
**Glass in building — General technical
requirements of building integrated
photovoltaic modules recycling**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Glass in building — General technical requirements of building integrated photovoltaic modules recycling

1 Scope

This document specifies requirements for the recycling of building integrated photovoltaic (BIPV) modules. It is suitable for crystalline silicon PV modules and thin film modules.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 472, *Plastics — Vocabulary*

ISO 11469, *Plastics — Generic identification and marking of plastics products*

3 Terms and definitions

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

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

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

3.1

waste photovoltaic module

waste PV module

photovoltaic module that the holder discards, or intends to discard, or is required to be discarded

3.2

laminated solar photovoltaic glass

laminated solar PV glass

double glass photovoltaic module

double glass PV module

laminated glass that integrates the function of photovoltaic power generation

Note 1 to entry: This term covers both laminated glass (see ISO 12543-3) and laminated safety glass (see ISO 12543-2).

[SOURCE: ISO/TS 18178:2018, 3.1, modified — Photovoltaic has been changed to PV.]

3.3

hazardous material

item, element or substance with a potential for harm in terms of human injury or ill health (both short and long term), damage to property, damage to the environment, or a combination of these

[SOURCE: ISO 30000:2009, 3.5]

3.4 collection

logistical process of moving waste photovoltaic module from its source to a place where it can be recovered

[SOURCE: ISO 472:2013, 2.1682, modified — Domain of application has been deleted, and "plastics waste" has been changed to "waste photovoltaic module".]

3.5 storage

temporary storing activity of waste photovoltaic modules at a special place which meets the requirements for the purpose of *collection* (3.4), transportation, *treatment* (3.10) and *disposal* (3.11)

3.6 disassembly

set of activities of demounting and disintegrating waste photovoltaic modules by a manual or mechanical way for the convenience of *treatment* (3.10)

3.7 re-use

use of a product more than once in its original form

[SOURCE: ISO 472:2013, 2.1708, modified — Note to entry has been deleted.]

3.8 recycling

processing of waste materials for the original purpose or for other purposes, excluding energy recovery

[SOURCE: ISO 472:2013, 2.1706]

3.9 recovery

processing waste material for the original purpose or for other purposes, including energy recovery

[SOURCE: ISO 472:2013, 2.1704]

3.10 treatment

set of activities of decontamination, *disassembly* (3.6), comminution and *recycling* (3.8) of waste photovoltaic modules

3.11 disposal

set of activities for diminishment or elimination of the danger of waste photovoltaic modules

Note 1 to entry: This can be by means of changing physical, chemical and biological characteristics.

Note 2 to entry: The activities of final placement for waste photovoltaic modules in a place or facility that meets the requirements for environmental protection.

3.12 termination

component that is used to extract the direct current from photovoltaic module

3.13 photovoltaic laminate PV laminate

portion of a photovoltaic module consisting of substrate, encapsulant, complete photovoltaic cell circuit, and superstrate

Note 1 to entry: A photovoltaic module includes a laminate and a junction box. A frame and other accessories can also be added.

[SOURCE: IEC/TS 61836:2016, 3.1.50, modified — The preferred term has been changed to photovoltaic laminate.]

3.14

photovoltaic modules that lose safety performance

PV modules that lose safety performance

photovoltaic modules that have structural, electrical and other types of the safety risk

3.15

recovery rate

ratio of the weight of the recovery materials or components to the whole weight of the waste photovoltaic modules

4 Fundamental principles

4.1 The fundamental principles are the maximizing of resource utilization and the minimizing of environmental pollution.

4.2 The treatment shall be conducted according to the following order: re-use, recycling and energy recovery. The re-use and energy recovery should meet the requirements of related standards or specifications.

4.3 Treatment and disposal shall adopt the current optimal feasible technology. All necessary measures shall be employed in order to ensure that the effect of recycling process on personnel and the environment are in accordance with relevant standards during treatment and disposal.

4.4 The participants, including dismantlement, transportation and recycling organizations, shall establish appropriate information statistic systems for the collection, treatment and disposal of waste PV modules. The relevant data/information (see [Table A.1](#)) shall be saved and be available to competent departments or organizations.

4.5 Waste PV modules should not be landfilled or burnt directly.

4.6 Recovery materials or components should be used in PV modules.

4.7 Matters needing attention for recycling should be given (see [Annex B](#)) in the documentation of PV module.

5 Classification

5.1 It can be classified according to the type of cell:

- a) Crystalline silicon PV module;
- b) Copper indium gallium selenide (CIGS) PV module;
- c) Cadmium telluride (CdTe) PV module;
- d) Silicon-based thin film PV module;
- e) Other types of PV module.

5.2 It can be classified according to the structure of encapsulation:

- a) Single glass PV module;

- b) Laminated solar PV glass;
- c) Multi-layer glass PV module.

5.3 It can be classified according to abandoned condition:

- a) PV module that lose safety performance;
- b) PV module with damaged appearances, but the power generation performance works properly;
- c) PV module where the power generation performance shows obvious attenuation, but the appearances are not damaged;
- d) PV module with undamaged appearances and proper power generation performance, which the holder discards, or intends to discard for other causes.

NOTE Such PV modules can be reused without recycling.

6 Dismantlement

6.1 Dismantlement of waste PV modules shall avoid excessive emissions of pollutants, such as screw, rubber and metal components.

6.2 According to the methods of ISO 15928, the safety level of building after dismantlement of waste PV module should not be lower than that of building before dismantlement.

6.3 The electrical safety of the whole dismantlement should conform with the requirements of IEC 60364-7-704, IEC 60364-5-54 and IEC 60364-5-55.

6.4 The requirements related to the dismantlement of waste PV module can be found in national or local building safety codes.

6.5 Structure safety of buildings and safety of users shall be ensured during dismantlement process.

6.6 The system shall be electrically isolated before dismantlement, and it shall not be powered on until the whole system is repaired after being partly dismantled.

6.7 Safety nets should be installed in the working area to avoid tools and materials falling. Workers should be equipped with the safety devices such as safety helmets, safety ropes, safety shoes and safety clothes.

6.8 The integrity of PV modules should be ensured during the dismantlement process.

6.9 In order to avoid electric shock accidents, after the waste PV module is separated from the inverter, the cables of the module and inverter shall be insulated with insulating materials.

6.10 For cracked module, in order to prevent electric shock, the surface of the cracked waste PV module should be insulated in advance, if it is necessary to dismantle in rain and snow weather. Condition a) and b) should not be met at the same time:

- a) sunlight irradiates directly on module illumination side;
- b) human gets in contacts with the internal electrode of module directly or through conductive fluid.

6.11 For cracked module, before dismantlement, safety measures should be set to prevent the broken parts from falling.

6.12 The inner side of the building where waste PV module is disassembled shall be properly secured.

6.13 According to the disassembly height of the waste PV module, the appropriate size of the no walking area on the ground shall be set referring to [Table 1](#).

Table 1 — Determination of the size of the no walking area

Dismantlement height, h m	No walking area radius m
$2 \leq h \leq 5$	3
$5 < h \leq 15$	4
$15 < h \leq 30$	5
$h > 30$	6

6.14 During the entire dismantlement process, safety measures for waste PV module should be taken to avoid accidents such as module falling, severely swinging, and bursting, caused by operation, wind and rain, etc.

6.15 For waste PV module on the side of the building, if conditions permit, dismantlement work should be operated from the interior of the building rather than from outside the building.

6.16 If traffic is too heavy, the operation time should select the daytime period when traffic is not heavy. If the above condition cannot be met, the road can be temporarily closed, or the radius of the no walking area can be expanded.

6.17 In the case of wind speed greater than 10 m/s, or other bad weather such as rain, thunder, snow and fog, the waste PV module dismantlement work should not be operated, unless authorized by national or local regulations.

6.18 Before dismantlement, workers shall clean the work area, and remove water, snow, oil, dust and other slippery materials from the surface of waste PV module components.

6.19 Before dismantlement, a safety plan shall be set according to building conditions. The workers shall track the safety of both the tool and the dismantling worker in real time during dismantlement process, avoiding accidents such as tool falling, rope breaking, unstable fixed point. The communication between the workers shall be clear.

6.20 Safety and construction equipment shall be fully prepared before waste PV module dismantlement work.

6.21 If the building of disassembled waste PV modules is in use, it should install new BIPV modules or materials with building function to repair the building immediately.

6.22 The dismantled modules should be recorded into the information statistics system to form a complete information system with the transportation and recycling parts.

6.23 The dismantlement of photovoltaic insulating glass units with PV power generation should avoid glass breakage caused by operation.

6.24 The accessories of BIPV modules should be removed during the dismantlement processing. If the accessories cannot be removed on the spot, these modules should be collected separately, and the accessories should be removed before recycling processing.

6.25 The requirements related to dismantlement work can be found in national or local regulations for work at height.

NOTE Refer to [Annex C](#) for common requirements for work at height.

7 Collection, transportation and storage

7.1 General provisions

7.1.1 In the process of collection, transportation and storage, the harm caused by electric leakage of solar cell shall be prevented.

7.1.2 For PV modules that lose safety performance, these shall be classified prior to collection, transportation and storage. This shall be conducted in a manner that ensures personal injury is avoided.

7.1.3 For PV modules having risk of heavy metals leakage, these shall be classified prior to collection, transportation and storage. This shall be conducted in a manner that ensures environmental pollution is avoided.

7.1.4 PV modules shall avoid secondary pollution influencing the recycling, such as oil pollution and saline-alkali corrosion.

7.1.5 Sort waste PV modules according to the size and shape of waste PV modules before transportation and storage.

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7.2 Collection

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7.2.1 Waste PV modules shall be prohibited from being mixed with domestic garbage or industrial solid waste.

7.2.2 Collected waste PV modules shall be stored according to the requirements of [7.4](#).

7.2.3 Collector shall deliver collected waste PV modules to qualified organizations for disassembly and treatment.

7.2.4 Protection measures shall be set up to avoid harming of modules and broken components falling in the process of collection, such as broken glass, interlayer, termination, cable and solar cell, which can cause injury or pollute the environment.

7.3 Transportation

7.3.1 The waste PV module should be recorded in the statistical information management system before transportation.

7.3.2 In the process of transportation, unauthorized disassembly and treatment to waste PV modules shall not be conducted in any form.

7.3.3 Protective measures shall be set up to avoid harming of modules and broken components falling in the process of transportation, such as broken glass, interlayer, termination, cable and solar cell, which can cause injury or pollute the environment.

7.3.4 Secondary pollution to waste PV modules shall be prevented in the process of transportation, especially oil pollution and saline-alkali corrosion. Transportation organization should connect with a

recycling organization to ensure whether the recycling process requires avoiding secondary damage to PV modules or other requirements.

7.4 Storage

7.4.1 Requirements for the storage site of waste PV modules can be found in the relevant regulations, i.e. national and local laws and regulations.

7.4.2 All kinds of waste PV modules shall be classified prior to storage and all module types (see 5.1) shall be appropriately marked at prominent positions.

7.4.3 It shall be guaranteed that pollutants, such as broken glass, solar cell, termination and cable, cannot drop down during storage, avoiding pollution to environment.

7.4.4 Secondary pollution, especially oil pollution and saline-alkali corrosion, should be prevented during storage. Storage organization should connect with a recycling organization to confirm whether the recycling process requires avoiding secondary damage to PV modules or other requirements.

8 Disassembly

8.1 General provisions

8.1.1 It shall be strictly prohibited to discard any part of waste PV modules, which are taken out in advance.

8.1.2 Materials and all the taken-out parts shall be stored in appropriate classified containers and be marked clearly. Hazardous material should be classified correctly and stored carefully avoiding dangers to personnel and pollutants to environment.

8.2 Termination

8.2.1 The gas containing dust, which is produced in the process of sorting and crushing, shall be dealt with by the waste gas processing system. After treatment, waste gas should conform with the relevant requirements shown in [Table D.1](#).

8.2.2 After the treatment of scrap wire and cable, all metals, plastic and rubber shall be recycled.

8.2.3 Termination waste should not be landfilled directly.

8.2.4 Waste water, produced in the process of waste termination cleaning, should be dealt with by the waste water treatment system, and should be recycled. After treatment, waste water should conform with the relevant requirements shown in [Table D.1](#).

8.3 Frame

8.3.1 The frame should be mechanically disassembled before other recycling processing.

8.3.2 Mechanical disassembly shall be performed in a manner that prevents disassembled metal components from hurting workers.

8.3.3 After disassembly, the metal components that can be directly recycled should be subjected to cleaning, polishing and edge grinding.