BFIRST
Building-integrated fibre-reinforced solar technology

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D.1.1. Report on the status of European Directives and Standards applicable to BIPV products

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Summary

The overall objective for BFIRST project is the development and demonstration of a set of standardized multifunctional photovoltaic products for building integration based on a recently developed technology for solar cells encapsulation within glass fibre-reinforced composite materials.

An objective of BFIRST project is to provide clearly defined performance characteristics of these products and to develop all accompanying guidelines for their use. This will help the exploitation of the newly designed products by all the parties involved in the design of buildings such as architects, engineers etc.

As part of BFIRST project the products will be characterized and tested for their intended use, according to the current normative framework. The first step in doing so is the inquire and identification of the requirements applicable on BIPV products, both as units for electricity production and as building elements, originated by European Standards and National Building Codes.

In WP1 of the project the regulatory framework for BIPV systems is identified, with emphasis on requirements of BIPV according to European Directives and Standards and National Building Codes, especially for the countries involved in the demonstration part of the project.

This deliverable contains the results of the survey on European Directives and Standards applicable on BIPV products, both as units for electricity production and as building elements, focused on requirements and test methods. The requirements of BIPV products as building elements are categorized according to the type of building element, e.g. façade, roofing element etc.

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Abbreviations

BIPV	Building Integrated Photovoltaics
BFIRST	Building-integrated fibre-reinforced solar technology

1. Introduction

The objective of this document is to present the results of a survey on European Directives and Standards applicable to BIPV systems.

As there are not yet any standards developed specific for BIPV products, the survey on standards was based on the requirements for the dual function of BIPV products, as units for generating electricity and as building elements.

The survey was focused on the performance requirements of BIPV products as defined by the European normative framework, as the result of the BFIRST project will be a set of standardized BIPV products of well defined characteristics.

The standards presented in this document refer to electrotechnical standards, related to the electricity generation function of a BIPV product and to standards related to construction products. The standards related to construction products are presented according to the type of construction product, following the product types which are going to be developed within the BFIRST project. Following the identification of the performance requirements of these families of products, in compliance to European Directives and the essential requirements set by these, a series of relevant tests are described.

2. Description of work

Building integrated PV modules, being at the same time generators of electricity and building elements, have to fulfill various regulations and (inter)national standards on electro technical as well as building technical level. Therefore they should not only be compliant with electro technical standards but also be compatible with the existing building codes and practices.

The legal framework in the E.U. applicable on BIPV systems is generally given by European Directives, which define the essential requirements, while detailed technical requirements are provided by European harmonized standards.

For a BIPV system the following three directives apply:

• 89/106/EEC Construction Products Directive (CPD).

• 73/23/EEC Low Voltage Directive (LVD) and the new one 2006/95/EC on Low Voltage.

• 89/336/EEC and the recent Directive 2004/108/EC (20 July 2007) on Electromagnetic Compatibility Directive (EMC).

For PV systems, it is the inverters and the rest of the electrical installation which are most important to fulfil the Low Voltage and Electromagnetic Compatibility directives.

For building integrated PV modules the main requirements are originated by the CPD.

Within the BFIRST project five different products are foreseen to be developed, namely for the following applications:

1. Product 1 (P1). Ventilated façade panel. A multifunctional hybrid element, PV and thermal, substitute for a conventional façade cladding
2. Product 2 (P2). Curtain wall. Prefabricated monolithic PV composite panel as a middle layer of a triple glazing, for curtain wall applications.
3. Product 3 (P3). Skylight. Prefabricated monolithic PV composite panel
4. Product 4 (P4). Shingles. Roof covering element
5. Product 5 (P5). Solar Shading system.

In the following chapters, the requirements of these products will be presented, based on the relevant directives, and within the normative framework of CENELEC / CEN.

3. Essential requirements for BIPV according to CPD

According to the Construction Products Directive (CPD), 89/106/EEC, all building products should carry the CE-mark, showing that the product is suitable for its intended use. Main goal of the CPD is the removal of technical barriers to trade in the construction products sector.

A product is suitable for intended use if it complies with:

- A harmonized European Standard, or
- A European Technical Approval (ETA), or
- A non-harmonized technical specification recognized at Community level.

On 1 July 2013, the current CPD, will be replaced by the Construction Products Regulations (CPR), 305/2011/EU

The CPR is already in force and during a transition period until 1 July 2013, both the CPD and the CPR will apply. The main elements of the CPR will, however, not take effect until 1 July 2013.

The general objectives and main instruments of the CPD have not changed in the CPR.

However, the CPR introduces stricter and more transparent procedures for the marketing of construction products. Also the terminology has partly changed in the CPR to be more precise.

The seven essential requirements which construction products should be fulfilled, as defined in the new CPR, and are presented in the following, as these will be valid after 1 July 2013.

1. Mechanical resistance and stability

The construction works must be designed and built in such a way that the loadings that are liable to act on them during their constructions and use will not lead to any of the following:

(a) collapse of the whole or part of the work;

(b) major deformations to an inadmissible degree;

(c) damage to other parts of the construction works or to fittings or installed equipment as a result of major deformation of the load-bearing construction;

(d) damage by an event to an extent disproportionate to the original cause.

2. Safety in case of fire

The construction works must be designed and built in such a way that in the event of an outbreak of fire:

(a) the load-bearing capacity of the construction can be assumed for a specific period of time;

(b) the generation and spread of fire and smoke within the construction works are limited;

(c) the spread of fire to neighboring construction works is limited;

(d) occupants can leave the construction works or be rescued by other means;

(e) the safety of rescue teams is taken into consideration.

3. Hygiene, health and the environment

The construction works must be designed and built in such a way that they will, throughout their life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbors, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition, in particular as a result of any of the following:

(a) the giving-off of toxic gas;

(b) the emissions of dangerous substances, volatile organic compounds (VOC), greenhouse gases or dangerous particles into indoor or outdoor air;

(c) the emission of dangerous radiation;

(d) the release of dangerous substances into ground water, marine waters, surface waters or soil;

(e) the release of dangerous substances into drinking water or substances which have an otherwise negative impact on drinking water;

(f) faulty discharge of waste water, emission of flue gases or faulty disposal of solid or liquid waste;

(g) dampness in parts of the construction works or on surfaces within the construction works.

4. Safety and accessibility in use

The construction works must be designed and built in such a way that they do not present unacceptable risks of accidents or damage in service or in operation such as slipping, falling, collision, burns, electrocution, injury from explosion and burglaries. In particular, construction works must be designed and built taking into consideration accessibility and use for disabled persons.

5. Protection against noise

The construction works must be designed and built in such a way that noise perceived by the occupants or people nearby is kept to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions.

6. Energy economy and heat retention

The construction works and their heating, cooling, lighting and ventilation installations must be designed and built in such a way that the amount of energy they require in use shall be low, when account is taken of the occupants and of the climatic conditions of the location. Construction works must also be energy-efficient, using as little energy as possible during their construction and dismantling.

7. Sustainable use of natural resources

The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:

(a) reuse or recyclability of the construction works, their materials and parts after demolition;

(b) durability of the construction works;

(c) use of environmentally compatible raw and secondary materials in the construction works.

One of the innovations in the new CPR is that sustainability is now included as one of the essential requirements. It also introduces simplified procedures, related to the Attestation of Conformity, which will reduce the costs incurred by enterprises, in particular small and medium enterprises (SMEs).

The CE mark may be applied to any construction product for which there is a harmonized Product Standard (hEN) or a European Technical Assessment Approval (ETA). A European Technical Approval (ETA) for a construction product is a favourable technical assessment of its suitability for an intended use, based on the contribution made by this product to the fulfilment of the Essential Requirements, as stated in the CPD for the construction works in which the product is installed.

An ETA can be granted when any of the following conditions apply:

- no relevant Harmonized Standards for the product exist
- no mandate for such a Standard has been given by the European Commission
- the European Commission considers that a Standard cannot be developed (yet)
- a product deviates significantly from the relevant Harmonized Standards

In most cases an ETA for a product will be granted to a manufacturer based on the assessment principles set out in an ETA Guideline for the relevant product sector.

An ETA Guideline (ETAG) is a document containing the guidelines for the evaluation of the specific characteristics/requirements of a product or family of products. According to the CPD Guidelines must comprise the following:

- a list of the relevant Interpretative Documents
- the specific requirements for the products within the meaning of the Essential Requirements
- the test procedures
- the methods of assessing and judging the results of the tests
- the procedures related to the Attestation of Conformity
- the period of validity of the approval

A CE mark shows the performance of a construction product with regard to the aforementioned essential requirements.

In general, if a certain characteristic is not subjected to a threshold or specified value, harmonized standards leave open for the manufacturer the possibility of declaring the characteristic as “No Performance Determined” (NPD). However, the standards exclude this possibility if the characteristic is subjected to a threshold level and/ or corresponding Building Codes impose any requirement on the characteristic. The Building Codes of each member state are the ultimate reference for the characteristics to be tested and declared.

A list of harmonised standards relevant to CPD, which have been published in the Official Journal of European Union, can be found in the following link:

http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/construction-products/index_en.htm

These standards are usually categorised according to the materials used, the application etc., and cover the basic performance characteristics required by a product or family of products. More technical details, e.g. on calculation methods or on test methods, are referenced and covered by more specific supporting standards.

A construction product is defined in CPD as any product or kit which is produced and placed on the market for incorporation in a permanent manner in construction works or parts thereof and the performance of which has an effect on the performance of the construction works with respect to the basic requirements for construction works.

A construction product is a "kit" when it is a set of at least two separate components that need to be put together to be installed permanently in the works (i.e. to become an "assembled system"), and typically this is the case of a BIPV product.

In the following, the study of standards for BIPV related to the essential requirements of construction products is based on the categories of the project products, e.g. ventilated facades, curtain walls, skylights, shingles and solar shading.

4. Standards framework for BIPV products

4.1 Electrotechnical European Standards for BIPV

The IEC technical committee on photovoltaics, TC 82, is responsible for developing PV related standards.

The main IEC standards for PV, concerning the PV module and the requirements as a unit for generating electricity (not as a building element) are the following:

Standard	Title
IEC 61215:2005	Crystalline silicon Terrestrial Photovoltaic (PV) Modules – Design qualification and type approval
IEC 61646:2008	Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC 61730-Part 1:2004	Photovoltaic (PV) module safety qualification – Requirements for construction
IEC 61730-Part 2:2004	Photovoltaic (PV) module safety qualification – Requirements for testing
IEC 61701:2011	Salt mist corrosion test for PV modules
EN 50548:2011	Junction boxes for PV modules

IEC 61215 for crystalline silicon modules and IEC 61646 for thin film modules are the main standards used for initial type approval and certification of respective PV modules.

A series of tests are defined in the above standards, which the samples of a type of PV module should undergo. The nature of the tests described in IEC 61215 and IEC 61646 is as follows:

- *Diagnostic*: Visual inspection, hot spot.

- *Electrical*: Insulation resistance, wet leakage current.

- *Performance*: Pmax at STC, temperature coefficients, NOCT, Pmax at low irradiance.

-*Thermal*: Bypass diode test, hot spot.

-*Irradiance*: Outdoor exposure, UV exposure, light soaking.

-*Environmental*: Temperature cycles, humidity freeze, damp heat.

-*Mechanical:* Mechanical load, robustness of terminations, hail impact.

IEC 61730 mainly focuses on the particular requirements for construction and is to be used in connection with IEC 61215 or IEC 61646. It is an important standard which complements the previous ones, with additional tests to be performed during the initial type testing.

IEC 61730 Parts 1 and 2 describe the fundamental construction requirements for photovoltaic modules in order to provide safe electrical and mechanical operation during their expected lifetime. Specific topics are mentioned to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses.

Three application classes for PV modules, A, B and C, are defined in this standard, with the appropriate requirements and testing for each Class. Modules rated for use in Application Class A are intended for systems operating at greater than 50 V DC or 240 W, where general contact access is anticipated, and is obviously the application class required by BIPV products. Modules qualified within this application class are considered to meet the requirements for safety class II, which is a characteristic of major importance regarding the safety requirements of the electrical installation of a PV system.

The additional tests of IEC 61730 Part 2 include electrical shock hazard tests (accessibility test, cut susceptibility test, ground continuity test, impulse voltage test, dielectric withstand test), fire hazard tests (temperature tests, fire test, reverse current overload tests), mechanical stress tests (module breakage tests) and component tests (partial discharge test, conduit bending, terminal box knock out test).

The purpose of the module breakage test is to provide confidence that cutting or piercing injuries can be minimized if the module is broken.

The purpose of the fire test is to establish the fundamental fire resistance of PV modules serving either as roof covering materials or mounted over an existing roof, indicating their fire resistance characteristics when exposed to a fire originating from outside the building. A minimum fire resistance rating of Class C (fundamental fire resistance) is necessary for any building-mounted module.

This test specifies fundamental requirements and may not be sufficient to satisfy the requirements for a module intended for building applications according to local or national building code requirements. Additional testing, beyond or in addition to this test, may be required. The test described in IEC 61730 is required as minimum safety qualification. For PV modules integrated in buildings, if any other requirements are not available, the following international standards give information for tests which could be used:

ISO 834-1, Fire resistance tests – Elements of building construction – Part 1: General requirements.

ISO 834-3, Fire resistance tests – Elements of building construction – Part 3: Commentary on test method and test data application

ISO 5657, Reaction to fire tests – Ignitability of building products using a radiant heat source

Regarding the electrical installation of a PV system, the international standards and harmonised documents should be followed (e.g. the parts of IEC 60364/HD 60364 Low voltage electrical installations, HD 60364-7-712 Electrical installations of buildings- Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems).

At the DC side of the electrical installation of a PV system, in Europe generally the practice is to leave the live conductors floating (unearthed system), unless there are special requirements due to the technology of the PV modules.

Due to the special electrical characteristics of the PV generator, a probable fault at the DC side of the system is not easy to trigger an automatic disconnection of supply, and may lead to hazardous situations. The electrical installation at the DC side is usually erected so that the probability of a short-circuit or ground fault is minimised. This is achieved by the use of safety class II equipment (double insulation) and installation practices that result to safety class II or equivalent. A prerequisite for this is the use of PV modules of safety class II.

From the European standards, there is not a clear requirement for grounding the metallic parts of the PV modules. In some cases, for unearthed systems with safety class II modules and inverters with galvanic separation (e.g. including transformer), it may be possible to leave the metallic parts unearthed. However grounding of metallic parts may be required by local codes, and generally it is a good practice for safety reasons.

4.2 European Standards applicable to BIPV products as Construction Products

As stated in the DoW of BFIRST project, the objective of this section is to elaborate a list of required tests for the BIPV products, as construction products, to be developed and demonstrated during the project:

1. Ventilated façade
2. Curtain wall
3. Skylight
4. Roofing shingles
5. Shading element

Testing must include, in principle, photovoltaic and construction standards. Photovoltaic standards evaluate products performance by considering them as photovoltaic modules, while construction standards focus on the elements as construction elements to be incorporated into buildings. PV standards have been analysed in subsection 4.1.

A new standard focused on BIPV products is currently being developed by CEN. If this standard is approved within the project development period, additional requirements therein will be taken into account for BFIRST products development and testing.

4.2.1 European standards for facades

Product 1 of BFIRST project concerns a ventilated façade panel, a multifunctional hybrid element, PV and thermal, proposed as a substitute for a conventional façade cladding.

For this type of applications the European Organisation for Technical Approvals EOTA has issued an ETAG, containing all the information required for the CE-marking of such products.

Standard	Title
ETAG 034 Part 1:May 2011	ETAG of kits for external wall claddings Part 1- Ventilated cladding kits comprising cladding components and associated fixings
ETAG 034 Part2:May 2011	ETAG of kits for external wall claddings Part 2- Cladding kits comprising cladding components, associated fixings, subframe and possible insulation layer

The Guideline sets out the performance requirements for cladding kits for use as external wall claddings, the verification methods used to examine the various aspects of performance, the assessment criteria used to judge the performance for the intended use and the presumed conditions for the design and execution.

This guideline covers kits for vertical exterior wall claddings consisting of an external cladding, mechanically fastened to a framework (specific to the kit or not), which is fixed to the external wall of new or existing buildings (retrofit). An insulation layer is usually fixed on the external wall.

This guideline does not cover external wall cladding kits where the cladding is:

- Made of self-supporting double skin faced insulating panels according to EN 14509 (sandwich panels),

- Made of composite panels not covered by ETAG 016 or for which an assessment method is not specified in ETAG 016 nor in a related specific TR,

- Made with a render sprayed in situ on metal mesh,

- Made of panels covered by a render applied in situ.

This guideline does not cover cladding kits where the cladding is bonded directly to the subframe.

This guideline does not cover curtain walls which are covered by EN 13830.

This guideline does not cover external wall cladding made of glass and agglomerated stone.

These products can be covered by CUAPs based on this guide with additional requirements.

This guideline does not deal with external cladding in contact with the ground.

Part I of the guideline covers only the external claddings and associated mechanical fixings intended to be used with a ventilated air space. Forming the kit are the cladding elements and their fixing devices (which fasten the cladding elements to the framework).

External wall claddings are considered as ventilated when the following criteria are fulfilled:

· The distance between the cladding elements and the insulation layer or the substrate accordingly (ventilation air space) amounts to at least 20 mm. This air space may be reduced locally to 5 to 10 mm depending on the cladding and the subframe, provided that it is verified that it does not affect the draining and/or ventilation function,

· Ventilation openings are envisaged, as a minimum, at the building base point and at the roof edge with cross-sections of at least 50 cm^2 per linear meter.

Part II of the guideline covers the kit of all the components of claddings (external cladding element and their fixing devices, the subframe and their fixings to an external wall, and any insulation layer) intended to be used with an air space, ventilated or not.

The requirements and product characteristics which have to be assessed are shown in the following Table.

Essential requirement	Product requirement or characteristic to be assessed	Comments
Mechanical resistance and Stability	-	Mechanical resistance and stability requirements are dealt under Safety in use

Essential requirement	Product requirement or characteristic to be assessed	Comments
Safety in the case of fire	Reaction to fire	
Hygiene, health and the environment	Protection against driving rain Drainability Water permeability Water vapour permeability Content and/or release of dangerous substances	Indoor environment dampness Water and Water vapour permeability not applicable to kits with ventilated air space Outdoor environment
Safety in use	Effect of intrinsic weight Impact resistance Shatter properties Horizontal point loads Effect of wind loads Effect of seismic actions Behaviour under hygrothermal variations	
Protection against noise	Sound insulation	Relevant only for kits of Part 2 of ETAG
Energy economy and heat retention	Thermal conductivity/resistance	Relevant only for kits of Part 2 of ETAG
Sustainable use of natural resources	Fatigue Dimensional stability Freeze-thaw chemicals and biological resistance corrosion UV radiation	

A ventilated facade is an external wall whose envelope is made of different layers installed in dry conditions, having only the role of protecting the building from the weather. The facade is mechanically tight to the building. The inner layer is spaced apart from the behind wall where insolating materials, not hydrophillic in nature, are been used. The function of this layer is to provide a thermal barrier so to avoid thermal bridges.

Ventilated wall system is a complex, multi-layer structural solution that enables "dry" installation of the covering elements and together with porcelain tile, guarantee considerably better appearance and performance standards than those obtained using traditional building materials.

These systems can also be used to create complete thermal insulation by wrapping and protecting the building in a "coat", without any of the disadvantages (being exposed to atmospheric agents, having to support the covering and the insulating material's lack of aeration).

The resulting total energy behaviour minimizes dispersion and promotes thermal balance by reducing energy requirements to a minimum.

Protection from Water
The external facing, separated from the building walls, "takes away" from the walls both the heat from solar radiation and the rainwater, thus avoiding direct contact with the perimeter wall and eliminating one of the main causes of building deterioration. Even when open joints are used, the quantity of water that is able to reach the insulation is minimal with respect to the total amount. Studies conducted in Germany have shown that the amount of water able to penetrate into the ventilated air gap and reach the insulating layer is a negligible percentage.

Breatheability
Compared to traditional cladding systems, the ventilated facade ensures a significant improvement in the dispersion of water vapour present inside the walls, with clear benefits for the preservation of the walls themselves. The natural ventilation in the air gap, in fact, helps remove the moisture present in the walls of both new and renovated structures. Even the water vapour produced inside the building can in part come out through the wall without particular barriers, leading to greater preservation of both the perimeter wall and the insulating layer.

Soundproofing
The layered construction, typical of the ventilated wall, along with the use of soundproofing materials, ensures better sound insulation. In fact, the external facing, the air gap, and the insulating layer work as further protective barriers towards noise coming from the outside.

Thermal Insulation
The ventilated facade system creates complete thermal insulation by entirely wrapping the building in a "coat", preventing heat dispersion and eliminating heat bridges, e.g the non homogeneous distribution of the surface temperatures which, in traditional walls, are normally created around beams and pillars. This prevents the formation of condensation and mould in the coldest areas. The continuous insulating layer positioned outside the building structure guarantees homogeneous thermal protection and an indoor temperature that is more constant over time. In addition, this system reduces the temperature ranges on the building walls, thus reducing structural movements due to the different expansion coefficients of the different materials composing the building.

Thermal Shock Resistance
The ventilated facade system is much more adaptable than traditional systems to thermal shocks caused by the outside temperatures and to the structural movements of the building. As the single slabs are anchored to the structural support independently, they can expand according to their own thermal expansion coefficient and adapt to the settling movements of

the building thanks to the elasticity of the anchorings. This prevents stress in the covering that can cause deterioration of the facade and require maintenance operations.

Highly Practical Installation and Maintenance
Since the installation is carried out "dry", it can be done independently of the atmospheric conditions, since these do not affect the quality of the facade. The maintenance of a ventilated facade is extremely limited and easier. Thanks to the excellent resistance of the slabs, the enclosure of the building does not require frequent restoration, and any damaged slabs can be easily removed and replaced. When equipped with technical hollow areas, this system also makes inspections easier. These areas act as housing of wiring and cabling inside the structure. The fact that the slabs can be replaced without carrying out works on the walls also makes it possible to change the facing completely when desired, thus changing only the exterior appearance of the building

4.2.2 Standards for curtain walls

Product 2 and 3 of BFIRST project are of similar construction, e.g. a double glazing system with an internal PV layer based on fibre-reinforced material. However, the two products are of different dimensions and intended for different applications, vertical curtain walls and skylights respectively. In the following, the requirements regarding curtain walls, which are considered as the basis for both products, are presented.

The relevant product standard to curtain walls is the EN 13830: 2003 ‘Curtain walling – Product standard’.

In general, the standard applies to curtain walling ranging from a vertical position to 15° from the vertical, onto the building face. This covers fire performance, weather tightness, wind loading, other applied loads, impact and thermal transmittance.

The performance characteristics which may be required for this family of products, considering product standard EN13830 and Building Regulations, are shown in the following Table, with relevant standards for the assessment of these characteristics.

Essential requirement	Performance characteristics	Comments
Mechanical resistance and stability	-	
Safety in the case of fire	Reaction to fire Fire resistance Fire propagation	Classification for reaction to fire: EN 13501-1 ,“Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests.”

Essential requirement	Performance characteristics	Comments
		Fire resistance tests: EN 1364-3 'Fire resistance tests for non-loadbearing elements. Curtain walling. Full configuration (complete assembly) ' EN 1364-4 'Fire resistance tests for non-loadbearing elements. Curtain walling. Part configuration'
Hygiene, health and the environment	Watertightness Air permeability	EN12154 'Curtain walling. Watertightness. Performance requirements and classification' EN12155 'Curtain walling. Watertightness. Laboratory test under static pressure' EN12152 'Curtain walling. Air permeability. Performance requirements and classification' EN12153 'Curtain walling - Air permeability - Test method'
Safety in use	Effect of intrinsic weight Impact resistance Horizontal point loads Effect of wind loads Effect of seismic actions Snow load (for sloping portions of wall)	Impact resistance EN14019 'Curtain walling. Impact resistance. Performance requirements' Wind load EN12179 'Curtain walling - resistance to wind load - test method' EN13116 'Curtain walling. Resistance to wind load. Performance requirements'
Protection against noise	Direct Airborne Sound insulation Flanking sound transmission	EN ISO 717-1 'Acoustics -- Rating of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation' EN ISO 717-2 'Acoustics -- Rating of sound insulation in buildings and of building elements -- Part 2: Impact sound insulation'
Energy economy and heat retention	Thermal transmittance	EN ISO 10077-2:2012 'Thermal performance of windows, doors and shutters -- Calculation of thermal transmittance -- Part 2: Numerical method for frames' EN 13947:2006 'Thermal performance of curtain walling. Calculation of thermal

Essential requirement	Performance characteristics	Comments
		transmittance’
Sustainable use of natural resources	Durability	

A curtain wall system is an external wall of a building, whose function is non-structural, but merely withstand the weather effects. The main difference between a curtain wall and a generic side wall is how the element is related with the building structure. The curtain wall performs all the functions of a side wall but not withstand vertical loads transmitted by the ceilings. The curtain wall itself is supported by the building.

As the curtain wall is non-structural and does not carry any dead load weight from the building other than its own dead load weight it can be made of a lightweight material reducing construction costs.

A curtain wall is designed to resist air and water infiltration, sway induced by wind and seismic forces acting on the building, and its own dead load weight forces.

In any case the mechanical characteristics of a curtain wall should be well designed.

One of these parameters is safety in use. The action of wind, impacts, earthquake, its own weight has to be taken into account. The safety requirements should be of general meaning air tightness, wind resistance and water tightness.

Loads

The loads imposed on the curtain wall are transferred to the building structure through the anchors which attach the mullions to the building. The building structure design must account for these loads.

Dead load

Dead load is defined as the weight of structural elements and the permanent features on the structure.
In the case of curtain walls, this load is made up of the weight of the mullions, anchors and other structural components of the curtain wall, as well as the weight of the infill material. Additional dead loads imposed on the curtain wall, such as sunshades, must be accounted for in the design of the curtain wall components and anchors.

Wind load

Wind load acting on the building is the result of wind blowing on the building. This wind pressure must be resisted by the curtain wall system since it envelops and protects the building. Wind loads vary greatly throughout the world, with the largest wind loads being near the coast in hurricane-prone regions.

For each project location, building codes specify the required design wind loads. Often, a wind tunnel study is performed on large or unusually shaped buildings. A scale model of the building and the surrounding vicinity is built and placed in a wind tunnel to determine the wind pressures acting on the structure in question. These studies take into account vortex shedding around corners and the effects of surrounding area

Seismic load

Seismic loads need to be addressed in the design of curtain wall components and anchors. In most situations, the curtain wall is able to naturally withstand seismic and wind induced building sway because of the space provided between the glazing infill and the mullion. In tests, standard curtain wall systems are able to withstand three inches (75 mm) of relative floor movement without glass breakage or water leakage.
Anchor design needs to be reviewed, however, since a large floor-to-floor displacement can place high forces on anchors. (Additional structure must be provided within the primary structure of the building to resist seismic forces from the building itself.)

Snow load

Snow loads and live loads are not typically an issue in curtain walls, since curtain walls are designed to be vertical or slightly inclined. If the slope of a wall exceeds 20 degrees or so, these loads may need to be considered.

Thermal load

Thermal loads are induced in a curtain wall system because aluminum has a relatively high coefficient of thermal expansion. This means that over the span of a couple of floors, the curtain wall will expand and contract some distance, relative to its length and the temperature differential. This expansion and contraction is accounted for by cutting horizontal mullions slightly short and allowing a space between the horizontal and vertical mullions. In unitized curtain wall, a gap is left between units, which is sealed from air and water penetration by wiper gaskets. Vertically, anchors carrying wind load only (not dead load) are slotted to account for movement. Incidentally, this slot also accounts for live load deflection and creep in the floor slabs of the building structure.

Blast load
Accidental explosions and terrorist threats have brought on increased concern for the fragility of a curtain wall system in relation to blast loads. Since the curtain wall is at the exterior of the building, it becomes the first line of defense in a bomb attack. As such, blast resistant curtain walls must be designed to withstand such forces without compromising the interior of the building to protect its occupants. Since blast loads are very high loads with short

durations, the curtain wall response should be analyzed in a dynamic load analysis, with full-scale mock-up testing performed prior to design completion and installation.

Air Infiltration
Air infiltration is the air which passes through the curtain wall from the exterior to the interior of the building. The air is infiltrated through the gaskets, through imperfect joinery between the horizontal and vertical mullions, through weep holes, and through imperfect sealing.

Water Penetration

Water penetration is defined as water passing from the exterior of the building through to the interior of the curtain wall system. Sometimes, depending on the building specifications, a small amount of controlled water on the interior is deemed acceptable. Controlled water penetration is defined as water that penetrates beyond the inner most vertical plane of the test specimen, but has a designed means of drainage back to the exterior. To test the ability of a curtain wall to withstand water penetration in the field, an ASTM E1105 water spray rack system is placed on the exterior side of the test specimen, and a positive air pressure difference is applied to the system. This set up simulates a wind driven rain event on the curtain wall to check for field performance of the product and of the installation. Field quality control and assurance checks for water penetration has become the norm as builders and installers apply such quality programs to help reduce the number of water damage litigation suits against their work.

Deflection
One of the disadvantages of using aluminum for mullions is that its modulus of elasticity is about one-third that of steel. This translates to three times more deflection in an aluminum mullion compared to the same steel section under a given a load. Building specifications set deflection limits for perpendicular (wind-induced) and in-plane (dead load-induced) deflections.It is important to note that these deflection limits are not imposed due to strength capacities of the mullions. Rather, they are designed to limit deflection of the glass (which may break under excessive deflection), and to ensure that the glass does not come out of its pocket in the mullion. Deflection limits are also necessary to control movement at the interior of the curtain wall. Building construction may be such that there is a wall located near the mullion, and excessive deflection can cause the mullion to contact the wall and cause damage.

Also, if deflection of a wall is quite noticeable, public perception may raise undue concern that the wall is not strong enough. Deflection limits are typically expressed as the distance between anchor points divided by a constant number. However, some panels require stricter movement restrictions, or certainly those that prohibit a torque-like motion. Deflection in mullions is controlled by different shapes and depths of curtain wall members. The depth of a given curtain wall system is usually controlled by the area moment of inertia required to keep deflection limits under the specification. Another way to limit deflections in a given section is to add steel reinforcement to the inside tube of the mullion. Since steel deflects at 1/3 the rate of aluminum, the steel will resist much of the load at a lower cost or smaller depth.

Strength

Strength (or maximum usable stress) available to a particular material is not related to its material stiffness (the material property governing deflection); it is a separate criterion in curtain wall design and analysis. This often affects the selection of materials and sizes for design of the system. For instance, a particular shape in aluminum will deflect almost three times as much as the same steel shape for an equivalent load (see above), though its strength (ie the maximum load it can sustain) may be equivalent or even slightly higher, depending on the grade of aluminum.

Because aluminum is often the material of choice, given its lower unit weight and better weathering capability as compared with steel, deflection is usually the governing criteria in curtain wall design.

Thermal criteria

Relative to other building components, aluminum has a high heat transfer coefficient, meaning that aluminum is a very good conductor of heat. This translates into high heat loss through aluminum curtain wall mullions. There are several ways to compensate for this heat loss, the most common way being the addition of thermal breaks. *Thermal breaks* are barriers between exterior metal and interior metal, usually made of polyvinyl chloride (PVC). There are several ways to compensate for this heat loss, the most common way being the Additions of thermal breaks. These breaks provide a significant decrease in the thermal conductivity of the curtain wall. However, since the thermal break interrupts the aluminum mullion, the overall moment of inertia of the mullion is reduced and must be accounted for in the structural analysis of the system.

Thermal conductivity of the curtain wall system is important because of heat loss through the wall, which affects the heating and cooling costs of the building. On a poorly performing curtain wall, condensation may form on the interior of the mullions. This could cause damage to adjacent interior trim and adjacent walls.

Rigid insulation is provided in spandrel areas to provide a higher R-value at these locations.

Fire safety

The curtain wall itself is not ordinarily required to have a rating on fire resistance. This causes a quandary, as compartmentalization (fire protection) is typically based upon closed compartments to avoid fire and smoke migrations beyond each engaged compartment. A curtain wall by its very nature prevents the completion of the compartment (or envelope). The use of fire sprinklers has been shown to mitigate this matter. As such, unless the building is sprinklered, fire may still travel up the curtain wall, causing flames to lick up the outside of the building. Falling pieces can endanger pedestrians or firefighters below. The fire can leapfrog up the building by shattering or consuming transparent components and then consuming the aluminum skeleton holding them. Aluminum's melting temperature is 660°C, whereas building fires can reach 1,100°C. The melting point of aluminium is typically reached within minutes of the start of a fire. The melting point of aluminium is typically

reached within minutes of the start of a fire. Firestops for such building joints can be qualified to UL 2079 -- Tests for Fire Resistance of Building Joint Systems. Sprinklering of each floor has a profoundly positive effect on the fire safety of buildings with curtain walls. Exceptionally sound cementitious spray fireproofing also helped to delay and ultimately to avoid the possible collapse of the building, due to having the structural steel skeleton of the building reach the critical temperature.

Maintenance and repair

Curtain walls and perimeter sealants require maintenance to maximize service life. Perimeter sealants, properly designed and installed, have a typical service life of 10 to 15 years. Removal and replacement of perimeter sealants require meticulous surface preparation and proper detailing.

Aluminium frames are generally painted or anodized. Factory applied fluoropolymer thermoset coatings have good resistance to environmental degradation and require only periodic cleaning.

Recoating with an air-dry fluoropolymer coating is possible but requires special surface preparation and is not as durable as the baked-on original coating.

Anodized aluminum frames can't be "re-anodized" in place, but can be cleaned and protected by proprietary clear coatings to improve appearance an durability.

Exposed glazing seals and gaskets require inspection and maintenance to minimize water penetration, and to limit exposure of frame seals and insulating glass seals to wetting.

4.2.3 Standards for skylights

The skylight product to be developed within BFIRST will be installed in the Spanish demonstration building. It will have the structure of a horizontal curtain wall and will be composed by a double glazing system with an internal PV layer based on fibre-reinforced material.

Horizontal curtain walling is not covered by curtain wall standard EN 13830:2003, "Curtain walling. Product standard", that considers only vertical envelopes. However, the usual practice is to test glass-based skylights as horizontal curtain walling in order to have a reference for performance values.

Applicable tests on curtain walls have been previously described for product 2.

The glazing structure of the projected skylight will presumably be as follows:

- An external toughened glass
- A fibre-reinforced composite material layer containing PV cells as middle layer
- An internal laminated glass

External and internal glass should in principle be toughened and laminated, respectively, in order to comply with Spanish regulations on safety and security. Mechanical requirements do not apply on the internal layer, as it is not accessible and it is not directly overhead.

External toughened layer must comply with compulsory CE marking following EN 12150-2: 2004, Erratum 2011 standard “Glass in building - Thermally toughened soda lime silicate safety glass - Part 2: Evaluation of conformity/Product standard”. CE marking of toughened glass is a responsibility of glass manufacturer, so these tests will not be performed within BFIRST.

Internal laminated glass must comply with compulsory CE marking following EN 14449:2005 “Glass in building - Laminated glass and laminated safety glass - Evaluation of conformity/Product standard”. As in the case of toughened glass, laminated CE marking is a responsibility of glass provider and not a competence of BFIRST project.

As a double glazing system, both the skylight (product 2) and the curtain wall (product 3) to be developed within BFIRST should be tested following EN 1279-5:2005+A2(2010) standard, at least as a reference. The standard does not explicitly specify if a double glazing index with a non-decorative insert falls within its scope, but we will take this standard as a reference, as the skylight must still comply with Constructions Product Directive essential requirements.

EN 1279-5 is a harmonised standard, which means that it contains the requirements for double glazing CE marking, including factory production control and initial type testing. We will assume that the double glazing unit is assembled by a manufacturer complying with factory production control and we will focus on initial type testing.

The following table compiles the tests to be performed on double glazing units, together with number of samples and dimensions needed.

Essential requirement	Test standard	Samples and dimensions	Comments
Safety in case of fire	UNE-EN 13501-1: 2007+ A1:2009,“Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests.” and tests included therein	Most probably testing not needed	It has been proposed by CEN that glass products are considered as “Not contributing to fire”, arguing that EN 13501-1 methodology is not adapted to glass properties. This would be applied by extending EC decision 96/603/EC, amended by EC Decision 2000/605/EC, to all glass products nowadays used in buildings. Insulating

Essential requirement	Test standard	Samples and dimensions	Comments
			glazing products would then be exempt from testing. Issue to be followed.
Protection against noise	EN 12758:2011,"Glass in building - Glazing and airborne sound insulation - Product descriptions and determination of properties."	--	Values from reference table, no testing needed.
Energy and heat conservation: thermal properties	UNE-EN 673: 2011, "Glass in building - Determination of thermal transmittance (U value) - Calculation method."	Calculation method	No samples required. Just some physical properties of glass and composite.
Energy and heat conservation: luminous and solar characteristics.	UNE-EN 410:2011 "Glass in building - Determination of luminous and solar characteristics of glazing."	- 1 sample of front glass (before toughening). - 1 sample of laminated glass - 1 sample of composite layer Dimensions depending on spectrophotometer (around 100x50 mm)	UNE-EN 410 does not include the case of an intermediate, light-diffusing sample. It will be taken only as a reference for optical properties determination.
(Durability)	UNE-EN 1279-2:2002 "Glass in building - Insulating glass units - Part 2: Long term test method and requirements for moisture	15 double glazing samples Glass panes and composite sheet: (502±2)mm x (352±2) mm x	Climatic chamber testing at different T and humidity conditions. Initial and final dew point and moisture content are measured.

Essential requirement	Test standard	Samples and dimensions	Comments
	penetration."	4mm Air gap: as closer as possible to 12 mm	
(Durability)	UNE-EN 1279-3:2002 "Glass in building - Insulating glass units - Part 3: Long term test method and requirements for gas leakage rate and for gas concentration tolerances."	At least 6 double glazing samples Glass panes and composite sheet: (502±2)mm x (352±2) mm x 4mm Air gap: as closer as possible to 12 mm	Only for gas-filled double glazing systems

Mechanical resistance and stability essential requirement must be guaranteed by a correct calculation of glazing dimensions, according to Eurocodes and National Building Codes.

4.2.4 Standards for shingles

Product 4 concerns a shingle, a roof covering element. Roofing shingles developed within BFIRST will be flat, lightweight and monolithic modules with embedded crystalline silicon cells. The composite panels will be designed and manufactured so that the fixing or joining elements are integrated within the panel, thus enabling a rapid and easy manipulation and assembly into the building. The shingles will be installed in the Belgian demonstration building.

In the case of tiles, testing standards are in general very closely related to tile material (clay, concrete, slate, etc.). So no standard has been found which can be applied a composite-based material.

For this study, most general characteristics that tile manufacturers usually declare for their products have been analysed, and the corresponding standards have been specified. But, as said before, none of these tests method can be directly applied to BFIRST shingles without further considerations.

For this type of products, relevant CEN standards under the Construction Products Directive, are under the responsibility of CEN/TC 128, within work programme entitled 'Roof covering products for discontinuous laying and products for wall cladding'.

A list of published standards can be found in the following link:

http://www.cen.eu/cen/Sectors/TechnicalCommitteesWorkshops/CENTechnicalCommittees/Pages/Standards.aspx?param=6110&title=CEN/TC%20128

For roof covering elements usually the performance characteristics regarding to wind loads, fire resistance to external fire, and weather tightness have to be assessed.

In the following Table the performance characteristics which may be assessed, in relation to the essential characteristics of the CPD, are presented, together with EN standards which may be relevant for the assessment of the product performance characteristics. Besides EN, which are also National Standards in CEN member states, some Technical Specifications (TS) and Technical Reports (TR) are presented.

Technical Specifications (TSs) can be used by CEN Technical Committees as a European Pre-Standard for innovative features of technology. They are also helpful in a case where various alternatives need to co-exist in anticipation of future harmonization. They are not full European Standards and so they do not require the withdrawal of any conflicting National Standards.

Technical Reports (TRs) are documents produced within a CEN Technical Committee that provide background information, for example on how to implement standards in specific cases.

Essential requirement	Product requirement or characteristic to be assessed	Comments
Mechanical resistance and stability	Resistance to wind uplift Flexural strength Frost resistance	EN 14437:2004, "Determination of the uplift resistance of installed clay or concrete tiles for roofing - Roof system test method.**"** CEN/TS 15087:2005 "Determination of the uplift resistance of installed clay and concrete interlocking tiles for roofing – Test method for mechanical fasteners." EN 538:1995, "Clay roofing tiles for discontinuous laying - Flexural strength test."

Essential requirement	Product requirement or characteristic to be assessed	Comments
		EN 539-2:2006/AC:2008, "Clay roofing tiles for discontinuous laying - Determination of physical characteristics.- Part 2: Test for frost resistance."
Safety in the case of fire	Fire Resistance	EN 13501-5:2005 'Fire classification of construction products and building elements - Part 5: Classification using data from external fire exposure to roofs tests' CEN/TS 1187:2012 – Test methods for external fire exposure to roofs
Hygiene, health and the environment	Weathertightness	EN 539-1:2005: "Clay roofing tiles for discontinuous laying - Determination of physical characteristics - Part 1: Impermeability test." CEN/TR 15601:2012 Hygrothermal performance of buildings - Resistance to wind - driven rain of roof coverings with discontinuously laid small elements - Test methods
Safety in use		
Protection against noise		
Energy economy and heat retention		EN ISO 6946:2007, **"**Building components and building elements - Thermal resistance and thermal transmittance - Calculation method."
Sustainable use of natural resources		

Further considerations:

- EN 14437 has been developed for clay or concrete tiles for roofing but may apply to other discontinuously laid small elements. 16 samples needed and any damaged tile should be replaced during the tests. Testing consists in applying a determined force

on the samples and measuring the corresponding displacements of the tiles, failure of fixings, or breakage. In case of mechanically fixed tiles, at least every third tile shall be fixed. The test method is not applicable to curved surfaces.

- Following EN 538, 10 samples of tiles must be prepared for testing. Every tile, resting on two lateral support structures, is subjected to a central load up to breakage and the corresponding applied forced is registered.

- EN 539-1 includes two alternative methods for permeability measurement. Test 1 determines the amount of water filtered by every cm^2 of tile in 48 hours, for a constant 10 cm water load. Testing equipment includes a recipient, a graduated, water containing cylinder and another cylinder for the control of evaporation rates. Test 2 measures the time for the first water droplet transmitted through the tile sample to fall onto a control surface. In this case a waterproof frame is constructed on the tile and filled with water. 10 samples must be tested in every test procedure.

- In EN 539-2 five different testing procedures are proposed, but only one is said to be applicable in all CEN member countries. Every country states its minimum performances through national regulation. In this test, 8 samples are progressively immersed in water during 7 days, then their back surface is covered with a wet fabric, and finally they are introduced in a refrigerating chamber where frost-defrost cycles are applied. Samples are frosted with air and defrosted with water on all their surfaces. Damage occurred during the test is registered.

Durability testing for BFIRST roofing shingles should complementarily rely on PV standards, described in section 4.1.

Mechanical resistance and stability essential requirement should be guaranteed by a correct dimensioning of the elements, according to Eurocodes and National Building Codes.

4.2.5 Standards for shading elements

The photovoltaic shading element to be developed within BFIRST project will be installed in the Greek demonstration building. It will be a monolithic PV module made of fibre-reinforced composite material with embedded crystalline silicon cells installed outside the windows with a certain slope in order to provide solar control to the building as well as an optimal PV production.

There is no specific standard for such a PV shading element. Following EN 12216:2002, “Shutters, external blinds, internal blinds - Terminology, glossary and definitions” standard, these elements could be considered as a “solar screen”, defined in the standard as a “product located externally, arranged horizontally, vertically or sloping. It can be fixed or adjustable, and provides shading only”. This definition refers to the element only as a construction product, but its PV characteristics will be evaluated by other means (see chapter 5.3).

EN 13561:2004+A1:2008, “External blinds - Performance requirements including safety” standard refers mainly to external fabric awnings, but includes also solar screens. However,

most requirements and tests methods are not applicable on these. As an example, the standard explicitly states that it does not cover wind resistance for solar screens, as no test method is currently available.

The following table on requirements and test methods could be taken as a reference:

Essential requirement	Test method	Samples and dimensions	Comments
Safety in use: snow load	Calculation following Structural Eurocodes	--	Performance levels fixed by corresponding national regulations
Safety in use: potentially hurting elements	--	--	Accessible elements must be rounded with a minimum radius of 0.5mm.
Energy and heat retention: thermal resistance	Calculation following EN ISO 10077-1: 2006, "Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 1."	--	In principle, standard applicable for vertical elements. It will be taken as a reference.
Energy and heat retention: luminous and solar properties	Calculation following EN 13363-1:2003+A1:2008, "Solar protection devices combined with glazing - Calculation of solar and light transmittance - Part 1: Simplified method" And/or EN 13363-2:2005, "Solar protection devices combined with glazing - Calculation of total solar energy transmittance and light transmittance - Part 2: Detailed calculation	--	Simplified and detailed method for calculation of luminous and solar characteristics

Essential requirement	Test method	Samples and dimensions	Comments
	method”		
(Durability) • Colour instability • Aspect degradation • Breakage resistance • Corrosion resistance • Dimensional stability • Water penetration	--	--	EN 13561 refers mainly to standards for textiles. We suggest that PV standards are used to determine durability.

Thermal and visual comfort can be evaluated by means of EN 14500:2008, “Blinds and shutters - Thermal and visual comfort - Test and calculation methods” and EN 14501:2005, “Blinds and shutters - Thermal and visual comfort - Performance characteristics and classification”. It must be taken into account that some of the included characteristics are not applicable if the solar screen is not parallel to the glazing.

If reaction to fire properties were to be determined by requirement of national regulations, dispositions included in EN 13501-1:2007+A1:2009 would have to be considered.

Conclusions

1. BIPV elements are affected by European Directives for Construction Products, Low Voltage and Electromagnetic Compatibility.

2. Electrotechnical standards for PV products have been defined and described.

3. Construction products must comply with harmonized standards where available, or the corresponding alternatives allowed by Construction Products Directive.

4. Harmonized standards define for every product the corresponding tests to comply with every essential requirement established by CPD.

5. In the case of composite material-based construction products, most current tests standards are not directly applicable, but they will be taken as a reference for product testing.

6. A specific standard for BIPV products is currently being developed and will be taken into account in further stages of the project.

7. Further requirements on construction products are given by the national building codes of every country. Deliverable 1.2 must be taken into consideration together with the present one in order to consider the whole regulation framework for BIPV products.

Acknowledgements

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Appendix A:

Applicable Standards for facade

NTC 2008, Norme Tecniche per le Costruzioni January 2008 the 14th, - UNI EN 1999-1-1, Eurocodice 9, Progettazione delle strutture di alluminio, Parte 1-1: Regole strutturali generali; - UNI EN 01/01/1999, Eurocode 9, Design of aluminum structures, Part 1-1: General structural rules;
- UNI EN 13830 – Facciate continue – Norma di prodotto (norma armonizzata - UNI EN 13830 - Curtain - Product standard (harmonized standard).
List of applicable Standards

EN 410: Glass in building- Determination of luminous and solar characteristics of glazing

EN 572-9 Glass in building- basic soda lime silicate glass products-Part 9: Evaluation of conformity/Product standard

EN 673 Glass in building- determination of thermal transmittance (U-value)- Calculation method

EN 674 Glass in building-determination of thermal transmittance (U-value)- Guarded hot plate method

EN 675 Glass in building-determination of thermal transmittance (U-value)- Heat flow meter method

EN 1096-4 Glass in building-Coated glass- Part 4: Evaluation of conformity/Product standard

EN 1279-1: Glass in Building-Insulated glass units- Part 1: Generalities, dimensional tolerances and rules for the system description

EN 1279-2: Glass in Building-Insulated glass units- Part 2: Long term test method and requirements for moisture penetration

EN 1279-3: Glass in Building-Insulated glass units- Part 3: Long term test method and requirements for gas leakage rate and for gas concentration tolerances

EN 1279-4: Glass in Building-Insulated glass units- Part 4: Methods of test for the physical attributes of edge seals

EN 1279-5: Glass in Building-Insulated glass units- Part 5: Evaluation of conformity

EN 1863-2: Glass in building –Heat strengthened soda lime silicate glass –Part 2 Evaluation of conformity/Product standard

EN 1990: Eurocode: basis of structural design

EN 1991: Eurocode 1: Actions on structures – Part 1-4: general actions - Wind actions

EN 1993: Eurocode 3: Design of steel structures

EN 1999: Eurocode 9. Design of aluminium structures

EN 6946: Building components and building elements – Thermal resistance and thermal transmittance- Calculation method

EN 12150-2: Glass in building – Thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

En 12179: Curtain walling- Resistance to wind load –Test method

prEN 12488: Glass in building- Glazing requirements-Assembly rules

EN ISO 12543-1: Glass in building- Laminated glass and laminated safety glass- Part 1: Definitions and description of component parts

EN ISO 12543-2: Glass in building- Laminated glass and laminated safety glass- Part 2: Laminated safety glass

EN ISO 12543-3: Glass in building- Laminated glass and laminated safety glass- Part 3: Laminated glass

EN ISO 12543-4 Glass in building- Laminated glass and laminated safety glass- Part 4: Test methods for durability

EN ISO 12543-5: Glass in building- Laminated glass and laminated safety glass- Part 5: Dimensions and edge finish

EN ISO 12543-6: Glass in building- Laminated glass and laminated safety glass- Part 6: Appearance

EN 12600: Glass in building- Pendulum tests – Impact test method and classification for flat glass

EN 12758: Glass in building- Glazing and airborne sound insulation

EN 13022: Glass in building – Structural sealant glazing

EN 13116: Curtain walling- Resistance to wind load- Performance requirements

EN 13119: Curtain walling- Terminology

EN 13363-1: Solar protection devices combined with glazing- Calculation of total solar energy transmittance and light transmittance- Part 1: Simplified method

EN 13363-2: Solar protection devices combined with glazing- Calculation of total solar energy transmittance and light transmittance- Part 2: Detailed calculation method

EN 13501-1: Fire classification of construction products and building elements- Part 1: Classification using data from reaction to fire tests

EN 13501-5: Fire classification of construction products and building elements- Part 5: Classification using data from external fire exposure to roofs tests

EN 13830: Curtain walling –Product standard

EN 13947: Thermal performance of curtain walling- Calculation of thermal transmittance

EN 13956: Flexible sheet for waterproofing –Plastic and rubber sheets for roof waterproofing- Definitions and characteristics

EN 14179: glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 2: Evaluation of conformity/Product standard

EN 14351-1: windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics

prEN ISO 14439: Glass in building – Glazing requirements- Use of glazing blocks

EN 14449: Glass in buiding: Laminated glass and laminated safety glass- Evaluation of conformity/Product standard

EN 14500. Blinds and shutters – Thermal and visual comfort – Test and calculation methods

EN 14782: Self-supporting metal sheet for roofing, external cladding and internal lining- Product Specification and requirements

EN 14783- Fully supported metal sheet and strip for roofing, external cladding and internal lining - Product Specification and requirements

prEN 15601:2006 Hygrothermal performance of buildings- Resistance to wind-driven rain of roof coverings with discontinuously laid small elements- Test method

EN 50380: datasheet and nameplate information for photovoltaic modules

IEC 60364. Low voltage installations- Part 7-712. Requirements for special installations or locations –Solar Photovoltaic (PV) power supply system

IEC 61215: Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval

IEC 61646: Thin film terrestrial photovoltaic (PV) modules – Design qualification and type approval

IEC 61730-1: Photovoltaic module safety qualification- Part 1. Requirements for construction

IEC 61730-2: Photovoltaic module safety qualification- Part 2. Requirements for testing

IEC 61836: Solar Photovoltaic energy systems – Terms, definitions, symbols

IEC 62446: Grid connected photovoltaic systems- Minimum system documentation, commissioning tests and inspection requirements

ETAG 002: Guideline for European Technical Approval for Structural Sealant Glazing Systems- SSGS

ETAG 006: Guideline for European Technical Approval of Systems of Mechanical Fastened Flexible Waterproofing Memebranes