ELECTRICAL SAFETY

Objective

Better awareness and understanding on:

- The possible hazards caused by electricity
- Safety measures and practices to avoid those hazards
- Duties of building/premises management in ensuring safety of electrical installations
- Applicable Statutory requirements on safety standards regarding electrical works, equipment and installations.

Hazards of Electricity

Primary Hazards

Electrocution (Electric Shock)

Fire and Explosion

15% of all causes of fire

Accidents involving Electricity – Mostly electric shocks

Secondary Hazards

- ***Burns***
  - ***Contact Burn***
  - ***Flash Burn***

Secondary Hazards

–***Contact Burn***

Secondary Hazards*

–Flash Burn

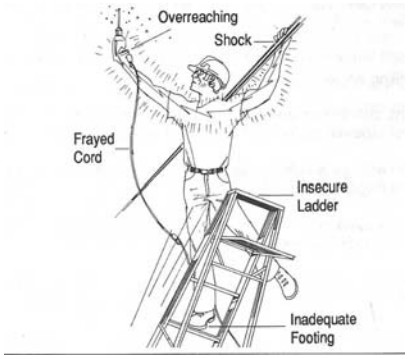
When performing maintenance work inside a switch room, a technician accidentally dropped his torch into a switch cubicle, resulting in an explosive short circuit. The technician was seriously burnt.

Secondary Hazards

–***Flash Burn***

Secondary Hazards

- Falls
  – jerk reaction



Characteristics of Hazard

The Invisible Danger

- The Electric **Current**
- The **Voltage**

Effects of Electrocution

Harmful Effect to Body:

Sufficient current flowing through the body will create serious harm:

- **Ventricular Fibrillation** 心室纖維性顫動– heartbeats disrupted by electric current. The heart flutters rather than beats. The heart pumps little or no blood thru' the circulation system. (need a defibrillator 電擊器 to resume heartbeats).
- **Suffocation** – electric current causes the lung to contract violently, affecting respiration
- **Cell damage** – by electrical energy
- **Burns** – by heating effect of electric current

Effects of Electrocution

Degree of Harmful Effect:

- Magnitude of current
  - Voltage
  - Body resistance
- The current pathway through the body
- Duration of contact

Lethal Path

Effects of Electric Current in the Human Body

Expected Current thru' body

Current passing through the body depends on:

- Voltage applied
- Resistance of body
  - moisture of skin
  - other factors (e.g. size, weight etc.)

(Current = Voltage / Resistance)

Body Resistance

Skin Contact Resistance:

- From 1000 kilo-ohms (dry skin) down to 100 ohms (wet skin)

Internal Body resistance:

- From 100 to 500 ohms.

Current through body

Worst Condition:

220V / 200 ohms = 1.1 Amp.

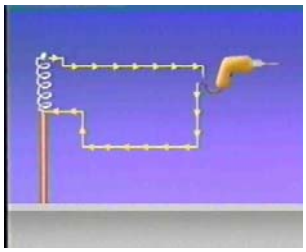
Best Condition:

220V / 1,000,000 ohms = 0.22 mA

Electric Shock Hazards and Prevention

Cause of Electric Shock

- A person gets an electric shock when he becomes part of a circuit.
- Shock occurs in following ways:
  - Contact with both wires
  - Contact with one wire and ground
  - Contact with energized equipment and ground

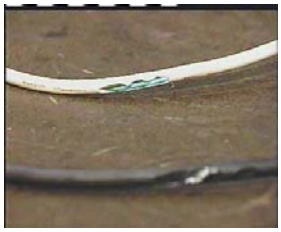


Hazardous Conditions

- **Direct contact** with exposed current carrying parts
  - Maintenance process - need to open up enclosure
  - Defective/damaged enclosure or insulation materials
  - Unsafe design
  - Maintenance people are more at risk
- Contact with energized conductive parts (**Indirect Contact**)
  - Electric/Ground faults
  - Leaking out of electricity
  - All users are at risk

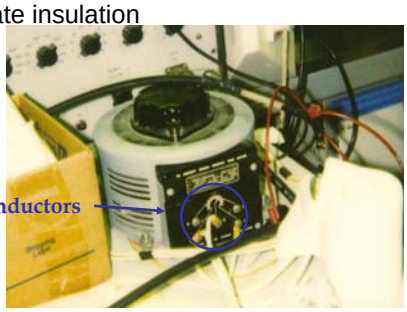
Examples

- Contact with current carrying parts inadvertently
  - Damaged casing/cable/plugs etc. where live conductors are exposed.



Examples

- Contact with current carrying parts inadvertently
  - Inadequate insulation



Examples

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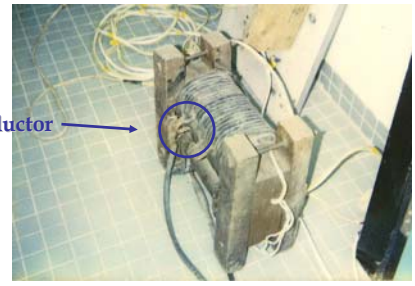
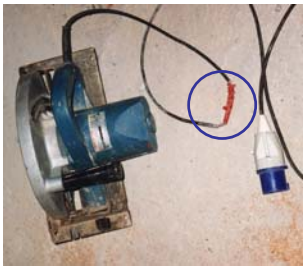


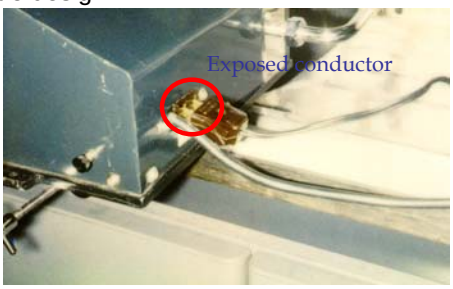
Examples

- Contact with current carrying parts inadvertently
  - Inadequate insulation (Fray wire)



Examples

- Contact with current carrying parts inadvertently
  - Unsafe design



Prevention of Electrocution

Goal:

*Prevent people from contact with electric current **directly** or **indirectly**.*

Prevention of Electrocution

Principles/Means:

- Safe Electrical System
  - Protective Devices in the electrical supply system
  - Required by local code and regulations
  - Required for fixed installation and portable equipment
- Safe Equipment
  - Use of Safe Equipment (with adequate protection)
- Proper Maintenance
- Safe Work Practices
  - Safe use of equipment (Proper Use)

Legislative Controls

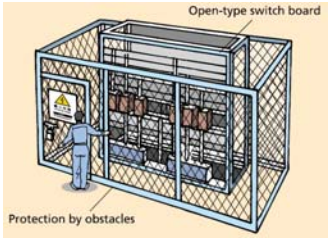
- Rely on compliance of statutory requirements set in the Law.
  - Ensuring safety electricity supply systems
  - Ensuring safe electrical products
  - Ensuring competence of people working on electrical systems
- **Electricity Ordinance and Regulations**
  - Strict requirements for hardware and systems
  - Work practice is difficult to control

Safeguard against Direct Contact with Live Electrical Parts

- Adequate insulation of live conductors
  - Ensured by safe design and proper inspection and maintenance
  - Stringent requirements in Electricity (Wiring) Regulation

Safeguard against Direct Contact with Live Electrical Parts

- Restrict access or contact by Enclosure/ Guarding/ Barrier



Safeguard against Direct Contact with Live Electrical Parts

- Interlocking devices 連鎖裝置
  - Normally installed at access doors for dangerous parts.
  - Fool-proof device to ensure electricity supply is cut-off with the device is activated (when the door is opened)

Safeguard against Ground Fault Conditions (Indirect Contacts)

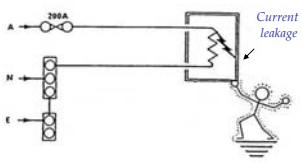
Safeguard against Ground Fault Conditions

- **Grounding/Earthing**
  - Draining of "leaked out" current to the earth/ground using a conductor (earth wire)
  - Eliminate the build up of potential difference between the equipment and the ground.

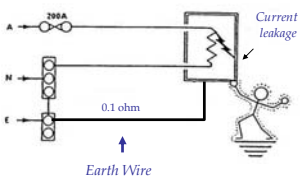
Hazardous Condition

Potential Difference (P.D.) is dangerous

P.D. between the metal casing and ground is 220V, and hence the "Touch Voltage" for the person.



- Safeguard
  - Use an earth wire to limit the "Touch Voltage" under fault conditions
    - Hence the current flowing through the human body



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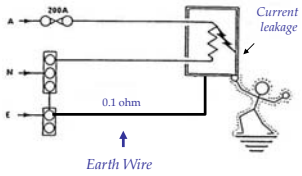


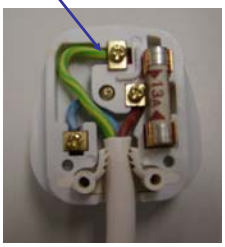
V=IR
=200x0.1
=20Volts

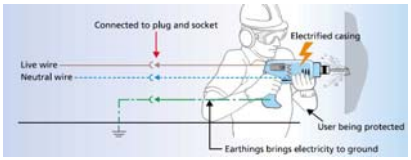
V=Touch Voltage
Fault Current=200A

Ensure that Earth Connection is Continuous

Proper Wiring

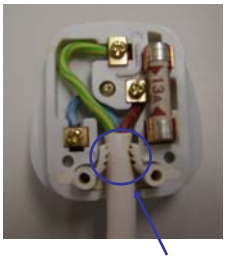
- Earth wire must be securely connected for providing earth protection

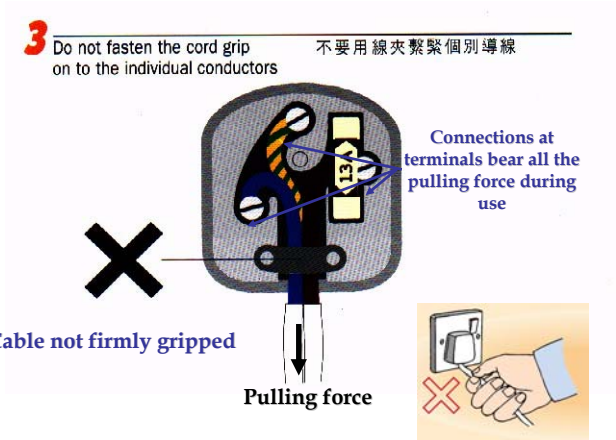




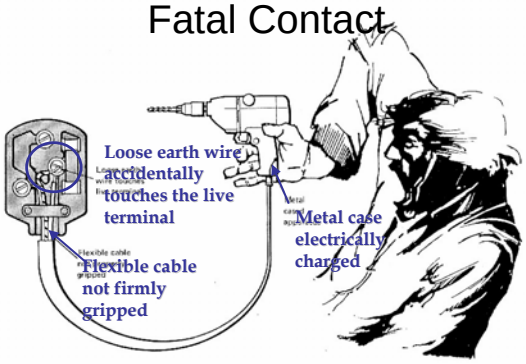
Proper Wiring

- Cable must be firmly gripped to release strain from the conductor wires
  - To ensure that the conductors would not be pulled out of the terminals





Fatal Contact



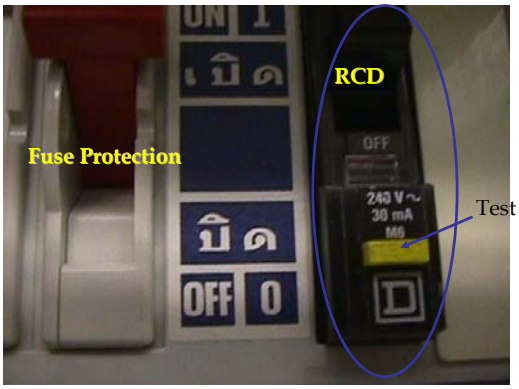
Grounding of Conductive Surfaces

- Metallic conductive surfaces may be electrically charged accidentally
  - e.g. Work benches on which electrical equipments are placed

Automatic Protection Device

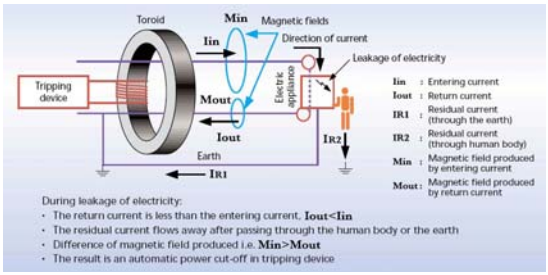
- Automatic disconnection of power when an electricity leak is detected
- Devices
  - Residual Current Device (RCD)
  - (Earth Leakage Circuit Breaker (ELCB)
  - Ground Fault Circuit Interrupter (GFCI)

Residual Current Device



Residual Current Device

Schematic Diagram



Double Insulation

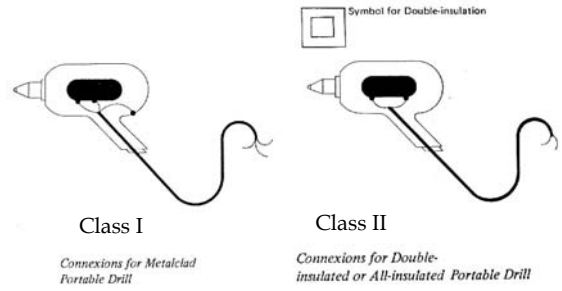
雙重絕緣

Protection for Portable Electrical Equipment

Safeguard against electricity leaks

Two Methods of Protection

- Class I apparatus:
  - protection against electric shock achieved by providing proper earthing for the apparatus
  - Earth wire required
- Class II apparatus (double insulated):
  - protection against electric shock achieved by double insulation or reinforced insulation. There is no provision for protective earthing.
  - Earth wire not required



Safe Work Practices/ Procedures

General Safety Practices

- Only authorized, competent, and qualified (e.g.... by training) persons are allowed to work on or around electrical equipment and/ or wiring.
  - Required by **Electricity (Registration) Regulation**

General Safety Practices

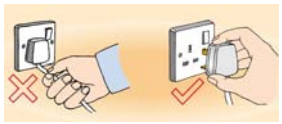
- Purchase up-to-standard electrical equipment equipped with appropriate protective devices.
  - Required by **Electrical Products (Safety) Regulation**

General Safety Practices

- Use lower voltages
  - 110 volts or lower
  - Suitable for lighting
  - Need a step-down device

General Safety Practices

- Proper use of electrical equipment (not to interfere with protective devices)



General Safety Practices

- Do not use conductive ladders for electrical work or work near electrical installation

General Safety Practices

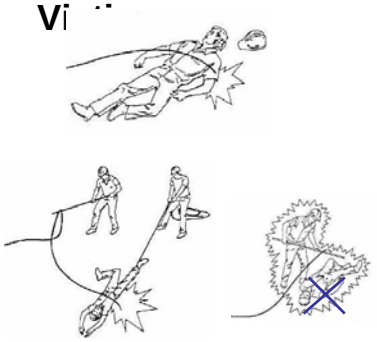
- Proper maintenance of system and equipment

General Safety Practices

- Emergency procedures in the event of an accident
  - Equipment emergency shutdown procedure, e.g. power cut-off switch can be easily reached.
  - Electric shock first aid procedure
    - The need for first-aid training

First Aid for Electrocuted Victims

- Electric shock victim MUST be removed from contact with electricity by safe means before doing any necessary first aid treatment.



First Aid for Electrocuted Victims

- CPR 心肺復甦
  - Should be performed by a competent person

Specific Safety Procedures

Specific Safety Procedures

- Electrical/Mechanical System Maintenance

➔**Lockout / Tagout Procedures**

Lockout/ Tagout Arrangement

Purpose:

- To avoid inadvertent release of energy (electrical and / or mechanical) causing serious harm to people working on the system.
- Effective isolation of power supply.

Steps for Lockout/Tagout Procedure

- Plan the shut down of the system.
- Alert operator and other users of the shut down.
- Lockout the power supply to the system at the most appropriate point.

Steps for Lockout/Tagout Procedure (cont)

- Have all teams/workers place their personal & individual padlocks on the lockout point.
- Put a warning tag at the lockout.
- Release all stored or residual energies (e.g. capacitors, loaded spring etc.)
- Test the circuit to confirm it is dead.

Steps for Lockout/Tagout Procedure (cont)

- Each team/worker should remove only his own padlock upon completion of his part of work.

High Voltage

Specific Hazards:

- Generate much larger current
- Current can jump through air -- arcing
  - Maintain safe Distance

Classification of Voltages

- Extra low voltage : n.e. 50 volts a.c. / 120 volts d.c. (between conductors or to earth)
- Low voltage : Exceed ELV but n.e. 1000 /600 volts a.c.(between conductors/to earth); or n.e. 1500/900 volts d.c.
- High voltage : Any voltage normally exceeding LV.

Safeguard against Stored Energy

Hazards of Stored Electrical Energy

- Still be there after power cut out – **Stored Up**.
- Can cause nasty shocks or kill people

Stored Energy

- **Capacitors**
  - Store up electrical energy
  - Energy dissipates very slowly
  - Memory effect
  - Have to be discharged and grounded.

Stored Energy

- Batteries
  - Can cause fire and explosion when shut-circuited.

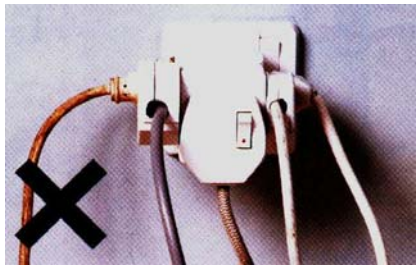
Fire & Explosion Hazards

Common Causes for Fire & Explosion

- **Cable with insufficient size**

Common Causes for Fire & Explosion

- **Abused use of adaptors and extension socket boards**



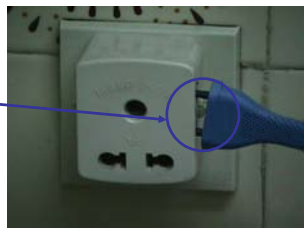
Common Causes for Fire & Explosion

- **Improper wiring (poor connection)**
- **Substandard plugs/adaptors**

Common Causes for Fire & Explosion

- **Poor electrical contacts**
  - **Plugs are loosely fitted to socket (poor electric contact) -- esp. for two pin plugs**

Power Plug loosely fitted

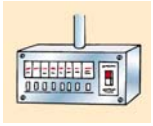


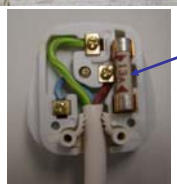
Over-current Protection

- Use conductor of sufficient size
  - Specified in Wiring Regulations

- Fuse Protection

MCB Box





Fuse

Working in Hazardous Environment

- Sparks generated by certain electrical tools and equipment, e.g.... motor, plugging and unplugging –
- Especially in hazardous atmosphere……

Avoid Generation of Sparks in Hazardous Atmosphere

- Use **spark proof** / **intrinsically safe** equipment and installation in hazardous areas where there are:
  - flammable liquids;
  - combustible liquids operating at a temperature above their flash point; or
  - gases or combustible dusts that may be present in flammable, explosive and combustible concentrations.

Legal Requirements

Legislative Controls

Legal Requirements

- Electricity Ordinance Cap. 406
  - Electricity (Wiring) Regulation
    - Code of Practice
  - Electricity (Registration) Regulation
  - Electrical Products (Safety) Regulation
  - Electricity Supply Lines (Protection) Regulation
  - Enforced by EMSD

Electricity (Wiring) Regulation

- Set forth safety requirements (mostly engineering controls) on wiring of fixed electrical installations.
- Requirements on inspection, testing and certification.
- Ensure that the electrical supply system is safe.

Code of Practice for Electrical (Wiring) Reg.

Gives detail technical guidance on how the statutory requirements can be met:

- Arrangements of protective devices
- Standards and Workmanship of electrical works e.g. size of conductors, cable jointing and termination, etc.
- Procedures for inspection, testing and certification.
- etc.

Statutory Safety Requirements for Electrical Installations in Buildings

In accordance with Electricity (Wiring) Regulation

Responsibilities of Owners of Electrical Installations

- Take appropriate measures (e.g. arrange for proper maintenance and repairs) to prevent electrical accidents.
- Ensure that their electrical installations are free of illegal additions and alterations.
- Ensure that only registered electrical contractors are employed for carrying electrical installation works.
- Arrange for periodic inspection and maintenance of electrical installations (WR2)

New Installations, Additions and Alterations

- Employ a register electrical contractor to perform a feasibility study. Consider if additional power supply is need from power company.
- The installations must be installed, tested and inspected by a registered electrical contractor before the installation is energized.
- A Work Completion Certification **(WR1)** must be issued by the electrical contractor to confirm that the installation is safe and comply with statutory safety requirements.
- Owner of the installation should keep the Certification for future reference.

Periodic Testing, Inspection and Certification of Electrical Installations*

- At least once every 5 year for electrical installations in:
  - Residential units, communal areas, shops and offices if approved loading exceeds 100A.
  - Hotels, hospital or maternity homes, schools, child care certers
- At least once every year for electrical installations in:
  - Places of public entertainment
  - Premises for manufacturing or storing dangerous goods
  - Premises with a high voltage fixed electrical installation fed directly from a high voltage supply.

Periodic Testing, Inspection and Certification (cont)

- Must be conducted by registered electrical contractors according to a checklist.
- The electrical contractor should issue a Periodic Test Certificate (**WR2**)to the owner of the installation to confirm the installation is same and complies with statutory safety requirements.
- The owner is required to submit the Certificate to EMSD for endorsement and then keep it for future reference

Other Regulations

Electricity (Registration) Regulations

- Requirements and procedures for registering:
  - Electrical Workers
  - Electrical Contractors
- Types of electrical works (demanding for different qualification and experience):
  - Grade A – 400A low voltage fixed installation
  - Grade B – 2500 A
  - Grade C – Any capacity low voltage
  - Grade H – High voltage electrical installatin
  - Grade R – electrical work in neon sign/air conditioning/ generating facility installation etc.

Electrical Products (Safety) Regulation

- Effective since May 1998
- Ensure the safety standards of electrical products designed for domestic use, including plugs, sockets, adaptors and extension boards.
- Ensures safe equipments/appliances

Electricity Supply Lines (Protection) Regulation

- Enacted in November 1999
- To protect electricity supply lines so as to prevent occurrence of electrical accident or interruption to power supply.
- Risk assessments required before work starts.
  - Conducted by competent persons
  - Detection of cable locations

Electricity Supply Lines (Protection) Regulation

1. Before carrying out any underground works in the vicinity of an underground electricity cable; or works in the vicinity of an overhead electricity line:
2. all reasonable steps must be taken to ascertain the existence within the proposed works site and its vicinity of any such underground electricity cable and its alignment and depth or of any such overhead electricity line and its alignment, distance from the ground and voltage, as the case may be.
3. ensure that all reasonable measures are taken to prevent the occurrence of an electrical accident or an interruption to the supply of electricity arising from those works.
4. Appoint a **competent person** to carry out the works in (2) & (3) above, in accordance to the **Code of Practice** approved by Director of EMSD

Factories & Industrial Undertakings (Electricity) Reg.

- Complementary to Electricity (Wiring) Regulations.
- Safety requirements on electrical installations and use of electrical tools and equipment specifically applicable to all industrial undertakings.
- Enforced by Labour Department

Standards and Codes

Relevant Standards for Electrical Equipment/Accessories

- **BS 415** -- Safety requirements for mains operated electronic and related apparatus for household and similar general use
- **BS 4743** -- Specification for safety requirements for electronic measuring apparatus
- **BS 3456** -- Specification for safety of household and similar electrical appliances
- **BS 546** -- Two pole and earthing pin plugs, socket-outlets and socket-outlet adaptors
- **BS 1363** -- Specification for 13A fused plugs and switched and unswitched socket-outlets