Chapter P
Residential and other special locations

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1 Residential and similar premises

Electrical installations for residential premises need a high standard of safety and reliability

1.1 General

Related standards

Most countries have national regulations and-or standards governing the rules to be strictly observed in the design and realization of electrical installations for residential and similar premises. The relevant international standard is the publication IEC 60364.

The power distribution utility connects the LV neutral point to its MV/LV distribution tranformer to earth.
All LV installations must be protected by RCDs.
All exposed conductive parts must be bonded together and connected to the earth.

The power network

The vast majority of power distribution utilities connect the low voltage neutral point of their MV/LV distribution transformers to earth.

The protection of persons against electric shock therefore depends, in such case, on the principle discussed in chapter F. The measures required depend on whether the TT, TN or IT scheme of earthing is adopted.

RCDs are essential for TT and IT earthed installations. For TN installations, high speed overcurrent devices or RCDs may provide protection against direct contact of the electrical circuits. To extend the protection to flexible leads beyond the fixed socket outlets and to ensure protection against fires of electrical origin RCDs shall be installed.

The quality of electrical equipment used in residential premises is commonly ensured by a mark of conformity situated on the front of each item

1.2 Distribution boards components (see **Fig. P1**)

Distribution boards (generally only one in residential premises) usually include the meter(s) and in some cases (notably where the supply utilities impose a TT earthing system and/or tariff conditions which limit the maximum permitted current consumption) an incoming supply differential circuit-breaker which includes an overcurrent trip. This circuit-breaker is freely accessible to the consumer.

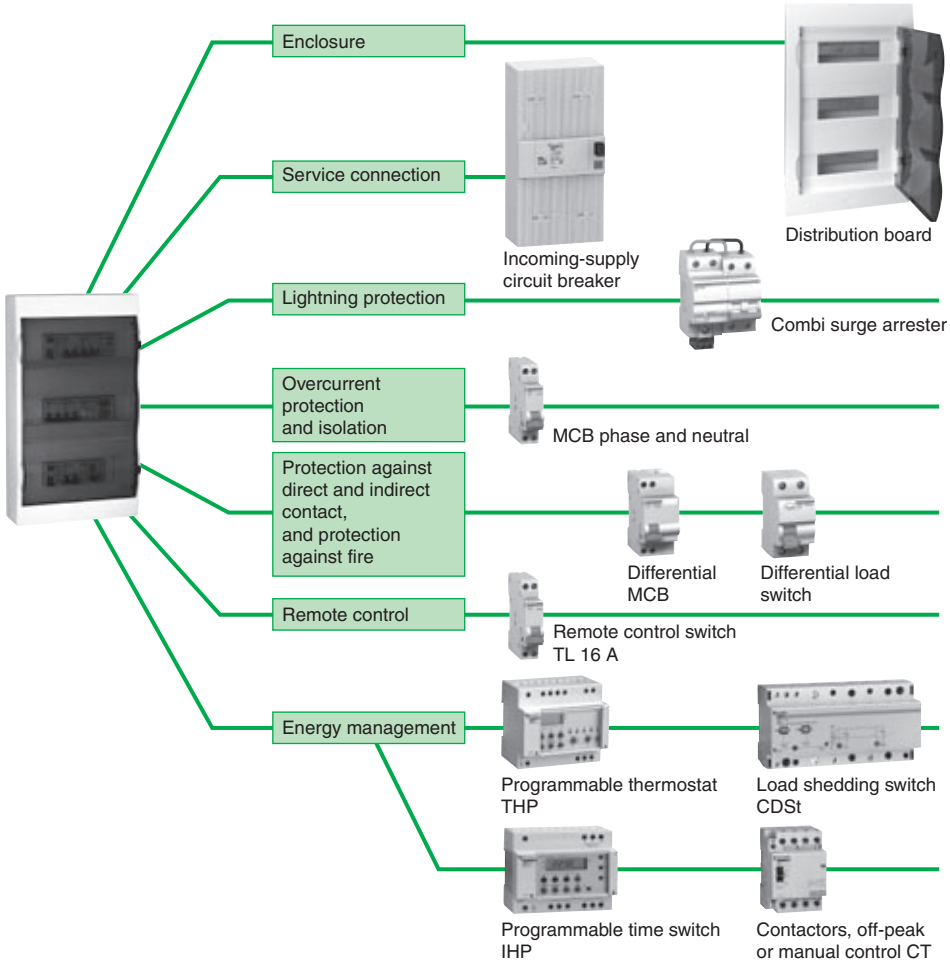


Fig. P1 : Presentation of realizable functions on a consumer unit

1 Residential and similar premises



Fig. P3 : Incoming-supply circuit-breaker



Fig. P4 : Control and distribution board

If, in a TT scheme, the value of 80 Ω for the resistance of the electrode can not be met then, 30 mA RCDs must be installed to take over the function of the earth leakage protection of the incoming supply circuit-breaker

On installations which are TN earthed, the supply utilities usually protect the installation simply by means of sealed fuse cut-outs immediately upstream of the meter(s) (see **Fig. P2**). The consumer has no access to these fuses.

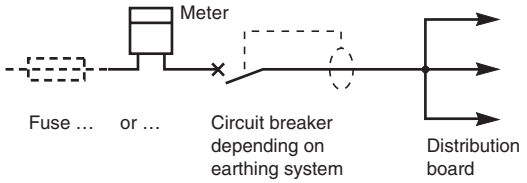


Fig. P2 : Components of a control and distribution board

The incoming supply circuit-breaker (see **Fig. P3**)

The consumer is allowed to operate this CB if necessary (e.g to reclose it if the current consumption has exceeded the authorized limit; to open it in case of emergency or for isolation purposes).
The rated residual current of the incoming circuit-breaker in the earth leakage protection shall be 300 mA.
If the installation is TT, the earth electrode resistance shall be less than

$R = \frac{50\ V}{300\ mA} = 166\ \Omega$. In practice, the earth electrode resistance of a new installation shall be less than 80 Ω ($\frac{R}{2}$).

The control and distribution board (consumer unit) (see **Fig. P4**)

This board comprises:

- A control panel for mounting (where appropriate) the incoming supply circuit-breaker and other control auxiliaries, as required
- A distribution panel for housing 1, 2 or 3 rows (of 24 multi 9 units) or similar MCBs or fuse units, etc.
- Installation accessories for fixing conductors, and rails for mounting MCBs, fuses bases, etc, neutral busbar and earthing bar, and so on
- Service cable ducts or conduits, surface mounted or in cable chases embedded in the wall

Note: to facilitate future modifications to the installation, it is recommended to keep all relevant documents (photos, diagrams, characteristics, etc.) in a suitable location close to the distribution board.
The board should be installed at a height such that the operating handles, indicating dials (of meters) etc., are between 1 metre and 1.80 metres from the floor (1.30 metres in situations where handicapped or elderly people are concerned).

Lightning arresters

The installation of lightning arresters at the service position of a LV installation is strongly recommended for installations which include sensitive (e.g electronic) equipment.

These devices must automatically disconnect themselves from the installation in case of failure or be protected by a MCB. In the case of residential installations, the use of a 300 mA differential incoming supply circuit-breaker type S (i.e slightly time-delayed) will provide effective earth leakage protection, while, at the same time, will not trip unnecessarily each time a lightning arrester discharges the current (of an overvoltage-surge) to earth.

Resistance value of the earth electrode

In the case where the resistance to earth exceeds 80 Ω, one or several 30 mA RCDs should be used in place of the earth leakage protection of the incoming supply circuit-breaker.

Where utility power supply systems and consumers' installations form a TT earthed system, the governing standards impose the use of RCDs to ensure the protection of persons

1.3 Protection of people

On TT earthed systems, the protection of persons is ensured by the following measures:

- Protection against indirect contact hazards by RCDs (see **Fig. P5**) of medium sensitivity (300 mA) at the origin of the installation (incorporated in the incoming supply circuit-breaker or, on the incoming feed to the distribution board). This measure is associated with a consumer installed earth electrode to which must be connected the protective earth conductor (PE) from the exposed conductive parts of all class I insulated appliances and equipment, as well as those from the earthing pins of all socket outlets
- When the CB at the origin of an installation has no RCD protection, the protection of persons shall be ensured by class II level of insulation on all circuits upstream of the first RCDs. In the case where the distribution board is metallic, care shall be taken that all live parts are double insulated (supplementary clearances or insulation, use of covers, etc.) and wiring reliably fixed
- Obligatory protection by 30 mA sensitive RCDs of socket outlet circuits, and circuits feeding bathroom, laundry rooms, and so on (for details of this latter obligation, refer to clause 3 of this chapter)

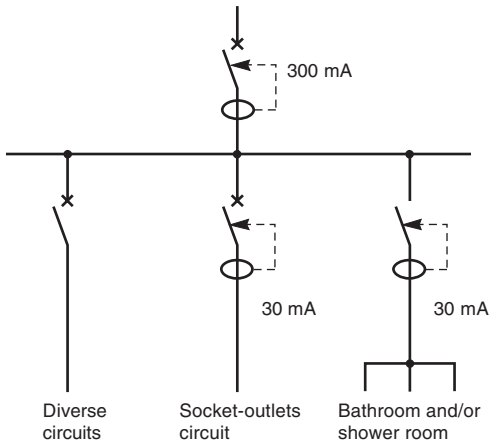


***Fig. P5** : Installation with incoming-supply circuit-breaker having instantaneous differential protection*

Incoming supply circuit-breaker with instantaneous differential relay

In this case:

- An insulation fault to earth could result in a shutdown of the entire installation
- Where a lightning arrester is installed, its operation (i.e. discharging a voltage surge to earth) could appear to an RCD as an earth fault, with a consequent shutdown of the installation

Recommendation of suitable Merlin Gerin components

- Incoming supply circuit-breaker with 300 mA differential and
- High sensitivity 30 mA RCD (for example differential circuit-breaker 1P + N type Declic Vigi) on the circuits supplying socket outlets
- High sensitivity 30 mA RCD (for example differential load switch type ID'clic) on circuits to bathrooms, shower rooms, laundry rooms, etc. (lighting, heating, socket outlets)

Incoming supply circuit-breaker with type S time delayed differential relay

This type of CB affords protection against fault to earth, but by virtue of a short time delay, provides a measure of discrimination with downstream instantaneous RCDs. Tripping of the incoming supply CB and its consequences (on deep freezers, for example) is thereby made less probable in the event of lightning, or other causes of voltage surges. The discharge of voltage surge current to earth, through the surge arrester, will leave the type S circuit-breaker unaffected.

Recommendation of suitable Merlin Gerin components (see **Fig. P6**)
- Incoming supply circuit-breaker with 300 mA differential type S and
- High sensitivity 30 mA RCD (for example differential circuit-breaker 1P + N type Declic Vigi) on the circuits supplying washing machines and dish-washing machine
- High sensitivity 30 mA RCD (for example differential load switch type ID'clic) on circuits to bathrooms, shower rooms, laundry rooms, etc. (lighting, heating, socket outlets)

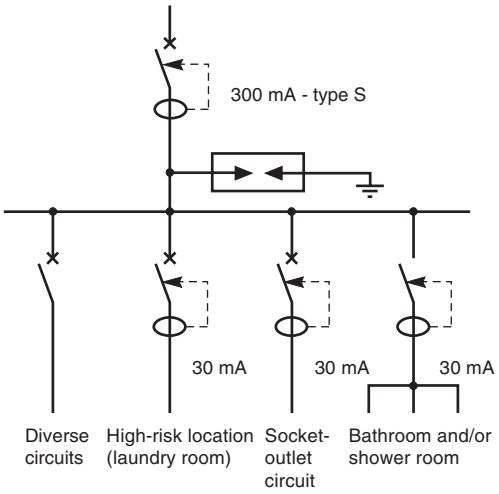


Fig. P6 : Installation with incoming-supply circuit-breaker having short time delay differential protection, type S

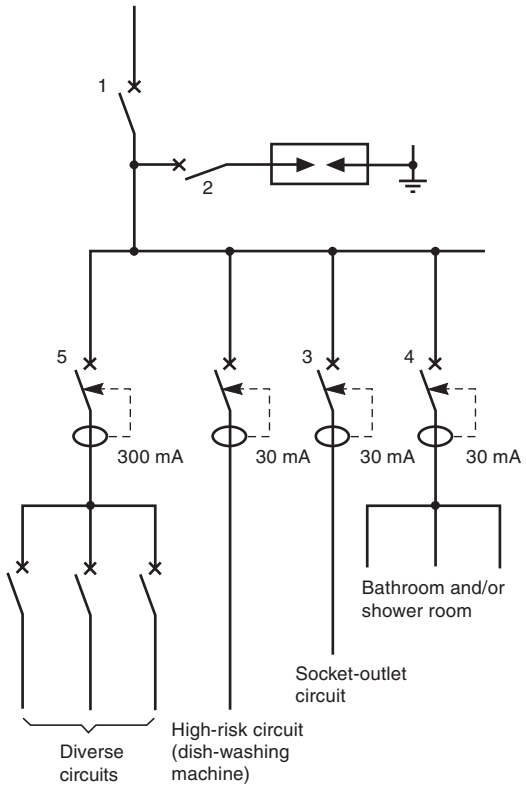


Fig. P7 : Installation with incoming-supply circuit-breaker having no differential protection

Incoming supply circuit-breaker without differential protection

In this case the protection of persons must be ensured by:
- Class II level of insulation up to the downstream terminals of the RCDs
- All outgoing circuits from the distribution board must be protected by 30 mA or 300 mA RCDs according to the type of circuit concerned as discussed in chapter F.

Where a voltage surge arrester is installed upstream of the distribution board (to protect sensitive electronic equipment such as microprocessors, video-cassette recorders, TV sets, electronic cash registers, etc.) it is imperative that the device automatically disconnects itself from the installation following a rare (but always possible) failure. Some devices employ replaceable fusing elements; the recommended method however as shown in **Figure P7**, is to use a circuit-breaker.

Recommendation of suitable Merlin Gerin components

Figure P7 refers:
1. Incoming-supply circuit-breaker without differential protection
2. Automatic disconnection device (if a lightning arrester is installed)
3. 30 mA RCD (for example differential circuit-breaker 1P + N type Declic Vigi) on each circuit supplying one or more socket-outlets
4. 30 mA RCD (for example differential load swith type ID'clic) on circuits to bathrooms and shower rooms (lighting, heating and socket-outlets) or a 30 mA differential circuit-breaker per circuit
5. 300 mA RCD (for example differential load swith) on all the other circuits

The distribution and division of circuits provides comfort and facilitates rapid location of fault

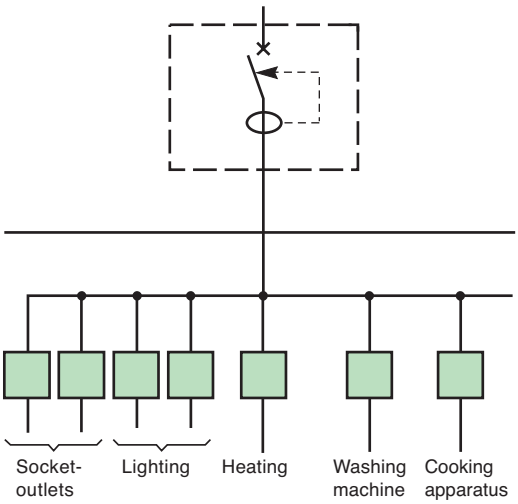


***Fig. P8** : Circuit division according to utilization*

The inclusion of a protective conductor in all circuits is required by IEC and most national standards

1.4 Circuits

Subdivision

National standards commonly recommend the subdivision of circuits according to the number of utilization categories in the installation concerned (see **Fig. P8**):

- At least 1 circuit for lighting. Each circuit supplying a maximum of 8 lighting points
- At least 1 circuit for socket-outlets rated 10/16 A, each circuit supplying a maximum of 8 sockets. These sockets may be single or double units (a double unit is made up of two 10/16 A sockets mounted on a common base in an embedded box, identical to that of a single unit
- 1 circuit for each appliance such as water heater, washing machine, dish-washing machine, cooker, refrigerator, etc. Recommended numbers of 10/16 A (or similar) socket-outlets and fixed lighting points, according to the use for which the various rooms of a dwelling are intended, are indicated in **Figure P9**

Room function	Minimum number of fixed lighting points	Minimum number of 10/16 A socket-outlets
Living room	1	5
Bedroom, lounge, bureau, dining room	1	3
Kitchen	2	4 (1)
Bathroom, shower room	2	1 or 2
Entrance hall, box room	1	1
WC, storage space	1	-
Laundry room	-	1

(1) Of which 2 above the working surface and 1 for a specialized circuit: in addition an independent socket-outlet of 16 A or 20 A for a cooker and a junction box or socket-outlet for a 32 A specialized circuit

***Fig P9** : Recommended minimum number of lighting and power points in residential premises*

Protective conductors

IEC and most national standards require that each circuit includes a protective conductor. This practice is strongly recommended where class I insulated appliances and equipment are installed, which is the general case.
The protective conductors must connect the earthing-pin contact in each socket-outlet, and the earthing terminal in class I equipment, to the main earthing terminal at the origin of the installation.
Furthermore, 10/16 A (or similarly sized) socket-outlets must be provided with shuttered contact orifices.

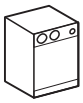
Cross-sectional-area (c.s.a.) of conductors (see **Fig. P10**)

The c.s.a. of conductors and the rated current of the associated protective device depend on the current magnitude of the circuit, the ambient temperature, the kind of installation, and the influence of neighbouring circuits (refer to chapter G)
Moreover, the conductors for the phase wires, the neutral and the protective conductors of a given circuit must all be of equal c.s.a. (assuming the same material for the conductors concerned, i.e. all copper or all aluminium).



***Fig. P10** : Circuit-breaker 1 phase + N - 2 x 9 mm spaces*

Figure P11 indicates the c.s.a. required for commonly-used appliances
Protective devices 1 phase + N in 2 x 9 mm spaces comply with requirements for isolation, and for marking of circuit current rating and conductor sizes.

Type of circuit single-phase 230 V 1 ph + N or 1 ph + N + PE	c. s. a. of the conductors	Maximum power	Protective device	
Fixed lighting 	1.5 mm² (2.5 mm²)	2,300 W	Circuit-breaker Fuse	16 A 10 A
10/16 A 	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Individual-load circuits				
Water heater 	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Dish-washing machine 	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Clothes-washing machine 	2.5 mm² (4 mm²)	4,600 W	Circuit-breaker Fuse	25 A 20 A
Cooker or hotplate (1) 	6 mm² (10 mm²)	7,300 W	Circuit-breaker Fuse	40 A 32 A
Electric space heater 	1.5 mm² (2.5 mm²)	2,300 W	Circuit-breaker Fuse	16 A 10 A

(1) In a 230/400 V 3-phase circuit, the c. s. a. is 4 mm² for copper or 6 mm² for aluminium, and protection is provided by a 32 A circuit-breaker or by 25 A fuses.

Fig. P11 : C. s. a. of conductors and current rating of the protective devices in residential installations (the c. s. a. of aluminium conductors are shown in brackets)

1.5 Protection against overvoltages and lightning

The choice of surge arrester is described in chapter J

Installation rules

Three principal rules must be respected:
1 - It is imperative that the three lengths of cable used for the installation of the surge arrester each be less than 50 cm i.e.:
- the live conductors connected to the isolating switch
- from the isolating switch to the surge arrester
- from the surge arrester to the main distribution board (MDB) earth bar (not to be confused with the main protective-earth (PE) conductor or the main earth terminal for the installation.The MDB earth bar must evidently be located in the same cabinet as the surge arrester.

2 - It is necessary to use an isolating switch of a type recommended by the manufacturer of the surge arrester.

3 - In the interest of a good continuity of supply it is recommended that the circuit-breaker be of the time-delayed or selective type.

2 Bathrooms and showers

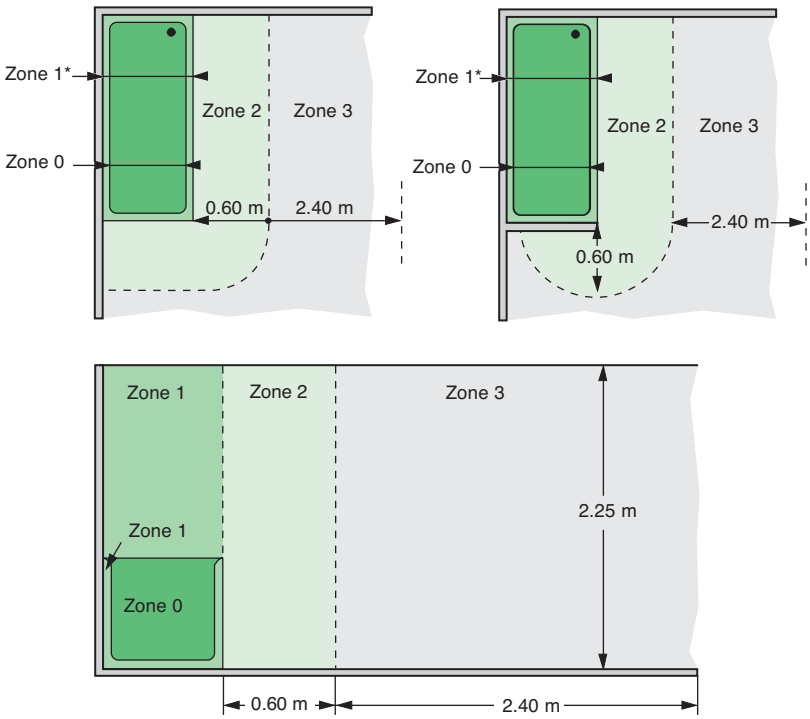
Bathrooms and showers rooms are areas of high risk, because of the very low resistance of the human body when wet or immersed in water.
Precaution to be taken are therefore correspondingly rigorous, and the regulations are more severe than those for most other locations.
The relevant standard is IEC 60364-7-701.

Precautions to observe are based on three aspects:

- The definition of zones, numbered 0,1, 2, 3 in which the placement (or exclusion) of any electrical device is strictly limited or forbidden and, where permitted, the electrical and mechanical protection is prescribed
- The establishment of an equipotential bond between all exposed and extraneous metal parts in the zones concerned
- The strict adherence to the requirements prescribed for each particular zones, as tabled in clause 3

2.1 Classification of zones

Sub-clause 701.32 of IEC 60364-7-701 defines the zones 0, 1, 2, 3 as shown in the following diagrams (see **Fig. P12** below to **Fig P18** opposite and next pages):



(*) Zone 1 is above the bath as shown in the vertical cross-section

Fig. P12 : Zones 0, 1, 2 and 3 in proximity to a bath-tub

2 Bathrooms and showers

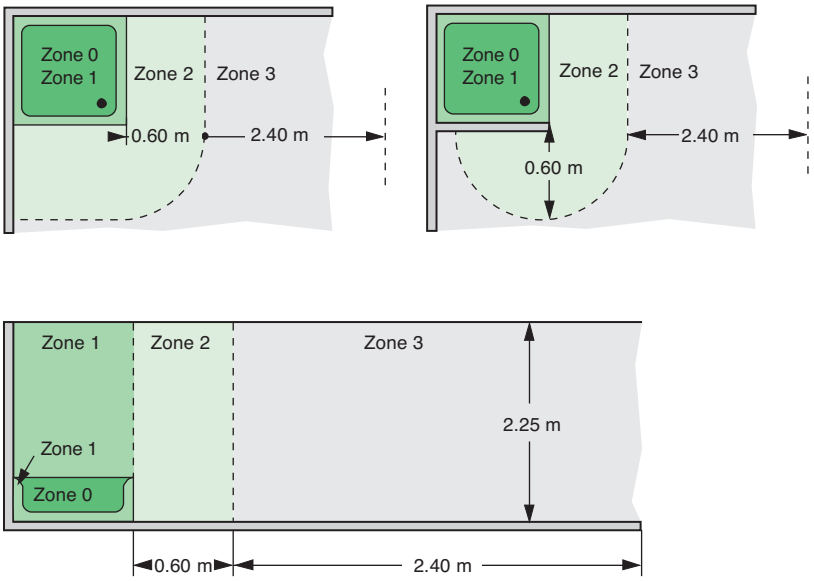
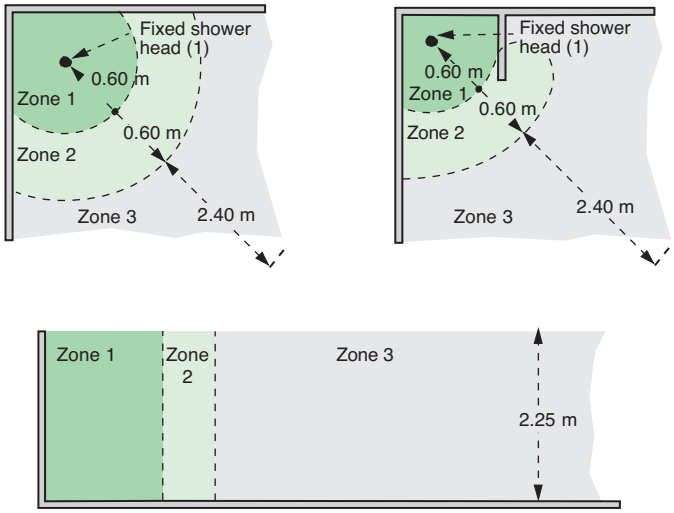


Fig. P13 : Zones 0, 1, 2 and 3 in proximity of a shower with basin



(1) When the shower head is at the end of a flexible tube, the vertical central axis of a zone passes through the fixed end of the flexible tube

Fig. P14 : Zones 0, 1, 2 and 3 in proximity of a shower without basin

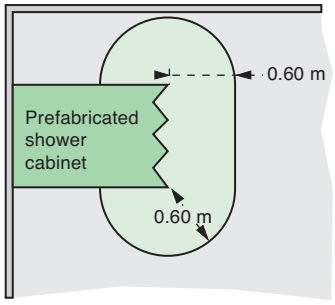


Fig. P15 : No switch or socket-outlet is permitted within 60 cm of the door opening of a shower cabinet

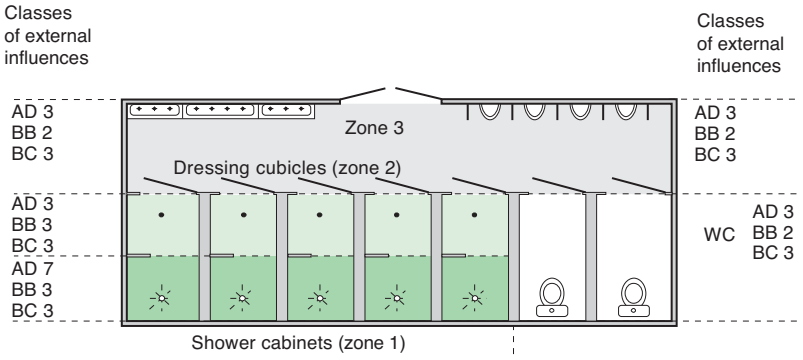


Fig. P16 : Individual showers with dressing cubicles

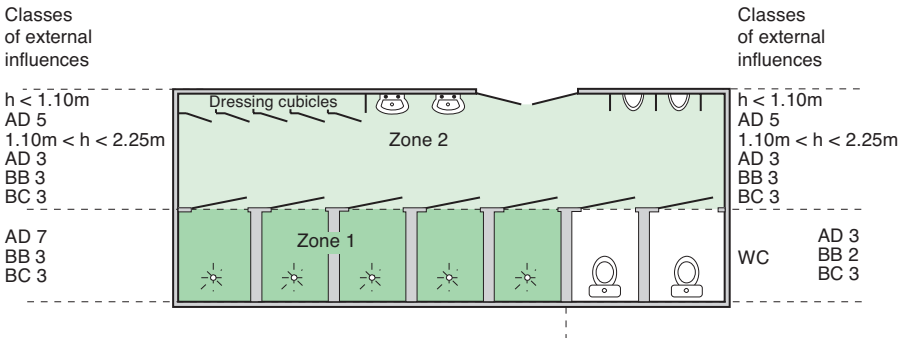


Fig. P17 : Individual showers with separate individual dressing cubicles

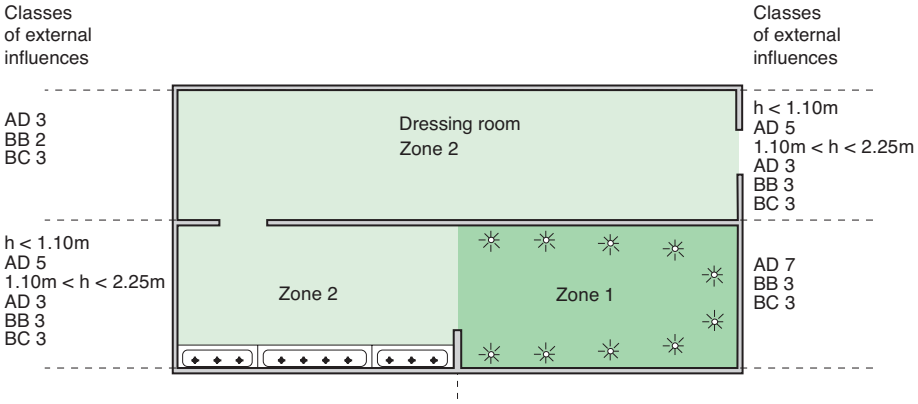


Fig. P18 : Communal showers and common dressing room

Note: Classes of external influences (see Fig. E46).

2 Bathrooms and showers

2.2 Equipotential bonding (see **Fig. P19**)

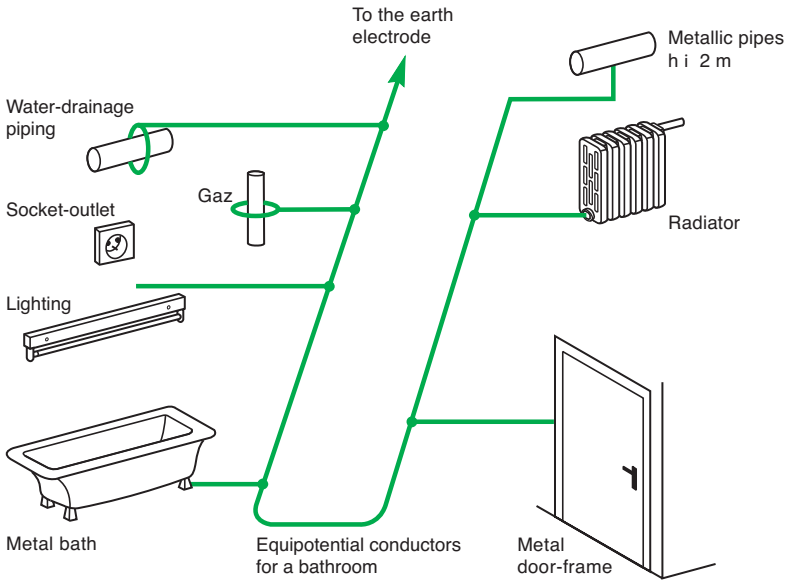


***Fig. P19** : Supplementary equipotential bonding in a bathroom*

2.3 Requirements prescribed for each zone

The table of clause 3 describes the application of the principles mentioned in the foregoing text and in other similar or related cases

3 Recommendations applicable to special installations and locations

Figure P20 below summarizes the main requirements prescribed in many national and international standards.
Note: Section in brackets refer to sections of IEC 60364-7

Locations	Protection principles	IP level	Wiring and cables	Switchgear	Socket-outlets	Installation materials
Domestic dwellings and other habitations	■ TT or TN-S systems ■ Differential protection □ 300 mA if the earth electrode resistance is ⩽ 80 ohms instantaneous or short time delay (type S) □ 30 mA if the earth electrode resistance is ⩾ 500 ohms ■ surge arrester at the origin of the installation if □ supply is from overhead line with bare conductors, and if □ the keraunic level > 25 ■ a protective earth (PE) conductor on all circuits	20		Switch operating handles and similar devices on distribution panels, to be mounted between 1 metre and 1.80 metre above the floor	Protection by 30 mA RCDs	
Bathrooms or shower rooms (section 701)	Supplementary equipotential bonding in zones 0, 1, 2 and 3					
Zone 0	SELV 12 V only	27	Class II limited to strict minimum			Special appliances
Zone 1	SELV 12 V	25	Class II limited to strict minimum			Special aplliances Water heater
Zone 2	SELV 12 V or 30 mA RCD	24	Class II limited to strict minimum			Special appliances Water heater Class II luminaires
Zone 3		21		Only socket-outlets protected by : ■ 30 mA RCD or ■ Electrical separation or ■ SELV 50 V		
Swimming baths (section 702)	Supplementary equipotential bonding in zones 0, 1, and 2					
Zone 0	SELV 12 V	28	Class II limited to strict minimum			Special appliances
Zone 1		25	Class II limited to strict minimum			Special appliances
Zone 2		22 (indoor) 24 (outdoor)		Only socket-outlets protected by : ■ 30 mA RCD or ■ electrical separation or ■ SELV 50 V		
Saunas (section 703)		24	Class II			Adapted to temperature
Work sites (section 704)	Conventional voltage limit U_L reduced to 25 V	44	Mechanically protected		Protection by 30 mA RCDs	
Agricultural and horticultural establishments (section 705)	Conventional voltage limit U_L reduced to 25 V Protection against fire risks by 500 mA RCDs	35			Protection by 30 mA RCDs	
Restricted conductive locations (section 706)		2x				Protection of: ■ Portable tools by: □ SELV or □ Electrical separation ■ Hand-held lamps □ By SELV ■ Fixed equipement by □ SELV □ Electrical separation □ 30 mA RCDs □ Special supplementary equipotential bonding

Fig. P20 : Main requirements prescribed in many national and international standards (continued on opposite page)

3 Recommendations applicable to special installations and locations

Locations	Protection principles	IP level	Wiring and cables	Switchgear	Socket-outlets	Installation materials
Fountains (section 702)	Protection by 30 mA RCDs and equipotential bonding of all exposed and extraneous conductive parts					
Data processing (section 707)	TN-S system recommended TT system if leakage current is limited. Protective conductor 10 mm^2 minimum in aluminium. Smaller sizes (in copper) must be doubled.					
Caravan park (section 708)		55	Flexible cable of 25 metres length		Socket-outlets shall be placed at a height of 0.80 m to 1.50 m from the ground. Protection of circuits by 30 mA RCDs (one per 6 socket-outlets)	
Marinas and pleasure craft (section 709)	The cable length for connection to pleasure craft must not exceeded 25 m				Protection of circuits by 30 mA RCDs (one per 6 socket-outlets)	
Medical locations (section 710)	IT medical system equipotential bonding				Protection by 30 mA RCDs	
Exhibitions, shows and stands (section 711)	TT or TN-S systems	4x			Protection by 30 mA RCDs	
Balneotherapy (cure-centre baths)	Individual: see section 701 (volumes 0 and 1) Collective: see section 702 (volumes 0 and 1)					
Motor-fuel filling stations	Explosion risks in security zones		Limited to the necessary minimum			
Motor vehicules	Protection by RCDs or by electrical separation					
External lighting installations (section 714)		23			Protection by 30 mA RCDs	
Mobile or transportable units (section 717)	The use of TN-C system is not permitted inside any unit				30 mA RCDs must be used for all socket-outlets supplying equipment outside the unit	

Fig. P20 : Main requirements prescribed in many national and international standards (concluded)