

4 Electrical Installations

This chapter deals with the safety of electrical installations with the emphasis on residual current monitoring based on the International standard IEC 60364-4-41: 2001-08, *Electrical installations of buildings – Part 4-41: Protection for safety – Protection against electric shock*, published in its fourth edition in August 2001. The standard is currently under review and is expected to be published in 2004.

The application of electrical energy has been taken for granted in all walks of life. But handling electrical power naturally places a high demand on the safety of all electrical devices and installations. An electrical installation is made up of two sub-systems:

- the supply system and
- the safety system.

The supply system is providing electrical energy to users, the safety system shall guarantee the protection of persons and animals against electric shock [4.1].

4.1 Protection against electric shock

The protection against electric shock is meant to prevent dangerous electrical current flowing through a human or animal body. The terminology for this pathological effect is both generally and specifically known as electric shock. The protective measures are distinguished into two main classifications:

- protection against **direct contact**, which is essentially achieved by insulation, obstacles, barriers, placing out-of-reach or non-hazardous voltage;
- protection against **indirect contact** by automatic disconnection or indication.

There are also protective measures for a combination of both.

Generally it can be said that the protection against electric shock shall be provided through appropriate measures for both normal condition and for the fault condition.

The introduction of IEC 60364-4-41:2001-08, *Electrical installations of buildings, Part 41: Protection against electric shock*, clause 411, specifies the essential requirements for the protection of persons, livestock and property against direct contact and indirect contact. The protective measures may be applicable to the entire installation, to a part thereof, or to an item of equipment.

4.1.1 Protection against both direct and indirect contact

All electrical equipment shall be subject to one of the measures of protection against direct and against indirect contact or both. The methods of protection (**Table 4.1**) which combines protection against both direct and indirect contact are described below.

Type of Separation		Relation to Earth of Protective Conductor		Method
Current source	Circuits	Circuits	Exposed conductive part	
Current source with safe separation, for example a safety transformer or equivalent current source	Circuits with safe separation and	Unearthed circuits	Parts may not intentionally be connected to earth or to a protective conductor	SELV
		Earthed and unearthed circuits permitted	Parts may be connected to earth or to a protective conductor	PELV
Current source without safe separation, this means a current source with only basic separation, for example a safety transformer according to IEC 60989	Circuits without safe separation or	Earthed circuits permitted	Parts shall be connected to the protective conductor on the primary circuit of the supply system	FELV

Table 4.1 Survey of the low-voltages SELV, PELV and FELV in relations to safe separation and the relation to Earth

4.1.1.1 SELV and PELV

According to IEC 60364-4-41 protection against electric shock is deemed to be provided when:

- the nominal voltage cannot exceed an upper limit in accordance with IEC 60449 (50 V AC / 120 V DC),
- the supply is from a safety isolating transformer in accordance with IEC 60742 or equivalent (e.g. motor generator with windings providing an equivalent isolation),
- an electrochemical source (e.g. battery) or another source independent of a higher voltage circuit (e.g. diesel-driven generator),
- mobile sources or certain electronic devices all complying with appropriate standards, where measures have been taken in order to ensure that, even in the case

of an internal fault, the voltage at the outgoing terminals cannot exceed the above mentioned levels;

or

- when all above conditions are fulfilled and in addition electrical separation with either SELV for unearthed circuits or PELV for earthed circuits is provided.

4.1.1.2 Arrangement of circuits

IEC 60364-4-41 states that live parts of SELV and PELV circuits shall be electrically separated from each other and from other circuits. Arrangements shall ensure electrical separation not less than that between the input and output circuits of a safety isolating transformer.

Circuit conductors of each SELV and PELV system shall preferably be physically separated from those of any other circuit conductors. When this requirement is impracticable, one of the following arrangements is required:

- Plugs and socket-outlets of SELV and PELV systems shall comply with the following requirements:
 - plugs shall not be able to enter socket-outlets of other voltage systems;
 - socket-outlets shall not admit plugs of other voltage systems;
 - socket-outlets shall not have a protective conductor contact.

4.1.1.3 Requirements for unearthed circuits (SELV)

According to IEC 60364-4-41, live parts of SELV circuits shall not be connected to earth or to live parts or to protective conductors forming part of other circuits.

Exposed conductive parts shall not be intentionally connected to:

- earth; or
- protective conductors or exposed conductive conductors of another circuit; or
- extraneous conductive parts.

If nominal voltage exceeds 25 V AC r.m.s or 60 V ripple-free DC, protection against direct contact shall be provided by:

- barriers or enclosures affording a degree of protection of at least IP2X or IPXXB; or
- insulation capable of withstanding a test voltage of 500 V AC r.m.s for 1 minute.

In general, protection against direct contact is unnecessary if the nominal voltage does not exceed 25 V AC r.m.s. or 60 V ripple-free DC. However, it may be necessary under certain conditions of external influences, which is currently under consideration by the IEC.