UNIT V Patient Safety

➲ GROSS SHOCK or Macroshock

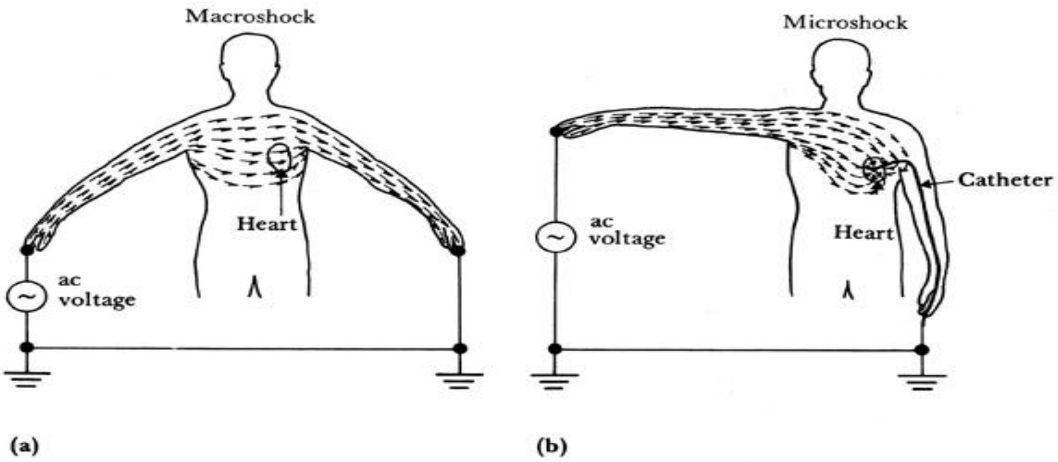
Gross shock is experienced by the subject by an accidental contact with the electric wiring at any point on the surface of the body. The majority of electric accidents involve a current pathway through the victim from one upper limb to the feet or to the opposite upper limb and they generally occur through intact skin surfaces. In all these cases, the body acts as a volume conductor at the mains frequency.

For a physiological effect to take place, the body must become part of an electric circuit. Current must enter the body at one point and leave at some other point. In this process, three phenomena can occur. These are:

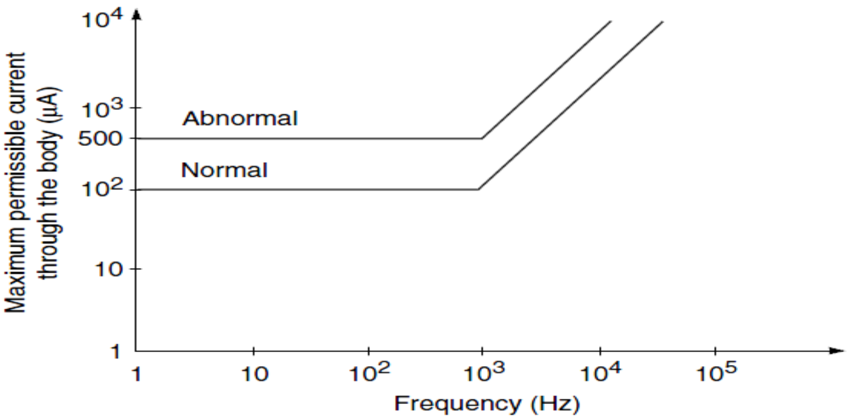
(i) Electrical stimulation of the excitable tissues—nerves and muscles

(ii) Resistive heating of tissue

(iii) Electro-chemical burns and tissue damage for direct current and very high voltages.



(a) Gross shock or Macroshock, externally applied current spreads through-out the body. (b) Microshock, all the current applied through an intracardiac catheter flows through the heart.



➤ **Fig. 18.1** *Maximum permissible leakage currents through the body versus frequency (Courtesy: Philips Medical Systems, Netherlands)*

Gross shock hazards are usually caused by electrical wiring failures, which allow personal contact with a live wire or surface at the power line voltage. This type of hazard is dangerous not only to the patient but also to the medical and attending staff.

The most vulnerable part in the system of electrical safety is the cord and plug. Physical abuse and deterioration are so common that human perception is blunted and faulty cords and plugs are continued in use.

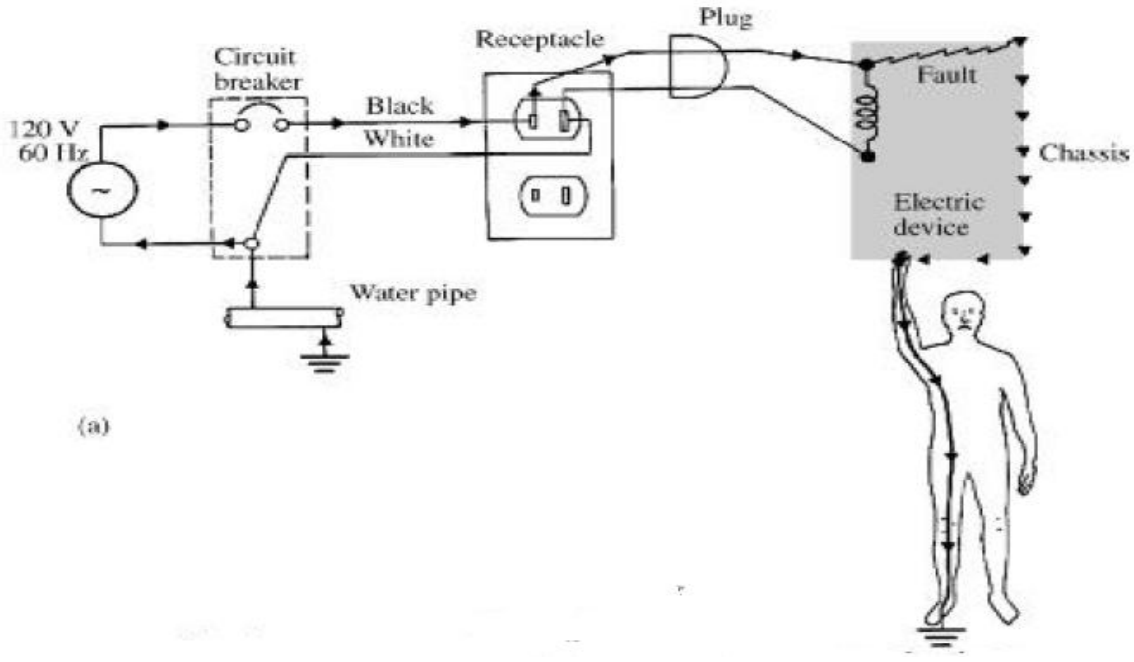
Their use can result in fatal accidents. Broken plugs, faulty sockets and defective power cords must be immediately replaced.

The commonly found fluids in medical practice such as blood, urine, intravenous solutions, etc. can conduct enough electricity to cause temporary short circuits if they are accidentally spilled into normally safe equipment.

This hazard is particularly more in hospital areas that are normally subject to wet conditions, such as haemodialysis and physical therapy areas. The cabinets of many electrically operated equipment have holes and vents for cooling that provide access for spilled conductive fluids, which can cause potential electric shock hazard.

Whalen and Starmer (1967) have published comprehensive data on shock hazards arising from polarity reversal or wiring errors. The frequency with which such errors create hazards has prompted the designing of many testers for checking outlets or appliances. The cords of the instruments must be limited in length as the leakage current is a function of the length.

The length should be standardized, say at 3 m. This should be shielded and a low dielectric loss insulation be used. Extension cords introduce needless risk. They should be avoided as far as possible.



- Direct faults between the hot conductor and the ground is not common, and technically speaking, ground connection is not necessary during normal operation.

- In fact, a ground fault will not be detected during normal operation of the device, only when someone touches it, the hazard becomes known. Therefore, ground wire in devices and receptacles must be periodically tested.

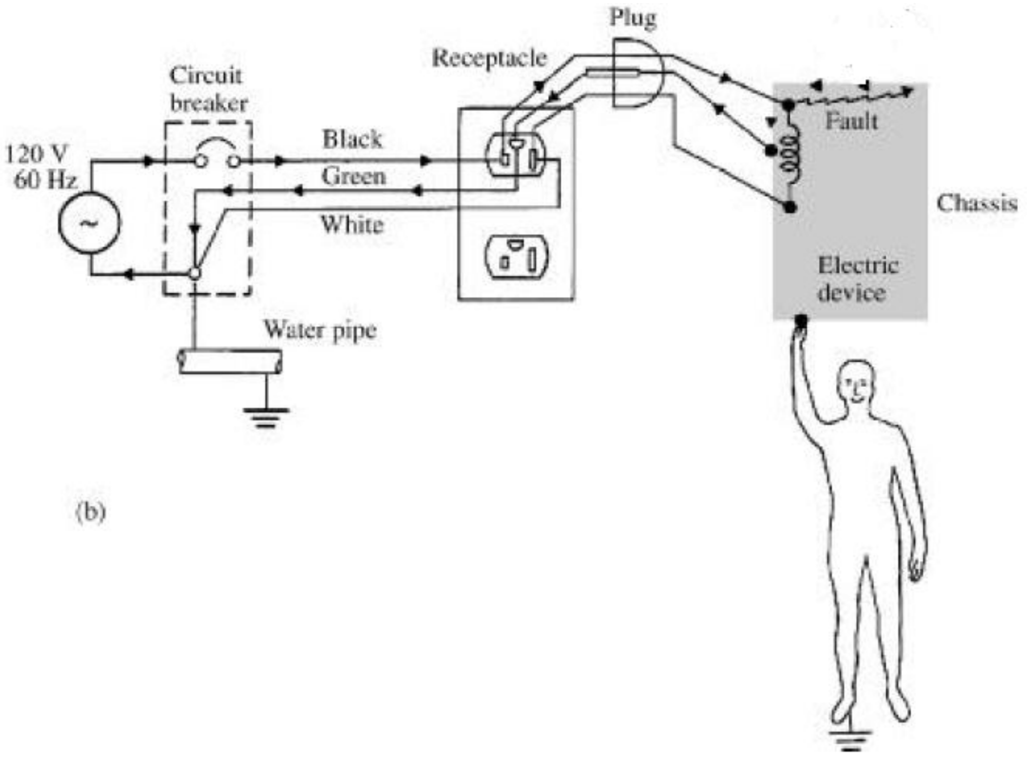


Figure 14.10 Macroshock due to a ground fault from hot line to equipment cases for (a) ungrounded cases and (b) grounded chassis.

Microshock Hazard

The threshold of sensation of electric currents differs widely between currents applied arm to arm and currents applied internally to the body. In the latter case, a far greater percentage of the current may flow via the arterial system directly through the heart, thereby requiring much less current to produce ventricular fibrillation. Such situations are commonly encountered in hospitals; for example, the patients in the catheter laboratory or in the operating room, with a catheter in the heart, would have very little resistance to electric currents.

A **cardiac catheter** connected to an electrical circuit for the measurement of pressure provides a conductive fluid connection directly to the heart. This makes the patient highly vulnerable to electric shock because the protection he would have had from layers of intact skin and tissue between his heart and the outside electrical environment has now been by-passed by the wire of fluid column within his heart or blood vessels.

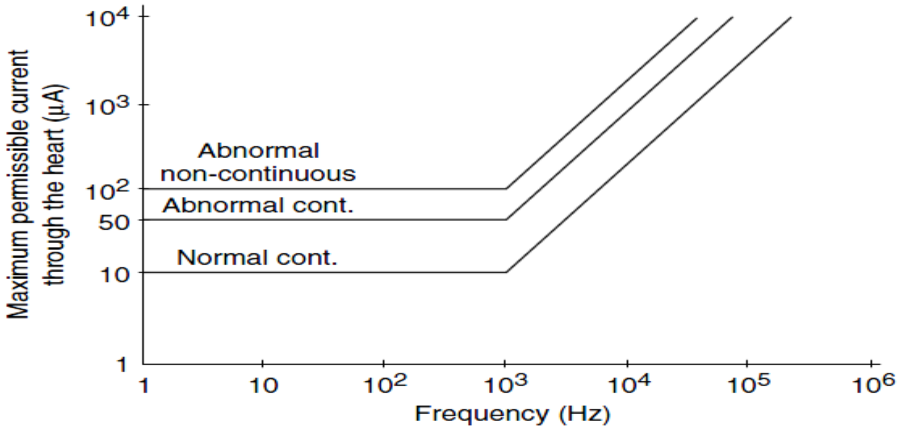
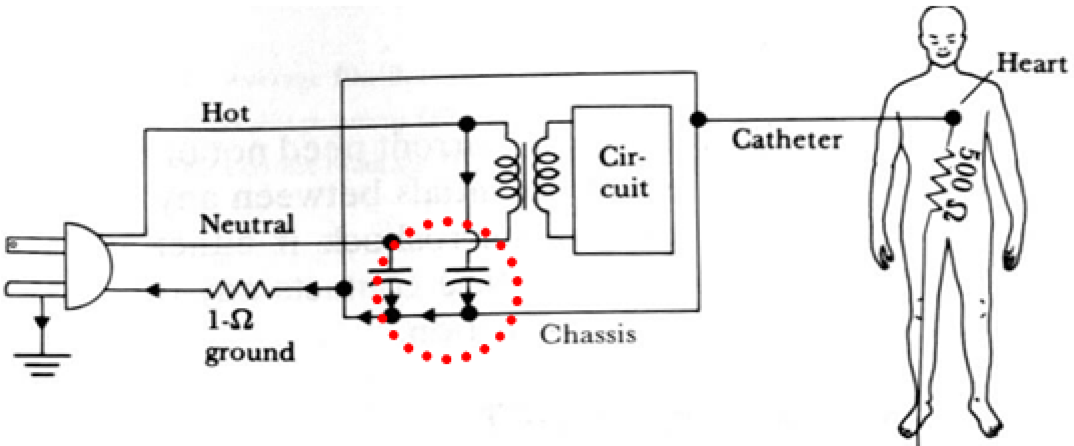


Fig. 18.2 *Maximum permissible leakage-current through the heart versus frequency (Courtesy: Philips Medical System, Netherlands)*

Experiments on human beings have not been and are not likely to be conducted for the determination of hazardous threshold when internal electrodes are applied to the patient. Experiments with dogs have indicated that in some animals ventricular fibrillation can be produced with currents as low as **17 µA applied directly to the dog’s heart**. Based on the data collected by several researchers, **10 µA has been postulated as the safe upper limit.** The International Electrotechnical Commission’s recommendations covering the safety aspects of electrical equipment for medical applications stipulate that the current that flows continuously through the heart shall not exceed **10 µA for a frequency range of 0 to 1 kHz**

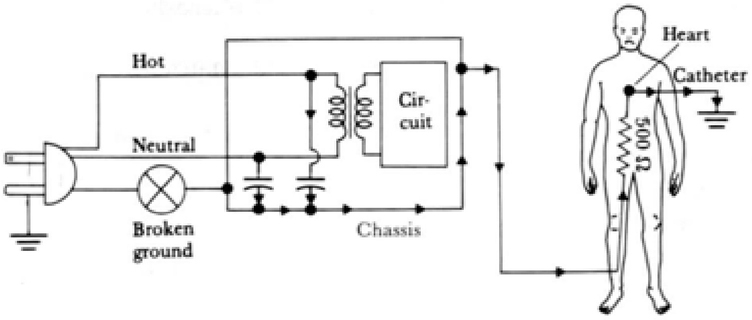
In abnormal situations (e.g. in the case of equipment failure), the maximum value in this frequency range may be 50 µA for currents which can flow continuously through the patient’sheart. It could be 100 µA for non-continuous current which can flow through the patient’s heart in an abnormal situation. The limits of current increase proportionally for frequencies above 1 kHz.

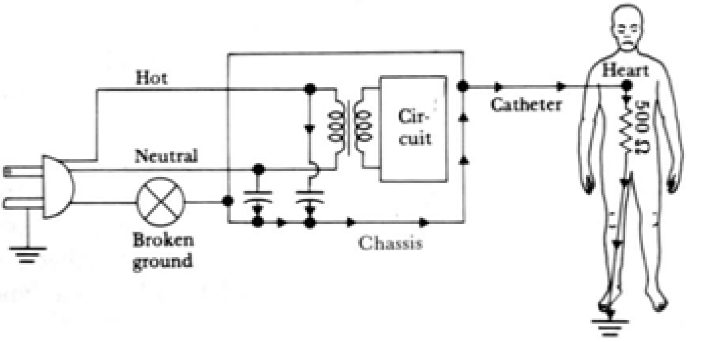


‘Small currents inevitably flow between adjacent insulated conductors at different potentials
→ ***leakage currents*** which flow through stray capacitances, insulation, dust and moisture

Leakage current flowing to the chassis flows safely to the ground, if a low-resistance ground wire is available.

- If ground wire is broken, the chassis potential rises above the ground; a patient who has a grounded connection to the heart (e.g. through a catheter) receives a microshock if s/he touches the chassis.
- If there is a connection from the chassis to the patient's heart, ***and*** a connection to the ground anywhere in the body, this also causes microshock.
- Note that the hazard for microshock only exists if there is a direct connection to the heart. Otherwise, even the internal resistance of the body is high enough top prevent the microshocks.





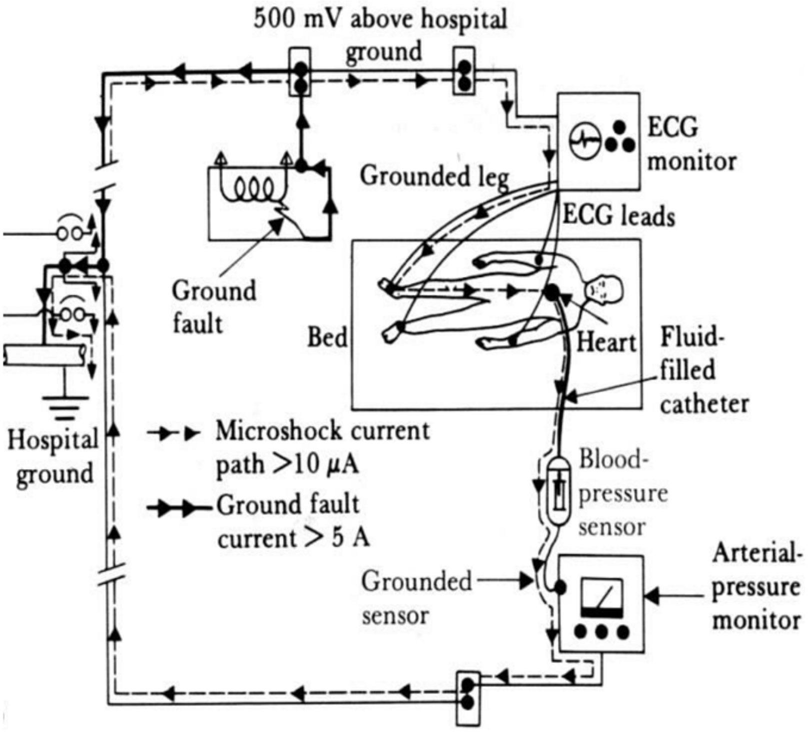
Microshock Via Ground Potentials

Microshocks can also occur if different devices are not at the exact same ground potential.

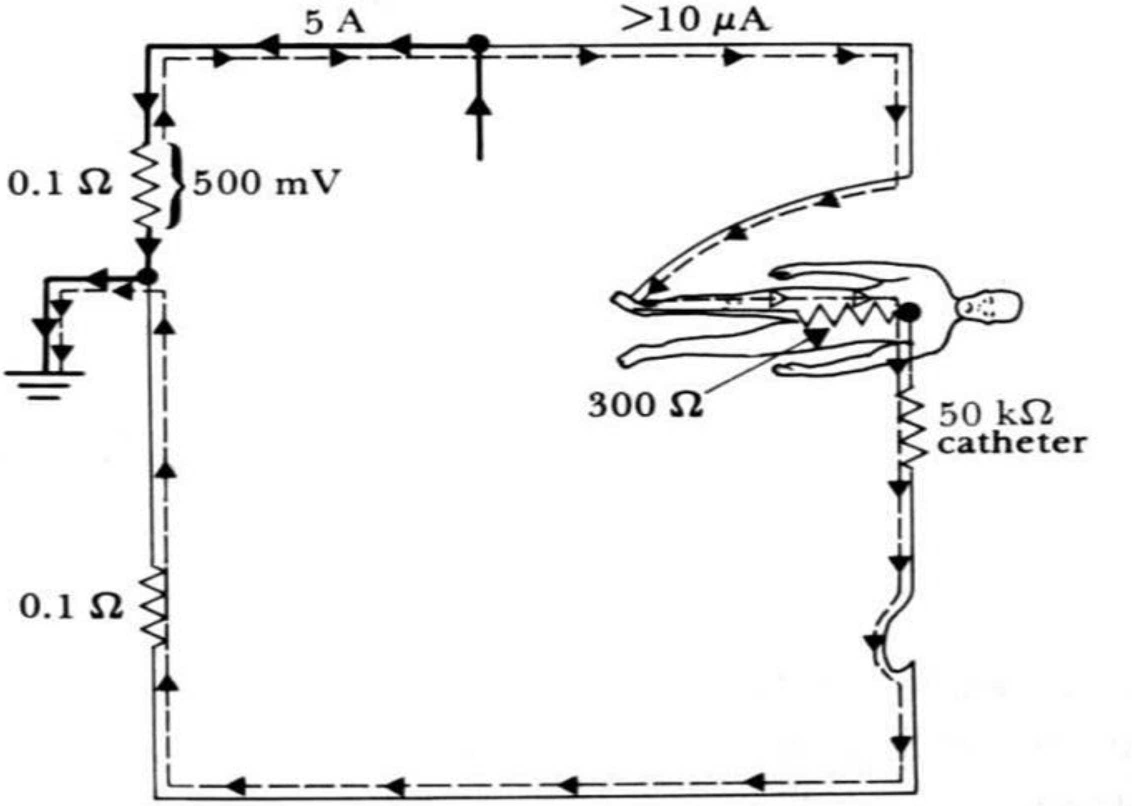
In fact, the microshock can occur ***even when*** a device that does not connected to the patient has a ground fault!

A fairly common ground wire resistance of 0.1Ω can easily cause a a 500mV potential difference if initiated due to a, say 5A of ground fault.

If the patient resistance is less then 50kΩ, this would cause an above safe current of 10μA



Microshock Via Ground Potentials



- Patient- Right leg grounded to reduce 50Hz interferences.
- Also Patient with Left Ventricular blood pressure is monitored by an intracardiac saline filled catheter connector to a mettalic pressure sensor is also grounded.
- Assume the two monitors are grounded through a 3 wire wall receptacles on a separate circuit that comes from a central distribution panel.
- Microshock can occur when any device with a ground fault does not open the circuit breakers is operated on either circuit faulty
- Faulty floor Polisher – used on damp ground
- Not recognized by the workers