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**Connectors for DC-application in
photovoltaic systems — Safety
requirements and tests**

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Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Act.

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Connectors for DC-application in photovoltaic systems — Safety requirements and tests

Introduction

This Japanese Industrial Standard has been prepared based on **IEC 62852** : 2014, Edition 1, and Amendment 1 : 2020 with some modifications of the technical contents to incorporate specifications for wires in Japan. The amendment to the said International Standard has been incorporated into this Standard.

In this Standard, subclause and table numbers followed by a capital letter of Latin alphabet starting with “A” indicate that the subclause or table includes items not given in the corresponding International Standard. The dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies safety of connectors for use in the DC circuits of photovoltaic systems according to Class II protection against electric shock specified in **IEC 61140** with rated voltages up to 1 500 V DC and rated currents up to 125 A per contact.

This Standard applies to connectors without breaking capacity but which might be engaged and disengaged under voltage.

This Standard also applies to connectors which are intended to be built-in or integrated in enclosures of devices for photovoltaic systems. This Standard may be used as a guide for connectors in photovoltaic systems of Classes 0 and III protection against electric shock according to **IEC 61140** as well as for protection for Class II equipment intended for use at less than 50 V DC. This Standard does not apply to connectors for data collection, tracker controls or similar, but it may be used as a guide for those connectors.

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

IEC 62852 : 2014 *Connectors for DC-application in photovoltaic systems — Safety requirements and tests* + Amendment 1 : 2020 (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amend-

ments) made thereafter shall not be applied. For those without the indication of the year, the most recent editions (including amendments) shall be applied.

JIS C 0922 *Protection of persons and equipment by enclosures for electrical apparatus — Probes for verification*

NOTE Normative reference in the corresponding International Standard : IEC 61032 *Protection of persons and equipment by enclosures — Probes for verification*

JIS C 2134 *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

NOTE Normative reference in the corresponding International Standard : IEC 60112 *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

JIS C 2143-1 *Electrical insulating materials — Thermal endurance properties — Part 1 : Ageing procedures and evaluation of test results*

NOTE Normative reference in the corresponding International Standard : IEC 60216-1 *Electrical insulating materials — Thermal endurance properties — Part 1 : Ageing procedures and evaluation of test results*

JIS C 2143-5 *Electrical insulating materials — Properties of thermal endurance — Part 5 : Determination of relative thermal endurance index (RTE)*

NOTE Normative reference in the corresponding International Standard : IEC 60216-5 *Electrical insulating materials — Thermal endurance properties — Part 5 : Determination of relative thermal endurance index (RTE) of an insulating material*

JIS C 2809 *Connecting devices — Flat quick-connect terminations for electrical copper conductors — Safety requirements*

NOTE Normative reference in the corresponding International Standard : IEC 61210 *Connecting devices — Flat quick-connect terminations for electrical copper conductors — Safety requirements*

JIS C 2814-2-3 *Connecting devices for low-voltage circuits for household and similar purposes — Part 2-3 : Particular requirements for connecting devices as separate entities with insulation-piercing clamping units*

NOTE Normative reference in the corresponding International Standard : IEC 60998-2-3 *Connecting devices for low-voltage circuits for household and similar purposes — Part 2-3 : Particular requirements for connecting devices as separate entities with insulation-piercing clamping units*

JIS C 3664 *Conductors of insulated cables*

NOTE Normative reference in the corresponding International Standard : IEC 60228 *Conductors of insulated cables*

JIS C 5402 (series) *Connectors for electronic equipment*

NOTE Normative reference in the corresponding International Standard : IEC 60512 (all parts) *Connectors for electronic equipment — Tests and*

measurements

JIS C 8285 *Plugs, socket-outlets and couplers for industrial purposes*

NOTE Normative reference in the corresponding International Standard : IEC 60309-1 *Plugs, socket-outlets and couplers for industrial purposes — Part 1 : General requirements*

JIS C 8960 *Glossary of terms for photovoltaic power generation*

JIS C 60068-1 *Environmental testing — Part 1 : General and guidance*

NOTE Normative reference in the corresponding International Standard : IEC 60068-1 *Environmental testing — Part 1 : General and guidance*

JIS C 60068-2-14 *Environmental testing — Part 2-14 : Tests — Test N : Change of temperature*

NOTE Normative reference in the corresponding International Standard : IEC 60068-2-14 *Environmental testing — Part 2-14 : Tests — Test N : Change of temperature*

JIS C 60068-2-75 *Environmental testing — Part 2-75 : Tests — Test Eh : Hammer tests*

NOTE Normative reference in the corresponding International Standard : IEC 60068-2-75 *Environmental testing — Part 2-75 : Tests — Test Eh : Hammer tests*

JIS C 60068-2-78 *Environmental testing — Part 2-78 : Tests — Test Cab : Damp heat, steady state*

NOTE Normative reference in the corresponding International Standard : IEC 60068-2-78 *Environmental testing — Part 2-78 : Tests — Test Cab : Damp heat, steady state*

JIS C 60664-1 *Insulation coordination for equipment within low-voltage systems — Part 1 : Principles, requirements and tests*

NOTE Normative reference in the corresponding International Standard : IEC 60664-1 *Insulation coordination for equipment within low voltage systems — Part 1 : Principles, requirements and tests*

JIS C 60695-2-11 *Fire hazard testing — Part 2-11 : Glowing/hot-wire based test methods — Glow-wire flammability test method for end-products (GWEPT)*

NOTE Normative reference in the corresponding International Standard : IEC 60695-2-11 *Fire hazard testing — Part 2-11 : Glowing/hot-wire based test methods — Glow-wire flammability test method for end-products (GWEPT)*

JIS C 60695-11-10 *Fire hazard testing — Part 11-10 : Test flames — 50 W horizontal and vertical flame test methods*

NOTE Normative reference in the corresponding International Standard : IEC 60695-11-10 *Fire hazard testing — Part 11-10 : Test flames — 50 W horizontal and vertical flame test methods*

- IEC 60060-1 *High-voltage test techniques — Part 1 : General definitions and test requirements*
- IEC 60352-2 *Solderless connections — Part 2 : Solderless crimped connections — General requirements, test methods and practical guidance*
- IEC 60352-3 *Solderless connections — Part 3 : Solderless accessible insulation displacement connections — General requirements, test methods and practical guidance*
- IEC 60352-3 : 1993 *Solderless connections — Part 3 : Solderless accessible insulation displacement connections — General requirements, test methods and practical guidance*
- IEC 60352-4 *Solderless connections — Part 4 : Solderless non-accessible insulation displacement connections — General requirements, test methods and practical guidance*
- IEC 60352-4 : 1994 *Solderless connections — Part 4 : Solderless non-accessible insulation displacement connections — General requirements, test methods and practical guidance*
- IEC 60352-5 *Solderless connections — Part 5 : Press-in connections — General requirements, test methods and practical guidance*
- IEC 60352-6 *Solderless connections — Part 6 : Insulation piercing connections — General requirements, test methods and practical guidance*
- IEC 60352-7 *Solderless connections — Part 7 : Spring clamp connections — General requirements, test methods and practical guidance*
- IEC 60364-7-712 *Electrical installations of buildings — Part 7-712 : Requirements for special installations or locations — Solar photovoltaic (PV) power supply systems*
- IEC 60512 (all parts) *Connectors for electronic equipment — Tests and measurements*
- IEC 60529 *Degrees of protection provided by enclosures (IP Code)*
- IEC TR 60943 *Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals*
- IEC 60999-1 *Connecting devices — Electrical copper conductors — Safety requirements for screw-type and screwless-type clamping units — Part 1 : General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*
- IEC 60999-2 *Connecting devices — Electrical copper conductors — Safety requirements for screw-type and screwless-type clamping units — Part 2 : Particular requirements for clamping units for conductors above 35 mm² up to 300 mm² (included)*
- IEC 61140 *Protection against electric shock — Common aspects for installation*

and equipment

IEC 61984 *Connectors — Safety requirements and tests*

IEC 62444 *Cable glands for electrical installations*

IEC 62548 *Photovoltaic (PV) arrays — Design requirements*

ISO 868 *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 4892-2 *Plastics — Methods of exposure to laboratory light sources — Part 2 : Xenon-arc sources*

ISO 6988 *Metallic and other non organic coatings — Sulfur dioxide test with general condensation of moisture*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions, and those given in JIS C 8285, JIS C 8960, JIS C 60664-1, IEC 60999-1 and IEC 61140 apply.

3.1

connector

component which terminates conductors for the purpose of providing connection to and disconnection from a suitable mating component

3.2

multi-way connector

connector with more than one contact

Note 1 to entry Multiple single-way connectors used in a PV-junction box are not to be regarded as a multi-way connector according to this Standard.

3.3

connector under voltage

(In the corresponding International Standard, this term not used in the main body is defined, but it is not necessary and is not adopted in this Standard.)

3.4

connector without breaking capacity

(In the corresponding International Standard, this term not used in the main body is defined, but it is not necessary and is not adopted in this Standard.)

3.5 type of connector

3.5.1

free connector

connector for attachment to the free end of a wire or cable

3.5.2**built-in connector**

pre-manufactured connector that is subsequently integrated into an enclosure

3.5.3**integrated connector**

connector assembly that is manufactured as an integral component during enclosure fabrication

3.6**non-rewirable connector**

connector so constructed that the cable cannot be separated from the connector without making it permanently useless

3.7**connector for Class II equipment**

connector in which the protection against indirect contact is realised by double or reinforced insulation

Note 1 to entry Class II according to **IEC 61140**.

3.7A**cable gland**

part which makes it possible to introduce one or more cables into a terminal box in order to maintain the related degree of protection

3.8**intended use**

application conditions of connectors which are included within the permissible rated values and environmental conditions and characteristics assigned by the manufacturer

3.9**interlock**

(In the corresponding International Standard, this term not used in the main body is defined, but it is not necessary and is not adopted in this Standard.)

3.10**cycle of mechanical operation**

(In the corresponding International Standard, this term not used in the main body is defined, but it is not necessary and is not adopted in this Standard.)

3.11**clamping unit**

part(s) of the terminal necessary for the mechanical clamping and the electrical connection of the conductor(s), including the parts which are necessary to ensure the correct contact pressure

3.12

upper limiting temperature, ULT

maximum temperature of a connector as defined by the manufacturer, in which the connector is intended to operate

3.13

maximum ambient temperature

maximum temperature of the ambient assigned from the manufacturer, in which the connector is able to operate permanently without the upper limiting temperature being exceeded

3.14

lower limiting temperature, LLT

minimum temperature of a connector as defined by the manufacturer in which a connector is intended to operate

3.14A

minimum ambient temperature

minimum temperature of the ambient assigned from the manufacturer, in which the connector is able to operate permanently without the lower limiting temperature being fallen short of

3.15

clearance

shortest distance in air between two conductive parts

3.16

creepage distance

shortest distance along the surface of the insulating material between two conductive parts

3.17

overvoltage category

numeral defining a transient overvoltage condition

3.18

pollution

any addition of foreign matter, solid, liquid, or gaseous, that can result in a reduction of electric strength or surface resistivity of the insulation

3.19**pollution degree**

numeral characterising the expected pollution of the micro-environment

3.20**rated voltage**

value of voltage assigned by the manufacturer to the connector and to which operation and performance characteristics are referred

Note 1 to entry Rated voltage used in this Standard is equivalent to the rated system voltage according to **JIS C 61730-1**.

3.21**rated insulation voltage**

r.m.s. withstand voltage value assigned by the manufacturer to the connector, characterising the specified (long term) withstand capability of its insulation

Note 1 to entry The rated insulation voltage is not necessarily equal to the rated voltage, which is primarily related to functional performance.

3.22**rated impulse voltage**

impulse withstand voltage value assigned by the manufacturer to the connector, characterising the specified withstand capability of its insulation against transient over-voltages

3.23**impulse withstand voltage**

highest peak value of impulse voltage, of prescribed form and polarity which does not cause breakdown of the insulation under specified conditions

Note 1 to entry The impulse withstand voltage is equal to or higher than the rated impulse voltage.

3.24**r.m.s. withstand voltage**

highest r.m.s. value of a voltage which does not cause breakdown of the insulation under specified conditions

3.25**rated current**

current value assigned by the manufacturer, which the connector can carry continuously (without interruption) and simultaneously through all its contacts wired with the bypass diode (if applicable, it shall be current value at which all its contacts are wired with the largest specified conductor and the upper limiting temperature is not exceeded).

ed at maximum temperature)

Note 1 to entry If other ambient temperature values are used for the definition of the rated current, the manufacturer should state in the technical documentation the ambient temperature on which the rating is based, with reference, if appropriate, to the derating curve defined in **JIS C 5402-5-2**, test 5b.

3.26

functional insulation

(In the corresponding International Standard, this term not used in the main body is defined, but it is not necessary and is not adopted in this Standard.)

3.27

basic insulation

insulation applied to live parts to provide basic protection against electric shock

Note 1 to entry Basic insulation does not necessarily include insulation used exclusively for functional purposes.

3.28

supplementary insulation

independent insulation applied in addition to basic insulation, in order to provide protection against electric shock in the event of a failure of basic insulation

3.29

double insulation

insulation comprising both basic insulation and supplementary insulation

3.30

reinforced insulation

single insulation system applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant IEC standard (**IEC 61140, 3.10.4**)

Note 1 to entry A single insulation system does not imply that the insulation is a homogeneous piece. It may comprise several layers which cannot be tested separately as basic or supplementary insulation.

3.31

internal insulation

part of basic insulation providing the required clearance and creepage distances inside a conductive housing or enclosure

4 Classification

4.1 General

In order to apply the relevant test requirements in Clause 5, connectors shall be classified by the manufacturer's specification according to 4.2 and 4.3, according to their intended use under consideration of Class II protection against electric shock specified in IEC 61140 and characteristics.

4.2 Type of connector

- a) Free connector
- b) Built-in connector
- c) Integrated connector

4.3 Additional characteristics

- a) Connector with cable anchorage
- b) IP-code of a connector according to IEC 60529
- c) Connector for Class II equipment
- d) Non-rewirable connector
- e) Rewirable connector
- f) Terminations and connection methods

5 Constructional requirements and performance

5.1 General

This Standard does not define electrical rating values for voltage and current. These values are assigned by the manufacturer.

Connectors shall be suitable for durable outdoor use in an ambient temperature area from $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$.

Multi-way connectors shall be designed so that these requirements for earth-faulted and short-circuit-proofed installation complies with IEC 62548 or IEC 60364-7-712.

Compliance with the requirements is verified by the specified tests of this Standard.

5.2 Marking and identification

5.2.1 Identification

Connectors shall be identified and characterised by the following :

- a) manufacturer's name, trademark or mark of origin;
- b) type reference (for example, the catalogue number);
- c) rated current;
- d) rated voltages or rated insulation voltages;
- e) rated impulse voltage, if specified;
- f) pollution degree;
- g) degree of protection by enclosure according to IEC 60529;

- h) range of temperature : ULT and LLT, maximum ambient temperature (85 °C or higher);
- i) type of terminals;
- j) connectable conductors;

NOTE For current capacity of cables and wires, see **JIS C 60364-5-52**.

- k) reference to this Standard or to the Detail Specifications (DS), if applicable;
- l) symbols “Do not disconnect under load“, as given in Annex A; alternatively an adequate warning notice can be found;
- m) polarity of PV connector, if applicable;
- n) relative thermal endurance index (RTE) of all insulating resin materials used for connectors/relative temperature index (RTI) or temperature index [TI, (mechanical and electrical)].

5.2.2 Marking

After the test specified in **6.3.2**, the marking shall be legible to normal or corrected vision without additional magnification. The marking shall be easily legible.

The minimum marking on the connector shall be that of item **a)**, **l)** and **m)** in **5.2.1**.

Symbol or warning notice listed in **l)** of **5.2.1** shall be imprinted or labelled close to connector.

A notice to attach the label shall be given in technical documentation.

Markings **a)** and **b)** of **5.2.1** shall be applied on the smallest package unit.

5.2.3 Technical documentation

Identification items of **5.2.1** not marked on the connector according to **5.2.2** and the following information shall be given in the technical documentation of the manufacturer. The appearance and dimensions shall conform to the specifications given in the technical documentation of the manufacturer.

- a) Information regarding the type of cable suitable for termination, if applicable
- b) Information regarding mounting, if applicable
- c) Assembly information such as jigs (part number) specified by manufacturer, if applicable

5.3 Provision against incorrect mating (non-intermateable)

A multi-way connector shall be so designed that contact between live contacts of different polarity is not possible by engagement.

Compliance shall be tested by performing a polarisation test (see A3 of Table 5).

5.4 Protection against electric shock

5.4.1 Protection against electric shock in engaged condition

A connector shall be so designed that, after mounting, its live parts are not accessible in the test performed using probes for verification specified in **JIS C 0922**.

5.4.2 Protection against electric shock in unengaged condition

Protection against electric shock shall be ensured also during insertion and withdrawal. Compliance shall be tested in accordance with **6.3.3.1**.

5.5 Terminations and connection methods

Terminations and connection methods of connectors shall be as follows :

- a) **crimped connections** according to **IEC 60352-2**
- b) **accessible insulation displacement connections** according to **JIS C 2814-2-3** (accessible IDC) or **IEC 60352-3**
- c) **non-accessible insulation displacement connections** according to **JIS C 2814-2-3** (non-accessible IDC) or **IEC 60352-4**
- d) **press-in connections** according to **IEC 60352-5**
- e) **insulation piercing connections** according to **JIS C 2814-2-3** or **IEC 60352-6**
- f) **screwless-type clamping units** according to **IEC 60999-1**, **IEC 60999-2** or **IEC 60352-7**
- g) **screw-type clamping units** according to **IEC 60999-1** or **IEC 60999-2**
- h) **flat, quick-connect terminations** according to **JIS C 2809**

As a minimum, the applicable tests according to **6.3.15** shall be performed for all terminations and connection methods intended to be used.

Other terminations and connection methods shall be tested in accordance with the relevant standards.

Soldering and welding connections are also permitted.

Termination and connection methods shall provide sufficient means for retaining the conductor in position.

Electrical connections shall be so designed that the contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any shrinkage or yielding of the insulating material (see **JIS C 8285 : 2018**, **25.3**, **IEC 60999-1**, Clause **7** or **IEC 60999-2**). Insulation piercing terminations and insulation displacement connections are excluded from this requirement because of the tests performed according to **JIS C 2814-2-3** or **IEC 60352-6**.

Precautions shall be taken to ensure that adequate contact pressure is maintained during connector lifetime.

To compensate for changes during use, (e.g. loosening at screw-type clamping units caused by thermal cycles) the use of a lock washer, spring washer or similar could be sufficient.