IEC/TS 62257-9-4

Edition 1.0 2006-10

TECHNICAL SPECIFICATION

colour inside

Recommendations for small renewable energy and hybrid systems for rural electrification –
Part 9-4: Integrated system – User installation

IEC/TS 62257-9-4:2006(E)

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Recommendations for small renewable energy and hybrid systems for rural electrification –
Part 9-3: Integrated system – User installation

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-4: Integrated system – User installation

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62257-9-4, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This part of IEC 62257-9 is based on IEC/PAS 62111 (1999); it cancels and replaces the relevant parts of IEC/PAS 62111.

This part of IEC 62257-9 is to be used in conjunction with the IEC 62257 series.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/414/DTS	82/441/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62257 series, under the general title *Recommendations for small renewable energy and hybrid systems for rural electrification*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an international standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The IEC 62257 series intends to provide to different players involved in rural electrification projects (such as project implementers, project contractors, project supervisors, installers, etc.) documents for the setting up of renewable energy and hybrid systems with a.c. nominal voltage below 500 V, d.c. nominal voltage below 750 V and nominal power below 100 kVA.

These documents are recommendations:

- to choose the right system for the right place,
- to design the system,
- to operate and maintain the system.

These documents are focused only on rural electrification concentrating on but not specific to developing countries. They should not be considered as all inclusive to rural electrification. The documents try to promote the use of Renewable energies in rural electrification; they do not deal with clean mechanisms developments at this time (CO_2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems and at the lowest life cycle cost as possible. One of the main objectives is to provide the minimum sufficient requirements, relevant to the field of application that is: small renewable energy and hybrid off-grid systems.

RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-4: Integrated system – User installation

1 Scope

The purpose of this part of IEC 62257 is to specify the general requirements for the design and the implementation of a user's installation.

This part of IEC 62257-9 applies to single phase user's electrical installations with maximum power of 500 VA, in Decentralized Rural Electrification Systems (DRES).

NOTE For installations above 500 VA in decentralized electrification systems, IEC 62257-5 applies.

This part of IEC 62257-9 is applicable to installations supplied by a microgrid (120 V a.c. or 230 V a.c.) and to installations encompassing their own single-unit micropowerplant (120 V a.c. or 230 V a.c. or 12 V d.c. or 24 V d.c.)

The part of IEC 62257-9 applies neither to the electric power production and distribution installations described in the sections concerning microplants and microgrids, nor to user electrical equipment. It details the rules governing the design and construction of consumer's electrical installations for the purpose of ensuring the safety of persons and property, and satisfactory operation in accordance with the purpose for which the installations are designed.

It applies to new installations and modifications of existing installations.

2 Normative reference

The following referenced documents are essential for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60269 (all parts), *Low-voltage fuses*

IEC 60364-5-52, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 62257 (all parts), *Recommendations for small renewable energy and hybrid systems for rural electrification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
protective conductor
(identification: PE)
conductor provided for purposes of safety, for example protection against electric shock

NOTE In an electrical installation, the conductor identified PE is normally also considered as protective earthing conductor.

[IEV 195-02-09]

3.2
PEN conductor
conductor combining the functions of a protective earthing conductor and a neutral conductor

[IEV 195-02-12]

3.3
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

NOTE The role of the equipotential bonding is to decrease the difference in potential that can exists between two exposed-conductive parts of an installation.

3.4
surge arrester
device designed to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently, the amplitude of the follow-on current

3.5
supply point
contractual limit between the grid and the user's installation

NOTE In rural electrification systems, it is generally located on the input terminals (microgrid side) of the user's interface.

3.6
Surge Protective Device
SPD
device that is intended to protect the electrical apparatus from transient overvoltages and divert surge current; it contains at least one non-linear component

4 General considerations

4.1 General

User installations shall be designed to ensure protection of persons, animal and equipment in compliance with IEC 62257-5.

Specific requirements for generators associated with stand-alone user installations are provided in the relevant part of the IEC 62257-7 series.

4.2 Installation limits

Installation limits are illustrated in following Figure 1.

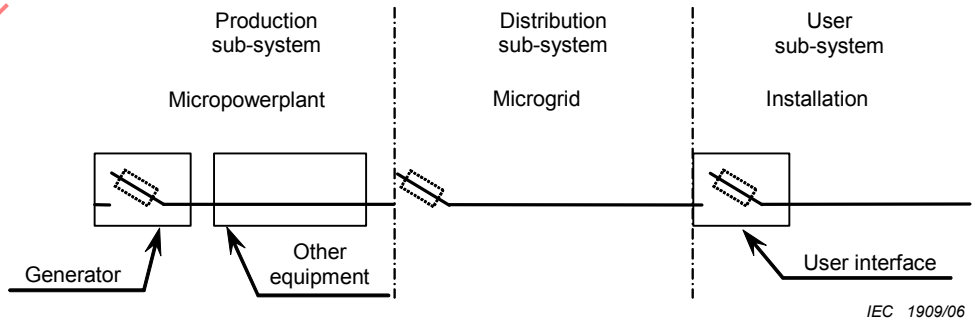


Figure 1 – Installation limits

4.3 User interface

See IEC 62257-9-3.

5 Protection against electric shock

5.1 Requirements for d.c. parts of installation

Simple separation, at least, shall be provided between the d.c. side and the a.c. side of a stand-alone installation (for a PV array, see also IEC 62257-7-1).

5.2 Requirements for a.c. parts of installation

5.2.1 General

The characteristics of the protective devices shall be such that if a fault of negligible impedance occurs anywhere in the installation between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within 0,4 s.

A residual current protective device, with a rated operating residual current not exceeding 30 mA shall be provided as additional protection for each installation. It shall be placed in the user's interface housing.

5.2.2 Neutral earthing system

5.2.2.1 Installation supplied from a microgrid or standalone installation encompassing a micropowerplant 230 V or 120 V a.c.

User's electrical installation should be preferably designed according to a TN-S system.

NOTE 1 The TT system is not recommended for the user's installation, because for the TT system, each house is equipped with an earth electrode. For the electrification of remote villages, it could be difficult to install and maintain an effective earth electrode in each house.

Figure 2 illustrates the fault current circulation in TN-C-S systems.

NOTE 2 The "grey box" called "user interface" is specified in IEC 62257-9-3.

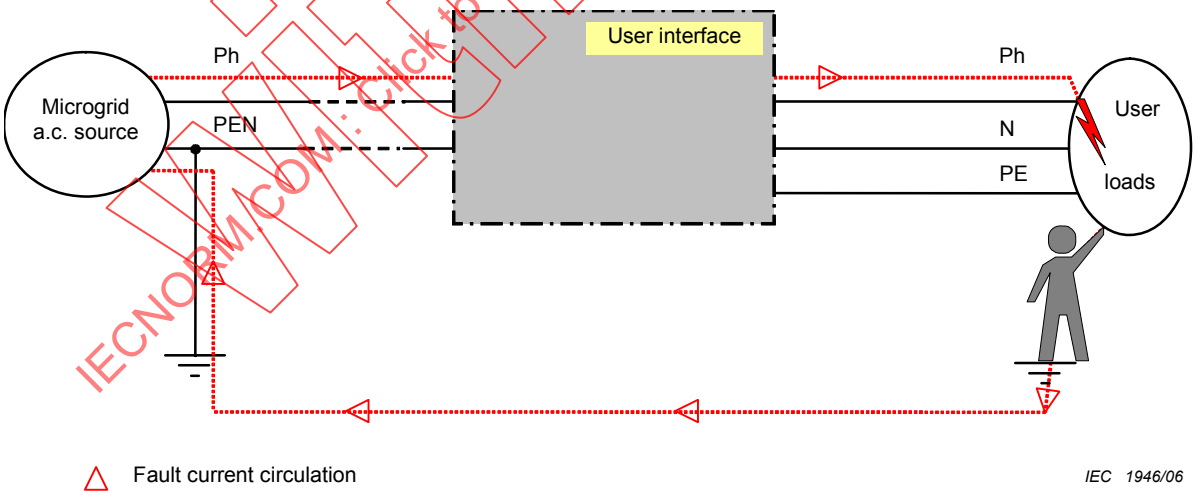


Figure 2 – Protection of persons in an installation supplied from a microgrid according to a TN-C-S system

5.2.2.2 Standalone installation with a.c. and d.c. electrical circuits, encompassing d.c. micropowerplant (ex: PV generators)

IEC 62257-5 provides provisions to apply on d.c. and a.c. circuits.

For combined systems in which a part of the installation is 12 V / 24 V d.c. and the other part is 120 V or 230 V a.c., through a d.c./a.c. converter, a TN-S system shall be created for the a.c. part. The PE conductor shall be earthed.

Figure 3 shows the fault current circulation and the principles for protection of persons in a combined d.c. and a.c. system.

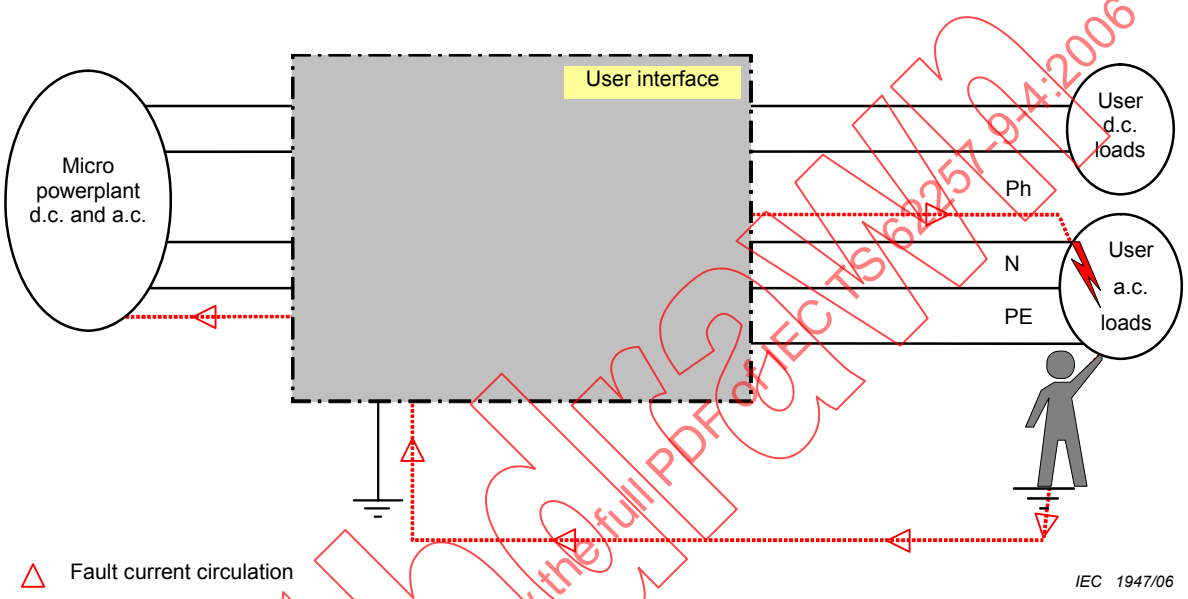


Figure 3 – Protection of persons in a combined d.c. and a.c. system

6 Protection against overcurrent

The installation may consist of one single circuit or be divided in several sub-circuits. Each circuit shall be protected against overcurrent. Where the installation comprises only one circuit, the overcurrent protective device is located in the user's interface housing.

NOTE 1 if the sub-circuits have the same cross sectional area as the main supply circuit (see 8.1.3), protection may be provided by a single device on the main supply circuit.

Table 1 shows the maximum design current of the circuits in a 500 VA installation.

Table 1 – maximum design current of circuits depending on voltages

Voltage	Maximum design current
120 V a.c.	5 A
230 V a.c.	2 A
12 V/ 24 V d.c.	40 A / 20 A

NOTE 2 Protection against fire is also performed by RCD's defined in 5.2.1. for a.c. circuits.

7 Protection against effect of lightning

7.1 Installation supplied from a microgrid

The overvoltage protection, where necessary, is provided on the microgrid side.

7.2 Standalone installation

If the distance between the external generator and the user's installation is less than 15 m: no special measure is required.

If the distance between the external generator and the user's installation is greater than 15 m and the number of thunderstorm days per year (obtained from iso-keraunic maps) is high (generally more than 25 days per year), a conductor made of bare copper with a sectional area of at least 10 mm² shall be installed between the external generator and the user's installation.

It shall be installed in the same ditch as the electrical cable (laid in a conduit) as close as possible to it. This creates an equipotential bonding system as shown in Figure 3. One of the ends shall be connected to the earthing electrode of the external generator and the other shall be connected to a special terminal provided for this purpose at the user's installation. SPDs shall be installed between the two polarities and between each polarity and the earth at the two ends of the bonding conductor.

For specific requirements for generators, refer to the appropriate parts of the IEC 62257-7 series.

8 Selection and erection of electrical equipment

8.1 Wiring system

8.1.1 General

The number of subcircuits shall be determined according to the position of the consumption points, their nature and the foreseeable load.

Separate neutral and protective conductors shall be provided for each subcircuit.

The cross-sectional area of conductors is chosen to provide for a satisfactory lifetime of conductors and insulation subjected to the thermal effects of carrying current for prolonged periods of time in normal service (See tables in IEC 60364-5-52).

Other considerations that affect the choice of cross-sectional area of conductors are:

- to fulfill maximum acceptable voltage drop,
- to withstand the electro-dynamic stresses which can occur in the event of a short-circuit,
- to withstand the other mechanical stresses to which the conductors may be subjected,
- to ensure an impedance value compatible with operation of the short-circuit protection devices.

8.1.2 Voltage drops

The maximum voltage drops in the installation shall not be greater than those indicated in Table 2.

Table 2 – Maximum acceptable voltage drop values in installations

Type of installation	Lighting and socket-outlets
Installation supplied from a 120 V or 230 V distribution microgrid or standalone installation with an a.c. source	3 %
Standalone installation with a d.c. source	5 %

8.1.3 Cross sectional area of conductors

The cross-sectional area of line conductors in a.c. circuits and live conductors in d.c. circuits shall be chosen among the values given in Table 3.

The smallest value given fulfills the main design requirement, which is based on thermal effects. It is possible to select a larger cross-sectional area in order to fulfill other requirements such as voltage drop and/or mechanical stresses or for economical considerations such as the harmonization of conductors.

Protective conductors shall be made of the same material and shall have at least the same cross section area as the line conductors provided that they are part of the same cable or are located in the same enclosure as line conductors. If the protective conductor is not part of the supply cable, the minimum cross section area shall be 4 mm^2; this is to ensure an acceptable level of mechanical durability.

Table 3 – Cross-sectional area for copper conductors in fixed installations

Type of system wiring	Material	Use of the circuit	Voltage	Cross-sectional area mm²
Cables and insulated conductors	Copper	Lighting or/and power outlet	120 V or 230 V a.c.	0,75
				1
				1,5
			12 V d.c.	2,5
				4
				6
				10
			24 V d.c.	2,5
				4
				6

8.1.4 Connections

Connections between conductors and between conductors and other equipment shall provide durable electrical continuity and adequate mechanical strength and protection.

The selection of the means of connection equipment shall, as appropriate, take into account:

- the material of the conductor and its insulation,
- the number and shape of the wires forming the conductor,
- the cross-sectional area of the conductors,

- the number of conductors to be connected together.

Where necessary, precautions shall be taken so that the temperature attained by the connections in normal service shall not impair the effectiveness of the insulation of the conductors connected to them or supporting them, the following requirements shall be followed:

- All connections shall be accessible for inspection, testing and maintenance.
- Soldered connections and splices shall not be used.
- The connections shall have a protection degree of IP2X by construction or assembly.
- The connections shall not be subject to any tension, torsion, or vibration.
- Multiple conductors joined on the terminals of a device, will be allowed provided the following two conditions are satisfied:
  - the terminals are specially designed for this purpose and are sized to receive the total cross-sectional area of all the conductors concerned,
  - the rated current of the terminals is not lower than the current for which the upstream circuit is designed.

8.1.5 Installation method

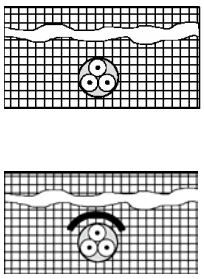
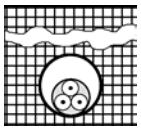
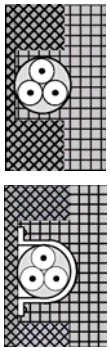
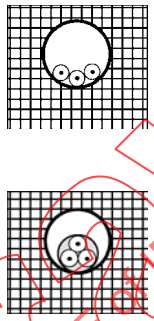
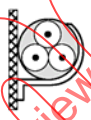
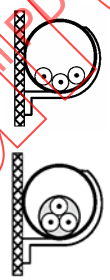
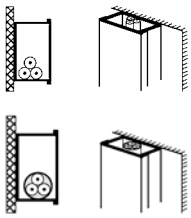
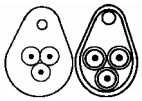
The method of installation of a wiring system in relation to the type of conductor or cable used shall be in accordance with Table 4, provided the external influences are covered by the requirements of the relevant product standards.

Table 4 – Selection of wiring systems

Conductors and cables	Method of installation				
	Without fixing	Clipped direct	Conduit	Cable trunking	Support wire
Insulated conductors	not permitted	not permitted	permitted	permitted	not permitted
Sheathed single core cables	not permitted	permitted	permitted	permitted	permitted
Sheathed multicore cables	permitted	permitted	permitted	permitted	permitted

The method of installation of system wiring shall be completed in accordance with Table 5.

Table 5 – Installation of wiring systems

Situations	Method of installation				
	Without fixing	Clipped direct	Conduit	Cable trunking	Support wire
Buried in earth		Not applcable		Not applicable	Not applicable
Embedded in structure		Not applicable		Not applicable	Not applicable
Surface mounted (wooden, or masonry wall)	Not permitted			 Run horizontally and vertically	Not applicable
Overhead	Not applicable	Not applicable	Not applicable	Not applicable	 Suspended cable incorporating a support wire

A multi-core cable should only contain the conductors of a single circuit.

Multi-core cables and insulated conductors belonging to a single circuit shall be laid in the immediate vicinity of each other. This rule also applies to the corresponding protection conductor.

For outdoor installation, cables or conduits shall be rated for outdoor use.

The choice of conduit installation method depends on:

- the nature of the facilities and locations,
- the nature of the walls and other construction elements supporting the conduits,
- the accessibility of the conduits to persons and animals,
- the other external conditions,
- other stresses to which the conduits may be subjected during realization of the electrical installation, or in service.

Outdoor, cables shall be laid in conduits.

For links between buildings, cables shall be installed in underground conduits or be suspended from a support wire.

8.1.6 Selection and erection of wiring systems in relation to external influences

8.1.6.1 Ambient temperature

Wiring systems shall be selected and erected so as to be suitable for the highest local ambient temperature.

Wiring system components including cables and wiring accessories shall only be installed or handled at temperatures within the limits stated in the relevant product specification or as given by the manufacturers.

8.1.6.2 External heat sources

In order to avoid the effects of radiated, convected or conducted heating such as:

- solar gain of the wiring system or its surrounding medium,
- through heat conducting materials,
- from other hot sources,
- internal current direct heating.

One of the following, or equally effective method, shall be used to protect wiring systems:

- shielding,
- increasing ventilation,
- placing sufficiently far from the source of heat,
- selecting a system with due regard for the additional temperature rise which may occur,
- local reinforcement or substitution of insulating material.

8.1.6.3 Presence of water

Wiring systems shall be selected and erected so that no damage is caused by the ingress of water. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.

Where water may collect or condensation form in wiring systems, provision shall be made for its escape and ventilation.

8.1.6.4 Presence of solid foreign bodies

Wiring systems shall be selected and erected so as to minimize the danger arising from the ingress of solid foreign bodies. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.

8.1.6.5 Presence of corrosive or polluting substances

Where the presence of corrosive or polluting substances, including water, is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or manufactured from a material resistant to such substances.

8.1.6.6 Impact

Wiring systems shall be selected and erected so as to minimize the damage arising from mechanical stress, e.g. by impact, penetration or compression.

8.1.6.7 Vibration

Wiring systems supported by or fixed to structures of equipment subject to vibration shall be suitable for such conditions, particularly where cables and cable connections are concerned.

Fixed installation of suspended current-using equipment, e.g. luminaires, shall be connected by cable with flexible core. Where no vibration nor movement can be expected, cable with non-flexible core may be used.

8.1.6.8 Other mechanical stresses

Wiring systems shall be selected and erected so as to prevent during installation, use or maintenance, damage to the sheath and insulation of cables and insulated conductors and their terminations.

When buried in the structure, conduits for each circuit shall be completely installed before any insulated conductor or cable is drawn in.

The radius of every bend in a wiring system shall be such that conductors or cables shall not suffer damage.

Conductors or cables not contained in conduit shall be supported by suitable means at appropriate intervals (maximum 1 m) in such a manner that the conductors or cables do not suffer damage by their own weight. In addition, provision shall be made to avoid or account for the use of conductors or cables as a means to hang objects.

The inside dimensions of the conduits and connection accessories shall be such that cables and insulated conductors can be easily run and withdrawn after the conduits and their accessories have been installed.

Where a permanent tensile stress is applied to the wiring system (e.g. by its own weight in vertical runs), a suitable type of cable or conductor with appropriate cross-sectional areas and method of mounting shall be selected in such a manner that the conductors or cables do not suffer damage.

Wiring systems intended for the drawing in or out of conductors or cables shall have adequate means of access to allow this operation.

Wiring systems that are rigidly fixed and buried in the walls shall be run horizontally or vertically or parallel to the room edges.

Wiring systems concealed in the structure but not fixed may follow the shortest practical route.

Flexible wiring systems shall be installed so that excessive tensile stress to the conductors and connections is avoided.

8.1.7 Specific rules to wiring systems buried in earth

8.1.7.1 General

Wiring system buried in earth shall be protected by conduits or sleeves or by equivalent devices against mechanical deterioration. The diameter of the conduits shall be at least three times the diameter of the cables. After laying the cable, the ends of the sleeve shall be closed (for example with plaster) to avoid clogging.

To compensate for the effects of the settling of the soil, the cables shall be buried at a depth of at least 60 cm in areas inaccessible to motor vehicles and at a depth of 1 m in areas accessible to motor vehicles. A red plastic grid placed 10 cm above the conduits shall indicate the electrical conduits.

These depths can be reduced in rocky terrain or if the sleeves used are designed to ensure that the cables do not directly withstand the settling effect of the soil.

8.1.7.2 Presence of fauna, flora and/or mould growth

Where conditions experienced or expected constitute a hazard, the wiring system shall be selected accordingly or special protective measures shall be adopted, for example, by:

- the mechanical characteristics of the wiring system, or
- the location selected, or
- the provision of additional local or general mechanical protection, or
- by any combination of the above.

8.1.7.3 Solar radiation

Where significant solar radiation is experienced or expected, a wiring system suitable for the conditions shall be selected and erected or adequate shielding shall be provided.

8.1.7.4 Flame propagation

Conduits designed to inhibit flame propagation are recommended.

8.1.8 Circuits identification

When an installation contains both a.c. and d.c. wiring, circuits (cables + accessories) shall be permanently marked to identify the circuits at least every 2 m.

8.2 Isolation and switching

8.2.1 Overcurrent protective devices

Table 6 indicates the fuse rating to be implemented in a 120 V or 230 V a.c. system and in a 12 V or 24 V d.c. system. Circuit breakers with appropriate rating may also be used.

Table 6 – Fuses/circuit breakers rating and selection for overcurrent protection

	Fuses		Circuit breaker type
	Design current	Type	
120 V a.c.	1 A	gG 8,5/31,5	1 A
	2 A	gG 8,5/31,5	2 A
	5 A	gG 8,5/31,5	6 A
230 V a.c.	1 A	gG 8,5/31,5	1 A
	2 A	gG 8,5/31,5	2 A
12 V or 24 V d.c.	20 A	gG 10/38	According to manufacturer's products
Type of fuses are defined in reference to IEC 60269.			

8.2.2 Residual current devices

See IEC 62257-5.

8.3 Surge protective devices

See IEC 62257-5.

8.4 Earthing arrangement, protective conductors and protective bonding

See IEC 62257-5.

8.5 User interface

A type tested assembly following IEC 62257-9-3 called "User interface" shall be provided for installations supplied from a microgrid or for stand alone systems supplied from a micropowerplant.

The PE protection conductor shall be connected to the PEN conductor of the microgrid in the user interface housing upstream of the RCD, on a terminal provided for this purpose.

9 Verification

9.1 Pre-commissioning checks

9.1.1 General information

The electrical installations shall be verified prior to commissioning and whenever any major modifications are made to ensure that they comply with the requirements of this part of IEC 62257-9.

The pre-commissioning checks shall be performed by a skilled person.

All installations, during realization and once completed and prior to turning over to the user, shall be verified by inspection and tested to ensure, that insofar as possible, the requirements of this part of IEC 62257-9 have been observed.

The installer shall provide "as installed" diagrams to the consultant engineer in charge of commissioning under the responsibility of the project developer.

The safety rules shall be observed during the verification procedure to avoid any danger to persons, animals and property.

When extensions or modifications are made, all the necessary measures shall be taken to verify that the extensions or modifications satisfy the requirements of this part of IEC 62257-9 and do not compromise the safety of the existing installation.

9.1.2 Verification by inspection

The verification is performed prior to the tests with the installation not energized.

This procedure is aimed at verifying that the permanently connected equipment satisfies the requirements of the standards by which it is governed. This can be verified by examining the markings or compliance certificate when such a certificate exists.

The inspection should cover, as a minimum, verification of the following items insofar as they apply:

- cross sectional area of conductors appropriate for design currents and voltage drops,
- selection of equipment appropriate to external influences,
- correct identification of neutral, phase and protective conductors, using recognized colour code,
- identification of circuits, fuses, switches, terminals,
- conductor connections,
- accessibility for verification and maintenance,
- correct position of conductors in all the socket-outlets,
- connection of the PE conductor to the PEN microgrid conductor in the user's interface at the terminal provided for this purpose,
- where applicable, connection between PE conductor and earth electrode.

Tightness of connections shall be spot checked particularly for 12 V and 24 V d.c. systems.

9.1.3 Verification by tests

9.1.3.1 Installation not energized

A test of continuity of the PE conductor shall be performed for example using a multimeter.

9.1.3.2 Installation energized

Tests shall consist of verifying correct operation of all the electrical equipment and measuring that the voltage drops at the terminals of the electrical equipment are within the limits defined in this part of IEC 62257-9.

Additionally, the following shall be checked:

- phase to neutral voltages,
- correct operation of differential protection device,
- correct operation of current limiter if any, using an appropriate portable device.

10 Operation and maintenance

Isolation devices shall be provided to isolate the electrical installation from the circuits or individual devices to enable servicing, verification, fault isolation and repair procedures.