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TECHNICAL SPECIFICATION

Recommendations for renewable energy and hybrid systems for rural electrification –
Part 3: Project development and management

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International Electrotechnical Commission

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RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 3: Project development and management

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 62257-3, 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 2004. It constitutes a technical revision.

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

– redefine the maximum AC voltage from 500 V to 1 000 V, the maximum DC voltage from 750 V to 1 500 V;
– removal of the limitation of 100 kVA system size. Hence the removal of the word “small” in the title and related references in this technical specification.

This technical specification is to be used in conjunction with the latest editions of the IEC 62257 series.

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

Enquiry draft	Report on voting
82/948/DTS	82/999A/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 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.

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 AC voltage below 1 000 V and DC 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 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 mechanism 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 aiming 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, renewable energy and hybrid off-grid systems.

The purpose of this part of the IEC 62257 series is to propose a framework for project development and management and includes recommended information that should be taken into consideration during all the steps of the electrification project.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 3: Project development and management

1 Scope

This part of IEC 62257 provides information on the responsibilities involved in the implementation of rural power systems.

In Clause 5, this technical specification presents contractual relationships to be built between the different participants to a project. Throughout the project, responsibilities are to be clearly defined and contractual commitments controlled.

Clause 6 provides relevant tests to be applied to renewable energy and hybrid electrification systems.

Clause 7 provides proposed quality assurance principles to be implemented.

In Clause 8, requirements are proposed for recycling and protection of the environment.

In Annex A of this technical specification, further technical considerations for contractual liabilities are provided.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-5, *Environmental testing – Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-10, *Environmental testing – Part 2-10: Tests – Test J and guidance: Mould growth*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-52, *Environmental testing – Part 2: Tests – Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60076-10, *Power transformers – Part 10: Determination of sound levels*

IEC 60364-6:2006, *Low-voltage electrical installations – Part 6: Verification*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-12, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability index (GWFI) test method for materials*

IEC 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

IEC 60721-2-1, *Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60721-3-1, *Classification of environmental conditions – Part 3-1: Classification of groups of environmental parameters and their severities – Storage*

IEC 60721-3-2, *Classification of environmental conditions – Part 3-2: Classification of groups of environmental parameters and their severities – Transportation*

IEC 60721-3-3, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*

IEC 60721-3-4, *Classification of environmental conditions – Part 3-4: Classification of groups of environmental parameters and their severities – Stationary use at non-weatherprotected locations*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-5, *Electromagnetic compatibility (EMC) – Part 3-5: Limits – Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A*

IEC 61000-4-1, *Electromagnetic compatibility (EMC) – Part 4-1: Testing and measurement techniques – Overview of IEC 61000-4 series*

IEC 61000-4-2, *Electromagnetic compatibility – Part 4-2: Testing and measuring techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61180-1, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements*

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

IEC TS 62257-5, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards* [1]

IEC TS 62257-6, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement* [1]

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

ISO 14000 (all parts), *Environmental management*

3 Terms and definitions

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

3.1
general specification
specification prepared by the project developer using the present series of IEC 62257 documents which mainly defines the level and cost of services to be reached and project conditions including the administrative frame and techno-economic context of the project as well as of the project timetable

3.2
identification file
IF
document describing the equipment in terms of detailed technical specification, design and associated performance

3.3
project developer
organization, company or person who defines and promotes the rural electrification project, assigns the project implementer, determines compliance with the specifications and is also responsible for obtaining resources for financing the project

3.4
engineering consultant
organization, company or person responsible for translating the needs of the potential user into technical requirements, in accordance with the relevant IEC technical specifications, and preparing the call for tenders

3.5
project implementer
general contractor
organization, company or person entrusted by the project developer to perform the work or have this work performed pursuant to the general specification (possibly through some subcontractors)

3.6
subcontractor
organization, company or person in charge of the execution of a selected part of the work relative to the project

3.7
operator
organization, company or person in charge of system operations, management and maintenance

3.8
maintenance contractor
organization, corporate company, operator or person contracted by the operator for performing maintenance operations on the installation

3.9
user
person or organization that makes use of the installation service(s) to satisfy their energy demand

3.10
training provider
organization, company or person contracted by the project developer to provide training to the different participants in charge of using, operating and maintaining the system

3.11
owner
organization, company or person financially responsible for the whole system and maintaining titles of all the equipment. The owner could have also another role, such as project developer or operator, but may be a completely separate organization

4 Responsibilities of the participants

4.1 Overview

The participants mentioned in this clause refer to the terms defined in Clause 3.

The responsibilities described herein are intended to indicate function. They may be combined into different parties depending on the structure and participants in the implementation programme. In some cases, such as government-implemented programmes, many of the different roles may actually be fulfilled by the same institution. If this is the case, it does not dispense with the need for the different development steps discussed in this technical specification.

Table 1 summarizes the main responsibilities to be achieved by the different participants involved in a project.

Table 1 – Responsibilities of the different participants

Participants	Responsibilities
Project developer	To obtain resources for financing the project To define the general specification To define environmental constraints, requirements and decommissioning plan To designate a project implementer To decide if a quality assurance plan is necessary and to launch it To prepare a warranty plan To check the compliance of the installation with the general specification
Engineering consultant	To translate user needs into technical requirements To prepare the call for tenders
Project implementer or general contractor	To perform the sizing of the system complying with the general specification To build the project on behalf of the project developer To achieve the whole installation or to achieve appropriate parts of the latter pursuant to the general specification To implement the quality assurance process with the subcontractors decided by the project developer Responsible to the project developer for the conformity of the installation with the following parts of the general specification: – locally available materials and local skills – local laws – time schedule – system level specifications according to what has been written in the tender – warranty – quality assurance plan (if specified), including acceptance requirements – commissioning plan, maintenance plan, decommissioning plan (including responsibility) – training initial operators – education of initial users – delivering documentation as described in the quality assurance plan – other information as required To negotiate the best possible warranty for system and components To check the conformity of all or part of the installation-related work performed by other subcontractors involved with the project
Subcontractor	Responsible to the project implementer for the satisfactory execution of the selected part of the work as agreed with the project implementer or satisfactory supply of the equipment lot under the project implementer's supervision
Operator	To comply with the quality assurance plan To operate the system in accordance to safety rules for assets and persons To provide the quality of service as contractually agreed by the user To collect the fees To plan the renewal of parts and components To manage connection of new customers
Maintenance contractor	To manage maintenance and repair pursuant to the contract with the operator including the supply of spare parts
Training provider	To organize and implement the training supports and courses for operating and maintenance agents and for users
User	To use the installation according to the contract with the operator

4.2 General specification

The general specification provided by the project developer should include:

- agreed level of service to the users;
- system specification which can be done by defining:
  - the level of service; or
  - energy required; or
  - full sizing of systems;
- financial plan (capital, recurrent, replacement);
- ability, willingness to pay;
- checking of the local energy resources (renewable or not), locally available materials and local skills;
- local regulations (standards, laws, etc.);
- time schedule;
- quality assurance plan (if specified), including acceptance requirements;
- commissioning plan, maintenance plan, decommissioning plan (including responsibility);
- ownership transition plan when applicable (including responsibility);
- operation, training of operators and users (including responsibility);
- dispute resolution including contract or disagreement;
- provisions for warranty;
- other information as required.

Relevant documents of this general specification shall be attached to the tender or request for proposal.

5 Contractual relationship between participants

5.1 Overview

This clause deals with contractual relations between the different participants. It is designed to define the mutual responsibilities with regard to design, construction and operation of the electrification system.

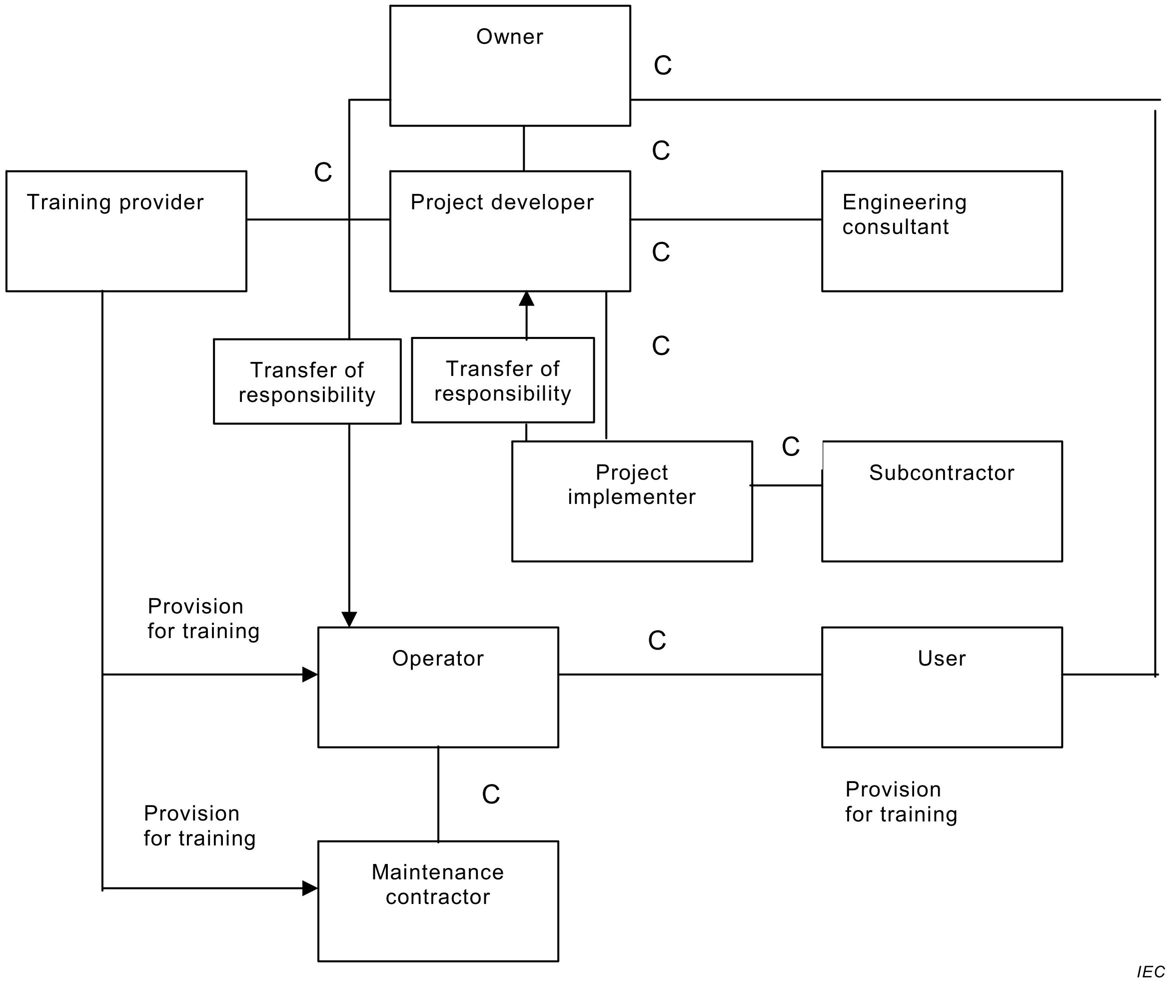
5.2 Notion of contract

During the progress of such phases as the request for proposal, construction, handing-over of the installation to an operator or utilization of this installation, provisions shall be made for the various participants to check that the other parties duly adhere to the commitments they have made. These commitments and the resulting lines of responsibility are represented by a contract or contracts between the parties designated by the letter "C" in Figure 1.

The notion of a contract can cover both written contracts and implicit contracts (for example, keeping to standard practice). Each contract will require certain data that will be needed for implementation and verification of contractual commitments.

The partners shall seek reliable data. The best way is usually to get data from existing reputable and reliable sources, and, if not possible, the required information shall be agreed to by all relevant parties. The quality assurance plan should provide for verification devices as necessary (see Clause 7).

The source of the data shall be documented.



Key

C represents a potential contractual arrangement between two connecting parties.

Figure 1 – Contractual relationship between project participants

5.3 Contractual commitments

5.3.1 Contract between the project developer and the project implementer

The project implementer is contracted by the project developer to build the installation in accordance with the general specification. The latter will check the installation for compliance with this general specification.

The project developer entrusts the project implementer with the responsibility of contractually binding contracting companies, i.e., the subcontractor and major component manufacturers, in order to clearly define their individual responsibilities.

To summarize, and for each project achieved within the framework of the present specifications, the project implementer shall be responsible for the quality of the installation and the application of the said guidelines.

Before signing any contract, the project implementer shall make sure that the project developer and all participants have duly obtained all administrative authorizations as required.

5.3.2 Contract between the project implementer and subcontractors

The project implementer remains responsible for the basic design and suitable sizing of the system pursuant to the general specification, regardless of subcontracts with subcontractors.

The subcontractors in charge of the installation (or parts of it) shall give proof of the conformity of the installation they have built pursuant to the general specification. They are also responsible to give proof of the conformity to the requirements of the local accreditation organization, local standards and rules for the project implementer's satisfaction, with regard to performances and quality. These can be drawings, diagrams, calculation notes of the installed equipment, measurement results, etc.

The project implementer shall check that the work executed by various subcontractors comply with the general specification.

If decided as relevant for the project, the project implementer shall implement a quality assurance process with the subcontractors.

5.3.3 Contract between the owner and the operator

NOTE In some cases, the project developer can be the owner.

The owner shall transfer the responsibility of the system at the time of the transaction to the operator with the agreed performances, pursuant to the general specification. On handing over, the operator shall verify that the actual installation performances correspond to those stated by the owner.

There shall be an agreement between the owner and the operator about the operation of the system.

5.3.4 Contract between the operator and the user

With regard to the user, the operator of the installation commits to keep to the agreed characteristics of energy availability as defined in IEC TS 62257-2.

There shall be a contract between the operator and the user in order to prevent a use of the installation that would exceed the specified limits.

Conversely, the user shall make use of the installation in conformity with the specified clauses. He/she shall not make use of power in excess of the amount stated before sizing the system. In case of an outage, provisions shall be made to allow the operator to check if such failure was generated by the system itself or by clients over consumption.

The contract may include the entire clauses specific to the local legislation.

5.3.5 Contract between the owner and the project developer

In some cases the project developer and the owner can be two different bodies. The project developer is entrusted by the owner to carry out an electrification project matching an agreed level of performances and investment as defined by the latter.

5.3.6 Contract between the owner and the user

The user and the owner contractually commit:

- to keep the power requirements within the specified limits;
- to use the installation in accordance with the project developer's, operator's and maintenance authority's guidelines and instruction notes;
- to keep to their financial commitments.

5.3.7 Contract between the project developer and the engineering consultant

The engineering consultant shall provide the project developer with the general specification of the project and its related justifications.

5.3.8 Contract between the project developer and the training provider

The project developer defines the training requirements. The training provider commits itself to achieve the objectives of the training programme.

5.4 Contractual commitment verification procedures

The general specification shall provide the necessary criteria enabling the project developer to assess the conformity of the installation. The system may have a metering or measuring system that, if available, shall provide system performance, possible alarm and fault signals.

Depending on the size of the installation and as desired by the project implementer or the operator, provisions shall be made to check system sizing, operation and performances using a recording instrument capable of supplying the information specified in the aforementioned document.

If available, this information may be collected by the operator or communicated to him by the maintenance contractor at such frequency and in such format as specified by the maintenance contract.

This will allow performing a preliminary analysis of the installation operation, in particular, system over-/under-utilization coefficient.

Dispute resolution will be used to substantiate the system sizing and instrumentation data report, allowing determination of the cause for failure. This could be, for example:

- incorrect sizing;
- client over consumption versus forecast consumption.

5.5 Consequences of non-adherence to the commitments

The contract shall make provision for the following situations:

- dispute resolution between any of the parties;
- non-adherence to warranties;
- situation resulting from “force majeure”.

5.6 Technical considerations

Technical considerations on the following items are provided in Annex A:

- technical guarantees;
- sizing;
- design;
- procurement items;
- installation;
- system commissioning;
- operator or technician training;
- user training syllabus;
- contractual warranty;
- maintenance contract;
- maintenance organization;
- replacement of components.

5.7 Documentation

5.7.1 General

After commissioning, the project implementer should forward the documents indicated below, prepared in the project developer specified language, to the attention of the project developer.

The project developer should further provide these documents to the operator to whom he has handed over the installation.

If the installation is later modified, either through extension, expansion or other modification, the contractor should update the documentation.

5.7.2 Project implementation documentation

The following contractual documents are required for the project developer and operator:

- procurement documents;
- technical specifications including normal operating limits of the system and assembly instructions, sizing data sheet including the retained number of days of autonomy and estimated number of days of outage without the use of a standby generator;
- commissioning report including a guide for technical acceptance and system testing with additional information about the specific conditions that were locally prevailing at the time of installation commissioning;
- training manual;
- safety manual;
- warranty contracts;
- legal documentation.

5.8 Operational/technician documentation

5.8.1 General

The project developer, intended for the operator and/or the system technician, should provide the following contractual documents. It should be noted that, depending on the project and support structure, the break-up of the following list could differ.

5.8.2 System installation manual

This document will be used by technicians and system integrators in the installation process and thus should provide instruction for the installation of the power system. The depth of this document will depend on the type and number of systems being implemented. A single large hybrid power system will require a document that provides very specific details on critical items. In a programme to implement many hybrid home systems, the document will be more general with regard to the site layout but very specific with regard to design, connection and equipment specification. Manuals should include, when appropriate, the following:

- appropriate safety considerations for system installation, including safety information on any specific components or actions that may cause personnel injury or damage to the system;
- layout drawing;
- detailed one-line schematics;
- component installation directions and schematics;
- design of foundations for towers and/or other fixed equipment;
- parts list for system including specification of the amount, length and size of all wire that may be required;

- list of special tools and materials required for the assembly, installation and adjustment of equipment;
- system control specification that describes any system controls settings that shall be made;
- site documentation forms which document the site and ownership of the system and which should be filled out at the time of initial investigation or installation and be kept on record for the life of the system. These forms should also include the project name, site description, information on land ownership, photo of the owner and/or installed equipment and any other site-specific information. They can also be constructed to provide initial assessment of resource, load requirements and system layout;
- installation log which, combined with the site documentation form should include the date and time of installation, a description of major components including part, model and serial numbers and any notes on system installation. This document may be imbedded in the system commissioning forms;
- system commissioning forms which provide a checklist of proper system installation and operation and include items specific to each installation, such as certain design parameters or possibly compliance with existing building codes. The form also includes a number of tests to be carried out by the system installer to ensure that the system is operational prior to its approval. An example of a commissioning form is provided in Annex A.

5.8.3 Users' basic operation manual

5.8.3.1 General

The operating manual is designed for the operator, the owner or possibly the system technician. The manual will include information on basic system operation and limited trouble-shooting and repair that can be performed prior to calling in more experienced personnel. It is usually written from the perspective of someone who has little or no skill in electrification systems although technicians with more understanding may still use it. The type and level of complexity of the system will decide the content of this manual. Generally, the document should be written using very simple language and make liberal use of simple diagrams and figures to illustrate points or service issues. Consideration should be given to the fact that any repair, made by a local owner or operator, results in an expense not incurred in sending a technician to the site to conduct the same repairs. Such a manual should include, when appropriate, the following:

- appropriate safety considerations for the operation. These should include instructions on methods to disconnect loads, power-generation devices and how to shut the system off completely. Safety information should also be provided on any specific components or actions that may cause personal injury or damage to the system;
- basic instruction on electricity and energy safety;
- basic instruction on energy management and energy efficiency;
- basic system one-line drawing including major fuses and circuit-breakers;
- expanded power diagram including all inter-component fuses, disconnects and relays;
- component description and details on basic operation;
- description of basic system operation and control;
- description of system and interface between components;
- description of any visual display of system status or operation and the level of system capacity if applicable;
- common failure diagnosis instructions;
- service contact information;
- service schedule for major components;

- explicit description of any service or maintenance items that can be provided by the owner and/or technician;
- list of special tools or equipment and materials required for the assembly, adjustment/ setting, operation and maintenance of the equipment;
- a possibly pre-printed operations log book to record the following events:
  – periodical measurements (voltage, density of battery cells),
  – possible incidents,
  – useful comments of any nature.

5.8.3.2 Maintenance manual

The maintenance manual should provide all information required regarding regularly scheduled service and maintenance to specific components of the power system. The manual should be written with the system technician in mind. Such manuals should include:

- appropriate safety considerations for operation. These should include instructions on methods to disconnect loads, power-generation devices and how to shut the system off completely. Safety information should also be provided on any specific components or actions that may cause personal injury or damage to the system;
- list of all routine maintenance requirements and detailed servicing instructions;
- list of spare parts required for each level of service specified in the maintenance manuals;
- list of special tools or equipment and materials required for the maintenance of all equipment;
- timetable of maintenance based on system operation hours, kWh operation and/or season;
- maintenance log book. This record should be kept for each system to note and log any service issue or maintenance conducted. This book will be invaluable in determining component issues or chronic system problems, either associated with the technology or operation;
- site visit log which is used to document site visits and the level of support specific systems require. This log may also be used to justify operational expenses passed on to the consumer.

5.8.3.3 Shop manual

The shop or repair manual should provide detailed descriptions of each component and is expected to be used in a shop setting where units are brought from field locations for technical repair or major overhaul. If items cannot be repaired at this facility, it is assumed that they are transferred back to the point of manufacture for repair. Specific issues for each component should include the following information:

- single-line diagram;
- expanded power diagram;
- description and data sheets for each component;
- detailed trouble shooting instructions for each component;
- detailed repair instructions for each component;
- instructions on the assembly of each system component;
- part and model number for each component including manufacturer contact information.

6 Relevant tests for renewable energy electrification systems

6.1 Purpose

This clause concerns all the general functional and environment tests to be applied to electrification systems of isolated sites and their constituent equipment. Each installation or equipment specification shall indicate the tests to be performed from amongst this list, their severity level and the requisite measures to be applied.

This specification referring to IEC 60068 is applicable to independent installations using renewable energies for supplying power to isolated sites and their constituent equipment.

6.2 References to standards

Project implementers shall verify that all equipment used in their project comply with the IEC tests. This can be verified by obtaining certificates from the different manufacturers. If the manufacturer has not tested the equipment, the following document describes which test shall be performed before the equipment can be used. Some of the tests are applicable to the whole system. Although identified here, the tests are described in the future IEC TS 62257-5 and IEC TS 62257-6 as they pertain to the complete power system.

6.3 Conditions of environment

6.3.1 General

The equipment items described in this document are expected to operate in a variety of environmental conditions. IEC 60721-1 lists the environmental factors and their severity ratings within the limits of the conditions to which this equipment is subjected during transport, storage, installation, and use.

6.3.2 Climatological/environmental conditions

IEC 60721-2-1 defines statistics on outdoor climates in terms of temperature and humidity prevalent in every region of the world, except for central Antarctica and high-altitude zones (above 5 000 m). These climate types provide part of the basic information needed to choose the appropriate temperature and humidity severity ratings for a given application. There are nine such types, namely:

- extremely cold;
- cold;
- temperate cold;
- temperate hot;
- dry hot;
- dry hot temperate;
- extremely dry and hot;
- damp hot;
- permanently damp hot.

IEC 60721-2-1 also defines groups of statistics on climates concerning outdoor installations:

a) “restricted” outdoor climate limited to temperate hot climate;
b) “moderate” outdoor climate comprising temperate cold, temperate hot, dry hot and dry hot temperate;
c) “general” outdoor climate comprising all statistics concerning climates except extremely cold and extremely hot;
d) “worldwide” outdoor climate comprising all climate statistics.

These groups enable equipment to be defined for use in regions with a variety of climates.

6.3.3 Environmental conditions affecting equipment service life

Standards in the IEC 60721-3 series define categories of environmental factors and their levels of severity for the following equipment applications:

- storage (IEC 60721-3-1);
- transport (IEC 60721-3-2);
- use as a fixed installation, protected against the weather (IEC 60721-3-3);
- use as a fixed installation, without protection against the weather (IEC 60721-3-4).

These categories are defined by the following means:

- a figure defining the application (1 for storage, 2 for transport, 3 for fixed installation applications, protected against the weather, etc.);
- a letter:

  K = conditions of climate (cold, hot, humidity, pressure, rainfall/snowfall, radiation, etc.);

  B = biological conditions (flora, fauna);

  C = chemically active substances (marine salt, ice-protection salt, other chemical compounds, etc.);

  S = mechanically active substances (sand, dust, mud, etc.);

  F = fluid contaminants (oils, greases, hydrocarbons, etc.);

  M = mechanical conditions (vibrations, dropping, impacts, overturning, etc.);

  P = electrical and electromagnetic interference;
- another figure indicating the severity, for example,

  category 2K3, where

  2 = transport,

  K = conditions of climate,

  3 = severity.

The different parts of IEC 60721-3 define the real-life extreme conditions of environment. The purpose of this data is to characterize the tests to be performed.

The environmental tests prescribed are described by the following items:

- the environmental factor;
- the test procedure;
- the test severities.

Requirements are indicated for the equipment tested – for instance, the operating conditions assigned, operating requirements, acceptable degradation, etc.

The procedures for most of the climate and mechanical tests indicated in Table 2 form part of the IEC 60068 series.

6.4 Tests

6.4.1 General

Table 2 lists the tests to be performed on the equipment. As far as possible, the order indicated shall be complied with. If a power system is designed and marketed as a self-contained unit, the whole system may be considered as a component, in which case all IEC standards may be applicable.

Table 2 – List of tests

Test			Reference standard	Application	
Designation	Type	See		Component	System
Safety					
Grounding continuity		6.4.3.1		X	X
Operation		6.4.3.2		X	X
Dielectric shock		6.4.3.3.2	IEC 60060-2	X	X
50/60 Hz frequency dielectrics		6.4.3.3.3		X	
Differential current device		6.4.3.6		X	X
Environment					
Cold	Ab, Ad	6.4.4.1	IEC 60068-2-1	X	
Dry heat	Bb, Bd	6.4.3.2	IEC 60068-2-2	X	
Temperature rise		6.4.4.3		X	
Protection against physical impacts (code IK)		6.4.3.4	IEC 62262	X	
Shocks	Ea	6.4.4.5	IEC 60068-2-27	X	
Sinusoidal vibrations	Fc	6.4.4.6	IEC 60068-2-6	X	
Damp heat, cyclic	Db	6.4.4.7	IEC 60068-2-30	X	
Salt mist, cyclic	Kb	6.4.4.8	IEC 60068-2-52	X	
Penetration of water (IP code)		6.4.4.9.2	IEC 60529	X	Yes *
Penetration of solid bodies (IP code)		6.4.4.9.3	IEC 60529	X	Yes *
Fire behaviour: incandescent wire		6.4.3.10	IEC 60695-2-10	X	X
Overturning		6.4.4.11		X	Yes *
Noise		6.4.3.12	IEC 60076-10	X	Yes *
Free fall	Ed	6.4.4.13	IEC 60068-2-31	X	
Simulated solar radiation at ground level	Sa	6.4.4.14	IEC 60068-2-5	X	
Mould growth	J	6.4.4.15	IEC 60068-2-10	X	
EMC					
Power-supply voltage fluctuations		6.4.5.2	IEC 61000-4-1	X	
Frequency variation		6.4.5.2.2	IEC 61000-4-1	X	
Voltage imbalance		6.4.5.2.3	IEC 61000-4-1	X	
Harmonics		6.4.5.2.4	IEC 61000-2-2	X	Yes *
Undervoltages and transient cut-offs		6.4.5.3	IEC 61000-4-11	X	Yes *
Rapid burst transients		6.4.5.4	IEC 61000-4-4	X	
Shock waves		6.4.5.5	IEC 61000-4-5	X	
Electromagnetic field		6.4.5.6	IEC 61000-4-3	X	
Electrostatic discharges		6.4.5.7	IEC 61000-4-2	X	
Emission of low-frequency interference		6.4.5.8	IEC 61000-3-2 and IEC 61000-3-5	X	
Emission of high-frequency interference		6.4.5.9		X	
Emission of electric fields		6.4.5.10	CISPR 22	X	
* If applicable, given the design of the power system.					

6.4.2 General information on tests

6.4.2.1 General verifications

General verification consists of checking that the equipment complies with the identification file, IF, the document describing the equipment. All discrepancies in relation to the IF are recorded. The supplier shall give written justification of the discrepancies and the steps to be taken to remedy them.

The results of the verification are noted in the test report.

6.4.2.2 Normal atmospheric conditions

IEC 60068-1 defines normal atmospheric conditions.

Unless otherwise stipulated, the tests shall be performed under the following conditions:

- Wide tolerances: as indicated in the IEC test.

  The special specification indicates whether some tests are to be performed under tight atmospheric conditions defined as follows.
- Tight tolerances
  - ambient temperature: 23 °C ± 1 °C
  - relative humidity: 48 % to 52 %
  - atmospheric pressure: 86 kPa to 106 kPa (860 mbar to 1 060 mbar)

If possible, tight tolerances are conditions for revision and overhaul for the equipment tests. They are also the reference criteria for atmospheric conditions.

6.4.2.3 Preparation of equipment for testing

The equipment is prepared for testing in the following ways:

a) Preparation 1 (equipment off-line)

   The equipment is prepared in compliance with the IF installation manual. The voltage is switched off.

b) Preparation 2 (equipment in service)

   The equipment is supplied at its nominal voltage and puts out its nominal current against a resistive load.

Implementation shall comply with the application description provided by the manufacturer.

6.4.3 Safety tests

6.4.3.1 Continuity of grounding circuits (first trial)

Measuring the resistance between all the accessible parts of the grounds and the general connecting system, grounds or earth of the equipment checks the electrical continuity of the grounding and protection circuits. It is recommended to use a source with an e.m.f. of 12 V capable of passing a current of 2 A as a minimum.

For this test, the equipment is mounted in accordance with preparation 1.

Result sought:

The resistance of the grounds shall be less than, or equal to, 0,1 Ω.

6.4.3.2 Equipment functional test

The purpose of this test is to check that the equipment operates in compliance with its special specification by checking the functions it shall perform and the safety features it shall ensure.

For this test, the equipment is connected in accordance with preparation 2.

Result sought:

The equipment preparation is declared correct provided:

- all the functions defined in the special specification are ensured;
- all the safety devices defined operate correctly.

6.4.3.3 Dielectric tests

6.4.3.3.1 General

The dielectric tests are performed in accordance with IEC 61180-1.

The test voltage is applied between each galvanically independent circuit (terminals connected together) and ground, with all the other circuits interconnected and connected to ground via their terminals.

NOTE If necessary, grounding can take the material form of a metal sheet connected to earth applied to the external envelope of the equipment and its supporting surface. This metal sheet will be connected electrically to all metal parts of the equipment accessible from the outside.

For these tests, the equipment is connected in accordance with preparation 1.

6.4.3.3.2 Dielectric test at shock voltage

A shock voltage generator with positive and negative polarities is used (see IEC 60060-2).

The generator puts out a pulse every 10 s.

For each test, 5 negative waves and 5 positive waves are applied in succession.

Severity:

- x kV between the terminals of the 230/400 V power-supply circuit and ground, with the other circuits connected together and grounded;
- x kV between the terminals of all the circuits (other than the 230 V power-supply circuit) and ground with the terminals of the other circuits connected together and grounded.

The values x shall be indicated in the relevant section of the general specification.

Result sought:

- Should no disruptive discharge occur, the tests are satisfactory.
- Should a disruptive discharge occur, 10 additional shock waves shall be applied (with the same polarity) without any resulting in a disruptive discharge, for the equipment to be considered correct.

Following the tests, the equipment shall meet all the operating requirements.

6.4.3.3.3 Dielectric test at industrial frequency (50 Hz)

The test voltage is applied for 1 min.

Severity:

- x kV between the terminals of the 230/400 V power-supply circuit and ground, with the other circuits connected together and grounded;
- x kV between the terminals of all the circuits (other than the 230 V power-supply circuit) and ground with the terminals of the other circuits connected together and grounded.

The values x shall be indicated in the relevant section of the general specification.

Results sought:

Neither perforation nor flashover shall be observed during the tests.

Corona discharges that occur unrelated to voltage drops are to be ignored for this test.

6.4.3.4 Insulation resistance

The insulation resistance is measured in accordance with IEC 61140 immediately after the end of the dielectric test. It is measured at the same application points as the dielectric voltage test.

The equipment is mounted in the normal service configuration and the measurement is made after applying a d.c. voltage of 500 V for 1 min.

NOTE If necessary, the ground takes the material form of a metal sheet connected to earth applied to the external surface of the envelope and the supporting surface. This metal sheet is connected electrically to all metal parts accessible from the outside.

For this test, the equipment is mounted in accordance with preparation 1 (see 6.4.2.3).

Results sought:

The insulation resistance shall be at least:

- class I insulation equipment: 2 MΩ;
- class II insulation equipment: 7 MΩ.

6.4.3.5 Leakage current between ground and local earth

Measurements are made in accordance with the method described in IEC 61140.

For this test, the equipment is mounted in accordance with preparation 2 (see 6.4.2.3).

Results sought:

The maximum leakage current measured shall not exceed 3,5 mA.

6.4.3.6 Differential-residual current device test

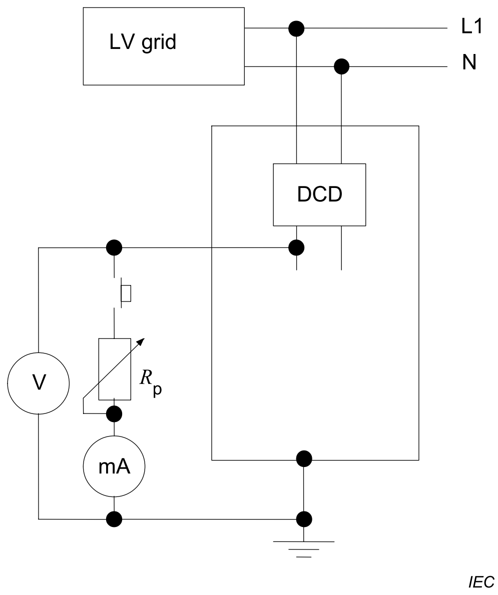
The operation of the differential-residual current device is tested in accordance with IEC 60364-6:2006, Annex B, method 1.

This test is performed as follows. It is repeated 5 times.

Figure 2 shows the principle of the method, whereby:

- a variable resistor R_p is connected to a live conductor (downstream from the power supply) and to earth;
- next, the value of this resistor is gradually reduced until the differential current protection device trips out;
- lastly, the current I_Δ causing trip-out is measured.

Current I_Δ triggering the device shall be 0,5 $I_{\Delta n} \leq I_\Delta \leq I_{\Delta n}$ where $I_{\Delta n}$ is the residual current assigned.



Key

DCD Differential-residual current device

Figure 2 – Verification of operation of differential current device

Result sought:

The device is rejected if one or more attempts prove negative.

6.4.4 Climatological and mechanical tests

6.4.4.1 Cold test

The purpose of the cold test is to check the ability of the components and equipment to be used when stored at low temperatures.

The cold test is performed in accordance with IEC 60068-2-1 (test Ab if the equipment dissipates no energy and test Ad if it does). The information required for this IEC test shall be specified in the specification of the equipment.

This test is conducted in two phases:

- an initial phase, to check operation of the equipment at the lower limit of its service temperature range,
- a second phase, to check operation of the equipment after exposure to a temperature below its storage range.

Result sought:

The equipment shall satisfy all the operating requirements at the lower limit of its operating range and on returning to the ambient temperature in the laboratory following a holding period at a temperature below its storage temperature range.

No visible degradation or damage shall be perceived.

6.4.4.2 Dry heat test

The purpose of the dry heat test is to verify the ability of the components and equipment to be used or stored under conditions of high temperature.

The dry-heat test is performed in accordance with IEC 60068-2-2 (test Bb if the equipment does not dissipate energy or Bd if it does). The information required for this IEC test shall be specified in the specification of the equipment.

This test is conducted in two phases:

- an initial phase, to check operation of the equipment at the upper limit of its service temperature range;
- a second phase, to check operation of the equipment after exposure to a temperature exceeding its storage range.

Result sought:

The equipment shall meet all the operating requirements at the top end of its service temperature range and on returning to the ambient temperature of the laboratory following a holding period at a temperature exceeding its storage temperature range.

No visible degradation or damage shall be perceived.

6.4.4.3 Temperature-rise test

The purpose of this test is to check that the acceptable maximum temperature rise is not exceeded at an ambient temperature of 40 °C.

The test is also used to check that equipment users will not suffer burns should they come in contact with any accessible parts.

This test should be carried out only at the conditions indicated in the above specification or, preferably, at a temperature of 40 °C during the dry-heat test.

6.4.4.4 Protection against physical impacts (code IK)

The test is performed in accordance with IEC 62262 using the pendular hammer described in IEC 60068-2-75 (test Eha).

The equipment shall be prepared for 1 h by placing it in a chamber at a temperature of –10 °C; the tests shall be conducted within 1 min after leaving this chamber at the normal atmospheric conditions in the laboratory.

The number of impacts on each face exposed shall be:

- 3 for faces the largest dimension of which is less than, or equal to, 1 m;
- 5 for faces the largest dimension of which is greater than 1 m.

The impacts shall be distributed over the faces of the casing as indicated in Figure 3.

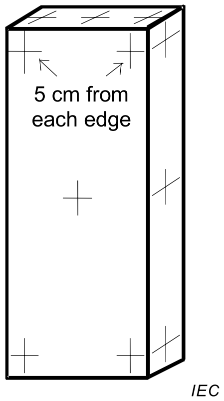


Figure 3 – Distribution of the impacts of an impact test

The equipment is mounted in accordance with preparation 1.

The information required for this IEC test shall be specified in the specification of the equipment.

Severity:

A protection level of IKx is required, indicating the following caracteristics:

- a shock energy of x J;
- a hammer weight of x kg ± x g;
- a dropping height of x m.

The values of x will be indicated in the relevant special specification.

Table 3 indicates the equivalence between the IK code and the impact energy.

Table 3 – List of tests

Code IK	IK00	IK01	IK02	IK03	IK04	IK05	IK06	IK07	IK08	IK09	IK10
Impact energy (joules)	*	0,15	0,2	0,35	0,5	0,7	1	2	5	10	20
* Not protected under the standard.											

Result sought:

The envelope shall show no signs of cracks or distortions detrimental to satisfactory operations. The initial degree of protection (Code IP: see 6.4.4.9) shall be maintained.

6.4.4.5 Impact test

The impact test is performed with the equipment packed in accordance with IEC 60068-2-27.

The special specification of the equipment tested shall indicate all the necessary information.

Severity:

To be defined as appropriate for the equipment to be tested.

Result sought:

After the test, the equipment shall display neither operating faults nor degradation or damage of its mechanical structure.

6.4.4.6 Sine-wave vibration test

The sine-wave vibration test is performed in accordance with IEC 60068-2-6.

The information required for this IEC test shall be specified in the specification of the equipment.

Severity:

To be defined as appropriate to the equipment to be tested.

The equipment is mounted in accordance with preparation 2 see 6.4.2.3).

Result sought:

During and after the test, the equipment shall display neither any operating faults nor any degradation or damage to its mechanical structure.

6.4.4.7 Damp heat cyclic test

This test is performed in accordance with IEC 60068-2-30.

The equipment is mounted in accordance with preparation 1.

The information required for this IEC test shall be specified in the specification of the equipment.

Result sought:

After the test, the equipment shall show no traces of deterioration that may be detrimental to satisfactory operation.

In addition, it shall successfully pass the following checks:

- the electrical continuity of the grounding circuits (see 6.4.3.1);
- the dielectric tests (see 6.4.3.3);
- measurement of the insulating resistance (see 6.4.3.4).

These checks shall be made within 3 h following each damp test cycle.

6.4.4.8 Salt mist cyclic test

This test is performed in accordance with IEC 60068-2-52.

The equipment is mounted in accordance with preparation 1.

The initial temperature and relative humidity conditions inside the test chamber are those prevailing in the laboratory.

The information required for this IEC test shall be specified in the specification of the equipment.

Severity:

The testing method comprising exposure to a saline mist should be defined as appropriate for the equipment to be tested.

Result sought:

On completion of this test, the equipment shall show no traces of deterioration that may be detrimental to satisfactory operation.

It shall pass the following checks:

- the continuity of the grounding circuits (see 6.4.3.1);
- the dielectric tests (see 6.4.3.3);
- measurement of the insulation resistance (see 6.4.3.4).

These checks shall take place within 3 h after completion of the saline mist test.

Colour photographs of the parts liable to corrode are taken before and after the test.

6.4.4.9 Rating of protection provided by equipment casings (IP)

6.4.4.9.1 General

The tests are performed in accordance with IEC 60529 in the following order.

The specification of the equipment shall specify the following information, where necessary:

- the requisite IP index*;
- the number of samples to be tested;
- the preconditioning;
- the final measurements.

NOTE For the points followed by an asterisk, the information is mandatory.

6.4.4.9.2 Penetration by water (code IP, second digit)

The water penetration test carried out with the equipment not operating (preparation 1).

Results sought:

The equipment shall display no operating faults or any accumulation of water inside its casing.

6.4.4.9.3 Penetration of solid bodies (code IP, first digit)

The solid bodies penetration test is carried out in compliance with IEC 60529 with the equipment not operating (preparation 1),

- rating: IP xx for…
- rating: IP xx for…
- rating: IP xx for…

Result sought:

After the test, the equipment shall display neither faults nor any accumulation of dust (in accordance with the IP rating) inside the envelope that may prove detrimental to operation. A check shall also be carried out to ensure that the heat exchange surfaces remain efficient and that, if the equipment comprises filters, they are not choked to such an extent as to impair satisfactory operation.

6.4.4.10 Fire behaviour: incandescent wire test

The purpose of this test is to check the fire behaviour of the synthetic materials used in the equipment.

This test is performed in accordance with IEC 60695-2-10, Clause 8, and IEC 60695-2-12.

The minimum test temperature is 960 °C ± 15 °C applied for 30 s ± 1 s.

Result sought:

The incandescent wire test is considered as successful if the conditions of Clause 12 of IEC 60695-2-10 are met.

NOTE This test can be performed on test samples taken from each of the different materials encasing the equipment.

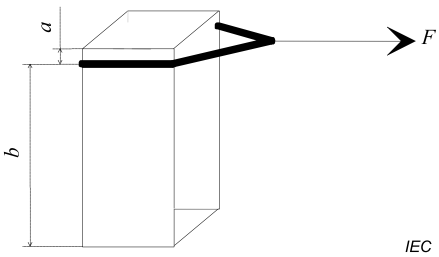
This test shall be performed only on synthetic materials, the characteristics of which are not guaranteed by their manufacturer.

6.4.4.11 Overturning test

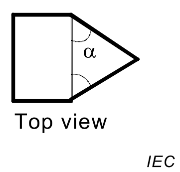
The equipment is secured under the actual real-life conditions of installation defined in the identification files and the test is conducted in accordance with the following requirements.

The point on which the force is applied is situated at the top part of the equipment casing; its height above the ground is limited to 1,60 m. This force is applied gradually and in succession to all the faces of the casing in directions perpendicular to these faces.

The force is applied through a flat handling strap about 60 mm in width, as shown in Figure 4.



a = 0,0 m min, b = 1,60 m max.



α = 60° min.
(angle between strap and equipment)

The force $F = x$ N shall be applied for 1 min.

Figure 4 – Layout for overturning test

Result sought:

On completion of the test, it shall be checked that the equipment has suffered no deterioration. The highest points of the equipment shall shift by less than 20 mm when a force of 1 500 N is applied and by only 5 mm after this force is reduced to zero.

6.4.4.12 Noise test

The equipment shall generate an acoustic power level of no more than 49 dB(A), including the tolerance of 2 dB for measurement errors, by a noise test conducted in accordance with the requirements of IEC 60076-10.

6.4.4.13 Free fall test

The free fall test is performed in accordance with IEC 60068-2-31, Procedure 1. The equipment is mounted in accordance with preparation configuration 1. The specification of the equipment shall give all the information required in this IEC test.

Severity:

- height 50 mm, 1 drop on vertical axis.

Result sought:

Neither operating faults nor degradation of the mechanical structure of the equipment after the test.

6.4.4.14 Simulated solar radiation test at ground level

This test is performed in accordance with IEC 60068-2-5.

The specification of the equipment shall give all the information required in this IEC test.

Severity:

- procedure A, at 40 °C, for 10 days.

Inside the chamber, the initial temperature and relative humidity conditions are those of the laboratory.

The outer parts of the casing are photographed in colour before and after the test.

Result sought:

The equipment casing shall have the following caracteristics:

- no degradation;
- no change in appearance;
- no deformation detrimental to satisfactory operation.

The equipment IP protection rating shall be maintained.

A mechanical impact behaviour test shall also be conducted (see 6.4.4.4).

6.4.4.15 Mould growth test

This test is performed in accordance with IEC 60068-2-10 in order to evaluate all unforeseen causes of deterioration of the equipment, whether they have been built using mould-proof materials or not.

The information required for this IEC test shall be specified in the specification of the equipment.

Severity:

- test variant 1;
- duration: 28 days.

6.4.5 Electromagnetic compatibility tests (EMC tests)

6.4.5.1 General conditions

6.4.5.1.1 General

Electromagnetic immunity tests are listed in IEC 61000-4-1. They are conducted in the nominal conditions of environment in the laboratory, that is as follows:

- temperature range 15 °C to 35 °C;
- relative humidity 25 % to 78 %, atmospheric pressure 860 hPa to 1 060 hPa.

The equipment is connected in its normal operating conditions and mounted in accordance with preparation 2.

6.4.5.1.2 Performance criteria

Execution of the immunity tests shall not destroy or inflict permanent damage to the equipment, nor lead to subsequent deterioration of its performance.

To validate the immunity tests, the following two criteria are applied.

Criterion A: The equipment behaves normally within the limits of its special specifications.

Criterion B: Temporary degradation or inability to function, or self-recoverable behaviour; except for the equipment control inputs/outputs, where no loss of performance is allowed. In the period during which these disturbances are applied, the equipment control data can be ignored, but in no case changed or rendered false, whether they are memorized or not. No modification to the active operating mode or data stored is allowed.

The equipment tested shall never become dangerous or lose its safety functions as a result of the tests defined in this specification.

6.4.5.1.3 Verification of performance

Performance tests are made under the following conditions:

- under any random conditions within the operating environment range specified for the equipment and at its nominal supply voltage;
- in all operating modes;
- with the minimum auxiliary equipment necessary.

The operating mode leading to the greatest susceptibility is sought.

6.4.5.2 Frequency-related disturbances

6.4.5.2.1 Immunity to fluctuating power supply voltages

This test is performed in accordance with IEC 61000-4-1.

Severity:

- power-supply voltage variations in the range 230/400 V – 10 %, + 15 %, 50 Hz.

Result sought:

The equipment shall withstand fluctuations in its power supply voltage for at least 4 h, in accordance with performance criterion A.

6.4.5.2.2 Frequency variations

Severity:

- normal frequency variation range: (f_n ± 2 %) i.e. 51,0 Hz to 49,0 Hz or 61,2 Hz to 58,8 Hz;
- extended frequency variation range: ($f_n\ {}^{+4}_{-6}$ %) i.e. 52 Hz to 47 Hz or 62,4 Hz to 56,4 Hz.

The frequency range will be chosen as appropriate for the equipment to be tested.

Result sought:

The equipment shall be capable of withstanding power-supply frequency variations in accordance with performance criterion A.

6.4.5.2.3 Voltage imbalances

This test applies to three-phase equipment only.

Severity:

- voltage imbalances of less than, or equal to, 2 % (inverse component/direct component).

Result sought:

The equipment shall withstand voltage imbalances in accordance with performance criterion A.

6.4.5.2.4 Immunity to supply voltage harmonics

Severity:

- voltage harmonics in the 50 Hz to 2 kHz frequency range;
- amplitude equal to the compatibility level indicated in IEC 61000-2-2, corrected by an immunity factor of 1,7.

Result sought:

The equipment shall withstand voltage harmonics in accordance with performance criterion A.

6.4.5.3 Immunity to undervoltages, transient cut-offs and voltage variations

The test is performed in accordance with IEC 61000-4-11.

The equipment shall withstand:

- an undervoltage of 60 % of U_{nom} lasting 500 ms, in accordance with performance criterion B;
- transient cut-offs of 100 % of U_{nom} lasting less than, or equal to, 20 ms in accordance with performance criterion A;
- transient cut-offs of 100 % of U_{nom} lasting less than, or equal to, 500 ms in accordance with performance criterion B;
- voltage variations of 40 % of U_{nom}.

For each of the above cases, 20 consecutive tests are performed, at least 1 min apart.

6.4.5.4 Immunity to fast-burst transients

The fast-burst transient test is performed in accordance with IEC 61000-4-4.

According to performance criterion B, the equipment shall withstand the following fast transient signals:

- 2 kV and 5 kHz by direct coupling with the equipment power supply cables;
- 1 kV and 5 kHz by capacitive coupling with the control and command cables.

The tests are conducted in the common mode.

6.4.5.5 Shock waves

The shock wave tests is performed in accordance with IEC 61000-4-5.

According to performance criterion B, the equipment shall be capable of withstanding the following shock waves:

- 4 kV in the common mode and 2 kV in the differential mode on the equipment power supply cables;
- 2 kV in the common mode on the control and command cables.

The shock generator impedance is chosen as follows:

- 2 Ω in the differential mode and 12 Ω in the common mode on the power supply,
- 42 Ω on the other cables.

6.4.5.6 Immunity to electromagnetic radiation

The electromagnetic radiation test is performed in accordance with IEC 61000-4-3.

According to performance criterion A, the equipment shall withstand the following electromagnetic radiation flux:

- 10 V/m generated at a distance of 1 m in the 27 MHz to 1 000 MHz frequency band.

6.4.5.7 Immunity to electrostatic discharges

The electrostatic discharge test is performed in accordance with IEC 61000-4-2.

According to performance criterion A, the equipment shall withstand the following electrostatic discharges:

- 6 kV in contact or, should this not prove possible, 8 kV in air.

6.4.5.8 Release of low-frequency interference by conduction

The limits for harmonic currents generated by the equipment in its power supply network are given in IEC 61000-3-2 and IEC 61000-3-5.

6.4.5.9 Release of high-frequency disturbance by conduction (10 kHz to 30 MHz)

To comply with IEC 61000-6-3, the amplitudes of the interference signals emitted on the equipment power supply line shall not exceed the following levels.

The amplitudes of interference generated by the equipment tested in the power supply networks shall not exceed the following:

- from 0,15 MHz to 0,5 MHz: 66 dB(mV) in quasi-peak value (56 dB(mV) in mean value), decreasing linearly with the logarithm of the frequency;
- from 0,5 MHz to 5 MHz: 56 dB(mV) in quasi-peak value (46 dB(mV) in mean value);
- from 5 MHz to 30 MHz: 60 dB(mV) in quasi-peak value (50 dB(mV) in mean value).

6.4.5.10 Release of electric field (30 MHz to 1 000 MHz)

The amplitude of the electric field measured at a distance of 10 m from the equipment shall not exceed the following levels:

- 30 dB (μV/m) in quasi-peak value for the 30 MHz to 230 MHz range;
- 37 dB (μV/m) in quasi-peak value for the 230 MHz to 1 000 MHz range.

7 Minimum quality assurance provisions for project implementation

7.1 Purpose

This clause provides general quality assurance principles to be implemented to decentralized rural electrification systems. This is not replacing or competing with other quality system organization but intends to recall some basic actions to be managed during the project and system life.

7.2 Quality assurance targets

The life cycle of a stand-alone power production system (single- or multiple-user type) intended for supplying power to an isolated site, includes at least five major phases as follows:

- analysis of the requirements and sizing;
- engineering and design of the plant;
- construction and commissioning of the plant;
- maintenance of the plant, and
- recycling and disposal/salvage of components on life-cycle completion (for example, batteries).

A quality assurance approach allows control of the quality of the design, construction and operation of a stand-alone power plant by systematically implementing such actions as required for prevention, verification, validation and traceability (written documents, follow-up sheets, etc.) and the provision of evidence of the said actions to project developers, project implementers and users.

For REN-based, stand-alone production systems, quality assurance is implemented by the participants defined in Clause 6 of this technical specification which details the roles of each of them.

A quality assurance approach allows these participants to provide evidence of the steps made to ensure the quality of the required services they supply to their partners.

For example, a quality assurance approach allows the project developer responsible for the quality of the work performed, to reinforce his position by involving the various successful project implementers or subcontractors of work contracts.

7.3 Quality assurance basic principles

A quality assurance approach is a sequence of scheduled actions related to construction and verification of the quality. A well-identified participant implements each action. This sequence of actions is designated as a quality plan.

A quality assurance approach consists of the following major phases:

- analysis of users' requirements;
- design and construction follow-up;
- system units acceptance and commissioning;
- organization of plant maintenance follow-up;
- information feedback as a basis for lessons learned.

The participants in charge of implementing the quality plan can differ according to the different project phases. However, the documents substantiating the quality assurance actions executed during one of the phases shall be communicated to the participant in charge of the quality plan for the next phase.

For example, concerning the construction of a system, the project developer shall, via the project implementer, forward the construction quality assurance data report to the system operator who is in charge of the maintenance quality plan for this system.

The various project design, construction and maintenance phases shall be conducted pursuant to the clauses defined in the quality plan. Practices implemented to ensure operating performance shall comply with the content of the quality plan.

The validation phase of system commissioning shall ensure that the plan complies with the expectations of the interested parties.

A quality assurance data report is designed to ensure the traceability of the quality assurance actions performed; monitoring, inspection, and verification.

This data report contains all the elements evidencing the execution of the quality actions defined in the quality plan for each of the design, construction and maintenance phases applicable to each plant.

To summarize, the following components of the quality assurance plan shall be accounted for:

- verification that the documentation is complete, readable and traceable;
- specification (in written form) of those actions to be performed;
- checking of the performance of the specified actions;
- tracing of project and quality assurance elements;
- record and track responses.

7.4 Quality assurance phases and participants

7.4.1 Implementing a quality assurance procedure

Depending on the importance of the operation to be performed, the project developer decides whether or not there is a requirement for launching a quality assurance procedure. If there is, the project developer decides the level of quality assurance to be assigned as a function of the type of unit concerned.

The project developer will ask the project implementer designated for preliminary sizing or for sizing, design and construction of this plant unit to propose a quality plan.

Likewise, the project developer will require from the operator a quality plan for the systems maintenance and operation. If the operator is known at the time of the design phase, the project developer may ask the project implementer to aggregate the two plans.

The project developer shall be responsible for the QA system and shall warrant that the final quality of the system is as specified.

For this reason, the project developer validates the quality plan and may assign this responsibility to a competent authority.

The project implementer and operator remain responsible for implementing this quality plan for the parts with which they are concerned.

7.4.2 Certification of components

If certified components are required by the project developer, the relevant tests shall be performed by an accredited testing organization.

7.4.3 Design and construction quality assurance

7.4.3.1 Sizing

The system sizing shall be included in the quality assurance process.

7.4.3.2 Design and construction

Clause 4 of this document specifies that the project developer will entrust the project implementer with the responsibility of this unit quality. Therefore, the project implementer is responsible for building quality into the engineering design and unit construction work.

As requested by the project developer, the project implementer will propose a quality plan and implement it. This quality plan should include all design and work phases. All companies participating in the unit construction should adhere to, and implement, any quality plan. Likewise, the project implementer shall ask equipment or component suppliers to fulfil the qualifications specified in the quality plan.

It is preferable that suppliers implement a quality plan for equipment manufacturing and delivery themselves. This plan should be forwarded to the project developer.

For example, the project implementer will ask the suppliers of photovoltaic modules for a manufacturing specification sheet indicating the class of quality for the supplied modules including related specifications and specific standards that the product meets.

7.4.3.3 Acceptance and commissioning of the works

On commissioning, the project implementer is in charge of presenting an evaluation of the results of the quality assurance approach. The results shown will have to demonstrate that the plant complies with the project developer's requirements.

7.4.4 Maintenance quality assurance

The project implementer is responsible for the quality assurance applied to system maintenance. This person will write the quality plan while accounting for that prepared by the project developer for the system design.

If the operator is not known at the time of design, the project developer will propose a maintenance quality plan to be discussed with the operator once the latter is known.

7.4.5 Independent verification

This specific procedure can be adopted in case of installations requiring a specifically strong quality assurance similar to that applied to a number of professional telecommunication or signalling sites.

The project developer decides on this procedure, which shall be implemented by a participant not directly involved with the work and having no interest linked to its operation.

7.4.6 Processing failures and complaints

Anomalies shall be processed as soon as they are detected. Findings of anomalies and related processing methods will be logged with the greatest care in order to ensure the most exhaustive traceability and render the balance more efficient upon commissioning.

7.5 Procedures

Prior to preparing a quality plan, it will be advisable for the project implementer to:

- analyse the client's request and jointly define the characteristics, required levels of quality of service and performances expected from this plant unit. The identification of the "client" shall be perfectly established: this may be the end-user, a local community, and/or a power distribution authority;
- collect documents related to the following:
  - sizing (or preliminary sizing) design;
  - installation engineering design;
  - equipment and components procurement (supplier's quality assurance);
  - performance of the works;
- identify such items likely to evidence potential risks of non-quality along the different phases (analysis of the risk) and to propose means to reduce these risks;
- establish a methodology for executing the design and the work;
- define the organization of the operation (planning, participants, implemented means, suppliers, subcontractors).

At this stage, the project implementer may start writing the quality plan.

7.6 Quality plan

7.6.1 General

The quality plan shall indicate those documents which were used as references for its preparation (ISO standards, etc.).

7.6.2 Operation context

- Definition of the operation.
- Identification of the participants involved with this operation:
  - project developer;
  - project implementer;
  - suppliers;
  - clients (users or others).
- Other participants (for example, inspection organizations).

7.6.3 Traceability and archiving of quality assurance actions

Tables 4 through 6 are examples of sheets that could be used for recording information concerning the following:

- the analysis of the requirements and definition of quality targets;
- the analysis of risks;
- the modification of the design;
- the record of actions performed (including originators of these actions) and the result of these actions.

It is the responsibility of the quality assurance supervisor to define what kind of document shall be produced, who is in charge of these documents and their maintenance, and where they shall be stored. All this information shall be available in the quality plan.

- Definition of expected levels of quality of service and performance.

Table 4 – Analysis of the requirements and definition of quality targets

Identification of users	Identification of the requirements	Quality criteria and targets	Dates

- Analysis of risks.

Table 5 – Analysis of risks

Task/risk context	Risk generating factor	Level and predictable consequences of the risk	Preventative action against the risk	Dates

7.6.4 Organization of the operation

Table 6 – Sequence of actions and corresponding results

Task	Contributor	Lead time	Result	QA (yes/no)	Quality action provided

7.6.5 Quality assurance implementing supervisors

For each task under this operation, someone shall be identified as responsible for each action.

An example is shown in Table 7. Everyone involved in a project will have to draw this kind of list.

Table 7 – Quality assurance implementing supervisors

	Quality Assurance implementing supervisor (responsible)			
Nature of action	**(Owner) Project developer**	**Project implementer**	**Operator**	**Contractor**
Decision to apply QA	●			
Identification of participants and implemented means				
• Project implementer	●			
• Contractors		●		
• Suppliers		●		
• Operator	(●) possibly			
Sizing design data and associated documentation				
• Meteorological data accounted for		●		
• Project implementer's specific data		●		
• Calculation principles		●		
• Software used		●		
Sizing design progress and result		●		
Data required for plant engineering design and associated documentation				
• Equipment specifications		●		
• Design methods		●		
• Software used		●		
Anomalies and modifications		●		●
Selection of suppliers and subcontractors				
• Selection criteria		●		
• Procured out products		●		
• Subcontracted required services		●		
Scheduled quality assurance actions concerning:				
• Sizing design follow-up		●		
• Engineering design follow-up		●		
• Supplier's selection		●		
• Subcontractor's selection		●		
• Equipment/materials purchasing		●		
• Commissioning situation report		●		●
Scheduled quality assurance actions related to operation and maintenance			●	
Experience feed-back actions			●	●

	Quality Assurance implementing supervisor (responsible)			
Nature of action	**(Owner) Project developer**	**Project implementer**	**Operator**	**Contractor**
Building foundations				●
Environmental impact assessment		●		

8 Protection of the environment, recycling and decommissioning

8.1 Purpose

The purpose of this clause is to propose requirements for recycling and protection of the environment. In general, these requirements are expressed by the project developer and addressed to the suppliers of the equipment to be implemented in rural electrification projects.

These requirements are limited to requesting a certain amount of information concerning the recyclability and impact on the environment of the equipment used in the project.

In addition, in the installation and work phases of project implementation, the participants shall restrict to a minimum all changes to the local environment such as the felling of trees. On completing the work sites, the participants shall restore the condition of the site and remove all waste produced by the work.

8.2 Protection of environment

If the project developer decides to initiate an environment impact assessment, this action shall conform to ISO 14000.

8.3 Recycling process and decommissioning

8.3.1 Recycling components

At the end of their service life, all the equipment shall be dismantled and properly disposed of or recycled. Since precedence is to be given to recycling, the equipment should be designed to enable all or part of its constituent elements to be recycled. Manufacturers shall clearly identify the kind of materials used for the different components in accordance with the existing relevant standards.

On delivery, the suppliers shall provide a "recycling plan" in their technical documentation giving the details of the following:

- various elements of the equipment that cannot be recycled in any manner**.** The supplier shall provide the following information:
  - – guidelines or instructions for the proper disposal of such items;
  - – any precautions to be taken when destroying the element;
  - – the main reasons for these precautions;
- a brief description of the treatment required when the element shall be treated before it may be disregarded or destroyed:
  - – contact information of companies, local when they exist, capable of carrying out this destruction and/or treatment;
- the elements of the equipment capable of being recycled after transformation or treatments indicating the following for each element concerned:
  - – a brief description of the transformation or treatment process;

  – contact information of companies, local where they exist, capable of carrying out this transformation or treatment;
- the elements of the equipment capable of being recycled without transformation or treatment, that are capable of being used immediately after the equipment has been dismantled, or possibly following minor work carried out locally.

8.3.2 Decommissioning

The cost of the decommissioning of the system shall be taken in account from the beginning of the project implementation. Financing for decommissioning shall also be planned at the same time. The choice of components shall be made in order to facilitate decommissioning and recycling. The decommissioning process shall be described in the quality plan and given to the operator.

Annex A
(informative)

Technical considerations on contractual liabilities between project participants

A.1 Technical guarantees

The project implementer remains responsible for the technical guarantees which apply both to the system sizing pursuant to a functional general specification approved by the project implementer and the user, and to the design, supply, installation, maintenance and product support services for the various equipment.

The project implementer may also be responsible for ensuring that all the systems or equipment warranties are in place. The project developer should ensure that a maintenance contract is in place, whether this contract is negotiated by the project implementer or the operator.

For each element in the system and for the system itself, the various sets of the IEC 62257 guidelines contain the minimum recommendations required for implementation. Depending on the types of applications, it may occur that technical instructions will be more drastic.

A.2 Sizing

Responsible: project implementer (in coordination with the engineering consultant).

A process for sizing a system is detailed in IEC TS 62257-4. The analysis of the system requirements and user demand may be performed by an investigator including a visit allowing specification of the site-specific constraints as deemed necessary by the project implementer.

Sizing can be performed by software or using state-of-the-art calculation methods, the principles of which should be clearly identified.

A.3 Design

Responsible: project implementer (in coordination with the engineering consultant)

Provisions shall be made for the system design to meet the requirements of the recommendations in force: IEC, ISO, national standards or local recommendations, and companies in-house specifications.

In all cases, the proposed solutions shall aim at achieving the best discounted cost efficiency with all the equipment as necessary to fulfil the requirements (generators, storage, back-up, special adaptations of receivers and promoting high-efficiency appliances).

Provisions shall be made to verify the system performances and offer related guarantees.

A.4 Procurement items

Components shall comply with the standards and recommendations in force: IEC, ISO, national standards or local recommendations, best existing recommended engineering practices, and in-house specifications if they exist.

It is the responsibility of the project implementer to negotiate the best possible warranty for system and components.

The equipment shall be selected complying with the recommendations contained in the various sets of IEC 62257 specifications. It will be manufactured subject to a quality assurance plan designed and implemented for each manufacturer; an objective expert shall verify the application of this plan. Recommendations for preparing quality plans are provided in Clause 6 of this technical specification.

A.5 Installation

Installation work shall be conducted pursuant to best available practices in accordance with the project implementer's and various component manufacturers' instructions in order to guarantee satisfactory system operation and durability. As required, these recommendations will include such actions performed by verification organizations, pursuant to local regulations, environment considerations, or as requested by the project implementer.

The safety of persons and assets shall be ensured during and after the execution of the work. The installation shall comply with the instructions given in IEC TS 62257-5, and all operations shall be performed complying with the health and safety rules in force in the country concerned.

A.6 System commissioning

It is important that all systems, from -scale home systems to more complex village systems, go through a system commissioning process following their installation. The process of commissioning checks, given a standard set of tests, that the system is installed correctly and is operational. This commissioning process should be carefully described on a standardized commissioning form that requires check boxes or spaces for specific entry. The commissioning form not only assists the technician with checking the system installation but also acts as a source of documentation covering specific details of system installation.

A.7 Operator or technician training

It is critical that some technical training be provided for individuals or organizations that will have direct responsibility for the installation, operation, and maintenance of the system(s). The level of training required would depend on the type, size and complexity of the system and the level of work the individuals will be expected to perform. System operators are expected to live in close proximity to the system and shall be capable of turning the system off and on, providing low-level system maintenance, responding to emergencies and being able to trouble-shoot basic system and component integration problems. Technicians should be capable of completing system installation within the specifications of the technology, intermediate system maintenance, component replacement and, in some cases, component trouble-shooting and repair. The technician should have the technical skills, tools and spare parts to visit a site and leave with the system operating, through repair of units or on-site component replacement. If a technician is required to make trips frequently to the site to perform a single repair, the system is likely to be economically unviable.

It is also critical that all operators and technicians be properly trained in all appropriate safety measures, which include electrical safety and possibly working at dangerous heights. There are many international certification programmes for technicians which organizations may find of value. All training should be conducted with sufficient documentation and manuals to allow each participant to retain something for reference at a later date as strict memorization will be insufficient. Training shall also be a continuous event due to personnel turnover, advancement and technology change. Depending on the programme size, the number of fielded units, technician and operator training should be conducted on a regularly defined schedule. Technically competent technicians are a requirement for any successful technology implementation.

A.8 User training syllabus

Under the project developer's responsibility, the project implementer commits himself to insuring that the user is provided with suitable training in order to use the installation safely and efficiently (see notably IEC TS 62257-5).

Training shall emphasize the importance of the selection of appliances.

This information will be fully documented.

A.9 Contractual warranty

Wherever possible, the components and systems shall be contractually guaranteed as provided for by the supplier/installer/manufacturer's product support service.

This warranty can be obtained for various levels of services:

a) simple warranty for "parts";
b) "parts and labour" warranty;
c) extended service warranty for "parts, labour and lead time for servicing";
d) transport of items under warranty.

A.10 Maintenance contract

In addition to this guarantee provided, the operator shall provide a maintenance plan to be implemented by the maintenance contractor.

The maintenance contractor's action will be at such lead time for execution and conditions as specified under the contract signed with the operator.

Depending on the QoS (quality of service) desired for this client, maintenance can be of the preventive or remedial types or only remedial.

With preventive maintenance, provisions shall be made for scheduled visits in order to monitor the state of the various components subjected to early ageing (batteries, cables, regulators, etc.). The maintenance contractor commits itself to periodically communicating to the concerned participants, in particular to the operator and the user, such major information as may concern the operation of the installation.

The system operator shall be alerted about any incident, either by the user's call, or by a call from a tele-monitoring system suitably programmed with installation alarm states. The system will trigger an action by the maintenance contractor or manufacturer's product support services as necessary.

Maintenance-related actions shall be recorded in the system operation logbook. This log-book shall remain with the system to permit event history follow-up.

A.11 Replacement of components

The replacement and recycling of batteries and other fixed-life components should be duly accounted for, if not already provided for under the warranty, for the designed life of the system.

The project developer or the operator shall implement a financial plan to provide for the above.

A.12 Maintenance organization

Depending on the project contexts, the maintenance structures to be implemented will be different. Maintenance authorities commit themselves to proposing services likely to meet all maintenance requirements. Maintenance contract models are provided in IEC TS 62257-6.

They will ensure maintenance services based upon previously and contractually defined lead times for servicing and possibly based upon a tele-monitoring/control system.

A number of spare parts (modules, regulation and control elements, accessories, etc.) will be held in stock including a minimum range of logistic and substitution means (vehicle, tooling, generator set, work teams, etc.).

Simplified maintenance contract models for installations fitted with wind power or photovoltaic generators are proposed in IEC TS 62257-6.

Likewise, in all cases, an organization or person will take over the installation operation and maintenance as this is a vital requirement for the system's durability.

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