



# Fire Investigation in Malaysia

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FIRE RESCUE DEPARTMENT of MALAYSIA (FRDM)

# Introduction

- 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.
- Many fires are caused by defective equipment, such as shorting of faulty electrical circuits for example.

# Introduction

- A fire investigator looks at the **fire remains**, and obtains information to **reconstruct** the **sequence of events** leading up to the fire.
- One of the challenging aspects of fire investigation is the **multi-disciplinary**. (including construction, electricity, human behavior, vehicles etc).

# Introduction



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Principal among these is a 13-point list of areas in which a fire investigator is required to have education beyond high school level. These 13 topics are:

- 1) Fire science
- 2) Fire chemistry
- 3) Thermodynamics
- 4) Thermometry
- 5) Fire dynamics
- 6) Explosion dynamics
- 7) Computer fire Modelling
- 8) Fire investigation
- 9) Fire analysis
- 10) Fire investigation methodology
- 11) Fire investigation technology
- 12) Hazardous materials
- 13) Failure analysis and analytical tools





# Fire in Malaysia

*Source: Investigation Div. FRDM*

Type	2018	2019	2020
Structure	6,626	7,393	6,910
Vehicle	2,834	3,387	3,242
TOTAL	9,460	10,780	10,152

# Investigation of Structure Fire

Source: Fire Investigation Div. FRDM

No.	Premises	2018		2019		2020	
		Qty.	%	Qty.	%	Qty.	%
1	<b>Residential</b>	4,369	<b>65.9</b>	4,788	<b>64.8</b>	4,396	<b>63.6</b>
2	Hotel	56	<b>0.8</b>	60	<b>0.8</b>	51	<b>0.7</b>
3	Hostel/Boarding	71	<b>1.1</b>	67	<b>0.9</b>	50	<b>0.7</b>
4	School	104	<b>1.6</b>	155	<b>2.1</b>	95	<b>1.4</b>
5	Higher Learning Inst.	25	<b>0.4</b>	36	<b>0.5</b>	13	<b>0.2</b>
6	Hospital / Clinic	75	<b>1.1</b>	69	<b>0.9</b>	61	<b>0.9</b>
7	Office	207	<b>3.1</b>	202	<b>2.7</b>	191	<b>2.8</b>
8	Shop	736	<b>11.1</b>	844	<b>11.4</b>	871	<b>12.6</b>
9	Shopping Complex	28	<b>0.4</b>	32	<b>0.4</b>	47	<b>0.7</b>
10	Place of Assembly	86	<b>1.3</b>	45	<b>0.6</b>	38	<b>0.5</b>
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13	Petrol Station	9	<b>0.1</b>	13	<b>0.2</b>	8	<b>0.1</b>
14	Special structure	41	<b>0.6</b>	55	<b>0.7</b>	115	<b>1.7</b>
15	Others	169	<b>2.6</b>	266	<b>3.6</b>	243	<b>3.5</b>
<b>TOTAL</b>		<b>6,626</b>		<b>7,393</b>		<b>6,910</b>	

# Fire Investigation in Malaysia



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- Fire Investigation in FRDM was form in 2003 with 144 officers.
- Fire Investigator Officers – attended course in Japan, USA, UK & Australia.
- In 2008, the role of fire Investigation become important, it form one division called Fire Investigation Division with 391 Officers.
- ▶ Train Fire Investigator (Fire Officer) – by the expert from IAAI (International Arson Association Investigation).



# Fire Investigation in Malaysia

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- ▶ Member of International Association of Arson Investigators (IAAI).
- ▶ Members of Malaysia Quality Assurance (MQA) in Forensic Science.
- K-9 unit.
- 9 Fire Investigation Laboratories with 8 types of analysis equipments.
- 1 Fire Investigation Electrical Laboratory (FIvEL)

# What is Fire Investigation?

- Fire Investigation is the process of determining the origin, cause and **development** of fire (NFPA 921)
- Fire Investigation is the process of determining the cause, origin and **circumstance** of fire (Fire Services Act 1988)



# The Purpose of Fire Investigation

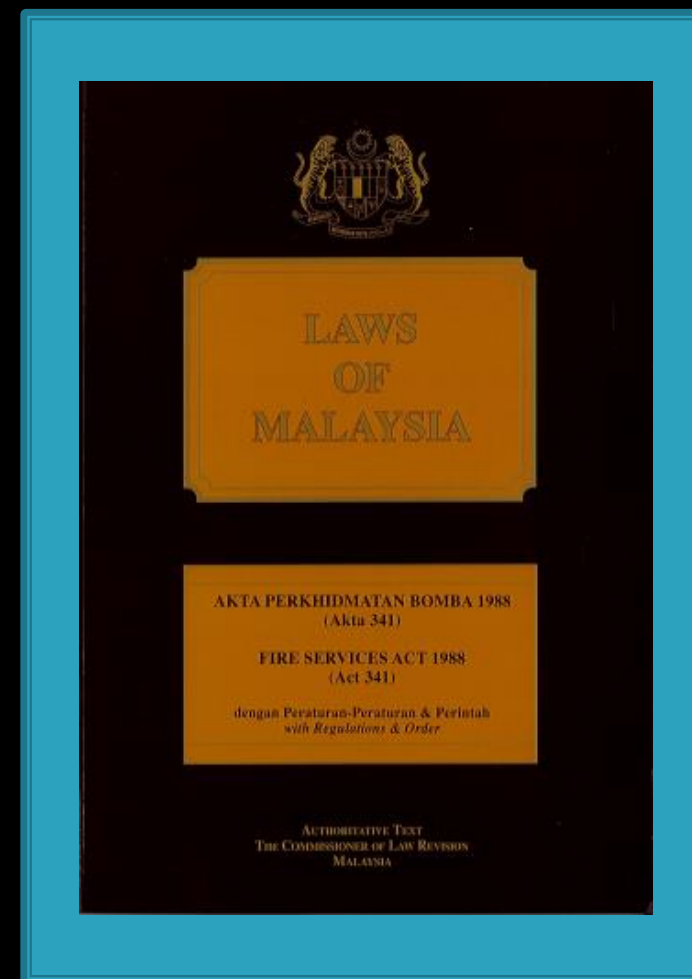
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1. To determine the cause, origin and circumstance of fire systematically and scientifically.
2. To prepare the investigation paper for Incendiary Fire.
3. To evaluate the effectiveness of operation tactic, fire prevention and enforcement of fire safety.
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<sup>11</sup> 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

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- **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 Act

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(Amendment 2018)

- **Section 18A – Power requires information**
  - (1) For the purposes of paragraph 5 (1) (b) of the Act, a Fire Officer may, by notice in writing served on a person, require the person—
    - to provide all fire -related information; and
    - to appear before a Fire Officer to give an oral statement and the Fire Officer shall, as soon as practicable, convert the oral statement into written form.
  - (2) Any person who contravenes subsection (1) commits an offense and shall, on conviction, be liable to a **fine** not exceeding **one thousand ringgit**.



# Provision from Penal Code (Act 574)

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- ▶ **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 57)

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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:-*

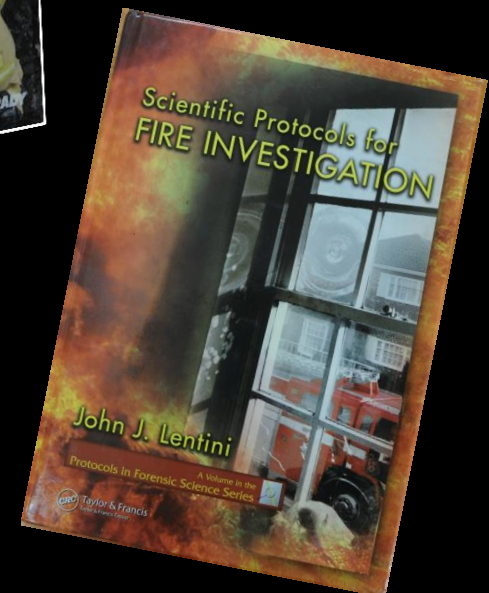
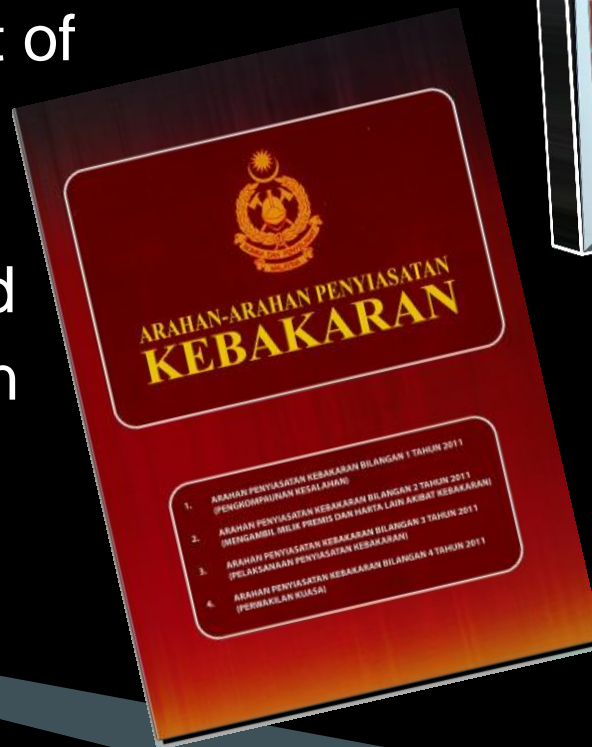
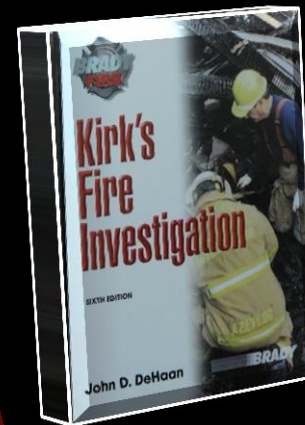
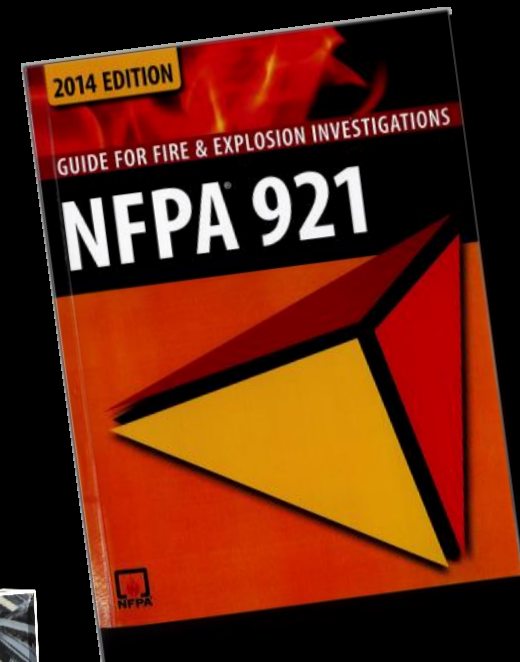
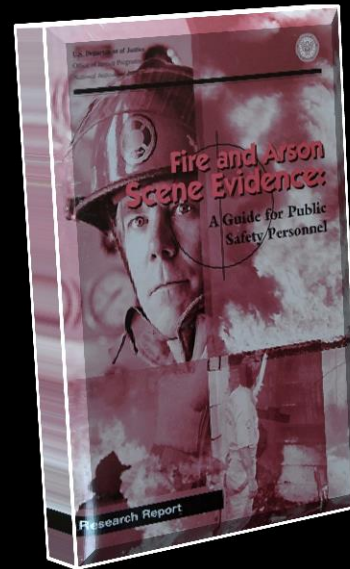
shall be punished with imprisonment for a term which may extend to 20 years and shall also be liable to fine.





# Procedure Protocol

- ▶ 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
  - Arahan Penyiasatan Kebakaran





Camera



Hydrocarbon Search  
Detector



Computer simulation -  
Pyrosim

# Fire Investigation Equipments



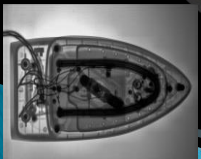
K-9 Unit



Stereo Microscope



XR200 Portable X-ray  
Machine





# Equipments at Fire Investigation Lab

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- ▶ Polymer
  - Thermal Gravimetric Analyzer (TGA),
  - Thermomechanical Analyzer (TMA)
  - Differential Scanning Calorimetry (DSC),
- ▶ Organic Compound
  - High Performance liquid chromatography (HPLC),
  - Automated Thermal Desorption – Gas Chromatography Mass Spectrometry (ATD-GCMS)
- ▶ Inorganic Compound
  - Fourier Transform Infra-Red Spectroscopy (FTIR),
  - Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES),
  - Ultra Violet Spectrophotometry (UV-VIS).



# Equipments at Fire Investigation Electrical Laboratory (FIvEL)



- ▶ Electrical Laboratory
  - Workbench, stools, tools, dismantle process
- ▶ Fire Investigation Electrical Testing System (FIETS)
  - Voltage Test Station
  - Current Test Station
  - Load Test Station
  - DC Test Station
- ▶ Microscope Station
  - Stereo microscope
- ▶ Portable X-Ray Machine
  - Analyze electrical sample
  - X-Ray images

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## Electrical laboratory



## Fire Investigation Electrical Testing System (FIETS)



## X-ray room



## Microscope station





# 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



# Fire Effect & Fire Pattern

The major objective of any fire scene examination is to collect data as required by the scientific method.

## Fire Effect

The observable or measurable changes in or on a material as a result of a fire.

## Fire Pattern

The visible or measurable physical changes, or identifiable shapes, formed by a fire effect or group of fire effect



# Fire Effects

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**Fire Effects** are the observable or measurable changes in or on a material as the result of a fire. (NFPA 921, 2014)

*(Perubahan fizikal pada bahan akibat kebakaran yang boleh dilihat atau diukur)*

- ▶ Untuk mengenalpasti corak kebakaran, pegawai penyiasat hendaklah mengetahui perubahan kepada bahan-bahan yang berlaku akibat daripada kebakaran.
- ▶ Perubahan ini adalah merujuk kepada akibat daripada kebakaran, yang mana perubahan yang boleh diperhati atau diukur ke atas bahan-bahan akibat daripada kebakaran.



# Fire Pattern

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**Fire Patterns** – the visible or measurable physical changes or identifiable shapes, formed by a fire effect or group of fire effects. (NFPA 921, 2014)

*(Corak kebakaran adalah perubahan fizikal yang dapat dilihat atau diukur atau pembentukan bentuk yang dapat dikenalpasti oleh kesan kebakaran atau kumpulan dari kesan kebakaran)*



**Fire  
Effects**

1) Temperature Estimation  
Using Fire Effects

2) Mass Loss of Material

3) Char

4) Spalling

5) Oxidation

6) Colour Changes

7) Melting of Material

8) Thermal Expansion and  
deformation of Material

9) Deposition of Smoke on  
Surface

10) Clean Burn

11) Calcination

12) Window Glass

13) Collapsed Furniture  
Springs

14) Distorted Lightbulbs

15) Rainbow Effect

16) Victim Injuries

# Patterns Geometry

1. V-pattern on Vertical Surfaces
2. Inverted Cone (Triangular) Patterns
3. Hourglass Patterns
4. U- shaped Patterns
5. Truncated Cone Patterns
6. Pointers and Arrow Patterns
7. Circular-Shaped Patterns
8. Irregular Patterns
9. Doughnut-Shaped Patterns
10. Linear Patterns
  - a) Trailers
  - b) Protected Floor Areas
  - c) Fuel Gas Jets
11. Area Patterns
12. Saddle Burns

# Principles of Fire Behaviour



**FIGURE 7.8A** ♦ Coffeemaker fire involving other fuels (cereal boxes, towels).  
*Courtesy of Jamie Novak, Novak Investigations.*



**FIGURE 7.8B** ♦ Fire spreads into cabinets. Plume entering air return grille in suspended ceiling. *Courtesy of Jamie Novak, Novak Investigations.*



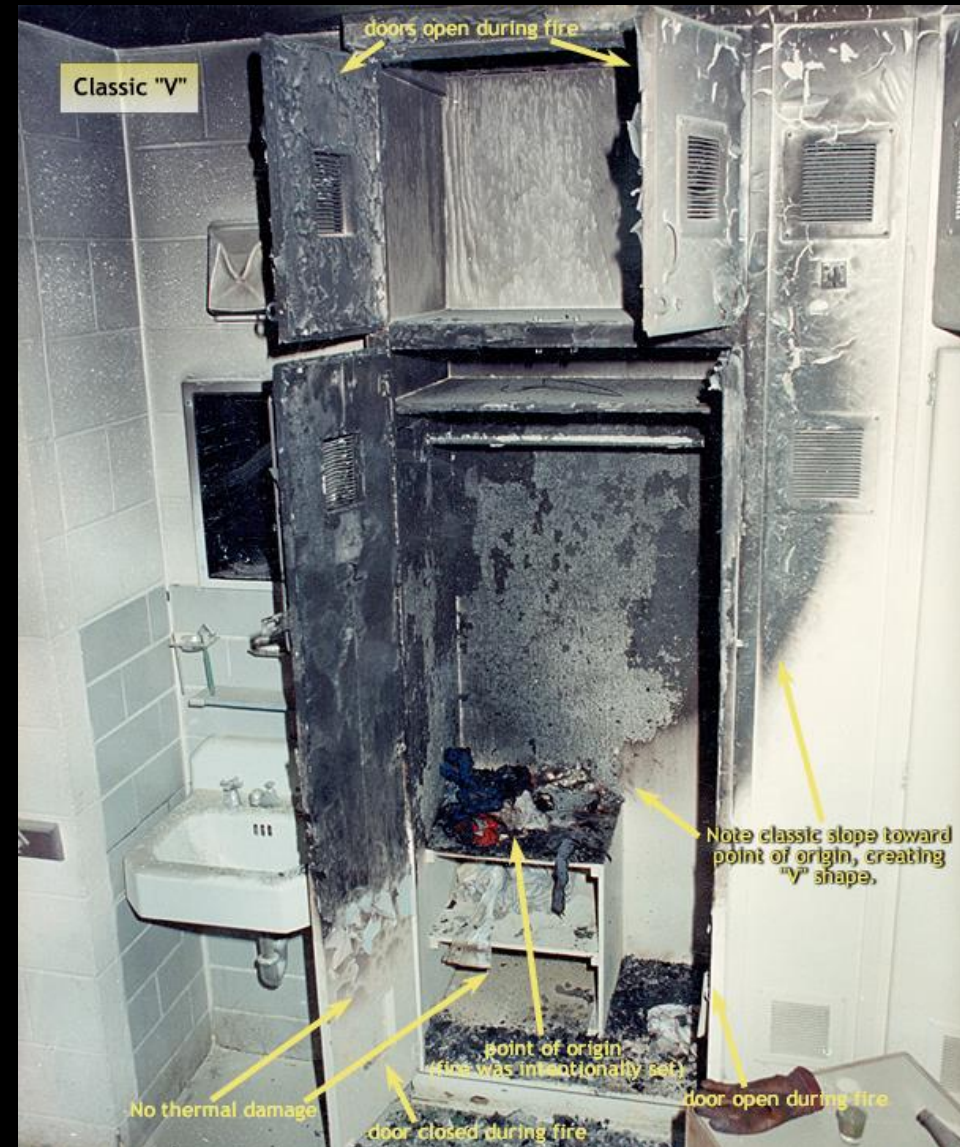
**FIGURE 7.8C** ♦ Extension above suspended ceiling very rapid. Light fixture diffuser softens and falls out. *Courtesy of Jamie Novak, Novak Investigations.*

Smoke  
Layer



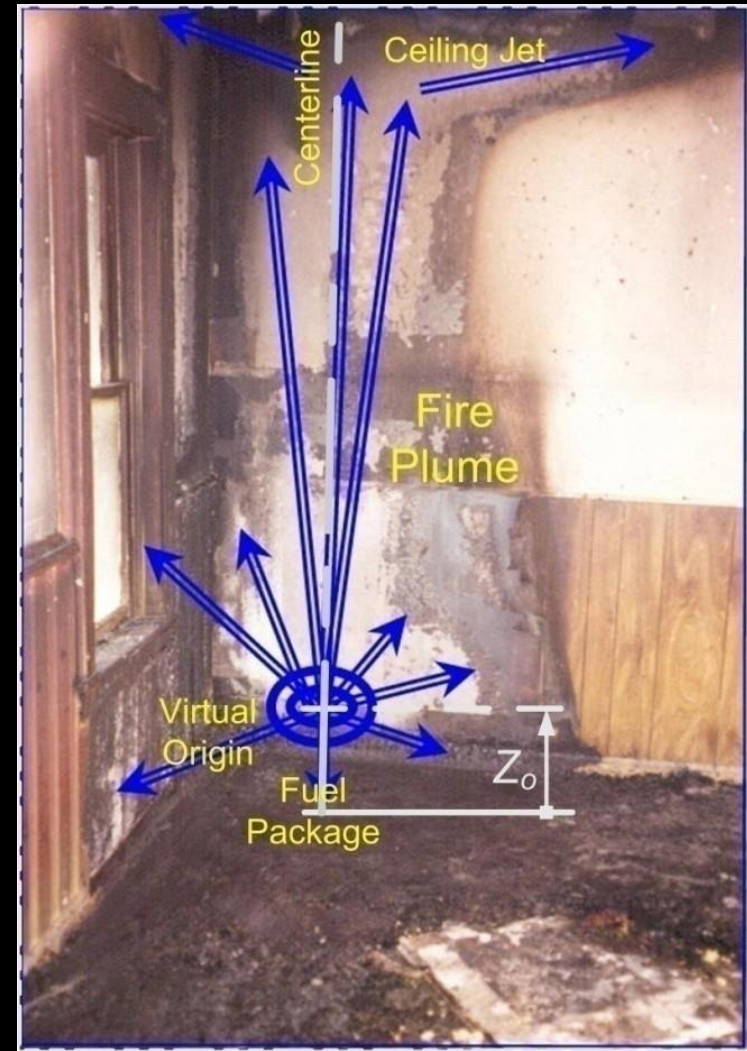
# V - Patterns on Surfaces

- ▶ This pattern is created by flames, convective or radiated heat from hot fire gases and smoke within the fire plume.
- ▶ V pattern – often appears as line of demarcation (2.1) defining the borders of the fire plume and less heated areas outside the plume. (figure)



# Fire Intensity versus Duration

- ▶ Intensity/Duration—The total fire damage to an object observed after a fire is the result of both the intensity of the heat applied to that object and the duration of that exposure.
- ▶ Time-Varying Conditions—Both the intensity and exposure of that heat may vary considerably during the fire.





# Example

## FIRE PATTERN ANALYSIS

### *DEMARCATIONS*

- 1. V-pattern
- 2. Calcination

### *SURFACE EFFECTS*

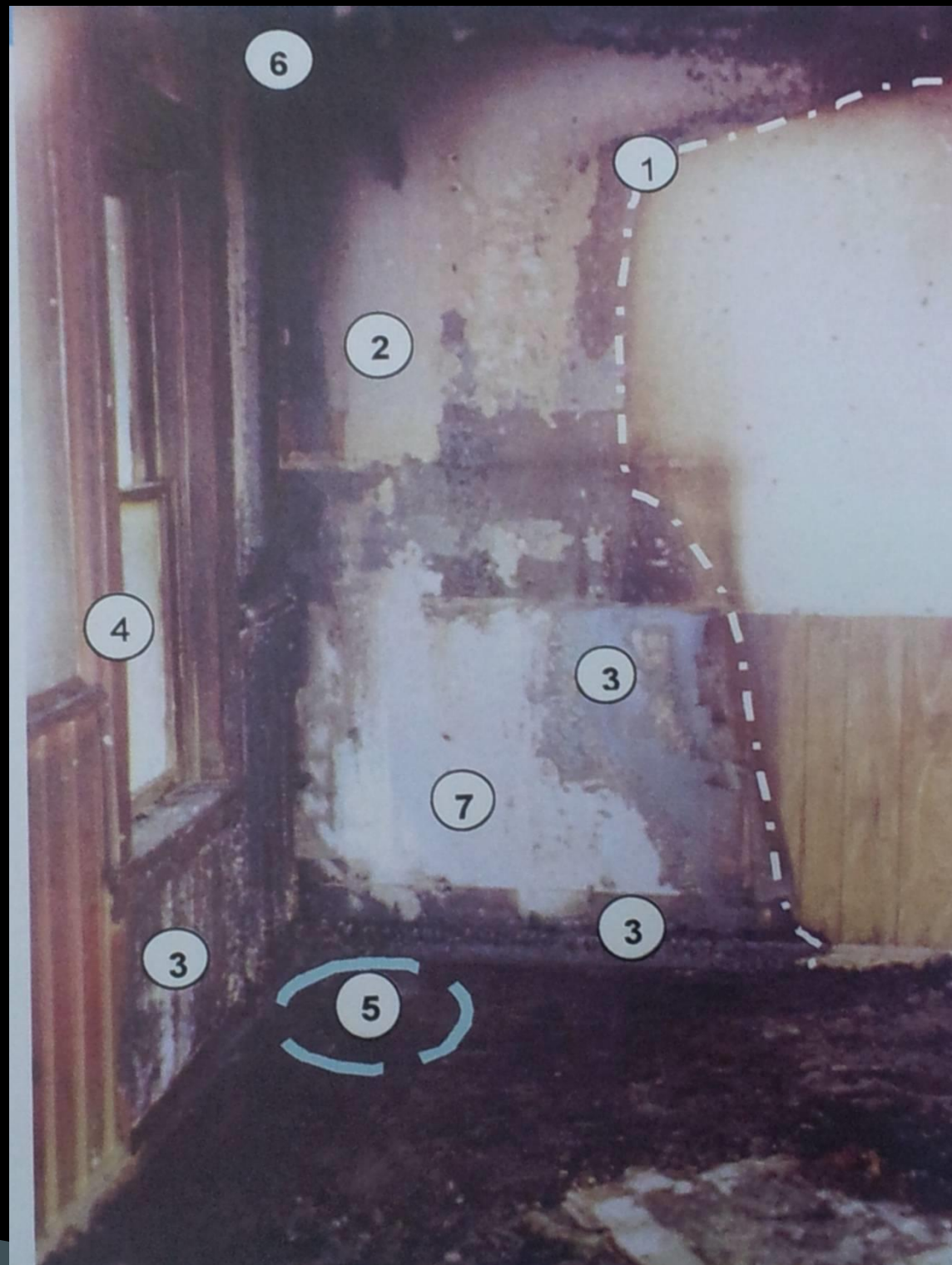
- 3. Charring
- 4. Cracked glass
- 5. Flammable liquid burn pattern

### *PENETRATIONS*

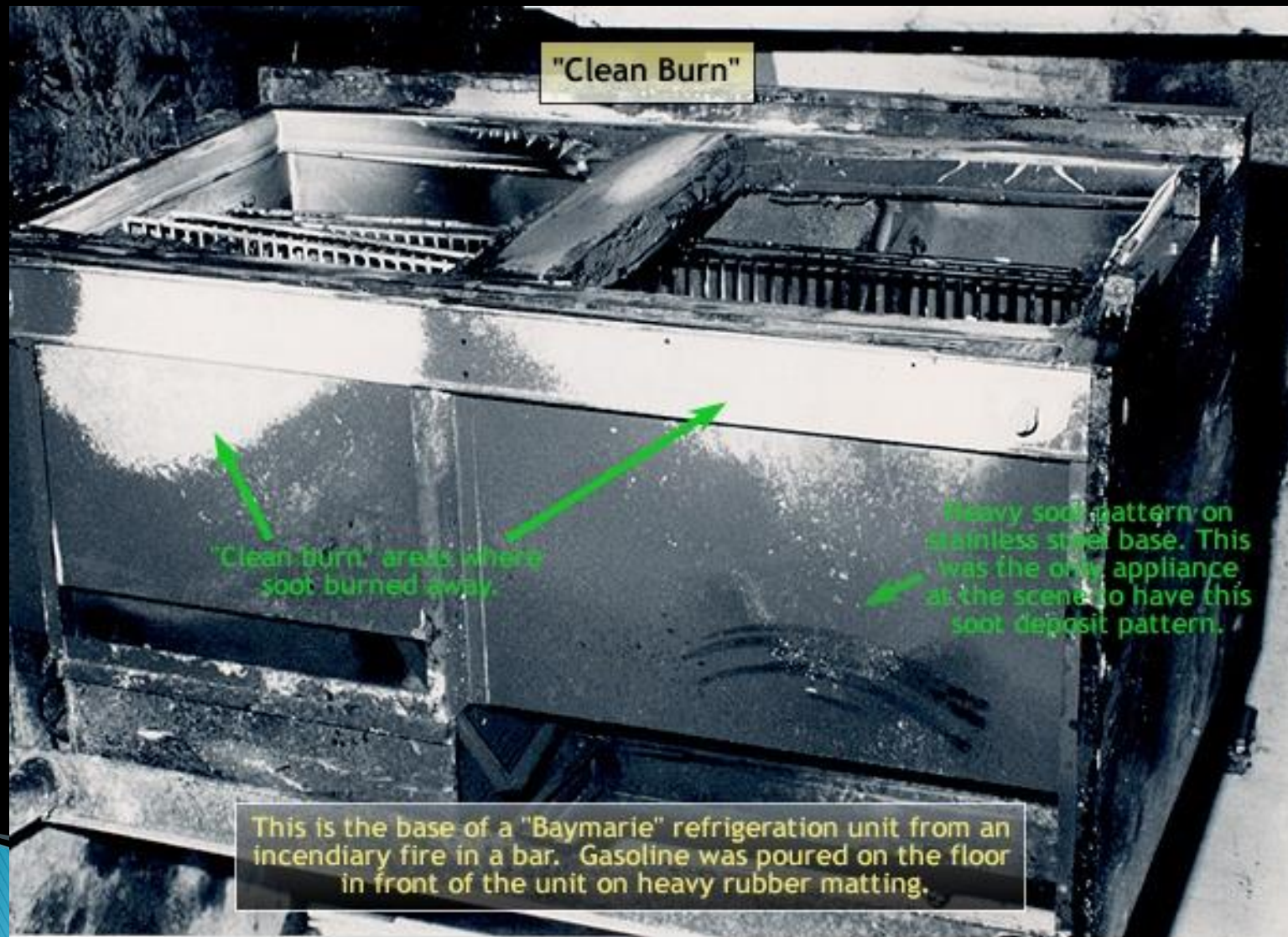
- 6. Damage to ceiling

### *LOSS OF MATERIAL*

- 7. Combustible surface



# Examples of Fire Patterns: “Clean Burn”







**FIGURE 4.13B** ♦ Plume damage (clean burn) on the back of the stove from the same gas plume. (The stove had been moved away from the wall prior to fire.) *Courtesy of Det. Richard Edwards, Los Angeles County Sheriff's Department, Whittier, CA.*



# Spalling





# Oxidation





# Thermal Expansion and Deformation of Material





# Thermal Expansion and Deformation of Material





# Break Glass





## Break Glass





## Collapse Furniture Spring









# Pointer & Arrow Pattern





# Char



**Gambar 7 :** Kesan *char* yang terhasil di bahagian dalam dan bahagian luar bingkai pintu Bilik No.1.

Tanda	Bacaan kedalaman <i>char</i> di bahagian luar (mm)	Bacaan kedalaman <i>char</i> di bahagian dalam (mm)
Tanda A	0.2	0.3
Tanda B	0.1	0.3
Tanda C	0.0	0.2

**Jadual 2:** Bacaan kedalaman *char* di bahagian dalam dan di bahagian luar bingkai pintu.



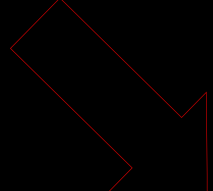


# Mass Loss of Materials





# Melting of Materials





## Trailer( Liquid Trail)





## 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

- Source of heat energy (Competent heat source)

## 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 / Lighters
2	Torches / Candles
Secondary Sources	
3	Hot object / Hot Surfaces / Welding
4	Friction / Impact
5	Chemical Reaction
The Role of Service & Appliances in Starting Fires	
6	Gas Appliances
7	a) Arcs b) Short Circuit / Spark c) Overload / Overcurrent/ Overvoltage d) Resistance Heating
8	Glowing Fire (smoking, mosquito coil etc)

Primary Ignitors	
9	Firecrackers
10	Lightning
11	Spontaneous Combustion / Self Heating
12	Explosions
13	Others



# Source of Ignition



## Primary Ignitors

- |   |                 |
|---|-----------------|
| 1 | Matches/Lighter |
| 2 | Torches/Candles |

## Secondary Sources

- |   |                                 |
|---|---------------------------------|
| 3 | Hot Object/Hot Surfaces/Welding |
| 4 | Friction/Impact                 |
| 5 | Chemical Reaction               |

## The Role of Service & Appliances in Starting Fires

- |   |   |
|---|---|
| 6 | Gas Appliances  |
| 7 | Electrical<br>a) Arcs<br>b) Short Circuit/Spark<br>c) Overload/Overcurrent<br>d) Resistance Heating |
| 8 | Glowing fire (smoking, mosquito coil etc)   |

## Others

- |    |                                      |
|----|--------------------------------------|
| 9  | Firecrackers                         |
| 10 | Lightning                            |
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| 12 | Explosions                           |
| 13 | Others                               |



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## 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

Intentionally ignited under circumstances in which the person knows that the fire should not be ignited

## Natural

Natural fire causes involve fires without direct human intervention or action, such as fires resulting from lightning.



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Vehicle	2,834	3,387	3,242
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# Cause of Fire for Structure Fire

Source: Fire Investigation Div. FRDM



No	Cause of Fire	2018		2019		2020	
		Qty	%	Qty	%	Qty	%
1	Natural	52	0.8	77	1	55	0.8
2	Accidental	6,301	95.1	7,046	95.3	6,615	95.7
3	Incendiary	267	4.0	268	3.6	240	3.5
4	Undetermined	6	0.1	2	0.1	0	0
	<b>TOTAL</b>	<b>6,626</b>		<b>7,393</b>		<b>6,910</b>	



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# Source of Ignition for Structure Fire

Source: Fire Investigation Div. FRDM



NO	SOURCE OF IGNITION	2018		2019		2020	
		Qty	%	Qty	%	Qty	%
1	Lightning	40	0.6	70	0.9	43	0.6
2	Spontaneous Combustion – self heating	12	0.2	7	0.1	12	0.2
3	Electrical	<b>3,893</b>	<b>58.7</b>	<b>4,334</b>	<b>58.62</b>	<b>4,256</b>	<b>61.6</b>
4	Lighter	538	8.1	586	7.9	494	7.1
5	Gas Equipment	1,189	17.9	1,388	18.8	1,225	17.7
6	Firework/firecracker	18	0.3	16	0.2	8	0.1
7	Friction	42	0.6	41	0.6	43	0.6
8	Open Flame (Pelita/Lilin/Obor)	169	2.6	206	2.8	167	2.4
9	Glowing fire	464	7.0	524	7.1	441	6.4
10	Explosion	8	0.1	12	0.2	13	0.2
11	Chemical Reaction	13	0.2	9	0.1	8	0.1
12	Hot Surface	217	3.3	174	2.4	189	2.7
13	Others	17	0.3	24	0.3	11	0.2
14	Undetermined	6	0.1	2	0.03	0	0
	<b>TOTAL</b>	<b>6,626</b>		<b>7,393</b>		<b>6,910</b>	<b>55</b>

*Thank You*