The Dawn of New PV Safety Requirements:

IEC 61730 2ND EDITION

The international standards for photovoltaic (PV) module safety qualification, IEC 61730 series (61730-1 and 61730-2), were recently updated to reflect changes in PV module technologies. Published in 2016, the new second edition relies on the important and fundamental concepts from IEC horizontal standards, in particular, the IEC 60664 series. This standard series defines and uses the concepts of "insulation coordination" and, in combination with IEC 61140, defines "application classes" that apply to PV modules.

Both IEC 60664 and IEC 61140 include requirements regarding the coordination of insulation systems. These include internal and external factors such as material groups, installation type, location of the installation, pollution degree, system voltages and overvoltages. The new material and component requirements in the updated IEC 61730 standards were derived from those in IEC 60664 and IEC 61140, which have been successfully used in connection with standards for other electrical equipment.

This also helped to develop the fundamental understanding of 1500 V DC components and the materials used in the construction of PV modules. New concepts are included in the IEC 61730 revisions, like distance through insulation and cemented joints. These new concepts are ideal for further development of PV modules and will help support the expanded deployment of PV-based solar panel systems. This paper will review the specifics of these changes.

INTRODUCTION

The worldwide installed photovoltaic capacity reached over 220 gigawatt peak (GWp) in 2015, and is expected to grow to more than 500 GWp by the year 2020.[1] While the installation of small (about 1 kilowatt [kW] – 20 kW) rooftop PV systems still constitutes a significant portion of the overall market, the trend in today's PV systems is moving toward medium (about 100 kW – 1 megawatt [MW]) and larger scale (greater than 1MW) installations, with some installations even reaching the 1 gigawatt (GW) level.

This trend is being driven in large part by the economics of PV system design. Average PV module sales prices have decreased to around 0.40 USD per watt peak (Wp). At the same time, other "balance of system" (BOS) costs, such as labor and cabling, now constitute a greater portion of the total installed cost of a PV system. As a result, system designers are focusing increased attention on systems that support higher voltages in the 1000-1500 volt (V) range, and adopting a more comprehensive approach to system development planning.

Higher voltage PV systems use less current, allowing for smaller conductor diameters throughout the system and further reducing electrical system losses. However, higher DC voltages also constitute new challenges for PV system component designs and materials that need to be addressed in the applicable standards. As such, these standards must remain technologically up to date to address essential safety requirements for evolving products and systems.

Therefore, IEC 61730-1, "Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction," and IEC 61730-2, "Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing," have been revised to include clear requirements developed for system voltages of up to 1500 V, including more stringent material and spacing requirements to reflect elevated operating voltages. Based on PV module design, used concepts and utilized materials, the new standards will also help to promote further module innovation that will not only drive down module price per watt but also overall system costs.

BACKGROUND

The first international standard governing minimum construction requirements for the safety of PV modules was the first edition of IEC 61730, published in 2004. Prior national standards were based on commonly observed field failure modes, most prominently those observed during the Flat-Plate Solar Array (FSA) project, sponsored by the U.S. National Aeronautics and Space Administration (NASA) and conducted by the California Institute of Technology's Jet Propulsion Laboratory (JPL) between 1975 and 1981.[2,3] The main focus was on crystalline silicon (c-Si) PV modules with solar cells of typically 500µm thickness.

UL 1703, "The Standard for Flat-Plate Photovoltaic Modules and Panels," was largely based on the JPL's block-buy module development and test experience. UL 1703 then led to the development of the first edition of the IEC 61730 to supplement the type approval standards IEC 61215, "Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements," and IEC 61646, "Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval" (Essential elements of IEC 61646 were merged into the latest edition of IEC 61215, and IEC 61646 was withdrawn in 2016).[4]

Advancements in PV technology, along with actual experience in the use of the original versions of the first edition of IEC 61730, prompted the need for a revised version of both standards. The new second editions of the standards were developed over a period of more than eight years with significant contributions from UL and industry participants. Figure 1, on page 5, illustrates the development timeline of the new edition of IEC 61730 series.[5]

As with the original versions of the IEC 61730, the two parts of the series work in conjunction with each other. Part 1 details the construction and component requirements for individual applications, while Part 2 provides safety testing requirements to verify which materials are being used, how they are integrated into the PV module specific design, and how the design is produced into a finished module. The revised standards also eliminate overlapping and duplication of requirements that characterized the original versions, such as some testing requirements formerly found in Part 1.

The revised standards are now also closely aligned with the recently revised IEC 61215 Standards. For example, several of the tests in the revised IEC 61730 Standards are identical to those in the revised IEC 61215 series, and failure modes and requirements are similar for both performance and safety aspects. However, the IEC 61730 places greater emphasis on safety aspects related to protection against electric shock, as well as fire hazards.

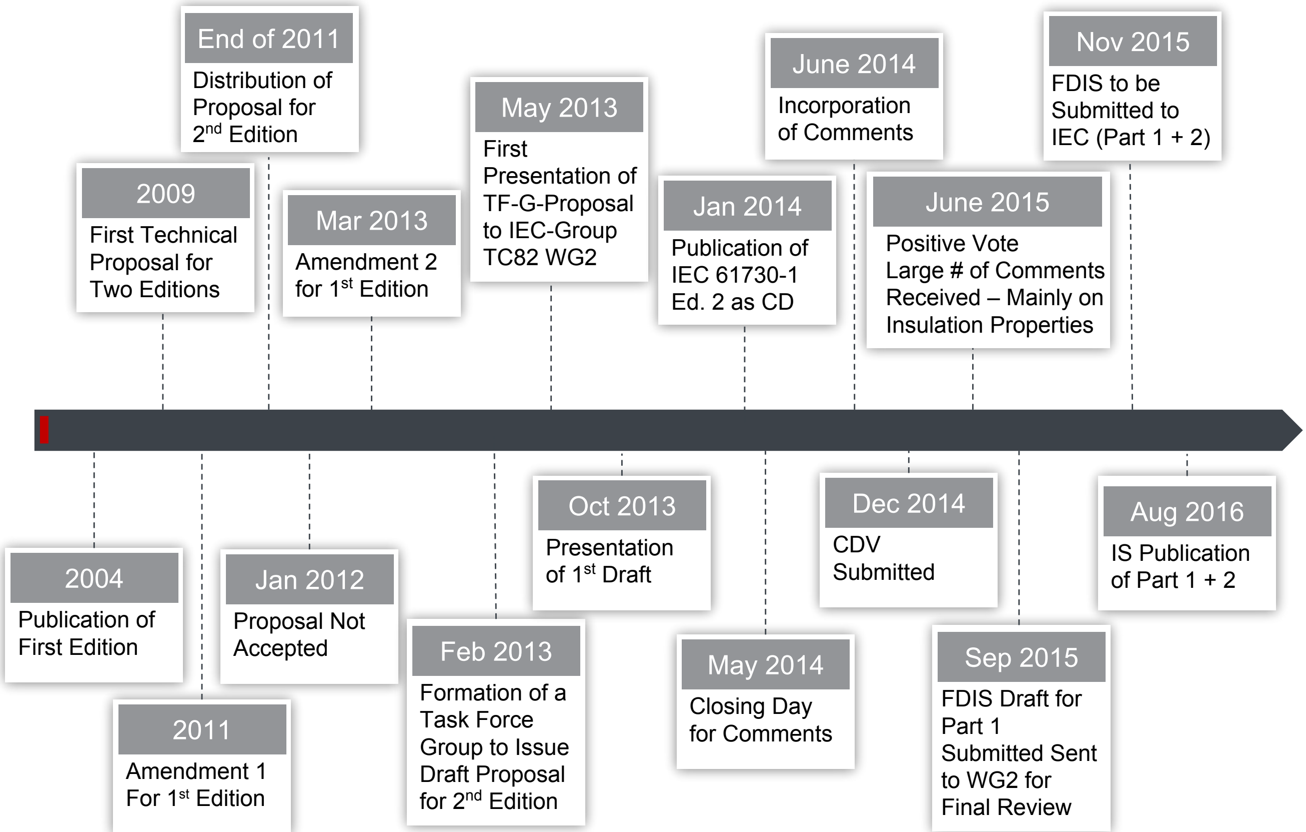


Figure 1: Summarized timeline of the development stages of IEC 61730-1 and IEC 61730-2

It is important to note that PV module components can't be assessed in isolation from the rest of a PV module. Any changes in a module's bill of material (BOM) requires a further technical assessment to assess any potential impacts associated with the change, including unanticipated interactions between module materials. A detailed retesting guidance document, currently identified as IEC/TS 62915, is under development and is expected to reference any retesting requirements under IEC 61215 and IEC 61730 when changes are made.

MOTIVATION TO IMPLEMENT NEW CONCEPTS

Over the past several years, Working Group (WG) 2 of IEC Technical Committee (TC) 82 had expended significant effort in updating the IEC 61730 series of standards, issuing amendments and decision sheets to address the most pressing issues. However, those efforts did not eliminate the need to eventually undertake a full revision and updating of the standards.

Understanding the specifics of the relevant horizontal standards as they relate to concept of insulation coordination is essential for its successful application in PV modules. Therefore, one of the key objectives in the IEC 61730 revision effort was to align the concept of insulation coordination for PV modules with that presented in the IEC 60664 series of horizontal standards, "Insulation coordination for equipment within low-voltage systems." Additional information on the importance of alignment with horizontal standards is available in the IEC Guide 108, "Guidelines for ensuring the coherency of IEC publications – Application of horizontal standards." The information presented in this guide is intended to help ensure overall coherence in the body of standardization documents, while also minimizing contradictory requirements and avoiding duplication of standards development efforts.

CONTENTS

The balance of this paper will focus on how these new PV concepts are presented in the revised IEC 61730 Standards. The following topics will be addressed:

INSULATION COORDINATION

OVERVOLTAGE CATEGORY

CLASS OF PROTECTION AGAINST ELECTRIC SHOCK

POLLUTION DEGREE (PD)

MATERIAL GROUPS (MG)

PROTECTION AGAINST ELECTRIC SHOCK

TERMS, CONCEPTS AND DEFINITIONS

The revised editions of the IEC 61730 Standards require numerous key definitions and a detailed understanding of the relevant electro-technical horizontal standards. To better comprehend the underlying concepts, we'll review the essential definitions based on their origin. The first five subsections that follow describe in detail the horizontal standards and their input in the revised IEC 61730 Standards. The last subsection highlights some crucial terms that are new in IEC 61730 and important for the understanding of these revised standards.

PRINCIPLE OF INSULATION COORDINATION

Insulation coordination is a method to proactively structure or coordinate the electrical insulation levels of different components in an electrical power system. The failure of any insulator is confined to the place where it would result in the least amount of damage of the system and is easy to repair or replace. Testing the validity of an insulation coordination approach requires a probability of failure study of all insulating parts to identify the weakest insulation point closest to the power source.

The IEC 60664 series of standards, "Insulation coordination for equipment within low-voltage systems," defines the concepts of insulation coordination. Most terms used in IEC publications are summarized in IEC 60050 series, "International Electrotechnical Vocabulary." For insulation coordination, [IEV 604-03-08] the following applies:

"THE SELECTION OF THE ELECTRIC STRENGTH OF EQUIPMENT IN RELATION TO THE VOLTAGES WHICH CAN APPEAR ON THE SYSTEM FOR WHICH THE EQUIPMENT IS INTENDED, AND TAKING INTO ACCOUNT THE SERVICE ENVIRONMENT AND THE CHARACTERISTICS OF THE AVAILABLE PROTECTIVE DEVICES."

Based on this definition and the scope for electronic devices, a number of aspects are essential in coordinating electrical insulation. These aspects include overvoltages, system voltage and working voltage, and the intended use of the equipment including the environment and serviceability. Each of these aspects will be addressed in the subsections that follow.

OVERVOLTAGE CATEGORY

Transient overvoltages can occur in electrical distribution systems (sometimes referred to as the low voltage mains) based on a number of different real-world events. In general, overvoltage is a voltage in a circuit or part of a circuit that has increased above its upper design limit or the circuit or part. Overvoltage conditions may be hazardous, depending on the duration of the overvoltage event. For insulation coordination, anticipating the nature and likelihood of such events are important in effectively mitigating any unintended consequences.

Overvoltage categories are used in IEC 60664 to systematically quantify exposure for equipment connected to the low voltage mains. In general, these overvoltage categories have a probabilistic implication rather than being defined by the physical attenuation of the transient overvoltage in the installation. Overvoltage Categories I, II, III and IV are defined in IEC 60664-1.

Figure 2 provides an illustration showing the locations anticipated by each category as it would relate to PV systems. At the grid interface, the overvoltage category is highest based on direct exposure to the grid. As more impedance is introduced into the system by interposed conductors, the propagation of the overvoltage is progressively more limited.

PV installations must comply with these requirements, and PV modules are defined as Overvoltage Category III equipment, per IEC 60664.

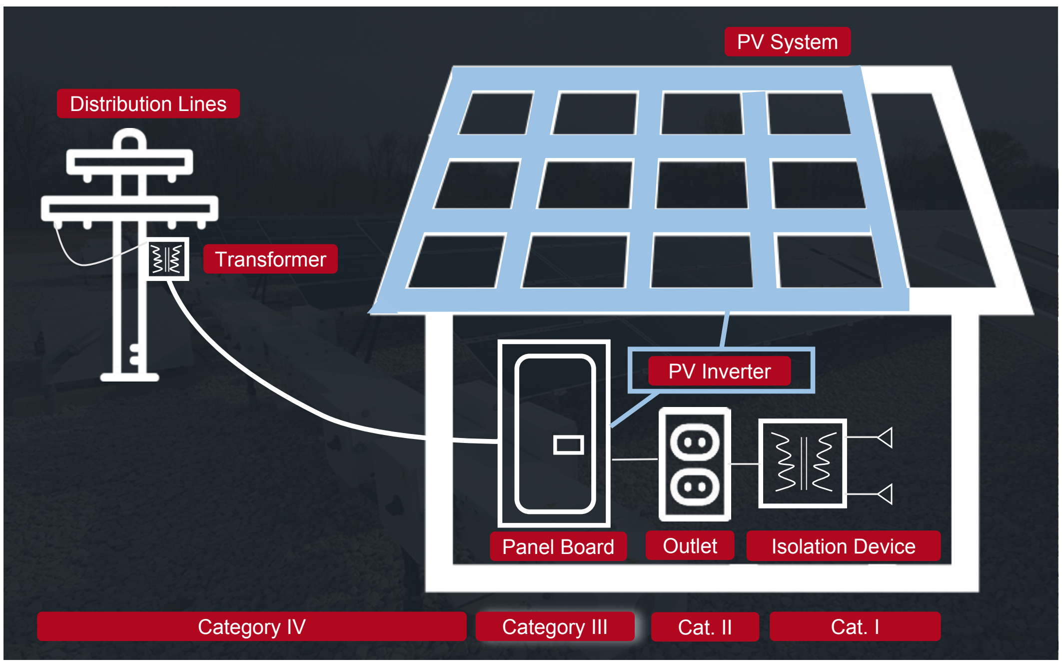


Figure 2: Schematic representation of places where to use a particular overvoltage category. The blue part is the PV system, which is defined as Overvoltage Category III.

Accounting for the applicable overvoltage category is important in insulation coordination. Air serving as insulation between electrically conductive parts, known as clearances, can break down if stressed by transient overvoltages. However, once the overvoltage is removed, the insulation heals itself as the air is renewed.

This is in contrast to distances between conductive parts along the surface of insulation, known as creepages, which can leave residual conductive material after a failure and permanently compromise the insulation. It is also different from solid insulation materials placed between conductors, which can be punctured by overvoltages and also become permanently compromised.

Insulation coordination techniques establish a reasonable level of confidence that clearances will not break down. But they also work to coordinate the breakdown of a self-healing clearance in advance of a permanent failure of surface or solid insulation. To reduce the risk of a permanent failure, each overvoltage category has clearly defined clearance requirements.

EQUIPMENT CLASSES

Protection against electrical shock in any given equipment, device or component is achieved through both attention to the construction of equipment or component, as well as the method of installation.

Four classes (Class 0, I, II and III) are defined in IEC 61140, "Protection against electric shock - Common aspects for installations and equipment." The fundamental idea behind the classes is to categorize electronic equipment according to the respective methods used to protect against electric shock. These methods can include the optional provision of protective earthing (sometimes referred to as grounding). But protection against electrical shock is primarily achieved through the use of internal insulation. Levels of internal insulation include:

- Functional, which may provide a level of protection from fire hazards but does not serve as protection from electric shock hazards;
- Basic, which provide a basic level of protection from shock hazards;
- Supplementary, which satisfies basic insulation but also meets a minimum through-insulation distance;
- Double, comprised of basic plus supplementary insulation; or
- Reinforced, a single integrated level of insulation that is equivalent to double insulation including the minimum through-insulation distance.

The class definitions in the revised IEC 61730 Standards are now identical to those found in IEC 61140. Table 1, on page 10, provides a brief overview and provides correlation with the application classes used in the prior version of the IEC 61730 Standards. This defines the following for PV modules:

- **MODULES OF CLASS 0:**
  Class 0 modules have individual and/or system level electrical outputs at hazardous levels of voltage, current and power. These modules are provided with basic insulation only as provision for basic protection and have no provisions for fault protection. All conductive components that are not separated from hazardous live parts by at least basic insulation shall be treated as if they are hazardous live parts. Due to the limited safety features of Class 0 modules, their application is limited to areas that are physically protected from the public with fences or other measures that restrict access.

- **MODULES OF CLASS I:**
  Class I devices generally rely on protective grounding and basic insulation to mitigate the risk of electric shock. These devices are not addressed in IEC 61730-1:2016. Class I equipment requires special installation measures for electrically safe operation, which is outside the scope of IEC 61730.

- **MODULES OF CLASS II:**
  Class II modules may have individual and/or system level electrical outputs at hazardous levels of voltage, current and power. The modules must provide outputs with basic insulation as basic protection and supplementary insulation as a precaution for fault protection or, alternatively, reinforced insulation that provides both basic and supplementary insulation. Accessible conductive parts must be separated from hazardous live parts by double or reinforced insulation, or constructed in such a way as to provide comparable protection. These modules are intended for installation where general access by operations and maintenance personnel is anticipated, and can include any kind of PV installation, from a standard roof-top application to large MW-type PV power plants. Most current PV modules fall into this class.

- **MODULES OF CLASS III:**
  Representative modules and series/parallel connections thereof are not allowed to have electrical ratings greater than 35 V DC, 240 W and 8 A maximum current available when evaluated under standard test conditions. Based upon the inherently limited electrical output capability of Class III modules, their use, misuse or failure is unlikely to result in a risk of electric shock or fire. Consequently, there are no requirements for construction or insulation beyond functional insulation. These modules are intended for installation where general user access and contact to uninsulated parts is anticipated, such as in consumer electronics. These modules are not intended for use in parallel with other modules or energy sources unless the combination provides protection from back feed current and overvoltage protection.

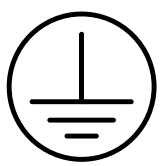
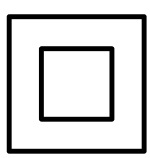
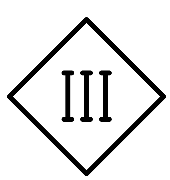
CLASS OF EQUIPMENT	EQUIPMENT MARKING OR INSTRUCTIONS	CONDITIONS FOR CONNECTION OF THE EQUIPMENT TO THE INSTALLATION	APPLICATION CLASS (IEC 61730-1:2004)	DESCRIPTION FROM IEC 61730-1:2016
Class 0	Only for use in non-conducting environment; or Protected by electrical separation	Non-conducting environment Electrical separation provided for each equipment individually	B	Application in restricted access area
Class I	Marking of the protective bonding terminal with symbol no. 5019 of IEC 60417 [13]  or letters PE, or color combination green/yellow	Connect this terminal to the protective-equipotential bonding of the installation	Special installation measures required	Special installation measures required
Class II	Marking with symbol no. 5172 of IEC 60417 [13] 	No reliance on installation protective measures	A	Application in non-restricted access area
Class III	Marking with symbol no. 5180 of IEC 60417 [13] 	Connect only to SELV or PELV systems	C	No restrictions for protection against electric shock

Table 1: Application of equipment in a low-voltage installation from IEC 61140 Table 1 and correlation to IEC 61730-1:2004.

POLLUTION DEGREE

The pollution degree (PD) is an important parameter that systematically evaluates the potential for pollution, such as dust and water, to collect on the surface of insulation, and to either compromise its effectiveness or make it conductive. A PD evaluation considers conditions in both the macro-environment, the ambient location of the equipment, and the micro-environment, the conditions that exist within the equipment.

Evaluating both macro- and micro environmental conditions is important as their impact may differ depending on the system, device or component being evaluated. With PV equipment, for example, the micro-environment may be more limited when measures are taken to inhibit the ingress of pollutants, such as the effective use of enclosures, encapsulation or hermetic sealing. But these measures may not be as effective when the equipment is subject to condensation of moisture from the ambient air.

Small clearances can be completely bridged by pollutants, such as solid particles, dust and water, which must be accounted for in meeting the minimum clearance requirements. Creepage distances may be similarly affected by pollutants. In general, pollution, such as dust or soot, can become conductive in the presence of humidity or water. Pollution caused by water, metal or carbon dust is inherently conductive.

To design a product that meets the required clearance and creepage distances, the micro-climate must be assessed first. IEC 60664-1 identifies four degrees of pollution, ranging from pollution degree 1 (PD=1), in which no pollution or only dry, non-conductive pollution occurs that has no influence on insulation properties, to pollution degree 4 (PD=4) where continuous conductivity occurs due to dust, rain or other wet conditions. The dimensions for creepage distance cannot be specified where permanently conductive pollution is present (PD=4). For temporarily conductive pollution (PD=3), the surface of the insulation may be designed to avoid a continuous path of conductive pollution, for example, by means of ribs and grooves.

PV modules are exposed to a variety of climates with very different temperatures and various levels of humidity, rain, dust, contaminants and irradiance. Based on the definition of pollution degree from IEC 60664-1 and knowledge of the intended installation location, PV modules should generally be designed to withstand at a minimum the conditions of a PD=3 micro-environment. However, meeting this PD=3 minimum would require the development of a PV module with extreme required spacing.

The challenge, therefore, is to design a PV module that allows for a reduction in the applicable PD. In cases where the enclosure provides component protection equal to or greater than an ingress protection IP55 rating, the applicable PD may be reduced to PD=2. For components and parts within an enclosure satisfying the relevant requirements specified in Annex C of IEC 61730-1, the applicable PD may be reduced to PD=2 or even PD=1. Additionally, the application of coatings is another option that may result in a reduction of the applicable PD.

MATERIAL GROUP

Breakdowns on the surface of insulating materials between conductive parts can compromise the insulation. To address this potential concern, insulating materials are characterized with respect to their surface tracking behaviour. The comparative tracking index (CTI) is a material specification, originally developed by UL, with variations of the index also used in several IEC standards.

A CTI assessment provides an assessment of the propensity of a given insulation material to form conductive tracks on the surface of the material when exposed to high voltages. The principle test setup is shown in Figure 3 below, taken from IEC 60112. Insulating materials are categorized into one of four groups, from Group lllb to l, with Group I materials demonstrating the greatest resistance to track formation. Specific material group categories are as follows:

MATERIAL GROUP I:	$600 \le$ CTI;	PLC=0
MATERIAL GROUP II:	$400 \le$ CTI $<$ 600;	PLC=1
MATERIAL GROUP IIIa:	$175 \le$ CTI $<$ 400;	
MATERIAL GROUP IIIb:	$100 \le$ CTI $<$ 175.	PLC=4

As previously noted, insulation coordination principles are based on the concept that clearances should break down before creepages based on the nature of self-healing insulation. Accordingly, creepage is never less than clearance. For glass, ceramics or other inorganic insulating materials which do not track, creepage distances need not be greater than their associated clearance for the purpose of insulation coordination.

1. *Platinum electrode*
2. *Brass electrode (optional)*
3. *Table*
4. *Tip of dropping device*
5. *Specimen*
6. *Glass specimen support*

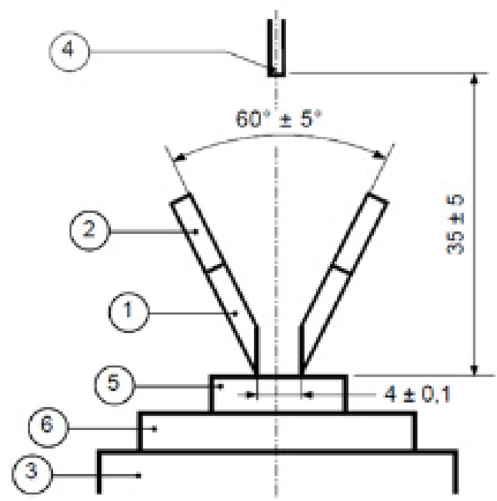


Figure 3: Determination of CTI values following IEC 60112.

HOW INSULATION IS COORDINATED: CLEARANCES, CREEPAGES AND DISTANCES THROUGH INSULATION

The previous subsections of this paper highlight the fundamental concepts that have been introduced into the revised IEC 61730 Standards. Within that framework, the differences in insulation (basic, double, functional, reinforced and solid insulation) are critically important, since they significantly impact clearance, creepages and thickness of materials used for insulation and, ultimately, the design of a PV module.

The following definitions apply:

- **CLEARANCE (cl):**
  The shortest distance through air between two conductive parts, or between a conductive part and an accessible surface.
- **CREEPAGE (cr):**
  The shortest distance along the surface of the insulating material between two conductive live parts or between conductive live parts and accessible parts.

In addition to clearance (air-gap) and creepage (surface), insulation can also be achieved through the use of a solid (for example, front glass or a back-sheet) material, so-called solid insulation. However, surface properties are not adequate in characterizing these materials, making solid/volume properties important. The term "distance through insulation" (dti) defines the distances through insulation that are required for supplementary, double or reinforced insulation. Thickness depends on several parameters and distances are stated in Figures 4 and 5 on page 14 of the revised IEC 61730-1.

Besides solid parts, like the front glass, thin insulating sheets are often used as, for example, the backside of a standard c-Si PV module. Here, the concept of "thickness in thin layers" applies, for example, where a back-sheet is made from either a single or multiple layers. In these cases, additional criteria apply, including material requirements and minimum thickness to minimize risks from issues, such as pinholes that can compromise the insulation.

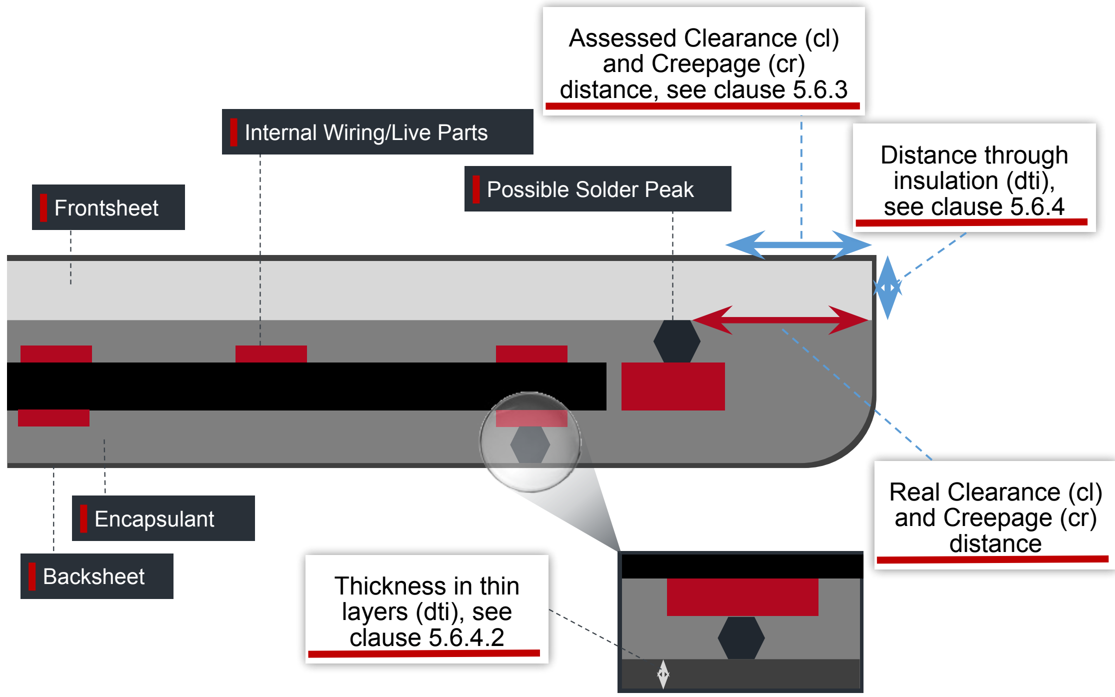


Figure 4: Side view of a PV module. The different live parts are highlighted and the important spacing are marked.

The concept of cemented joints is illustrated in Figure 5. The fundamental idea behind cemented joints is to address spacing requirements through intermediate layers of insulation. For products like PV modules with many layers, the use of cemented joints is a possible method to reduce spacing. This requires the demonstration that the different material layers are adequately cemented together to form a cemented joint. If a joint is proven to be cemented, the concept of creepage does not apply (surface property). Instead, the effective cementing of insulation layers means that they can't be separated, allowing it to be classified as solid insulation. In practice, this means that tracking can't occur at the interfaces between internal layers.

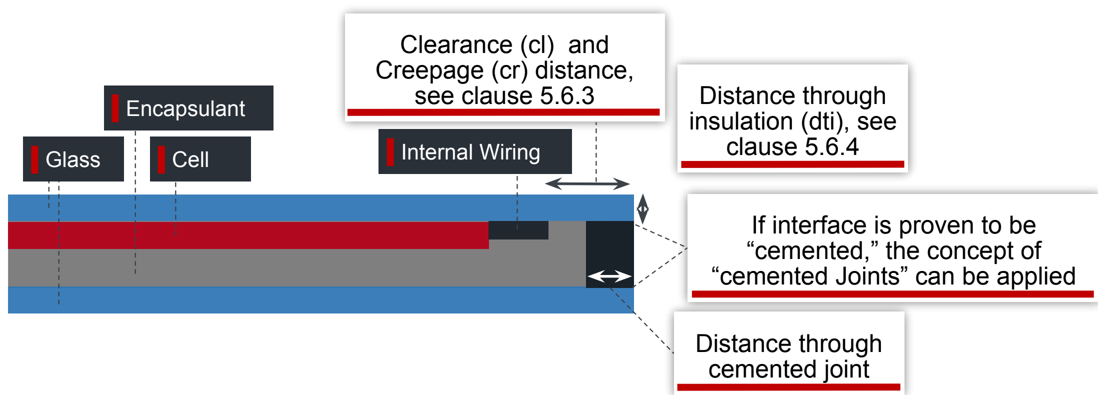


Figure 5: Side view of a PV module. The different live parts (e.g. cells, internal wiring) are shown. At the edge of the module (black), the concept of cemented joints is illustrated.

All of these changes have important, practical implications for PV modules. The more sophisticated methods of assessing insulation through insulation coordination methods result in a more rigorous investigation of PV module insulation than previous approaches of assessing the insulation of a PV module, which had worked well for many years but had a different, broader, performance-based nature of assessment. At the same time, insulation coordination provides new, scientifically-validated methods that enable the systematic placement of conductors within a module in closer proximity to each other and to earthed (grounded) parts, such as frames. This advancement supports the development of advanced module designs with more active energy generating area because the distances to the module edge could be reduced. Insulation coordination methods can also support the use of different, advanced materials with higher confidence. These and other benefits can result in greater innovation within the PV industry, leading to advanced products offering better energy output performance while still further reducing costs, all based on long-term, acknowledged science.

OTHER MAJOR CHANGES

We have seen that conceptual and design requirements have changed significantly in the revised IEC 61730 Standards. However, the testing approaches presented in the standards have also changed. New technological evolutions in the PV industry meant that the testing concepts and protocols of IEC 61730 required an overhaul. The following subsections highlight some of the most important changes.

MODIFICATIONS TO IEC 61730 PART 1

The revised edition of IEC 61730-1 brings additional clarity to the requirements for component level equipment used in the PV industry. Specifically, the changes means that components used in or on a PV module, for example, a junction box with cables and connectors, will also have to comply with the relevant component standards. In the case of this example, that would mean compliance with applicable standards for junction boxes (IEC 62790), cables (IEC 62930) and connectors (IEC 62852). By explicitly stating in the standard that such components must comply with applicable safety requirements, the revised IEC 61730-1 takes the necessary steps to promote safety of the entire PV module.

As the work of IEC TC 82 has progressed, a number of new standards for PV components and balance of system equipment have been introduced. Accordingly, the requirements for the safety of PV modules must also be updated to reference these new standards and to fully leverage the benefits that can be achieved by compliance with their requirements. This updating follows the same approach used by UL in the development of more specific safety requirements for components and balance of system equipment in its standards and certification programs, and supports the continued advancement of PV safety in important ways.

MODIFICATIONS TO IEC 61730 PART 2

The new material requirements lead to new test requirements, which are now fully addressed in the revised IEC 61730-2. Test requirements previously found in IEC 61730-1 were removed as part of the revision process, resulting in a clear separation in the focus of each of the revised standards. This separation between fundamental design and testing requirements simplifies cross standard references and will help ease the process of updating the standards in the future.

The implementation of new tests in the revised version of IEC 61730-2 reflects changes in the requirements of the revised IEC 61730-1, particularly those new requirements derived from applicable horizontal standards. As a result, the test flow has also been updated significantly. The following list gives a brief summary of the test changes in IEC 61730-2:

- Updated test sequences, especially the introduction of sequence B and B1;
- MST 05 Durability of markings, MST 06 Sharp edge test, MST 33 Screw connections test and MST 37 Materials creep test were added to update the requirements of the standard;
- MST 23 Fire Test: new reference, also see Appendix of IEC 61730-2:2016 and implementation of MST 24 Ignitability test;
- MST 35 Peel test and MST 36 Lap shear strength test were added in order to assess cemented joints.

COORDINATION OF TESTING PLANS

Because there are a number of similarities in the testing specified in IEC 61730 and IEC 61215, a combined test plan is currently under development, and an updated test flow is expected to be published sometime in 2017 following consultation with IEC ETF-9. Similarly, testing requirements for upgrading from prior edition of the standard will be published. Based on changes to both IEC 61730 and IEC 61215, additional testing will almost certainly be required. However, the extent of additional testing will depend on materials, material combinations (different Bill of Materials BOMs) and the fundamental design of the PV module.

SUMMARY

Over the past eight years, a significant amount of work has been invested in developing next edition of IEC 61730 that led to the publication of the revised standards in August 2016. During the period in which the revised standards were developed, the rapid reduction in the price of PV modules raised concerns about both their quality and their safety. As a result, the revised standards integrate the concepts of insulation coordination, Classes, pollution degree and materials groups. The integration of these concepts provide broader parameters for PV module design while also defining clear and unambiguous limits regarding module safety.

As such, the revised editions of IEC 61730-1 and IEC 61730-2 will support the advancement of the global safety of PV modules in a responsible and practical way. The revised standards adopt widely accepted approaches in a way that specifically addresses PV technology and manufacturing processes. The standards will also support innovation in the design and manufacture of PV modules, and provide greater design flexibility in achieving the most efficient and productive outcomes.

For more information about IEC 61730-1:2016 and IEC 61730-2:2016 and UL's PV module testing and certification services, visit **UL.com/solar** or **RenewableEnergyQuote@UL.com**.

END NOTES

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