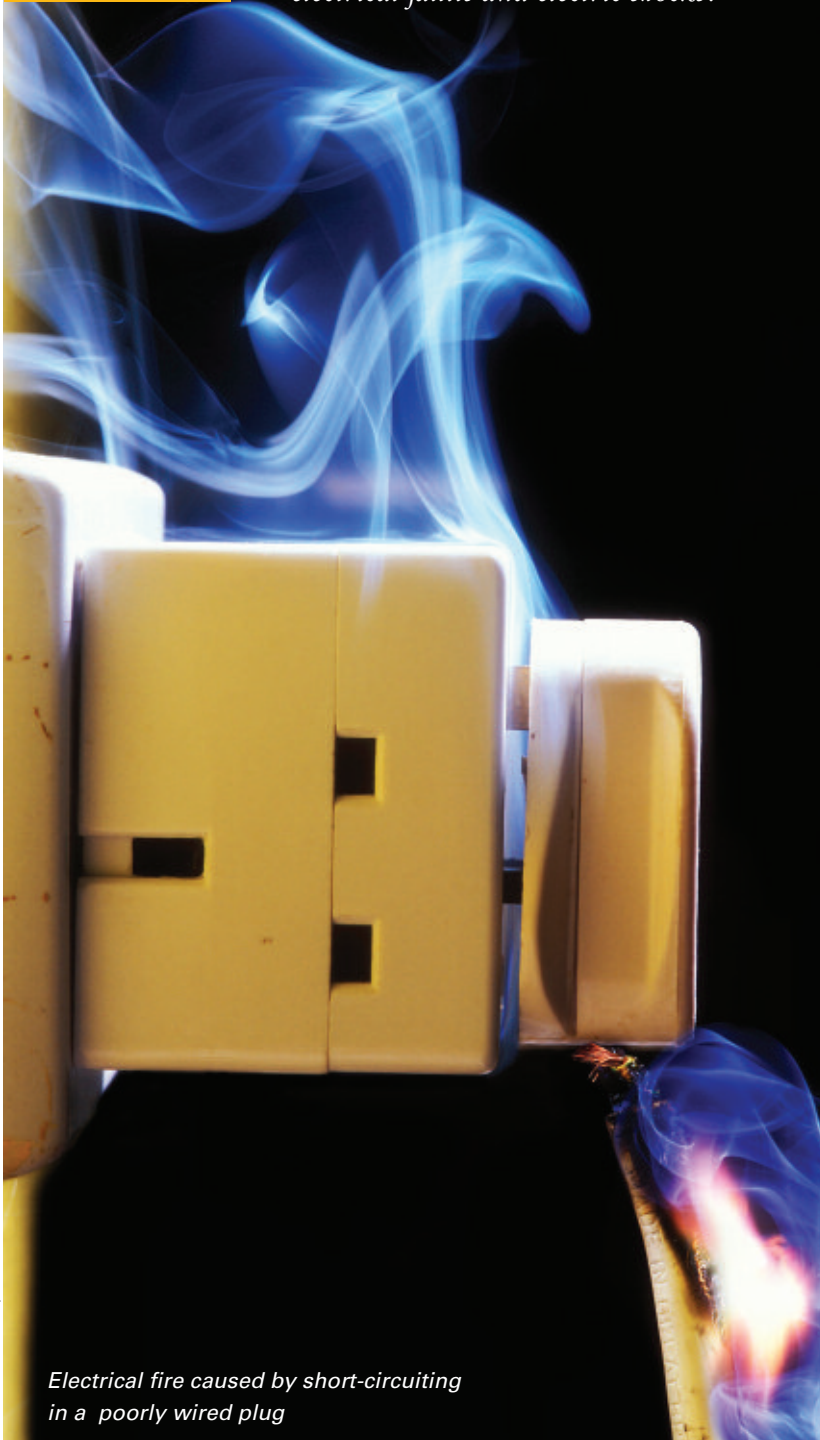


# Electrical safety

## GCSE key words

Circuit breaker  
Fuse  
Residual current  
device

*What causes faults in electrical appliances and the wiring installations in homes, and why do people receive electric shocks? How can regulations reduce the risk of electrical faults and electric shocks?*



*Electrical fire caused by short-circuiting in a poorly wired plug*

Dr John Brackebury/SPL

**E**lectrical appliances are items such as electric cookers, washing machines, toasters, televisions, computers and battery chargers which draw current from the mains supply. The **electrical installation** in a house has three parts: the consumer unit (containing the main switch and either circuit-breakers or fuses), the fixed wiring to power and lighting points, and the associated switches, socket-outlets and light fittings, all on the consumer's or load side of the electricity meter.

Electricity is generally safe to use, but there are some potential hazards (see Box 1).

## Faults and fires

Two types of fault can occur in an electrical circuit:

- An **earth fault** occurs when a live part comes into contact with earthed metalwork. This can happen, for example, if the insulation of the windings of a washing machine motor fail.
- A **short-circuit** occurs when a live part, such as the live conductor in a cable, comes into contact with a neutral conductor.

Each type of fault may cause currents of 1000 amps or more to flow. If such a current is not detected and interrupted straightaway, it will cause rapid heating, damaging the electrical installation; this could in turn set fire to the surroundings (see Box 2).

## Box 1 Electrical hazards

Some of the ways in which hazards can arise in using electricity include:

- overloading circuits
- damaged adaptors and extension leads
- not following equipment manufacturer's instructions
- drilling into a cable buried in a wall or partition
- touching electrical equipment with wet hands
- using electrical equipment outside when it is raining
- trailing cables under carpets or across walkways
- not repairing damaged equipment
- cleaning or repairing equipment that is plugged in
- cutting through cables with lawn mowers or hedge trimmers
- leaving electrical equipment unattended
- drying wet clothes above an electric heater
- installing equipment incorrectly
- accidental damage to equipment

## Box 2 Fire and electric shock statistics

The government collects statistics relating to electrical hazards. These indicate that 20% of all fires in homes in England and Wales are caused by electrical faults. These result in about 24 deaths and 590 non-fatal injuries each year. A further 12 deaths and 750 non-fatal injuries are caused by electric shock. Visit [www.communities.gov.uk](http://www.communities.gov.uk) and search for 'electrical safety' to find the sources of the figures quoted here.

## Electric shocks

The effects on the human body of a shock from mains electricity are complex. They depend on both the size of the current and the time for which it flows:

- A current through the body of as little as 0.5 mA (0.0005 A) may be felt, but generally will not startle the person affected.
- Currents between 0.5 mA and 10 mA are likely to be painful and will cause involuntary muscular contractions, but will not usually have any harmful effects.
- A current of 10 mA (0.01 A) is called the 'threshold of let-go'. With currents greater than this, it may not be possible to release your grip on a pipe or equipment that has become electrically live. Currents of between about 10 mA and 50 mA, which last for a long time, can cause strong involuntary muscle contractions, difficulty in breathing and disturb heart function, but probably no lasting organic damage.
- Sustained currents of over 50 mA (0.05 A) can cause serious effects, such as cardiac arrest, breathing arrest, burns and other tissue damage.

The main reason why people die from electric shock is ventricular fibrillation, when the heart loses its regular waves of contraction. The risk of this happening increases with the magnitude and duration of the current. Alternating current (a.c.) is more dangerous than direct current (d.c.) because it is more likely to affect the natural rhythm of the heart.

## Why do people receive electric shocks?

There are two ways in which people can suffer electric shock: direct and indirect contact.

### Direct contact

Direct contact occurs when someone touches an exposed live part, such as a bare wire. Such contact should not be possible, unless a cable's insulation is damaged, or a plug top or socket-outlet is missing or broken. Other common causes of direct contact are included in Box 1. Figure 1 shows how the current flows when direct contact happens.

### Indirect contact

Indirect contact occurs when someone touches a part which is not normally live. It becomes live due to a fault in the electrical installation or appliance. For

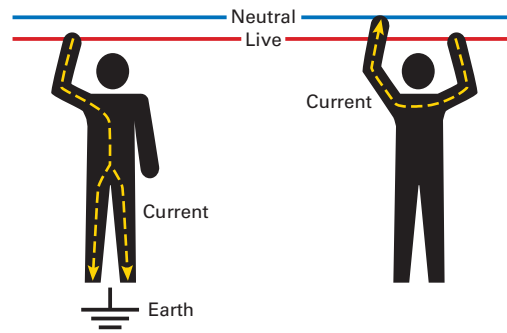


Figure 1 Flow of current in the event of direct contact

example, failure of the electrical insulation between a live part and the metal casing of an appliance would cause the casing to become live. You can identify other examples of indirect contact in Box 1.

## Protection against shocks

People are usually protected from direct contact with electricity by the insulation and enclosure of live parts. For example, there is insulation around the conductors in a flexible cable (which in turn is mechanically protected by the outer sheath), and the live parts of a light switch are enclosed by the switch plate and back box.

It is important to recognise that even the smallest fuse or circuit breaker will not protect against electrocution by direct contact. For example, the smallest fuse in a normal electric plug is 3 A. It takes less than a twentieth of that current to kill an adult in less than one tenth of a second.

## RCDs

A **residual current device (RCD)** can provide additional protection against direct contact. RCDs compare the sizes of the currents flowing in the live and neutral conductors of a circuit. In a healthy circuit, the currents will be equal. But if some of the current leaks to earth, for example through a person's body, the device will sense the imbalance and, if it reaches a predetermined threshold size, will rapidly disconnect the circuit.

RCDs have a rated tripping current of 30 mA or less, and they are designed to operate within 40 ms (0.04 seconds). Anyone making direct contact with an RCD-protected circuit will still receive a painful electric shock, but it is unlikely to be lethal.

Anyone working with mains powered equipment outdoors should always use an RCD. This is particularly true for lawn mowers and hedge trimmers. People often cut through the supply cable accidentally, exposing themselves and others to the risk of electric shock.

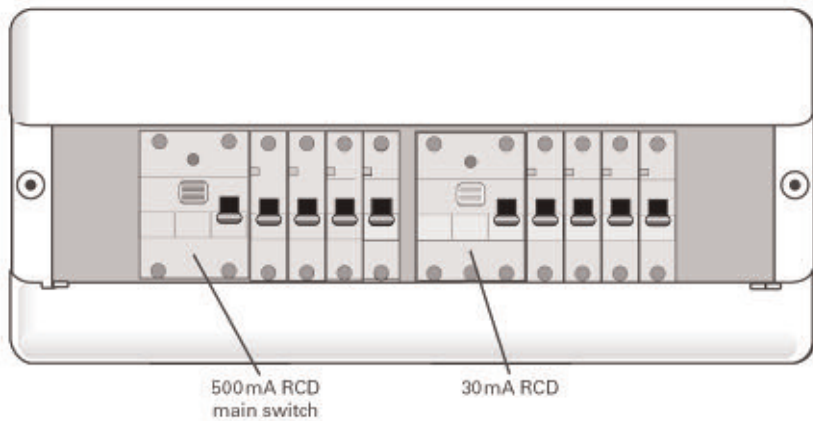
A significant proportion of electrocutions occur in the garden. This is because the effects of electric shock are generally more severe outdoors, where people are in contact with the ground. Damp ground provides a relatively low resistance path for shock currents to

Electricians refer to the 'live' wire as the 'line' or 'phase' conductor.

The nominal supply voltage and frequency for domestic electrical installations in the UK are 230 volts and 50 Hz (cycles per second).

RCDs are sometimes known as RCCBs (residual current circuit breakers). Don't confuse these with ordinary circuit breakers, which act as resettable fuses.

Answers to Box 4 on page 14, 'CE mark': appliance meets minimum safety requirements of the Low Voltage Electrical Equipment (Safety) Regulations 1989. 'Double square' appliance is double-insulated, so no earth connection is needed.



**Figure 2** Front view of a consumer unit containing a 500 mA RCD (used as main switch), circuit-breakers and a 30 mA RCD (used to protect circuits where portable equipment may be used outdoors)

Some house fires are caused when mice, rats or squirrels gnaw through the insulation on cables in roof spaces.

flow through the body. Ideally, RCD protection should be built into the consumer unit (fuse box) to ensure it is always present (Figure 2). Alternatively, plug-in RCDs are available which, for less than £10, can literally be life-savers.

### Fuses

Contrary to popular belief, the fuse in the plug of an appliance is not there to protect the appliance from overload, but to protect the flexible cord supplying it from overheating in the event of a fault (i.e. short circuit or earth fault).

If an appliance needs to be protected against overload, the means of protection must be built in to the appliance (see Box 3).

### Safer appliances and regulations

Most mains powered portable appliances on sale these days have double or reinforced insulation. This includes electric kettles and irons which have metallic casings. These appliances do not have a protective (earth) conductor, and are less dependent for their safety on the condition of the electrical installation to which they are connected.

All electrical equipment put on to the UK market must comply with the Low Voltage Electrical Equipment (Safety) Regulations 1989. These regulations require electrical equipment to be safe and to be constructed in accordance with good engineering practice. Manufacturers must confirm that their equipment meets the minimum safety requirements by affixing the 'CE' mark (see Box 4).

The safety of electrical installations in all workplaces in the UK, including schools, is subject to the Electricity at Work Regulations 1989. These require all electrical installations to be constructed and maintained so as to prevent danger, as far as is reasonably practicable. Failure to comply with these regulations may result in criminal prosecution, especially if someone is injured or killed. The regulations do not generally apply to domestic electrical installations.



Sheila Terry/SPL

Anyone working with mains powered equipment outdoors should use an RCD

### Box 3 Fuse wires

You should be clear about what a wire fuse does and does not do. If an appliance develops a fault:

- too large a current causes the fuse to melt
- preventing the flow of current
- preventing the flex overheating and causing a fire
- preventing further damage to the appliance

The appliance itself could be protected by a built-in electromagnetic trip switch.

### Box 4 Electrical appliances

Electrical appliances may carry these two marks (among others). What do they mean?



Answers on page 13.

In January 2005, most electrical installation work in homes in England and Wales became subject to the Building Regulations. Similar requirements are in force in Scotland. The intention of the regulations is to improve the general safety standard of domestic electrical installation work.

To reduce the risk of danger, it is important that any electrical work is carried out by a competent person – someone who has sufficient technical knowledge and experience to carry out the work successfully and safely.

This article has been written by **Howard Goodenough** of the Electrical Safety Council. Check its website for further information on electrical safety ([www.electricalsafetycouncil.org.uk](http://www.electricalsafetycouncil.org.uk)).

All electrical appliances in schools are checked annually for safety. You will see 'passed' stickers on them, showing the date of the check.

Always treat electricity with care and respect.

