IEC TS 62257-9-1

Edition 2.0 2016-09

TECHNICAL SPECIFICATION

colour inside

Recommendations for renewable energy and hybrid systems for rural electrification –
Part 9-1: Integrated systems – Micropower systems

IEC TS 62257-9-1:2016-09(en)

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RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-1: Integrated systems – Micropower systems

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 62257-9-1, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition, issued in 2008. It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- Changing the voltage range covered by the technical specification to a.c. nominal voltage below 1 000 V and d.c. nominal voltage below 1 500 V (introduction)
- Defining the rating of the microgrids to be the output of the microgrid (introduction)
- Including 240 V 1-Ø/415 V 3-Ø, in the voltage levels (introduction)
- Specifying Non-separated MPPTs connecting LV d.c. arrays to ELV d.c. battery banks are not allowed (5.3.1.1)
- Noting that systems can now include a.c. bus arrangements and use MPPT's as the solar controllers thus increasing the internal voltages that occur in systems (5.3.1.2)
- Increased equipotential bonding for lightning protection from minimum 10 mm^2 to minimum 16 mm^2 (6.1.2.2)
- Included a new subclause (7.1.6) on battery enclosures including possible arrangements shown as Clause D.6
- Rewritten LV Multiple sources (7.2.2.3.1)
- Included start-up procedure in documentation (10.2)

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

Enquiry draft	Report on voting
82/1028/DTS	82/1087/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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

This technical specification is to be used in conjunction with the IEC 62257 series and with future parts of this series as and when they are published.

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

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

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INTRODUCTION

The IEC 62257 series of documents intends to provide to the 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 1 000 V, and d.c. nominal voltage below 1 500 V.

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 must 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 RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-1: Integrated systems – Micropower systems

1 Scope

Decentralized Rural Electrification Systems (DRES) are designed to supply electric power for sites which are not connected to a large interconnected system, or a national grid, in order to meet basic needs.

The majority of these sites are:

- isolated dwellings;
- village houses;
- community services (public lighting, pumping, health centres, places of worship or cultural activities, administrative buildings, etc.);
- economic activities (workshops, micro-industry, etc.).

The DRESs fall into the following three categories:

- process electrification systems (for example, for pumping);
- individual electrification systems (IES) for single users;
- collective electrification systems (CES) for multiple users.

Process or individual electrification systems exclusively consist of two subsystems:

- an electric energy generation subsystem;
- the user's electrical installation.

Collective electrification systems, however, consist of three subsystems:

- an electric energy generation subsystem;
- a distribution subsystem, also called microgrid;
- user's electrical installations including interface equipment between the installations and the microgrid.

This technical specification applies to a micropower plant which is the electric energy generation subsystem associated with a decentralized rural electrification system.

It provides general requirements for the design, erection and operation of micropower plants and general requirements to ensure the safety of persons and property.

The micropower plants covered by this specification are low-voltage a.c., three-phase or single-phase, with rated capacity less than, or equal to, 100 kVA. The rated capacity is at the electrical output of the micropower plant, that is, the upstream terminals of the main switch between the micropower plant and the microgrid. They do not include voltage transformation.

The voltage levels covered under this specification are:

- the 240 V 1-Ø/415 V 3-Ø, the 230 V 1-Ø/400 V 3-Ø, the 220 V 1-Ø/380 V 3-Ø, and the 120 V 1-Ø/208 V 3-Ø systems at 60 Hz or 50 Hz; or obeyed by local code.

- the ELV (less than 120 V) d.c. systems.

The requirements cover "centralized" micropower plants for application in:

- process electrification;
- individual electrification systems and collective electrification systems.

It does not apply to distributed generation on microgrids.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC TS 62257-2:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 2: From requirements to a range of electrification systems*

IEC TS 62257-4:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 4: System selection and design*

IEC TS 62257-5:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards*

IEC TS 62257-6:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement*

IEC TS 62257-7-1:2010, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-1: Generators – Photovoltaic generators*

IEC TS 62257-7-3:2008, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-3: Generator set – Selection of generator sets for rural electrification systems*

IEC TS 62257-9-2:2016, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-2: Integrated systems – Microgrids*

IEC TS 62257-9-4:2016, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-4: Integrated systems – User installation*

IEC 62548:2016, *Photovoltaic (PV) arrays – Design requirements*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
generator set
equipment producing electricity from a fossil fuel; it consists basically of an internal combustion engine producing mechanical energy and a generator which converts the mechanical energy into electrical energy and mechanical transmission, support and assembly components

3.2
reference earth
reference ground (US)
conductive part of the earth, considered as conductive, the electric potential of which is conventionally taken as zero, being outside the zone of influence of any earthing arrangement

[SOURCE: IEC 60050-826:2004, 826-13-01]

3.3
skilled person
person with relevant education or experience to enable him/her

- to perceive risks and to avoid hazards which electrical, chemical or mechanical equipment may create;
- to perform or supervise correctly the required task

3.4
instructed person
person adequately advised or supervised by skilled persons to enable him/her

- to perceive risks and to avoid hazards which electrical, chemical or mechanical equipment may create;
- to perform correctly the required task

3.5
ordinary person
person who is neither a skilled person nor an instructed person

3.6
licenced person
person who is authorized to perform electrical work under the appropriate state or territory statutes and regulations

Note 1 to entry: Only skilled or instructed persons can be licenced.

3.7
microgrid
subsystem of a DRES intended for power distribution, the prefix "micro" being intended to express the low level of transmitting capacity

3.8
micropower plant
subsystem of a DRES for power generation, the prefix "micro" being intended to express the low power level generated

3.9
protective conductor
identification: PE
conductor provided for purposes of safety, for example protection against electric shock

[SOURCE: IEC 60050-826:2004, 826-13-22]

3.10
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-826:2004, 826-13-25]

3.11
power line
overhead or underground line installed to convey electrical energy for any purpose other than communication

3.12
renewable energy
RE
energy generated from natural resources such as sunlight, wind, rain, waves, tides, geothermal heat (list not exhaustive), which are renewable (naturally replenished)

Note 1 to entry: Renewable energy technologies include solar power, wind power, hydroelectricity, micro hydro, biomass, biofuels (list not exhaustive).

3.13
selectivity of protection
ability of a protection to identify the faulty section and/or phase(s) of a power system

[SOURCE: IEC 60050-448: 1995, 448-11-06]

3.14
lightning arrester
surge diverter
surge arrester
device intended to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently the amplitude of the follow-on current

[SOURCE: IEC 60050-811: 1991, 811-31-09]

3.15
technical room
cabinet
room or cabinet in which are located devices and apparatus dedicated to inter-connection of the different generators, protection of the different circuits, monitoring and control of the micropower plant and interfacing with the application

4 General

4.1 Boundary of a micropower plant

The micropower plant is defined as illustrated in Figure 1.

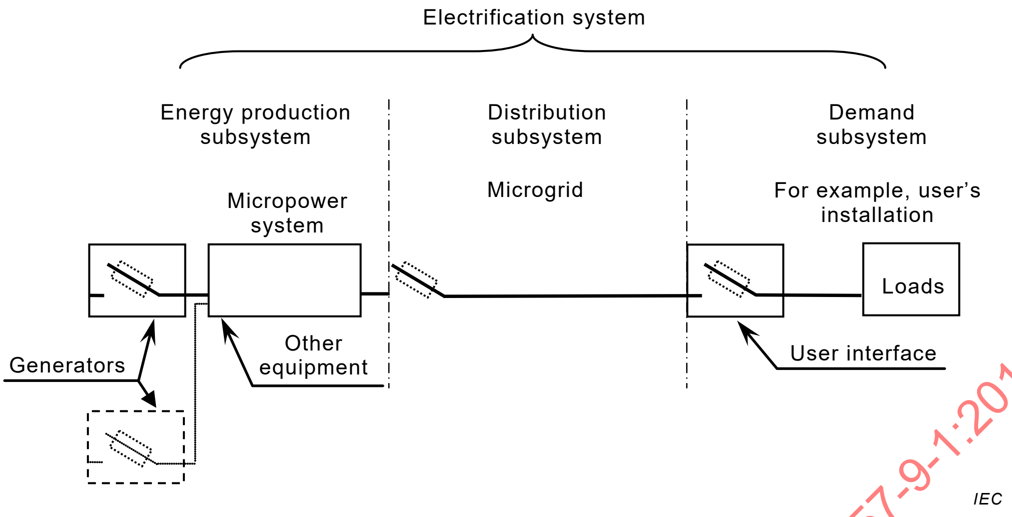


Figure 1 – Micropower system limits

The physical limits of the micropower plant are the upstream terminals of the main switch between the micropower plant and the microgrid.

4.2 Composition of a micropower plant

A micropower plant includes:

- one or several generators;
- storage devices (if needed) and associated charge controller;
- other equipment, such as
  – energy management device;
  – energy converter;
  – telecommunication equipment (if any);
  – main board;
  – interfaces:
    - between generators;
    - between the micropower plant and the microgrid or the application;
    - between the micropower plant and the operator;
  – switches;
  – protection devices;
- equipotential bonding;
- earthing system;
- civil works.

4.3 General functional layout of a micropower plant

Figure 2 illustrates an example of the general functional layout of a micropower plant combining the different equipment listed in 4.2.

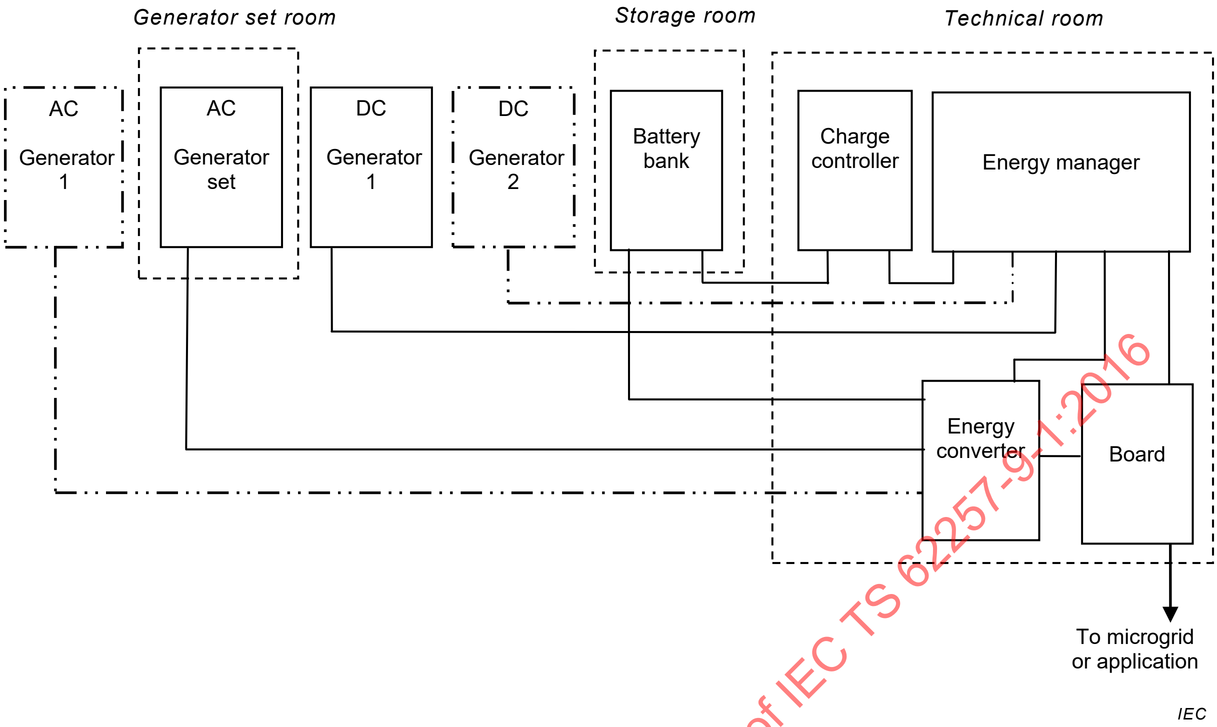


Figure 2 – Example of functional layout for a micropower plant supplying a.c. energy

5 Design

5.1 Design criteria

The design of any system should be guided by a number of criteria, determined by the project implementer (for example, user's affordable needs, lowest economic life-cycle cost, lowest environmental impact, site constraints). Some of the major areas to be considered are:

- average daily design d.c. load energy and average daily design a.c. load energy;
- maximum and surge power demand;
- system bus bar voltage and service (output) voltage;
- energy resources (sun, wind, hydro, fuel, biomass, etc.);
- budget constraints;
- power quality (for example, waveform quality or continuity of supply);
- environmental impact (for example, trimming or removal of trees for a PV system, civil works and diversion of water in a hydro system);
- use of existing equipment;
- acceptable extent of generator set running versus renewable energy contribution;
- acceptable noise levels;
- availability of spare parts and maintenance service;
- site accessibility;
- acceptable level of reliability and maintenance;
- level of automation versus direct user control;
- aesthetics.

The level of reliability should be determined in order to match the quality of service which is intended to be provided to the user in the general specification.

NOTE The necessity for special design techniques to achieve very high levels of reliability will depend on the application and on the willingness to pay of customers for high quality of service.

The provision of electrical energy should be dealt with in the context of provision of all energy services to the dwelling or group of buildings. Such an integrated approach to the provision of energy services should yield the lowest cost outcome and can ensure lower overall energy consumption from non-renewable sources.

The design process performance specifications shall take into account the considerations above and shall be based on renewable energy resource data including adjustments for site conditions and design parameters (for example, PV array tilt angle and orientation, wind turbine tower height).

Major system parameters which shall be provided by the design process (for annual, seasonal or monthly periods, as appropriate to the basis of the design) are:

- load management strategies or conditions necessary for performance as specified;
- design d.c. load energy and design a.c. load energy;
- maximum and surge demand;
- average daily energy output of each renewable energy generator under design conditions;
- expected contribution to the load from each generator under design conditions, as a percentage;
- nominal generator set run time under design conditions;
- system voltage;
- ratings of major components.

5.2 Power generation mix

5.2.1 General

Energy sources to be used in the micropower plant should be chosen on the basis of:

- assessment of affordable energy needs (see IEC TS 62257-2);
- quality of service as defined in the general specification (see IEC TS 62257-2:2015, Annex C);
- capability of the different technologies to match the electrical needs, the affordable services cost and the user's preferences IEC TS 62257-2:2015, Annex D;
- local availability of energy sources (see IEC TS 62257-4);
- installed cost, maintenance costs and business plan of the project (see IEC TS 62257-4:2015, Annex D);
- local regulations or constraints regarding use of the resource or installation of the generator and associated equipment;
- aesthetic and environmental impacts.

The project implementer shall determine the proportion of power and energy to be provided by the different energy sources.

NOTE See also the calculations of renewable energy fraction in Annex E.

In selecting renewable energy generators, the following additional factors shall be taken into account:

- time and cost for obtaining reliable resource data;
- adequacy of the renewable resource based on measured or estimated data;

- where more than one renewable energy generator is used, the seasonal and short-term complementarity of the energy sources.

Recommendations for the use of small renewable energy generators are provided in IEC TS 62257-7.

The methodologies for assessing the renewable energy resources are provided in the specific documents dedicated to each generation technology (see IEC TS 62257-7-3).

5.2.2 Internal combustion generator sets

Selection should be based on consideration of the following additional factors:

- estimated monthly run time;
- fuel costs;
- use of the fuel on site for other purposes;
- noise levels emitted by the set, and required noise levels for the installation.

Recommendations for the use of generator sets are provided in IEC TS 62257-7-3.

5.3 Electrical design

5.3.1 System voltage selection

5.3.1.1 Output voltage

The power system shall be able to provide the following low-voltage a.c. levels for 60 Hz or 50 Hz systems, as specified in IEC TS 62257-9-2:

- 240 V 1-Ø / 415 V 3-Ø;
- 230 V 1-Ø / 400 V 3-Ø;
- 220 V 1-Ø / 380 V 3-Ø;
- 120 V 1-Ø / 208 V 3-Ø;
- or obeyed by local code

or ELV d.c. levels, especially 12 V or 24 V as specified in IEC TS 62257-9-4.

Non-separated MPPTs connecting LV d.c. arrays to ELV d.c. battery banks are not allowed.

5.3.1.2 Internal voltages

Voltages at the output of generators or components may be different from the voltages at the output of the power system.

The maximum levels of voltages shall be chosen in accordance with the maximum level of skill of the local operating staff. Levels of skill are defined in IEC TS 62257-6.

The different voltage domains and the operation rules are also defined in IEC TS 62257-6. If the local level skill is relatively low, it is recommended that the ELV domain be chosen.

Consideration should be given to the fact that many arrays are now using the a.c. bus configuration or using MPPTs where the array is LV d.c. and that appropriate additional training might be required to provided if the local skill level is low.

5.3.2 Interconnection of generators

Several cases may be considered depending on the type of energy sources and the type of application of equipment to be supplied. Where more than one generator is used, their outputs may be connected in common at an a.c. or a d.c. bus. The following Figure 3 and Figure 4 provide examples of generators interconnection schemes.

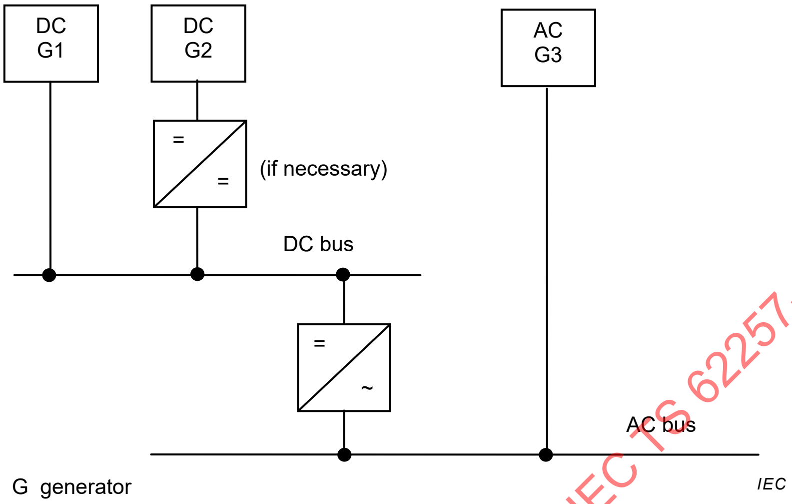


Figure 3 – Interconnection configuration with d.c. bus and a.c. bus

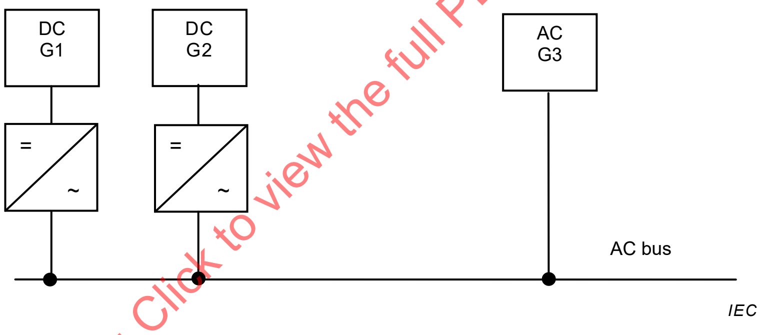


Figure 4 – Interconnection configuration with a.c. bus only

Examples of architectures of complete systems are provided in IEC TS 62257-2:2015, Annex E.

Attention shall be paid to the synchronization of a.c. generators which may be manual or automatic. Generally it is the most powerful and the longest running time a.c. generator which forms the grid and the other generators have to be synchronized with it when running.

5.4 Mechanical and civil works

5.4.1 Civil works

All structures shall be constructed to appropriate local statutory requirements and standards.

All civil works should be carried out in such a way as to minimize the environmental impacts, especially with regard to soil erosion and damage to vegetation.

5.4.2 Technical room

Some equipment, such as energy management device, charge controller, energy converter, main board, switches and protective devices as well as interconnection of the different circuits shall be installed in a technical room. For small systems, this technical room may be a cabinet.

This technical room shall be designed and installed in accordance with the requirements of IEC TS 62257-5 and IEC TS 62257-6.

5.4.3 Battery room

Special requirements for the battery room are given in Annex D.

NOTE Methodology for the selection of batteries and batteries management systems for stand-alone electrification systems – specific case of automotive flooded lead-acid batteries available in developing countries is provided in IEC TS 62257-8-1.

5.4.4 Specific requirements

Specific requirements for PV arrays, wind turbine, generator sets and microhydro turbines are provided in the related documents (IEC 62548, IEC TS 62257-7-1, IEC TS 62257-7-3).

6 Safety issues

6.1 Electrical issues

6.1.1 General

All installations shall comply with IEC TS 62257-5 and more generally with IEC 60364 concerning the following items:

- protection against electric shock
  - requirements on the d.c. side;
  - requirements on the a.c. side;
- protection against overcurrent;
- protection against overload currents;
- protection against short circuits;
- protection against effects of lightning;
- wiring;
- isolation and switching;
- surge protective devices.

6.1.2 Specific requirements

6.1.2.1 Selectivity of the protection

Attention shall be paid to the selectivity of the protection; an example of a complete protection scheme taking account of selectivity is addressed in Annex A.

6.1.2.2 Protection against effects of lightning

For most stand-alone power systems, lightning risk is often low, and protection is usually not needed. The exceptions are installations on high ground and in lightning-prone areas, wind generator towers or masts, and aerial wiring where any part is exposed to a lightning risk.

In order to asses the necessity of providing protection to micropower plants against effects of lightning methodologies are provided in Annex B. As the cost of installing surge protection devices could be high, this assessment shall be made carefully.

If the risk assessed is quoted as being higher than 14 (Clause B.3) or if the number of thunderstorm days per year is higher than 25 days per year (Clause B.2), special provision shall be made in order to protect the micropower plant from the effect of lightning.

In any case, an equipotential bonding shall be made using a copper conductor (or conductor of other material e.g. aluminium and stainless steel, which has the resistivity equivalent to 16 mm^2 copper) with a sectional area of at least 16 mm² installed between the different generators and the "technical room". This conductor shall be installed direct in the earth, in the same ditch as the power cable as close as possible to it. 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 in the technical room. This creates an equipotential bonding system as shown in Figure 5.

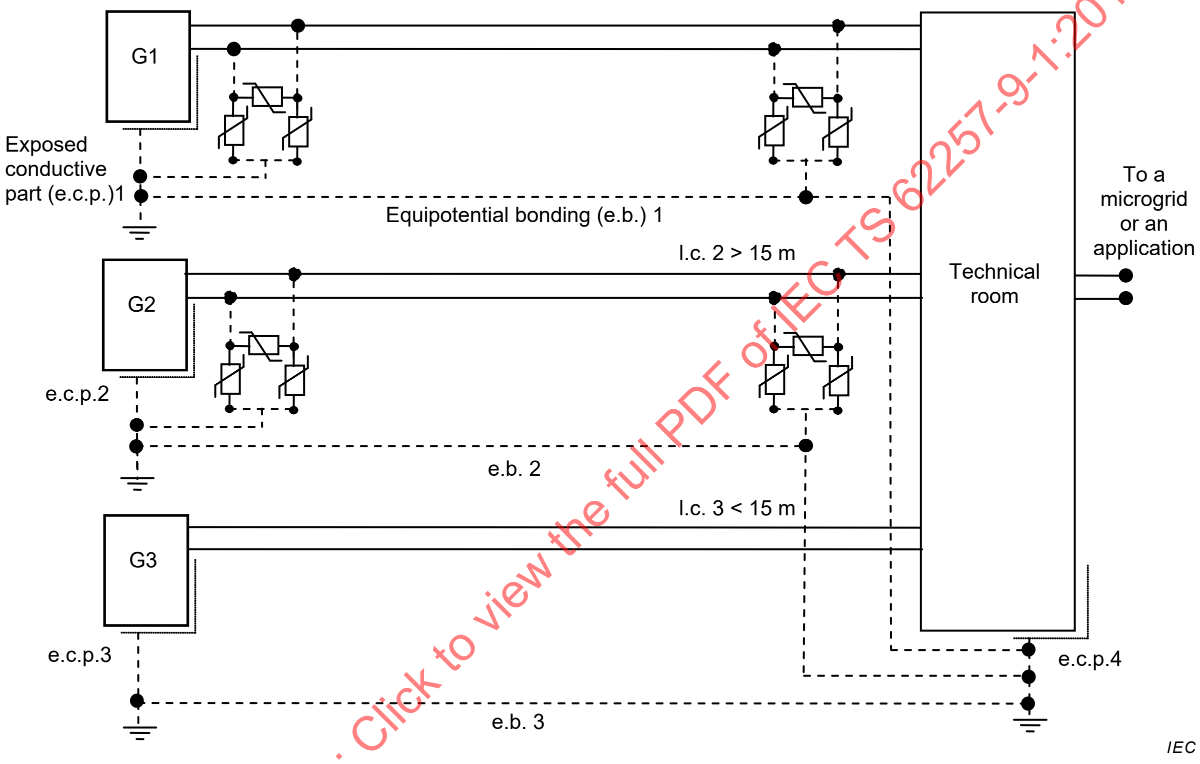


Figure 5 – Example of protection against effects of lightning and over-voltage for generators with two live conductors output (d.c. or a.c.) TNS P+N

If the distance between the external generators and the technical room is less than 15 m, no additional special measure is required.

If the distance between the external generators and the technical room is greater than 15 m, surge arresters shall be installed according to Figure 5.

Surge protective devices shall be installed between each live conductor (a.c. or d.c.) and between each live conductor and the earth at the two ends of the bonding conductor.

Another example is given in Figure 6 for a three phase a.c. (TNS P+N) system.

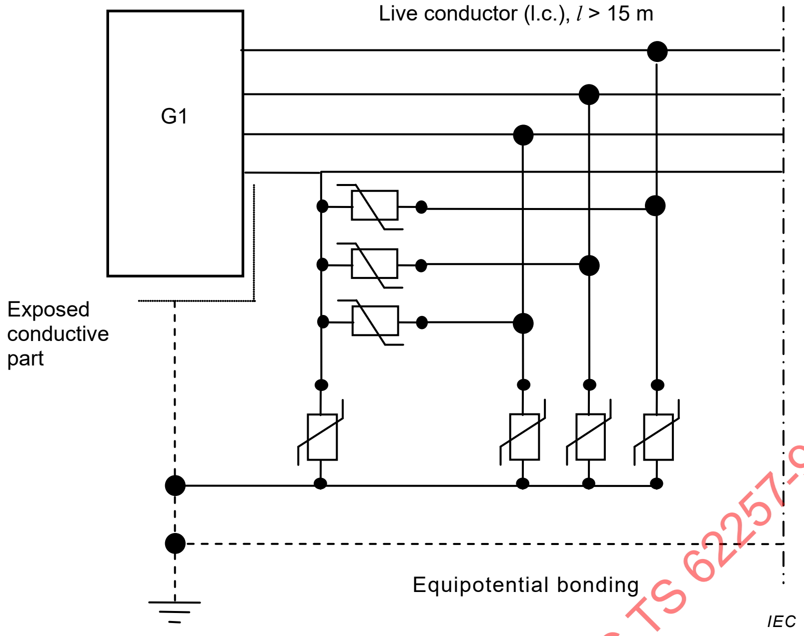


Figure 6 – Example of protection against effects of lightning over-voltage for three phase generators with four live a.c. conductors (TNS P+N scheme) – Generator side

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

Where protection against direct lightning is required, the following additional provision to the equipotential bonding shall be made:

- installation of a rod or a protecting wire to capture the lightning;
- installation of down conductors between the rod and the earth termination;
- construction of a crow's foot earth termination as illustrated in Figure 7.

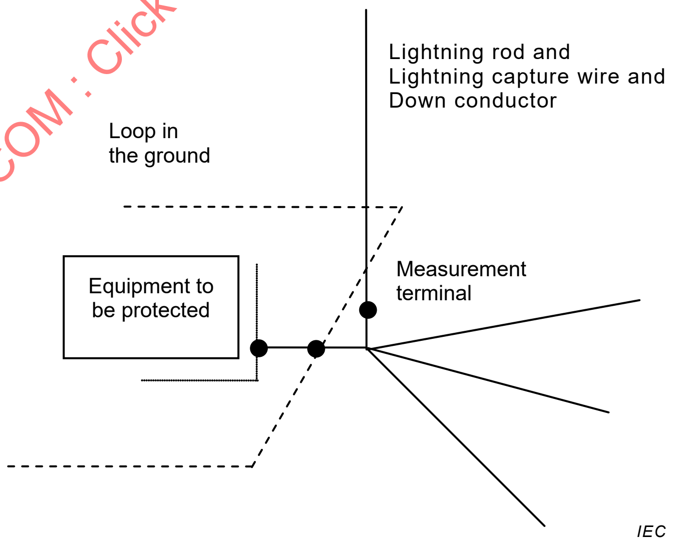


Figure 7 – Example of a simplified lightning protection including a crow's foot earth termination

The minimum cross-section of the conductors shall be as indicated in Table 1.

Table 1 – Minimum dimensions for lightning protection wires

Material	Lightning capture mm^2	Down conductor mm^2	Earth termination mm^2
Cu	35	16	50

As the lightning current is a high-frequency current, the down conductors shall be preferably ribbons or flat braided wires.

The following provisions apply.

- In the case of wind-powered generation, the lightning rod should be installed at the summit of the mast.
- Where PV generation coexists with wind-powered generation, protection against direct lightning is generally achieved by placing the panels inside the pick-up zone of the wind-powered generator mast.
- Where PV generation is alone, the panels can be protected by installing a protective wire above the PV panel with an appropriate pick-up area.
- Protection should be completed by the installation of SPDs between conductors and between conductors and earth, with appropriate characteristics (see IEC 60364-5-53:2001, 534).

An example of a configuration of protection for a photovoltaic array is given in Figure 8.

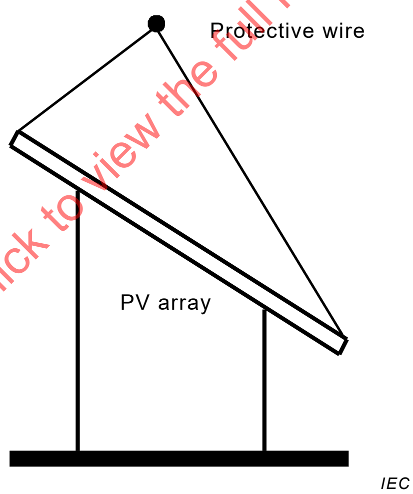


Figure 8 – Protection of a photovoltaic array

The protection of electronic equipment within the technical room is ensured by high-quality equipotential bonding.

- Equipotential links as short as possible.
- No loops in equipotential links as illustrated in Figure 9.

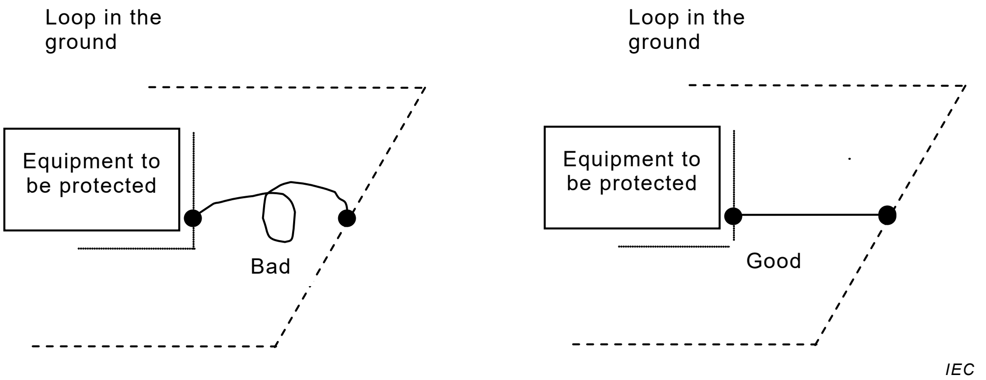


Figure 9 – Wiring arrangement for equipotential link

6.2 Mechanical issues

All components including mechanical parts, fuel systems, wiring, switches, instruments and controls shall be adequately protected against mechanical damage.

All moving parts that may cause injury to persons shall be protected by barriers to prevent unintentional personal contact with such parts. The protection shall be provided by guards, enclosures, railing or fences.

6.3 Thermal and fire issues

All hot parts which operate at temperatures in excess of 80 °C shall be out of reach or lagged so as to prevent accidental personal contact.

To avoid any risk of destruction due to fire caused by an earth fault in an electrical link between a generator and the technical room, a residual current protective device should be provided at least at the entry to the technical room. Its rated operating residual current should be ≤300 mA. Such a device should switch all live conductors.

The decision whether to install the residual protective device or not is left to the project implementer according to what is at stake in case of destruction of the technical room.

Direct current systems and photovoltaic systems, in particular, pose various hazards in addition to those derived from conventional a.c. power systems, for example, the ability to produce and sustain electrical arcs with currents that are not much greater than normal operating currents.

Fire-fighting equipment (at least sand bin and preferably extinguishers) shall be provided.

The technical room doors shall open outwards and be fitted with anti-panic devices.

6.4 Noise issues

Steps should be taken to ensure that noise produced by any of the system components is of an acceptably low level. The components of most concern in this respect are

- generator sets;
- wind turbines;
- inverters and other electronic equipment using high-frequency power conversion techniques.

In critical situations, the advice of a specialist should be sought.

Some recommendations for noise control are given in Annex F.

6.5 Access security

After commissioning, access to the different parts of the micropower plant shall be defined by the operator according to the operation plan.

Access should only be granted to skilled authorized staff. The necessary levels of skill shall be defined according to the part of the system to which they have to access and the kind of operation to be carried out (see levels defined in IEC TS 62257-6).

Any relevant provision shall be made to avoid access to unauthorized persons.

7 Erection of equipment

7.1 Siting

7.1.1 Photovoltaic array

The siting of the photovoltaic (PV) array shall comply with the requirements of IEC 62548:2016 and IEC TS 62257-7-1.

The photovoltaic array should be located where it will be unshaded for at least 4 h before and after solar noon (the time when the sun is highest in the sky) during all seasons. Where appropriate, vegetation causing significant shading should be removed. Where this is not possible or desirable, allowance should be made for reduced irradiation in array output calculations.

Consideration should also be given to minimizing the length of cable run to the battery, in particular with d.c bus systems using standard charge controller (that is no MPPT).

7.1.2 Wind turbine

Providing that the general location has an adequate wind resource, factors to be considered in the selection of the wind turbine site include

- suitable geography (for example, siting on flat or raised land);
- distance from the dwelling (for example, typically within several hundred metres);
- terrain clear of obstacles (trees and built structures);
- sufficient room for erection and any operation and maintenance action.

If there are obstacles in the vicinity then the tower should be high enough to raise the turbine above turbulence caused by the obstacles.

7.1.3 Micro-hydro turbine

In selecting a site for a micro-hydro turbine the following points should be considered:

- obtaining the maximum static head and/or the maximum flow according to the technology of the turbine;
- being within a suitable distance for transmission of electrical power to the dwelling;
- accessibility of the site.

The likely flood level for the site should be assessed, in order to either locate the turbine above flood level, or, where the turbine-generator will withstand flooding, make provision for adequate protection from floodwaters and flood-borne debris.

Any local regulations regarding diversion of water from the watercourse should be met.

7.1.4 Generator set

Generator set accommodation should meet the following requirements.

- Generator set accommodation should allow for an adequate air flow for combustion and cooling sufficient to maintain the air temperature around the generator set within the manufacturer's specified operating temperatures, during normal operating conditions.
- The generator set should be easily accessible for maintenance purposes.
- The generator set accommodation should be constructed in such a way as to reduce noise emission to an acceptable level.
- Attention should be given to the orientation of the air discharge outlet with respect to any prevailing wind. Exhaust gas should be vented to the atmosphere so that no gas accumulates inside a building.
- There should be adequate clearance between the exhaust outlet and any flammable material.

For a complete specification of a generator set, refer to IEC TS 62257-7-3.

7.1.5 Technical room

Each RE generator has specific siting constraints in order to maximize its production according to the renewable energy available resource. This means that the distance between generators and the technical room may be not optimum from an electrical point of view.

In order to minimize losses and to reduce the sensitivity of the whole system to perturbations, the siting of the technical room shall be chosen in order to minimize:

- the total length of the electrical links between generators and the technical room;
- the total length of the electrical links between the technical room and the microgrid (or application circuit).

Where possible the technical room should be installed as close as possible to the largest generator which requires the largest cross-section of power cables.

If the distance between a generator and the technical room is difficult to minimize (for example, for a microhydro turbine), it could be necessary to use a medium-voltage link.

7.1.6 Battery bank (battery enclosure)

All batteries shall be located in an area that shall be designed to prevent access by unauthorized persons.

Batteries should be installed in one of the following:

a) a dedicated equipment room or battery enclosure; or

NOTE 1 See examples in Clause D.6.

b) a fenced off section in a larger room where the room does not have restricted access, for example part of a larger shed.

Ventilation shall ensure that there is airflow across the batteries and that there is no possibility for the formation dangerous gas-pockets.

NOTE 2 Example of acceptable arrangements of battery equipment and ventilation are shown in Annex D.

A minimum horizontal separation of 500 mm shall be provided between the battery and all other equipment from 100 mm below battery terminals except where there is a solid separation barrier.

NOTE 3 See example in Figure D.1.

If a battery is separately enclosed in a battery box with no other equipment installed in the box there is no need for 500 mm clearance from the battery to the walls of the battery box.

NOTE 4 No equipment is installed in the same enclosure, as the batteries is the preferred option.

No equipment shall be placed above the batteries or battery enclosure except for non-metallic battery maintenance equipment.

A purpose-built equipment enclosure may be installed above a purpose built battery enclosure where all of the following apply:

NOTE 5 See Annex D for example.

c) A sealed (valve regulated) battery is installed in the battery enclosure.
d) A gas proof horizontal barrier is in place between the battery enclosure and the equipment enclosure.
e) The battery and equipment enclosures are accessed separately (e.g. via separate doors).
f) The ventilation paths for the battery enclosure and the equipment enclosure are specifically designed to minimize the possibility of air exhausted from the battery enclosure entering the air inlets on the equipment enclosure

7.2 Equipment installation

7.2.1 Mechanical

Specific requirements for each technology are given in IEC 62548, IEC TS 62257-7-1 and IEC TS 62257-7-3.

7.2.2 Electrical

7.2.2.1 Wiring

All ELV and LV wiring shall be installed by an instructed person (see Table 5 of IEC TS 62257-6:2015) and shall be in accordance with the local regulations and IEC 60364.

7.2.2.2 Cables

The output voltage of the power system shall be such as to guarantee the voltage level for all the customers connected to the microgrid or for all the loads connected to the micropower plant in accordance with the recommendations of IEC TS 62257-9-2.

The project implementer shall make any necessary provision to ensure the correct output voltage of the micropower plant taking into account the voltage drops in the internal power cables. This can be achieved by choosing the relevant output voltage of the internal sources or by implementing any relevant solution for voltage adjustment.

Minimum cross-sections for power cables within the micropower plant are indicated in Table 2.

Table 2 – Cross-section of 230 V a.c. power cables

Power kVA	Number of phases	Conductor material	Minimum cross section mm^2
0,1	1	Cu	1,5
0,5	1	Cu	1,5
1	1	Cu	2,5
5	1	Cu	4
10	3	Cu	4
20	3	Cu	6
30	3	Cu	6
40	3	Al	16
50	3	Al	16
60	3	Al	25
80	3	Al	35
100	3	Al	35

NOTE Some information about the maximum possible length of circuits with different cables and conductors to handle maximum voltage drops is provided in Annex B of IEC TS 62257-9-2:2016 and in Annex A of IEC TS 62257-9-4:2016.

7.2.2.3 Connections and accessories (see Tables 3 to 5)

7.2.2.3.1 Multiple LV sources

Connecting a generating set in parallel with an interactive inverter

The electrical output of a generating set shall only be connected with an interactive inverter using fixed wiring.

The use of plug connected generating sets is not permitted due to the possibility that the pins on the connection cord may become live due to 'back feeding' from the inverter.

7.2.2.3.2 Isolation and switching devices

Within the system, isolation of the different parts of the micropower plant shall be made using the appropriate type of circuit-breakers (a.c. or d.c.) or disconnecting devices sized to be able to switch off the nominal current of each generator or circuit.

7.2.2.3.3 Overcurrent protection devices

Within the system, wiring shall be protected from short circuit and overload by high rupturing capacity (HRC) fuses or appropriate type of switchgears (a.c. or d.c.), sized to limit the current below the maximum current-carrying capacity of any part of the connected circuit.

Attention is drawn to the possibility of the battery providing high currents due to faults in renewable inputs or associated wiring.

Table 3 – Fuse ratings for protection from short-circuiting in 230 V/400 V a.c. circuits

Power kVA	Fuse rating A	Fuse type
0,1	0,5	gG 8,5/23
0,5	2	gG 8,5/23
1	5	gG 8,5/23
5	25	gG 10,3/31,5
10	3 × 15	gG 10,3/38
20	3 × 30	gG 10,3/38
30	3 × 50	gG 22/58
50	3 × 80	gG 22/58
100	3 × 160	gG size 00

Table 4 – Fuse ratings for protection from short-circuiting in 120 V/208 V a.c. circuits

Power kVA	Fuse rating A	Fuse type
0,1	1	gG 8,5/23
0,5	5	gG 8,5/23
1	10	gG 8,5/23
5	15	gG 10,3/38
10	3 × 30	gG 10,3/38
20	3 × 60	gG 22/58
30	3 × 100	gG 22/58
50	3 × 160	gG Size 00
100	3 × 315	gG Size 2

Table 5 – Circuit-breaker ratings for protection from short-circuiting

Power kVA	Number of phases	230 V/400 V a.c.		120 V/208 V a.c.	
		I A	Rating A	I A	Rating A
0,1	1	0,4	1	1	2
0,5	1	2	3	4	6
1	1	4	6	8	10
5	1	21	25	42	63
10	3	14	16	28	32
20	3	29	32	55	63
30	3	44	50	83	100
50	3	73	100	139	160
100	3	145	160	278	320

For d.c. systems, rules for ratings of protection against overcurrent and short-circuiting are provided in IEC TS 62257-7-1.

8 Acceptance process

8.1 General

An acceptance process shall be performed to ensure that the system installation meets all the requirements of the general specification.

A general system acceptance process description is given in IEC TS 62257-6:2015, Table 2, 4.1, in which actions and responsibilities of the different parties involved in this process are defined. Specific issues for the acceptance of the different generators are addressed in the document specific to these generators.

Once the parties have come to an agreement, the responsibility of the whole system is transferred to the operator.

The acceptance date shall be clearly confirmed as it is a starting-point for the warranty.

All the operating actions described in the operating procedure shall be tested before the commissioning of the micropower plant.

8.2 Phase 1: Preparation

The project implementer shall collect all contractual documents that have to be supplied by the different manufacturers and subcontractors.

8.3 Phase 2: Documentation

The project developer shall verify (through a consultant engineer) that all the required documents (manuals, spare parts, drawings, procedures (including the operating procedure), warranty contracts, list of tests, etc.) have been provided and comply with the contractual requirement of the general specification.

8.4 Phase 3: Commissioning

8.4.1 Step 1: Evaluation of the conformity of the installed system with the accepted design

The project developer shall verify that all generators, components, technical parts, etc., have been supplied and installed in compliance with the list specified in the general specification.

8.4.2 Step 2: Evaluation of qualification of the installation

The project implementer shall provide to the project developer the certificates from the subcontractors declaring that the concerned components are ready to be operated.

8.4.3 Step 3: Preliminary tests

Before starting the production of electricity, pre-operation actions shall be performed in order to prepare each generator and other equipment for operation according to the general specification, the manufacturer's specifications, and the operating procedure.

Pre-operation actions for each generator are given in the specific documents.

The project developer shall verify, possibly through an impartial engineer consultant, component by component:

- the proper type and reference according to the as-built list;
- the proper installation through a check list of key points such as:

- mechanical: visual inspection on civil works and equipment, etc.;
- electrical (power off):
  - visual control of the electrical installation and wirings;
  - IP levels (for all parts);
  - control of connections;
  - test of the equipotential bonding;
  - measure of the earth resistance;
  - test of the mechanical operation of the switches (main and secondary if any);
  - etc.
- electrical (power on);
- the proper operation of each component according to the specific test list collected in phase 2.

All components shall pass the tests. All nonconformity shall be fixed before going to step 4.

8.4.4 Step 4: Performance testing

The project developer shall test through an engineer consultant:

- off load:
  - the operating procedure for the whole system (especially coupling of the different generators);
- on load:
  - the operating procedure for connecting the micropower plant to the microgrid or the application circuit;
  - on a short time basis: the performances of the micropower plants as defined in the general specification, especially the quality of power supply (see Table C.1 of IEC TS 62257-2:2015):
    - system voltage;
    - ratings of major components;
    - d.c. energy and a.c. energy supplied to the loads;
    - etc.
  - on a long time basis (seasonal, annual if relevant):
    - same parameters as before;
    - load management strategies or conditions necessary for performance as specified;
    - expected contribution to the load from each generator under design conditions, as a percentage;
    - nominal generator set run time under design conditions;
    - maximum and surge demand;
    - average daily energy output of each renewable energy generator under design conditions;
    - etc.

Any under performance of the system shall be assessed by the engineer consultant. Proposal for correction shall be made to the project developer who shall decide whether to implement the corrective actions or not.

8.5 Phase 4: Agreement

A letter of agreement shall be signed by the different parties: the project developer/project implementer, owner/operator.

This agreement could be confirmed through two steps:

- a provisory agreement signed immediately after the short-term performance testing;
- a final agreement signed after the long-term performance testing.

8.6 Commissioning records

Examples of commissioning records are provided in Annex G.

9 Operation, maintenance and replacement

All operation, maintenance and replacement actions shall be conducted in compliance with IEC TS 62257-6.

An operating procedure written by the project implementer shall provide the operator with any necessary information on how to operate the micropower plant: starting procedure, shutdown procedure, coupling procedure, isolation and switching for maintenance or replacement operation, etc.

The level of skill of the person authorized to have access to the different parts of the system shall be thoroughly described.

Provision shall be made to forbid access to any part of the micropower plant to unauthorized person (and also to animals).

All LV parts of the micropower plant shall be operated and maintained by a licenced person.

All ELV parts of the micropower plant shall be operated and maintained by a competent person.

10 Marking and documentation

10.1 Marking

10.1.1 Information for emergency services

A sketch shall be prominently displayed in, or immediately adjacent to, the main LV switchboard indicating the location, in relation to the main LV switchboard, of the emergency de-energization procedure to isolate the system, including the location(s) of all isolation devices.

10.1.2 Information for maintenance

Other signs shall include information sketches for maintenance shutdown procedure such as:

- isolation of the battery bank by disconnecting battery fuses or opening battery circuit-breakers;
- isolation of the generator set (if any) and prevention of operation by automatic or remote start;
- isolation of the renewable power inputs.

10.1.3 Information for batteries

Safety signs in accordance with existing IEC standards shall be provided and fixed in position where they will be seen when the battery is approached.

A sign bearing the following words shall be mounted above the batteries or located on the battery enclosure.

"WARNING: SPARK HAZARD. Follow shutdown procedure before connecting or disconnecting any equipment."

10.1.4 Signs

Signs shall be indelible. They shall be legible from a distance of 2 m except where otherwise stated and shall comply with the existing IEC standards.

10.2 Documentation

The following documentation shall be provided.

- System manual

  A manual complete with the following.

  List of equipment supplied

  – list with model description and serial numbers for future reference.

  System performance estimate/guarantee

  – including daily energy consumption for both a.c. and d.c. loads, design load energy requirement, maximum and surge power demand, an estimate of each renewable energy input, showing expected seasonal variation and an estimate of generator run time.

  Operating instructions (systems and components)

  – a short description of the function and operation of all installed equipment. More detailed information should be available from the manufacturer's documentation.

  Shutdown and isolation procedure for emergency and maintenance

  – copy of the shutdown procedure.

  Start up procedure

  – copy of the start up procedure after the system has been shut down.

  Maintenance procedure and timetable

  – a maintenance checklist for the installed equipment.

  Commissioning records and installation checklist

  – a record of the initial system settings at the time of system installation and commissioning checklists for quality assurance.

  Warranty information

  – a statement of the system warranty period and limitations complete with period and limitation of supplied equipment warranties.

  Original energy usage estimate

  – a copy of the initial energy usage estimate supplied by the customer and used to design the power system.

  System connection diagram

  – a diagram showing the electrical connection of the power system. In larger installations separate schematic (circuit) and unit wiring diagrams might be required.

Equipment manufacturer's documentation and handbooks for all equipment supplied.

- Battery record logbook

  A separate logbook for ongoing recording of battery operating parameters, such as battery voltage, ambient temperature and cell specific gravity, voltage and temperature.

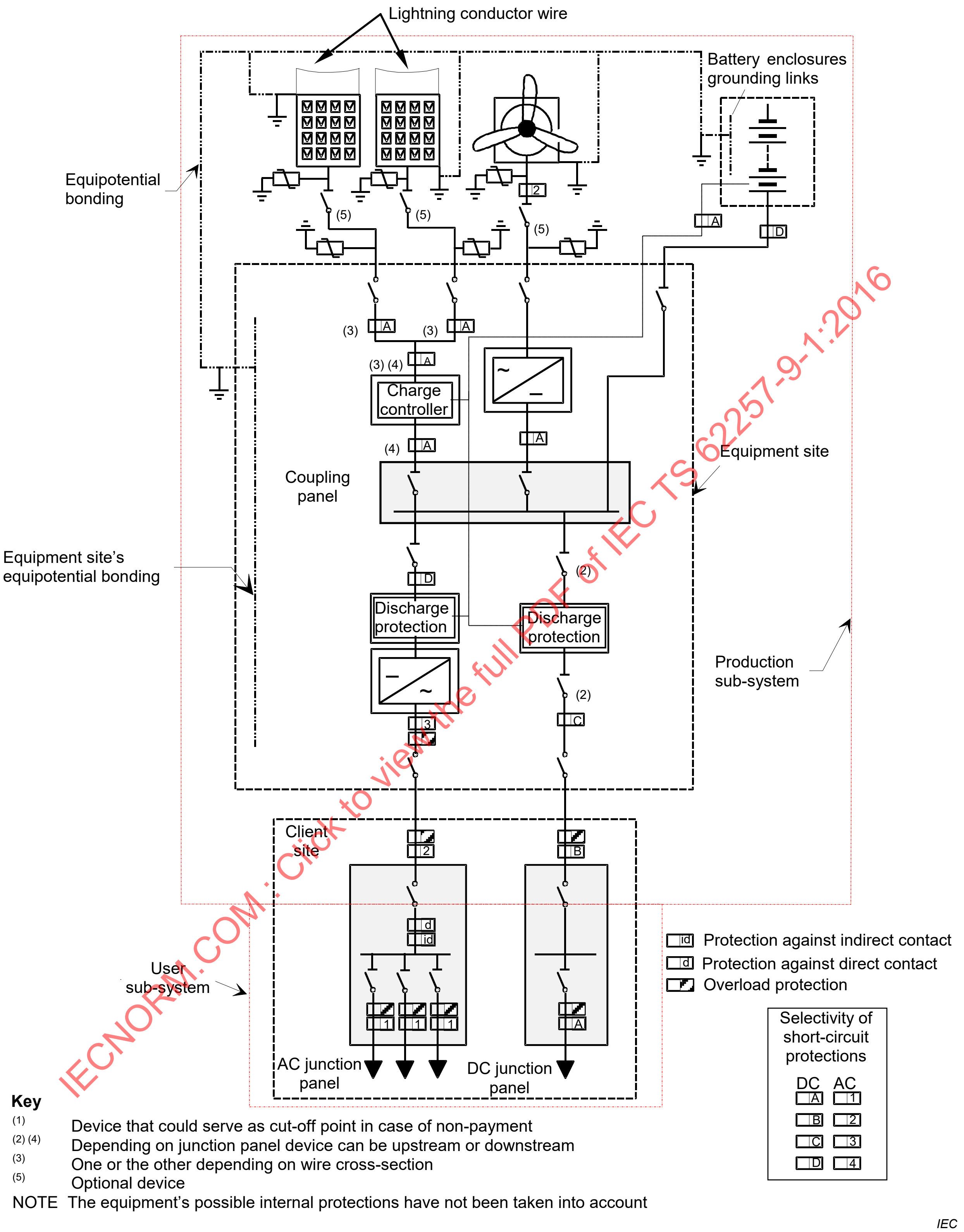
- Generator set record manual

  A separate logbook to record periodic generator set maintenance.

Annex A
(informative)

Selectivity of protection

Figure A.1 gives an example of the selectivity of protection against overcurrent, lightning and overvoltages.



Key

(1) Device that could serve as cut-off point in case of non-payment
(2) (4) Depending on junction panel device can be upstream or downstream
(3) One or the other depending on wire cross-section
(5) Optional device

NOTE The equipment's possible internal protections have not been taken into account

Figure A.1 – Example of the selectivity of protection

Annex B
(informative)

Risk assessment of lightning stroke

B.1 General

Where it is desired to minimize all avoidable risk, a lightning protection system should be installed. Given the value of equipment and potential for personal injury with stand-alone power systems, a lightning risk assessment should be made.

Two methodologies are proposed hereinafter.

B.2 Risk assessment simplified methodology

A basic assessment of the lightning risk can be made by counting the number of days in a year when thunder is heard. This information may be obtained from locals. Protection against lightning is only envisaged if the number of thunder days is over 25.

B.3 Risk assessment multi-criteria methodology

A risk index, R, is obtained as follows:

$$R = A + B + C + D + E$$

where

A is the “stake” index;

B is the “construction” index;

C is the “height” index;

D is the “situation” index;

E is the “lightning prevalence” index.

The index values A to E are obtained from Table B.1 to Table B.5. After obtaining the risk index, the risk assessment and need for protection can be obtained from Table B.6.

Table B.1 – Stake index values

Usage and contents of the building or equipment	Value of index A
Structure and contents inert, occupation infrequent, for example, domestic outbuilding, farm shed, roadside hoarding	0
Structure containing ordinary equipment or a small number of people, for example, domestic dwelling, store, shop, small factory, railway station, tent or marquee	1
Structure or contents of fair importance, for example, water tower, store with valuable contents, office, factory or residential building	2
Collective buildings: cinema, church, school, meeting hall	3
Stadium, entertainment complex, telephone installation, aircraft hangar, light house, industrial plant, power station	4
Fuel storage, health centre	5

Table B.2 – Construction index values

Construction (structure and material)	Value of index B
Fully metallic structure, electrically continuous	0
Reinforced concrete or steel frame with metallic roof	1
Reinforced concrete or steel frame with concrete or other non-metallic roof Cottage or small building of timber or masonry with metallic roof	2
Large area building of timber or masonry with metallic roof Small building of timber or masonry with non-metallic roof	3
Large area building of timber or masonry with non-metallic roof Tent or marquee of flammable material	4

Table B.3 – Height index values

Height of structure m		Value of index C
Exceeding	Not exceeding	
0	6	0
6	12	2
12	17	3
17	25	4

Table B.4 – Situation index values

Situation	Value of index D
On the flat, at any elevation	0
Hillside up to three-quarters of the way up, or mountainous country up to 1 000 m	1
Mountain top above 1 000 m	2

Table B.5 – Lightning prevalence index values

Average thunder-days per year		Value of index E
Exceeding	Not exceeding	
0	2	0
2	4	1
4	8	2
8	16	4
16	32	4
32	64	5
64	—	6

Table B.6 – Assessment of risk and need for protection

Risk index R (R = A + B + C + D + E)	Assessment of risk	Need for protection
<12	Negligible	Not needed
12 to 14	Small	Might be advisable
>14	Great	Essential

Annex C
(normative)

Voltage domains

Voltage domains are listed in Table C.1.

Table C.1 – Voltage domains

Voltage domain	Voltage V	
	Alternating current	**Smoothed direct current**
ELV	$U_n \leq 50$ V	$U_{oc} \leq 120$ V
LV	50 V $< U_n \leq$ 1 000 V	120 V $< U_{oc} \leq$ 1 500 V
NOTE ELV limits are provided in IEC TS 61201.		

Annex D
(informative)

Battery room

D.1 Administrative formalities

The legal conditions for each country shall be complied with. An inventory of installations equipped with batteries shall be kept in order to avoid the spreading of material and electrolyte into the environment after their useful life.

At the end of their useful life, the batteries must be recycled by one of the following organizations:

- the operator;
- the agent;
- the vendor.

The person designated shall be able to store the batteries and then submit them for recycling.

D.2 Battery siting

The installation conditions for a set of stationary storage batteries depend greatly on gas emissions which may occur during charging (non-sealed and sealed battery).

The access to the battery bank shall be restricted to authorized skilled persons. The battery bank shall be located in a specific room, or in a non-metal locker.

Battery accessibility is defined by the operator.

D.3 Characteristics of the battery storage site: specific battery room or locker

The room or locker shall be fitted with ventilation at least at the top and bottom to enable gases to escape and provide a protection rating of IP 24 (see IEC 60529).(See examples of ventilation location in Clause D.5) It is recommended that the ventilation inlets or outlets consist of a number of holes spaced evenly or of a slot running along the side of the room or enclosure.

The room shall be designed in particular with the following characteristics:

- construction with incombustible materials;
- the roof shall not have an upper floor (basement forbidden);
- door opening outwards and normally closed;
- preferably the room has no other use;
- impermeable floor;
- walls with leak-proof covering, suitable for the type of battery electrolyte, up to 1 m from the floor (or more, if battery on different levels);
- electrolyte-proof drip tray (dump to sewers forbidden) with a capacity of 100 % of the biggest case, or 50 % of the total case capacity;
- if the room is heated, it shall only be so by a heating utility (air, water, steam);
- water source close at hand in case of need to bathe eyes;

- fire-fighting equipment (at least a sand bin or electrical fire extinguisher).

The batteries may also be located in a locker. This may be installed in a battery room. It shall be linked to the exterior by sealed ducting connected to openings enabling proper isolation. The locker shall be designed with the following characteristics:

- construction with non-electricity conductive materials;
- electrolyte-proof drip tray (drain to sewers forbidden) with a capacity of either 100 % of the largest case, or 50 % of the overall capacity of the cases;
- it is forbidden to expel toxic or corrosive gases into the atmosphere (suitable conduits). The locker shall have top and bottom ventilation points enabling proper and suitable ventilation;
- exhaust air should not pass over other electrical devices;
- eye bathing equipment close at hand;
- fire-fighting equipment close at hand (sand bin, electrical fire extinguisher).

D.4 Electrical equipment

The electrical equipment installed in the battery room should be limited to the strict necessary:

- connections;
- connecting cables.

The cut-off and protection devices shall be located outside the room. The measuring and regulation apparatus shall also be located outside the room. The measuring link protection systems, in particular for voltage measurement, shall be of the spark-free type.

If there is fixed lighting in the room, it shall be of the flameproof type.

The batteries should not have live bare parts exposed. However, during certain operations, if a battery with a voltage over ELV (120 V) has live parts exposed, one shall:

- install an isolating floor of 1 m wide around the battery;
- make it impossible for a person to simultaneously come into contact with the two live parts whose voltage differs by over 120 V.

All of the electrical installation components shall be suitable for use with risk of corrosion and any mechanical risk (no oxidation-prone metal parts such as sheet metal, screened rigid metal conduits, etc.).

The electrical conduits should not be a possible source of inflammation of a potentially explosive atmosphere.

The battery cut-off device, installed outside the room, but as close as possible to it, shall be easily accessible and marked as such as the emergency cut-off system.

For working on the batteries in a dark room, the worker shall carry a spark-proof autonomous lighting system.

The layouts of the rooms and lockers shall be designed so that the links between the batteries and the devices are as short as possible.

Insofar as possible, and due to the peak power of the photovoltaic installation, exceeding 48 V is not recommended.

D.5 Safety instructions

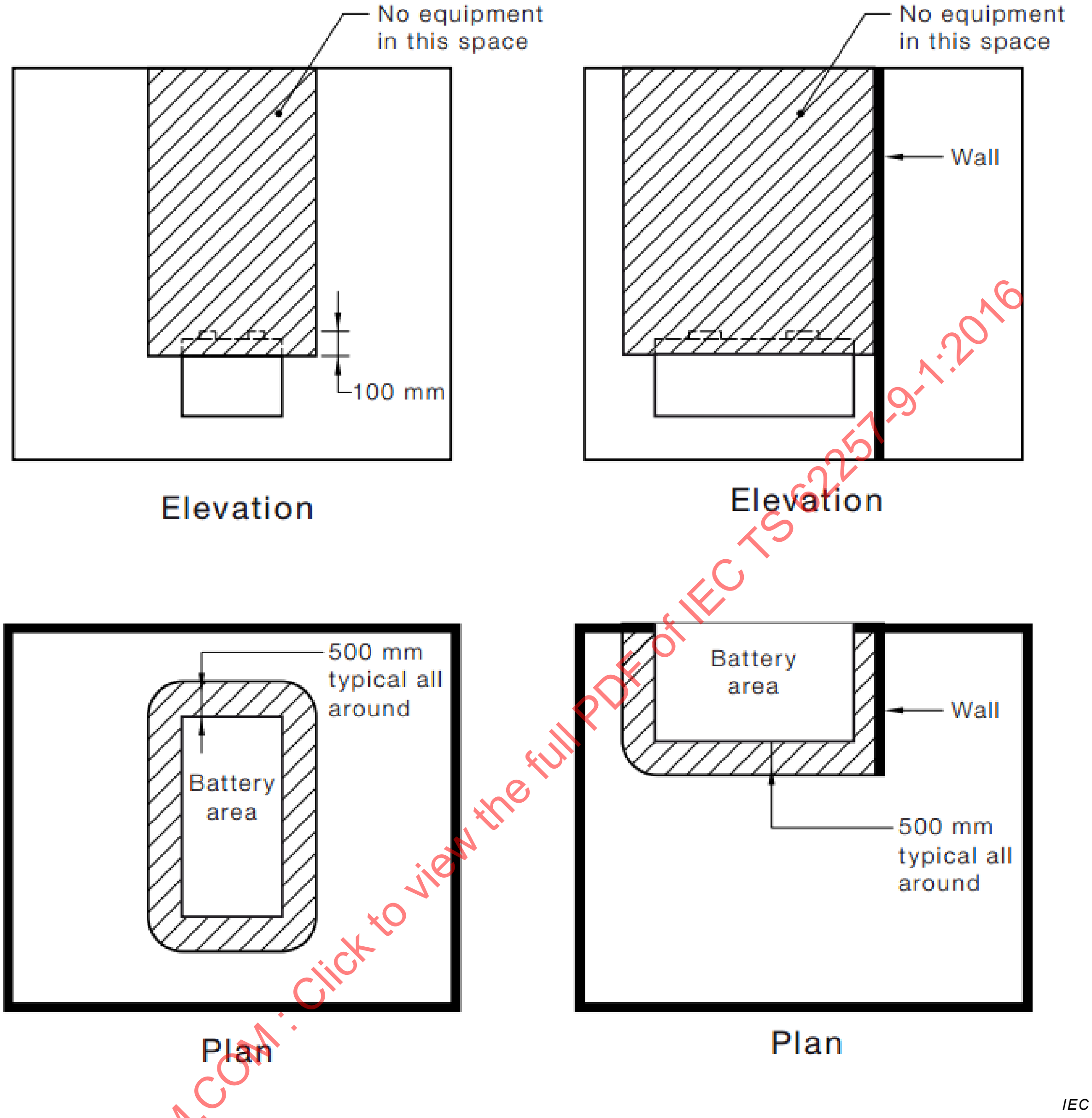
The following notices shall be posted visibly outside the room or locker:

- access forbidden to all non-authorized persons;
- no smoking;
- no live flames;
- electric shock first aid;
- acid splashes.

D.6 Battery enclosure examples (informative)

Examples of acceptable arrangements for housing and ventilation of batteries are shown in Figures D.1 to D.4. This is not an exhaustive set of possible arrangements.

These have been reproduced from AS/NZS4509.1:2010, *Stand Alone Power Systems – Part 1: Safety and Installation,* Appendix C.



NOTES:

1. This is a dedicated equipment room that is secured to prevent unathorised entry
2. The equipment room is ventilated to the outside

Figure D.1 – Two examples of a battery installed in a dedicated equipment room showing clearances from equipment

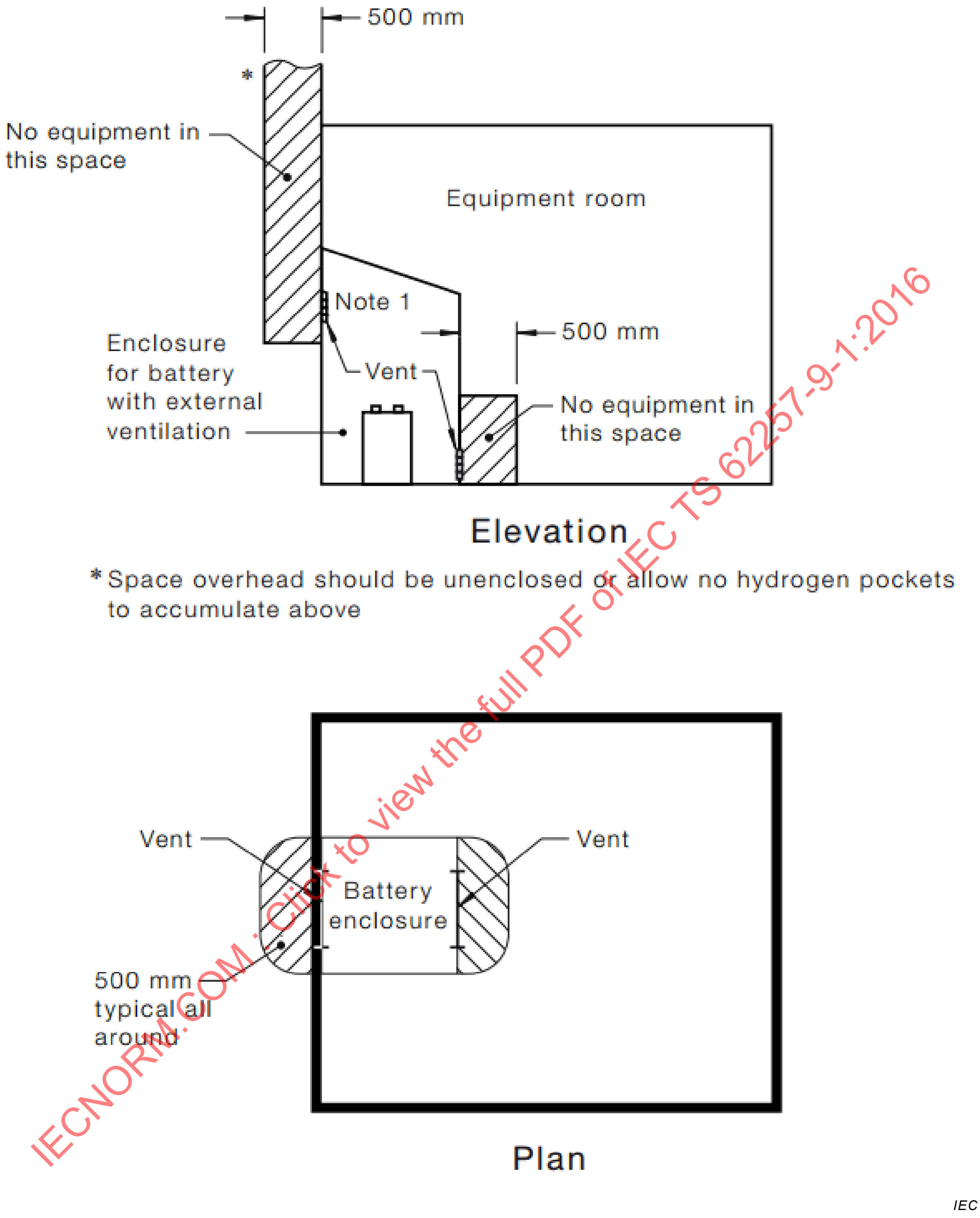
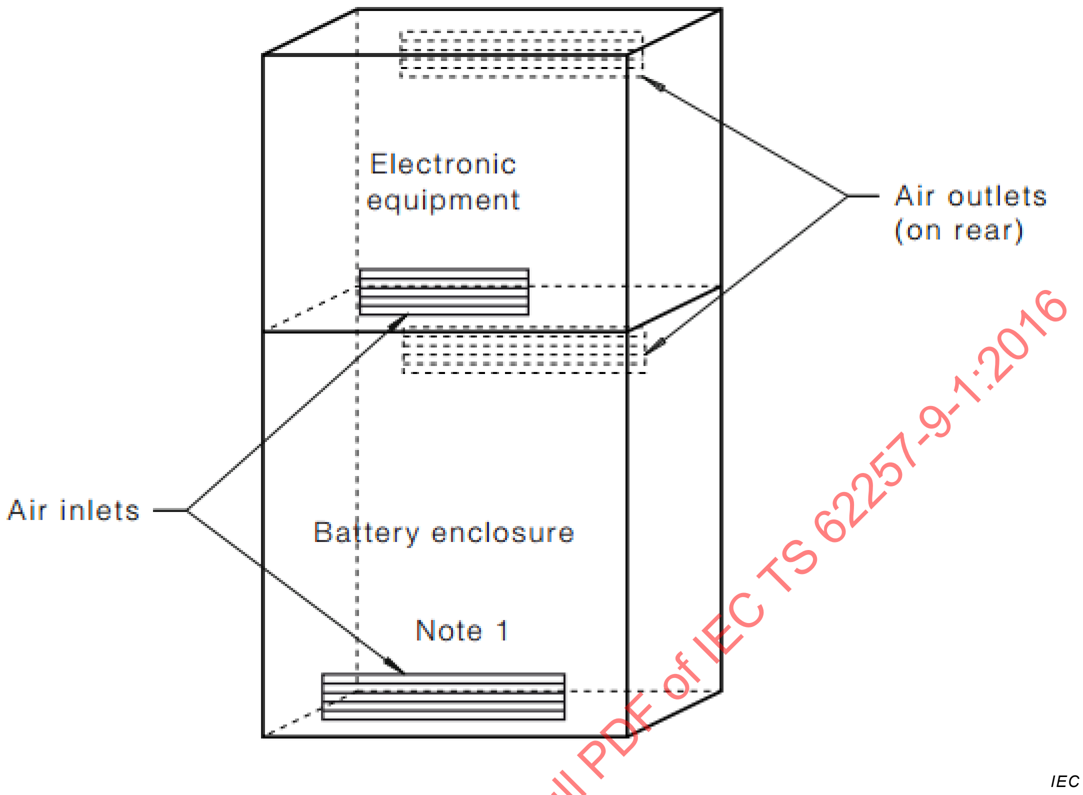


Figure D.2 – Example of a battery enclosure within a room where the battery enclosure is vented to outside the building



NOTES:

1. The battery enclosure is ventilated externally
2. Cross flow ventilation
3. The battery vents and electronic vents are on different sides
4. The barrier between battery enclosure and electronics is sealed to prevent hydrogen ingress

Figure D.3 – Example of a battery enclosure with equipment enclosure immediately adjacent

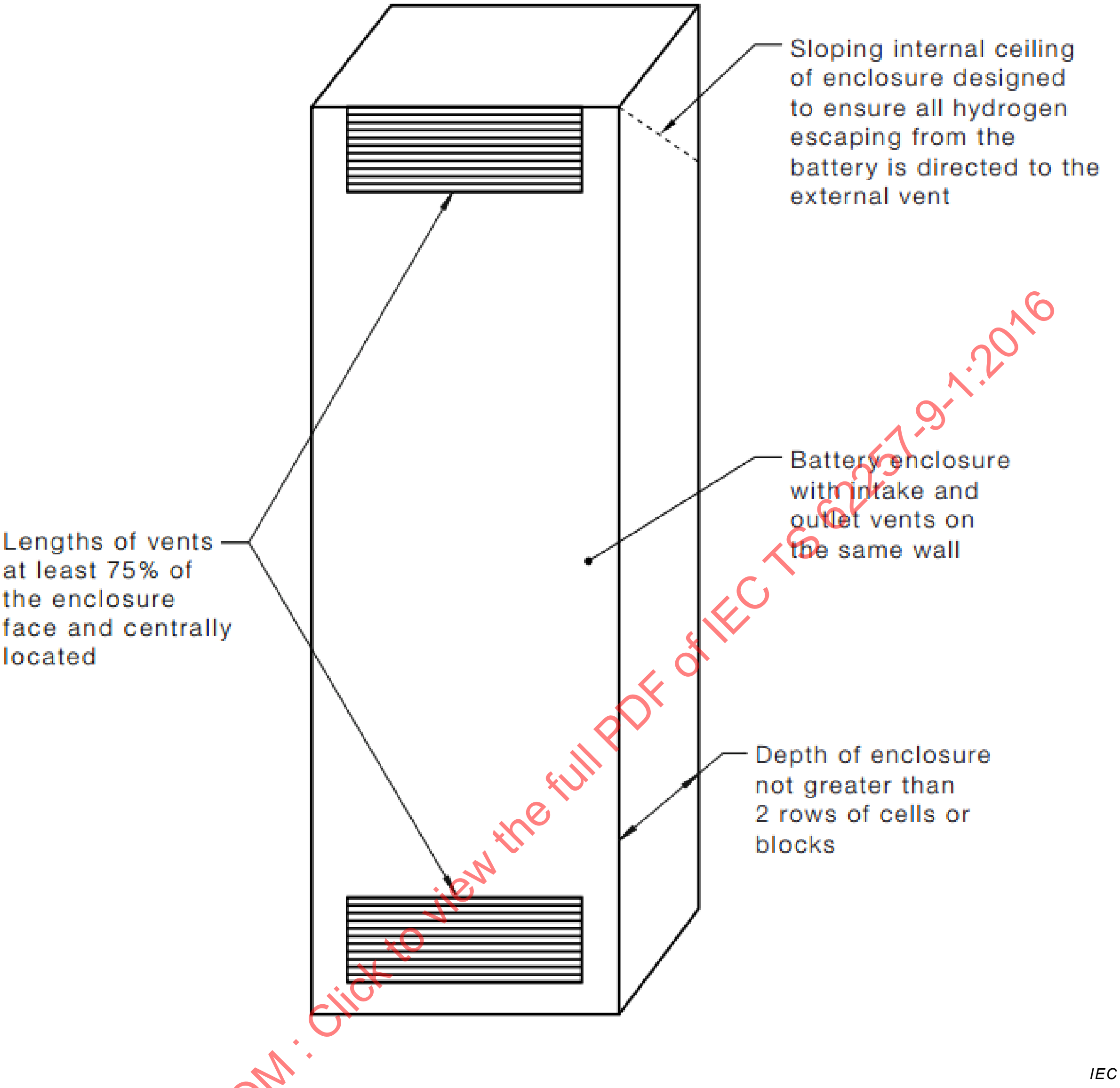


Figure D.4 – Example of a battery enclosure with the intake and outlet vents on the same wall

Annex E
(informative)

Energy fraction calculations

The renewable energy fraction is made up of contributions from each of the renewable energy generators which are used in the system. For each renewable energy generator, a fraction can be defined for the design conditions. This is often expressed as a percentage.

Where PV array sizing calculations are based on watt hours, the following formula may be used:

$$\text{Solar fraction} = f_{pv} = \frac{E_{pv} \times \eta_{pvss}}{E_{tot}}$$

Where array sizing calculations are based on ampere hours, the following formula can be used:

$$\text{Solar fraction} = f_{pv} = \frac{I_{mod} \times H_{tilt} \times N_p \times V_{dc} \times \eta_{coul}}{E_{tot}}$$

Other fractions can be calculated as follows:

$$\text{Wind fraction} = f_{wind} = \frac{E_{wind} \times \eta_{windss}}{E_{tot}}$$

$$\text{Hydro fraction} = f_{hyd} = \frac{E_{hyd} \times \eta_{hydss}}{E_{tot}}$$

$$\text{Renewable energy fraction} = f_{ren} = f_{pv} + f_{wind} + f_{hyd}$$

where

E_{pv} is the design daily energy from photovoltaic array, in watt hours;

η_{pvss} is the efficiency of the photovoltaic sub system, dimensionless;

E_{tot} is the total design load energy demand, in watt hours;

I_{mod} is the derated output current of the photovoltaic module, in amperes;

H_{tilt} is the daily irradiation on the tilted plane, in peak sun hours;

N_p is the number of parallel strings in the array (an integer), dimensionless;

V_{dc} is the nominal voltage of the d.c. bus, in volts;

η_{coul} is the coulombic efficiency of the battery, dimensionless;

E_{wind} is the design daily energy from wind turbines, in watt hours;

η_{windss} is the efficiency of the wind sub system, dimensionless;

E_{hyd} is the design daily energy from hydro-electric sources, in watt hours;

η_{hydss} is the efficiency of the hydro-electric subsystem, dimensionless.

Fractions of approximately 90 % or above should be treated with some caution, as some generated energy may not be used and weather variations within the month may reduce the actual fraction. A calculated solar or wind fraction of greater than 100 % does not guarantee sufficient energy generated to meet the load at all times.

Annex F
(informative)

Noise control

F.1 General

Any provision made in order to reduce the noise annoyance for inhabitants could be counter-productive in terms of cost and electrical constraints. For example, it is better to install the generator set far from any dwelling, but that means that the construction of the power wires may be larger and more costly and that in some cases protection against lightning may be necessary due to the larger distance between the generator and the technical room.

F.2 Assessment of noise annoyance

In cases where local authorities have guidelines or by-laws specifying maximum acceptable noise levels, these should be referred to. Where no such guidelines or by-laws exist, the following factors should be considered.

- Equipment noise levels which are less than 5 dB above the background noise level are unlikely to cause annoyance in any circumstances.
- Irregular or inconsistent noises are generally more annoying than steady noises.
- The annoyance value of any noise is subjective and depends on the kind of activities being carried out in the area in question and the listener's expectations.

F.3 Principles of noise attenuation

Application of the following principles may be of use in attenuating noise to acceptable levels.

- Sound levels are reduced by 6 dB for every doubling of distance from the noise source.
- Generally, vegetation provides little sound attenuation whereas 10 m depth of thickly wooded forest could provide a reduction of 10 dB.
- Solid barriers are most effective. Small openings in walls, around doors and in other barriers allow significant noise to pass through.
- Sound propagation is affected by wind speed and direction and will be higher in the downwind direction.
- Low-frequency sound diffracts (bends) around corners more than high-frequency sound.
- Low-frequency sound can be attenuated only by distance and by the use of massive (i.e., heavy construction) barriers between the source and the listener.
- Sound may be easily reflected off solid barriers, especially mid- and high-frequency sound.
- The use of sound absorbing material (for example, sound batts) as a lining on walls or other barriers may provide benefit in two ways:
  - by reducing reverberation, especially in enclosures of solid construction such as brick; and
  - by reducing the transmission of sound through the wall or barrier, especially through walls of lightweight construction.

F.4 Noise reduction methods for specific items of equipment

F.4.1 Generator sets

Generator sets produce noise covering a wide range of frequencies, with low frequencies predominating. Sound is emitted from two sources – the engine body and the exhaust pipe outlet.

Exhaust noise can be reduced by the following means:

- using a muffler of adequate noise reduction grade;
- pointing the exhaust away from any residence;
- ensuring that there is no direct sound path to any residence.

Noise from the engine body can be reduced by any or all of the following means, as appropriate.

- Locate the generator set as far as possible from any residence, preferably not upwind of the residence in the prevailing wind direction.
- Locate the generator set so that there is no direct sound path from the generator set to any residence (erect a barrier if necessary).
- Enclose the generator set in a soundproof enclosure or room (taking care to ensure that adequate cooling air is available to the engine). Heavy construction is preferred, or light construction with sound absorbing lining.
- Ensure proper sealing around doors and other openings.
- For permanent openings in an enclosure (for example, for cooling air inlet or discharge), incorporate some form of attenuation (for example, cowl or louver, preferably acoustically lined, or air attenuator/silencer).
- Use a generator set with integral noise reducing enclosure.

NOTE 1 Confining generator set run times to daytime only will reduce the level of noise attenuation required.

NOTE 2 Noise levels are dependent on fuel type, engine operating speed, and load. Fuel types, in order of increasing noise levels, are gas, petrol, and diesel.

F.4.2 Wind turbines

Wind turbines may produce noise from two sources – turbine blades and gearbox. There are few options available to reduce noise levels, due to constraints in the system design and turbine siting. The main considerations when minimizing noise levels are

- choice of machine; and
- location of turbine – as far as possible or practicable from the residence, and downwind in the prevailing wind direction from the residence, if possible.

NOTE Background noise levels at windy sites will be elevated by the noise of the wind blowing through vegetation and over built structures.

F.4.3 Inverters and other electronic equipment

Noise produced by inverters or electronic equipment is generally of mid to high frequencies. Noise levels may be of concern where equipment is located within a residence. In such a case, the equipment may be housed in an enclosure of adequate construction to attenuate noise to the required level. In small enclosures, care should be taken to ensure that the equipment will have an adequate flow of cooling air.

Annex G
(informative)

Commissioning record sheet (examples)

SHEET 0: SYSTEM IDENTIFICATION

Proposal for identifying a system type 1, 2 or 3

Site or user's name:
Site or user's phone number:

Owner's name:
Owner's phone number:

System commissioning date:
Battery commissioning date:

Peak power/installed battery capacity (C100):
Rated voltage:

Installer or assembler:
Installer phone number:
Date of visit:
Inspector's name:

SHEET 1: ACCEPTANCE OF PHOTOVOLTAIC GENERATOR

(see also IEC TS 62257-7-1)

Solar field		Reference value	Remarks		Comments
			Conform	Nonconform	
Modules	Unit peak power				*Forward individual sheets to the supplier, indicating Pmax, Imax and Vmax*
	Technology				
	Quantity				
	Manufacturer				
	Reference				
	Aspect				
	Sealing efficiency of junction boxes				
	Existence of by-pass diodes				
Assembly	Orientation				
	Inclined/horizontal				
	Masks (if any)				*Record mask if necessary*
Structures	Type of structure				
	Structure material				
	Mechanical strength				
	Bolts and nuts material				
	Resistance to corrosion				
	Theft prevention device				
	Quality of attachment fittings				
	Quality of anchors				
	Earthing				

Cabling		Reference value	Remarks		Comments
			Conform	Nonconform	
Interconnections of modules	Cable type				
	Cross-section				
	Length				
	Protection of junction				
	Junction attachment				
Modules-to-junction boxes connections	Cable type				
	Cross-section				
	Length				
	Quantity				
	Protection of junctions				
	Attachment of junctions				
Junction boxes	Quantity of boxes				
	Number of strings per box				
	AR diode specifications				
	Control of diodes				
	Sealing efficiency of cable junction and penetrations				
	Torque value for terminal strips				
	Protection of contacts (grease)				
	Box attachment quality				