Case Studies Revisited

by Tan Boon Kee

- I have singled out 3 cases for deliberation, we will view them from a wider perspective.

- We will put aside the specifics and consider the outlines as: “A general review of the Past Events”.

- At the same time we will take the opportunity to refresh some basic electrical engineering principles that the governing safety rules built on.

- Not paying adequate attention to safety rules due to one’s negligence and rash act is serious damage to properties, grievous hurt and loss of lives.

- We will not only highlight the obvious mistakes committed and identify the dos and don’ts, but also explore jointly to find even better ways to prevent these incidents/accidents from recurring.

- On the other hand we will also ask ourselves whether these incidents were done intentionally or unintentionally. If it is unintentionally can the accidents be prevented by more training, technical exchanges and dialogue sessions of sharing work experience. Work experience is important as we are aware that for every fatal accident there many near miss, the ratio may be as high as 1 to 100 or more, a figure I came across some years back.

- No matter whichever way we view the happenings of an accident the point to remember is that Electricity & Fire have no respect for human lives and properties, especially when the installations are not properly designed, installed and handled with care.

Case Study # 1

- The following are some of the selected slides that were collected from an investigation of a “Fire Site”

- Before we go into the details, let us refresh our understanding of the intertwine relationship between Electricity & Fire that can bring benefits but also destruction to men.

Fire & Electricity

Their Beneficiary & Destructive Natures

- When Fire was first discovered it immediately becomes the vital force of primitive men in their fight for survival;
- Electricity on the other hand frees them from laborious task, and brings them comfort & convenience, so much so that we cannot do without both of them.
- A point of interest for us to note is that the efforts contributed by electrical engineers to maintain a quality and reliable supply were not adequately rewarded.

- The consequence of not providing a safe supply is dangerous. A certified fit installation can also turn deadly if it is not properly operated, used and periodically maintained & upgraded.
- Many a time we come across reports of fire out break at odd hours of the night. The uncontrolled fire is said to be of electrical origin.
- Is this possible? To answer the question, let us look at the combustion mechanism of fire by considering a domestic scenario where there is a simple final sub-circuit fitted with a 16 amps MCB supplying a 3.0 kW storage water heater.

- To quantify the relationship between fire and electricity, we will consider a line-earth loop impedance of 1.0 ohm. Over time let us assume this line-loop impedance value deteriorated to 6.0 ohms.

- Under normal circumstances, the situation is safe for use, however it does pose a potential danger to fire & electric shock.

- Danger would arise when the said circuit supplying the 3.0 kW water heater developed a 40 ohms high resistance fault to earth.

- Such partial insulation failures do occur where nailing of walls for multi-purposes is common which is just example.

- Consequently we will have an earth fault current of : 230/(6+40) = 5.0 amps in the premises.
- Immediately we all know that the earth potential of the premises would rise and any one in direct contact will experience electric shock. The question is: do we realise the possibility of a fire outbreak?
- The solution to the above problem is obvious and that also explain the reasons why we insist the installation of elcbs in all premises receiving electricity supply.

- Following the solution to the above mentioned problem with the installation of 30 mA elcb,

- The next question that we are likely to ask is how frequent do Singaporeans check the working & accuracy of these safety devices on a monthly or annual basis?

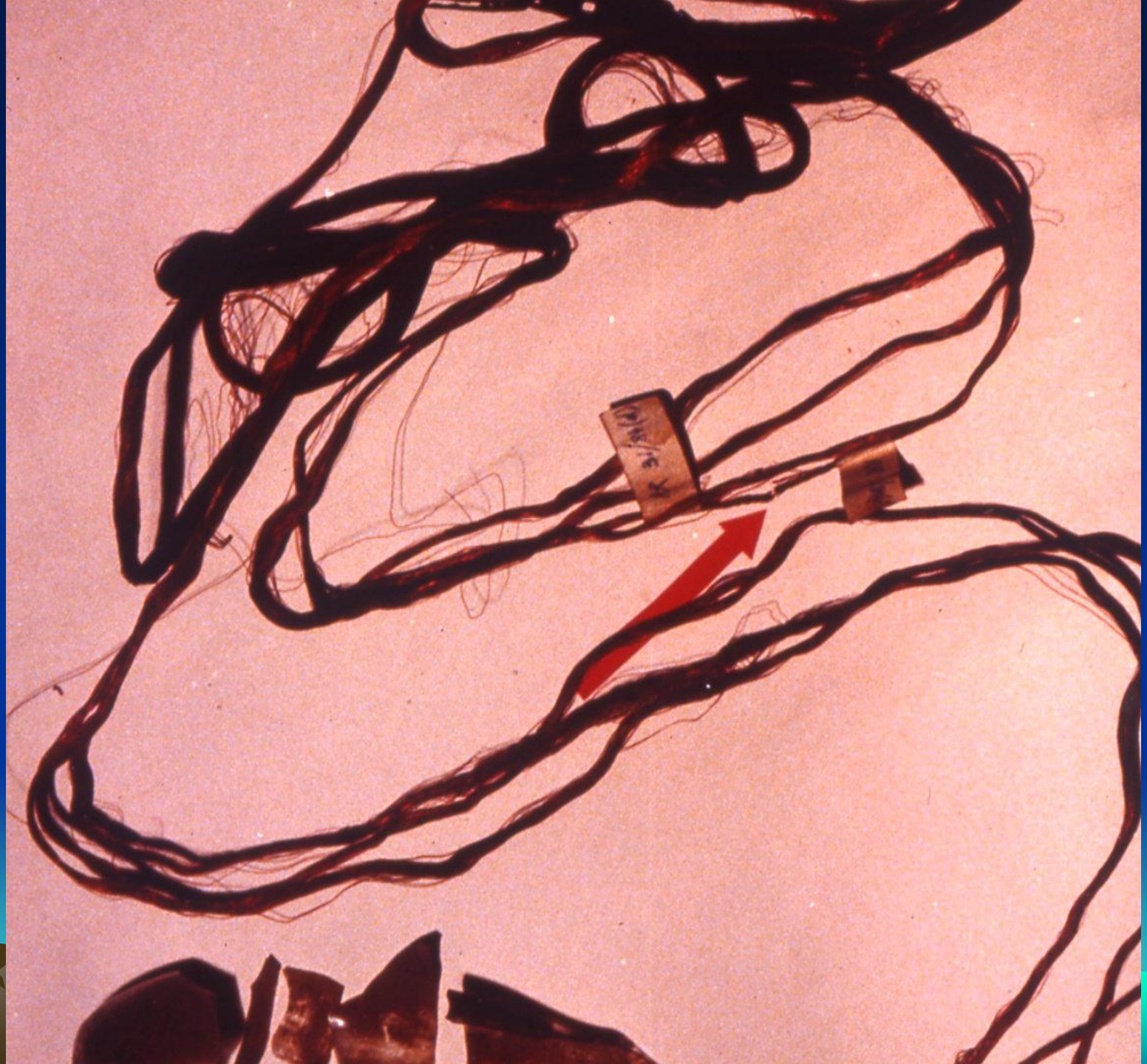
- If not, the affected premises would be in danger of an outbreak of a fire in addition to a cause of electric shock.

- When the 5.0 amps earth fault current is not detected by faulty elcb and the 16 amps MCB, the result is a down pour of 1000 watts of energy to earth at the point of partial insulation failure. Mathematically it is the simple Ohm's Law:

$$I^2R = 25 \times 40 = 1000 \text{ watts}$$

- The result is the generation of Heat at the point of insulation failure. An energy of such magnitude concentrated at a specific point where easily combustible materials are in close proximity. It is a matter of time for a fire to start.

- My experience tell me that it can be a prime cause of unintentional/intentional fire outbreak which brings me to share with you the first Case Study I recalled to talk about.
- The next is a series of slides collected from a “Fire Site” We will study together and draw our own conclusions and steps to prevent similar happenings.
- We will now examine & evaluate the material evidence that were gathered at the fire site.

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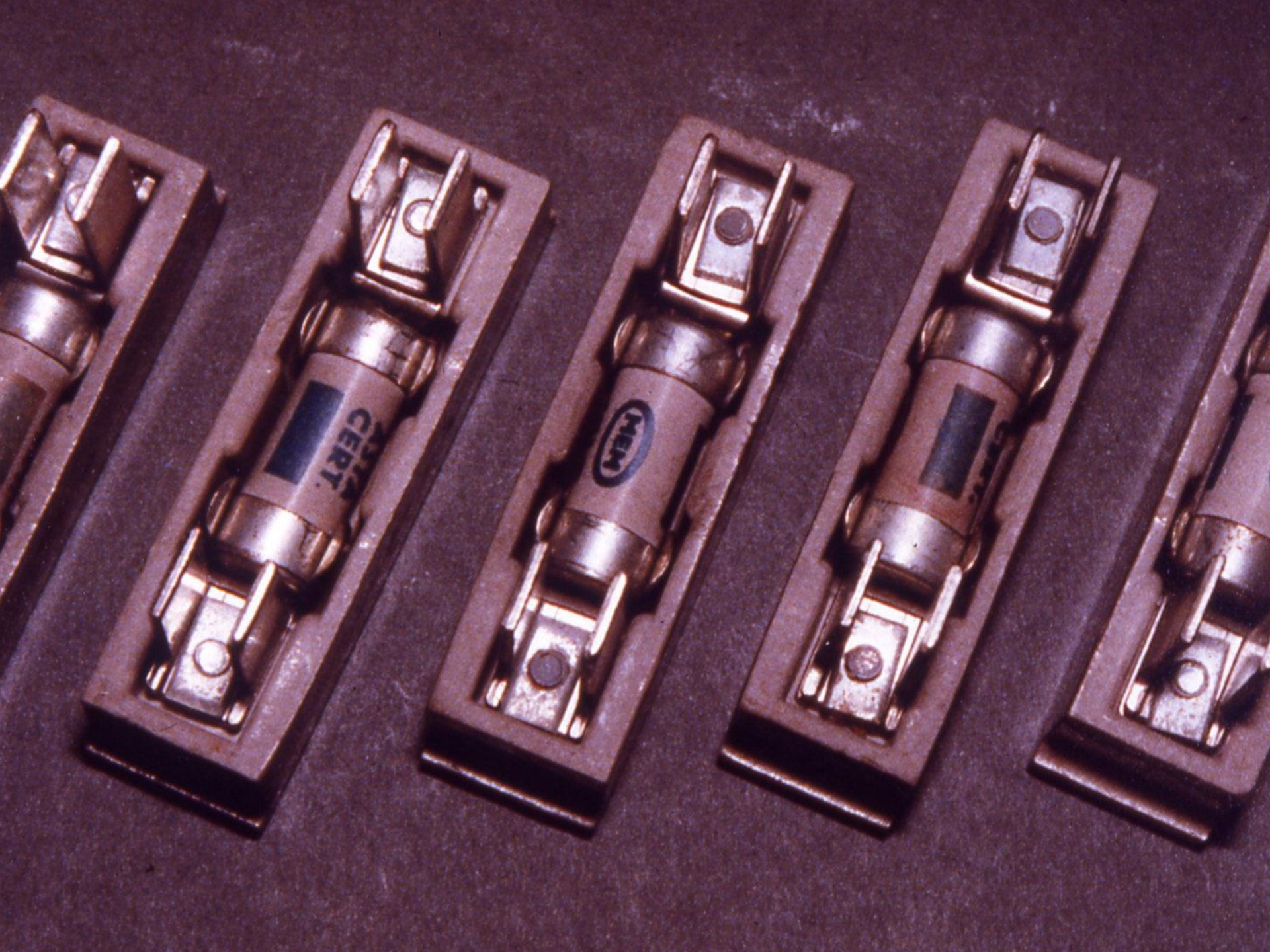
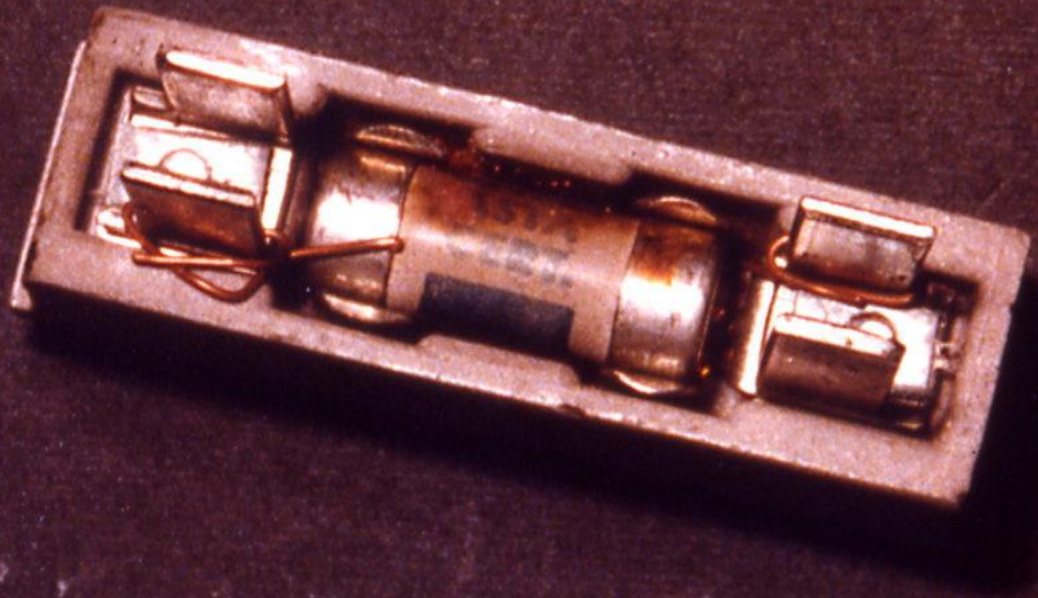
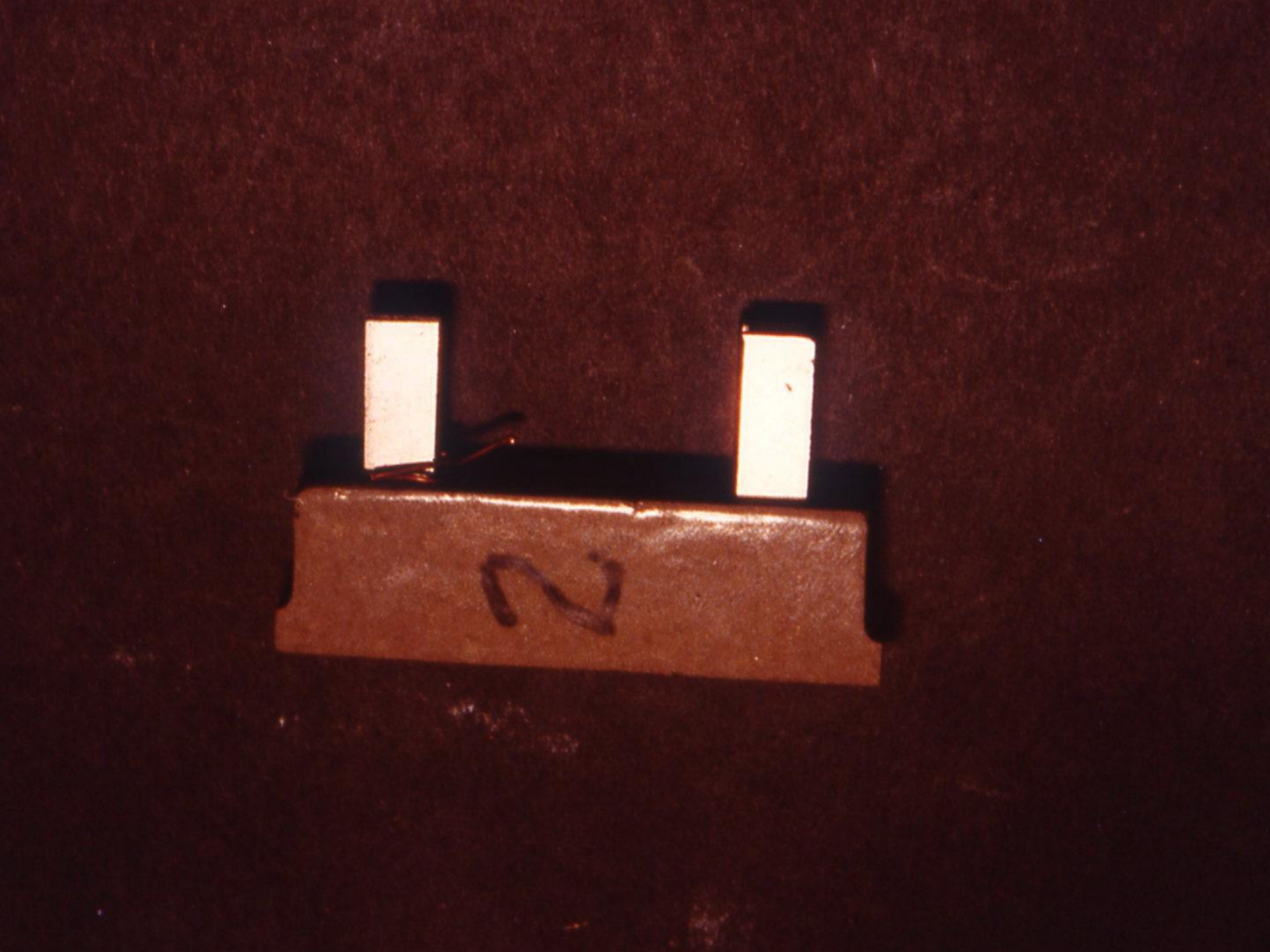






- Before I close this case may I say that for a fire to start without aid, 4 causing factors must be present simultaneously. For this to happen the probability is not high. The 4 causes are:
- (i) deterioration of line earth loop impedance ≥ 6.0 ohms;
- (ii) a partial insulation failure of supply circuit with a high impedance earth fault of ≥ 40 ohms;
- (iii) a mal-function elcb and a 13/16 amp MCB;
- (iv) presence of easily combustible materials at the point of insulation failure.

- To follow up with the suspicion of arson a simulation tests were conducted to verify the effect of thermal energy of an equivalent rating lighted electric bulb on combustible materials.

- The following slide shows the Laboratory Test Results recorded from a 300 watts electric lamp as that fragmented lamp bulb found on site.

- The temperature recorded on the envelope of the 300 amp electric bulb were as follows:

Location of Thermocouple	Recorded Temp.
Ambient	25ºC
Screw cap of lamp holder	183.9ºC
Base of lamp bulb	164.5ºC
Circumferential surface of bulb	153.2ºC

- Evidently all the temperature measured on and around the 300 watts electric bulb is significantly higher compared with the ignition temperature of fabrics, nylons, papers, plastic bags etc

- All these materials have an ignition temperature as low as 75ºC.

- The end results based on the collection of all these electrical accessories found at the fire site is apparently obvious without further elaboration.

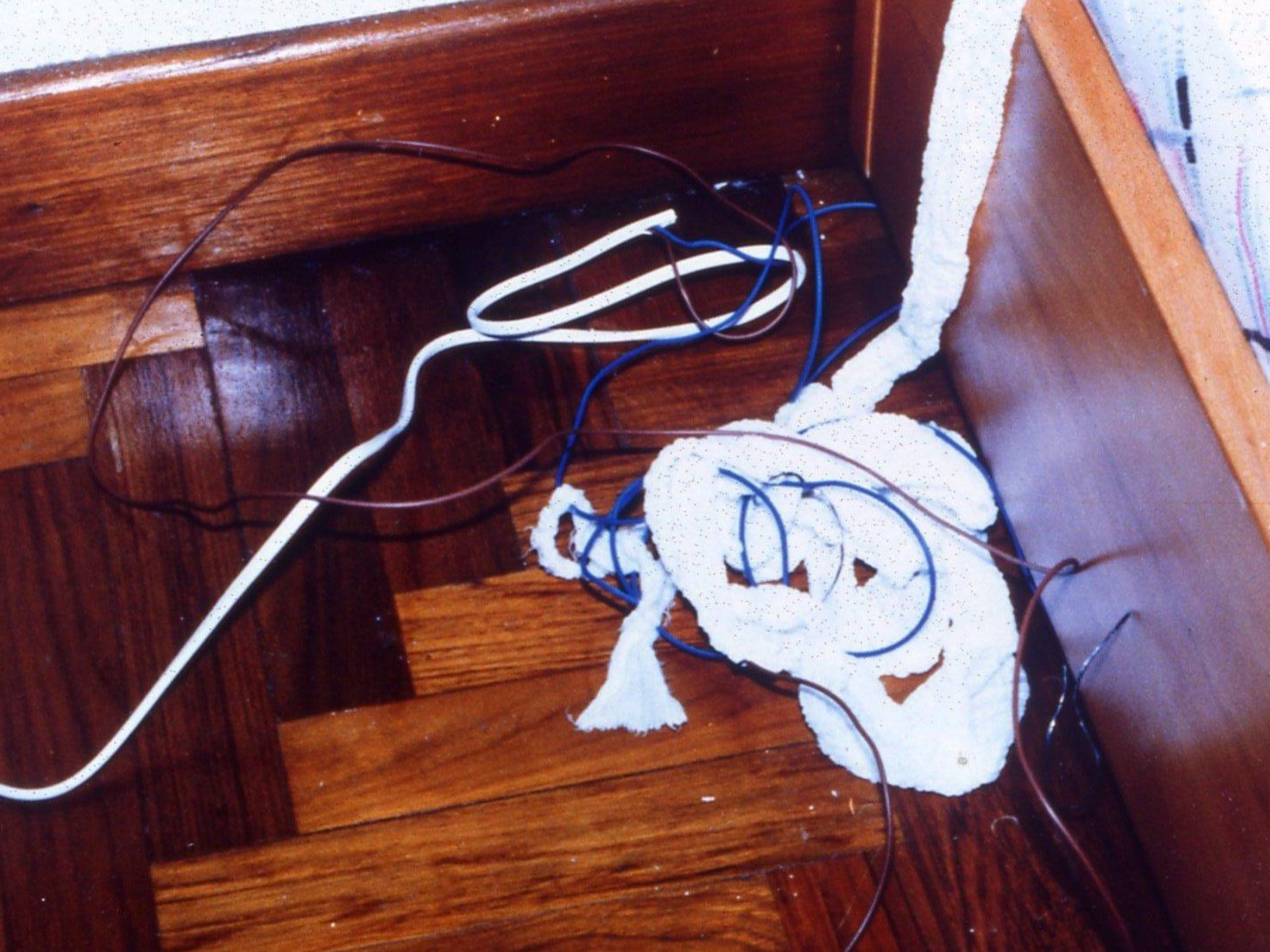
Case Study # 2

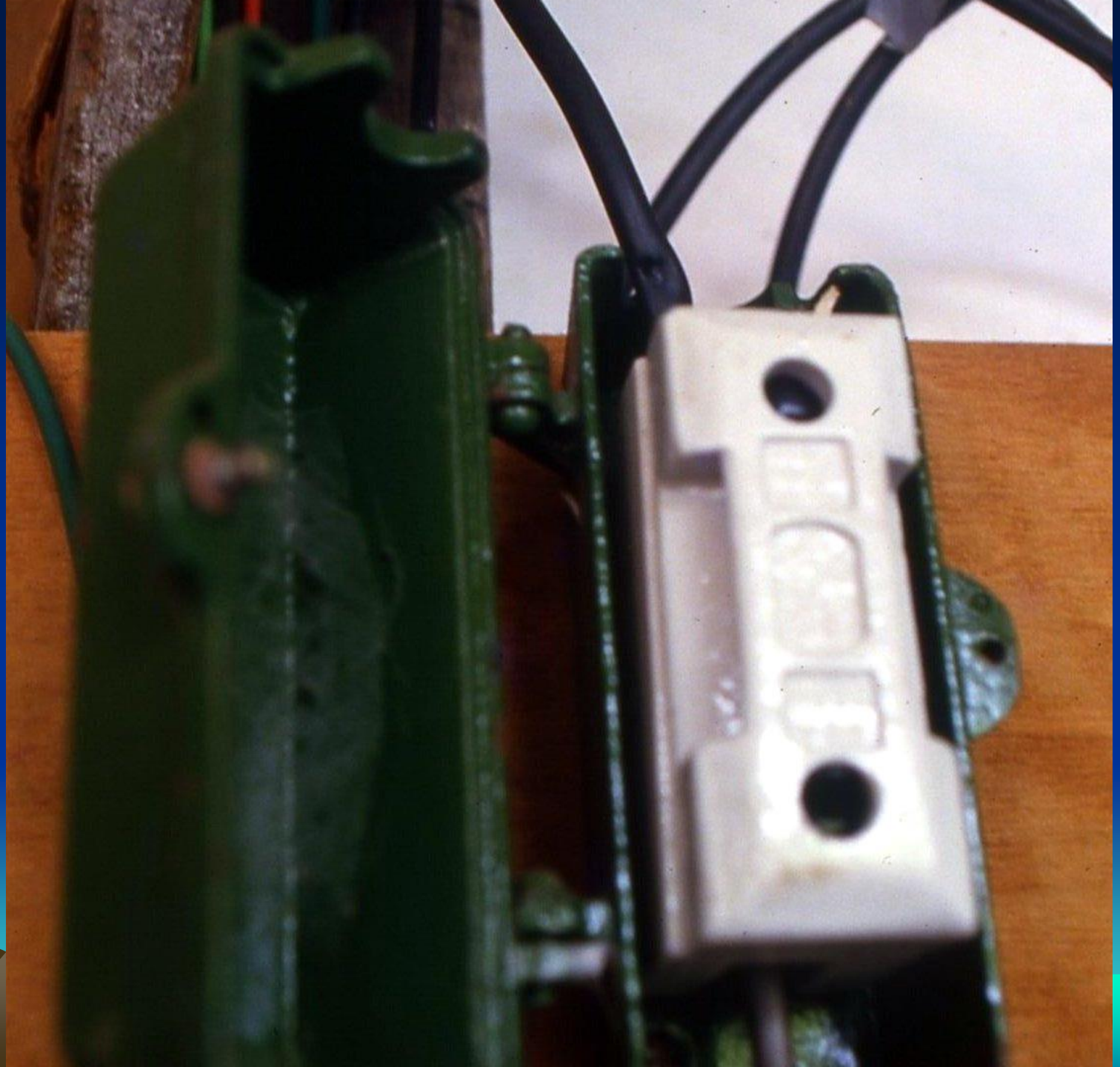
- Before I present the slides I would like to share with you all some of the medical findings of the “Effects of Current & Voltages on Human Body” published by IEC.

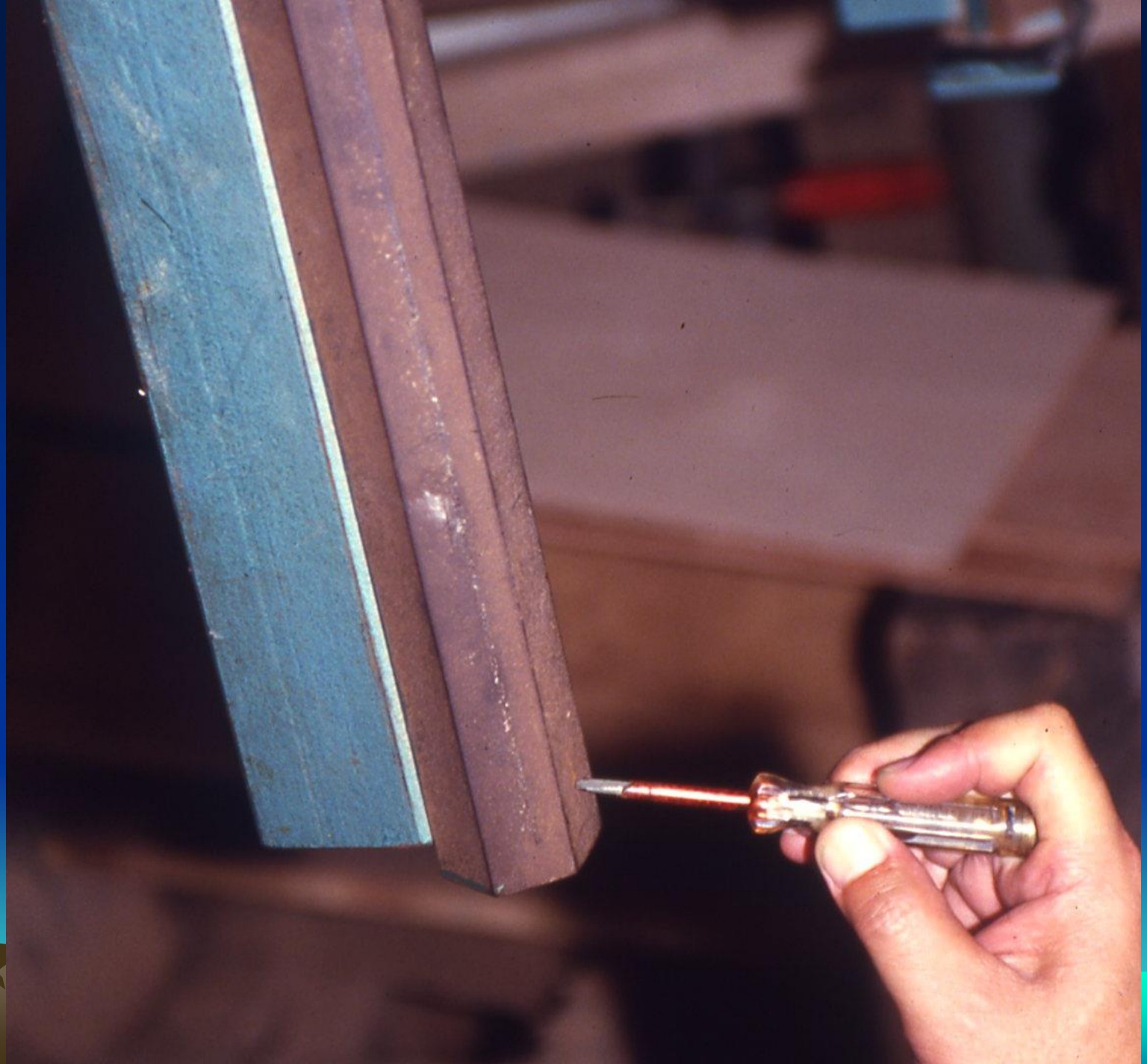
- The importance point to remember is that the safe touch voltage duration for AC 50 volts is the same as DC 120 volts under normal dry condition.

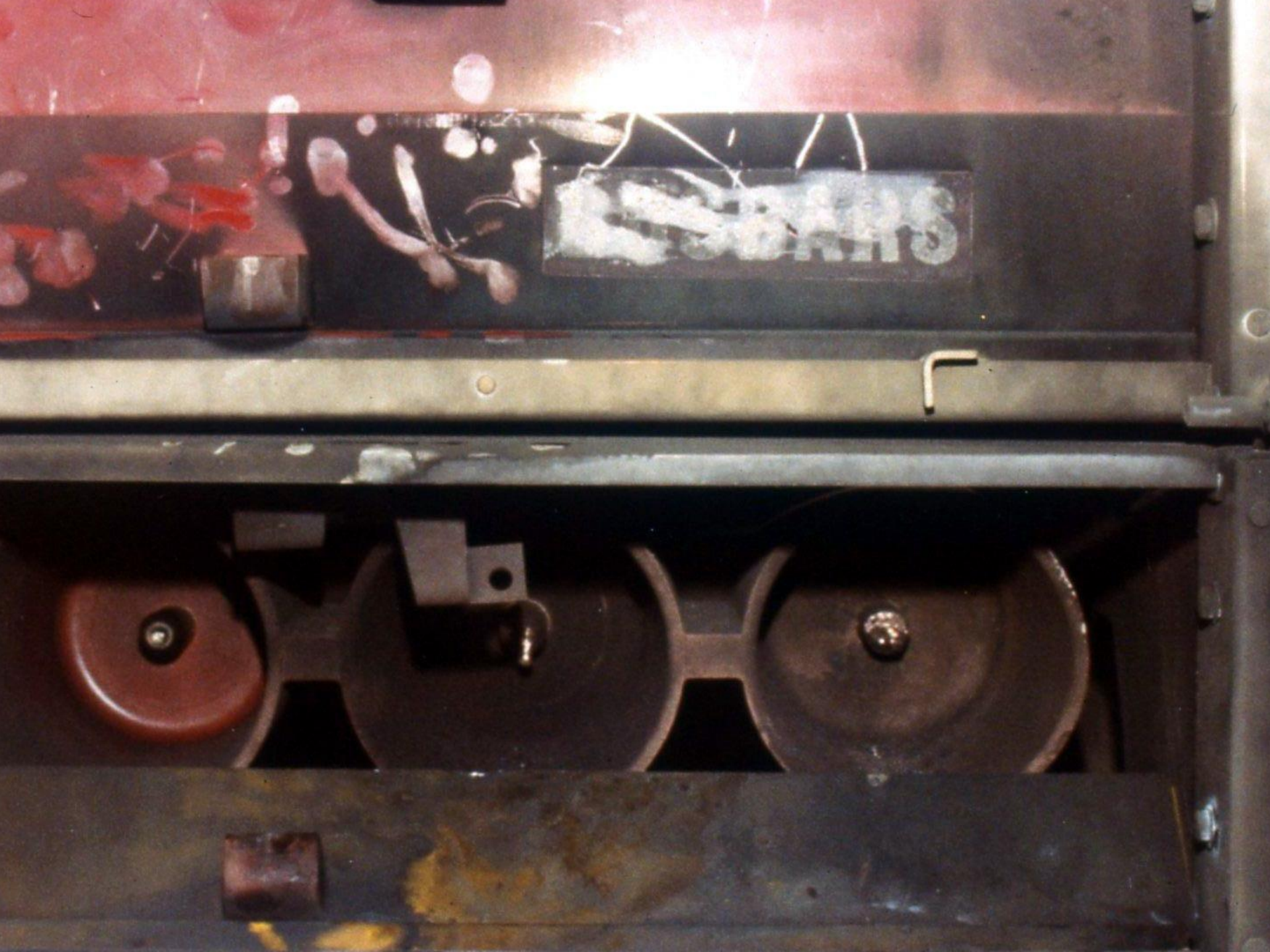
Current (mA)		Hand to Hand
0.9 to 1.2		First sensation of current felt
1.2 to 1.6		Tickling sensation as ants clawing
1.6 to 2.2		Sensation of numbness to the hand
2.2 to 2.8		Similar sensation noticeable up to the wrist
2.8 to 5.0		First of cramp & stiffening of the hand
5.0 to 7.0		Slight cramp in upper arm with unpleasant feeling
7.5		Let go of hand still possible
10 to 15		Cramp reaching limit of “Let-go”
15 to 20		Release of hand not possible
25 to 30		Severe cramp extend to thoracic region. Limit of save current

Current (mA)		Hand to Hand
30 to 40		Serious& severe contraction of muscles, pain and breathing stops. The feeling will cease if flow current is interrupted
50 to 60		Function of respiratory system is impaired followed by loss of consciousness
60 to 100		Ventricular fibrillation causing erratic pumping of the heart, and death will soon occur.
100 to 200		Serious burns & muscular contraction of such degree that the function of the hear is inhibited. RIP.









Case Study # 3

- The following are some of the selected slides that were collected from the investigation of a case where “Maintenance & CT Upgrading” was in progress.

- This case is worthy of your attention and deep reflection. I shall present the slides in 3 stages:

- First, the scenario at the ground floor where the electrocution took place;
- Second, the scenario at the 5th floor where the electrical switching took place; and
- Third, the scenario at the 7th floor where the electrical joints were made.