrical Safety Foundation International, undated.
11	Have you ever checked the entire electrical wiring system in your home?	Unless the residence is rewired, will it have an electrical inspection as a part of responsible electrical system management? If no, cite reasons; if yes, cite reasons.	Rasdall, 2005.
12	Is the electrical appliances material you are buying made of non-combustible materials?	Many appliances use electricity as the power source, and electricity should be considered as a possible source of ignition. The material presented in Chapter 16 should be carefully considered and applied in this condition. Only under a specific set of condition can sufficient heat be generated by electricity as a result of an overload or fault within or by an appliance and subsequently cause ignition.	National Fire Protection Association, 2001.

A.	ELECTRICAL EQUIPMENT'S FAILURE	CITATION	REFERENCES
13	Have you ever checked your house circuit breaker every six months by pressing the "TEST" button?	The GFCI test is simple. Plug a nightlight into a GFCI-protected outlet and turn it on. Press the "TEST" button; the light should turn off. Press the "RESET" button; the light should turn on. If the light does not go out when the "TEST" button is pressed, discontinue use of this circuit and contact a qualified electrician to correct the problem. When did you last test your ground fault circuit interrupter? If you can't recall, the Electrical Safety Foundation International (ESFI) reminds consumers that it is important to do so at least once a month, and after electrical storms.	Electrical Safety Foundation International, 2010.
B.	**OVERLOADING**		
1	You have touched on the ubiquitous cable and felt hot.	Warm the electrical cord. If an electrical cord is warm to the touch, the cord is under rated or defective.	U.S Fire Administration, 2000.
2	Deprived of the plug at home, you use an extra extension plug permanently and not make a permanent wiring system.	You must be careful to use only extension cords that are rated for the power used by the device they are powering. Extension cords should never be used as a long term solution to the need for another receptacle. Extension cords must never be run inside walls or under rugs or furniture. Extension cords can get warm in use and must be able to dissipate this heat or they can start a fire.	U.S Fire Administration, 2000.
3	You make a connection on an extension plug for more than a plug.	Never overload an extension cord. If any part of the cord feels warm to the touch, the cord is drawing too much power and could present a fire or shock hazard.	Electrical Safety Foundation International, undated.
4	You have had a light bulb in your house frequently burnout.	Frequent bulb burnout. A light bulb that burns out frequently is a sign that the bulb has too high a wattage for the fixture.	U.S Fire Administration, 2000.
5	Fuse in your house often blows and the circuit breaker always trips.	If too much current is drawn from the circuit, the circuit breaker trips or the fuse blows, breaking the circuit to prevent an overload.	Josh, 2007.

C.	POOR CONNECTION	CITATION	REFERENCES
1	You have seen the discoloration on the socket or switch outlet in your house.	Discoloured or warm wall outlets, or Sparks from an outlet. This can indicate arcing, smouldering, burning happening behind your outlets,damaged or improperly installed wiring in the outlet, or a problem with the receptacle itself. Avoid using the outlet or switch and contact a qualified electrician as soon as possible.	National Fire Protection Association, 2009.
2	You repair the cable that is damaged or disconnected by using electrical tape.	Never try to repair a damaged extension cord with electrical tape; replace it instead.	Electrical Safety Foundation International, undated.
3	You see sparks in the socket when you switch off the switch or pull the plug from the socket before switching off the switch.	Sparks. If sparks appear when you insert or remove a plug, they could be a sign of loose connections.	U.S Fire Administration, 2000.
4	Your house is close to rail traffic or heavy traffic.	Connections in electrical outlets, switches, light fixtures, and the like can loosen due to a variety of reasons-Vibrations from trains, sonic booms from jet aircraft, other noisy vehicles high decibel level music/radio equipment, and thunder.	Rasdall, 2005.
5	Your residential areas often experience flash, thunder and lightning.	Connections in electrical outlets, switches, light fixtures, and the like can loosen due to a variety of reasons-Vibrations from trains, sonic booms from jet aircraft, other noisy vehicles high decibel level music/radio equipment, and thunder.	Rasdall, 2005.
6	You have experienced interference lights in your house such as lights dim.	Flickering or dimming lights. This sign could indicate a short in the wiring, dangerous arcing, or an over-extension of your home's electrical systems. Contact a qualified electrician to discuss potential reasons for this problem and to have an inspection completed.	National Fire Protection Association, 2009.
7	In normal circumstances during the lights in your house turned on, you have experienced flickering lights. .	Flickering lights. If the lights dim every time you turn on an appliance that circuit is overloaded or has a loose connection.	U.S Fire Administration, 2000.

C.	POOR CONNECTION	CITATION	REFERENCES
8	When you were watching television, you have experienced this: your television screen shrinks in size.	To make your home as electrically safe as possible, the Electrical Safety Foundation international suggests that you take a few minutes each year to inspect the condition of your electrical system, electrical cords, extension cords, plugs and outlets. Symptoms of home electrical wiring problems include: Household lights that dim or flicker, or a TV picture that shrinks in size.	Electrical Safety Foundation International, 2010.
D.	**SHORT CIRCUIT**		
1	Wiring system in your home does not use a PVC conduit or the like.	Covering wiring rated for open use is an issue. Covering wiring with attic insulation can cause a fire hazard in attics and other concealed spaces. If insulation is added to a house , then any wiring or fixtures covered with insulation must be certified/rated for such conditions(USCPSC,2004)	Rasdall, 2005.
2	You have ever seen rodents and other creature such as mouse's bites on your home cable.	Rodents and other creatures can damage insulation over the years.	Rasdall, 2005.
3	You have seen damage to the cable insulation in your home, such as frayed or worn.	Frayed or worn wiring is a red flag that you should replace the device it's attached to. The rubber insulation is meant to cut down on heat output and eliminate current arcing, and when it's missing, the risk of fire increases greatly.	How Stuff Works, 2009.
E.	**AGING**		
1	Wiring systems in your homes are over 40 years of age.	According to the United States Consumer Product Safety Commission, home over 40 years of age are the greater risk, but newer ones can have dangers of unacceptable wiring practice and environmental stress on their wiring.	Rasdall, 2005.

E.	AGING	CITATION	REFERENCES
1		This summer, CPSC and ESFI are encouraging homeowners to: 1) have an electrical inspection conducted for homes 40 years and older, for homes 10 years and older with major renovations or new appliances added, or that have been resold; 2) learn the potential hazards posed by aluminum wiring systems and contact CPSC if your home is among the two million built with aluminum wiring between the late 1960s and early 1970s; and 3) consider installing arc fault circuit interrupters in place of ordinary circuit breakers, especially if your home is over 40 years old. AFCIs are new technology designed to prevent electrical fires by sensing unseen electrical arcing. AFCIs are particularly important where wiring may have degraded with age.	U.S. Consumer Product Safety Commission, 2003.
2	You use a high-light halogen lamp in your home.	Excess heat from overlamped light fixtures causes brittle conductors	Rasdall, 2005.
3	In order to make your wiring system look neater, you have coiled or looped it.	For example, an overcurrent at 25A in a 14 AWG cooper conductor should pose no fire danger except in circumstances that do not allow dissipation of the heat, such as when thermally insulated or when bundled in cable application.	National Fire Protection Association, 2001.
		Never use extension cord while it is coiled or looped.	U.S. Consumer Product Safety Commission, undated.
F.	**LIGHTNING**	**CITATION**	**REFERENCES**
1	Your home television antenna is equipped with a lightning arrester?	It is certainly possible for TV receivers to provide sufficient heat to cause the ignition of flammables with a resultant fire. The manufacturers of TV's have improved their designs. The present technology and continuing introduction of safety factors has eliminated many of the TV fire hazard problems of the 1970's and early 1980's.	Kennedy and Kennedy, 1985.

F.	LIGHTNING	CITATION	REFERENCES
		Most TV aerials do not have lightning arresters. An arrester has no full protection in itself. The aerial must also be grounded, 10 feet deep if it is to serve any purpose in deflecting lightning bolts.	
2	The main cable that carries current to your house has been struck by lightning.	Lightning tends to strike the tallest object on the ground in the path of its discharge. Lightning enters structures in four ways-by hitting a nearby tree or other tall structure and moving horizontally to the building, by striking nearby overhead conductors and by being conducted into buildings along the normal power lines.	National Fire Protection Association, 2001.
3	Electrical equipment has been damaged due to main cable being struck by lightning.	Lightning tends to strike the tallest object on the ground in the path of its discharge. Lightning enters structures in four ways-by hitting a nearby tree or other tall structure and moving horizontally to the building, by striking nearby overhead conductors and by being conducted into buildings along the normal power lines.	National Fire Protection Association, 2001.

APPENDIX C

FREQUENCY TABLE

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	50	64.9	64.9	64.9
	Female	27	35.1	35.1	100.0
	Total	77	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-30	7	9.1	9.2	9.2
	31-40	23	29.9	30.3	39.5
	41-50	26	33.8	34.2	73.7
	51-60	15	19.5	19.7	93.4
	61-70	5	6.5	6.6	100.0
	Total	76	98.7	100.0	
Missing	999	1	1.3		
Total		77	100.0		

Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	5	6.5	6.5	6.5
	Married	72	93.5	93.5	100.0
	Total	77	100.0	100.0	

Qualification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	PMR/SRP	11	14.3	14.5	14.5
	SPM/MCE	37	48.1	48.7	63.2
	Diploma	4	5.2	5.3	68.4
	First Degree	3	3.9	3.9	72.4
	Master Degree	2	2.6	2.6	75.0
	Tiada	19	24.7	25.0	100.0
	Total	76	98.7	100.0	
Missing	999	1	1.3		
Total		77	100.0		

Type Of House

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Terrace	24	31.2	31.2	31.2
	Bungalow	3	3.9	3.9	35.1
	Semidetached	5	6.5	6.5	41.6
	Flat	1	1.3	1.3	42.9
	Timber	15	19.5	19.5	62.3
	Timberand Concrete	27	35.1	35.1	97.4
	Lain-Lain	2	2.6	2.6	100.0
	Total	77	100.0	100.0	

Television

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	71	92.2	92.2	92.2
	No	6	7.8	7.8	100.0
	Total	77	100.0	100.0	

Radio

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	54	70.1	70.1	70.1
	No	23	29.9	29.9	100.0

Radio

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	54	70.1	70.1	70.1
	No	23	29.9	29.9	100.0
	Total	77	100.0	100.0	

Ceiling Fan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	57	74.0	74.0	74.0
	No	20	26.0	26.0	100.0
	Total	77	100.0	100.0	

Air conditioner

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	13	16.9	16.9	16.9
	No	64	83.1	83.1	100.0
	Total	77	100.0	100.0	

Pendarflour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	70	90.9	90.9	90.9
	No	7	9.1	9.1	100.0
	Total	77	100.0	100.0	

Water Heater

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	18	23.4	23.4	23.4
	No	59	76.6	76.6	100.0
	Total	77	100.0	100.0	

Hair Dryer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	10.4	10.4	10.4
	No	69	89.6	89.6	100.0
	Total	77	100.0	100.0	

Iron

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	60	77.9	77.9	77.9
	No	17	22.1	22.1	100.0
	Total	77	100.0	100.0	

Desk Lamp

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	5	6.5	6.5	6.5
	No	72	93.5	93.5	100.0
	Total	77	100.0	100.0	

Wall Lamp

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	16	20.8	20.8	20.8
	No	61	79.2	79.2	100.0
	Total	77	100.0	100.0	

Mosquito

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	9.1	9.1	9.1
	No	70	90.9	90.9	100.0
	Total	77	100.0	100.0	

Rice Cooker

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	68	88.3	88.3	88.3
	No	9	11.7	11.7	100.0
	Total	77	100.0	100.0	

Stove

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	10	13.0	13.0	13.0
	No	67	87.0	87.0	100.0
	Total	77	100.0	100.0	

Kettle

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	34	44.2	44.2	44.2
	No	43	55.8	55.8	100.0
	Total	77	100.0	100.0	

Toaster

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	28	36.4	36.4	36.4
	No	49	63.6	63.6	100.0
	Total	77	100.0	100.0	

Oven

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	13	16.9	16.9	16.9
	No	64	83.1	83.1	100.0
	Total	77	100.0	100.0	

Cloth Dryer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3	3.9	3.9	3.9
	No	74	96.1	96.1	100.0
	Total	77	100.0	100.0	

Washing Machine

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	65	84.4	84.4	84.4
	No	12	15.6	15.6	100.0
	Total	77	100.0	100.0	

DownLight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	5.2	5.2	5.2
	2	73	94.8	94.8	100.0
	Total	77	100.0	100.0	

Others

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		28	36.4	36.4	36.4
	ais	1	1.3	1.3	37.7
	Down Light	1	1.3	1.3	39.0
	kiopas berdiri, peti ais	1	1.3	1.3	40.3
	kipas berdiri	2	2.6	2.6	42.9
	kipas berdiri, peti ais	3	3.9	3.9	46.8
	kipas duduk	1	1.3	1.3	48.1
	komputer	1	1.3	1.3	49.4
	peti ais	24	31.2	31.2	80.5
	peti ais, downlight	2	2.6	2.6	83.1
	peti ais, kipad duduk	1	1.3	1.3	84.4
	peti ais, kipas berdiri	4	5.2	5.2	89.6
	peti ais, kipas meja	3	3.9	3.9	93.5
	peti sejuk, kipas dinding	1	1.3	1.3	94.8
	petia ais	1	1.3	1.3	96.1
	Round Lamp	1	1.3	1.3	97.4
	television	1	1.3	1.3	98.7
	vcd player,lampu downlight,komputer,peti ais	1	1.3	1.3	100.0
	Total	77	100.0	100.0	

APPENDIX D

RELIABILITY ANALYSIS (PILOT)

Case Processing Summary

		N	%
Cases	Valid	35	94.6
	Excluded[a]	2	5.4
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.687	.699	12

Item Statistics

	Mean	Std. Deviation	N
Appliance1	1.51	.742	35
Appliance2	1.57	.815	35
Appliance3	2.06	.938	35
Appliance4	1.46	.657	35
Appliance5	1.74	.886	35
Appliance6	1.26	.611	35
Appliance7	1.63	.843	35
Appliance8	1.43	.608	35
Appliance9	1.60	.812	35
Appliance10	2.34	.838	35
Appliance11	2.03	.785	35
Appliance12	1.60	.736	35

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Appliance1	18.71	18.739	.056	.326	.705
Appliance2	18.66	15.997	.459	.541	.645
Appliance3	18.17	16.205	.340	.377	.665
Appliance4	18.77	15.946	.624	.768	.627
Appliance5	18.49	18.022	.112	.288	.703
Appliance6	18.97	17.793	.288	.583	.673
Appliance7	18.60	18.247	.096	.351	.704
Appliance8	18.80	17.988	.251	.268	.677
Appliance9	18.63	14.711	.688	.722	.605
Appliance10	17.89	18.457	.068	.434	.708
Appliance11	18.20	15.929	.495	.482	.640
Appliance12	18.63	15.770	.572	.531	.630

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.23	19.652	4.433	12

RELIABILITY ANALYSIS - OVERLOAD

Case Processing Summary

		N	%
Cases	Valid	36	97.3
	Excluded[a]	1	2.7
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.575	.595	5

Item Statistics

	Mean	Std. Deviation	N
Overload1	2.14	1.099	36
Overload2	2.44	.909	36
Overload3	2.39	.871	36
Overload4	2.36	.833	36
Overload5	2.22	1.045	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Overload1	9.42	6.079	.220	.194	.594
Overload2	9.11	5.873	.405	.368	.481
Overload3	9.17	5.914	.427	.266	.472
Overload4	9.19	6.104	.409	.373	.485
Overload5	9.33	6.057	.259	.094	.566

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
11.56	8.483	2.912	5

RELIABILITY ANALYSIS – POOR CONNECTION

Case Processing Summary

		N	%
Cases	Valid	34	91.9
	Excluded[a]	3	8.1
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.804	.806	8

Item Statistics

	Mean	Std. Deviation	N
Poor Connection1	1.94	1.099	34
Poor Connection2	2.03	1.000	34
Poor Connection3	2.26	1.109	34
Poor Connection4	1.76	.855	34
Poor Connection5	1.76	.855	34
Poor Connection6	1.59	.783	34
Poor Connection7	1.82	.834	34
Poor Connection8	1.68	.843	34

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Poor Connection1	12.91	17.295	.529	.503	.781
Poor Connection2	12.82	17.362	.598	.580	.769
Poor Connection3	12.59	16.977	.562	.437	.776
Poor Connection4	13.09	20.507	.272	.412	.815
Poor Connection5	13.09	18.325	.585	.572	.773
Poor Connection6	13.26	19.534	.461	.605	.790
Poor Connection7	13.03	17.787	.691	.721	.758
Poor Connection8	13.18	19.180	.467	.441	.789

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
14.85	23.341	4.831	8

RELIABILITY ANALYSIS – SHORT CIRCUIT

Case Processing Summary

		N	%
Cases	Valid	36	97.3
	Excluded[a]	1	2.7
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.681	.685	2

Item Statistics

	Mean	Std. Deviation	N
Short Circuit2	2.11	1.090	36
Short Circuit3	2.00	.956	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Short Circuit2	2.00	.914	.521	.271	.[a]
Short Circuit3	2.11	1.187	.521	.271	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
4.11	3.187	1.785	2

RELIABILITY ANALYSIS - AGING

Case Processing Summary

		N	%
Cases	Valid	36	97.3
	Excluded[a]	1	2.7
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.508	.538	2

Item Statistics

	Mean	Std. Deviation	N
Aging2	1.64	.762	36
Aging3	2.39	1.128	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Aging2	2.39	1.273	.368	.135	.[a]
Aging3	1.64	.580	.368	.135	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
4.03	2.485	1.576	2

RELIABILITY ANALYSIS - LIGHTNING

Case Processing Summary

		N	%
Cases	Valid	36	97.3
	Excluded[a]	1	2.7
	Total	37	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.588	.589	2

Item Statistics

	Mean	Std. Deviation	N
Lightning2	1.75	.770	36
Lightning3	1.81	.822	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Lightning2	1.81	.675	.418	.174	.[a]
Lightning3	1.75	.593	.418	.174	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
3.56	1.797	1.340	2

APPENDIX E

RELIABILITY ANALYSIS (ACTUAL)

APPLIANCES FAILURE

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.692	.691	12

Item Statistics

	Mean	Std. Deviation	N
Appliances2	1.5455	.89656	77
Appliances3	1.5974	.90699	77
Appliances4	1.6364	.91636	77
Appliances5	1.9351	.99125	77
Appliances6	1.3766	.77865	77
Appliances8	1.8831	.90283	77
Appliances9	1.8831	.91729	77
Apliances11	2.2857	.95775	77
Appliances12	2.2468	.63154	77
SC1A	1.9610	1.00579	77
SC7A	1.6623	.94047	77
SC10A	1.3636	.66707	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Appliances2	19.8312	19.300	.698	.673	.612
Appliances3	19.7792	20.253	.555	.556	.636
Appliances4	19.7403	19.616	.635	.737	.622
Appliances5	19.4416	19.460	.590	.385	.626
Appliances6	20.0000	22.342	.361	.220	.669
Appliances8	19.4935	21.780	.357	.382	.668
Appliances9	19.4935	24.569	.022	.101	.718
Apliances11	19.0909	20.742	.452	.386	.652
Appliances12	19.1299	23.667	.251	.142	.683
SC1A	19.4156	25.246	-.064	.113	.736
SC7A	19.7143	24.128	.064	.135	.713
SC10A	20.0130	24.329	.127	.160	.697

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
21.3766	25.606	5.06027	12

OVERLOAD

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.599	.591	5

Item Statistics

	Mean	Std. Deviation	N
Overload1	1.58	.978	77
Overload2	2.12	1.224	77
Overload3	2.49	1.373	77
Overload4	2.31	1.249	77
Overload5	2.29	1.234	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Overload1	9.21	12.009	.189	.119	.615
Overload2	8.68	9.327	.457	.263	.487
Overload3	8.30	9.370	.356	.202	.545
Overload4	8.48	9.779	.372	.350	.534
Overload5	8.51	9.674	.397	.378	.520

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
10.79	14.246	3.774	5

RELIABILITY ANALYSIS (ACTUAL)- POOR CONNECTION

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.546	.525	8

Item Statistics

	Mean	Std. Deviation	N
PoorConnection1	1.66	1.071	77
PoorConnection2	1.60	1.079	77
PoorConnection3	1.83	1.197	77
PoorConnection4	1.75	1.237	77
PoorConnection5	2.94	1.080	77
PoorConnection6	2.30	1.319	77
PoorConnection7	2.26	1.271	77
PoorConnection8	1.14	.479	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PoorConnection1	13.82	16.388	.192	.322	.535
PoorConnection2	13.88	14.526	.427	.276	.455
PoorConnection3	13.65	15.283	.266	.249	.511
PoorConnection4	13.73	17.517	.015	.180	.601
PoorConnection5	12.55	16.672	.154	.195	.547
PoorConnection6	13.18	12.756	.500	.945	.409
PoorConnection7	13.22	13.464	.442	.943	.438
PoorConnection8	14.34	18.621	.085	.059	.553

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
15.48	19.200	4.382	8

SHORT CIRCUIT

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.872	.880	2

Item Statistics

	Mean	Std. Deviation	N
Short2	1.64	1.111	77
Short3	1.48	.926	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Short2	1.48	.858	.786	.617	.[a]
Short3	1.64	1.234	.786	.617	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
3.12	3.710	1.926	2

AGING

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.607	.608	2

Item Statistics

	Mean	Std. Deviation	N
Aging2	1.69	.907	77
Aging3	1.87	.991	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Aging2	1.87	.983	.437	.191	.[a]
Aging3	1.69	.823	.437	.191	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
3.56	2.592	1.610	2

LIGHTNING

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.628	.630	2

Item Statistics

	Mean	Std. Deviation	N
Lightning 2	1.32	.834	77
Lightning 3	1.39	.934	77

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Lightning 2	1.39	.873	.460	.212	.[a]
Lightning 3	1.32	.696	.460	.212	.[a]

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
2.71	2.286	1.512	2

APPENDIX F

DESCRIPTIVE ANALYSIS

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Applian	77	100.0%	0	.0%	77	100.0%
Overld	77	100.0%	0	.0%	77	100.0%
Poor	77	100.0%	0	.0%	77	100.0%
Short	77	100.0%	0	.0%	77	100.0%
Aging	77	100.0%	0	.0%	77	100.0%
Light	77	100.0%	0	.0%	77	100.0%

	DESCRIPTIVE		Statistic	Std. Error
Applian	Mean		59.3795	1.60186
	95% Confidence Interval for Mean	Lower Bound	56.1891	
		Upper Bound	62.5699	
	5% Trimmed Mean		58.9927	
	Median		58.3333	
	Variance		197.579	
	Std. Deviation		1.40563E1	
	Minimum		36.11	
	Maximum		91.67	
	Range		55.56	
	Interquartile Range		25.00	
	Skewness		.346	.274
	Kurtosis		-.895	.541

	DESCRIPTIVE		Statistic	Std. Error
Overld	Mean		53.9610	2.15064
	95% Confidence Interval for Mean	Lower Bound	49.6777	
		Upper Bound	58.2444	
	5% Trimmed Mean		53.2684	
	Median		55.0000	
	Variance		356.143	
	Std. Deviation		1.88718E1	
	Minimum		25.00	
	Maximum		100.00	
	Range		75.00	
	Interquartile Range		30.00	
	Skewness		.259	.274
	Kurtosis		-.459	.541

	DESCRIPTIVE		Statistic	Std. Error
Poor	Mean		48.3766	1.56048
	95% Confidence Interval for Mean	Lower Bound	45.2687	
		Upper Bound	51.4846	
	5% Trimmed Mean		47.9640	
	Median		46.8750	
	Variance		187.503	
	Std. Deviation		1.36932E1	
	Minimum		25.00	
	Maximum		87.50	
	Range		62.50	
	Interquartile Range		18.75	
	Skewness		.343	.274
	Kurtosis		-.026	.541

	DESCRIPTIVE		Statistic	Std. Error
Short	Mean		38.9610	2.74374
	95% Confidence Interval for Mean	Lower Bound	33.4964	
		Upper Bound	44.4257	
	5% Trimmed Mean		36.3456	
	Median		25.0000	
	Variance		579.663	
	Std. Deviation		2.40762E1	
	Minimum		25.00	
	Maximum		100.00	
	Range		75.00	
	Interquartile Range		18.75	
	Skewness		1.611	.274
	Kurtosis		1.241	.541

	DESCRIPTIVE		Statistic	Std. Error
Aging	Mean		44.4805	2.29338
	95% Confidence Interval for Mean	Lower Bound	39.9129	
		Upper Bound	49.0482	
	5% Trimmed Mean		42.9924	
	Median		37.5000	
	Variance		404.990	
	Std. Deviation		2.01244E1	
	Minimum		25.00	
	Maximum		100.00	
	Range		75.00	
	Interquartile Range		37.50	
	Skewness		.601	.274
	Kurtosis		-.642	.541

	DESCRIPTIVE		Statistic	Std. Error
Light	Mean		33.9286	2.15365
	95% Confidence Interval for Mean	Lower Bound	29.6392	
		Upper Bound	38.2179	
	5% Trimmed Mean		31.0606	
	Median		25.0000	
	Variance		357.143	
	Std. Deviation		1.88982E1	
	Minimum		25.00	
	Maximum		100.00	
	Range		75.00	
	Interquartile Range		.00	
	Skewness		2.239	.274
	Kurtosis		4.413	.541

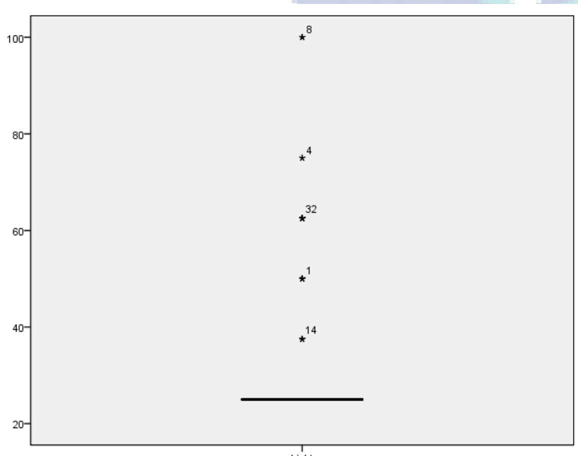
Light

```
Light Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

    59.00        2 .  55555555555555555555555555555555555555555555555555555555555
    18.00 Extremes    (>=38)

 Stem width:     10.00
 Each leaf:       1 case(s)
```



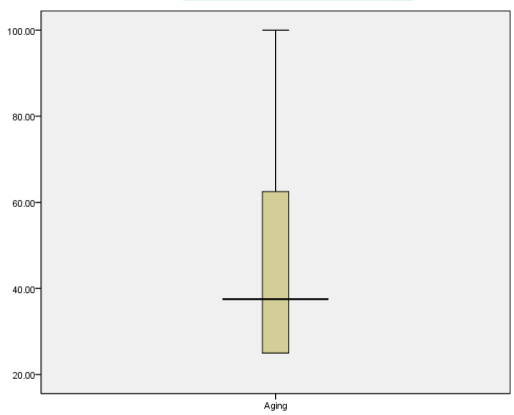
Aging

```
Aging Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

    32.00        2 .  55555555555555555555555555555555
    10.00        3 .  7777777777
      .00        4 .
     6.00        5 .  000000
    23.00        6 .  22222222222222222222222
     2.00        7 .  55
     3.00        8 .  777
      .00        9 .
     1.00       10 .  0

 Stem width:      10.00
 Each leaf:        1 case(s)
```



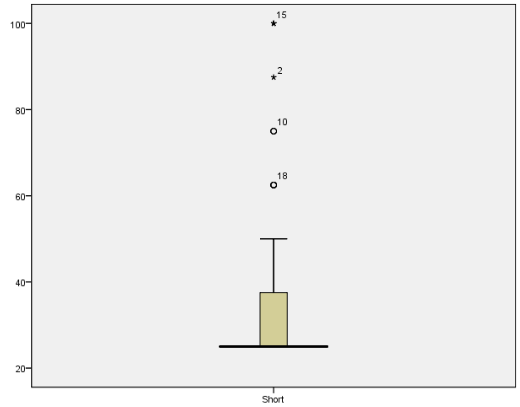
Short

```
Short Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

      .00        2 .
    51.00        2 .  555555555555555555555555555555555555555555555555555
      .00        3 .
     7.00        3 .  7777777
      .00        4 .
      .00        4 .
     3.00        5 .  000
    16.00 Extremes    (>=63)

 Stem width:      10.00
 Each leaf:        1 case(s)
```



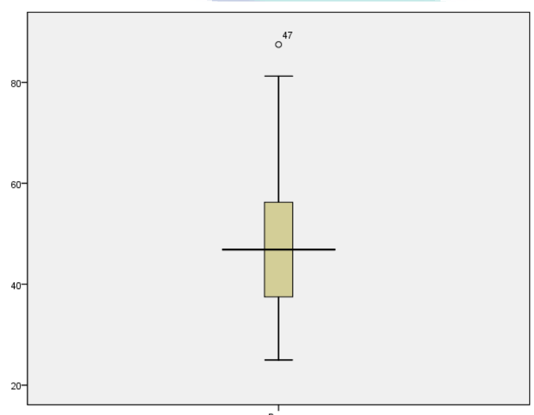
Poor

```
Poor Stem-and-Leaf Plot

 Frequency     Stem &  Leaf

     8.00        2 .  55558888
    13.00        3 .  1144444477777
    18.00        4 .  000033333336666666
    24.00        5 .  000003333333333336669999
    10.00        6 .  2222255888
     2.00        7 .  15
     1.00        8 .  1
     1.00 Extremes    (>=88)

 Stem width:     10.00
 Each leaf:       1 case(s)
```



Overld

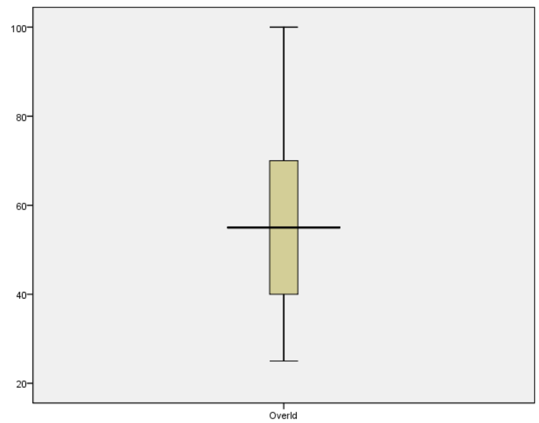
```
Overld Stem-and-Leaf Plot

 Frequency     Stem &  Leaf

     8.00        2 .  55555555
    10.00        3 .  0005555555
    13.00        4 .  0000000055555
    14.00        5 .  55555555555555
    11.00        6 .  00000055555
```

```
    15.00        7 .  000000000055555
     3.00        8 .  055
     1.00        9 .  5
     2.00       10 .  00

 Stem width:     10.00
 Each leaf:       1 case(s)
```



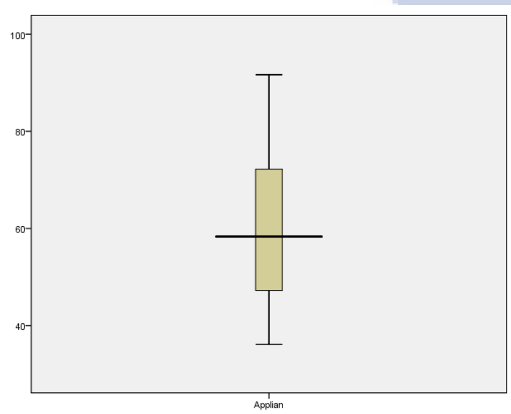
Applian

```
Applian Stem-and-Leaf Plot

 Frequency    Stem &  Leaf

     3.00        3 .  668
    19.00        4 .  1111111444447777777
    20.00        5 .  00000222225555558888
    13.00        6 .  1111111336669
    15.00        7 .  222225555555777
     6.00        8 .  000368
     1.00        9 .  1

 Stem width:     10.00
 Each leaf:       1 case(s)
```



APPENDIX G

T-TEST

APPLIANCES FAILURE

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
AppLev	77	1.4545	.50119	.05712

One-Sample Test

	Test Value = 59.38					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
AppLev	-1.014E3	76	.000	-57.92545	-58.0392	-57.8117

OVERLOADED

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
OverLev	77	1.5974	.49364	.05626

One-Sample Test

	Test Value = 53.96					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
OverLev	-930.805	76	.000	-52.36260	-52.4746	-52.2506

POOR CONNECTION

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PoorLev	77	1.4935	.50324	.05735

One-Sample Test

	Test Value = 48.38					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PoorLev	-817.563	76	.000	-46.88649	-47.0007	-46.7723

SHORT CIRCUIT

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
ShortLev	77	1.2468	.43395	.04945

One-Sample Test

	Test Value = 38.96					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
ShortLev	-762.607	76	.000	-37.71325	-37.8117	-37.6148

AGING

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
AgingLev	77	1.4545	.50119	.05712

	Test Value = 44.48					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	
AgingLev	-753.294	76	.000	-43.02545	-43.1392	-42.9117

LIGHTNING

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
LightLev	77	1.2338	.42600	.04855

One-Sample Test

	Test Value = 33.93					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	
LightLev	-673.493	76	.000	-32.69623	-32.7929	-673.493

APPENDIX H

REGRESSION ANALYSIS: OVERLOADED AS DEPENDENT VARIABLE

Model	Variables Entered	Variables Removed	Method
1	Poor	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	Aging	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	Applian	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
4	Cooking	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Overld

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.378[a]	.143	.132	17.58415	
2	.492[b]	.242	.222	16.64741	
3	.543[c]	.295	.266	16.16491	
4	.577[d]	.332	.295	15.84139	1.790

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3876.716	1	3876.716	12.538	.001[a]
	Residual	23190.167	75	309.202		
	Total	27066.883	76			
2	Regression	6558.804	2	3279.402	11.833	.000[b]
	Residual	20508.079	74	277.136		
	Total	27066.883	76			
3	Regression	7991.658	3	2663.886	10.195	.000[c]
	Residual	19075.225	73	261.304		
	Total	27066.883	76			
4	Regression	8998.510	4	2249.627	8.964	.000[d]
	Residual	18068.374	72	250.950		
	Total	27066.883	76			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	28.729	7.402		3.881	.000		
	Poor	.522	.147	.378	3.541	.001	1.000	1.000
2	(Constant)	17.370	7.902		2.198	.031		
	Poor	.484	.140	.351	3.457	.001	.993	1.008
	Aging	.296	.095	.316	3.111	.003	.993	1.008
3	(Constant)	1.656	10.193		.162	.871		
	Poor	.438	.137	.318	3.191	.002	.972	1.028
	Aging	.281	.093	.300	3.036	.003	.988	1.012
	Applian	.313	.134	.233	2.342	.022	.973	1.027
4	(Constant)	-3.423	10.306		-.332	.741		
	Poor	.418	.135	.303	3.097	.003	.967	1.034
	Aging	.237	.093	.253	2.536	.013	.933	1.072

	Applian	.330	.131	.246	2.515	.014	.969	1.032
	Cooking	4.150	2.072	.199	2.003	.049	.935	1.069

a. Dependent Variable: Overld

Excluded Variables[e]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	VIF	Minimum Tolerance
1	Applian	.254[a]	2.425	.018	.271	.978	1.023	.978
	Short	.101[a]	.932	.354	.108	.974	1.026	.974
	Aging	.316[a]	3.111	.003	.340	.993	1.008	.993
	Light	-.001[a]	-.009	.993	-.001	.991	1.009	.991
	Heating	.088[a]	.815	.418	.094	.980	1.020	.980
	Lamp	.020[a]	.183	.856	.021	1.000	1.000	1.000
	Cooking	.247[a]	2.368	.020	.265	.993	1.007	.993
	Other	.052[a]	.483	.631	.056	.995	1.005	.995
2	Applian	.233[b]	2.342	.022	.264	.973	1.027	.972
	Short	.024[b]	.230	.819	.027	.916	1.092	.916
	Light	-.018[b]	-.175	.862	-.020	.989	1.011	.983
	Heating	.003[b]	.029	.977	.003	.909	1.100	.909
	Lamp	-.002[b]	-.018	.985	-.002	.995	1.005	.988
	Cooking	.183[b]	1.779	.079	.204	.939	1.065	.939
	Other	-.016[b]	-.151	.880	-.018	.950	1.053	.948
3	Short	.016[c]	.158	.875	.019	.915	1.093	.915
	Light	-.028[c]	-.283	.778	-.033	.987	1.013	.962
	Heating	.025[c]	.238	.813	.028	.902	1.108	.902
	Lamp	-.017[c]	-.172	.864	-.020	.991	1.009	.969
	Cooking	.199[c]	2.003	.049	.230	.935	1.069	.933
	Other	-.007[c]	-.069	.945	-.008	.949	1.054	.942
4	Short	.018[d]	.179	.858	.021	.915	1.093	.880
	Light	-.015[d]	-.149	.882	-.018	.982	1.018	.929
	Heating	-.062[d]	-.561	.577	-.066	.771	1.298	.771
	Lamp	-.077[d]	-.761	.449	-.090	.914	1.094	.863
	Other	-.081[d]	-.770	.444	-.091	.846	1.182	.834

a. Predictors in the Model: (Constant), Poor

b. Predictors in the Model: (Constant), Poor, Aging

c. Predictors in the Model: (Constant), Poor, Aging, Applian

d. Predictors in the Model: (Constant), Poor, Aging, Applian, Cooking

e. Dependent Variable: Overld

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions				
				(Constant)	Poor	Aging	Applian	Cooking
1	1	1.963	1.000	.02	.02			
	2	.037	7.250	.98	.98			
2	1	2.842	1.000	.01	.01	.02		
	2	.123	4.805	.04	.16	.89		
	3	.035	9.018	.96	.84	.09		
3	1	3.790	1.000	.00	.00	.01	.00	
	2	.133	5.338	.01	.06	.94	.03	
	3	.055	8.323	.02	.74	.01	.37	
	4	.023	12.944	.97	.19	.04	.59	
4	1	4.612	1.000	.00	.00	.01	.00	.01
	2	.181	5.048	.01	.03	.00	.03	.87
	3	.130	5.954	.01	.05	.96	.02	.07
	4	.055	9.196	.02	.75	.01	.36	.00
	5	.022	14.540	.97	.17	.02	.59	.04

a. Dependent Variable: Overld

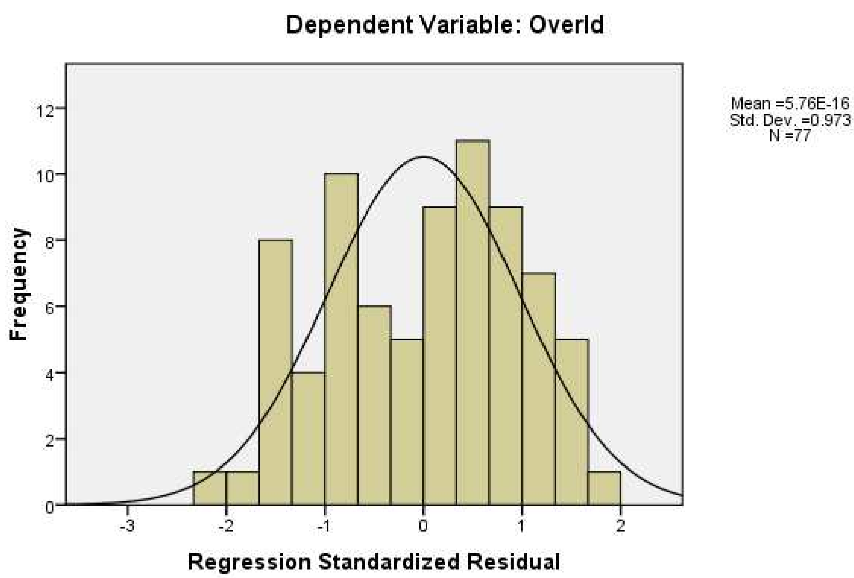
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	27.6332	80.1877	53.9610	10.88124	77
Residual	-3.22337E1	28.99926	.00000	15.41888	77
Std. Predicted Value	-2.420	2.410	.000	1.000	77
Std. Residual	-2.035	1.831	.000	.973	77

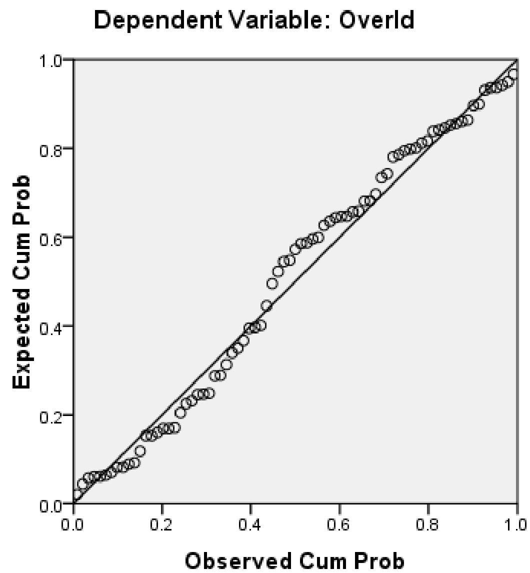
a. Dependent Variable: Overld

Charts

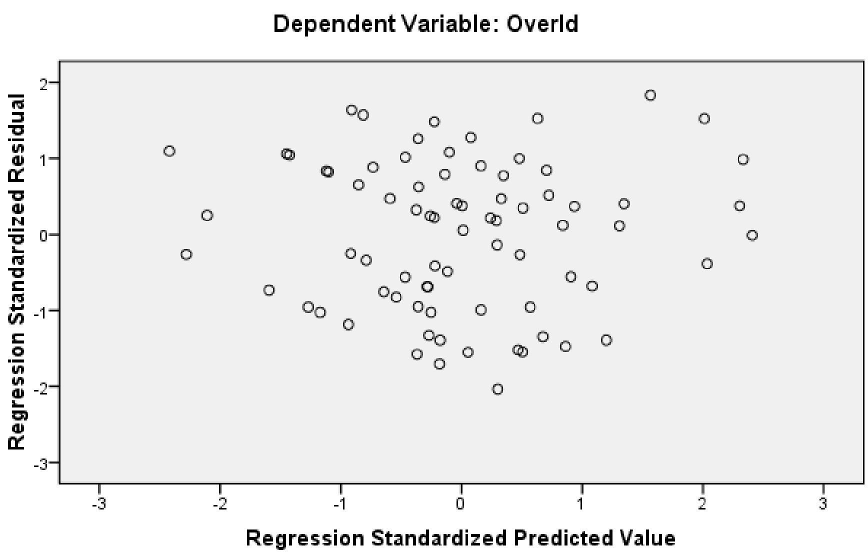
Histogram



Normal P-P Plot of Regression Standardized Residual

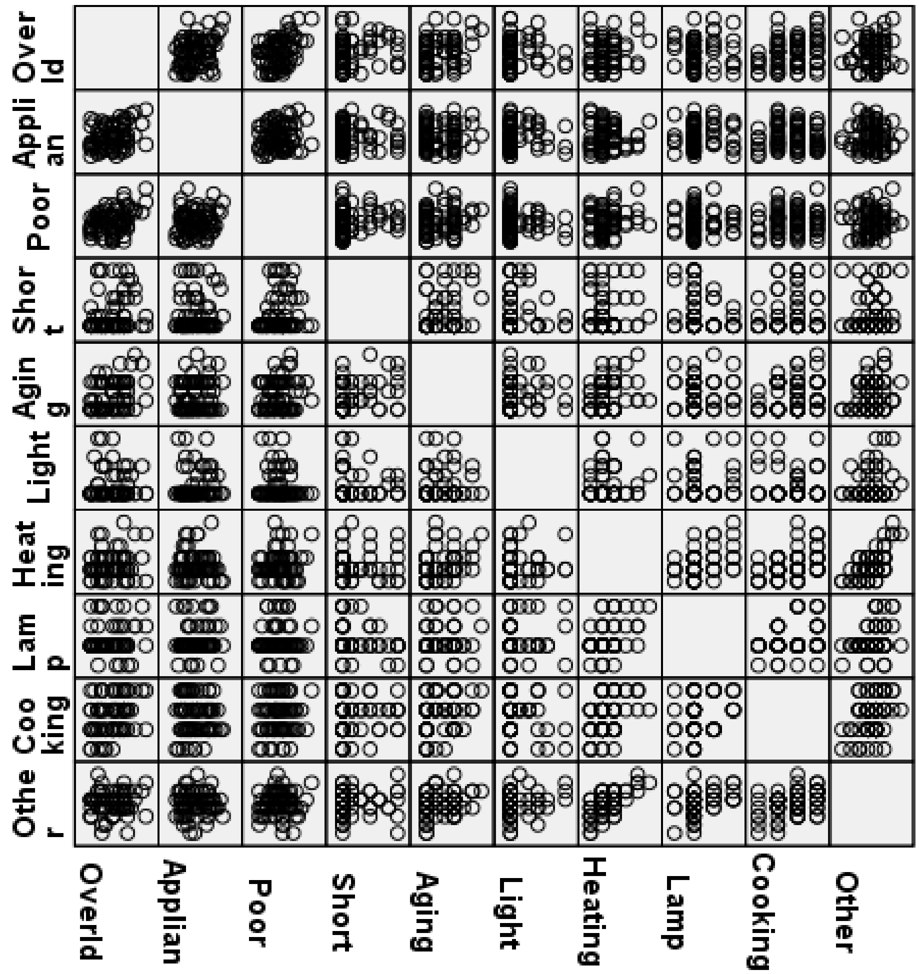


Scatterplot



APPENDIX I

GRAPH OF LINEARITY BETWEEN OVERLOADED AS DEPENDENT VARIABLE AND INDEPENDENT VARIABLES



APPENDIX J

FIRE INVESTIGATION STATISTICS TAKEN FROM FIRE & RESCUE DEPARTMENT OF MALAYSIA FROM 2006 TO 2008

STATISTIK PENYIASATAN KEBAKARAN STRUKTUR
BAHAGIAN PENGUATKUASA TAHUN 2006
JABATAN BOMBA DAN PENYELAMAT MALAYSIA

KOD	KATEGORI BANGUNAN	PENGKELASAN PENYEBAB KEBAKARAN																					JUMLAH SIASATAN
		SEMULAJADI		KEMALANGAN									SENGAJA DIBAKAR									TIDAK DAPAT DIPASTIKAN	
		SUMBER NYALAAN																					
		SN1	SN2	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10	SN11	SN3	SN4	SN5	SN6	SN7	SN8	SN9	SN10	SN11		
B1	Kilang / Bengkel	2	5	58	47	9	31	4	5	1	7	6	0	0	0	13	0	0	0	0	3	31	222
B2	Pejabat	2	1	52	33	2	15	6	0	0	0	1	0	0	0	9	0	0	0	0	2	9	132
B3	Kediaman	11	1	281	164	4	115	104	10	2	2	17	1	0	0	48	2	0	0	0	9	93	864
B4	Kedai	1	1	70	40	0	25	25	3	0	7	4	0	0	0	16	1	0	0	0	2	27	222
B5	Sekolah	4	0	16	9	0	6	6	0	0	0	1	0	0	0	9	0	0	0	1	1	5	58
B6	Pusat Membeli Belah	0	3	14	9	0	7	3	0	0	0	0	0	0	0	6	0	0	0	0	0	7	49
B7	Stor / Gudang	2	0	19	7	0	7	2	1	0	2	0	0	0	0	3	0	0	0	0	0	7	50
B8	Dewan Perhimpunan	1	0	5	2	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	11
B9	Hospital / Klinik	0	0	5	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	8
B10	Asrama / Hotel	1	0	5	9	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	23
B11	Stesen Minyak	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
B12	Struktur Khas	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
B13	Lain-lain Bangunan	2	1	24	6	0	20	8	0	1	3	6	0	0	0	1	0	0	0	0	0	24	96
JUMLAH		28	12	552	326	16	228	161	19	4	21	35	1	0	0	107	3	0	0	1	17	209	1740

* Pengkelasan kategori bangunan yang terbakar adalah berdasarkan kepada tempat bermula kebakaran (Fire Origin) atau tempat yang paling teruk terbakar (Worst Damage)

Petunjuk : Sumber Nyalaan

SN1	Kilat / Cahaya Suria	**SN7**	Api berbara (Glowing fire)
SN2	Tindakbalas spontan	**SN8**	Letupan
SN3	Kegagalan sistem pendawaian elektrik	**SN9**	Tindakbalas kimia
SN4	Kegagalan fungsi peralatan elektrik	**SN10**	Permukan bahan berhaba tinggi (Hot surface material)
SN5	Kesan geseran / hentaman	**SN11**	Lain-lain
SN6	Api terbuka (Open flame)		

STATISTIK PENYIASATAN KEBAKARAN STRUKTUR
BAHAGIAN PENGUATKUASA TAHUN 2007
JABATAN BOMBA DAN PENYELAMAT MALAYSIA

KOD	KATEGORI BANGUNAN	PENGKELASAN PENYEBAB KEBAKARAN																					JUMLAH SIASATAN
		SEMULAJADI		KEMALANGAN									SENGAJA DIBAKAR									TIDAK DAPAT DIPASTIKAN	
		SUMBER NYALAAN																					
		SN1	**SN2**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	**SN10**	**SN11**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	**SN10**	**SN11**		
B1	Kilang / Bengkel	2	5	119	61	10	28	22	2	3	27	3	0	0	0	14	0	0	0	0	4	39	339
B2	Pejabat	4	1	73	41	1	4	12	0	0	2	1	0	0	0	11	0	0	0	0	6	3	159
B3	Kediaman	14	4	249	113	0	232	97	9	0	70	16	0	1	0	62	1	0	1	0	21	91	981
B4	Kedai	1	0	112	49	2	48	14	2	0	15	5	0	1	0	29	0	0	0	0	6	29	313
B5	Sekolah	8	0	19	7	1	8	8	0	1	4	1	1	0	0	3	1	0	0	0	4	9	75
B6	Pusat Membeli Belah	0	1	6	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	13
B7	Stor / Gudang	0	0	32	12	0	5	8	0	0	5	1	0	0	0	13	0	0	0	0	6	14	96
B8	Dewan Perhimpunan	0	0	4	2	0	0	1	0	0	1	0	0	0	0	4	0	0	0	0	0	2	14
B9	Hospital / Klinik	0	0	6	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	4	4	20
B10	Asrama / Hotel	1	0	19	11	0	3	12	1	0	7	0	0	0	0	4	0	0	0	0	0	1	59
B11	Stesen Minyak	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
B12	Struktur Khas	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
B13	Lain-lain Bangunan	1	6	30	25	5	15	6	0	3	14	4	0	0	0	4	0	0	0	0	6	7	126
JUMLAH		32	17	670	326	19	347	186	14	7	145	31	1	2	0	144	2	0	1	0	58	199	2201

* Pengkelasan kategori bangunan yang terbakar adalah berdasarkan kepada tempat bermula kebakaran (Fire Origin) atau tempat yang paling teruk terbakar (Worst Damage)

Petunjuk : Sumber Nyalaan

SN1 Kilat / Cahaya Suria
SN2 Tindakbalas spontan
SN3 Kegagalan sistem pendawaian elektrik
SN4 Kegagalan fungsi peralatan elektrik
SN5 Kesan geseran / hentaman
SN6 Api terbuka (Open flame)
SN7 Api berbara (Glowing fire)
SN8 Letupan
SN9 Tindakbalas kimia
SN10 Permukan bahan berhaba tinggi (Hot surface material)
SN11 Lain-lain

STATISTIK PENYIASATAN KEBAKARAN STRUKTUR
BAHAGIAN PENGUATKUASA TAHUN 2008
JABATAN BOMBA DAN PENYELAMAT MALAYSIA

KOD	KATEGORI BANGUNAN	PENGKELASAN PENYEBAB KEBAKARAN																				TIDAK DAPAT DIPASTIKAN	JUMLAH SIASATAN
		SEMULAJADI		KEMALANGAN									SENGAJA DIBAKAR										
		SUMBER NYALAAN																					
		SN1	**SN2**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	**SN10**	**SN11**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	**SN10**	**SN11**		
B1	Kilang / Bengkel	0	11	99	39	14	20	15	3	7	41	20	0	0	0	15	1	0	0	1	10	59	355
B2	Pejabat	1	0	49	19	1	14	10	0	0	1	4	0	0	0	5	0	0	1	0	3	8	116
B3	Kediaman	14	21	449	163	10	357	87	2	1	19	147	3	0	1	83	9	1	2	1	55	153	1578
B4	Kedai	3	6	123	49	1	46	16	1	0	2	26	2	0	0	24	1	0	1	0	11	38	350
B5	Sekolah	6	1	19	8	0	4	8	0	0	0	3	0	0	0	10	1	0	0	0	2	4	66
B6	Pusat Membeli Belah	0	0	11	1	0	4	1	0	0	1	3	0	0	0	1	0	2	0	0	0	5	29
B7	Stor / Gudang	0	2	27	10	0	7	9	0	2	0	5	0	0	0	4	1	0	0	0	9	12	88
B8	Dewan Perhimpunan	0	0	10	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13
B9	Hospital / Klinik	1	0	4	4	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	1	1	15
B10	Asrama / Hotel	1	0	17	7	0	6	5	0	1	0	3	0	0	0	4	1	0	0	0	0	3	48
B11	Stesen Minyak	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
B12	Struktur Khas	1	0	11	6	1	2	2	1	0	1	1	0	0	0	0	1	0	0	0	2	3	32
B13	Lain-lain Bangunan	3	7	36	17	1	9	8	1	0	12	14	0	1	1	4	3	0	0	2	3	15	137
JUMLAH		30	48	856	323	28	471	163	8	11	77	228	5	1	2	151	18	3	4	4	96	302	2829

* Pengkelasan kategori bangunan yang terbakar adalah berdasarkan kepada tempat bermula kebakaran (Fire Origin) atau tempat yang paling teruk terbakar (Worst Damage)

Petunjuk : Sumber Nyalaan

SN1	Kilat / Cahaya Suria	**SN7**	Api berbara (Glowing fire)
SN2	Tindakbalas spontan	**SN8**	Letupan
SN3	Kegagalan sistem pendawaian elektrik	**SN9**	Tindakbalas kimia
SN4	Kegagalan fungsi peralatan elektrik	**SN10**	Permukan bahan berhaba tinggi (Hot surface material)
SN5	Kesan geseran / hentaman	**SN11**	Lain-lain
SN6	Api terbuka (Open flame)		