



D10: Electrical Safe Isolation

Length: 135 minutes

Theory

Learning outcomes

- Understand how electricity effects the human body
- Understand the difference between current and voltage
- Understand resistance/impedance
- Understand how duration of contact effects the human body
- Know what levels of current cause which problems on the human body
- Know which criteria effect the resistance of the human body
- Understand how to protect against electric shock
- Understand how an electric shock effects the human body
- Know how to differentiate between direct- and indirect contact
- Know how to safely remove someone who has come in to contact with live electrical equipment
- Know the first aid treatment for electric shock casualties
- Understand different electrical faults
- Know the measures used to protect against electric shock
- Know the electrical safety devices used in RACHP work
- Know the 5 safety rules
- Understand the safety measures incorporated in to electrical test equipment
- Know about the design (multifunctional) safe voltage tester
- Know the safety precautions when working on or near to live electrical equipment

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Effects of electrical current on the human body

Electric shock

Electrical faults

The five safety rules

Voltage indicating devices

Safety precautions when working on or near live electrical equipment

Effects of electrical current on the human body

The extent of the effect depends on:

- the current per area (current density)
- the type of current - AC or DC
- the frequency (only with pulsating direct current DC or alternating current AC)
- the current path **through** the body (e.g. hand - hand, hand - foot, left, right)
- the duration of the electric current
- the size of the contact surfaces
- the conductivity at the contact point
- the step voltage (in thunderstorms or **earthed** electrical systems)
- the state of health or the age of the affected person
- the presence or absence of medical implants



WARNING

Working on electrical circuits is one of the main causes of accidents at work of RACHP workers.

A faulty electrical circuit is also the main reason for accidents on an otherwise normally operating RACHP unit.

Effects of electrical current on the human body

Current	Influences on the human body
Up to 0.5 mA	Not noticeable or slight tingling
0.5 - 5 mA	Significant tingling to muscle spasms, which can usually be overcome
5 - 15 mA	Painful cramps, the release threshold is exceeded
15 - 25 mA	Obstruction of respiration and circulation
25 - 50 mA	Respiratory complaints, cardiac arrhythmias, blood pressure increase
> 50mA	Ventricular fibrillation, cardiac arrest after one heart period (≤ 1 s)

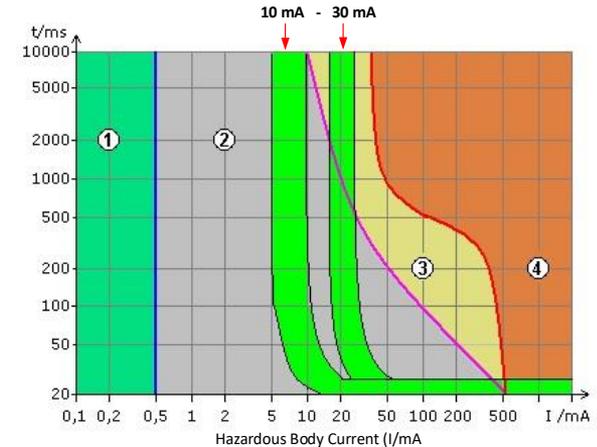
Effects of electrical current on the human body

- In addition to the value of the current that goes through the body and heart, the duration of the electrical impulse is also important;
- the longer the contact, the more severe the effect.
- Low currents can be sustained for a longer time without any effects; higher current can be deadly fast.

Effects of electrical current on the human body

The following figure shows dangerous currents and contact times.

- area (1): effects of currents up to 0.5 mA are largely harmless, even over a long time.
- area (2): no lasting damage to health is assumed up to 10 mA and a time ≤ 1 s. For higher body currents, the rate of a safe exposure time decreases. At 50 mA, this maximum may only be at 200 ms.
- area (3): noticeable health impairment on the body is expected.
- area (4): is considered as deadly.
- Light green areas indicate the operation of RCD devices for 10mA and 30 mA



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Effects of electrical current on the human body



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Electric shock

- An electric shock affects the nervous system, causing the muscles to contract and sometimes causes concussion.
- An electric shock can be received either by direct or indirect contact with electricity.
- Direct contact is when a person or livestock makes contact with parts or conductors that are intended to be live in normal use.
- Indirect contact is when a person or livestock makes contact with exposed conductive parts that have become live under fault conditions.

Electric shock

- Removing persons

Great care needs to be taken when removing a person who has come in contact with live conductors.

The following points should be considered:

- the rescuer must not put themselves in danger
- all necessary procedures must be undertaken as quickly as possible
- all necessary procedures must be carried out in a way that prevents further injury.

1) First, disconnect the electricity supply, wherever possible.

2) Push the victim away from the live conductors using a piece of dry wood or similar (broom handle) so that they can be removed effectively and quickly.

Electric shock

- Treatment
 - Summon assistance and call for an ambulance.
 - In the case of slight shock, reassure the patient and make them comfortable. Report the accident to the appropriate personnel.
 - If burns have been sustained, cool the areas with cold water or any other suitable non-flammable fluid at hand.
 - Remove anything of a constrictive nature if possible, such as rings, belts and boots.
 - If the burns are serious, cool the areas and send the patient to hospital without delay.
 - For severe cases of shock where the patient is unconscious and not breathing, clear the airway and administer mouth-to-mouth resuscitation. Remember, there is no time to waste because a lack of oxygen to the brain can cause damage within four minutes.
 - If the heart has stopped, then cardiac compression should be given and continued until further medical advice is given.
 - If the patient is breathing and has a heartbeat, after treatment, place them in the recovery position and send them to hospital without delay

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Electrical faults

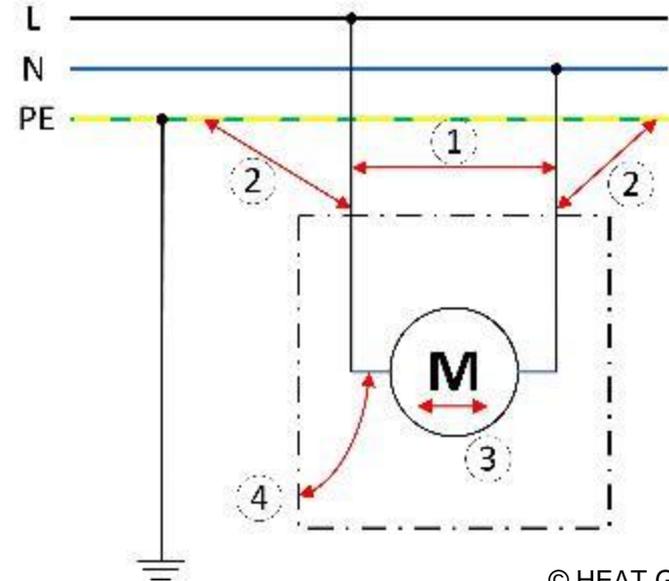
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Electrical faults

1)	Short circuit	A low-resistance, direct connection between two live wires.
2)	Earth fault	A low-resistance, direct connection of voltage-carrying lines to earth.
3)	Conductor short circuit	Parts or the entire load-resistor are bridged in the event of a fault.
4)	Short circuit to a housing	Insulation fault of live parts to the electrically conductive housing.



Protection against electrical faults

Designation	Plant protection	Device protection	Examples	
Level 1	Baseline protection	Protection against direct contact of live (active) parts	Protection against direct contact and foreign bodies	Basic insulation, covers, housings, obstacles, distance between parts
Level 2	Fault protection	Protection against indirect contact of active parts	Protection classes (chapter 12.2)	For example, the metallic housing of electrical equipment, which can become dangerous active parts in the event of a fault.
Level 3	Additional protection	Measures to protect against direct contact with active parts, e.g. residual current device with nominal residual current of ≤ 30 mA		This includes the residual current circuit-breaker (RCD) with its protective effect in the event of simultaneous failure of the basic protection and the fault protection.

Use of RCDs

- prevent dangerously high residual currents against earth
- contribute significantly to the reduction of life-threatening electrical accidents in low-voltage installations
- connected upstream of the overcurrent protection devices in distribution circuits



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Use of RCDs

The necessity of a residual current device as additional protection can be well illustrated in the following possible scenarios:

- Careless handling or misuse of electrical equipment
- Infants and small children
- Damage to the electrical system due to external influences
- Non-compliance with the five safety rules by electricians
- Educational purposes
- Manipulation of an electrical system or electrical equipment by unskilled persons or improper work by skilled personnel

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The five safety rules

- For safe work on electrical equipment, comply with the following safety rules in the given order!
- The rules make sure that active parts of appliances or systems are switched off before you start working and stay that way during your work.

Note: Active parts are conductors or conductive parts intended to carry voltage during undisturbed normal operation, including the neutral conductor.

- Depending on the system and the voltage, only steps 1-3 may be necessary. (This is for example the case for split ACs.)

The five safety rules

Five Safety rules for work with electric systems:

1. Switch off power
2. Secure against reclosure of the electric circuit
3. Check that lines and equipment are dead
4. Ground and short circuit phases
5. Cover partitions or screen off neighbouring line sections

Working on electrical parts: Five Safety Rules

Five Safety Rules



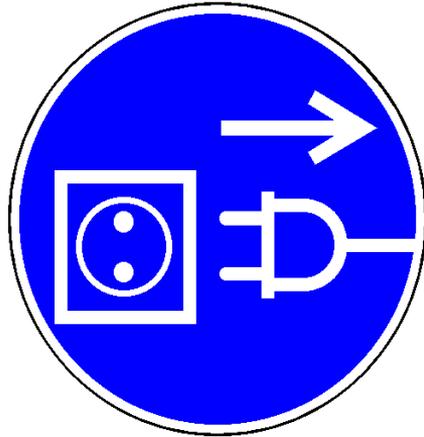
Five Safety Rules (DIN VDE 0105-100:2015-10)	
For the execution of works at electrical installation (Before Starting)	
	1 - Switch Off
	2 - Secure against restarting
	3 - Check that all lines dead
	4 - Ground and short circuit phases
	5 - Cover partition or screen of adjacent line sections
Resetting In Reverse Order	

Due to the risk of accident, working on parts which are **LIVE** is prohibited!!

In the case of operating voltages above 50V alternating voltage or 120V direct voltage, work on parts which are **LIVE** are only allowed if these parts cannot be switched off for important reasons (for example, large economic damage caused by a longer power failure).

Such work should be carried out by qualified and certified personnel only!

Working on electrical parts: Five Safety Rules



1. Switch Off

The voltage must first be switched off. This is done in households, for example, by removing the fuse or switching off the relevant line circuit breaker.

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2. Secure against restarting

In order to prevent a plant from being unintentionally restarted (specifically a refrigeration system with automatic Stop-Start function). Safety devices and /or main switches should be locked and protected against switching on without the knowledge of the service workers (using e.g. a padlock or keeping the fuses in your pocket). For the duration of the work a warning sign should be fitted to the system to prevent unintentional restarting.

Working on electrical parts: Five Safety Rules



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3. Check that all lines are dead

After you have followed steps 1 and 2, determine voltage free status by measurement before starting the work!! This is best done with a two-pole voltage tester or multimeter. Single-pole voltage testers do not provide reliable results.

Working on electrical parts: Five Safety Rules



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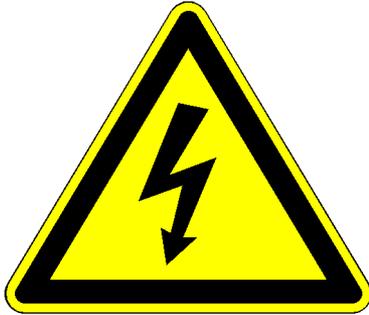


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3. Check that all lines are dead (continued)

- a. Test the voltage indicator against a proving unit or a known live supply.
- b. For single phase circuits, test between:
 - (i) Earth and Live,
 - (ii) Live and Neutral and
 - (iii) Neutral and earth.
- c. Then retest the voltage indicator.

Working on electrical parts: Five Safety Rules



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4. Grounding and short-circuiting

This rule has to be taken into account only at a voltage of 1000 volts and above. First earth must be grounded, then the earth must be connected to the active parts to be shorted. **Determine voltage free status.**

Working on electrical parts: Five Safety Rules



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Resetting In Reverse Order	

5. Cover partition or screen off adjacent line sections

In the case of installations below 1kV (=1000V), insulating cloths, hoses or mouldings are sufficient for covering. Above a voltage of 1kV additional safety boards, ropes and warning boards are necessary. In this case, the body must also be separately protected, e.g. through a protective helmet with face protection and highly insulated gloves.

Working on electrical parts: Five Safety Rules

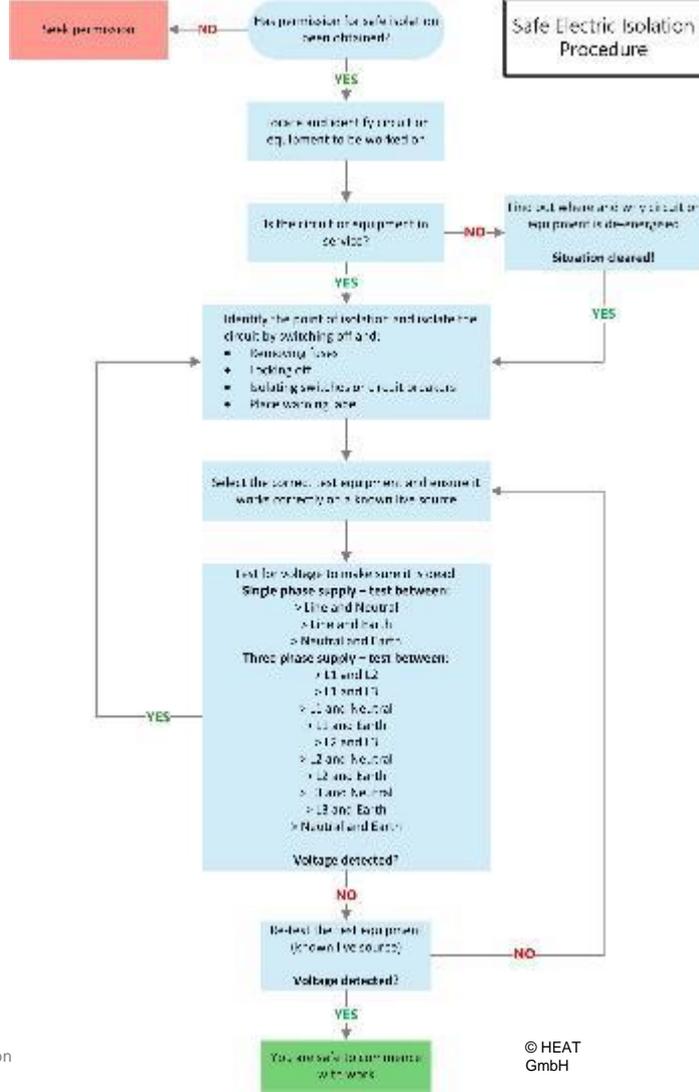


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Resetting In Reverse Order	

Resetting in reverse order

To re-instate the system, carry out the above-mentioned safety rule activities in reverse order.

1. Remove the cover over partition or screens from adjacent line sections.
2. Remove the short circuit lines and then the ground line.
3. Check that all lines are dead.
4. Remove the padlock and /or insert / activate the fuses.
5. Switch on the system.



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Voltage indicating devices



Example of CE approved digital multifunction tester

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Voltage indicating devices

Equipment used solely for detecting voltage fall into two categories.

1 of 2:

- Detectors which rely on an illuminated indication (e.g. a test lamp or similar) or a scale (e.g. a multi-meter).
- Test lamps fitted with glass lamps should not give rise to danger if the lamp is broken. It may be protected by a guard.
- These detectors require protection against excess current.
- This may be provided by a suitable high-breaking capacity (hbc or hrc) fuse or fuses, with a low current rating (usually not exceeding 500 mA), or by means of a current-limiting resistor and a fuse. These protective devices are housed in the probes themselves.
- The test lead or leads are held captive and sealed into the body of the voltage detector (equipment which conforms to the requirements of EN 61243-3 has internal protection that meets this requirement)

Voltage indicating devices

Equipment used solely for detecting voltage fall into two categories.

2 of 2:

- Detectors which use two or more independent indicating systems (one of which may be audible) and limit energy input to the detector by the circuitry used.
- An example is a 2-pole voltage detector, i.e. a detector unit with an integral test probe, an interconnecting lead and a second test probe.
- These detectors may be designed and constructed to limit the current and energy which can flow into the detector. The limitation is usually provided by a combination of circuit design, using the concept of protective impedance, and current-limiting resistors built into the test probes.
- These detectors may be provided with inbuilt test features to check the functioning of the detector before and after use.
- The interconnecting lead and second test probe are not detachable components.
- These types of detector do not require additional current limiting resistors or hbc fuses to be fitted provided that they conform to EN 61243-3.

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Safety precautions when working on or near live electrical equipment

Safety precautions when on or near to live electrical equipment

*Safety precautions when **working near to live circuit plant sections***

When working on a part of a plant, it is sometimes not possible to deactivate neighbouring active parts. These parts might also not be protected against direct contact. In this case, particular care must be taken to select the suitable tools and work at a safe distance.



The protective distance for systems up to 1000 V mains rated voltage is **0.5 m**

Persons who have neither been trained as qualified electrician or electrically instructed personnel may only work under expert supervision near live circuit plant sections.

Safety precautions when on or near to live electrical equipment

*Safety precautions when **working on** live circuit plant sections*

Working on live circuit plant sections requires a high level of knowledge, skills and responsibility from the worker as well as from the supervisor.



Always use appropriate personal protective equipment (PPE), tools, devices and instruments for the type of work, the voltage level and the surrounding conditions.

If working on live circuits components or sections is necessary, always use insulated safety tools. They offer increased protection against live wire contact and electrical shock.

Conduct risk assessment before decision to work and get permission by supervisor (if applicable, this may include obtaining a permit to work).

Safety precautions when on or near to live electrical equipment

Working on live circuit plant sections – Distinctions	
Up to AC 50 V Up to DC 120 V	<p>Skilled electrician, electrically trained person (according to IEC 60364 and EN 60204-1) and electro-technical layperson:</p> <ul style="list-style-type: none"> - All works, as far as a danger, e.g. by arcing, is impossible.
Above AC 50 V or DC 120 V Up to 1000 V AC and DC	<p>Skilled electrician, electrically trained person (according to IEC 60364 and EN 60204-1):</p> <ul style="list-style-type: none"> - Use of suitable testing, measuring and adjusting devices, e.g. voltage testers and suitable tools for moving smooth-running parts. - Prepare suitable tools and consumables for cleaning and install suitable covers and barriers. - Removal or insertion of non-direct-touch fuse-links, e.g. NH fuses, with suitable aids if this is possible without danger. - Sprinkling of live circuit parts during firefighting. - Work on batteries taking appropriate precautions. <p>Skilled electrician only:</p> <ul style="list-style-type: none"> - Fault location in auxiliary circuits, e.g. signal tracking, as well as the functional testing of devices and circuits. - Other work, if there is a compelling reason and in addition the instruction of a responsible person is present.

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