

## Túterhelés és biztosító

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E1	2	Lámpafoglat, E10	DE720-2A
E1	1	Ki-, bekapcsoló	DE720-2R
E4	2	Közösítő, mágneses	DE453-2V
E4	1	Fűtő tekercs	DE330-1H
EZ	1	Izzó, 6V/0.05A, E10, 5db-os készlet	DE309-4S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	Konstantán huzal, tekercs, d=0,5 mm, L=15 m	DE330-1B
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

We obtain electrical energy from lead-in wires which are heated by the current flowing through them. When too much power is drawn from the source ("overloading"), the heat build-up caused by the large amount of current can lead to danger of fire.

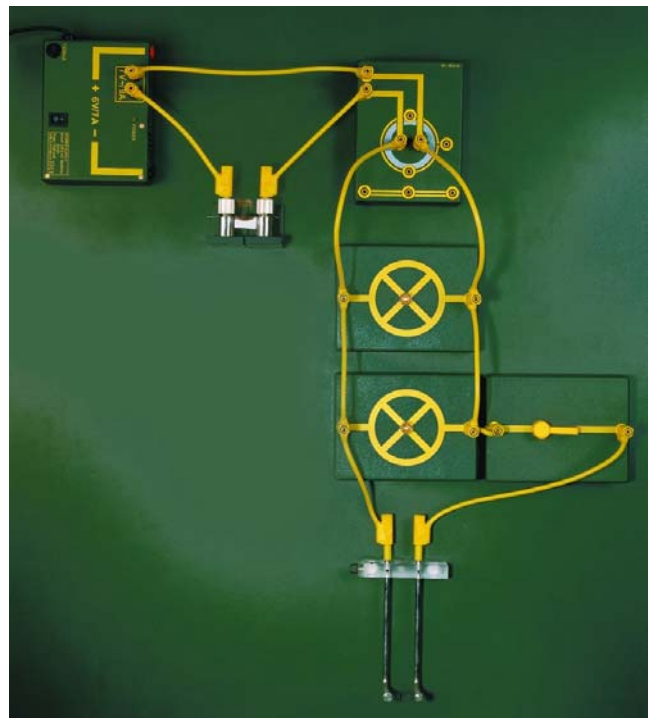
In order to protect ourselves from the effects of overloading, we connect fuses, either in the form of burn-through safety fuses or circuit breakers ("automatic cut-outs"), to the lead-in wires. Overheating reaches a dangerous level only after a certain amount of time, depending on the degree of overloading, allowing the interruption of the circuit also to be delayed (in the case of an automatic circuit breaker this is done using a bimetal trigger).

When a certain maximum amount of current is superseded, the circuit must be interrupted more or less quickly depending on the degree of overloading. This holds true for every gauge of wire. Wire gauges and fuses must, therefore, match each other.

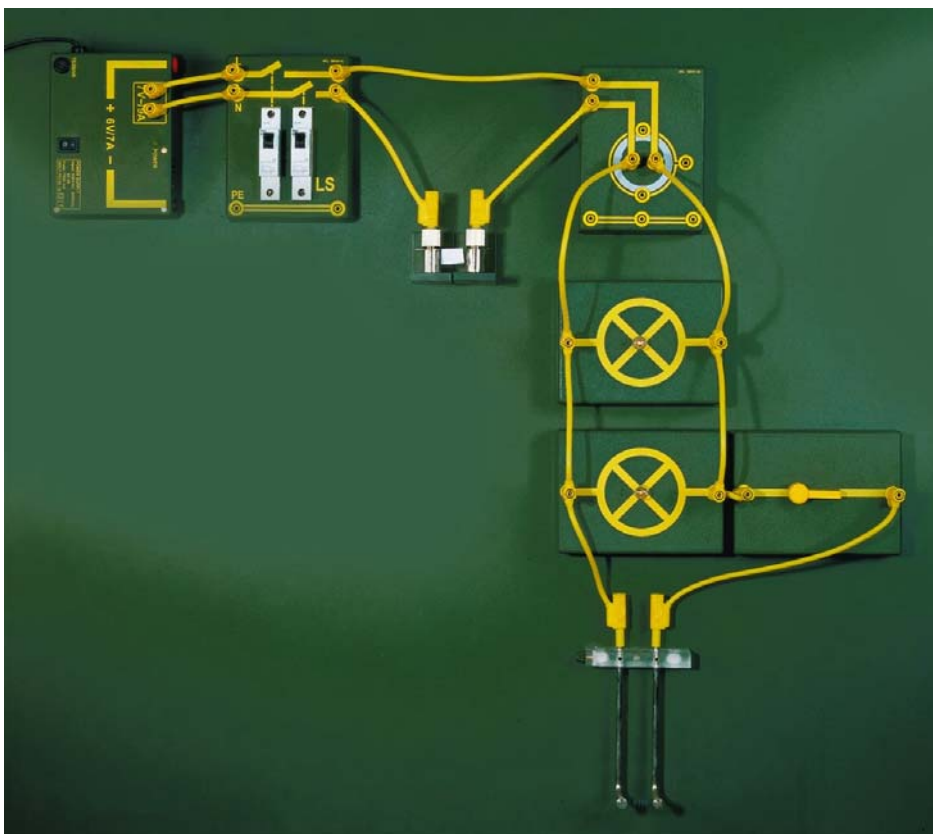
### Kísérlet 1:

Állítsuk össze a kísérletet az ábra szerint.

- Suspend constantan wire,  $d = 0.5 \text{ mm}$ ,  $l =$  approx. 4 - 6 cm, between the two terminal posts. Hang the paper slip over the wire.
- Screw the two light bulbs 6 V/1 A the into light bulb sockets, at first without touching the inside contact.
- Apply 7 V AC.
- Screw in the light bulbs one after the other until they touch the contacts.
- Include the filament in the circuit by means of the switch.
- The constantan wire heats up, paper slip burns.
- A universal multimeter (range: 10 A~) can be connected between the outlet and the light bulb socket in order to observe the rise in current.



## Kísérlet 2:



- Wire the box – circuit breaker into the circuit in front of the terminal posts and constantan wire as shown in the diagram.
- Put both switches of the circuit breaker in the upper position.
- Apply 7 V AC.
- Screw in the light bulbs one after the other until they touch the contacts.
- Include the filament in the circuit (the filament does not glow!).
- Overloading trigger of the circuit break disconnects after a maximum of 10 to 50 seconds.

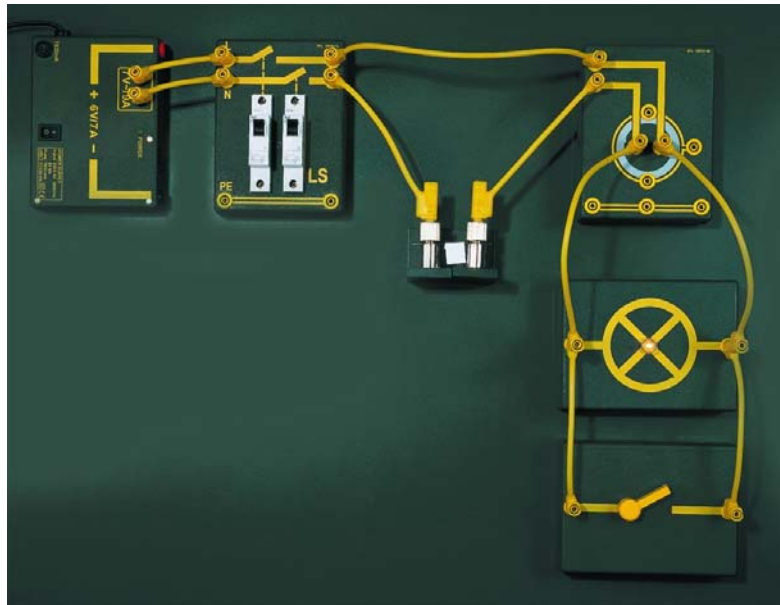
## A rövidzár

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E1	1	Lámpafoglat, E10	DE720-2A
E1	1	Ki-, bekapcsoló	DE720-2R
E4	2	Közösítő, mágneses	DE453-2V
EZ	1	Konstantán huzal, tekercs, $d=0,5$ mm, $L=15$ m	DE330-1B
EZ	1	6V/1A, E10 lámpa, 5db-os készlet	DE309-4S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

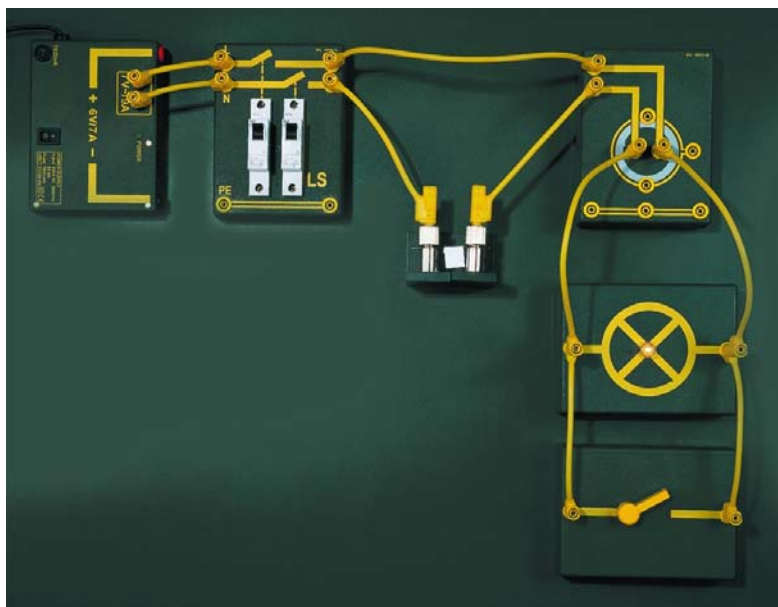
A connection between lead-in wires arising from an error (without any resistance due to a power-consuming device) is termed a "short circuit". The resulting increase in current causes the lead-in wires to heat up and glow, catch fire and then burn up. In a case like this the fuse must interrupt the circuit very quickly (electromagnetic tripping device).

### Kísérlet 1:



- Állítsuk össze a kísérletet az ábra szerint.
- Constantan wire  $d = 0.5$  mm,  $l =$  approx. 4 - 6 cm, is suspended between the two terminal posts. Hang the slip of paper over the wire.
- Box - light bulb socket E 10 with the light bulb 6 V/1 A is connected to the outlet.
- Apply 7 V AC, the light bulb glows.
- Short circuit is created by bridging the light bulb i.e. closing the switch. The constantan wire glows brightly, the paper slip burns up.
- Remove short circuit (open switch).

## Kísérlet 2:



- Állítsuk össze a kísérletet az ábra szerint.
- Automatic circuit breaker is wired into the circuit in front of the terminal posts with constantan wire as in experiment 1.
- After the short circuit is created by bridging the light bulb (close the switch), the circuit breaker interrupts the circuit after 5 seconds at the most (when 7 volts is used to carry out the experiment).

### Megjegyzés:

In this case too the circuit is interrupted thermally since the amount of current necessary for an electromagnetic triggering device is not achieved. To this end the voltage applied would have to be increased to 24 volts.

(Caution: use the light bulb DE309-6S 24V/100 mA!)

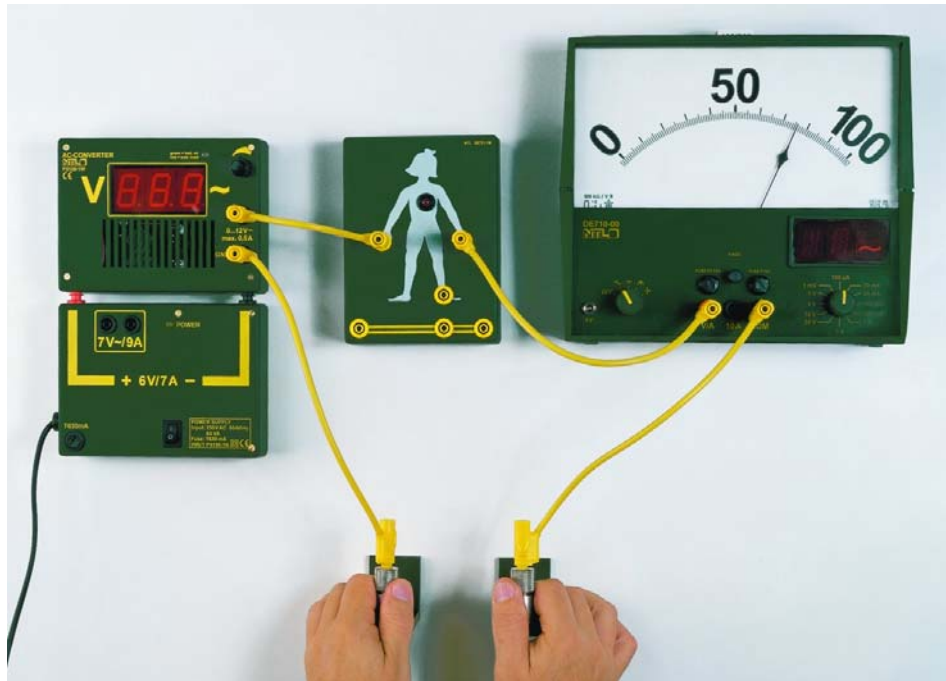
## Az emberi test ellenállása

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Emberi test modell	DE721-1M
E4	2	Közösítő, mágneses	DE453-2V
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	AC átalakító, mágneses	P3120-1W
EZ	1	Demonstrációs multiméter I, mágneses	DE710-00
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

1. Resistance depends on the size of the area touched and, to an even larger degree, on the amount of moisture in the skin.

2. Measuring the human body's resistance at varying voltages reveals that resistance decreases as voltage increases.



### Kísérlet:

Állítsuk össze a kísérletet az ábra szerint.

- a) The two metal parts of the terminal posts are held in each hand with two fingers in each case. MÉRJÜK az áramot.
- b) The two fingers press against the metal parts of the terminal posts; amperage is measured as in a).
- c) The two metal parts are held as in a) except that the fingers are moist; amperage is measured.

## Az emberi test az áramkörben

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

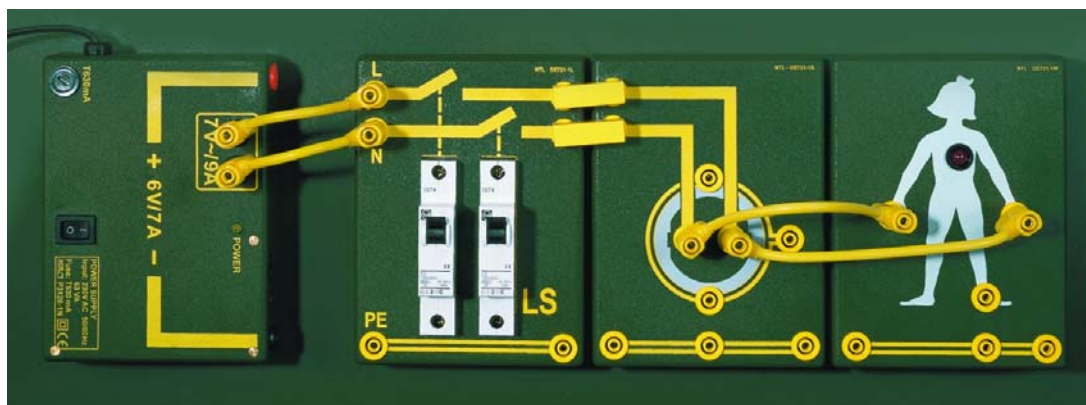
A mains voltage of 230 volts can kill a person if he or she becomes part of the circuit. The human body's resistance depends on the voltage applied since the skin lets increasingly more current through, the higher the voltage. Using a battery, a body resistance of about 100,000 ohms is measured, whereas this value is reduced to approximately 1000 ohms when 230 volts flow along a path from hand to hand or from hand to foot. A current of about 200 milliamperes results from 230 volts, an amount which is absolutely lethal.

Effects of alternating current flowing through the body:

- 1 mA Threshold of perception
- 15 mA Threshold at which cramping occurs
- 20 mA No longer able to release oneself from the circuit unaided
- 50 mA Threshold of danger
- 80 mA Unconsciousness and death when exposed for over one second

In the neighborhood of 70 volts body resistance may assumed to be 3500 ohms. In order for the current to remain under 20 mA, according to Ohm's Law the threshold of danger lies below 70 volts ( $0.02 \text{ A} \times 3500 \text{ Ohm} = 70 \text{ Volt}$ ). This is the reason that the boundary between small voltage and low tension was originally set at 65 volts and is now 42 volts.

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Throw both switches of the automatic circuit breaker in the upper position.
- Apply 7 V AC.
- Box – "model of the human body" is connected to the box – receptacle. The signal lamp ("danger LED") on the body lights up and an alarm sounds, signaling the fact that a lethal amount of current is flowing through the body.

## Az egyik pólus érintése is halálos lehet

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6 db-os készlet	DG500-6G
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

1. One of the two mains lead-in wires, the "neutral" lead marked with an "N", is grounded by the power company ("plant ground"). Thus, any other connection with the ground can serve to conduct electricity in the other direction. Any individual who, when well grounded, touches only one of the contacts of the power supply ("outer wire" or "phase lead") can be killed.

2. A lethal accident results from two factors:

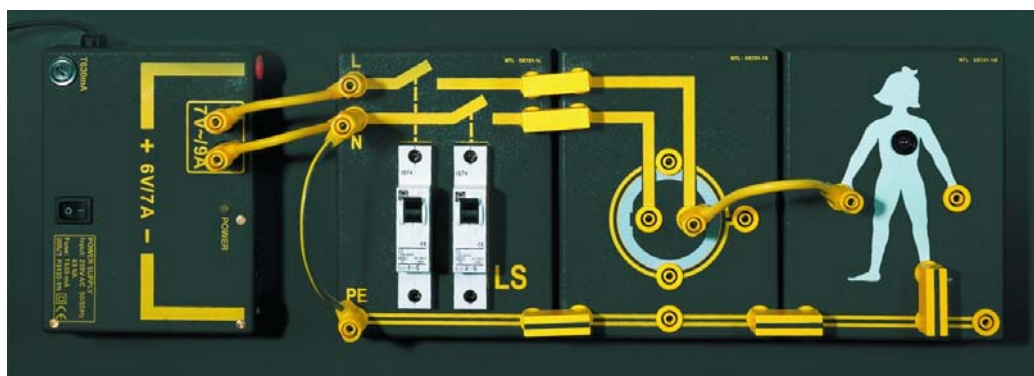
a) the person is relatively well grounded and touches only the outer wire "L".

b) One of the lead-in wires, the neutral lead "N", is well connected to a ground by the power company.

3. Thus we can follow the path of lethal electricity:

Coming from the outer wire "L" to the person, it flows through the body towards the ground and flows back to the neutral lead "N" by way of the plant ground "PE".

### Experiment:



Állítsuk össze a kísérletet az ábra szerint.

- Make a ground connection to the box – automatic circuit breaker (plant ground) using the green-yellow connection wire and a ground connection from the ground plug on the circuit breaker to the receptacle outlet and the model human body using another green-yellow wire.
- Apply 7 V AC.
- When the body touches the outer wire of the receptacle by way of a connection wire, the red warning LED lights up and the alarm sounds.
- Remove the ground plug from the body. There is no more danger for the person.
- Remove the ground connection (plant ground) from the box – circuit breaker. There is no more danger for the person, even when the ground connection on the body is restored.

### Note:

It is recommended to conduct this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## Az egyik pólus érintése a készülék házának érintésével

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
EZ	1	Izzó, 6V/0.05A, E10, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

1. Normally the metal housing of an electrical appliance (electric stove, refrigerator, iron, lamp etc.) are well insulated from the power source and may be touched without danger.

2. If a strand of wire in the power cord is sticking out, the insulation is cracked, moisture is present or there is internal damage to the appliance, the outer wire and the metal housing can come into contact. The technical term for this is a "body contact". In the case of a person who is well grounded (conductive floor, bathtub), the current flowing through that person can kill him or her.

3. The technical term "body contact" therefore has nothing to do with the human body, it refers to the body of an electrical appliance. The technical term used to be "housing contact".

4. Contact with one of the electrical leads may result from a body contact. Electricity flowing through a metal housing can be re-routed by a well grounded person touching the housing and the current can kill the person.

5. It is not quite accurate to say that "the current flows toward the ground" because, just like in any circuit, the current must flow to the other pole of the power supply. This means that the current must flow from the outer wire back to the generator by way of the ground and the plant ground. Yet even this description is merely a piece of imagery because in actuality electrons within a power system's potential do not flow but rather vibrate with tiny amplitudes at a rate of 50 times a second!

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Push both switches of the automatic circuit breaker to point upward.
- Establish ground connections to the box – fault current switch using the yellow-green connection wire and to the model human body using the yellow-green connection plug.
- Screw the light bulb 6 V/50 mA into the appliance socket.
- Make a body contact using the yellow short circuit plug on the box – electrical appliance (outer wire-housing).
- Apply 7 volts AC.

## ES 06

NTL – innoSYSTEM

RAPAS kft. 1184 Budapest, Üllői út 315. Tel.: 06 1 294 2900 Fax 06 1 294 5837 E-mail: rapas@axelero.hu

- The red warning LED on the appliance housing lights up. This indicates that the housing conducts electricity to the ground.
- The human body contacts the housing conducting current (connect the model human body and the housing). The red danger LED lights up and the alarm sounds, indicating that lethal current is flowing from the housing to the ground.

**Note:**

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## Halált okozó hibák

### Szükséges eszközök:

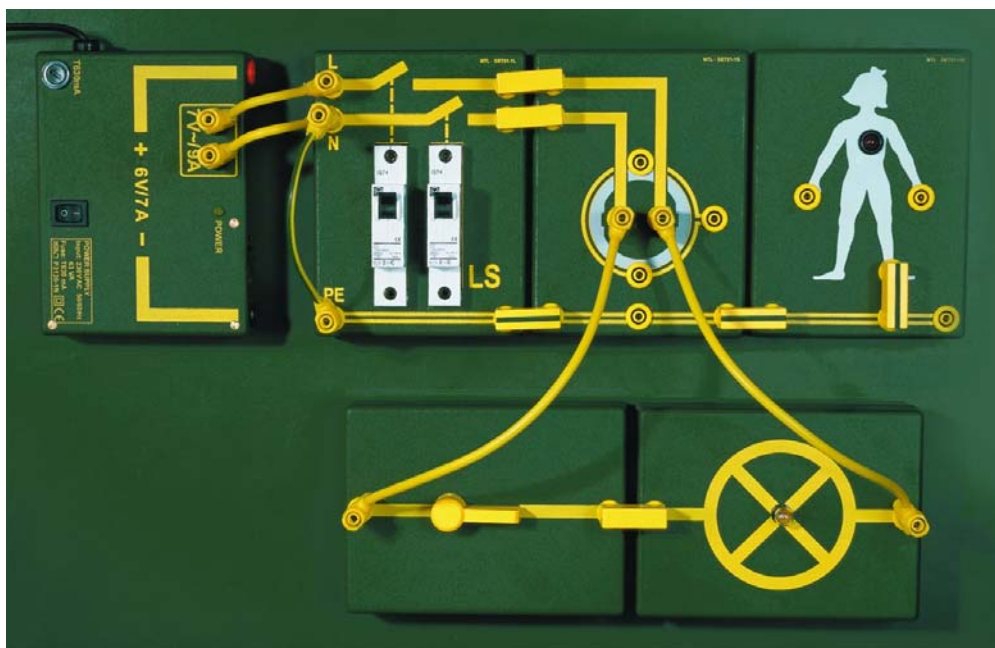
Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E1	1	Lámpafoglat, E10	DE720-2A
E1	1	Ki/Be bekapcsoló	DE720-2R
E4	1	Érintkező, L=140 mm	DE451-3W
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	6V/0.5A, E10 lámpa, 5db-os készlet	DE309-3S
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

1. People who do not understand enough about a subject can easily make mistakes. Some errors can be lethal.

A handyman working on an appliance (e.g. an electric lamp) turns the switch to the "OFF" position, thinking that no more electricity is flowing. This person's life is in danger. If the neutral lead is connected to the switch, the mains potential is still flowing through the appliance (e.g. through the light bulb socket), meaning that a well grounded person can be killed. A switch must always be connected to the outer lead!

2. Cutting just one circuit breaker during repairs does not necessarily mean that the power is cut; the situation might be lethal. If the circuit breaker happens to be connected only to the neutral lead, then the mains potential is still flowing through the appliance, which can kill a well grounded person.

### Kísérlet:

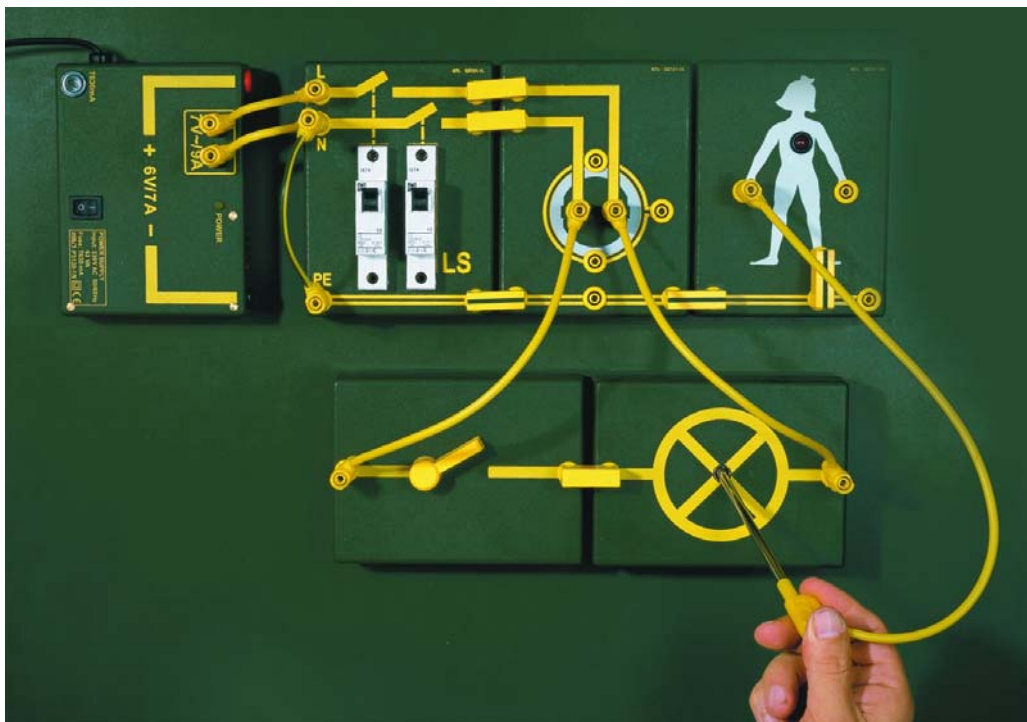


Ábra 1

Állítsuk össze a kísérletet az 1. ábra szerint.

- Put both of the switches of the automatic circuit breaker into the upper position.
- Make ground connections (plant ground), to the automatic circuit breaker using the yellow-green connecting wire and to the model human body using the yellow-green connecting plug.
- Connect the box ON-OFF switch, already connected to the box - light bulb socket E 10, to the receptacle outlet as in the diagram (the light bulb socket is connected to the outer lead).

- Apply 7 volts AC.
- Screw the 6 V/0.5 A light bulb into the light bulb socket and close the switch – the light bulb lights up; open the switch – the light bulb goes out.
- Remove the light bulb from the box - light bulb socket E10; by way of a contact pin the human body comes into contact with the bottom contact of the light bulb socket (diagram 2).
- The warning LED lights up and the alarm sounds even though the switch is open. This indicates a lethal accident since the light bulb socket is connected to the outer wire.
- Screw the 6 V/0.5 A light bulb into the light bulb socket E10 and close the switch – the bulb lights up.
- Put the right switch of the automatic circuit breaker into the lower position (switched off); the light bulb goes out.
- With the switch in front of the light bulb still open, the light bulb is screwed out of the socket.
- The human body touches the bottom contact of the light bulb by way of the connecting wire and contact pin. The signal LED on the human body lights up and the alarm sounds.
- Exchanging the lead-in wires on the receptacle outlet causes the signal LED on the human body to not light up.



Ábra 2

**Note:**

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## Helyi szigetelés

### Szükséges eszközök:

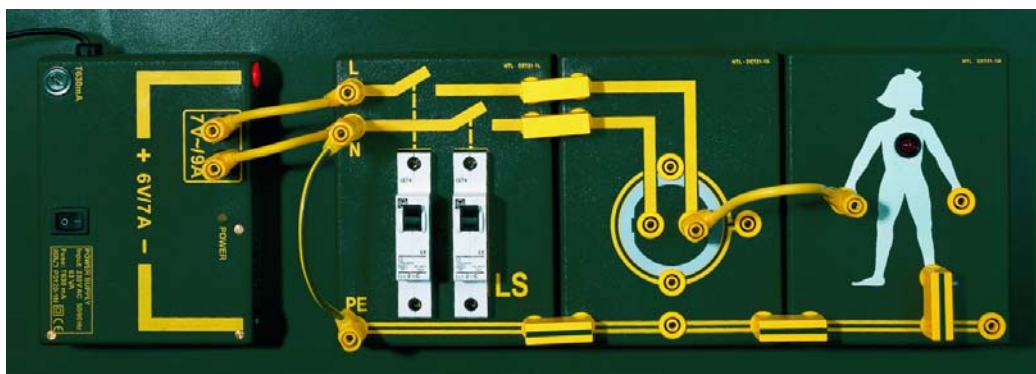
Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

1. Normally it is not dangerous to touch the neutral lead because this is connected to the ground potential (in the normal case). However, experiments further below will demonstrate that even the neutral lead can conduct a dangerous potential to the ground.

2. Touching the outer lead is dangerous when well grounded. This means that a dangerously high current can flow through the body to the ground. The threshold of cramping is 15 mA, meaning that any ground resistance below  $230/0.015 = 15.333$  ohms is dangerous. The human body's resistance of between 1000 and 3000 ohms plays no role in this case.

3. If no other protective measures are possible (e.g. during repairs), the site must be well insulated from the ground. This safety measure is termed "site insulation".

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Put both of the switches on the automatic circuit breakers into the upper position.
- Connect the automatic circuit breaker to the plant ground using the yellow-green connection wire and the model human body to the ground using the yellow-green ground plug.
- Apply 7 volts AC.
- The body touches the neutral lead (by way of the connecting wire to the left-hand contact on the receptacle); there is no danger as the signal LED on the human body does not light up.
- The body touches the outer lead (by way of the connecting wire to the right-hand contact on the receptacle); the signal LED lights up and the alarm sounds, indicating that lethal current is flowing through the human body.
- The human body is insulated from the ground: remove the ground plug from the human body to the ground connection. There is no danger to the body when one contact is touched, not even when the outer lead is contacted.

### Note:

Site insulation only protects from danger when touching one of the contacts!

## Védő-szigetelés

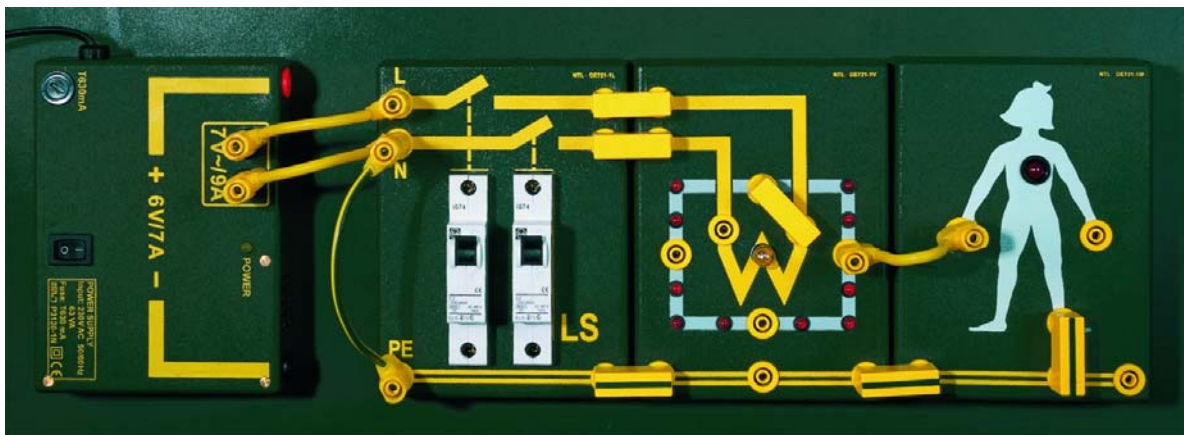
### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E7	2	300-menetes tekercs	DE453-1C
E7	1	Lemezelt U-vasmag	DE452-2B
E7	1	Vasmag, rövid, lemezzelt	DE452-3B
E7	2	Rögzítő	DE452-4B
E7	1	U-vasmagtartó, csúszó sínen	DS500-2G
S1	2	Állványtalp, mágneses, L=200 mm	DS102-1G
S1	1	Tartósín, L=325 mm	DS104-3G
EZ	1	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

Given the danger of body contact (e.g. due to moisture in the bathroom or in a factory), danger to human beings can be prevented by means of protective isolation. The potentially dangerous part of the power system is wired with a transformer with a turns ratio of 1 : 1. The connections proceeding from the secondary winding of the transformer are not grounded and thus no potential is possible between the appliance and the ground, even in the case of a body contact. The outlet for an electric razor in the bathroom is the most familiar example of protective isolation.

First we will once again demonstrate that the plant ground is responsible for death in cases when only one contact is touched. Then we will look at how to render the plant ground harmless by wiring a transformer into the circuit.

### Kísérlet 1:

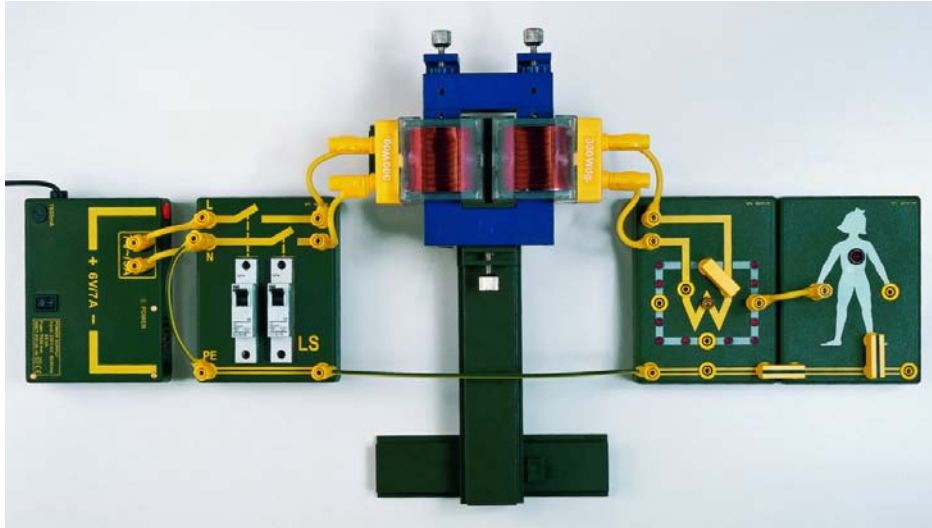


Állítsuk össze a kísérletet az ábra szerint.

- Set both of the circuit breaker switches into the upper position.
- Connect the circuit breaker to the plant ground using the yellow-green connection wire and ground model human body.
- Screw the light bulb 6 V/50 mA into the appliance.
- Apply 7 volts AC.
- Create a body contact using the short-circuit plug on the box – electrical appliance 1 (outer lead – housing). The red warning light on the side of the appliance housing lights up, indicating that the housing is conducting electricity to the ground.

- The human body contacts the housing conducting current (connecting wire between human body and housing); the signal LED lights up and the alarm sounds, indicating that a lethal situation has occurred.
- The plant ground (yellow-green connection wire) is removed from the automatic circuit breaker. There is no more danger since the ground can no longer conduct current back to the source.
- Turn off the power.

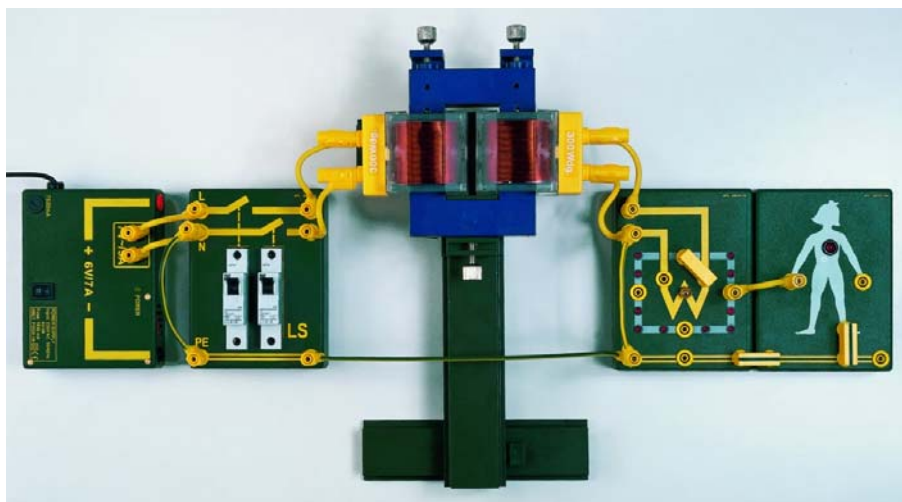
#### Kísérlet 2:



Állítsuk össze a kísérletet az ábra szerint.

- Re-connect the plant ground (yellow-green connecting wire) to the circuit breaker.
- A mountable transformer consisting of 2 X 300 turns with a closed iron core is connected between the circuit breaker and the receptacle outlet.
- Apply 7 volts AC.
- The human body contacts the housing of the appliance.
- The signal LED on the human body does not light up because the plant ground has no effect on the secondary circuit: the secondary step of the transformer is not grounded and therefore no current flows to the ground. Protective isolation isolates the circuit from the plant ground.

#### Kísérlet 3:



Állítsuk össze a kísérletet az ábra szerint.

- Ground the secondary step of the transformer (connect the left lead-in connector with the terminal of the appliance holding the yellow-green connecting wire to the ground connection).
- Death occurs immediately (signal LED – alarm from the human body) because now

there is a closed circuit from one of the transformer posts, through the appliance with a body contact, the human body and the ground, back to the other post of the transformer.

#### Note:

The secondary step of the transformer must not be grounded.

## Védőföldelés

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
EZ	1	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

The oldest method of protecting against a lethal shock due to a possible body contact is by grounding all metal housings by means of a "safety connection". In this case metal bands or pipes are buried in the ground and the safety connection (indicated by green-yellow wiring) is connected to this ground. Should a body contact occur, the electricity flows from the generator and to the appliance by way of the outer lead, traveling from the metal housing of the faulty appliance through the safety connection to the ground. Here it must overcome the ground's transfer resistance in order to flow to the plant ground and back to the generator.

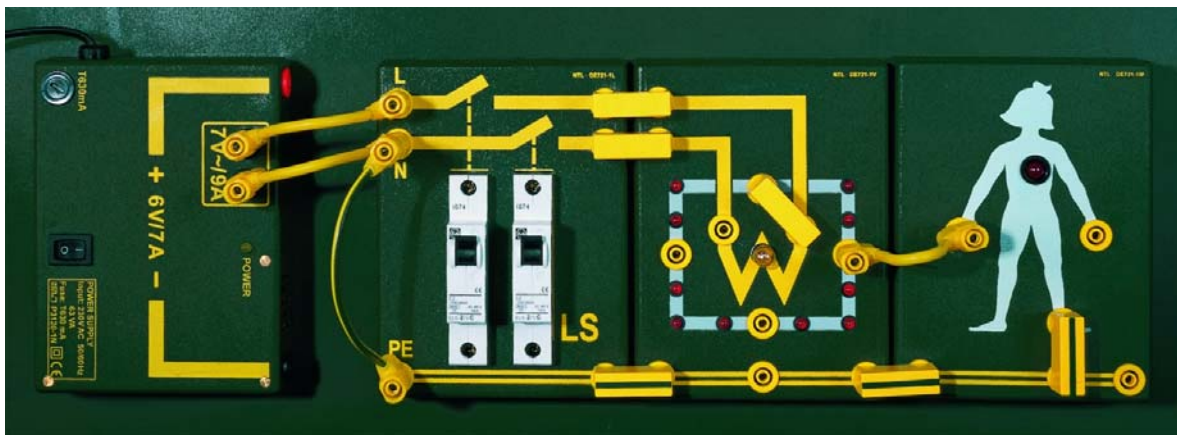
When the total resistance of the path of conduction from the metal housing to the generator, the "ground resistance", is small enough, the current becomes so strong that the safety switch breaks the circuit.



### Kísérlet:

Állítsuk össze a kísérletet az ábra szerint.

- Push both switches of the automatic circuit breaker to point upward.
- Connect the circuit breaker to the plant ground using the yellow-green connection wire and ground model human body (the person is standing on a conducting surface).
- Screw the light bulb 6 V/50 mA into the appliance.
- Connect the immovable appliance to protective grounding by inserting a yellow-green grounding plug.
- Apply 7 volts AC.
- Human body contacts the appliance housing by way of the connecting wire between the human body and the housing.
- Create a body contact in the appliance using the yellow short circuit plug. The safety switch cuts the power instantly, before the person is harmed by touching one of the contacts. (Signal LED on the human body does not light up and the alarm does not sound.)
- The appliance body contact is to be made again, with and without protective grounding (yellow-green grounding plug on the appliance), demonstrating how protective grounding can save life.



**Note:**

Point out that bridged ("patched") fuses not only increase the danger of fire, they also can endanger human life because fuses that are too strong do not cut the circuit, thus not eliminating a possible body contact in the appliance.

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

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**ES 10**

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RAPAS kft. 1184 Budapest, Üllői út 315. Tel.: 06 1 294 2900 Fax 06 1 294 5837 E-mail: rapas@axelero.hu

## Földelt csatlakozó aljzat

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S
EZ	1	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S

A movable appliance to be fitted with a protective grounding must have a power cord with three wires: an outer lead, a neutral lead and a ground lead (colored green and yellow). The ground wire terminates in the lateral contacts of the plug. These are held snugly by the ground contacts of the receptacle outlet in order to ensure good contact. The ground contacts in the outlet must be connected with a ground by way of an extension of the ground contact.

There are two potentially lethal mistakes in the case of a body contact:

1. The power cord contains no wiring for a ground contact.
2. There is no connection from the outlet to the ground.

In each of these cases the connection between the appliance and the ground is interrupted.

### Kísérlet:



- Set up the experiment according to the diagram above.
- Push both switches of the automatic circuit breaker to point upward.
- Connect the circuit breaker to the plant ground using the yellow-green connection wire and ground the model human body.
- Screw the light bulb 6 V/50 mA into the appliance.
- The grounded receptacle outlet is connected with the appliance by way of three wires. The connection between the ground contact of the outlet and the housing is made using the yellow-green connecting wire. The ground contact of the outlet is connected to the ground using the yellow-green grounding plug.
- The human body contacts the side of the housing – make contact using the connecting wire.
- Apply 7 volts AC.

- Create a body contact using the yellow short circuit plug on the appliance. The circuit breaker cuts the circuit.
- The power cord has no protective grounding: remove the yellow-green connecting wire between the appliance and the ground contact of the outlet.
- Reset the circuit breaker: push both switches on the circuit breaker to point upward.
- The signal LED on the human body lights up and the alarm sounds, indicating a lethal situation.
- Plug the yellow-green connecting wire from the ground contact of the outlet into the side of the appliance housing once more: the circuit breaker cuts out.
- Remove the yellow-green grounding plug from the grounded outlet to the ground and reset the circuit breaker by putting both switches into the upper position. The signal LED on the human body lights up and the alarm sounds.
- Reinsert the yellow-green grounding plug from the outlet to the ground; the circuit breaker cuts out.

**Note:**

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## A védőföldelés hátrányai

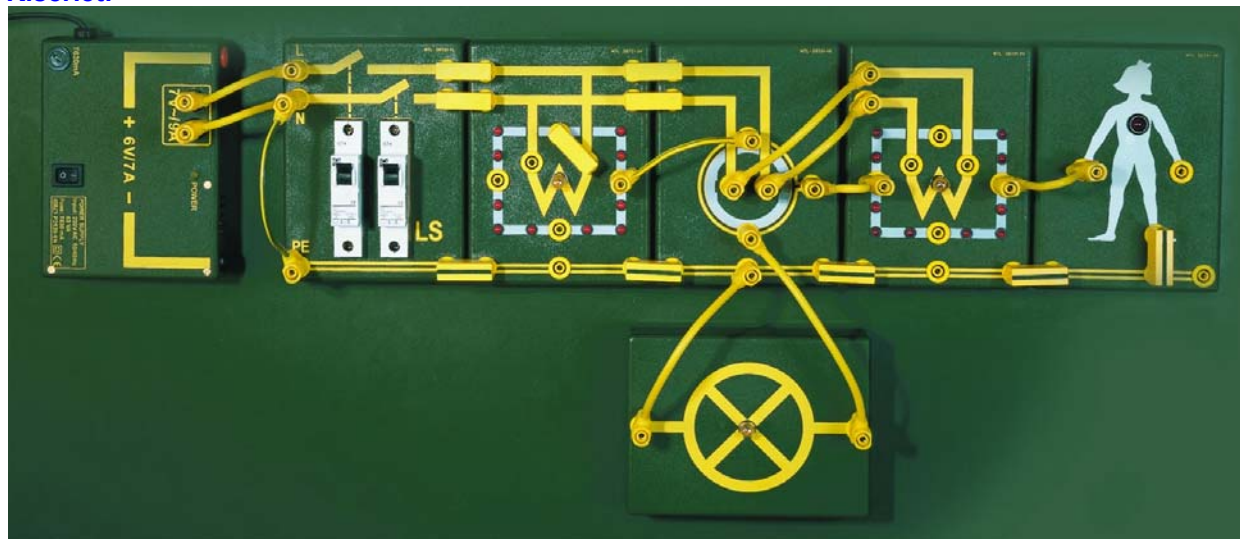
### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Elektromos készülék 2.	DE721-2V
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E1	1	Lámpafoglat, E10	DE720-2A
EZ	3	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

Consider how large the total resistance, from the body contact through the protective grounding and plant ground to the generator, may be in order for the fuse to cut the circuit quickly enough (in this case it requires about five times the nominal current!). A 10 A fuse would require 50 A; at 230 volts that would mean approximately 4 ohms total resistance, whereby 2 ohms are necessary just for the plant ground. The ground resistance could therefore be no more than 2 ohms (even less in the case of stronger fuses!).

It is often difficult to achieve such a small ground resistance. Metal water pipes, earlier the mainstay of protective grounding, are being increasingly replaced by plastic ones. Moreover, the ground has a high specific resistance. If the small ground resistance necessary is not achieved, the fuse does not cut out and the voltage not only is maintained on the faulty appliance but also comes to encompass all other appliances connected to the same protective ground. The appliances and outlets in a household are not individually grounded but rather are all connected to a common ground lead. Thus, protective grounding can turn into a deadly trap!

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Push both switches of the automatic circuit breaker to point upward.
- Connect the circuit breaker to the plant ground using the yellow-green connection wire and ground the model human body.
- Screw the light bulb 6 V/50 mA into the appliance.
- The right-hand appliance V 1 is connected to the outlet by way of three wires (connect the grounding outlet with the side of appliance 1 using the short yellow-green connecting wire).

- The high ground resistance is simulated by inserting the box - light bulb socket E 10 with the 6 V/50 mA light bulb into the ground connection of the outlet.
- The two appliances are connected to the badly grounded contact of the outlet.
- The model human body is well grounded by means of the grounding plug and touches the right-hand electrical appliance.
- Apply 7 volts AC.
- Create a body contact in appliance 2. Appliance 1, even though not faulty, is also under electricity (the red warning light in the housing lights up) and causes death. The signal LED on the human body lights up and the alarm sounds.

**Note:**

Due to the level of danger at 65 and 42 volts respectively, regulations specify that ground resistance may not be greater than (and, in the case of dry soil, may never supersede) 65 or 42 volts divided by the cut-out amperage. The cut-out amperage of automatic circuit breakers is five times the nominal current; in the case of fuses it is three and one-half times the nominal current.

**Note:**

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## Halál a zuhanyozóban - potenciál-kiegyenlítés

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Elektromos készülék 2.	DE721-2V
E9	1	Tusoló modell	DE721-1D
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E1	1	Lámpafoglat, E10	DE720-2A
EZ	3	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

It is dangerous to get caught up between two different potentials, as happens most commonly in the home in the bathtub or shower.

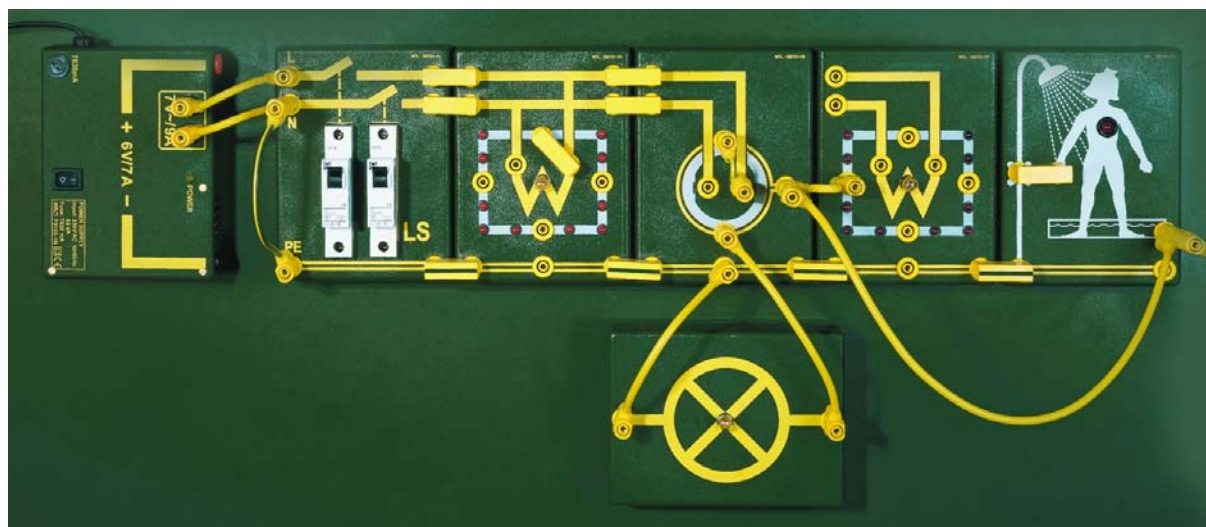
Not all grounds are equally as good. Let us assume that the shower basin is connected to a relatively bad ground lead. In this case it is connected to the protective grounding of a wall outlet. The light bulb between the plant ground lead and the ground contact of the outlet simulates the higher ground resistance in this case.

The water faucet in the shower, on the other hand, is well grounded. If a body contact occurs in any appliance connected to the relatively badly grounded ground contact of the outlet, electricity will flow through the person in the shower when he or she touches the faucet.

Grounded metal housings are no safety guarantee! It is obvious that a potential can be created between two grounded metal objects because of ground resistance!

A "potential compensation lead" between the faucet and the shower basin would have prevented death in this case. It is, therefore, important to give attention to "potential compensation" as a protective measure! When all conductive surfaces that can be touched simultaneously are well connected, there is no danger of getting caught up between different potentials.

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Push both switches of the automatic circuit breaker to point upward.

- Connect the safety contact switch to the plant ground by means of the yellow-green connecting wire and connect the "shower" to the ground.
- Screw the light bulbs 6 V/50 mA into both appliances.
- Simulate a bad ground by inserting the box – light bulb socket E 10 with light bulb 6 V/50 mA into the ground contact of the outlet.
- The shower bar and faucet are well grounded.
- Connect the shower basin with the right-hand ground lead contact of the outlet using the yellow-green connecting wire. By touching the shower basin, the person is connected to the same ground.
- For some reason a potential enters the ground circuit (e.g. a wire in the outlet comes loose from its terminal and touches the ground contact).
- Connect the right-hand contact in the outlet with the ground contact above using the short green-yellow connecting wire.
- Apply 7 volts AC.
- The person touches the faucet (insert the yellow short circuit plug). Death by shock ensues. The signal LED on the human body lights up and the alarm sounds.
- Add a potential compensation lead by connecting the shower basin with the ground using the short connection wire. The circuit breaker cuts out.

**Note:**

An important variation of this experiment may be recommended. The important aspect of potential compensation is not that it leads to the circuit breaker cutting out, as one might believe after this experiment, but that a potential between the faucet and the shower basin is prevented. For if the faucet had too much ground resistance to cause the circuit breaker to cut out, the dangerous potential would nonetheless have been avoided.

In order to demonstrate this, the light bulb is connected to the faucet to represent ground resistance. When the same procedure as above is followed, it may be observed that the potential in the human body disappears even though the circuit breaker does not cut out.

**Note:**

In this experiment the cut-out is caused thermally, since the amount of current necessary for an electromagnetic circuit breaker is not reached. In this case the voltage used must be raised to 24 volts (caution: use the light bulb DE309-6S 24V/100mA).

**Note:**

It is recommended to carry out this experiment with the fault current or safety switch (cf. ES 14 ff.) included in the circuit.

## A hibaáram megszakító (biztonsági kapcsoló)

### Szükséges eszközök:

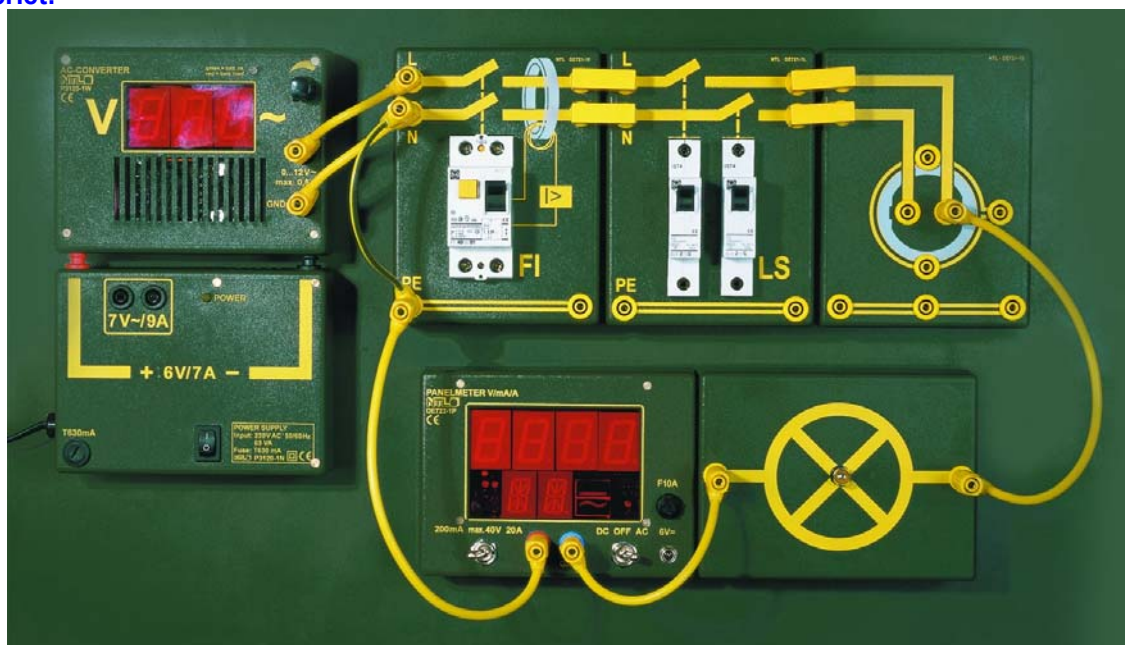
Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Hibaáram kapcsoló	DE721-1F
E9	1	Kismegszakító	DE721-1L
E9	1	Hálózati csatlakozó	DE721-1S
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E1	1	Lámpafoglat, E10	DE720-2A
E1	1	Digitális kijelző műszer	DE722-1P
EZ	1	6V/0.5A, E10 lámpa, 5db-os készlet	DE309-3S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	AC átalakító, mágneses	P3120-1W
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

The fault current (FI) circuit is based on the fact that electricity flowing toward the ground by way of a protective grounding ("fault current") comes from the outer lead but does not flow back into the building by way of the neutral lead, rather it reaches the generator by way of the plant ground. For this reason there is a difference in amperage between the two lead-in wires. This difference is recognized by the earth leakage circuit breaker and causes the switch to cut out.

In order to demonstrate how the circuit breaker cuts out when a certain amount of current is reached, fault current of a growing magnitude is generated by gradually increasing the voltage. This current flows from the outer lead of the outlet through an appliance and a measuring device and on to a ground connection, reaching the plant ground and finally the neutral lead.

The earth leakage circuit breaker used here has a nominal fault current rating of 100 milliamperes. It cuts out at between 40 and 90 milliamperes of fault current.

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Connect the safety switch (the earth leakage circuit breaker) to the plant ground using the yellow-green connecting wire.
- Connect the right-hand outer lead terminal of the outlet with the box – light bulb socket E 10 containing the light bulb 6 V/0.5 A.

## ES 14

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- Connect the other terminal of the light bulb socket to the box – panelmeter (mA ~ range).
- Connect the other terminal on the panelmeter with the plant ground.
- Activate the safety switch and the automatic circuit breaker (all switches in the upper position).
- Apply 7 volts AC.
- Gradually increase the AC voltage beginning at zero and observe the panelmeter. At what amperage does the circuit breaker cut out? Be careful to point out that the "fault current" in the outer lead flows through the safety switch but does not return through it. The "fault current" circumvents the safety switch by way of the plant ground.

**Note:**

The earth leakage circuit breaker is based on the principle of a "total current transformer". There are three coils around an iron core. The current flows to the appliance by way of the first coil and returns by way of the second coil, similar to the first in every way. The directions of the turns of the two coils are such that the magnetic fields produced oppose each other. When the current is the same in both directions, no magnetic field results and thus no induction voltage is created in the third coil. If, however, some of the current escapes the circuit by way of the ground and the plant ground and not all of it returns to the coil, the two magnetic fields no longer cancel each other out. Induction voltage is created in the third coil, which in turn serves to break the circuit.

## A hibaáram megszakító előnyei

### Szükséges eszközök:

Készlet	Db.	Megnevezés	Tápegység
	1	Komplett bemutatató tábla	DS103-1A
E9	1	Hibaáram kapcsoló	DE721-1F
E9	1	Kismegszakító	DE721-1L
E9	1	Elektromos készülék 1.	DE721-1V
E9	1	Emberi test modell	DE721-1M
E9	1	Rövidrezáró dugó, sárga, zöld-sárga, 11db-os készlet	DG500-5E
E9	1	Biztonsági mérővezeték zöld-sárga, 6db-os készlet	DG500-6G
E1	1	Lámpafoglat, E10	DE720-2A
EZ	2	6V/0.05A, E10 lámpa, 5db-os készlet	DE309-2S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

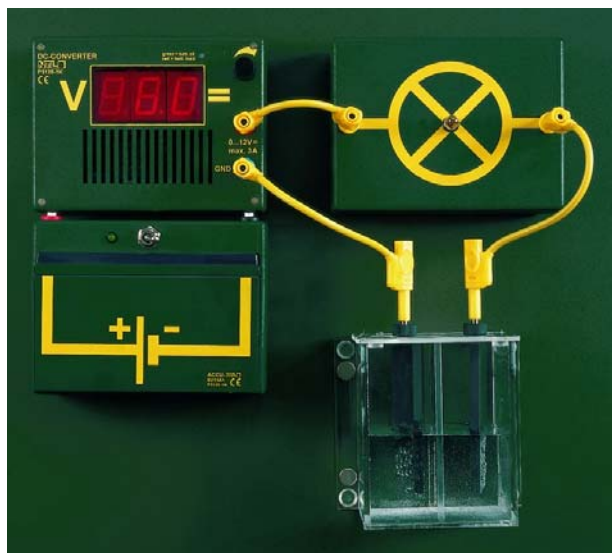
The fault current or safety switch makes a protective grounding much safer. In the experiment ES 12 "Disadvantages of protective grounding" it was calculated that an automatic circuit breaker requires at least 50 amperes to cut out. A safety switch, on the other hand, trips at less than 0.1 amperes. Thus, ground resistance may go as high as 650 ohms (65 volts / 0.1 amperes = 650 ohms), making up for the disadvantages of the protective grounding!

This experiment demonstrates that a higher ground resistance, as in experiment ES 12 "Disadvantages of protective grounding" symbolized by a light bulb, does not prevent a cut-out in the case of a body contact.

Even if the protective grounding is interrupted, a lethal amount of electricity will trip the safety switch, thus saving human life.

Beyond this it should be noted that any danger of fire is eliminated using this method because an electrical fire cannot be caused by a current of less than 100 mA.

### Kísérlet 1:



Állítsuk össze a kísérletet az ábra szerint.

- Connect the automatic circuit breaker to the plant ground using the yellow-green connecting wire.
- Screw the 6 V/50 mA light bulb into the appliance.
- The housing of the appliance is grounded by way of an increased ground resistance. The box – light bulb socket E10 containing the 6 V/50 mA light bulb is connected to the circuit.
- Apply 7 volts AC.

## ES 15

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- Create a body contact in the appliance using the yellow short circuiting plug. The red warning LED on the housing lights up. The automatic circuit breaker does not cut out due to the increased ground resistance.



## A hibaáram megszakító ellenőrzése

### Szükséges eszközök:

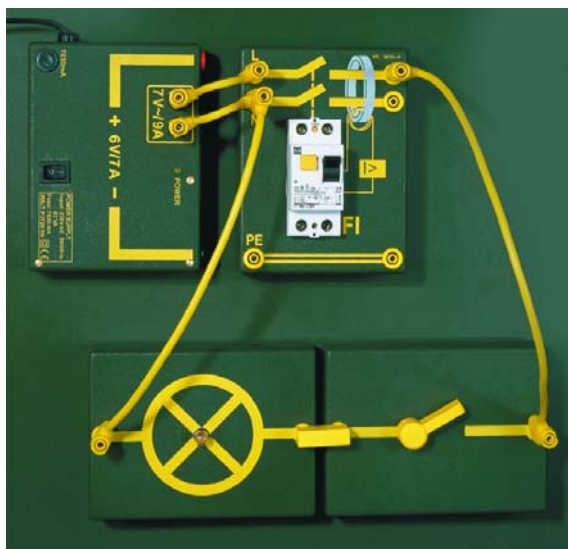
Készlet	Db.	Megnevezés	Rendelési szám
	1	Komplett bemutató tábla	DS103-1A
E9	1	Hibaáram kapcsoló	DE721-1F
E1	1	Lámpafoglat, E10	DE720-2A
E1	1	Ki-, bekapcsoló	DE720-2R
EZ	1	6V/0.5A, E10 lámpa, 5db-os készlet	DE309-3S
EZ	1	Hálózati transzformátor, mágneses	P3120-1N
EZ	1	20 db-os sárga mérővezeték készlet	DG507-1S

All things come to an end, even an earth leakage circuit breaker. That is the reason it should be checked regularly to see if it is working properly. This is done with the aid of the test button on the safety switch; pushing it should trip the circuit breaker.

Since we are not able to open up the switch, this experiment will demonstrate using a model what happens during such a check. A built-in resistor, represented in the experiment by a light bulb, serves to artificially produce a fault current of 100 mA which should trip the breaker. In order to simulate fault current, the test current must be measured after the switch but conducted back to the circuit in front of the switch (as seen from the household wiring).

It is important to understand that testing whether the safety switch works properly does not test whether the protective grounding is still in good order!

### Kísérlet:



Állítsuk össze a kísérletet az ábra szerint.

- Set the switch on the earth leakage circuit breaker in the upper position.
- Connect the outer lead after the safety switch with the switch, light bulb socket containing the 6 V/0.5 A light bulb and the neutral lead in front of the safety switch.
- Apply 7 volts AC.
- Close the switch; if the safety switch is functioning properly, it must cut out due to the artificially produced fault current.

### Megjegyzés:

Point out how important it is to test the safety switch regularly. Test it on a monthly basis by pushing the test button.