NATIONAL CONFERENCE ON ELECTRICAL SAFETY 2011
21-22 July 2011, KLCC

Structure Fire caused by electrical

National Conference Electrical Safety 2011 Organized Energy Commission

21- 22 July, 2011

Kuala Lumpur Convection Centre (KLCC), Malaysia

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Fire in Malaysia

Source: Operation Div. JBPM

	2008	2009	2010
Structure	3,556	5,067	7,249
Motor	1,053	1,155	2,759

Structure Fire in Malaysia

Source: Operation Div. FRDM

NO	PREMIS	2007	2008	2009
1	Factory	307	333	402
2	Office	96	86	193
3	Residential	**1,863**	**1,908**	**2,885**
	Squatters	75	65	69
4	Shop	396	498	627
5	School	54	48	89
6	Shopping Complex	10	11	31
7	Store	221	192	264
8	Place of Assembly	30	23	27
9	Hospital / Clinic	6	9	31
10	Hotel/Boarding	49	48	63
13	Others	340	335	386
	TOTAL	**3,447**	**3,556**	**5,067**

What is Fire Investigation?

- Fire Investigation is the process of determining the cause, origin and **circumstance** of fire (Fire Services Act 1988).
- Fire investigation is one of the most difficult of the forensic sciences to practice. Unlike most forensic disciplines, even the basic question of whether a crime has been committed is normally not obvious.
- During a fire investigation, an entire process must be undertaken just to determine if the case involves arson or not. The difficulty of determining whether arson has occurred arises because fire often destroys the key **evidence** of its origin.
- One of the challenging aspects of fire investigation is the multi-disciplinary (including construction, electricity, human behavior, vehicles etc).

Fire Investigation in Malaysia

- Fire Investigation in FRDM was form in 2003 with 144 officers . The officers have been attended course in Japan, USA, UK & Australia.
- In 2008, the role of fire Investigation become important, it form one division called Fire Investigation Div. with 460 Officers.
- Members of IAAI (International Arson Association Investigation).
- K-9 unit.
- 9 Fire Investigation Laboratories with 8 type analysis equipments.

Equipments at Fire Investigation Lab

- **Polimer**
  - Thermal Gravimetry Analyzer (TGA),
  - Thermomechanical Analyzer (TMA)
  - Differential Scanning Caloimetry (DSC),

- **Organic Compound**
  - High Performance liquid chromatography (HPLC),
  - Automatic Thermal Desorption – Gas chromatography and Mass Spectometer (ATD-GCMS)

- **Inorganic Compound**
  - Fourier Transform Infra-Red Spectroscopy (FTIR),
  - Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES),
  - Ultra Violet Spectrophotometry (UV-VIS).

The Purpose of Fire Investigation

1. To determine the cause, origin and circumstance of fire systematically and scientifically.
2. To prepare the investigation paper for Incendiary Fire.
3. To evaluate the effectiveness of operation tactic, fire prevention and enforcement of fire safety.
4. To determine the effectiveness of Fire Safety Installation at premises.
5. To purpose any standard of fire safety installation to Malaysia Standard.
6. To purpose effectiveness of fire safety campaign to public.
7. To advice the manufacture of electrical equipment or others manufacture about fire safety.

Provision from Act

- **Section 5(1)(b)** – making of investigation into cause, origin and circumstances of fire.
- **Section 45** – The Minister appoint any persons to hold an enquiry into the cause and circumstances of any fire and action taken.
- **Section 46** – taking possession of premises and other property damaged or destroyed by fire.
- **Section 47** – Unauthorized presence in premises possession whereof has taken under Section 46 shall be guilty of an offence.

Provision from Act

- **Section 38** –Power of entry.
- **Section 39** –Restriction on disclosure of information.
- **Section 40** – Power to arrest without warrant person found committing an offence under section 47.
- **Section 41** – power of investigation.
- **Section 42** – power to require attendance of witnesses
- **Section 43** – Examination of witnesses.

Provision from Penal Code (Act 574)

- Section 435 – Mischief by fire or explosive with intent to cause **damage to amount RM50.00**. Whoever commits mischief by fire or any explosive substance, intending to cause, damage to any property to the amount of RM50.00 or upwards.

  shall be punished with imprisonment for a term which may extend to 7 years and shall also be liable to fine.

- Section 436 – Mischief by fire or explosive with **intent to destroy a house** etc.

  Whoever commits mischief by fire or any explosive substance, intending to cause, or knowing it to be likely that he will thereby cause, the destruction of any building which is ordinary used as; a place of worship, or for the administration of justice, or for the transaction of public affairs, or for education, or art, or for public use, or Ornament, or as a human dwelling, or as a place for the custody of property.

  shall be punished with imprisonment for a term which may extend to 20 years and shall also be liable to fine.

Provision from Penal Code (Act 574)

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- Section 438 – Punishment for the mischief described in the last section when committed by fire or any explosive substance.

Whoever commits mischief by fire or any explosive substance, intending to cause, or knowing it to be likely that he will thereby cause, the destruction of any building which is ordinary used as:-

shall be punished with imprisonment for a term which may extend to 20 years and shall also be liable to fine.

Procedure Protocol

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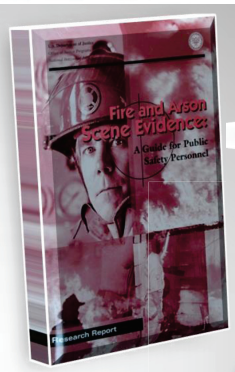
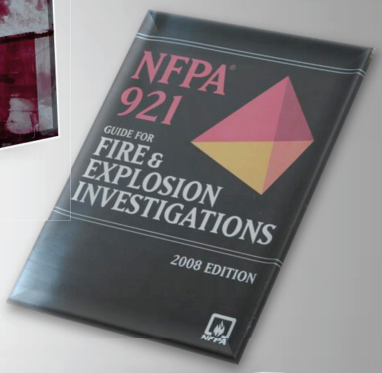
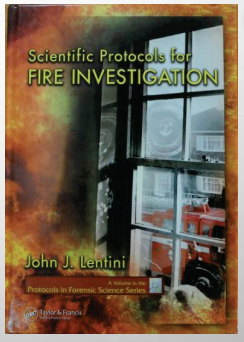
Using international

- ✧ Guide Fire and Explosion Investigation NFPA 921.
- ✧ Fire and Arson Scene Evidence: A Guide for Public Safety Personnel by U.S. Department of Justice.
- ✧ Professional guide
- ✧ Standard -Standard







The scientific Method

Scientific Method is systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of a hypothesis (NFPA 921).

Systematic Approach is that of the scientific method, which is used in the physical science.

Step 1 – Recognize the need
- A fire has occurred
- The origin is unknown

Step 2 – Define the Problem
- Determine the origin

Step 3 – Collect Data
- Basic site data
- Determine pre-fire conditions
- Documentation of post-fire conditions
- Excavation, examination, and reconstruction of the scene - Photograph, sketch and collect evidence
- Witness statements and observations
- FDRM information
- Alarm, detector ,and security.

Step 4– Analyze the Data
- Pattern analysis.
- Heat and flame vector analysis
- Depth of char and calcination surveys
- Arc mapping
- Event sequencing.
- Fire Dynamics consideration
- Building construction and occupancy consideration.

Step 5 – Develop a working Hypothesis
- Initial origin hypothesis
- Working origin hypothesis
- Alternate hypothesis

Step 6– Test the Working Hypothesis
- Is there a competent ignition source at the origin?
- Does the origin explain the data?
- Are contradictions resolved?
- Does an alternate origin explain the data equally well?

Step 7 – Select the Final Hypothesis
- Area of origin
- Point of origin
- Origin insufficient to the determine cause

Scientific Method

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The Science and "ART" of Fire Investigation

The investigator must apply the concept of :

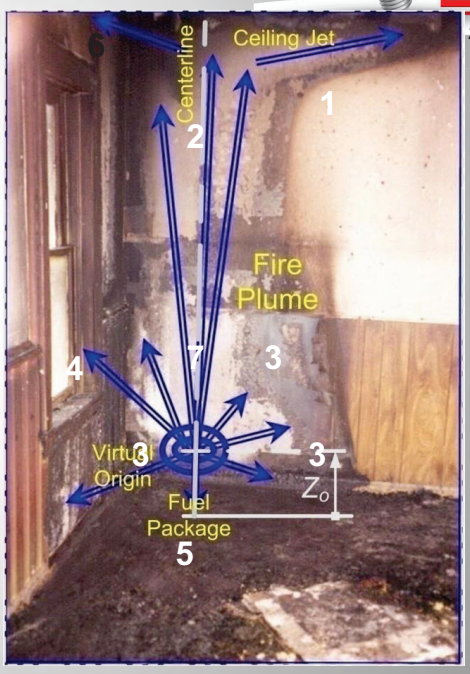
Scientific research is based on a methodology which firstly makes a full review of the scientific literature, then the research work is conducted in carefully controlled tests and then the results are scientifically scrutinized .

Art is about creativity and fire investigators are not at fire scene to ponder creativity but are there to physically find and interpret the evidence which will indicate the cause of the fire.

Fire Pattern

FIRE PATTERN ANALYSIS

- ***DEMARCATIONS***
  1. "V" patterns
  2. Calcination
- ***SURFACE EFFECTS***
  3. Charring
  4. Cracked glass
  5. Flammable liquid burn pattern
- ***PENETRATIONS***
  6. Damage to ceiling
- ***LOSS OF MATERIAL***
  7. Combustible surface



Point of Origin	• the exact physical location where a heat source and a fuel come in contact with each other and a fire begins.
Source of Ignition	

Cause of Fire	• The circumstance, conditions, or agencies that brings together a fuel, ignition source, and oxidizer (such as air and oxygen) resulting in a fire.
	• Fire cause be classified as
	  • Accidental,
	  • Incendiary, or
	  • Natural.

Source of Ignition

Primary Ignitors	
1	Matches/Lighter
2	Torches/Candles
Secondary Sources	
3	Hot Object/Hot Surfaces
4	Friction
5	Chemical Reaction
The Role of Service & Appliances in Starting Fires	
6	Gas Appliances
7	Electricity (Spark, Arc, Overload, over heating)

Others	
8	Glowing fire (smoking, mosquito coil etc)
9	Fire Cracker
10	Lightning
11	Spontaneous Combustion – self heating
12	Explosion

Accidental

- An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an **unexpected** happening due to **careless, ignorance, and the like**

Incendiary

- A fire that is **intentionally** ignited under circumstances in which the person knows that the fire should not be ignited.

Arson

- The crime of **maliciously and intentionally**, or **recklessly**, starting a fire.

Electrical Fire !

ELECTRICAL FIRE: A fire directly caused by the flow of electric current or by static electricity, if it is not due to normal, purposive heating produced by an electrical device.

Latter types of fires should be categorized as '*accidental contact of combustibles with a heat source.*'

Ignition by Electrical Energy

- Ignition to be from an electrical source, the following must occur:

  1) Electrical wiring, equipment or component must have been energized from a buildings wire, an emergency system, a battery or some other source.

  2) Sufficient heat and temperature to ignite a close combustible material must have been produced by electrical energy at the point of origin by the electrical source.

- Ignition by electrical energy involves generating both sufficiently high temperatures and heat (i.e. competent ignition source) by passage of electrical current to ignite material that is close.

Ignition by Electrical Energy

1. Resistance Heating
   a) Heat-Producing Devices
   b) Poor Connection
2. Overcurrent and Overload
3. Arcs
   a) High-Voltage Arcs
   b) Static Electricity
   c) Parting Arcs
   d) Arcing Across a Carbonized Path
4. Sparks
5. High-Resistance Faults.

Definition

Arc	A high-temperature luminous electric discharge across a gap or through a medium such as charred insulation.
Electric Spark	A small, incandescent particle created by some arcs.
Short Circuit	An abnormal connection of low resistance between normal circuit conductors where the resistance is normally much greater; this is an overcurrent situation but it is not an overload.
Overcurrent	Any current in excess of the rated current of equipment or the ampacity of a conductor; it may result from an overload, short circuit, or ground fault.

Definition

Overload	Operation of equipment in excess of normal, full-load rating or of conductor in excess of rated ampacity that when it persists for a sufficient length of time would cause damage or dangerous overheating.
Bend	A rounded globule of re-solidified metal at the end of the remains of an electrical conductor that was caused by arcing and is characterized by a sharp line of demarcation between the melted and unmelted conductor surfaces.
Spark	A moving particle of solid material that emits radiant energy due either to its temperature or the process of combustion on its surface.

Electrical Fires…

In such fires, damage is consistent with having been caused by:

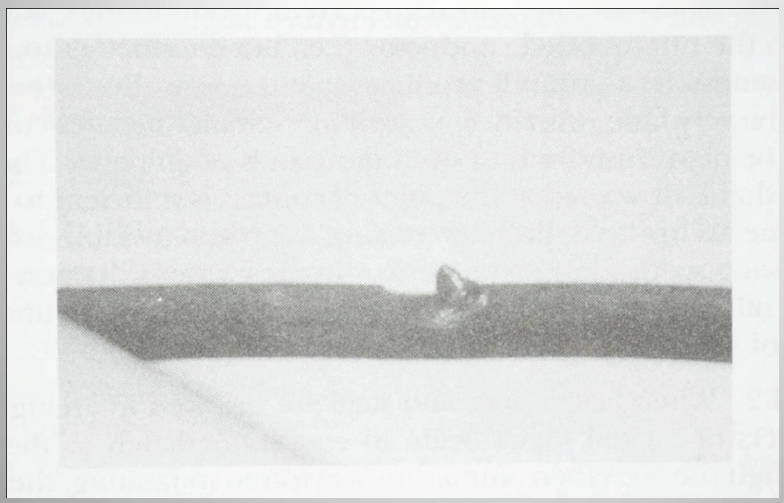
- Electrical insulation failure
- Arcing
- Overheating
- Radiation

Electrical Fusion

- Globules of melted copper
- Arc marks
- Pitting of electrical conductors

Short Circuit and Ground Fault Parting Arcs

Figure : A solid Copper Conductor Notched by a Short Circuit.



Short Circuit and Ground Fault Parting Arcs ..

Fig : Stranded Copper Lamp Cord That Was Severed by a Short Circuit

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Fig (a) : Copper Conductors Severed by Arcing Through the Charred Insulation

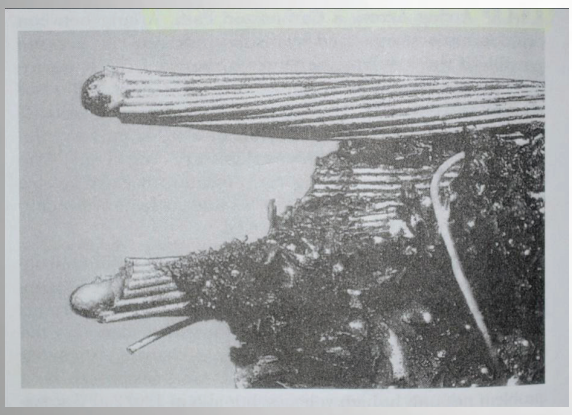

Fig (b) : Copper Conductors Severed by Arcing Through the Charred Insulation with a Large Bead Welding the two Conductors together

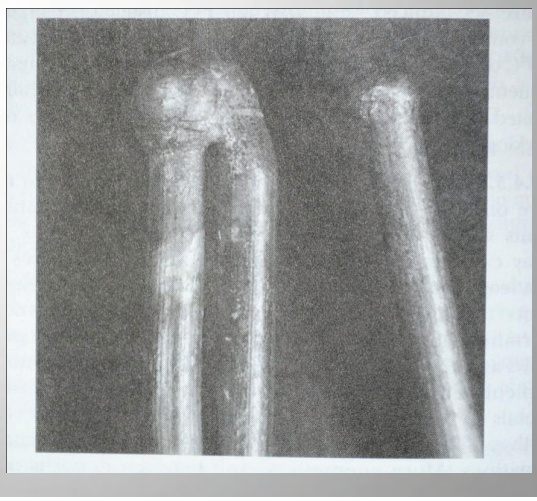

Fig (c) : Stranded Copper Conductors Severed by Arcing Through the Charred Insulation with the Strands Terminated in Beads.

Fig (d) Arc Damage to 18 AWG Cord by Arcing Through the Charred Insulation.

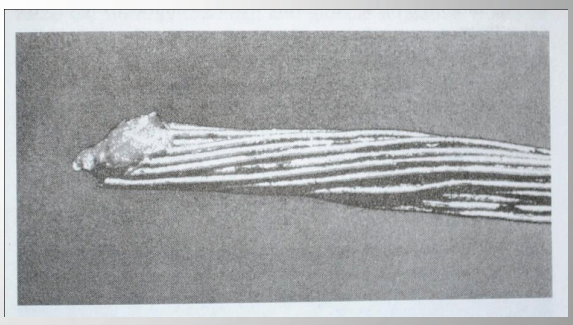

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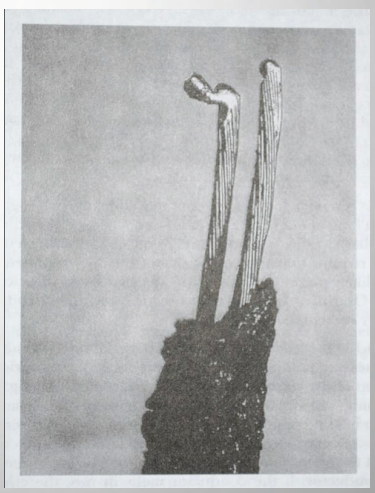
Fig (e) :) Spot Arc Damage to 14 AWG Conductor Caused by Arcing Through the Charred Insulator

Fig (f) Arc Damage to 18 AWG Cord by Arcing Through the Charred Insulation.



Overload….

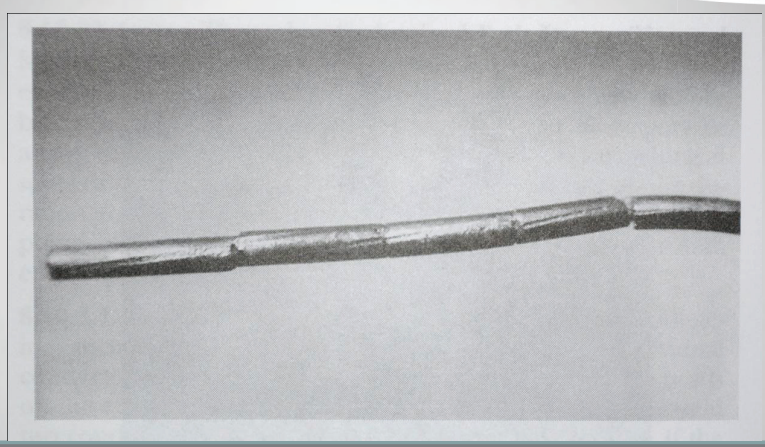
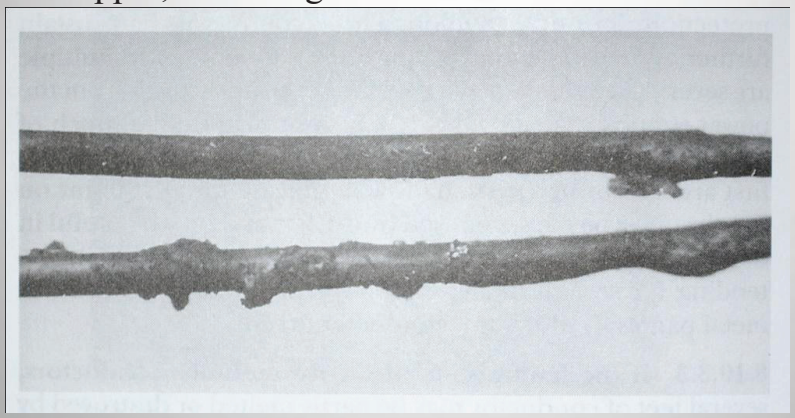


Fig: Aluminum Conductor Severed by Overcurrent Showing Offsets

Effects Not Caused by Electricity..

Fig :Copper Conductors Fire-Heated to the Melting Temperature, Showing Regions of Flow of Copper, Blistering and surface Distortion



Effects Not Caused by Electricity..

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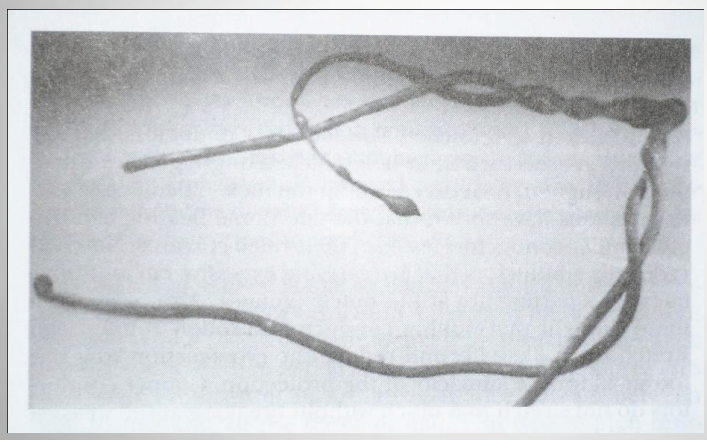
Fig: Fire Heated Copper showing Globules



Effects Not Caused by Electricity..

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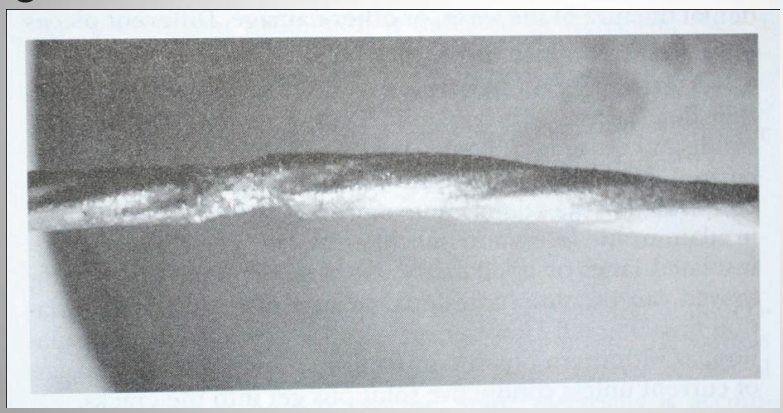
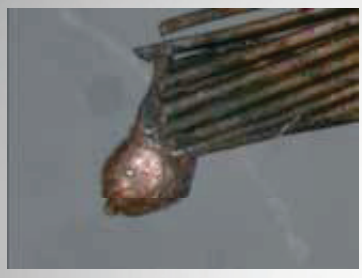
Fig: Stranded Copper Conductor in Which Melting by Fire Caused the Strands to be Fused Together



Bead (Energized)



- A rounded globule of resolidified metal at the end of the remains of an electrical conductor that was caused by arcing and is characterized by a sharp line of demarcation between the melted and unmelted conductor surfaces.
- A mate notch in the case of parallel conductors.

Investigation of Structure Fire

Source: Fire Investigation Div. FRDM

NO	PREMIS	2009		2010	
			%		%
1	Factory	320	10.6%	324	8.6%
2	Office	110	3.6%	119	3.2%
3	**Residential**	**1,712**	**56.7%**	**2,296**	**61.0%**
4	Shop	377	12.5%	459	12.2%
5	School	86	2.9%	100	2.7%
6	Shopping Complex	19	0.6%	15	0.4%
7	Store	116	3.8%	119	3.2%
8	Place of Assembly	24	0.8%	35	0.9%
9	Hospital / Clinic	24	0.8%	10	0.3%
10	Hotel	50	1.7%	38	1.0%
11	Petrol Station	3	0.1%	44	1.2%
12	Special structure	62	2.1%	51	1.4%
13	Others	113	3.8%	156	4.1%
TOTAL		**3,016**		**3,766**	

Source of Ignition for Structure Fire

Source: Fire Investigation Div. FRDM

NO	SOURCE OF IGNITION	2009		2010	
			%		%
1	Lightning	53	1.8	54	1.4
2	Spontaneous Combustion – self heating	23	0.8	24	0.6
3	Electrical wiring	**1,027**	**34.1**	**1,307**	**34.7**
4	Electrical Appliance	314	10.4	417	11.1
5	Friction	15	0.5	28	0.7
6	Open Flame	766	25.4	1,011	26.8
7	Glowing fire	148	4.9	231	6.1
8	Explosion	10	0.3	17	0.5
9	Chemical Reaction	16	0.5	14	0.4
10	Hot Surface	73	2.4	65	1.7
11	Others	241	8	260	6.9
12	Undetermined	330	10.9	338	9.0
	TOTAL	**3,016**		**3,766**	

Cause of Electricity for Structure Fire

Source: Fire Investigation Div. FRDM

NO	PREMIS	TOTAL	2009		2010	
1	Factory	320	82	8.0%	94	7.2%
2	Office	110	67	6.5%	59	
3	Residential	**1,712**	**536**	**52.2%**	**780**	**59.8%**
4	Shop	377	136	13.2%	183	14.0%
5	School	86	33	3.2%	38	
6	Shopping Complex	19	9	0.9%	5	
7	Store	116	40	3.9%	38	
8	Place of Assembly	24	12	1.2%	11	
9	Hospital / Clinic	24	12	1.2%	8	
10	Hotel	50	17	1.7%	10	
11	Petrol Station	3	0	0.0%	18	
12	Special structure	62	38	3.7%	11	
13	Others	113	45	4.4%	52	
	TOTAL	**3,016**	**1,027**		**1,307**	

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Cause of Fire for Structure Fire

Source: Fire Investigation Div. FRDM

No	Cause of Fire	2009	2010
1	Natural	76	78
2	Accidental	2,340	3,052
3	Incendiary	271	298
4	Undetermined	330	338
	TOTAL	**3,017**	**3,766**

Conclusion

- The highest Source of Ignition is electrical-34%.
- Electric Appliance and elements – shall design according to standard.
- Minimize Fire Load and good housekeeping which is good source of ignition.
- Installation and maintenance of electrical wiring must be enforcement by Authority, it cannot be “self regulate”.

Thank You

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