C2/115
Homologation procedure for prefabricated enclosures of HV substations according to the technical prescription C2/112

Part 3
Technical specification for homologation

(edition 3 - 12.2024)

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Versioning

04.2021	First edition
12.2021 V1.1	There has been an update to make some corrections, mostly without any impact on the composition of the homologation file. and mainly concern the following aspects: - distinction between substations suitable for global and those suitable for non-global earthing, and simplification for substations suitable for global earthing. (§6.5.2, §6.14.1 and .2, and the test conditions in §7.5). The test method for substations in non-global earthing (§9.2) are still under revision due to the most recent publishing of the AREI/RGIE. - clarification of the minimum dimensions of the door opening and no longer an obligation to use at least 3 hinges (§6.8.1) - slight change in the position of the ventilation openings (§6.8.2) - basement: clarification that the required height is the free height (§6.10) - execution of the mechanical test: clarification of the test conditions and execution (§7.4) - more detailed explanation about what is expected in the calculation notes (§8.1) - addition of an annex C5 for enclosure with partition walls The changes are also included in a limited update ed 1.1 of the xlsx checklist C2/115-3 (indicated with blue background and/or blue text).
02.2022 V1.2	The main goal of this update is to allow the (re)homologation of a larger range of enclosures by adding new tables in annex C (construction requirements for the enclosure). The changes mainly concern: - adding annexes C2, C3, C4 et C6 (sections 9.3.2-9.3.3-9.3.4 et 9.3.6) - adding chapter 9.2 which includes the test method to be carried out on the walls of the enclosure for a non-global earthing system. - Deletion of the last sentence of section 6.8.3 related to the requirement of a specific cable entry for earthing
05.2023 V2	- Slight adaptations and corrections in the body text of the document. - Determining the minimum required characteristics for the depth of the cellar - Adapted references to the AREI/RGIE - Corrections of the tables in chapter 9.3
09.2024 V3	- Adding the European regulation CE (EU) 2019/1783 concerning transformers in the list of reference documents - The removing of the paragraphs §5.6 and §5.7 - Adaptation of the text in §6.6, §6.10, - Adaptation of the treatment of the surfaces mentioned in §6.13.2, §6.13.3, §6.13.4 & §7.2 - Replaced class “AA31 with downwards gas exhaust “ by class “AA30” (conform the document C2/113-7) - § 9.3.8: added class AA13 - correcting the references to the NBN EN 62271-202

1 Object and scope

This technical specification defines the functional and technical characteristics with which the enclosures of **concrete prefabricated** electric substations connected to high-voltage networks of the public grid must comply to be homologated by Synergrid and included on the C2/115-0 list with homologated prefabricated enclosures.

The document is applicable to both walk-in enclosures (where service areas are located inside the enclosure) and non-walk-in enclosures (where service areas are located outside the enclosures).

Metallic and plastic enclosures are not in the scope of this document.

2 Reference documents

2.1 General provisions

The latest edition of the regulations, standards and technical specifications in paragraphs 2.2 and 2.3 below (non-exhaustive list), including any addenda, are intended as reference documents and will apply provided that they do not contradict the criteria set out in this specification. In the event of a contradiction, application of the part of the corresponding standard is superseded by the requirements of this specification (the rest of the standard remains fully applicable however).

2.2 Rules and regulations

Reference	Title
RGIE-AREI	Royal Decree of 28/03/2023 establishing the Book 1 on low voltage electrical installations and very low voltage, Book 2 on high voltage electrical installations and Book 3 on facilities for the transport and distribution of electrical energy, including all annexes.
Belgian Law of 4 August 1996	Well-being at Work Code
RGPT-ARAB-CODEX	(Règlement Général pour la Protection du Travail Algemeen Reglement voor de Arbeidsbescherming)
Code of Economic Law	Book IX: "Product and service safety"
Synergrid technical prescription C2/112 and its annexes	Technical prescriptions regarding connection to the high-voltage distribution network
Synergrid technical specifications C2/113-1/2/3/4/6/7	Procedure for the classification and homologation of HV switchgear
CR (EU) 2019/1783	Commission Regulation (EU) 2019/1783 of 1 October 2019 amending Regulation (EU) No 548/2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers

2.3 Standards

Where they exist and are set out, NBN, CENELEC, IEC and ISO standards apply.

If other test methods are used, the manufacturer must demonstrate their equivalence with the corresponding methods under the NBN, CENELEC, IEC and ISO standards.

2.3.1 Standards for electrical equipment used in electrical enclosures

Reference	Title
NBN EN 60364-4-41	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock
NBN EN 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules
NBN EN 50110-1	Operation of electrical installations Part 1: General requirements
NBN EN 50110-2	Operation of electrical installations Part 2: National appendices
NBN EN 50588	Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV Part 1: General requirements
NBN EN 60076-1	Power transformers – part 1: General
NBN EN 60076-11	Power transformers – part 11: Dry-type transformers

NBN EN 62271-202	High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation
NBN EN 60050	International Electrotechnical Vocabulary
NBN EN 62271-1	High-voltage switchgear and controlgear – Part 1: Common specifications
NBN EN 62271-100	High-voltage switchgear and controlgear - Part 100: Alternating-current circuit-breakers
NBN EN 62271-102	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches
NBN EN 62271-103	High-voltage switchgear and controlgear - Part 103: Switches for rated voltages above 1 kV up to and including 52 kV
NBN EN 62271-105	High-voltage switchgear and controlgear - Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV
NBN EN 62271-200	High-voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

2.3.2 Construction standards

Reference	Title
NBN EN 206 2014 +A1 2016	Concrete: Specification, performance, production and conformity
NBN B 15-001	Addendum to NBN EN 206 2014+A12016 – Cement – specifications, performance, production and conformity
NBN EN 13369	Common rules for precast concrete products
NBN EN 1990 and NBN ENV 1991	Eurocode 0 – Basis of structural design
NBN EN 1991 and NBN ENV 1991	Eurocode 1 - Actions on structures
NBN EN 1992 and NBN ENV 1992	Eurocode 2 - Design of concrete structures

2.3.3 Miscellaneous standards

Reference	Title
NBN EN 60529	Degrees of protection provided by enclosures (Code IP)
NBN EN 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
NBN EN ISO 12944-6	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Laboratory performance test methods
NBN EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
NBN EN ISO 9001	Quality management systems. Requirements
NBN EN ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories

3 Definitions

3.1 General definition

All terms used in this specification are defined in NBN EN 60050 "International Electrotechnical Vocabulary"

3.2 Terminology used in this specification

Terms	Definitions
Enclosure	Part of a prefabricated substation providing protection against external influences on the substation and a specified degree of protection for operators and the general public with respect to approach to, or contact with, live parts and against contact with moving parts.
Walk-in enclosure	A walk-in enclosure is an enclosure where the operator is able to enter in the switching room in order to operate the HV switchgear or LV switchboard
Non-walk-in enclosure	A non-walk-in enclosure is an enclosure where the operator is not able to enter in the switching room and must operate the HV switchgear or LV switchboard from outside of the enclosure.
Switching room	The switching room is a physically closed space where the HV switchgear or LV switchboard is installed and accessible to the operator.
LV	Low Voltage
FU	Functional unit: part of a metal-enclosed switchgear comprising all the equipment of the main circuits and auxiliary circuits that contribute to the performance of a single function
DSO	Distribution System Operator
DSU	Distribution System User
HV	High Voltage, i.e. High Voltage category 1 according to AREI/RGIE
LV Switchboard	Low Voltage Switchboard Energy distribution installation feeding a LV network
HV Switchgear	General term covering HV switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosure and supporting structures.

4 Normal and special service conditions

The enclosure must be designed and constructed in such a way that the service conditions inside shall correspond to the normal service conditions for indoor switchgear according to NBN EN 62271-1.

- Measures must be taken to limit the influence of solar radiation on the indoor ambient temperature.
- The average relative humidity must not exceed 95% over a 24-hour period and 90% over a one-month period.
- The average vapour pressure must not exceed 2.2 kPa over a 24-hour period and 1.8 kPa over a one-month period.

The enclosure shall be designed to withstand the normal service conditions for outdoor equipment according to NBN EN 62271-1 as follows:

- Ambient air temperature must remain between -25°C and +40°C, with a maximum average of +35°C over a 24-hour period (taking into account rapid temperature variations).
- Solar radiation: maximum 1000 W/m2.
- No exposure to excessive vibrations, shocks or tilting.
- Maximum altitude: 1000 m.
- Ambient air is not significantly polluted by dust, smoke and/or corrosive gases, vapours or salt and would be considered as having site pollution severity class (SPS) “very light” according to IEC TS 60815-1:2008.

In addition, low pollution P_L according to IEC TS 62271-304 can also apply outside the enclosure.

5 Rated characteristics

5.1 General rated characteristics

The justification of the building's resistance to various loads must be established in compliance with the aforementioned standards.

If, under the conditions described in chapter 4, condensation may occur, the enclosure must be designed in such a way as to prevent or reduce it as much as possible. Where condensation is unavoidable, its elimination must be guaranteed.

The structural safety, serviceability and durability of the entire construction must be guaranteed by compliance with standards NBN EN 206, NBN B 15-001, NBN EN 13369 and the Structural Eurocodes: the NBN series EN(V) 1990 to 1992.

In addition, for short-term stresses such as those mentioned above, it is also permissible to consider an increased factor of 1.3 in strength for reinforced concrete.

5.2 Degree of protection of enclosures

The degree of protection of the enclosure shall be in accordance with section 6.14 of NBN EN 62271-202 and C2/112. Therefore, the enclosure must be perfectly dry and waterproof and must remain so subsequently. The minimum degree of protection of the enclosure shall be IP23D in accordance with NBN EN 60529.

5.3 Protection of the prefabricated substation against mechanical stress

The protection against mechanical stress shall be in accordance with Eurocode 1 and C2/112. Additionally, section 6.101 of NBN EN 62271-202 applies.

In addition to the actions defined in the Eurocodes, the building is designed to withstand the following specific occurrences:

- Roof load: minimal overload of 250 daN/m2 on the roof (flat roof version to be taken into account for the calculation).
- For walk-in enclosures, a mobile overload due to the heaviest transformer the enclosure is designed for must be taken into account for the design of the floor slab, representing the movement of the equipment and the permanent loads of the equipment (see sections Construction requirements and Dimensions and encumbrances).
- Climatic loads as defined in Eurocode 1:
    - Minimum wind speed to be taken into account vb = 34 m/s following NBN EN 62271-1
    - Minimum characteristic snow load to be taken into account sk = 1 kN/m2.
- Ice layer: maximum 20 mm.
- Ice density is 920 kg/m^3.
- External mechanical impacts with an energy of 20 J corresponding to a degree of protection IK10 in accordance with NBN EN 62262.
- Overpressure inside the enclosure due to an internal arc (see subchapter 5.5).

5.4 Rated maximum power and class of enclosure

5.4.1 Rated maximum power of the prefabricated enclosure

There is no rated maximum power of the enclosure according to section 5.101.1 of NBN EN 62271-202.

Nevertheless, the manufacturer shall declare the maximum allowed power and losses of the transformer (as defined in NBN EN 60076-1, NBN EN 60076-11 or the CR (EU) 2019/1783) for which the enclosure is designed and check it according to subchapter 6.7 and 8.1.

5.4.2 Rated class of enclosure

There is no rated class of the enclosure according to NBN EN 62271-202.

Nevertheless, the enclosure class is mandatory and shall be checked according to subchapter 6.7 and 8.1

5.5 Internal arc withstand

According to the NBN EN 62271-202, an IAC classification will be given to the enclosure in regard to the hazards associated with an internal arc. This prescription deviates from the standard and will not attribute an IAC classification to the enclosure according to the NBN EN 62271-202.

This prescription will only focus on the withstand strength of the enclosure against the pressure rise inside in case of an internal arc. This will be discussed in detail in sections 6.6 and 9.3.

6 Design and construction

6.1 General requirements

As per NBN EN 62271-202 section 6.104:

- The degree of protection of the enclosure shall comply with subchapters 5.2 and 5.3
- The external walls of the enclosure shall meet the requirements of subchapters 6.13 and 6.14
- Rated class shall comply with sub chapter 6.7
- Internal arc withstand shall comply with sub chapter 6.6

6.2 Fire behaviour

The prefabricated substation shall comply with the requirements regarding fire behaviour of NBN EN 62271-202 section 6.104.2, as well as the AREI/RGIE law.

The materials listed as non-flammable are:

- concrete,
- metal (steel, aluminium, etc.),
- plaster,
- glass fibre or rockwool.

The use of synthetic or other materials is subject to agreement and if allowed must comply with NBN EN 62271-202 section 6.104.2.3. The necessary test reports shall be added to the technical file of the prefabricated substation.

Please note that the provisions of the Royal Decree of 07/07/94 set out the basic standards for fire and explosion prevention and indicate the RF values of doors, openings and walls. This is the responsibility of the manufacturer. Precast concrete elements must comply with Eurocodes 1 and 2.

6.3 Thermal isolation and condensation

The thermal inertia and day-night thermal stability of the enclosure must avoid excessive humidity levels in the enclosure, as set out by NBN EN 62271-1 for normal operating conditions. In order to achieve these properties, some types of thin-walled constructions with poor thermal characteristics may require a combination of additional means such as thermal insulation, adequate ventilation, targeted heating and thermal regulation.

In addition, all precautions must be taken to prevent condensation and the ingress of water, snow or animals, particularly at the seals or connections between the various parts of the enclosure (cellar, walls, panels, ceiling, roof, etc.) and at cable embeddings (HV, LV and earthing cables).

6.4 Building materials

The building materials must have the required mechanical and electrical characteristics and their durability must be guaranteed, as mentioned in the legal provisions and standards in force.

Building materials must comply with the requirements of the standards mentioned in the section *Reference documents*. The application of alternative or equivalent standards can only be accepted if the manufacturer proves its equivalence, and with the explicit approval of Synergrid.

The building must be maintenance-free.

6.5 Concrete composition and treatment

6.5.1 General provisions

The walls, ceiling, possible floor slab, foundation slab and cellar must be made of reinforced concrete. All concrete surfaces must be smooth.

Tolerance for dimensions:

- ±10 mm on the lengths, widths and connections of the construction's various concrete elements.
- ± 5 mm on wall, floor and ceiling thickness, ...
- ± 3 mm on the arrangement of the flush-mounted parts and holes.

Tolerance for the appearance of the different sides of the structure (both inside and outside the enclosure):

- Flatness: 5 mm tolerance with regard to the 2 m rule and 2 mm tolerance with regard to the 200 mm rule on flat surfaces.

- Texture:
    - The use of chamfered edges in the concrete moulds is optional. However, all edges and corners (including those of functional openings) must have a smooth finish and show no defects (i.e. gravel nest).
    - The surface area of a gravel nest is limited to 50 mm²/dm².
    - The presence of “sand streaks” is not acceptable.
    - The presence of “lime streaks” is not acceptable.
    - Hairline cracks must be limited in thickness to 0,1 mm.
    - A detachment of the top layer of the concrete walls is not acceptable.
    - Visible markings from spacers, reinforcement, rust, etc… are not acceptable.

Repairs performed on any surface of the enclosure are acceptable but are subjected to the following guidelines:

- The surface must be as flat as the surrounding non-repaired concrete.

6.5.2 Reinforcement

Reinforcement is carried out using reinforcements made of welded steel bars and/or mesh and/or reinforced fibres. Technical data sheets, certificates of conformity and certificate of origin must be provided.

Reinforcement of steels must be approved and identified (steels and reinforcements by markings and mesh by labels). Reinforced or prestressed concrete steels must comply with the properties defined in *NBN EN 1992-1-1.*

The electrical resistivity of the topcoat must be sufficient to meet the requirements for insulation resistance (see 6.14.2) of the building's outer walls and functional openings in relation to the earthing circuit.

When using reinforcing fibres, the dispersion of the needles constituting the reinforcement must be such that the homogeneity of the concrete is ensured.

The fittings must be designed to withstand the actions described in the section *Construction requirements*, without permanent damage to the enclosure.

For determining the withstand strength of the enclosure to sudden overpressures due to an internal arc fault, additional safety coefficients can be applied in the calculation of the reinforcement. Functional openings and related elements (covers, doors, …) shall not make galvanic contact with the building's reinforcement in any place in case of an enclosure in a non-global earthing system.

6.5.3 Concrete composition

A concrete composition must be considered for optimal durability and protection against corrosion.

This can lead to a higher compressive strength of the concrete than that required for the design of the structure (NBN EN 1992-1-1).

The enclosure’s duration of use shall be at least 50 years.

The minimum criteria required are:

- Resistance class: C30/37.
- Exposure class: EE3 XF1 in accordance with NBN EN 206 (Frost, contact with rain exterior walls exposed to rain, ...).
- Embedding (also applicable to holes and indentations in walls and floor slabs):
    - Pre-stressing steels for concrete exposed to external agents: 35 mm.
    - Pre-stressing passive fittings for concrete exposed to external agents: 25 mm.
    - Main concrete reinforcing bars and mesh not exposed to external agents: 25 mm.
    - Ancillary concrete reinforcing bars and anchors not exposed to external agents: 20 mm.

The above embedding conditions refer to Annex A of NBN EN 13369 (environmental condition E, high aggressiveness).

The consistency classes and grain size must be justified by the supplier according to the manufacturing conditions and must contribute to the achievement of the durability requirements.

6.6 Internal arc withstand - Overpressure effects

The overpressure withstand of the enclosure has been computed based on simulations. The result of these simulations is mentioned in paragraph 9.3 (appendix C).

The assumption used in the simulations is that the building can be reused after the occurrence of an internal arc. The structural integrity of the building is maintained but minor repairs may need to be carried out before the building is returned to service. It is up to the building manufacturer to take the necessary measures in its design to comply with this

The values of overpressure of the switching room and the cellar shall be determined depending on:

- the classification of homologated HV material (AAxx) following C2/113-7.
- the volume and shape of the switching room.
- the net surface of the (ventilation) openings to the outside.
- The free openings between the cellar and the switching room.

6.7 Rated class of the enclosure

The rated class of the enclosure shall be computed as required in subchapter 8.1

The rated class of the enclosure shall be determined depending on:

- The maximal power and losses of the transformer for which the enclosure is designed; The minimal rated class of the enclosure according to Annex D of NBN EN 62271-202:
    - Oil/winding maximum temperature rise: 60-65 K O/W
    - Average yearly ambient temperature: 10°C
    - Load factor of the transformer: 1

The enclosure class for the prefabricated substation is required to be 10 K or lower.

6.8 Functional openings

6.8.1 Doors

Doors are part of the enclosure and shall comply with the requirements as stated in NBN EN 62271-202, section 6.104.4 and in sub-chapter 6.13 and 6.14 of this document.

When closed, they shall provide the degree of protection as specified in sub-chapter 5.2 and 5.3 of this document.

The set door/frame shall be unsensitive to the efforts to which the enclosure shall be submitted during its transportation (neither dis-adjustment, nor deformation).

In a walk-in enclosure, the minimal dimensions and requirements of the door are determined according to the equipment for which the enclosure has been designed. The functional opening of the door must be at least 0,95 x 2,00 m. It is allowed to adjust the size of the functional opening of the door to accommodate the largest transformer that can be placed inside the enclosure. In case the functional opening of the door is not adjusted for the equipment, the manufacturer must indicate in his homologation file the following:

- Maximum dimensions of the transformer that can be installed in the enclosure using the door as entrance.
- Declaration and short description as to how a bigger transformer can be placed inside the enclosure.

For a non-walk-in enclosure, the dimensions and relative arrangement of the doors shall allow easy operation and maintenance of the equipment inside the enclosure.

As doors potentially constitute a cold surface with very low thermal inertia, the risk of condensation on their internal surfaces must be taken into account (water drainage to be provided).

Doors shall always open to the outside and be equipped with a device able to maintain them in two open positions namely at an angle of at least 90° and at an angle of at least 160°.

On the outside they shall be fitted with a fixed handle and opened by means of a key lock.

From the inside they shall always be openable without a key, even if they are locked from the outside.

Doors shall have closures with a minimum of three points (downward closing prohibited for walk-in enclosure)

Doors shall be designed so that no water infiltration is possible inside the enclosure with the door closed.

In non-walk-in enclosures only: to access the transformer, the door may be replaced by (a) removable(s) ventilation grid(s). In this case, the grid can be handled by two people which means that each segment of the grid has a maximum weight of 50kg in total.

6.8.2 Ventilation openings

Ventilation openings are part of the enclosure and shall comply with the requirements of NBN EN 62271-202 section 6.104.5 and in sub-chapter 6.13 and 6.14 of this document.

They shall also provide the degrees of protection as specified in sub-chapter 5.2 and 5.3 of this document.

Every substation with a transformer is equipped with at least two ventilation openings according to the following instructions:

- One lower ventilation opening, placed at a lower level either in a wall or in the door, operating as an inlet of fresh air.
- One upper ventilation opening placed as high as possible in the wall, operating as extraction point of the warm air out of the substation.
- Both ventilation openings shall be placed in the immediate vicinity of the transformer.
- It is allowed to place both ventilation openings on the same wall. Alternatively, they are placed on adjacent walls.
- The size and specification of the ventilation openings shall comply with the requirements of subchapter 9.3 in accordance with the requirements of subchapter 5.3 and 6.6 in order to comply with the overpressure withstand in case of internal arc.

The size of the ventilation openings may be increased compared to the minimum dimensions determined in subchapter 9.3. in order to meet the requirements for the heat dissipation of the substation linked to the maximum power of the transformer for which the substation is designed, in accordance with the requirements of subchapter 5.4 and 6.7 and verified by computation note in subchapter 8.1.

In case the general layout of the equipment needs to be adjusted to the needs of the client, it is the responsibility of the manufacturer to ensure at all times that the HS switchgear is placed out of the natural ventilation path. This is to prevent condensation on the HS switchgear as much as possible.

6.8.3 cable entries

The choice of the brand and type of cable entries used for the HV and LV cables will in most cases be made by the DSO and DSU.

Therefore, for the homologation of his enclosure, the manufacturer will only have to indicate for each wall the location, size, maximum number and the position of the cable entries for the HV and LV cables.

Regarding the position of the cable entries, the following requirements shall be taken into account:

- The distance between the HV cable entries and the HV switchgear shall take into account the necessary space to respect the maximum bending radius of the HV cable (typically a 240 mm² cable is used which has a bending radius of 600 mm).
- The cable entries shall be placed in such a location that no cable (HV or LV) will cross the oil retention tank.
- An indicative standard position for the HV and LV cable entries shall be included in the homologation file.

The manufacturer of the concrete enclosure is responsible for the incorporation of the cast part of the cable entries into the casted concrete enclosure. The adhesion of the concrete to the cable entry as to make the setup fully waterproof is the responsibility of the manufacturer.

The manufacturer of the enclosure shall also provide a waterproof entry of both ends of the earth loop inside the substation. Both ends shall be separated when entering the substation and shall be isolated from each other and from the surrounding concrete. The manufacturer shall include in his homologation application file which method/system he uses to achieve this.

6.8.4 Entry for cables of electric emergency generator/metering vehicle:

If an enclosure is foreseen to host a LV switchboard, it shall be fitted with a cable entry to connect an emergency generator.

The cable entry for the emergency generator is part of the enclosure and shall comply with the requirements of sub-chapter 6.13 and 6.14 of this document.

In closed position, it shall provide the degrees of protection as specified in sub-chapter 5.2 and 5.3 of this document.

The free opening of the cable entry for the connection of an emergency generator shall have a minimum dimension of 200mmx200mm and be either a square or a circle with an equivalent surface.

It shall only be opened from the inside.

It shall include no element that could damage the external insulation of the cables.

6.9 Switching room

The volume of the switching room complies with the values authorized by subchapter 9.3 but this volume must also be designed to contain the maximum number of elements that the manufacturer wishes to be able to homologate its enclosure for, such as:

- Number of HV FU's and maximal height of equipment (following C2/113-7)
- Size of the area designated for the LV switchgear
- Power and size of transformer(s)
- Remote control & telecom equipment
- Access hatch to the cellar
- Entry for emergency group
- …

In any case, the switching room must also take into account:

- An emergency escape corridor of 80cm;
- A minimal height of 2,25m
- Inner walls which also withstand the overpressure given at subchapter 9.3

6.10 Cellar

The cellar must be completely waterproof. Its watertightness, when required, must be guaranteed for at least 10 years by the supplier in the technical homologation file.

In case the cellar is made separately from the switching room, the sealing between both parts must be guaranteed, and dispositions are made to prevent water ingress in the cellar.

The manufacturer describes the means used to guarantee the tightness of the cellar and to avoid infiltration or penetration of outside water (tight materials used, origin and possible path followed by the water, type and nature of barriers set-up to interrupt this path).

The size of the cellar shall be designed to contain the maximum number of elements that the manufacturer wishes to be able to homologate its enclosure for, such as:

- Cable entries and their position.
- Oil leak collector shall be provided and placed following section 6.102 of NBN EN 62271-202 and following AREI/RGIE 4.3.3.7 paragraph b of book 2 or book 3.

  This volume shall always remain free and available in the event of an oil leak. No water infiltration is permitted in the oil collector. In order to guarantee the sealing of the tank, it should preferably consist of a single part; if this tank is composed of joined elements, the seals must be water- and oil-tight. No cables are permitted to pass through this tank or its walls.

In any case, the cellar shall have:

- A free height of minimal 80 cm.
- Walls which withstand the overpressure given at subchapter 9.3

6.11 Floor slab

The floor slab is designed to withstand the maximum mobile load and the internal arc overpressure for which the manufacturer wants to homologate its enclosure. In most cases the load to be taken into consideration will be the weight of the biggest transformer for which the manufacturer wants to homologate its enclosure. The slab may lift-up in case of an internal arc but shall mandatorily fall back into its normal position without damage to the floor slab itself or the equipment.

The floor is plain, slip-resistant, and free of any barrier or irregularity that could make an operator stumble and fall. The metallic rails anchored in the slab for fixation of the equipment may not exceed the level of the floor slab.

The flatness is less than 1mm/m.

6.11.1 *Floor slab's functional openings and characteristics*

The number and the size of the floor slab's functional openings is directly linked to the equipment which has to be installed in the enclosure:

- Opening(s) for the HV cables and gas expansion under/behind the HV switchgear
- Opening for the LV cables under LV switchboard as well as for public lightning when applicable
- Opening(s) behind the transformer for the HV cables and for the gas expansion of the hot gasses from the cellar into the switching room
- Opening under the transformer (not mandatory) for the collection of oil in case of an oil leak of the transformer.
- A guiding slope to the opening under/behind the transformer used for the collection of the oil in case of an oil leak.
- Opening for Telecom cables
- Opening for the earthing conductor
- Hatch to the cellar

The hatch shall have a functional opening of 600 x 600 mm. It shall always be accessible and be located at a minimum distance of 800 mm from the door. The cellar floor under the hatch shall be clear of cables. The hatch must be equipped with a cover fixed in such a way that it can be opened by one person, preferably without any tools. If tools are necessary, they must be present in the enclosure and be part of the delivery. This hatch shall withstand the overpressure that can occur in the cellar in case of an internal arc – see values in subchapter 9.3, as well as the mobile loads mentioned here-above. The hatch and its cover shall be at the same level as the slab.

For the expansion of the hot gases form the cellar into the switching room, the opening behind the transformer will be used. This opening will also serve as the entry point of the HV cables coming from the HV switchgear to the HV plugs of the transformer. In case a separate opening under the transformer is present for the collection of oil in case of an oil leak, this opening will also contribute to the expansion of the hot gases from the cellar to the switching room. The total size of both openings together will be at least 0,08 m² and maximum 0,12 m².

6.12 Roof

The roof shall be completely waterproof. Its watertightness must be guaranteed for at least 10 years by the supplier in the technical homologation file.

The roof is preferably monobloc (in one piece).

It shall be able to withstand an overload of 250 daN/m² and the overpressure resulting from an internal arc according to the table in subchapter 9.3.

The roof can be free or attached to the walls.

- In case it is free, all measures shall be taken to ensure that, in the event of lifting due to an explosion in the enclosure, it falls back into its place.
- The roof shall be designed to avoid cracking/breaking even when it is lifted due to the overpressure of an internal arc.

The roof shall be independent (separate part) and removable from the walls. Instructions for disassembly, removal and re-assembly shall be provided in the technical homologation file. It shall be easy to remove. The lifting system shall be a standard and compliant system available on the market.

The roof shall have an overhang (not exceeding 100 mm) and be equipped with a drip course (a "drip breaker" device) to interrupt the flow of water and to prevent it from flowing along the walls.

For non-walk-in enclosures, the roof shall always be flat.

In case of a flat roof, it shall have an inclination of at least 2 cm/m (2%). This inclination must be visible on the drawing.

6.13 Resistance to ageing and corrosion

6.13.1 *Enclosure*

Since the enclosure is usually intended to be installed outdoors, it is subjected to the environmental/climatic conditions listed in chapter 4. The enclosure shall therefore withstand climatic deterioration during its lifetime and comply with the requirements regarding corrosion of NBN EN 62271-202 section 6.104.3 The expected lifetime of an enclosure shall be at least 50 years.

6.13.2 *Functional openings*

The functional openings (doors, ventilation and cable ducts) and their frames shall be realized in solid, non-alterable, corrosion resistant material. They shall be protected against corrosion by a system suitable for climatic conditions corresponding to (for steel) or equivalent with (for other materials) the C4 High code in accordance with *NBN EN ISO 12944-2* during their lifetime. They shall not require maintenance, except for rotating or movable parts – in case maintenance is necessary for those parts, the minimum time interval between two maintenance sessions will be at least ten years.

This system shall be designed so that deteriorations can be fixed without the application of special measures. It shall also permit the application and the adherence of a paint coating (powder coating when applicable) of any RAL type.

The manufacturer shall describe the process (including preliminary treatments) and the different types of products used (compliant with the RoHS directive).

For functional steel openings:

- These shall be hot-dip galvanised and powder coated. in accordance with NBN EN ISO 1461.

For functional aluminium openings:

- Aluminium elements shall be painted or anodised.
- If applicable, anodizing shall be realized in accordance with Qualanod's (Quality Label for Anodic Oxide Coatings on Wrought Aluminium for Architectural Purposes) comparable specifications.
- Where applicable, the application of a paint coating shall be in accordance with the comparable Qualicoat specifications (Quality Label for Coating on Metal for Architectural Applications).

Other corrosion protection solutions may be submitted to Synergrid for approval. Where applicable, their equivalence shall be demonstrated.

6.13.3 *Door and door frame:*

Whichever the protection method, a painted version shall be proposed. An unpainted version can also be proposed as an alternative (except in the case of hot-dip galvanised steel).

6.13.4 *Frame, rails, screws and other fastening elements.*

Any frames, rails, screws and other fasteners shall be protected against corrosion by a system suitable for climatic conditions corresponding to code C4 High in accordance with NBN EN ISO *12944-2*.

Steel parts are anodised and powder coated in accordance with the NBN EN ISO 1461.:

luminium elements shall be painted or anodised. The requirements are the same as those mentioned above for functional openings.

Other corrosion protection solutions may be submitted to Synergrid for approval. Where applicable, their equivalence must be demonstrated.

6.14 Earthing and equipotential connections

6.14.1 *General provisions*

The earthing equipment must be in accordance with chapter 14 of the C2/112, the NBN EN 62271-202 section 6.3 and with the AREI/RGIE book 2 – sections 4.2.3.2 & 5.4 or book 3 – sections 4.2.5.2 & 5.5.

In case of a non-global earthing system the conductive elements that can be reached from outside the enclosure such as door(s), ventilation openings, cable entry for electric emergency generator /measuring vehicle are excluded from the interconnected earthing and shall be insulated from the concrete enclosure.

An indication of the position of the general earthing disconnector shall be indicated on the drawing(s) (see 6.16).

6.14.2 *Insulation level of the external walls of the enclosure in a non-global earthing system*

In the event of an electrical fault, the contact voltage for a person outside the enclosure touching its walls (including functional openings) may not exceed the values prescribed in the relevant section of the AREI/RGIE.

For this reason, the enclosure's outer coating (including the finishing coatings) shall be insulated from the earthing circuit. 'Outer enclosure' is defined as follows:

- the walls (including their buried part).
- the functional openings and their covers.
- the roof.

The level of insulation required between the outer surface of this enclosure and the earthing circuit for non-global earthing is: no disruptive discharges at 3000 VAC for 1 minute.

In addition,

- The walls (including the buried part below the ground level), ceiling and roof of the buildings must be made of materials that have a sufficient electrical insulation capacity.
- Non-insulating material, especially metallic materials, are not permitted except for the closing of functional openings (which cannot be connected to the earthing circuit).

6.15 Nameplates

In accordance with section 6.11 of NBN EN 62271-202, each prefabricated substation shall be provided with a durable and clearly legible nameplate, which shall contain at least the following information:

- Manufacturer's name or trade-mark;
- Type designation;
- Suitable HV switchgear classification (AAxx);
- Max. power rating and max weight of the transformer;
- Serial number of the enclosure;
- Reference of C2/115 homologation (homologation number);
- Year and month of manufacturing.
- Space for a QR-code

The nameplate shall be placed close to the door, inside the enclosure and shall remain legible for the whole lifetime of the enclosure.

An (design) example of this nameplate is given for approval in the homologation procedure.

6.16 Drawing and arrangement of enclosure

Drawings with the arrangement of the equipment inside the enclosure, indicating the provided space (dimensions) of the following equipment:

- space for FUs for the HV switchgear
- the max size and number of the transformer,
- space for feeders for the LV switchboard,
- space for the metering panel
- space allowing the possibility to place a remote-control cabinet/smart grid equipment
- The min required dimensions of the escape path and of the free service areas around every equipment depending on the type of enclosure (walk-in / non-walk-in) should be indicated.

Drawings with the arrangement and dimension of each cover, openings (included cable entries) shall be also submitted.

Drawings with outside and inside dimensions and position of each element which has been described in this specification.

All drawings must be submitted in pdf-format, and also be available on request in dwg-format.

7 Type test reports

7.1 General provisions

In order to perform the homologation assessment of the prefabricated enclosure:

- For § 7.2 to § 7.4: only test reports from an accredited laboratory following ISO 17025 are taken into consideration.
- For § 7.5: only test report from an independent laboratory designated by the manufacturer and accepted by Synergrid are taken into consideration.

7.2 Corrosion resistance for the enclosure's metallic elements (and their frames)

The manufacturer proves in his technical file that he takes sufficient measures to prevent ageing and corrosion. To this end, he provides Synergrid with the following documents:

- Qualicoat certification of the manufacturer responsible for the supply of metal or aluminium components of the cabin.
- Qualanod certification of the manufacturer responsible for the supply of metal or aluminium components of the cabin.
- Attestation/statement from the manufacturer responsible for the delivery of the steel parts that this galvanisation is done in accordance with NBN EN ISO 1461.
- Attestation/statement demonstrating conformity with the RoHS directive.

The manufacturer must provide a description of the process (including preliminary treatments). The manufacturer specify the different types of products used in accordance with the RoHS directive (leaded or chrome-plated components are prohibited).

7.3 Verification of degree of protection (IP-x-code)

The verification of the degree of protection of the prefabricated substation is done in accordance with NBN EN 62271-202 section 7.7.

The protection level IP 23D shall be verified and proved for all ventilation openings.

7.4 Mechanical impact test (IK-code)

A mechanical impact test according to NBN EN 62271-202 section 7.101.3 shall be performed on all external places of the enclosure (doors, covers, ventilation, hinges,…) to verify the IK10 degree of protection.

The test must be performed on at least the following parts of the enclosure:

- Door(s)
- Ventilation openings
- Hinges of the doors
- Entry for cables of electric emergency generator/metering vehicle
- Inspection window if present

In order to pass the test, the criteria as mentioned in NBN EN 62271-202 shall be met. Superficial deterioration/damage is allowed under the conditions as described in the standard.

7.5 Verification of insulation resistance of the building's exterior walls and functional openings for use in a non-global earthing system

An insulation test shall be performed in order to assess compliancy with subchapter 6.14.2.

Details of the test procedure and test report can be found in subchapter 9.2.

8 Computed simulation - calculation notes

Calculation notes shall be introduced in order to obtain product homologation.

They shall be carried out according to the latest edition of the specifications and reference standards in this specification by an architect or engineering bureau specialized in stability, static and/or dynamic loads computations.

8.1 Computed simulation related to the temperature class

The rated class of the enclosure shall be verified according to the test procedure described in NBN EN 62271-202.

Computing conditions:

- The enclosure shall be equipped with a transformer corresponding to the rated maximum power of the prefabricated substation as defined in section 5.4.1
- In accordance with NBN EN 62271-202, losses of HV switchgear are considered negligible.
- All other losses (LV panel, cable connections,…) are simulated at the location of the LV panel.
- To simulate the power losses of the LV panel, cable connections, etc…. a heat source must be used. The thermal power of the heat source shall depend on the number of transformers and the (individual) rated maximum power of the transformers that can be placed inside the prefabricated substation (e.g. if the enclosure is designed for two transformers 400 kVA each, two heat sources of 350 W shall be used). The table below shows the corresponding thermal power of the heat source in relation to transformer power rating:
    - Max. 200 kVA: 150 W
    - Max. 400 kVA: 350 W
    - Max. 630 kVA: 450 W
    - Max. 800 kVA: 700 W
    - Max. 1000 kVA: 700[1] W
    - Max. 1250 kVA: 800 W

  For substations with a higher power rating, the manufacturer shall provide a detailed calculation of the power losses of the LV switchboard, cable connections,… The result of the calculation will be used as the thermal power rating for the heat source. The calculation of the thermal power is added to the calculation note.
- The calculation will take into account the heat dissipation through ventilation and through transmission heat losses through walls, ceiling and floor.
- Solar irradiation of the roof or walls must not be taken into account.
- The calculation will be performed with a load factor of the transformer equal to 1 for every transformer (rated maximum power) as defined in subchapter 6.7.
- The ambient temperature (outside) is fixed at 10°C as defined in subchapter 6.7. Additional the calculation must be performed with an ambient temperature of 30°C.

The calculation note must clearly state the following information:

- The construction parameters of the switching room (length, width, height and internal volume), thickness of the floor, ceiling and walls and their respective thermal conductivity (W/mK).
- The construction parameters of the door (length, width, height and thickness) and its thermal conductivity (W/mK).
- The construction parameters of the ventilation openings (width and height) and their aerodynamic resistance. And this for both the lower and higher ventilation openings.
- The height difference (centre to centre) of the ventilation openings.
- Total number of transformers including their rated maximum power, heat losses (load and no load losses) and load factor respectively.
- Maximum power of the additional heat source for each transformer.

[1] There is no difference between 800 and 1000 kVA since the increase in section of the busbar of the LS-switchboard causes a decrease in Joule heating.

- The total internal heat developed in the prefabricated enclosure (transformer losses and heat source).
- Distribution in percentages of the heat dissipation between the ventilation and the transmission heat losses.
- The expected temperature rise inside the substation in regards to the outside ambient temperature (K of °C).
- The calculation note must also clearly state if the rated class of the enclosure (10K) has been achieved or not.

In case the calculation note indicates that the 10K class is not achieved for the enclosure than the calculation note must indicated the maximal loading factor of each transformer such that the 10K class is achieved.

Additionally the manufacturer must state which modifications to the heat dissipation are necessary in order for the transformer to have a loading factor of 1 while still guaranteeing the 10K class for the enclosure. The manufacturer must provide the necessary calculation notes to validates this. In case the manufacturer suggest using bigger ventilation openings, the manufacturers must also provide the necessary calculation notes as mentioned in subchapter 8.2.

8.2 Calculation notes – mechanical and pressure resistance of the enclosure

The entire construction (walls, cellar, roof, or a floor slab if present, etc.) must be able to withstand the maximum stresses as defined in subchapters 5.3 and 5.5.

At least the following calculations notes according to the Eurocode must be present:

- Verification of the wind pressure withstand strength of the prefabricated substation
- Verification of the roof loads withstand strength of the prefabricated substation
- Verification of the snow loads withstand strength of the prefabricated substation
- Verification of the floor loads withstand strength of the prefabricated substation
- Verification of the overpressure withstand strength of the prefabricated substation

9 Annexes

9.1 Annex A: conformity assessment guide (checklist)

See conformity assessment guide C2/115-3 xlsx file.

The technical file shall be composed of the following documents:

A. **The C2/115-3 xlsx checklist**, completely filled in:
   1. Sheet 1: Manufacturer's declaration about the correctness of all the provided information in the technical file.
   2. Sheet 2: list of prefabricated enclosures. The information filled in here will be copied into the list C2/115-0 in case a homologation is obtained.
   3. Sheet 3: technical file checklist, based on this technical prescription. If the characteristics are different for an enclosure or a series of enclosures listed in sheet 2, the manufacturer shall make as many copies of sheet 3 within the same xlsx-checklist as necessary.
   4. Sheet 4: Numbered list of proofs of conformity.

B. **The necessary accompanying documents**, as listed and numbered in sheet 4 of the checklist: certificates / test reports, plans, technical datasheets, certificates of origin, … The filename of each document must start with the reference number given by the manufacturer in sheet 4 of the xlsx checklist.

Where the checklist indicates that the necessary proof of conformity is a declaration, completion of the requested information is considered to be a declaration on honour by the manufacturer, and confirmed by the information provided on the first sheet of the checklist. No separate document stating a manufacturer's declaration is necessary.

A signed and dated pdf-file for publication purposes shall be provided by the manufacturer after approval of the technical file by Synergrid. This pdf-file shall contain sheet 1 and sheet 2 of the xlsx-checklist.

9.2 Annex B: Insulation tests of the building's exterior walls

This test is only needed for enclosures in a non-global earthing system.

9.2.1 Measuring electrode

The wet electrode consists of a 250 mm square metal plate and a wet and wrung-out hydrophilic paper or cloth approximately 270 mm square which is placed between the plate and the area to be tested, as stipulated in IEC 60364-6. The conductivity value of the water used to humidify the electrode cloth is comprised between 100 and 150 µS/cm as defined in NBN EN 62271-304 for classes 3 and 4.
During the measurements, a force of approximately 250 N is applied to the contact surface between the electrode and the enclosure.

9.2.2 Test method

Resistance measurement
Measurements of insulation resistance and dielectric strength are made on a finished structure ready for shipment.
Concrete walls: Measurements are made between the measuring electrode (described above) and the general grounding strip, with all grounding connections completed (metal reinforcement of walls, equipment, etc.).
Functional openings: Measurements are made between each functional opening and the general grounding strip, with all grounding connections completed (metal reinforcement of walls, equipment, etc.).

Measurement locations:
Concrete walls: Measurements are made at the most unfavourable locations, i.e., those with the minimum isolation distances between the measuring electrode and the metal masses. At least one measurement is made on each wall. If the walls have different properties (e.g., coating, concrete thickness), measurements are made on least at 3 different locations on each touchable side.
Functional openings: Measurements are made on each functional opening. If the opening is made up of several parts (e.g., door and frame), a measurement is made on each part.

9.2.3 Criteria for successful completion of the type test

Insulation resistance
The insulation resistance measured after 1 minute must be at least 100 kΩ for a voltage applied to the walls or functional openings of at least 3000 VAC.
Dielectric strength
The dielectric strength test is passed if no disruptive discharge occurs during the application of 3000 VAC for 1 min for each test surface.

9.3 Annex C – Construction requirements for the enclosure

9.3.1 Annex C1 – AA10 Material (SF_6) – Switching Room from volume 15 to 30m³ and ratio between length and width <2, flux of hot gas directly to the cellar and presence of two ventilation openings

Gross volume* switching room [m³]	Cd x ∑ A,gross ventilation openings [m²]	Maximum pressure rise in the switching room [mbar]		Maximum pressure rise in the cellar* [mbar]
		roof cannot lift up	roof can lift up	
15 < Vgross ≤ 18	0,15	80	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m²) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift unless : - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	120
	0,17	65		110
	0,19	**50**		110
	0,21	45		95
	0,23	40		90
	0,25	35		85
18 < Vgross ≤ 20	0,15	95		150
	0,17	80		130
	0,19	**63**		120
	0,21	55		110
	0,23	45		105
	0,25	40		100
20 < Vgross ≤ 24	0,15	100		160
	0,17	85		145
	0,19	**65**		130
	0,21	60		120
	0,23	50		105
	0,25	45		100
24 < Vgross < 30	0,15	100		180
	0,17	85		165
	0,19	**70**		150
	0,21	60		145
	0,23	50		135
	0,25	45		130

* Volume of an empty switching room without any equipment
** minimum cellar height of 80 cm;

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	Dimensions of ventilation openings	Cd x ∑ A,gross [m²]
0,172	80x60 cm² + 80x50 cm² = 0,88 m²	0,15
0,172	70x70 cm² + 70x70 cm² = 0,98 m²	0,17
0,172	90x70 cm² + 70x70 cm² = 1,12 m²	0,19
0,172	70x70 cm² + 90x80 cm² = 1,21 m²	0,21
0,172	90x70 cm² + 90x80 cm² = 1,35 m²	0,23
0,172	90x80 cm² + 90x80 cm² = 1,44 m²	0,25

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 2 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2.

9.3.2 *Annex C2 – AA30 Material (SF6)– Switching Room from volume 15 to 30m³ and ratio between length and width <2, flux of hot gas directly to the cellar and presence of two ventilation openings*

Gross volume* switching room [m³]	Cd x ∑ A,gross ventilation openings [m²]	Maximum pressure rise in the switching room [mbar]		Maximum pressure rise in the cellar* [mbar]
		roof cannot lift up	roof can lift up	
15 < Vgross ≤ 18	0,15	104	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m²) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift up unless: - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	269
	0,17	91		267
	0,19	**80**		266
	0,21	73		264
	0,23	66		264
	0,25	60		264
18 < Vgross ≤ 20	0,15	99		267
	0,17	87		265
	0,19	**77**		265
	0,21	69		264
	0,23	63		264
	0,25	57		262
20 < Vgross ≤ 24	0,15	98		246
	0,17	85		244
	0,19	**74**		243
	0,21	68		242
	0,23	61		241
	0,25	55		240
24 < Vgross ≤ 27	0,15	94		244
	0,17	82		243
	0,19	72		242
	0,21	65		241
	0,23	59		240
	0,25	53		240
27 < Vgross ≤ 30	0,15	91		230
	0,17	79		229
	0,19	**68**		228
	0,21	67		227
	0,23	56		227
	0,25	50		226

* Volume of an empty switching room without any equipment
** minimum cellar height of 80 cm;

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	Dimensions of ventilation openings	Cd x ∑ A,gross [m²]
0,172	80x60 cm² + 80x50 cm² = 0,88 m²	0,15
0,172	70x70 cm² + 70x70 cm² = 0,98 m²	0,17
0,172	90x70 cm² + 70x70 cm² = 1,12 m²	0,19
0,172	70x70 cm² + 90x80 cm² = 1,21 m²	0,21
0,172	90x70 cm² + 90x80 cm² = 1,35 m²	0,23
0,172	90x80 cm² + 90x80 cm² = 1,44 m²	0,25

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 2 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2.

9.3.3 Annex C3: AA10 Material (SF_6)– Switching Room from volume 30 to 55m³ , max inner length of 9m, , flux of hot gas directly to the cellar and presence of two ventilation openings*

Gross volume** switching room [m³]	Cd x ∑ Area gross ventilation openings [m²]	Maximum pressure rise in the switching room [mbar]		Maximum pressure rise in the cellar** [mbar]
		roof cannot lift up	roof can lift up	
30 < Vgross ≤ 35	0,15	48	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m²) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift up unless: - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	119
	0,17	44		117
	0,19	**38**		116
	0,21	35		114
	0,23	30		113
	0,25	28		112
35 < Vgross ≤ 40	0,15	45		111
	0,17	41		110
	0,19	**35**		108
	0,21	33		108
	0,23	29		106
	0,25	26		106
40 < Vgross ≤ 45	0,15	42		102
	0,17	38		100
	0,19	**33**		99
	0,21	30		98
	0,23	27		97
	0,25	25		97
45 < Vgross ≤ 50	0,15	39		94
	0,17	36		93
	0,19	**31**		91
	0,21	29		91
	0,23	25		90
	0,25	24		89
50 < Vgross ≤ 55	0,15	36		88
	0,17	33		87
	0,19	**29**		86
	0,21	27		85
	0,23	24		84
	0,25	22		84

* the max inner length of the longest wall used in the simulations was 9m; the inner width used was 2.5m.
** Volume of the switching room without any equipment
*** minimum cellar height of 80 cm; ;

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	Dimensions of ventilation openings	Cd x ∑ A,gross [m²]
0,172	80x60 cm² + 80x50 cm² = 0,88 m²	0,15
0,172	70x70 cm² + 70x70 cm² = 0,98 m²	0,17
0,172	90x70 cm² + 70x70 cm² = 1,12 m²	0,19
0,172	70x70 cm² + 90x80 cm² = 1,21 m²	0,21
0,172	90x70 cm² + 90x80 cm² = 1,35 m²	0,23
0,172	90x80 cm² + 90x80 cm² = 1,44 m²	0,25

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 2 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2.

9.3.4 Annex C3: AA10 Material (SF_6)– Switching Room from volume 30->55m^3, max inner length of 9m*, flux of hot gas directly to the cellar and presence of four ventilation openings

Gross volume** switching room [m^3]	Cd x ∑ Area gross ventilation openings [m^2]	Maximum pressure rise in the switching room [mbar]		Maximum pressure rise in the cellar* [mbar]
		roof cannot lift up	roof can lift up	
30 < Vgross ≤ 35	0,30	24	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m^2) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift up unless: - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	112
	0,34	21		112
	0,39	**17**		112
	0,42	15		112
	0,46	12		112
	0,50	10		112
35 < Vgross ≤ 40	0,30	22		105
	0,34	19		105
	0,39	**16**		105
	0,42	13		105
	0,46	11		105
	0,50	9		105
40 < Vgross ≤ 45	0,30	21		96
	0,34	18		96
	0,39	**15**		96
	0,42	12		96
	0,46	9		96
	0,50	7		96
45 < Vgross ≤ 50	0,30	20		89
	0,34	17		89
	0,39	**14**		89
	0,42	11		89
	0,46	8		89
	0,50	7		89
50 < Vgross ≤ 55	0,30	18		83
	0,34	16		83
	0,39	**12**		83
	0,42	10		83
	0,46	8		83
	0,50	7		83

* the max inner length of the longest wall used in the simulations was 9m; the inner width used was 2.5m.
** Volume of the switching room without any equipment
*** minimum cellar height of 80 cm.

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	Dimensions of ventilation openings	Cd x ∑ A,gross [m^2]
0,172	2 * (80x60 cm^2 + 80x50 cm^2) = 1,76 m^2	0,30
0,172	2 * (70x70 cm^2 + 70x70 cm^2) = 1,96 m^2	0,34
0,172	2 *(90x70 cm^2 + 70x70 cm^2) = 2,24 m^2	0,39
0,172	2 * (70x70 cm^2 + 90x80 cm^2) = 2,42 m^2	0,42
0,172	2 * (90x70 cm^2 + 90x80 cm^2) = 2,70 m^2	0,46
0,172	2 *(90x80 cm^2 + 90x80 cm^2) = 2,88 m^2	0,50

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 4 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2 + Cd3 x A,gross3 + Cd4 x A,gross4.

9.3.5 *Annex C4: AA30 Material (SF_6)– Switching Room from volume 30->55m³, max inner length of 9m*, , flux of hot gas directly to the cellar and presence of two ventilation openings*

Gross volume** switching room [m³]	Cd x ∑ Area gross ventilation openings [m²]	Maximum pressure rise in the switching room [mbar]		Maximum pressure rise in the cellar* [mbar]
		roof cannot lift up	roof can lift up	
30 < Vgross ≤ 35	0,15	95	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m²) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift up unless: - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	262
	0,17	86		261
	0,19	**77**		261
	0,21	71		261
	0,23	64		260
	0,25	60		260
35 < Vgross ≤ 40	0,15	92		245
	0,17	81		245
	0,19	**71**		243
	0,21	66		243
	0,23	60		242
	0,25	56		241
40 < Vgross ≤ 45	0,15	88		235
	0,17	78		234
	0,19	**66**		232
	0,21	60		232
	0,23	55		231
	0,25	51		230
45 < Vgross ≤ 50	0,15	85		219
	0,17	75		218
	0,19	**64**		217
	0,21	59		216
	0,23	52		216
	0,25	49		215
50 < Vgross ≤ 55	0,15	81		211
	0,17	72		207
	0,19	**62**		205
	0,21	57		204
	0,23	50		204
	0,25	46		204

* the max inner length of the longest wall used in the simulations was 9m; the inner width used was 2.5m.
** Volume of the switching room without any equipment
*** Minimum cellar height of 80 cm.

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	Dimensions of ventilation openings	Cd x ∑ A,gross [m²]
0,172	80x60 cm² + 80x50 cm² = 0,88 m²	0,15
0,172	70x70 cm² + 70x70 cm² = 0,98 m²	0,17
0,172	90x70 cm² + 70x70 cm² = 1,12 m²	0,19
0,172	70x70 cm² + 90x80 cm² = 1,21 m²	0,21
0,172	90x70 cm² + 90x80 cm² = 1,35 m²	0,23
0,172	90x80 cm² + 90x80 cm² = 1,44 m²	0,25

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 2 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2.

9.3.6 *Annex C4: AA30 Material (SF_6)– Switching Room from volume 30->55m³, max inner length of 9m*, , flux of hot gas directly to the cellar and presence of four ventilation openings*

Gross volume switching room [m³]**	**Cd x ∑ Area gross ventilation openings [m²]**	**Maximum pressure rise in the switching room [mbar]**		**Maximum pressure rise in the cellar* [mbar]**
		roof cannot lift up	**roof can lift up**	
30 < Vgross ≤ 35	0,30	50	This pressure value is determined by dividing the weight of the roof (N) taking by its internal surface f (m²) converted to mbar and by adding ice and snow loads required in sub chapter 5.3 If a seal is used between roof and walls we assume that the roof does not lift up unless: - A declaration is giving that the seal does not stick which means that there is no additional force needed to lift up the roof; - The added force needed (following technical file) to lift up the roof due to this sealing is taken into account.	259
	0,34	45		259
	0,39	**40**		259
	0,42	37		259
	0,46	34		258
	0,50	33		258
35 < Vgross ≤ 40	0,30	46		241
	0,34	42		240
	0,39	**37**		240
	0,42	35		240
	0,46	32		240
	0,50	31		240
40 < Vgross ≤ 45	0,30	43		224
	0,34	39		223
	0,39	**34**		222
	0,42	32		222
	0,46	30		222
	0,50	29		221
45 < Vgross ≤ 50	0,30	40		214
	0,34	37		213
	0,39	**33**		212
	0,42	31		212
	0,46	28		212
	0,50	27		212
50 < Vgross ≤ 55	0,30	38		202
	0,34	34		202
	0,39	**30**		202
	0,42	29		201
	0,46	26		201
	0,50	25		201

* the max inner length of the longest wall used in the simulations was 9m; the inner width used was 2.5m.
** Volume of the switching room without any equipment
*** minimum cellar height of 80 cm.

Explanation of the ventilation openings values

Coefficient dynamic of the grid (Cd)d in this example	**Dimensions of ventilation openings**	**Cd x ∑ A,gross [m²]**
0,172	2 * (80x60 cm² + 80x50 cm²) = 1,76 m²	0,30
0,172	2 * (70x70 cm² + 70x70 cm²) = 1,96 m²	0,34
0,172	2 *(90x70 cm² + 70x70 cm²) = 2,24 m²	0,39
0,172	2 * (70x70 cm² + 90x80 cm²) = 2,42 m²	0,42
0,172	2 * (90x70 cm² + 90x80 cm²) = 2,70 m²	0,46
0,172	2 *(90x80 cm² + 90x80 cm²) = 2,88 m²	0,50

If the Cd value of the different grids is not identical, the calculation of Cd x A,gross must be done by taking the sum of the separate calculations for each grid. In case of 4 different grids: ∑ (Cd x A,gross) = Cd1 x A,gross1 + Cd2 x A,gross2 + Cd3 x A,gross3 + Cd4 x A,gross4

9.3.7 *Annex C5: enclosure with partition walls*

These enclosures distinguish themselves from the rest because they are equipped with one or more partition walls in the switching room and cellar.

A partition wall is attached to the inner walls of the enclosure and the necessary joint sealants are applied. The enclosure is therefore divided into two or more compartments (switching rooms) which are fully separated from each other.

In case of an internal fault in one compartment, no hot gasses may escape to the other compartments and they must be limited to the compartment in which the fault occurred.

For the verification of the pressure resistance of the enclosure, the manufacturer must perform a calculation note for each compartment separately. The maximum pressure rise inside each compartment is dependent on the type of material placed inside the enclosure (AA10 or AA30), the gross volume of the compartment (switching room and cellar) and the ventilation openings present. These values are present in the tables of annexes C1, C2, C3 and C4.

The partition wall itself must be able to withstand the highest maximum pressure rise of its adjacent compartments. This must be clearly indicated in the calculation notes.

9.3.8 *Annex C6 – Concrete enclosure with AA10 or AA30 HV material <15m³ or >55m³*

If a homologation is requested for a concrete enclosure <15m³ of >55m³ with AA10 or AA30 HV-switchgear, the manufacturer must introduce a technical file following C2/115-3 and furthermore, pass the type test of NBN EN 62271-202 section 7.102.

This type test must comply with the requirements for a classification IAC-AB, and must be executed with homologated HV-switchgear from the C2/113-0 or C2/117 lists. Following NBN EN 62271-202, the enclosure can only be equipped with the HV-switchgear material for which the type test has been passed.

If this test is not performed, the use of the enclosure will be limited to homologated HV-switchgear of class AA13, AA20 and AA33 from the Synergrid C2/113-0 or C2/117 lists.