Electrical Accident Investigations Case Studies

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ENERGY MARKET AUTHORITY

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- What is electrical work?
- Case Study 1, 2, 3 & 4
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What is electrical work?

- In Singapore, all electrical works have to be carried out by licensed electrical workers as stipulated in the Electricity Act (Cap. 89A).
- In short, any work performed on a fixed wiring installation.
- Does not include manufacturing of switchgears, switchboards etc.
- Does not include the oiling, greasing, cleaning or painting of any electrical installation.

Case Study 1

- The electrical accident occurred in year 2002 at a building which was about to be completed.
- The deceased received a fatal electric shock while in the process of terminating cables to a ceiling rose.

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Background

- Prior to the accident, the deceased and his co-worker were assigned to shift the location of ceiling rose at some pillar columns (See Appendix I).
- Accordingly to the co-worker, they started work on column C2309. The cables in the conduit were removed from the terminals of the ceiling rose and were taped with PVC insulation tape before they stopped work for dinner.

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Background

- After dinner, the deceased proceed to terminate the cables into the ceiling rose at column C2309 while the co-worker proceed to start work at another column
- The deceased was supposed to join his co-worker after completion of the work at column C2309.
- After some time, the co-worker went back to column C2309 to look for the deceased. The co-worker saw the deceased sitting motionless on the steel frame (see Appendix II).

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Observations

- The pillar column C2309 was surrounded by steel brackets and covered with stone cladding (see Appendix III). The working area was confined and humid.
- 2 sets of 3 cables were identified. The cables were housed in a length of PVC flexible conduit. The PVC flexible conduit was terminated into the ceiling rose base and these cables were drawn beyond this ceiling rose ready to be cut, fitted and terminated.

Observations

- The first set of 3 cables was traced to be one of the circuits of DIM L1/CHI-GUTTER.
- The insulation of the black cable was found stripped at the end exposing 15mm of bare conductor. A pair of shears was jammed with a blue cable in-between the cutting blades and was found hanging.
- This pair of shears belonged to the deceased. (see Appendix IV)

Investigation & Findings

- It was established that the source of supply for the circuit was controlled by a 20A SPN MCB installed in the dimmer rack DIM L1/CHI-GUTTER which was connected via an 63A TPN isolator to a TPN 63A MCB. There was no RCCB protection for this circuit. (see Appendix V).
- According to the statement of a witness, the MCB and isolator was at "ON" position when the accident happened.

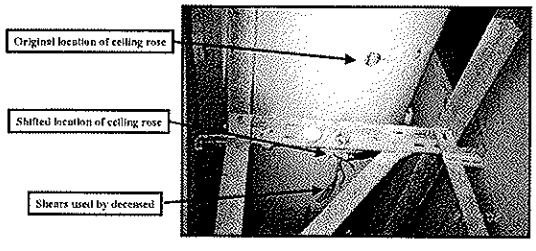
Conclusion

• Base on the above findings, it can be deduced that the blue cable was energised at the time of the accident.

• The deceased could have received a fatal electric shock which was transmitted through the shears that he was holding when he cut into the blue cable insulation.

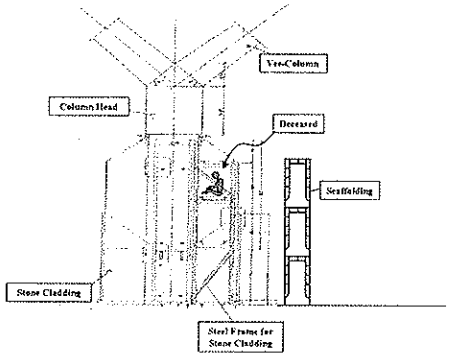
What should be done to avoid danger at this work site?

- This accident could have been prevented if the source of supply from the 63A TPN isolator was "Turned-Off", locked and tagged out when work was being carried out.
- The worker should verify the presence of voltage before commencement of work.

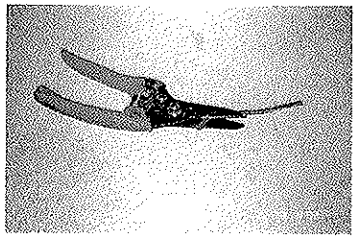


Appendix I - Inside view of the pillar column (C2309)

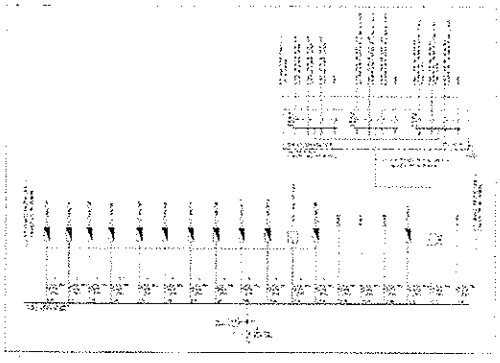
Appendix II - Co-worker demonstration the position of the deceased



Appendix III - Steel frame detail for stone cladding



Appendix IV - Shears used by the deceased



Appendix V - Single line drawing of the Dimmer Rack

Case Study 2

- The electrical accident occurred in year 2004 at a factory which was about to be demolished.
- The deceased received a fatal electric shock while in the process of disconnecting the power supply for a fluorescent lighting fitting installed in a aluminium container office.

Background

- Prior to the accident, the deceased and a few co-workers were assigned to pack and shift out the equipment from the factory's workshop in the morning and intended to shift out the aluminium container after lunch for shifting to a new factory.
- Accordingly to one of the co-worker, he saw the deceased squeezed through the small gap behind the aluminium container, to disconnect the incoming power supply of the fluorescent lighting fitting to the aluminium container while the co-worker continued to pack the equipment.

Background

- A few minutes later, the co-worker went behind the aluminium container to look for the deceased and found the deceased was lying motionless on the ground.
- The co-worker tried to reach the deceased, his hand accidentally touched the aluminium container and felt numbness. He suspected that it might be an electric shock and asked one of the workers to switch off the power supply to the 13-Amp two-gang socket-outlet at the distribution board (DB).

Observations

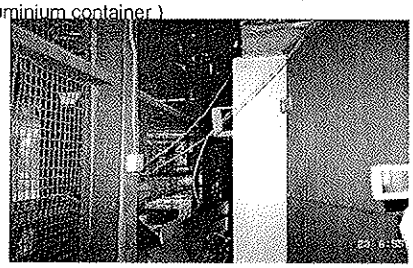
- The electricity supply to the 13-Amp two-gang socket-outlet was fed from a nearby distribution board, protected by a 20-Amp re-wireable fuse and controlled by a 60-Amp triple-pole neutral isolator.
- The electricity supply to the fluorescent lighting fitting was taken from the 13-Amp two-gang socket-outlet via two numbers of 1.5 sq mm PVC cables (blue and grey) connected to a 13-Amp plug.

Observations

- The connection of the blue PVC cable was found still intact in the 13-Amp two-gang socket-outlet. The insulation of the blue PVC cable was found damaged about 50 mm from the 13-Amp two-gang socket-outlet. About 10 mm of exposed copper conductor could be seen at the point of damage.
- The grey PVC cable was found disconnected from the 13-Amp two-gang socket-outlet.

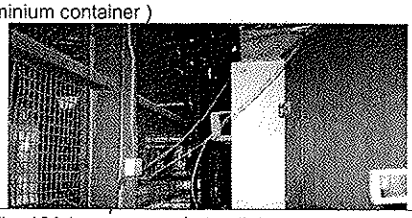
Observations

View of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



Observations

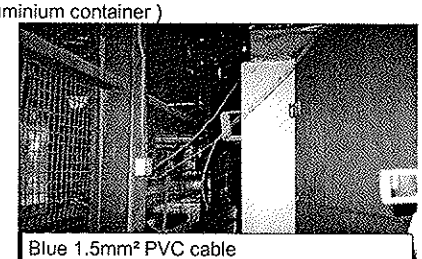
View of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



The 13A two-gang socket outlet
- Electricity supply was taken from nearby DB
- Protected by a 20A re-wireable fuse
- Controlled by a 60A TPN isolator

Observations

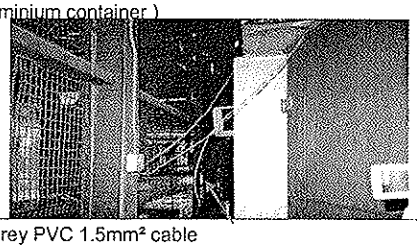
View of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



Blue 1.5mm² PVC cable
- Connected to a fluorescent light fitting inside the aluminium container

Observations

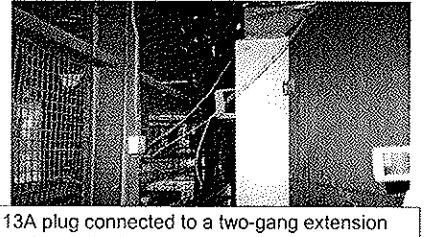
View of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



Grey PVC 1.5mm² cable
- Connected to a fluorescent light fitting inside the aluminium container

Observations

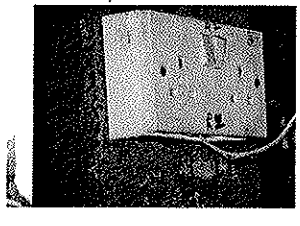
View of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



13A plug connected to a two-gang extension socket-outlet inside the aluminium container (with 4m cable)

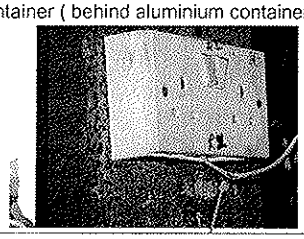
Observations

Close up look of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



Observations

Close up look of the 13A two-gang socket-outlet that supply electricity to the aluminium container (behind aluminium container)



The insulation of the blue PVC cable was found damaged . About 10mm of exposed copper conductor could be seen at the point of damage.

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Investigation & Findings

- Voltage readings of 230V was measured between exposed conductor (blue PVC cable) and the earth of the 13-Amp two-gang socket-outlet.
- Voltage readings of 230V was measured between exposed conductor (blue PVC cable) and the metal structure where the deceased was working.
- Voltage readings of 230V was measured between the frame of aluminium container and the metal structure. The test results indicated that the aluminium container was not earthed. Consequently, although it was energised to 230V, there was no fault current to "blow" the 20-Amp fuse.

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Investigation & Findings

- Without altering the set up at the accident site, the electricity supply to the 13A two-gang socket outlet was switched on. A voltage measurement was conducted on the exposed conductor of the blue PVC cable with a volt meter and the readings were tabulated as follows:-

	Voltage reading (V)
Between exposed conductor (blue PVC cable) and the earth of the 13A two-gang socket outlet	230 V
Between exposed conductor (blue PVC cable) and the metal structure	230 V

- A test lamp was lighted up when tested between the metal structure and the exposed conductor of the blue PVC cable.
- The line-earth loop impedance at the 13A two-gang socket outlet was measured and found to be 0.68 ohms

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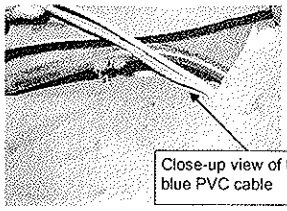
Investigation & Findings

- A voltage measurement was also conducted between the frame of the aluminium container and the metal structure. The voltage measured was 230 V.
- A close examination was carried out. Inside the aluminium container, the blue PVC cable was found to have a cut.



Close-up view of the cut on the blue PVC cable

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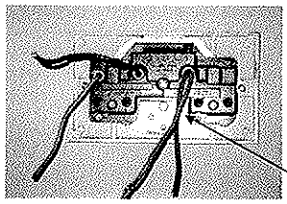
Investigation & Findings

- The cover of the 13A two-gang socket outlet was removed for close examination. The blue PVC cable was found connected to the terminal marked 'L' of the 13A two-gang socket outlet (which is ' Live')



Blue PVC cable connected to the terminal marked 'L' of the 13A two-gang socket outlet

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Conclusion

- The deceased could have used much force to pull out the grey PVC cable. He could also have attempted to similarly use force to pull out the blue PVC cable and he might have caused damage to its insulation thus exposing its copper conductor.

- At the same time, when the deceased was tugging the blue PVC cable, the deceased could have caused the cut on the blue PVC cable inside the aluminium container and caused the aluminium container to be energised to 230 V.

- The deceased could have received a fatal electric shock when his hand came into contact with the exposed conductor of the blue PVC cable or his back came into contact with the energised aluminium container.

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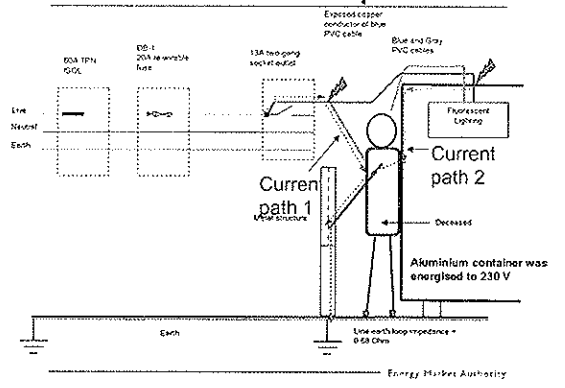
Electric current path



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What should be done to avoid danger at this work site?

- The contractor company should have cut off the electricity supply from the main switchboard before commencement of the dismantling work.
- Workers should refrain from touching any bare conductors or exposed metallic parts when handling electrical cables.

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Case Study 3

- The electrical accident occurred in year 1999 at a construction work site
- The deceased received a fatal electric shock while attempting to operate an electric stirrer to mix some cement for cement plastering work

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Observations

- Source of electricity supply was from a generator
- Equipment involved were an electric stirrer and associated accessories
- The supply installation was protected by a RCCB of 30mA tripping sensitivity and the electricity supply of the electric stirrer was taken from a wall mounted 13A SSO via a 13A ESO

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Investigation & Findings

- Insulation test was conducted at the DB and was found to be satisfactory.
- The incoming live and neutral cables to the DB were transposed at the junction box
- Continuity test revealed that the wall mounted 13A SSO has no earth continuity
- The live and neutral cables were transposed at 13A plug of the 13A ESO
- Polarity test on the 13A ESO revealed that the neutral and earth cable were transposed
- At the electric stirrer, the above mistakes resulted in the transposed in earth and neutral

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Investigation & Findings

- The voltage was measured at the DB:
  between phases – 397V
  between phase & neutral – 229V
  between phase & earth – 229V
  between neutral & earth – 0V

- The wall mounted 13A SSO was tested with a RCCB tester set at 30mA. The RCCB protecting the wall mounted 13A SSO did not trip

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Conclusion

- Based on the evidence gathered, the electric stirrer should not be working at the time
- The deceased could have inadvertently come into contact with the exposed strands of the live conductor at the joint and received a fatal electric shock
- Appropriate actions had been taken against the offender

What should be done to avoid danger at this work site?

- The main contractor should have engaged a licensed electrical worker (LEW) to take charge of the temporary supply installation
- The LEW would test and certify fitness before the supply installation is turned on
- The holder of supply installation licence should ensure that all electrical works are carried out under the direct supervision of his appointed LEW

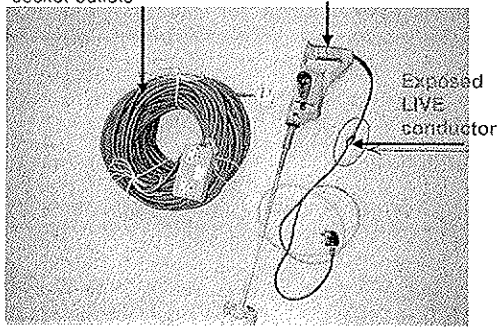
What should be done to avoid danger at this work site?

- Site safety officers, supervisor & worker should also play their roles to improve safety at work site
- In today's context, CP 88:Part 1:2001 requires the use of socket-outlet assembly (SOA) for the connection of portable electrical equipment at work site

Equipment & accessories involved

2-gang 13Amp extension socket-outlets

Electric Stirrer



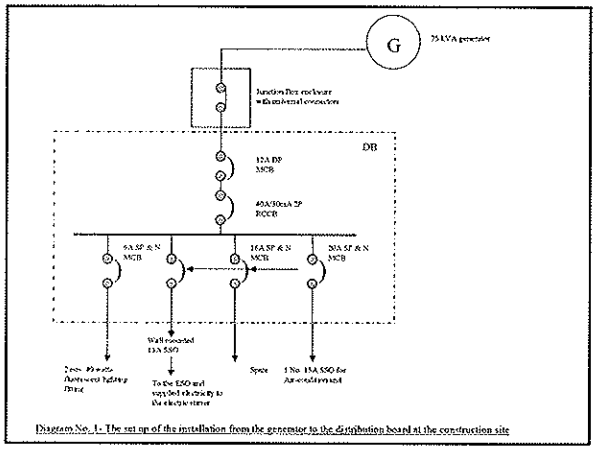


Diagram No. 1- The set up of the installation from the generator to the distribution board at the construction site

Photo No. 2

Neutral of generator supply

From generator yellow phase

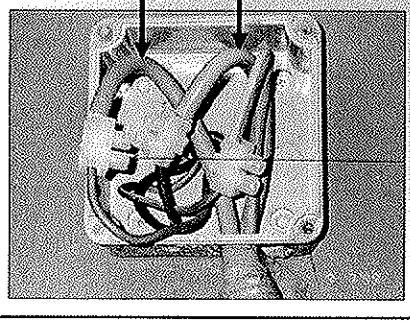


Photo No. 3

Loosen strands of live conductor found exposed at this joint

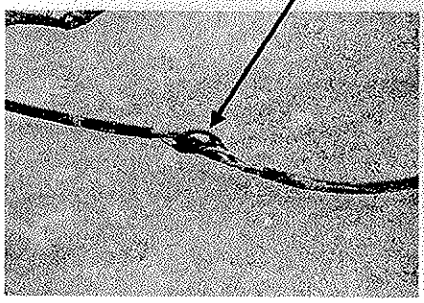


Photo No. 4

All the connections at the 2-gang 13A metal-clad switched socket outlet were wrongly connected

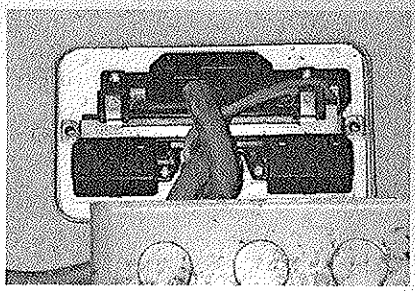


Photo No. 5

Transposed live and neutral at plug of ESO

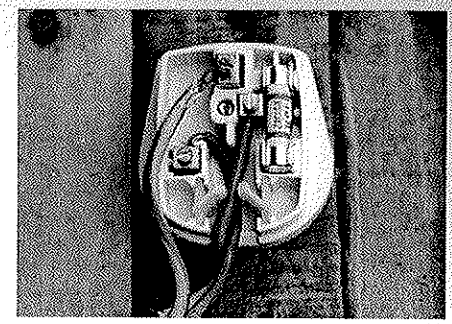
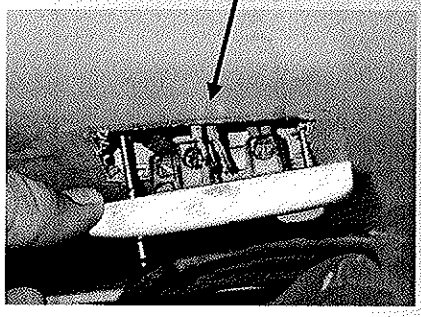


Photo No. 6

Earth conductor dislodged from terminal



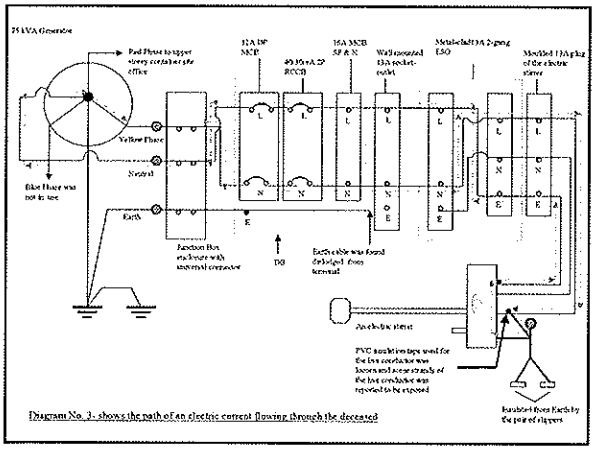


Diagram No. 3: shows the path of an electric current flowing through the deceased

Case Study 4

- The electrical accident occurred in year 1999 at a residential condominium building
- The deceased received a fatal electric shock while in the process of fixing current transformers (CTs) at the busbars compartment of the main incoming switchboard

Observations

- Two MCCBs were installed in this compartment, one on top of the other. The MCCB that was on top was rated at 500A and the MCCB at the bottom was rated at 300A
- There was no intermediate barrier put up to prevent direct contact with the busbars of the 500A MCCB while the deceased was working on the 300A MCCB

Observations

- A ring spanner was found in electrical contact with the blue phase outgoing terminal of the 300A MCCB catching on to a hexagonal nut
- Patches of burned human tissues were found stuck at the red phase outgoing terminal of the 500A MCCB

Investigations & Findings

- Voltage readings of 400V between phases and 230V between various phases and neutral were measured at the outgoing terminal with the 500A MCCB

Conclusion

- The deceased could be tightening the nut securing the last CT when his left shoulder accidentally came into contact with the exposed 'live' (red phase) outgoing of the 500A MCCB
- The other parts of his body were in contact with the metal frame of the panel and formed a return path for the current to flow through his body and received a fatal electric shock
- Appropriate actions were taken against the offender

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What should be done to avoid danger at this site?

- The 500A MCCB should have been switched off while work was being carried out on the 300A MCCB
- If switching off the 500A MCCB was not possible, insulating barrier should be used to cover the 'live' outgoing terminals of the 500A MCCB
- The holder of the electrical installation licence should inform his appointed LEW so that the necessary safety measures could put in place before commencement of work.

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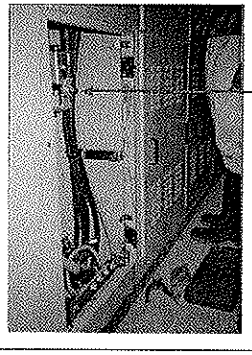
Photo No. 1



'Live' outgoing terminals of 500A MCCB were not covered with insulating barrier while work was being carried out at lower compartment of panel

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Photo No. 2

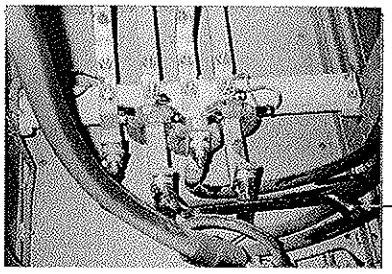
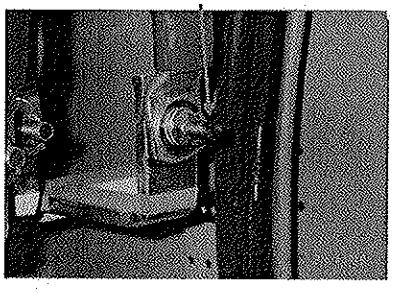


Photo No. 3

Patches of burned human tissues stuck at the red phase outgoing terminal of the 500A MCCB



Common Mistakes

- Human errors – negligence, ignorance, complacency etc
- No proper earthing, no RCCB protection

Preventive Measures

- Always appoint a licensed electrical worker to carry out/supervise electrical work and to take charge of temporary electrical/supply installation.
- The licensed electrical worker would design, test & certify fitness of the electrical/supply installation

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Preventive Measures

- The licensed electrical worker would put in place the necessary safety measures before commencement of electrical work.
- The contractor company can cultivate a safety culture and raise electrical safety awareness among the workers.

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