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TECHNICAL SPECIFICATION

colour inside

Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 5: Protection against electrical hazards

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 62257-5, 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 2005. 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 IEC 62257 series (specifically IEC TS 62257-1 to IEC TS 62257-6).

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

Enquiry draft	Report on voting
82/950/DTS	82/1001A/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.

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

INTRODUCTION

The IEC 62257 series intends to provide to different players involved in rural electrification projects (such as project implementers, project contractors, project supervisors, installers, etc.) documents for the setting up of renewable energy and hybrid systems with 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 mechanisms developments at this time (CO_2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems 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.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 5: Protection against electrical hazards

1 Scope

This part of IEC 62257 specifies the general requirements for the protection of persons and equipment against electrical hazards to be applied in decentralised rural electrification systems. Requirements dealing with protection against electric shock are based on basic rules from IEC 61140 and IEC 60364.

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

The majority of these sites are:

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

The DRE systems fall into three categories:

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

Process or individual electrification systems exclusively consist of two subsystems:

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

Collective electrification systems, however, consist of three subsystems:

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

The general requirements specified in this part of IEC 62257 should be applied to all the identified categories of DRES. Application to each subsystem of a DRES is dealt within a specific subpart of IEC TS 62257-9.

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 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-43, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015

IEC 60364-5-52:2009, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*
IEC 60364-5-53:2001/AMD1:2002
IEC 60364-5-53:2001/AMD2:2015

IEC 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60364-7-712, *Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

IEC 62305-2:2010, *Protection against lightning – Part 2: Risk management*

IEC 62305-3:2010, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 61140:2015, *Protection against electric shock – Common aspects for installation and equipment*

IEC TS 62257-1, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 1: General introduction to IEC 62257 series and rural electrification*

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 62257-3: *Recommendations for renewable energy and hybrid systems for rural electrification – Part 3: Project development and management*

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

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

3 Terms and definitions

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

3.1
decentralized rural electrification system
DRES
any electrical power system that is stand alone and not connected to the grid

3.2
Renewable Energy
RE
energy from a source that is not depleted when used

3.3
mini-grid
subsystem of a DRES intended for power distribution

3.4
mini-powerplant
energy source of a DRES

3.5
Surge Protection Device
SPD
device intended to limit transient overvoltages and divert surge currents; contains at least one non-linear component. An appliance/device designed to protect electrical devices from voltage spikes.

3.6
protection against electric shock
provision of measures reducing the risk of electric shock

3.7
basic protection
protection against electric shock under normal conditions

3.8
fault protection
protection against electric shock under single-fault conditions

3.9
hazardous-live-part
live part which, under certain conditions, can give a harmful electric shock

3.10
lightning protection system
LPS
complete system used to reduce physical damage due to lightning flashes to a structure

3.11
external lightning protection system
part of the LPS consisting of an air-termination system, a down-conductor system and an earth-termination system

3.12
earthing arrangement
grounding arrangement, US
all the electric connections and devices involved in the earthing of a system, an installation and equipment

3.13
equipotential bonding system
EBS
interconnection of conductive parts providing equipotential bonding between those parts

Note 1 to entry: If an equipotential bonding system is earthed, it forms part of an earthing arrangement.

4 Classification of decentralised rural electrification systems

DRESs are classified into six different types. See Table 1.

Table 1 – Typology of decentralized electrification systems

Type of generator		Classification of associated systems	
		Individual	Collective
REN only, hybrid or not	no storage	T_1.I	T_1.C
REN only, hybrid or not	storage	T_2.I	T_2.C
REN, hybrid or not plus Genset	no storage	T_3.I	T_3.C
REN, hybrid or not plus Genset	storage	T_4.I	T_4.C
Genset only	no storage	T_5.I	T_5.C
Genset only	storage	T_6.I	T_6.C
Notation principle: Ti.I = individual system, type i; Tj.C = collective system, type j.			
Storage: storage of energy produced by one of the generator of the system and which can be reconverted.			

Architecture and characteristics of the different electrification system types are developed in Clause 6 of IEC TS 62257-2:2015.

5 Protection against electric shock

5.1 General

Basic rules for protection against electric shock are given in IEC 61140 and IEC 60364-4-41. Information is also available in Annex A.

5.2 Requirements on the d.c. side of a DRES

The principles for the design and erection of a d.c. electrical circuit are similar to those for an a.c. circuit. The main differences concern short-circuit current calculation and the selection of the protective devices.

Protection by extra-low voltage (SELV and PELV systems) or protection by double or reinforced insulation should preferably be adopted on the d.c. side of DRES.

Simple separation, at least, should be provided between the a.c. side and the d.c. side unless the inverter is not able, by construction, to feed d.c. fault current into the a.c. installation.

Earthing of one of the live conductors of the d.c. side is permitted, if there is at least simple separation between the d.c. side and the a.c. side.

5.3 Requirements on the a.c. side of a DRES

5.3.1 General

Protection by use of automatic disconnection of supply should preferably be adopted on the a.c. side of a DRES. For each circuit, maximum disconnecting times given in IEC 60364-4-41 should apply.

TN-S or TN-C-S system should preferably be used for decentralized rural electrification system, TT system is acceptable. IT system is normally not used for DRES and has hence not been dealt with in this specification.

A residual current protective device, with a rated residual operating current not exceeding 30 mA, should be provided as additional protection for each installation.

5.3.2 TT system

Basic protection is provided by basic insulation of live parts or by barriers or enclosures. Fault protection is provided by residual current devices regarding the resistance value of the earth electrode to which the PE conductor is connected. The fault current should be high enough to activate the differential current device. The rated operating residual current $I_{\Delta n}$ of the device should fulfil the formula:

Formula: Rated operating residual current

$$I_{\Delta n} \leq \frac{U_L}{R_A} \text{ with } U_L = 50 \text{ V}$$

where U_L is the conventional maximum voltage and R_A is the earthing resistance.

This formula results in the values shown in Table 2.

Table 2 – Rated operating residual current of the protective device depending on the value of the earthing resistance

R_A Ω	$I_{\Delta n}$ A
$R_A \leq 50$	1
$50 < R_A \leq 100$	0,5
$100 < R_A \leq 167$	0,3
$167 < R_A \leq 300$	0,1
$300 < R_A \leq 500$	0,03

5.3.3 TN system

Basic protection is provided by basic insulation of live parts or by barriers or enclosures. Fault protection is provided by devices protecting against over-currents.

Additional information is given in Annexes A and B.

6 Protection against overcurrent

6.1 General

Protective devices should be provided to break any over-current flowing in the circuit conductors before such a current could cause a danger due to thermal and mechanical effects or a temperature rise detrimental to insulation, joints, termination (see IEC 60364-4-43).

6.2 Protection against overload currents

The operating characteristics of a device protecting a cable against overload current should satisfy the two following conditions:

$$I_B \leq I_n \leq I_z$$

$$I_2 \leq 1{,}45 \times I_z$$

where

I_B is the deign current of the circuit;

I_z is the continuous current-carrying capacity of the cable;

I_n is the rated current of the protective device;

I_2 is the current ensuring effective operation in the conventional time of the protective device.

6.3 Protection against short-circuits

For cables and isolated conductors, each short-circuit protective device should meet both of the following conditions:

- The breaking capacity should not be less than the prospective short-circuit current at the place of its installation, except where another protective device having the necessary breaking capacity and coordinated characteristics is installed upstream.
- All current caused by a short-circuit occurring at any point of the circuit should be interrupted in a time not exceeding that which brings the conductors to the admissible limit temperature. For short-circuits of duration up to 5 s, the time t, in which a given short-circuit current will raise the conductors from the highest admissible temperature in normal duty to the limit temperature can, as an approximation, be calculated from the formula:

$$\sqrt{t} = k \times S/I$$

where

t is the duration in s;

S is the cross-sectional area, in square millimetres;

I is the effective short-circuit current, in amperes, expressed as r.m.s. value;

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.

7 Protection against risk of fire

Where there is a risk of personal injury or property damage due to fire caused by an earth fault in the system, a residual current protective device should be provided at least at the origin of the user's installation. Its rated operating residual current should be ≤300 mA. Such a device should switch all live conductors.