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CONSTRUCTION REQUIREMENTS FOR A TESTING LABORATORY OF PHOTOVOLTAIC MODULES

Key words

Photovoltaics, PV module testing, accreditation.

Abstract

This article presents the requirements for the establishment of an accredited testing laboratory for photovoltaic modules with crystalline silicon. A process of the construction of the testing laboratory for PV modules, based on the expansion of an existing accredited testing laboratory, is proposed. The chosen standard test procedures in the field of the safety and quality of the operation of photovoltaic modules with crystalline silicon are described in detail. The analysis can help in making a rational decision on the appointment of an accredited laboratory for photovoltaic modules, particularly when there already is apparatus for performing tests in accordance with the Low Voltage Directive and the Electromagnetic Compatibility Directive.

Introduction

The creation of an accredited testing research laboratory for photovoltaic (PV) modules of crystalline silicon can be accomplished via different routes with the main ones presented in Fig. 1.

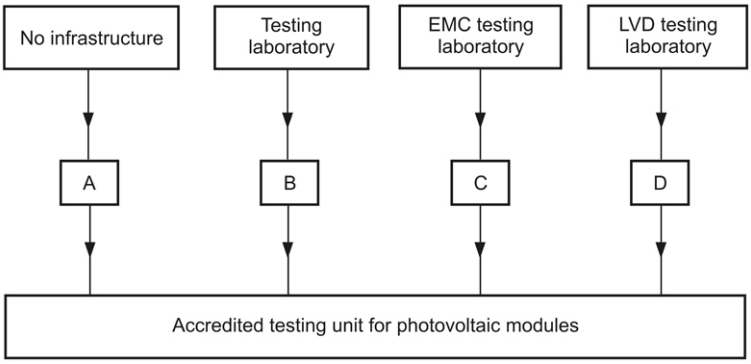

Fig. 1. Examples or ways to create an accredited research unit of crystalline silicon PV modules

The A route is the most expensive, entailing comprehensive construction and equipment of the photovoltaic module laboratory. The B route, with an existing Research Laboratory and its own quality control system, requires financial resources to create a complete infrastructure; however, it saves the costs associated with the launch and implementation of the quality system in the laboratory, required of accredited research entities. The C and D routes provide the largest cost reduction in creating a new accredited research unit, since it can be based on the existing quality system functioning in the laboratory and on the existing research infrastructure, which partly meets the requirements of test procedures of crystalline silicon photovoltaic modules.

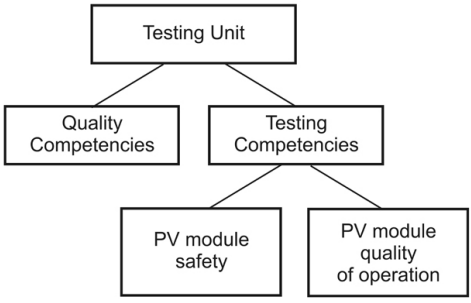

Fig. 2. The competencies of the research unit of crystalline silicon photovoltaic modules

The accreditation process of a testing unit for crystalline silicon PV modules requires of the entity (certifying or testing laboratory) the competences in both quality and research (Fig. 2). Quality competences for these types of units are included in the following norms: PN-EN ISO/IEC 17025 [1] i PN-EN ISO/IEC 17065 [2]. These norms include descriptions of the quality policy in the units, including the management and the general technical requirements for laboratories.

1. A description of model accredited research laboratory

At the Institute for Sustainable Technologies – National Research Institute in Radom, there is an accredited testing laboratory (AB 1476), which carries out accredited testing within the scope of Electromagnetic Compatibility Directive [3] and non-accredited testing within the scope of Low Voltage Directive [4]. The location of the accredited testing laboratory is indicated on the map of the Institute (Fig. 3). Room 101Ł is the headquarters of the laboratory, containing most of the test and measuring stands.

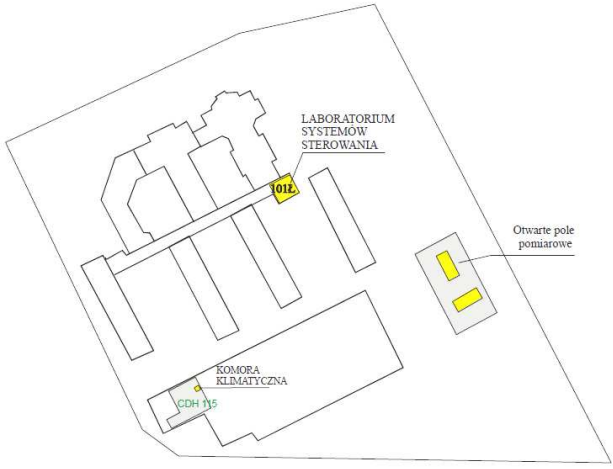

Fig. 3. A view of the layout of the research laboratory infrastructure at the Institute for Sustainable Technologies [5]

Additional infrastructure of the laboratory includes an open measuring field and climate chamber. Laboratory equipment allows the implementation of resistance to electric shocks testing (1.2/50 μs) [6]; testing resulting from the recommendations of the Low Voltage Directive on "Access to active components trial," where several samples are used as shown in Figure 4.

Fig. 4. Access samples for active components used in the laboratory and produced by ITeE – PIB

Part of laboratory testing, which include long-term tests in fixed or variable climatic conditions (temperature, humidity), are conducted in a special climatic chamber produced ITeE – PIB (Fig. 5).

Fig. 5. View the climatic testing stand, produced by ITeE – PIB

2. General requirements for a testing laboratory of photovoltaic modules

An accredited laboratory for PV modules, depending on its purpose, must meet the following quality competencies, included in the relevant norms for a testing laboratory (PN-EN ISO/IEC 17025) and for a certifying laboratory (PN-EN ISO/IEC 17065).

The PN-EN ISO/IEC 17025 norm contains general requirements for the competency of testing and calibration, and it describes the conditions for obtaining test samples. It specifies the procedure during testing and calibration performed using standardized methods, non-standardised methods, and specific procedures developed in individual laboratories. The main requirements of the PN-EN ISO/IEC 17025 norm include two sections: management requirements and technical requirements. Management requirements refer to a number of issues including organization, the management system, supervision documents, customer service, corrective action, the supervision of the entries, and maintenance management.

The PN-EN ISO/IEC 17065 norm includes requirements that apply to the operational consistency, competencies, and impartiality of units concerning the certification of products, processes, and services. Recommendations include

a number of requirements, such as structural and resource-relates requirements, certification processes, and management systems.

In regards to research competencies, a testing laboratory for the PV modules should meet a number of standards that describe the test units and test procedures for PV modules, including the following norms: PN-EN 61215 [7]; PN-EN 61646 [8]; PN-EN 61730-1 [9] and PN-EN 61730-2 [10]. These norms can be classified in general terms as norms describing the methods of PV modules testing in terms of safety and in terms of the quality of operation.

3. Specific requirements for a crystalline silicon photovoltaic modules testing laboratory

The testing of photovoltaic modules for safety is described the PN-EN 61730 norm "Safety assessment of the photovoltaic modules (PV)," which is divided into two parts: Part 1 – "Construction requirements" [9]; and Part 2 – "Testing requirements" [10]. Part 2 describes ten test methods for photovoltaic modules (Tab. 1).

The test methods listed in Table 1, such as "Access to active component trial" and "Continuity of protection circuit trial," are consistent with the typical testing done under Low Voltage Directive. Access to active component trial consists in determining the access to electrically active components, such as non-insulated electrical connections, which pose an electric shock hazard. The continuity trial of the protective circuit consists in measuring the resistance of the protective circuit while current passes through it with a specified value and within a specified interval of time. The current passes between the clamp of the protective circuit, and every available part of a metal object of testing.

The testing method for "impulse voltage test" fulfils the requirements of the Electromagnetic Compatibility Directive. The impulse voltage test method checks the strength of the insulation of module's casing against the electric surges of atmospheric origin.

Table 1. Testing methods in accordance with PN-EN 61730-2 [10]

No.	Name
1	Visual inspection
2	Access to active components trial
3	Cuttability trial
4	Protection circuit continuity trial
5	Impulse voltage trial
6	Dielectric strength trial
7	Temperature test
8	Flammability trial
9	Reverse current overload trial
10	Module destruction trial

This test requires a specialized test pulse generator of 1.2/50 μs (Fig. 6).

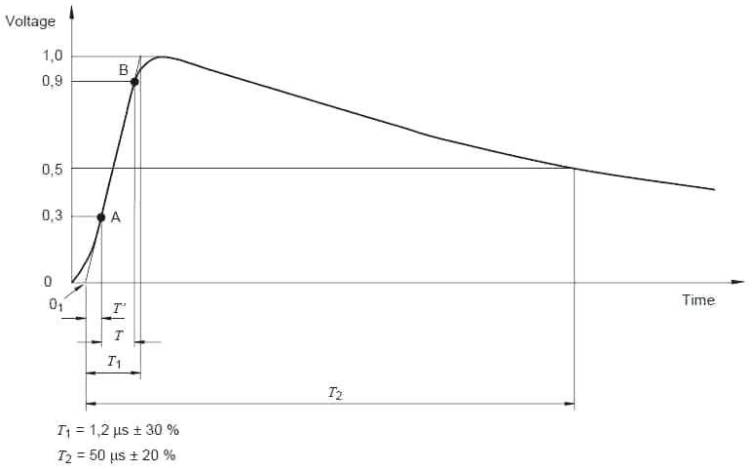

Fig. 6. Test impulse parameters in impulse voltage trial [10]

The testing of crystalline silicon photovoltaic modules in terms of the quality of operation is described by the PN-EN 61215 norm (Tab. 2). It provides eighteen test procedures, which require specialized equipment and test units, such as a climatic chamber, a light source, or specialized stand for test implementation.

Table 2. Test methods in accordance with PN-EN 61215 [7]

No.	Name
1	Visual inspection
2	Maximum power setting at STC
3	Insulation test
4	Determination of temperature coefficients
5	Measurement of the cell's normal temperature
6	Performance in the STC and NOCT conditions
7	Performance with low-intensity radiation
8	External test of resistance to external factors
9	Hot spots
10	Preliminary study on the resistance to UV
11	Cyclic thermal changes test
12	Moisture freezing test
13	Humid hot air test
14	Fixture and endpoint strength test
15	Leakance in elevated humidity test
16	Mechanical load test
17	Hail test
18	Shunt diode temperature

The insulation test method presented in Table 2, analogically to the previous norm, is consistent with tests carried out within the framework of the Low Voltage Directive.

The climatic test methods implemented within the framework of the PN-EN 61215 standard such as "Cyclic thermal change test," "Moisture freezing test," "Humid hot air test," and "Shunt diode temperature test."

The thermal cyclic change test consists in determining the strength of the module in relation to the non-uniformity of thermal environment, thermal fatigue, and other stresses caused by cyclically varying temperatures. The moisture freezing test is to determine the strength of the module to high temperature and humidity, and then to temperatures below 0°C. The humid hot air test consists in determining the strength of the module against the long-term penetration of humid air. The purpose of the temperature testing of the shunt diodes is to determine the thermal strength and life span of the shunt diode for photovoltaic cell group in the PV module.

Summary

This article presents some alternative ways to create an accredited testing unit for crystalline silicon PV modules. Based on this analysis, the best solutions for such a laboratory were selected based existing accredited testing laboratories in the field of EMC and LVD. This solution allows for maximum cost reduction in creating a new accredited research unit, based on the existing quality system and the existing research infrastructure that partly meets the requirements of test procedures for crystalline silicon photovoltaic modules.

The article gives examples of an accredited testing laboratory performing testing in accordance with the requirements of the Electromagnetic Compatibility and Low Voltage Directive, additionally equipped with specialized climate chamber. This type of laboratory can provide a basis for creating an accredited testing or certifying unit for photovoltaic modules with crystalline silicon.

An analysis was conducted on the normative requirements for the competencies of quality and testing aimed at meeting the requirements of an accredited testing and certifying unit for photovoltaic modules with crystalline silicon.

The presented results of the analysis allow a thoughtful decision concerning the construction of an accredited laboratory, taking into account requirements such as the expense limit for establishing the laboratory, or the possibility to expand an existing accredited entity.

An important factor in favour of the creation of such a unit is the increasing market demand for research on PV modules. Currently in Poland, the domestic

demand has been increasing for installing photovoltaic systems [11] and the development of the production of PV modules accompanies the demand.

A testing laboratory is also essential to conduct work in the field of the evaluation and testing of existing PV installations [12] and for the development and testing of various design solutions [13] and optimizing algorithms for PV installations.

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Uwarunkowania budowy laboratorium badań modułów fotowoltaicznych

Słowa kluczowe

Fotowoltaika, badania modułów PV, akredytacja.

Streszczenie

W artykule zaprezentowano wymagania dotyczące utworzenia akredytowanego laboratorium badawczego modułów fotowoltaicznych z krzemu krystalicznego. Zaproponowano proces utworzenia laboratorium badań modułów PV na bazie rozbudowy istniejącego akredytowanego laboratorium badawczego. Przedstawiono szczegółowo wybrane normatywne procedury badawcze z zakresu bezpieczeństwa i jakości funkcjonowania modułów fotowoltaicznych z krzemu krystalicznego. Zaprezentowana analiza może wspomóc podjęcie racjonalnej decyzji o powołaniu akredytowanego laboratorium badań modułów fotowoltaicznych, w szczególności w przypadku posiadania wyposażenia do realizacji badań zgodnych z wymaganiami Dyrektywy Niskonapięciowej lub Kompatybilności Elektromagnetycznej.