C2/113
Homologation procedure for HV switchgear according to the technical prescription C2/112

Part 4
Specific design and construction requirements for HV switchgear, intended for use in an installation connected to the public HV distribution loop of a Belgian DSO

Edition 2 (03.2024)

Version management

1.0	First edition, published 08.2018
2.0	Second edition, published 03.2024

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1 Object and scope

This document defines the specific design and construction requirements for the functional units (FUs) of HV metal enclosed switchgear according to EN 62271-200, intended for use in an installation connected to the public HV distribution loop of a Belgian DSO.

2 General

The requirements described in this document deal with the following functional units (FUs):

- FU K intended to be connected to the distribution loop (KKNx)
- FU D or T for the general protection[1] (DxGx and TxGx)
- FU D for DSO feeder (DKNx)
- FUs R, KKUx, TKUx, DKUx and P, installed downstream the general protection and the HV billing metering
- FU M for HV billing metering (Mxxx)

The specific design and construction requirements for the above mentioned FUs are summarized in Table 1 below.

Chapter / §	Specific design and construction requirements	FU KKNx	FUs TxGx DxGx	FU DKNx	FU M	FUs R KKUx TKUx DKUx P
Ch. 4	Man-machine interface	X	X	X	X	X
Ch. 5	Voltage detecting and indicating system (VDIS)	X		X		
Ch. 6	Specific requirements for a HV billing metering function				X	
Ch. 7	Practical requirements for cable connections	X		X		
§8.1	Accessibility to compartments	X		X	X	
§8.2	LSC category	X	X	X	X	
§8.3	Interlocks	X	X	X		X
§8.4	Locking facilities	X	X	X	X	X
§9.1	Arc suppression device (switchgear of category AA20)	X	X	X		X
§9.2	Indicating system for the dielectric withstand ability of the insulating gas for switchgear with gas insulated switching devices	X	X	X		X
§9.3	Earthing arrangements	X	X	X	X	X
§9.4	Raising base frames	X	X	X	X	X
§9.5	Features for installation of a Fault Current Indicator (FCI)	X				
§9.6	LV terminal block for protective current transformers		X	X		X
Ch. 10	Operating mechanism functionalities of switching devices	X	X	X		
Ch. 11	Installation and operating instructions	X	X	X	X	X
Y = specific design and construction requirements applicable for the FU(s)						

Table 1: overview table with specific design and construction requirements

This document shall be read in conjunction with Synergrid documents C2/112, C2/113-7 and C2/119.

[1] Also refers to the protection of the unique distribution transformer in a Client installation

3 References

The standards listed in Table 2 below are referenced in the present document.

NBN EN 62271-200 Ed.3 (2021) + Amd.1 (2024)[2]	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
NBN EN 62271-1 Ed.2 (2017) + Amd.1 (2021)	High-voltage switchgear and controlgear - Part 1: Common specifications
NBN EN 62271-102 Ed.2 (2018) + Amd.1 (2022)	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches
NBN EN 62271-213 Ed.1 (2021)	High-voltage switchgear and controlgear - Part 213: Voltage detecting and indicating system
NBN EN 61869-2 Ed.1 (2012)	Instrument transformers - Part 2: Additional requirements for current transformers
NBN EN 61869-3 Ed.1 (2011)	Instrument transformers - Part 3: Additional requirements for inductive voltage transformers
NBN EN 60073 Ed.6 (2002)	Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators
NBN EN 50110-1:2023	Operation of electrical installations
NBN EN 50181 Ed.2 (2010)	Plug-in bushings above 1 kV up to 36 kV and from 250 A to 1,25 kA for equipment other than liquid filled transformers
NBN HD 620 S3 (2023)	Distribution cables with extruded insulation for rated voltages from 3,6/6 (7,2) kV up to and including 20,8/36 (42) kV
DIN 6796 (2009-08)	Conical spring washers for bolted connections
IEC 60417 Ed.1 (2002)	Graphical symbols for use on equipment
ISO 7010: 2020 (Cor. 2020-08)	Graphical symbols - Safety colours and safety signs - Registered safety signs

Table 2: normative references

[2] Amendment 1 to be published in May/June 2024, presently in FDIS stage

4 Man-machine interface

4.1 General

The man-machine interface shall give a clear idea of:

- the way to operate the switchgear
- the status of the switching devices and other components of the FUs (e.g. circuit breaker springs charged/discharged, HV fuse blown)
- ratings of the switchgear

for the operator who is in front of the switchgear.

It consists of:

- Control interfaces of switching devices
- Synoptic
  - HV single line diagram
  - Position/status indicators
- Rating plates

The man-machine interface is applicable to all functional units (FU) used in substations accessible for the operators of the DSO.

The man-machine interface should not require any text or guideline. If for any reason text or guideline appears on or in a switchgear, it shall at least be shown in Dutch and French.

4.2 Basic rules

The man-machine interface comprises:

- control areas including the interfaces for manual operation of the switching devices
- a single line diagram with integrated mechanical position indicators of the switching devices, connecting or interrupting the electrical circuit(s) in which the corresponding switching device is located. The position indicator of the (switch)disconnector and earthing switch shall be reliable according to IEC 62271-102.

Its presentation shall be simple and logical. This ensures a clear, quick and reliable interpretation whilst standing in front of the FU. In order to achieve this requirement, the following basic rules must be set:

- The function of all operating interfaces is clearly indicated
- All operating interfaces are clearly linked to the corresponding position indicators showing the effect of operation
- Only the use of fully mechanical position/status indicators is allowed
- Unambiguous symbols shall be used
  - E.g. direction of rotation, lines, indications, …
- Any line, text, symbol, … which degrades the readability shall be omitted
- Lines and texts must be clearly visible by the operator, standing in front of the switchgear
- The use of colours and symbols shall be in accordance with the Belgian grid conventions explained in this document
- The man-machine interface is located at the front side on the FU
- The materials and fixation used ensure reliability of the man-machine interface during the entire lifetime of the switchgear.

4.3 Composition

A man-machine interface consists of lines, symbols that represent certain devices in the functional unit, position indicators for the switches, control elements integrated in colored area's and information regarding the FU.

4.4 Lines

4.4.1 General

A synoptic diagram comprises generally 2 types of lines:

- lines representing the electrical circuits (single line diagram) : continuous lines
- lines representing a link between components, or between the control interface and position indicator if not adjacent to each other : thin dotted lines

4.4.1.1 Colour of the lines

The colours of the lines used in the single line diagram are black over white background or white over black background. The colours red, yellow/green, yellow and/or green are forbidden.

4.4.1.2 Background colour and contrast with the lines

The lines themselves shall be clearly distinguishable.

4.4.1.3 Separation between FU

The interruption of the busbar between adjacent FUs shall avoid any confusion.

4.4.2 Representation of the main circuit

The main circuit is represented by a continuous line representing its path.

Figure 1 shows an example of the main circuit of one FU

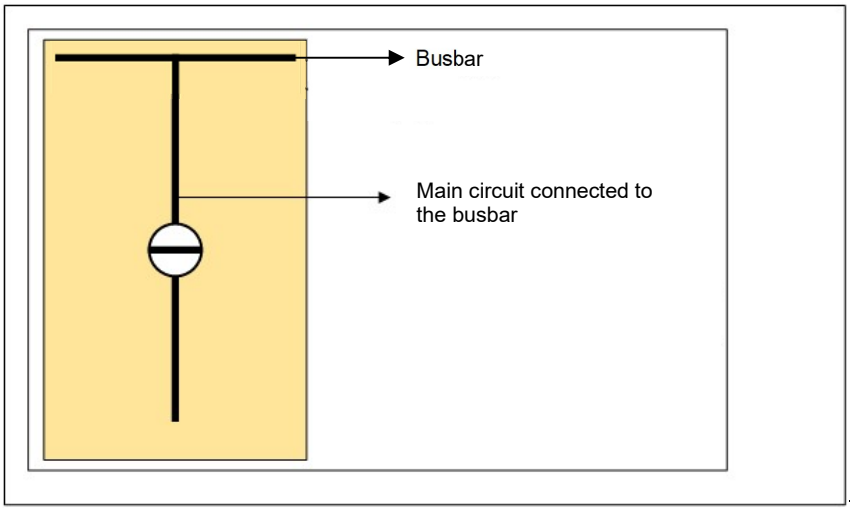


Figure 1

Any interruption in the main busbar or main circuit shall be as small as possible. It shall not exceed 50 mm (see Figures 2 and 3 below) and shall not cause any confusion.

Figure 2 shows an example of a non-extensible switchgear

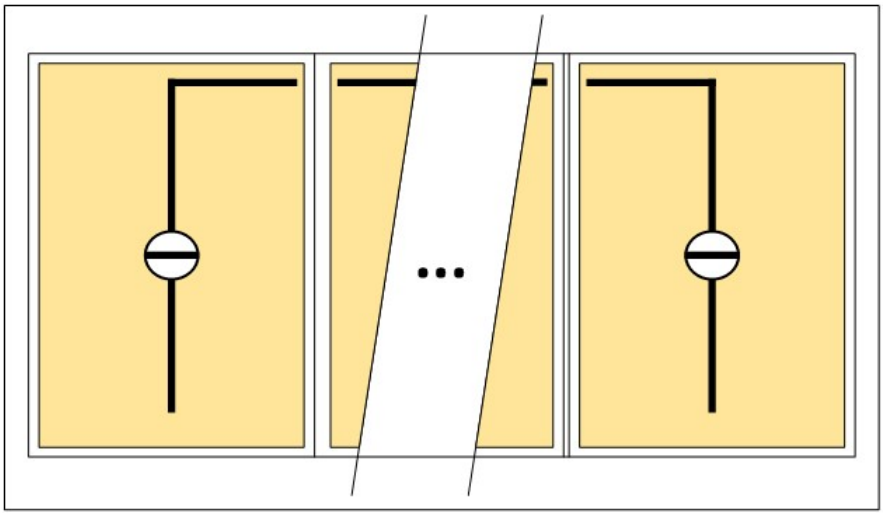


Figure 2

Figure 3 shows an example of an extensible switchgear

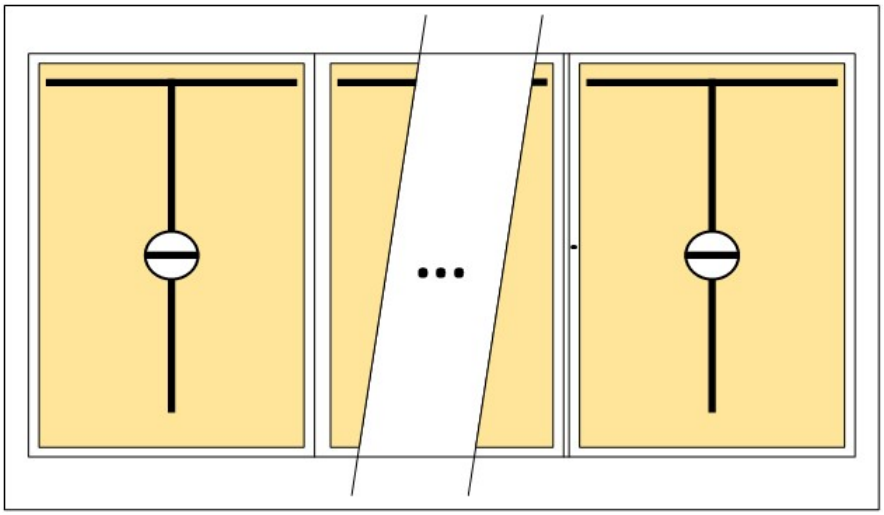


Figure 3

Figure 4 shows an example of the integration of a position indicator in the main circuit.

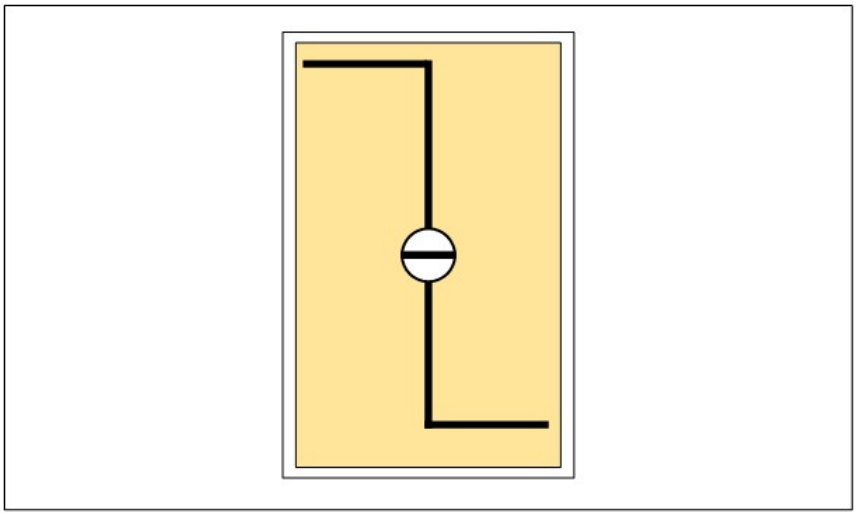


Figure 4

Figure 5 shows an example of the integration of the symbols of the metering CT and VT of a billing metering FU M

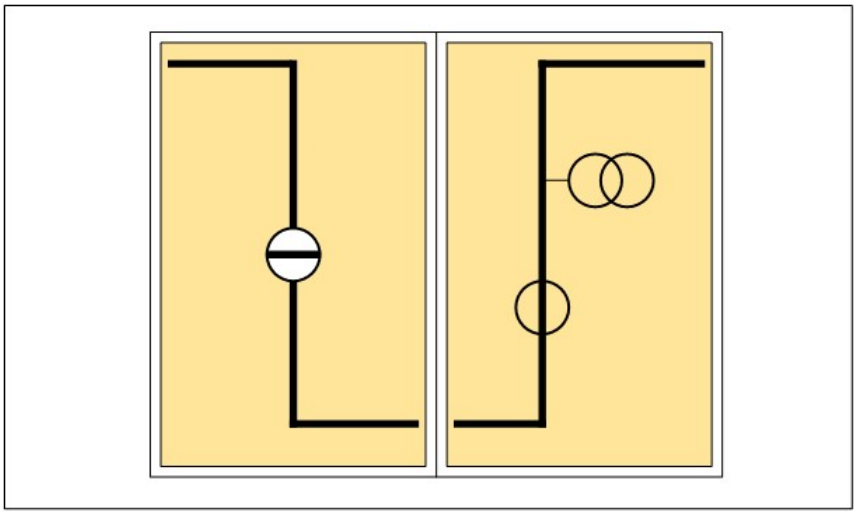


Figure 5

Figure 6 shows an example of one FU with 2 doors.

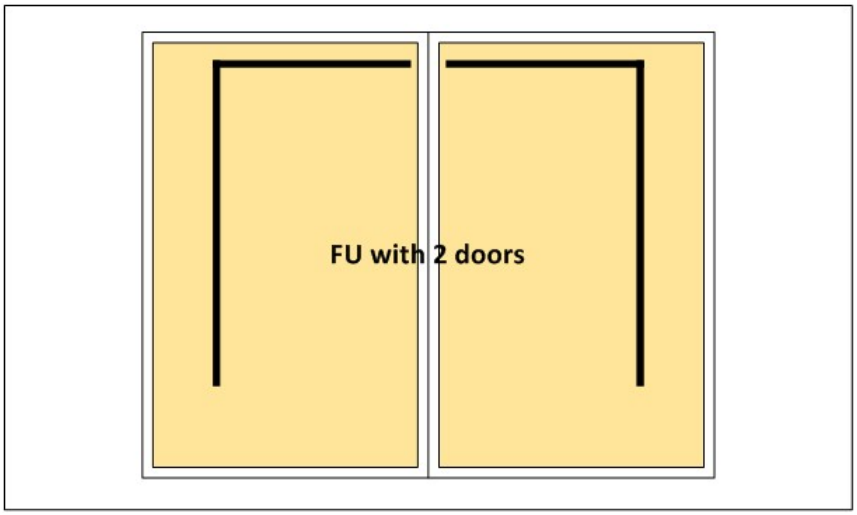


Figure 6

4.4.3 Representation of the main earthing circuit of the FU

Figure 7 shows the representation of the earthing circuit.

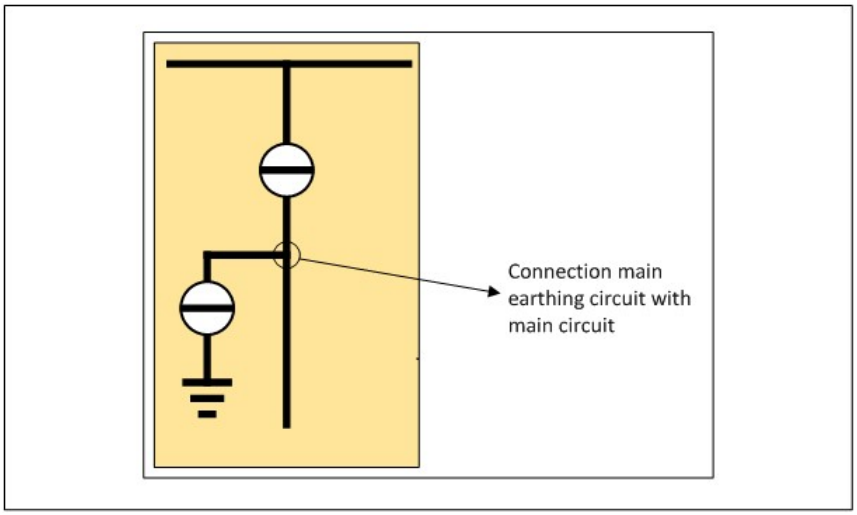


Figure 7

4.5 Symbols

4.5.1 General

The symbols of the components in or connected to the electrical circuits and the symbols of the switching devices are represented on the synoptic diagram. They have the same colour as the lines indicating the main circuit.

4.5.2 Symbols for components of the synoptic diagram

Terminal	If a FU can be connected with a HV cable, this feature is represented on the synoptic diagram. A cable connection is represented by an equilateral triangle, fully coloured and pointing downwards connected to the end point below the main circuit in derivation.	
Earthing	If a connection with the earth is displayed, withstanding the same short circuit current as the main circuit, the typical grounding symbol no. 5017 according to IEC 60417 in thick lines is used.	

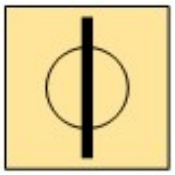
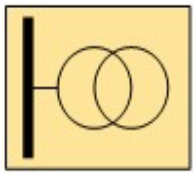
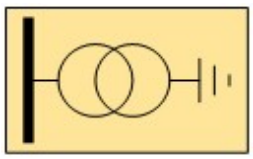
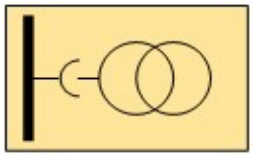
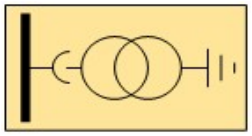
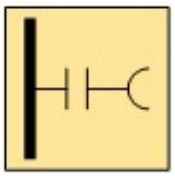
Current transformer	The current transformer (CT) is represented by a single circle which represents the primary coil. The line of the main circuit runs through this circle. Remark: Only CT's with a metering winding are represented on metering panels. CT's with only a protection winding used together with circuit breakers are never represented.	
Voltage transformer (fixed)	The voltage transformer (VT) is represented by two circles that intersect each other. A thin line runs from the main circuit to the first circle, representing the primary coil. If the voltage transformer is connected between a phase and the earth, an earth symbol no 5017 according to IEC 60417 is connected to the second circle.	 
Voltage transformers (pluggable)		 
Fuse	The fuse is represented by a rectangle. Its outlines can be thinner than that of the synoptic main circuit. Remark: the centre of the fuse symbol can be used to indicate if one of the fuses is blown.	
VDIS (voltage detecting and indicating system)	The voltage indicators are represented by the symbol of a capacitor linked to the main circuit on one side and to a plug represented by a half circle on the other side. The symbol to be used is symbol no 5017 according to IEC 60417. It is located where the capacitive divider is connected to the main circuit in the single line diagram	
Arc mitigation system	The arc mitigation device is represented by the symbol in the right column. This symbol shall be visible on the front on a non-removable part of the enclosure.	
HV cable test plug	The high voltage cable test plugs are represented by the symbol in the right column	

Table 3

4.5.3 Symbols for switching devices

Symbols for switching devices according to the standard IEC 60617 shall be printed in the control zone of the switching device in black on a white background. If the position indicator of a switching device is far from its control zone, the symbol shall be repeated next to the position indicator.

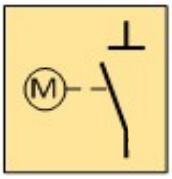
Switches	disconnector	
	switch	
	switch-disconnector Remark: Only switching devices where the clearance between open contacts is designed to meet the functional requirements specified for disconnectors are allowed.	
	earthing switch	
	circuit breaker	
Motorisation	The symbol for the motorisation of a switch is an encircled letter M. This symbol is placed next to the symbol for the switch and is connected with it by a dashed line. The symbol of the switch is random in this example	

Table 4

4.6 Indicators

4.6.1 Generalities

The paragraphs hereafter describe 3 types of indicators:

- position indicators of the switching devices
- state indicators of components
- status indicator to check dielectric withstand ability of the insulating medium in the gas-filled compartment

4.6.2 Location of the indicator

The position indicators of the switching devices shall be integrated in the HV single line diagram. They shall connect or interrupt the HV single line diagram representing the circuit, depending on the position of the switching device as shown in Figures 1 to 5 and Figure 7.

4.6.3 Colour and display

A similar colour shall be used as for the HV single line diagram.

The position indicator of a circuit-breaker shall be represented with a horizontal line for the open position and a vertical line for the closed position. Hence, the single line crossing the position indicator of the circuit-breaker shall be vertical. It is allowed to have a "O" instead of a horizontal line and a "I" instead of a vertical line for the indication of the open respectively closed position of the circuit-breaker.

4.6.4 Position indicators

The Tables 5 and 6 below show possible examples of position indicators

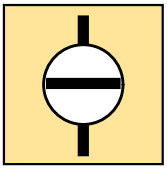
2 position switch for a disconnector, a switch-disconnector and an earthing switch			
	Closed position	Open position	
3 position switch for a disconnector or a switch-disconnector combined with an earthing switch			
	Closed position	Open position	Earthed position

Table 5

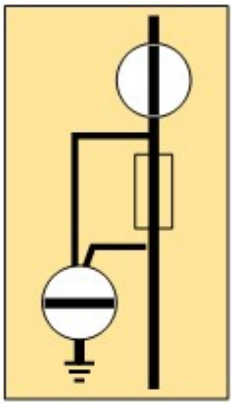
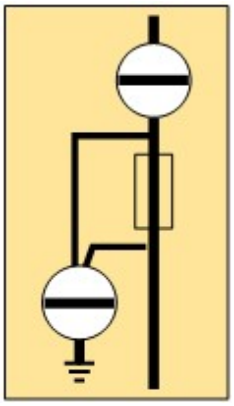
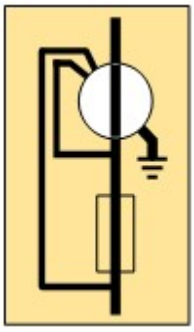
2 position switch for a switch-fuse combination with fuses and 2 earthing switches with one common position indicator			
	Closed position	Open position	Earthed position
3 position switch for switch-fuse combination with fuses and earthing switch and 1 supplementary earthing switch, integrated in one common position indicator			
	Closed position	Open position	Earthed position

Table 6

Table 7 shows the possibilities of position indication for a circuit breaker functional unit.

Position indicator of the circuit breaker with a line	• open position “-” (transverse line) • closed position “I” (in line)	
Position indicator of the circuit breaker with I & O	• open position “O” • closed position “I”	Colours: Red & Green can never be used on a position indicator

Table 7

A symbol "M" is placed near the position indicator of the motorised switching device (according to the standard IEC 60617). A dashed line connects the symbol “M” to this indicator (see also last figure in Table 4 of the motorisation symbol).
If the motorisation is used to pre-accumulate latched energy as a preparatory action, the symbol "M" shall not be used.

4.6.5 Status indicators of components

Basic rules:

- Circuit-breakers with fast auto-reclosing (DKNx) shall be equipped with a status indicator of the energy storage in the spring (charged or discharged). This indicator shall be mechanical.
- Circuit-breakers with fast auto-reclosing (DKNx) shall be equipped with a mechanical operations counter.
- FUs with arc mitigation system shall be equipped with a status indicator of this arc mitigation system. This indicator can be either integrated in the pressure indicator, or mechanical. In any case, the status of an activated arc suppression system can only be reset by a manual action.
- Switchgear/FUs with gas-filled compartment shall be equipped with a status indicator to check the dielectric withstand ability of the insulating medium in the gas-filled compartment.

4.6.5.1 Status indicator of the energy storage in a spring

The spring status indicator shall consist of symbols corresponding to both possible charged and discharged status. It shall be combined with a legend explaining both possible statuses.

Table 8 shows possible ways to display the status of the spring

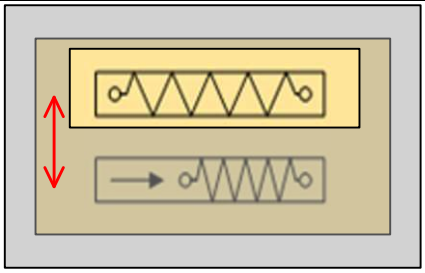
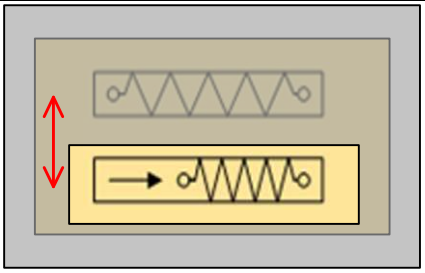
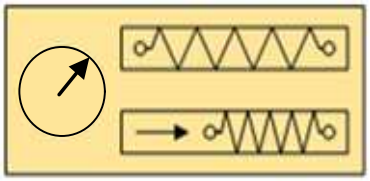
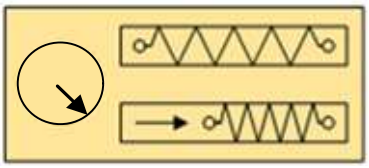
	Spring discharged	Spring charged
Only one of the symbols is visible while the other is hidden		
Both positions are displayed and an arrow indicates the status		

Table 8

4.6.5.2 Status indicator of an arc mitigation system

This indicator may not be integrated in the single line diagram. It shall be placed on a neutral place on the man-machine interface, e.g. on the manometer, avoiding any confusion with the indicators needed for the normal operations.
The arc mitigation system symbol shown in table 3 shall be placed next to the status indicator of this system.
If needed for reasons of clarity, the status indicator of the arc mitigation system shall be combined with a legend explaining all possible statuses.

4.6.5.3 Status indicator to check the dielectric withstand ability of the insulating medium in the gas-filled compartment

The dielectric withstand ability of the insulating gas can be checked in service. The control device shall not be influenced by ambient conditions (e.g. temperature).
The indicator is mandatory for FUs/switchgear with a gas-filled compartment. It shall be analogue and will allow a local visual check without the need of any auxiliary supply.
This status indicator shall be combined with a legend explaining all possible statuses.

4.7 Control zones and control buttons

4.7.1 General

This section explains all the details concerning the control zones of the FU. The operating interfaces are located in well-defined control zones to aid the operator selecting the required controls.

4.7.2 Control zone

The operating interfaces shall be integrated in coloured control zones:

- red for:
  - disconnectors,
  - switch-disconnectors,
  - switch-fuse combination,
  - circuit-breakers,
- yellow/green shaded for earthing-switches

Note: the interface to charge a spring and pre-accumulate energy that shall be latched is not considered as an operating interface and does not need to be integrated in a control zone. The same philosophy applies for all other switches that need more than one action to complete an operation.

4.7.3 Content of the control zone

A control zone includes:

- A small pad with the symbol of the controlled switching device as represented in Table 4 in black over white background.
- Pictograms O (open) and I (close) according to IEC 60417 (n°5007 & 5008) as visualized in Table 9 and in case of rotating action, arrows indicating the senses of rotation around the operating axis for the closing and opening operations.

closing		pictogram conforming to IEC 60417 (no. 5007)
opening		pictogram conforming to IEC 60417 (no. 5008)

Table 9

4.7.4 Control buttons

If two separate control buttons (mechanical activations) are used to open and close the switch, they both may be located in one single control zone. The pictograms "O" and "I" may be integrated onto the control buttons. The colour of the buttons and their pictograms are according to the standard NBN EN 60073 §5.2.1.4:

- the control button for the opening/disconnecting action has a black background with a white “O”;
- the control button for the closing/connection action has a white background with a black “I”.

It is also permitted to use the green (I) and red (O) colours.
In case of one unique button to trip/open a switch-fuse combination or a circuit-breaker of FU DxGx, this button must be red, with the required contrast, according to the standard NBN EN 60073, Table 9.
In any case, within a FU, one colour scheme shall be applied to avoid any possible confusion.

4.7.5 Motorised/automatic control

A local electrical operation of the motorisation is not allowed for FUs KKNx.

4.8 Information (other indicators)

4.8.1 Name plate

For modular cubicles, a name plate is applied for each cubicle. For RMUs, one name plate containing the general information may be provided per unit (block). Additionally, and per function, a name plate for the specific data of that function must be provided. The nameplate should contain all the information which must be specified according to the standard (in accordance with clause 6.11 of the standard NBN EN 62271-200). The name plate must be incorporated in the man-machine interface.

In addition to this data, the name plate also states:

- The "AAxx" category according to the prescription C2/113-7
- The code according to C2/119 for every FU
- The Synergid homologation reference (see C2/113-0)
- The applicable cable test voltage U_{ct} (d.c.)

4.8.2 Holder for feeder identification

The man-machine interface shall be fitted with an identification holder for every FU KKNx and DKNx.
This holder shall have a transparent cover with minimum dimensions of height (H) x width (W) = 40x150 mm.
This holder shall be located at the top of the FU or in an area near to the full triangle that represent the cables connection point.
They shall be mounted on (a) cover(s) on the FU(s) that cannot be dismantled without tools to minimise the risk of being interchanged.

4.8.3 Service voltage range for the Voltage Detection and Indicating System (VDIS)

The service voltage range shall be indicated next to the VDIS interface.

4.8.4 Fault Current Indicator (FCI)

The FCI will be part of the man-machine interface. The cutout for the FCI shall therefore be placed on the front side of the switchgear.

The additional requirements for incorporating the FCI are described in §9.4 of this document.

The type of FCI used by the different DSOs is indicated in the DSO specific requirements C2/113-5.

The following brands and types of FCI are used by the different DSOs:

- Horstmann type Compass A and Compass B
- Kries type IKI 50

5 Voltage Detection and Indicating System (VDIS)

Only integrated, capacitive VDIS according NBN EN 62271-213 are accepted.

The VDIS is mandatory for FU KKNx and FU DKNx.

The VDIS should be mounted horizontally and placed at the front, readable by the operator in front of the switchgear.

The VDS shall be mounted on a non-removable front cover in case it is flush-mounted.

The type of VDIS used by the different DSOs is indicated in the DSO specific requirements C2/113-5.

The same type of VDIS shall be used for the FU KKNx and for FU DKNx used as DSO feeder in one same installation.

6 Specific requirements for a HV billing metering function

6.1 General

This chapter describes the specific requirements for a HV billing metering function with code Mxxx according C2/119 intended to be used in a Client installation to be connected to the public HV distribution grid of a Belgian DSO.

The billing metering function and its current and voltage transformers shall also comply with the requirements specified in the Synergrid technical specification C2/113-3.

The billing metering function shall comprise 3 current transformers (CTs) and 3 voltage transformers (VTs). The VTs shall be connected between phase and earth. The billing metering FU shall be fully equipped by its manufacturer. This includes the mounting as well as the primary and secondary connections of the CTs and VTs.

The VTs shall be connected downstream of the CTs so that the burden of the VTs is included in the kWh measurement. The CTs and VTs connection scheme shall comply with the 3-Wattmeter method.

A HV billing metering FU shall not include HV switching device(s).

It is not allowed to install a protection against short-circuits through HV fuses on the primary side of VTs.

CTs and VTs with double primary and/or secondary windings are in principle not accepted, except if otherwise specified in the DSO specific requirements C2/113-5.

The billing metering function may be equipped with a second set of VTs if necessary. The second set of VTs shall only be used for voltage metering or for the connection of a network decoupling relay. The billing metering function with 2 sets of VTs shall also be subject to homologation.

Splitting up of the secondary VT circuit is in principle not accepted, except if otherwise specified in the complementary prescription C2/113-5 of some DSO's.

The manufacturer shall indicate with which types of CTs and VTs the functional unit is homologated.
He shall deliver the CTs and VTs. They shall be installed in advance by the manufacturer.

The internal LV wiring and their connection up on the LV terminals is done by the manufacturer. The manufacturer bears the responsibility for the correct LV wiring of the instrument transformers. The LV wiring shall be checked according subclause 7.10.5 of NBN EN 62271-1 and this check shall be reported in a routine test report.

6.2 Design and construction

6.2.1 General aspects

The billing metering function shall comprise at least two (2) compartments:

- an ambient air insulated HV metering compartment
- a LV compartment

The HV metering compartment shall have one (or more) front door(s) or (a) removable front cover(s). This compartment shall have tool based access, regardless of the aforementioned design.

The LV compartment shall have a front door or a removable front cover.

The sole possible access to the HV and LV compartments shall be through their front door(s) or cover(s).

The front door(s) or cover(s) of both the HV and the LV compartments shall be independently fitted with a padlock facility. Provision of a sealable bolt instead of a padlock facility is not acceptable.

It shall not be possible to remove parts of the enclosure from the outside for both LV and HV compartments without opening the respective front door(s) or front cover(s) of this (these) compartment(s).

The HV metering compartment comprises :

- 3 CTs and 3 VTs
- The primary connections to adjacent (up- and downstream) installed functional units
- A bottom plate equipped with cable sealings for cable entrance and cable clamps in case the billing metering function is connected by means of incoming and/or outgoing MV power cables
- One spherical earthing point with diameter 20mm on each phase, installed downstream of the VTs in such a way that a removable earthing (20kA-1s) can be connected to this earthing point

The CTs and VTs shall in any circumstances be accessible.

A fourth spherical earthing point (with diameter 20mm), connected to the earthing circuit, shall be placed in principle on the outside of the enclosure. In case the fourth spherical point is placed inside the HV metering compartment, closing of the door(s) or placement of the front cover(s) shall be prevented as long as the removable earthing is connected to the metering function. It is acceptable to equip a HV metering function of category AA10 with three spherical earthing points that are connected to the earthing circuit instead of one single (fourth) spherical earthing point.

The LV compartment comprises:

- A LV terminal block for the secondary CT circuits
- A 4-pole fuse-switch for the secondary VT circuits.
- 2 cable glands/grommets allowing LV cables outlet out of the metering FU; routing through the LV compartments of the adjacent FUs or through the HV compartment of the metering function is not allowed.

The LV terminal block for the secondary CT circuits shall be non-interruptible and equipped with:

- Short-circuit facility for which both short-circuited and opened position shall be clearly visible
- A test plug of 4 mm diameter on each phase and neutral terminal

The 4-pole fuse-switch for the secondary VT circuits shall be equipped with:

- Either a LV fuse with rating 0,5 A or a cylindrical link (conductor) for each phase, depending on the DSO specific requirements mentioned in document C2/113-5
- A switchable neutral containing a cylindrical link (conductor)

The LV wiring from the secondary terminals of the CTs and VTs to the LV compartment shall be done by means of 2 separate uninterrupted[3] cables type LIYY or LiHH:

- LIYY or LiHH 6 x 2,5mm² for the secondary CT circuits, directly connected to the LV terminal block
- LIYY or LiHH 4 x 2,5mm² for the secondary VT circuits, directly connected to the 4 pole fuse-switch

The LV wiring from the secondary terminals of the CTs and VTs to the LV compartment shall ensure double insulation. It shall be mechanically protected in the HV metering compartment.

The LV cables must be connected and routed in such a way that they are running outside the zone of electrical influence of the CTs and VTs and that they do not hinder the intervention when the HV compartment is opened.

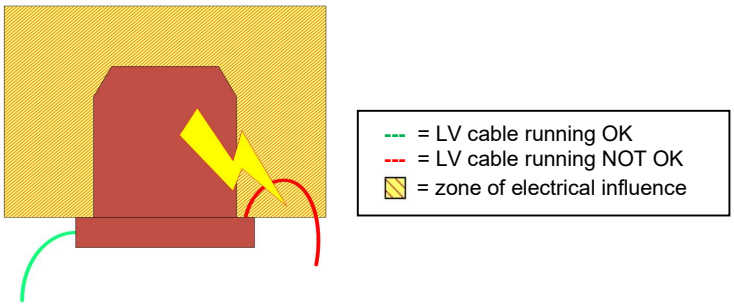


Figure 8: zone of electrical influence of CTs and VTs

In order to ensure proof against fraud on the LV wiring of the CTs and VTs:

- If present, the busbar connections between the HV metering compartment in the metering FU and the adjacent HV compartments in the metering FU or in the adjacent FUs shall run through busbar bushings in IP2X segregation plates. It shall not be possible to remove those plates from the adjacent HV compartments or FUs.
- If present, the cables connections between the HV metering compartment in the metering FU and the adjacent HV compartments in the metering FU or in the adjacent FUs or the cellar shall pass through IP2X partitions. It shall not be possible to remove those plates from the adjacent HV compartments or FUs.

6.2.2 CT mounting and wiring of secondary CT circuits

The CTs are mounted on an earthed base plate which is part of the metering function.

The visual earthing of the metallic base plate of the CTs shall be done by connecting the base plate to the main earthing bar through a green-yellow wire or a bare copper conductor with yellow/green marking. The minimum cross section of this conductor shall be 6mm².

[3] The use of connectors is not allowed

The secondary terminal "s2" shall be visually earthed. Hence, the use of an earthing screw on the “s2” terminal is not acceptable. The earthing shall be done by means of a green-yellow wire or a bare copper conductor with yellow/green marking which shall be connected to the earthing terminal of the metallic base plate (chassis) of the CT or directly to the earth collector: see Figures 9 and 10 in §6.2.5. The cross section shall be 2,5mm² if the earthing conductor is mechanically protected or 4mm² if this conductor is not mechanically protected.

The colour code of the wiring from the secondary terminals of the CT to the LV terminal block in the LV compartment is according the standardized colour scheme of a 6 cores LIYY or LiHH cable:

- Phase L1: Brown / Brown-Black
- Phase L2: Grey / Grey-Black
- Phase L3: Red / Red-Black

The coloured LV wires of the LIYY or LIHH cable shall be connected to the secondary terminals of the CTs according to the schematic diagram in Figures 9 and 10 in §6.2.5. For the CTs, the unicolor wires are connected to the terminal “s1” and the two-tones wires are connected to the terminal “s2”.

Each core of the 6 cores LIYY or LiHH cable shall have a cross section of 2,5mm².

Mounting and wiring of the CTs shall be such that primary and secondary connections can be easily checked, i.e. the connections shall be accessible and readable.

6.2.3 VT mounting and wiring of secondary VT circuits

The VTs are mounted on an earthed base plate part of the metering function.

The visual earthing of the metallic base plate of the VTs shall be done by connecting the base plate to the main earthing bar through a green-yellow wire or a bare copper conductor with yellow/green marking. The minimum cross section of this conductor shall be 6mm².

The terminals “n” and “N” shall be visually earthed. Hence, the use of an earthing screw for terminals “n” and “N” is not acceptable. The earthing shall be done by means of a green-yellow wire or a bare copper conductor with yellow/green marking which shall be connected to the earthing terminal of the metallic base plate of the VT or directly to the earth collector: see Figures 9 and 10 in §6.2.5. The cross section shall be 2,5mm² if the earthing conductor is mechanically protected or 4mm² if this conductor is not mechanically protected.

The colour code of the wiring from the secondary terminals of the VT to the 4-poles fuse-switch in the LV compartment is according the standardized colour scheme of a 4 cores LIYY or LiHH cable:

- Phase L1: Brown
- Phase L2: Grey
- Phase L3: Red
- Neutral “n”: Blue

The coloured LV wires of the LIYY or LIHH cable shall be connected to the secondary terminals of the VTs according to the schematic diagram represented in Figures 9 and 10 in §6.2.5.

Each core of the 4 cores LIYY or LiHH cable shall have a cross section of 2,5mm².

The wiring of the secondary star-point of the VTs, i.e. interconnecting the “n”- terminal of the 3 VTs, shall be done by means of a blue coloured wire with cross section 2,5mm².

Mounting and wiring of the VTs shall be such that primary and secondary connections can be easily checked, i.e. the connections shall be accessible and readable.

6.2.4 Nameplates and markings

The nameplate of the metering function shall contain the information specified in subclause 6.11 of NBN EN 62271-200. In addition, the following data shall be mentioned on the name plate:

- Synergrid category AAxx according to C2/113-7
- Internal arc classification IAC (if assigned):
    - Arc fault current and duration IA, tA for category AA3x
    - Single-phase-to-earth arc fault current and duration IAe, tAe for category AA10
- Code Mxxx according to C2/119

The nameplate of the CT shall contain the information specified in subclause 6.13.202 of NBN EN 61869-2, considering the rated values specified in C2/113-3 §4.2

The nameplate of the VT shall contain the information specified in subclause 6.13.302 of NBN EN 61869-3, considering the rated values specified in C2/113-3 §4.2

A second nameplate (duplicate) of the VTs and CTs shall be placed on a location accessible by the DSO, preferably on the outside of the front door (or cover) of the LV compartment or HV metering compartment. It shall be possible for the DSO to check the nameplate on the CTs and VTs with the duplicate during commissioning.

For billing metering functions with code MKK, a connection diagram illustrating the physical layout of the connections at the primary terminals of the CTs and VTs in the HV metering compartment shall be represented on an adhesive label or plasticised paper, stuck in a visible place at the inside of the HV metering compartment front door or cover.

The wiring diagrams of the complete secondary CTs and VTs circuits shall be present in the LV compartment.

A phase indication L1 – L2 – L3 shall be present in the HV metering compartment.

6.2.5 Schematic diagrams

The schematic diagrams are illustrated in Figures 9 and 10 below.

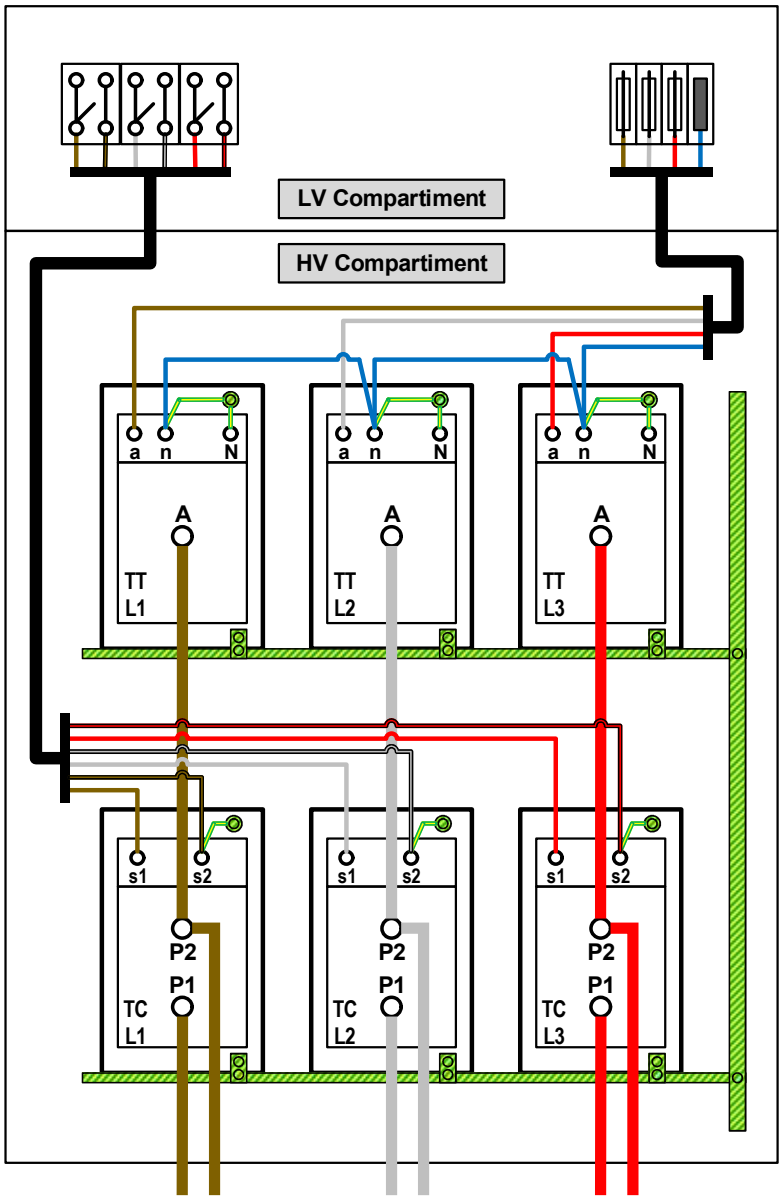


Figure 9:
terminals “n” and “N” (VTs) & “s2” (CTs) connected to the earthing terminal of VTs resp. CTs metallic base plate

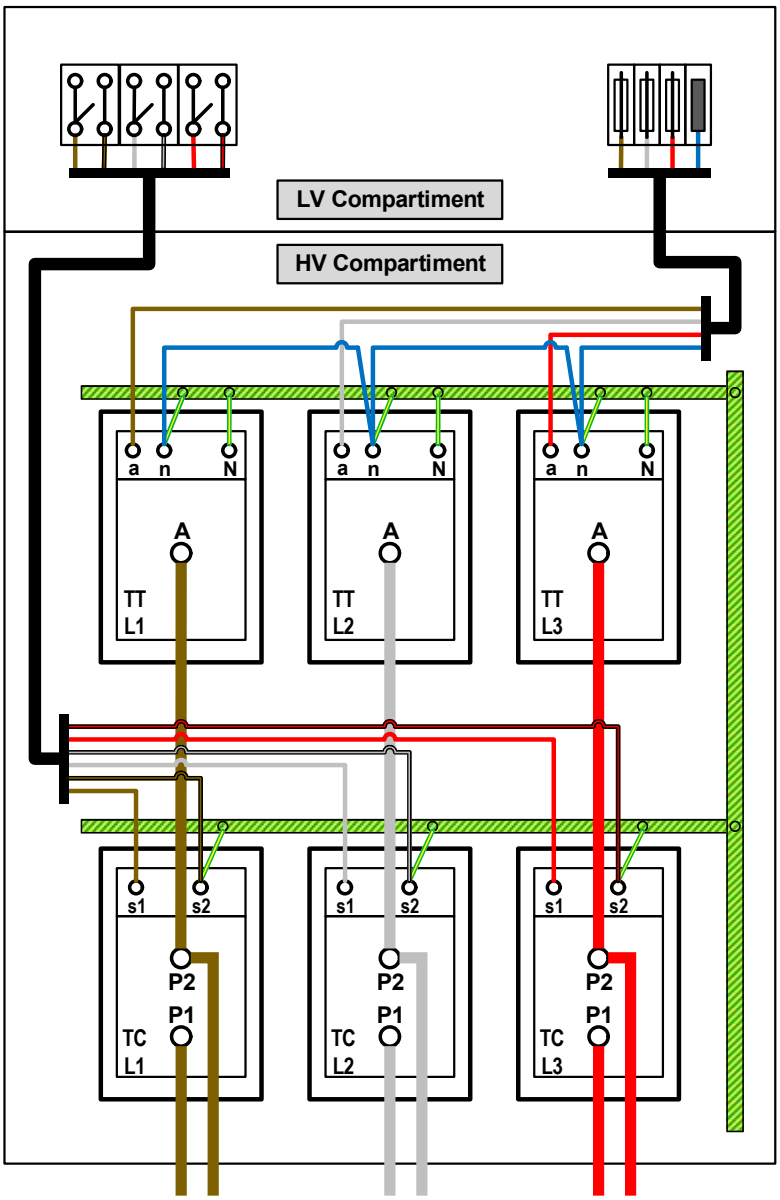


Figure 10:
terminals “n” and “N” (VTs) & “s2” (CTs) directly connected to the earthing collector

7 Practical requirements for cable connections

7.1 General

This chapter describes the practical requirements in relation to the connection of cables in the cable compartment of FU KKNx and FU DKNx. A difference is made between HV switchgear of categories AA1x/AA20 and switchgear categories of AA3x.

The following requirements apply in general for all HV switchgear regardless the assigned AAxx category(-ies):

- All cables connected to functional units are single-phase high voltage cables.
- The HV cables for connection to a distribution grid range from 150 mm² to 240 mm². All HV cables are in accordance with NBN HD 620. If connection with 400 mm² is necessary, the requirements are indicated in the DSO specific requirements C2/113-5.

7.2 HV switchgear of category AA1x/AA20

The cables to be connected to this category of switchgear have terminations made of screened insulated elbow plug connectors.

The interface for cable connection shall be outer cone type C in accordance with NBN EN 50181, size C1 cones (Ir = 630A).

They shall be horizontal and frontally arranged.

For FU KKNx, the minimum required height available between the centre of the outer cone and the top of the cable fixation clamp in the cable compartment is 425 mm, that is 375 mm for the HV cables connectors + 50 mm for the current sensors of the FCI as shown on the left in Fig 11. A minimum required available height of 375 mm for only the HV cables connectors is also allowed at the condition that a 2nd minimum required available height of 100 mm for the current sensors of the FCI is available between the underside of the cable clamps and the bottom of the cables compartment, as shown on the right in Fig 11, and that the material of the cable clamps is insulating.

For FU DKNx, the minimum required height available for the HV cables connectors in the cable compartment is 375 mm. This height is measured between the centre of the outer cone and the top of the current transformers (CTs), as shown on the left in Figure 12 below, when the CTs are mounted around the cables above the cable clamps. If the CTs are mounted on the bushings, this height is measured between the centre of the outer cone and the top of the cable fixation clamps, as shown on the right in Fig 12 below.

For FU KKNx, the height of the interface for the cable connection measured between floor of the switchgear and the centre of the outer cone, shall be at least 800 mm. If this height is < 800 mm, the switchgear manufacturer shall provide an appropriate raising base frame to reach this height between the floor of the switchgear room and the centre of the outer cone after installation.

The cable compartment of FUs KKNx and DKNx shall contain:

- cable fixation clamps covering the aforementioned range of the cables.

  The cable clamps are positioned inside the functional unit, and are part of the switchgear.
  The cable clamps shall be accessible from the opened cable compartment and can be mounted easily on the connected cables, using the prescribed tools.
  The holes for the cables in the cable clamps shall be aligned with the vertical part of the elbow connectors.

- An earthing circuit with at least one earthing M8 connection point per phase for the connection of the cable shield and/or the earthing wire of the HV-connector.

  The connection points shall be positioned as such that they are accessible from the opened cable compartment with the cables mounted.

- For FU KKNx, the space to mount the current sensors of fault current indicators (FCI) along the cables. This space shall be present on every phase, below the cable connectors.

  The current sensors can be either mounted above the cable clamps according to the left of Fig 11 or below the cable clamps according to the right of Fig 11. In any case, they shall always be mounted above the bottom of the switchgear.

  The current sensors shall be easily mountable from the opened/removed cable compartment door/cover, with the other cables and sensors already mounted.

- For FU DKNx, the space to mount the ring core LV current transformers (CTs) of the overcurrent protection relay. The CTs are mounted either on the bushings or around the cables.

If the cable compartment is fitted with bottom plates, then it shall fulfil the following requirements:

- It shall consist of different removable parts allowing efficient connection of the cables.
- These bottom plates shall seal the cable compartment after mounting the cables.
- The holes for the cables entries in the bottom plate shall be aligned with the vertical part of the elbow connectors and contain as many cable entries as there are cable clamps. All unused cable entries (spares) shall be closed.

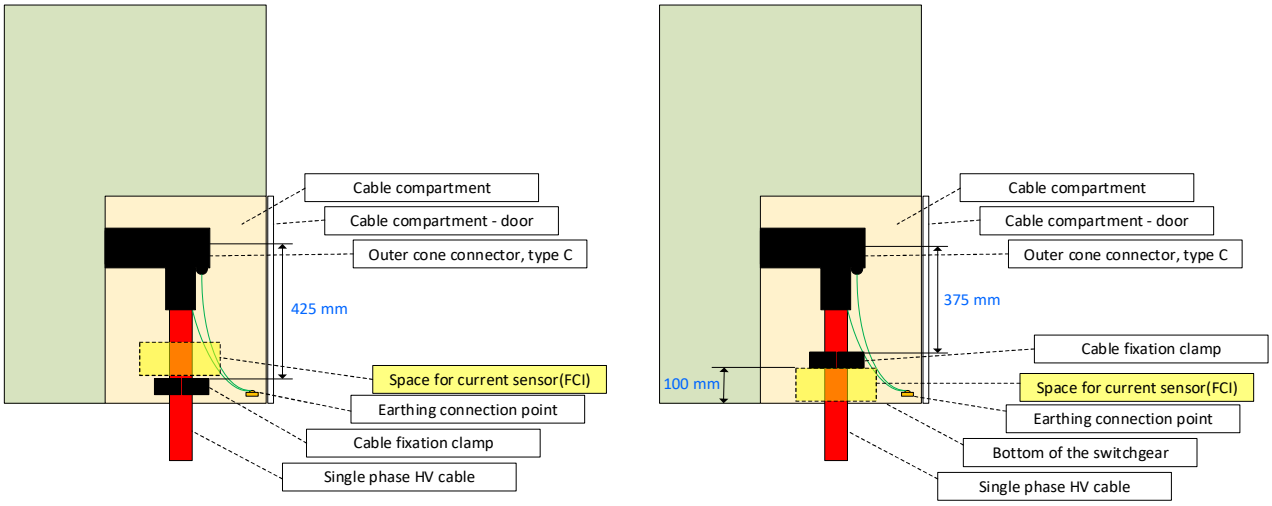


Figure 11: arrangements of the cable compartment for FU KKNx of categories AA1x/AA20

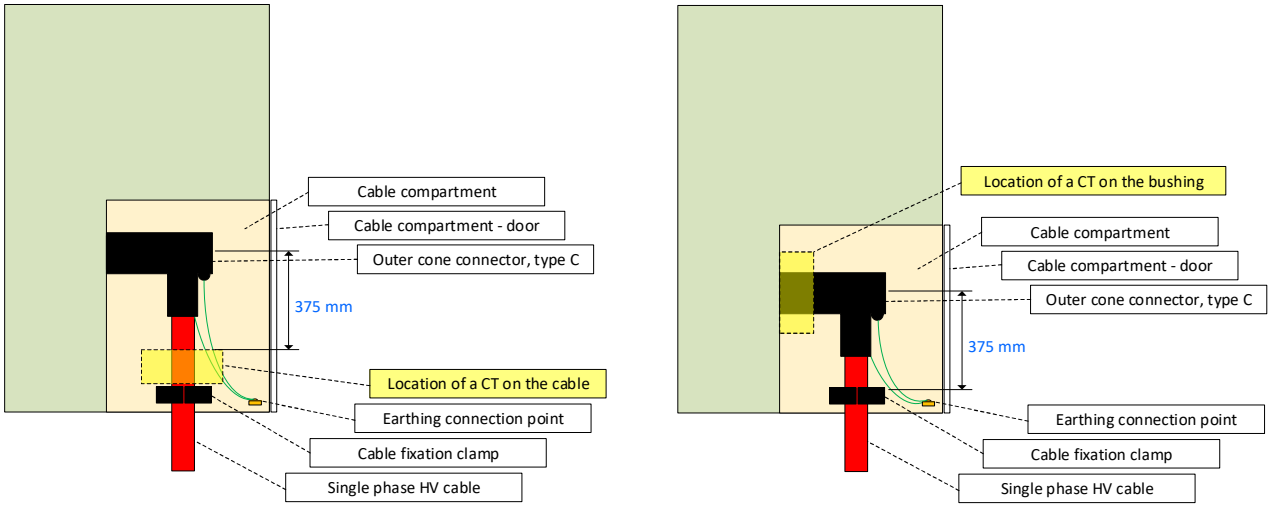


Figure 12: arrangements of the cable compartment for FU DKNx of categories AA1x/AA20

7.3 HV switchgear of category AA3x

The cables to be connected to this category of switchgear have terminations with field repartition in ambient air and with a cable lug.

The interface for cable connection shall be a connection flag, fitted with a fixed (prisoner) screw or stud size M12, with a minimum length 35 mm and with a conical spring washer according to DIN 6796, a plain washer and a nut M12.

One cable lug shall be mounted per connection flag. If more than one cable lug is mounted per connection flag, only side by side connection is allowed. The connection area on the terminal flag shall cover the entire connection area of the cable lug, without compromising the isolating distance of the cable termination.

The arrangement of the cables connection flags and the available space around them shall allow the connection of the HV cables by one person.

The FUs KKNx and DKNx shall have a minimum width of 500 mm.

For FU KKNx, the minimum required height available between the centre of the hole in the connection flag and the top of the cable fixation clamp in the cable compartment is 500 mm, that is 450 mm for the HV cables terminations + 50 mm for the current sensors of the FCI as shown on the left in Fig 14. A minimum required available height of 450 mm for only the HV cables terminations is also allowed at the condition that a 2nd minimum required available height of 100 mm for the current sensors of the FCI is available between the underside of the cable clamps and the upper side of the bottom plates of the cables compartment, as shown on the right in Fig 14, and that the cable clamps are made of insulating material.

For FU DKNx, the minimum required height available for the HV cables terminations in the cable compartment is 450 mm. With bloc type CTs, this height is measured between the centre of the hole in the connection flag and the top of the cable fixation clamps. With LV ring cores CTs placed in the bottom of the cables compartment, this height is measured between the centre of the hole in the connection flag and the top of the CTs.

The cable compartment of FUs KKNx and DKNx shall contain:

- cable fixation clamps, covering the aforementioned range of the cables.

  The cable clamps are positioned inside the functional unit, and are part of the switchgear.
  The cable clamps shall be accessible from the opened cable compartment and mounted easily on the connected cables, using the prescribed tools.

- A bottom plate, consisting of different removable parts enabling efficient connection of the cables.

  These bottom plates shall seal the cables compartment after mounting the cables.

  The bottom plate shall contain as many cable entries as there are cable clamps. All unused cable entries (spares) shall be closed.

  The bottom plates and the cable fixation clamps are designed in order to allow easy connection of HV cables with cross-section varying from 150 mm² to 400 mm². The cable entries in the bottom plate and the holes for the cables in the cable clamps shall be vertically aligned with the connection flags plus an offset of 25 mm corresponding to the distance between the contact surface and the axis of the barrel of the cable lug as shown in Figure 13 below.

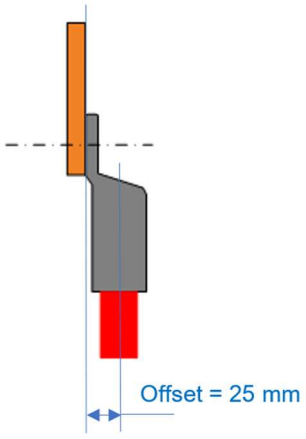


Figure 13: cable connection lug with an offset equal to 25 mm

- An earthing circuit with at least one earthing M8 connection point per phase for the connection of the cable shield.

  The connection points shall be positioned as such that they are accessible from the opened cable compartment with the cables mounted and no extension of the cable screen or earthing wire is necessary.

- A connection point on each phase (e.g. a temporary spherical bolt or a threaded stud) for connecting the cable testing equipment.

- For FU KKNx, the space to mount the current sensors of fault current indicators (FCI) along the cables. This space shall be present on every phase, below the cable terminations.

  The current sensors can be mounted either above the cable clamps as shown on the left of Fig. 14 or below the cable clamps according to the right of Fig. 14. In any case, they shall always be mounted above the bottom plate of the switchgear.

  The current sensors shall be easily mountable from the opened/removed cable compartment door/cover, with the other cables and sensors already mounted.

  A sheath with internal diameter > 28 mm for routing and protecting the connection cables from the current sensors to the FCI shall be installed on the internal wall of the cable compartment.
  This sheath shall be:
  - correctly fixed on the internal wall
  - running to the area where the current sensors will be installed
  - routed in such a way that it is running outside the zone of electrical influence from HV active parts

- For FU DKNx, the space to mount the current transformers (CTs) of the overcurrent protection relay. The CTs can be bloc-type CTs mounted upstream the HV cable connection flags or ring core LV CTs mounted around the cables above the cable clamps and the cable floor.

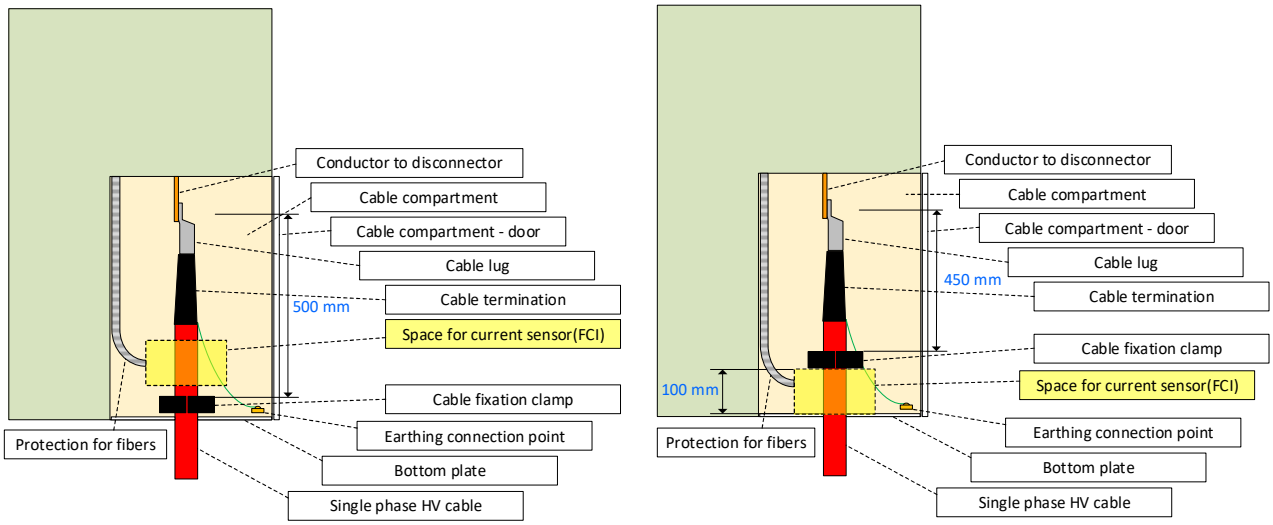


Figure 14: arrangements of the cable compartment for FU KKNx of category AA3x

8 Accessibility to compartments, LSC category & interlocks

8.1 Accessibility to compartments

Every non-interlocked door, cover or partition, removable from its accessible side, and giving access to hazardous HV live parts, shall be fitted with the symbol ISO 7010 code W012. 

The following accessibility requirements apply to FUs KKNx, to DKNx and to FU M:

- FUs KKNx & DKNx:
  - Cables compartment : interlock-based access
  - Test plug compartment (if present): interlock-based access
  - Other HV compartments
    (busbar – (switch)-disconnector – circuit-breaker - other than cables compartment)
    - sealed for life : inaccessible
    - ambient air insulated : tool-based access
  - Low voltage compartment:
    - DKNx : door with handle (without key lock)
- FU M:
  - HV metering compartment and LV compartment :
    - Front side : padlockable
    - Other side : not dismantlable from outside

8.2 LSC category

The following minimum loss of service continuity (LSC) categories are required for every FU in function of the type of FU :

- FUs KKNx, DKNx, DxGx, TxGx: LSC2
- FU M : LSC1

8.3 Interlocks

8.3.1 Scope

The following interlock requirements apply to:

- FUs KKNx and DKNx
- FUs DxGx and TxGx
- FUs KKUx, DKUx and TKUx

8.3.2 General principles

The switching devices and the doors/covers of interlock-accessible compartments in the same functional unit shall be automatically interlocked in order to avoid any operation endangering:

- the safety of DSO's personal
- the service continuity.

Interlocks shall prevent:

- to operate a switching device in unsafe condition(s) of the switchgear
- to remotely operate a switching device in abnormal condition(s) of the switchgear (e.g. pressure below p_{me}, operation of arc suppressor, …)
- to operate a disconnector under load
- to perform manual and motorized operation simultaneously that lead to harmful consequences
- to earth a part of a main circuit as long as it is not disconnected
- to connect an earthed part of the main circuit to the busbar
- to reconnect an accessible main circuit to the busbar.
- to open/remove or reclose/reset the interlocked door/cover of a high voltage interlock-accessible compartment if not all HV circuits to which this door/cover provides access are earthed.

For FUs type KKNx and DKNx, the design shall allow to reopen the earthing-switch when the door/cover of the cables or test-plug compartment is open/removed. If a special action is to be carried out, this must be clearly and explicitly indicated in the vicinity of the intervention point.

For FUs DKNx and DxGx used as general protection in which the circuit-breaker is part of the earthing of the circuit downstream this FU, its control circuit shall automatically prevent its tripping under the action of the protection, as long as the earthing-switch is closed.

For FU type DKN9 with sequential operations of the circuit-breaker and of the earthing-switch, an interlock shall prevent to close and open the earthing switch when the circuit breaker is opened.

8.3.3 Criteria

In general:

- the interlocks may not be disabled by the use of both hands of one operator nor by the use of an accessory for normal operating activities[4].
- An attempt to operate a switching-device blocked by an interlock cannot change the status of the switching-device; to allow its operation, the locking condition must disappear and a new attempt of operation must be made.
- An interlock must remain effective until the completion of the operation that releases it.

Interlocks of manual operations:

The interlocks of the manual operations shall be mechanical, i.e. they shall not use electrical components and shall be operational independent of any external energy source.
Key interlocks are not allowed.

Electrical interlocks of manual operations (blocking magnets) are not allowed, except for interlocks of manual operations in one FU depending on conditions in another FU.

Electrical interlocks shall lock in absence of auxiliary supply. Blocking magnets shall not be permanently supplied.

Interlocks of electrical operations:

The interlocks of electrical operations (remote-controlled operations or local electrical operations) shall be realized with hardware electrical contacts and wiring.

8.4 Locking facilities

8.4.1 Definition

Locking facility is a device that disables an operation by placing a padlock or a multi-lock on the operating interface.

8.4.2 Scope

- The HV switching device of every FU ensuring the isolating distance in open position shall be padlockable in this position. Therefore, both the interface for the manual closing operation and the motor switch (where present) in disabled position shall be fitted with a locking facility.
- In addition:
    - The switch-disconnectors of the FUs KKNx shall be padlockable in the closed and open positions. Therefore, the interface(s) for both manual closing and opening operations and the motor switch (where present) in both enabled and disabled positions shall be fitted with a locking facility.
    - The earthing-switch of the FUs KKNx shall be padlockable in both the open and closed positions.
    - The earthing-switch of the FU DKNx shall be padlockable in the closed position. In case of a FU DKNx for which the CB is part of the earthing circuit, the CB shall be padlockable in its closed position.
    - The access to the HV and LV compartments of a billing metering functional unit (FU M) shall be fitted with a locking facility.

8.4.3 Criteria

The design of the hosting system for the external locking device intended to lock the mechanical operation and the position of the motor switch shall be suitable for the following external locking devices:

- A padlock with a handle with a diameter between 4 mm and 8 mm and a inner radius of curvature between 10 mm and 15 mm
- A multi-lock with tongs with a thickness between 5 mm and 10 mm in locking position and an inner radius of curvature between 10 mm and 25 mm
- A nylon wire with a minimum diameter of 4 mm

The mechanical operation / the change of position of the motor-switch shall not be possible and cannot be forced when the one of the above-mentioned external locking device is set in the hosting system.

[4] normal operations include: switching operations, HV fuse replacement, cable testing, phase comparison

9 Miscellaneous and additional requirements

9.1 Arc suppression device

If the arc suppressor is a specific device different than the earthing-switch of the FU:

- it shall be armed in factory by the switchgear manufacturer before delivery
- it shall not be possible to rearm it

If the arc suppressor is the earthing-switch of the FU, it shall be ready to operate as soon as the earthing switch is opened.

For every FU fitted with an arc suppression device, a local indication on the man-machine interface shall be present (see §4.6.5), indicating if the arc suppression device has operated or not.

9.2 Indicating system for the dielectric withstand ability of the insulating gas for switchgear with gas insulated switching devices

Each gas insulated compartment shall be fitted with an appropriate indicator to check the ability of the insulating gas to ensure the dielectric withstand.
This device shall not be influenced by the ambient conditions.
This requirement applies to all FUs.

Sealed pressure systems ensuring the disconnecting function (isolating distance) shall be equipped with an indicator, integral part of the system, allowing to check the insulation capacity.

For each motorized switch-disconnector, the contact(s) of the indicator will change position in case of loss of the dielectric withstand ability of the insulating gas:

- Normally open (NO) contact(s) for locking the electrical opening and closing operations
- There shall be one normally closed (NC) contact signaling the loss of the dielectric withstand ability of the insulating gas
- In case the indicator is not able to drive more than one contact, this contact shall comply to point 1. The use of a relay for duplication of this contact is allowed. This relay shall always have at least 2 changeover contacts respecting the functionality of the 1st and 2nd bullet above.

NOTE:

- Normally open (NO) contact: a contact that shall be open in its normal (non-actuated) position and this normal position shall correspond to ”loss of the dielectric withstand ability of the insulating gas”
- Normally closed (NC) contact: a contact that shall be closed in its normal (non-actuated) position and this normal position shall correspond to ”loss of the dielectric withstand ability of the insulating gas”

The indicator shall be analogue. The local visual check shall be possible without the need of an auxiliary voltage supply. The indicator shall be replaceable without the need to de-energize the busbar.

9.3 Earthing arrangements

Each HV switchgear assembly is provided with a general earthing conductor. This earthing conductor may be composed of the metal enclosure of the several FUs connected to each other or of an uninsulated copper bar. The earthing conductor must be able to withstand a permissible short-time current of 2 kA for 1 sec without degradation of its functionality. The earthing conductor (copper bar or enclosure) features a hole for a 12 mm diameter bolt to be connected with the earthing system of the HV-installation. The connection point is indicated with the symbol 5019 of IEC 60417 typically for earthing indication.

This main earthing conductor ensures for each FU the connection to (non-exhaustive list):

- the metal enclosure (if a copper conductor is used)
- the star point of the earthing switch
- the screen of the HV cables and the equipotential wire of the conductive outer surface of the screened HV cable terminals
- the LV earthing connection terminals of the capacitive voltage dividers
- the conductive housing of the fault current detectors if applicable
- the earthing terminal of the instrument transformers if applicable
- one terminal for each secondary winding of the CT’s if applicable
- the N terminal of the VT’s between phase and earth if applicable
- the n terminal(s) of the VT’s between phase and earth if applicable
- the main earthing terminal in the LV compartment
- all exposed conductive parts of LV auxiliaries

It is assumed that the bolt connections between fixed panels, the bolted connections for covers and the hinges of doors ensure a sufficient electrical continuity between these metal enclosures. Metallic parts of the enclosures shall be designed to carry 30 A DC with a voltage drop of maximum 3 V to the earthing point provided.

The N terminal of VT's as well as his corresponding n terminal(s) and one of the secondary terminals of a CT are connected with the main earthing conductor by an as short as possible yellow/green marked copper conductor with adequate diameter[5].

9.4 Raising base frames

9.4.1 Raising base frame type AA1x–R and AA20-R

Raising baseframes associated to AA1x or AA20 switchgear shall be used:

- to improve the ergonomics for the execution of the cable plugs in case the height of the cable connection in the FU KKNx with reference to the floor of the switchgear is less than 800 mm in order to reach this minimum height of 800 mm
- or to allow respecting the 600 mm bending radius of the HV cables in case the height of the cable cellar is not sufficient.

The maximum height for raising base frames type AA1x–R and AA20-R is limited to 600 mm.

Raising base frames type AA15-R can be assembled together with energy absorbing base-frames type AA15-A.

9.4.2 Energy absorbing base frames type AA15–A

If applicable, a range of energy absorbing base frames AA15-A shall be available and cover all dimensions corresponding to the possible blocs of FUs within a switchgear family.

9.4.3 Raising base frame type AA3x–R

Raising baseframes associated to AA3x switchgear shall be used:

- to improve the ergonomics for the execution of the cable terminals in case the height of the cable connection in the FU KKNx with reference to the floor of the switchgear is less than 800 mm in order to reach this minimum height of 800 mm
- or to allow respecting the 675 mm bending radius of the HV cables in case the height of the cable cellar is not sufficient.

The maximum height for raising base frames type AA3x–R is limited to 675 mm.

9.5 Features for installation of a Fault Current Indicator (FCI)

All FUs KKNx shall comprise the following features to install Fault Current Indicators (FCI):

- A tube ∅ ≥ 20 mm with a pull-wire between the cables compartment and the position of the FCI, to guide the cables between the current sensors and the FCI
- A cutout width (W) x height (H) = $92^{+0.8/-0}$ mm x $45^{+0.6/-0}$ mm on the front side to mount the FCI

  Upon delivery, this cut-out shall be masked with a removable part in plastic or metal. Around the cut-out a minimal space of 4 mm must be free of any accessory. A free volume having the width and height of the cut-out and also a depth of 125 mm must be reserved behind the cut-out in order to introduce and embed the FCI and its connection wires.

Brands and types of FCI used by the different DSOs: see §4.8.4.

9.6 LV terminal block for protective current transformers (CTs)

Circuit-breaker functions with coding Dxxx shall be equipped with a LV terminal block for wiring the secondary circuits of the protective CTs.

This terminal block shall comprise non-interruptible terminals unless the terminals are interrupted following their short-circuiting. The short-circuiting shall be on the side where the wiring of the protective CTs is connected.

[5] For diameters, see chapter 6 - *"Specific requirements for a HV billing metering function"*

10 Operating mechanism functionalities of switching devices

10.1 Scope

The following requirements apply to

- FUs KKNx and DKNx
- FUs DxGx and TxGx

10.2 Generalities

Only spring-type mechanisms are allowed for stored energy mechanisms.

The required operating levers/handles shall be provided upon the delivery of HV installation. A collection system for these operating levers/handles shall be included with the delivery.

A list must be present with all the handles and accessories needed for operation, maintenance or interventions in the installation. Examples of such accessories are:

- Accessories for cable testing,
- Specific tools for performing switching operations or cable installations,
- …

The list must contain the manufacturer, model and order number for each accessory.

10.3 FU KKNx

10.3.1 Principle of operation of the switching devices

Switch-disconnector :

- The mechanism shall be designed to provide stored energy independent unlatched closing and opening operations.
  Stored and latched closing and opening operations are not allowed.

Earthing switch :

- The mechanism shall be designed to provide
  - For the closing operation : stored energy independent unlatched closing operation
  - For the opening operation : either dependent or stored energy independent

  Stored and latched closing and opening operations are not allowed.

10.3.2 Versions

Switch-disconnector :

- A motorized version for both the closing and the opening operations shall be available
- Motorization shall not impair manual closing and opening operations.

Earthing switch :

- Only manual version for both the closing and the opening operations is allowed.

10.3.3 Functionalities of switch-disconnector provided with a motor operation

Priority to opening : in case of 2 simultaneous commands for closing and opening,

- if the switch-disconnector is initially closed it shall open and stay open
- if the switch-disconnector is initially opened it shall stay open without closing

Anti-pumping: If a closing command is given and maintained, followed by an opening command, the switch-disconnector shall close and then open but shall not reclose. To allow a second closing, the maintained closing command must be released and a new command must be sent.

Behaviour in case of loss of auxiliary power during operation:
If the auxiliary power disappears during a closing or opening operation, this operation cannot go on when the auxiliary power supply reappears. A new command is necessary to pursue the operation.

The power supply of the electrical control and motor circuits of the switch-disconnector shall be interruptible from the front panel of the LV compartment of the FU. The motor switch ensuring this functionality shall be padlockable in both disabled and enabled positions.

10.4 FU TxGx

10.4.1 Principle of operation of the switching devices

Switch-disconnector (of the switch-fuse combination) :

- The mechanism shall be designed to provide stored and latched energy opening operation
- The energy for opening shall be stored and latched before or during the closing operation

10.4.2 Versions

Switch-fuse combination :

- The mechanism shall be designed to enable the energy release for the opening by :
  - fuse-striker
  - shunt release (associated with the transformer protection device)
  - time-delayed under-voltage release

10.5 FU DKNx

10.5.1 Principle of operation of the switching devices

Circuit-breaker :

- The mechanism shall be designed to provide stored and latched energy closing and opening operations
- The spring storing the energy for 1 CO cycle shall be automatically recharged after a closing operation, allowing the fast auto-reclosing sequence O-0.3s-CO-15s-CO

Disconnector :

- Stored and latched closing and opening operations are not allowed.

Earthing switch :

- The mechanism shall be designed to provide
  - For the closing operation : stored energy independent
  - For the opening operation : either dependent or stored energy independent

  Stored and latched closing and opening operations are not allowed.

10.5.2 Versions

Circuit-breaker :

- Manual opening and closing operating interfaces shall be present
- Shunt releases for opening and closing operations shall be present
- A motorized version for spring charging operation shall be available
- Motorization shall not impair manual spring charging operation.

Disconnector :

- Only manual version for both the closing and the opening operations is allowed.

Earthing switch :

- Only manual version for both the closing and the opening operations is allowed.

10.5.3 Functionalities of the circuit-breaker

Priority to opening : in case of 2 simultaneous commands (as well mechanical as electrical) for closing and opening,

- if the circuit-breaker is initially closed it shall open and stay open
- if the circuit-breaker is initially opened it shall stay open

Anti-pumping: If a closing command is given and maintained, followed by an opening command, the circuit-breaker shall close and then open but shall not reclose at the end of the spring charging. To allow a second closing, the maintained closing command must be released and a new closing command must be sent.

The control circuits shall react on opening and closing impulses of 20ms and more.

The power supply of the electrical control and motor circuits of the circuit-breaker, except the tripping circuit controlled by the protection relay, shall be interruptible from the front panel of the LV compartment of the FU. The motor switch ensuring this functionality shall be padlockable in both disabled and enabled positions.

10.6 FU DxGx

10.6.1 Principle of operation of the switching devices

Circuit-breaker:

- The mechanism shall be designed to provide stored and latched energy opening operation
- The energy for opening shall be stored and latched before or during the closing operation

10.6.2 Versions

Circuit-breaker:

- The mechanism shall be designed to enable the energy release for the opening by :
    - Low-energy release (associated with a CT-powered protection relay)
    - shunt release (associated with the transformer protection device)
    - time-delayed under-voltage release

10.6.3 Versions

(Switch-)disconnector :

- Only manual version for both the closing and the opening operations is allowed.

11 Installation and operating instructions

11.1 General

The installation and operation manuals shall cover the range of all possible variants of FUs for which the homologation has been requested.
The installation and operating instructions shall be available both in Dutch and French languages.
The installation and operating instructions of the execution of the switchgear and FUs presented to the homologation shall be submitted during the homologation procedure.

11.2 Installation

The manufacturer shall indicate all his requirements to install the switchgear in order to guarantee both the safety and the performances required by the Synergrid prescriptions C2/113-3, in the installation instruction, amongst others :

- the dimensions, position of the fixation points, and position of the HV cables output for the different FUs and baseframes
- the distances to be respected between the switchgear and the walls and ceiling of the switching room regarding the internal arc withstand
- the openings to be provided in the floor slab with regard to :
    - the connection of the HV cables,
    - the fixation of the switchgear to the ground
    - the evacuation of hot gases in case of internal arc in the different compartments
- the openings to be provided in the walls of the switching room with regard to the hot gases evacuation out of the room for switchgear categories AA13 & AA33
- the method to install the FUs :
    - handling of the FUs and the baseframes
    - fixation to the ground
    - fixation between FUs/blocs of FUs
    - placement of baseframes and of FUs over baseframes
    - mounting or extension of the busbar
    - mounting of gas deflectors
    - mounting of gas evacuation channel including the end element with the pressure relief
- the method to connect the HV cables in the different types of FUs
- the method to earth the switchgear
- the method to install the Fault Current Indicators (FCI) in the FU KKNx

11.3 Operating instructions

11.3.1 The essential requirements for dead working

The standard EN 50110-1 mentions in § 6.2 the five (5) essential requirements[6] that must be obtained to ensure safe dead working. The Belgian General Regulation for Electrical Installations (AREI/RGIE) also mentions these five rules expanded with two administrative requirements. The 5 and 2 accompanying requirements are:

- Preparations of the activities
- Complete disconnection (rule no. 1)
- Securing against re-connection (rule no. 2)
- Verifying the dead installation (rule no. 3)
- Earthing and Short-circuiting (rule no. 4)
- Providing protection against adjacent live part (rule no. 5)
- Releasing the installation

11.3.2 Operating instructions

The manufacturer shall provide the operating instructions as a quick user guide.

The quick user guide shall comprise the following operating instructions, based on the Belgian version of the synoptic diagrams:

- operating instructions to safely put a FU out of service
- operating instructions to safely put a FU back into service

[6] F: 5 Règles d'Or ; NL: Vitale 5

- normal operating procedures to proceed to:
    - a HV cable test on FU KKNx and DKNx when equipped with an interface for cable testing
    - HV fuses replacement for FU TxGx

The form of the quick user guide shall meet the following requirements:

- the operating instructions shall be illustrated with photos or drawings, possibly with text in the User's language (F, NL or both F and NL) with mention of a revision date
- the format (size) can be according the manufacturer standard, provided readability is not compromised
- the physical support shall be durable in time (e.g. plasticised pages)

The manufacturer shall make available the quick user guide for each Client installation, including a system that allows the quick user guide to be kept in its provided place. The provided place may be part of the collection system for the operating levers/handles, mentioned in §10.2 of this document.