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VX SE enclosure system

Technical documentation

PE conductor connection, current carrying capacity



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VX SE enclosure system

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Note:

The following values are based on a standard spray finish.
Where special paints are used, contact conditions may vary.

1. General remarks

1.1 Introduction

Even careful design of switchgear and expert advanced planning cannot always prevent unwanted short-circuits when operating these systems. Appropriate safety measures must be taken to prevent damage to personnel, property and electrical equipment which includes enclosures. These must therefore be equipped with appropriate short-circuit provisions. They must be able to conduct any short-circuit currents occurring for the fault duration without impairing safety.

This document deals specifically with earthing connections via built-in mechanical components within switchgear combinations.

The short-circuit resistance of a switchgear combination is a measurement of its resistance to the dynamic and thermal stresses. Thermal stress is of particular interest when observing the behaviour of enclosures or parts of enclosures.

When assessing permissible thermal stress, the decisive factor is the root mean square of the short-circuit current throughout its duration.

The connection points and elements through which the short-circuit current flows generate heat due to their electrical resistance. This heat must be withstood by the connection points. They must not be destroyed to such an extent that they are no longer able to fulfil their safety function.

Short-circuit stress is essentially influenced by the following factors:

- The duration of the short-circuit
Limitation by quick-breaking safety devices such as fuses, modern power switches with zero-current cut-off or current limitation etc.
- Impedance of the system short-circuit loop
This depends on the distance from the transformer and the capacity of the supplying system.
- Construction and design of the earthing connection point
This is usually prescribed or suggested by the manufacturer of the operating equipment.

The aim of this document is to provide the planning engineer with data to enable fast, reliable implementation of the required adjustments at the project planning stage. Details of the test methods used and the conversion for existing values can be found in the appendix.

The measurements quoted in this document are the results of a single test and are therefore subject to fluctuations which may depend upon both the test layout and the specimen (short-circuit current cycle). The manufacturer of the switching system should therefore include corresponding safety allowances in the design. In particular, the mounting technology must comply with our specifications.

1.2 Notes on the design of the earthing system

It is generally permissible to ensure the continuity of the earthing connections either through structural elements of the system or by way of a separate earth conductor (IEC/DIN EN 61439-1 item 8.4.3.2.2). In the case of covers, gland plates, etc. which are not serving as mountings for electrical equipment, the conventional metal screw connections are considered to be sufficient to provide for continuity of the earthing connection, provided that the permanent good conductivity is guaranteed. This applies for all such connections of the VX SE enclosure system (see 3.2). If electrical equipment is mounted on covers, doors, gland plates etc. or if there is a risk of potential transfer¹⁾ to the parts, then it is necessary to provide for careful connection of an earth conductor whose cross-section is governed by the greatest cross-section of the supply cables to the equipment concerned.

Generally speaking, the manufacturer of the switchgear enclosure must ensure that the PE conductor circuit is capable of withstanding the highest thermal and dynamic loads occurring at the installation site.

1.3 Regulations/standards

The following standards must be observed:

- DIN VDE 0100 – 200 (2006-06)
Low-voltage installations
– General terminology
- DIN VDE 0100 – 470 (2007-06)
Low-voltage installations
– Part 4-41: Protection for safety
- DIN VDE 0100 – 540 (2012-06)
Low-voltage installations
– Selection and erection of electrical equipment –
Earthing arrangements and protective conductors
- DIN EN 60 865-1 (VDE 0103 : 2012-09)
Short-circuit currents – Calculation of effects
– Part 1: Definitions and calculation methods
- DIN EN 60 204-1 (VDE 0113-1 : 2007-06)
Electrical equipment of machines
- DIN EN 61439-1 (VDE 0660-600-1 : 2012-06)
Low-voltage switchgear and controlgear assemblies;
– Part 1: General rules
- DIN EN 62 208 (VDE 0660-511 : 2012-06)
Empty enclosures for low-voltage switchgear and
controlgear assemblies;
– General requirements

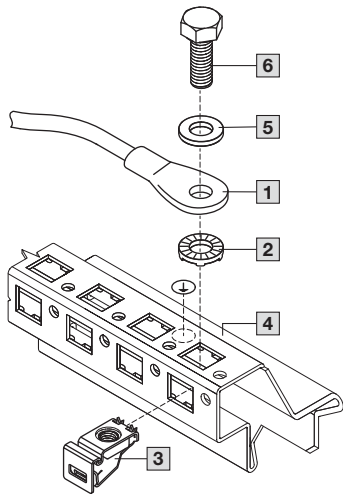
¹⁾ Contact with an active conductor of a defined cross-section

VX SE enclosure system

PE conductor connection

2. Earthing connection points

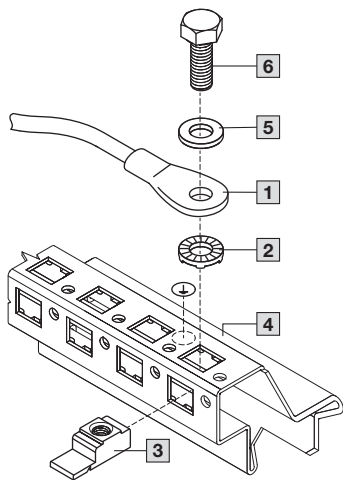
2.1 Frame – Captive nut



- 1 PE conductor with ring terminal
- 2 Contact washer 2335.000
- 3 Captive nut M8 4165.500
- 4 Frame
- 5 Plain washer A8.4
- 6 Hex screw M8

Rated surge current resistance	$I_p = 31.7 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 15.9 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 15.4 \cdot 10^6 \text{ A}^2 \text{ s}$
Recommended tightening torque	$M_A = 10 - 12 \text{ Nm}$

2.2 Frame – Threaded block

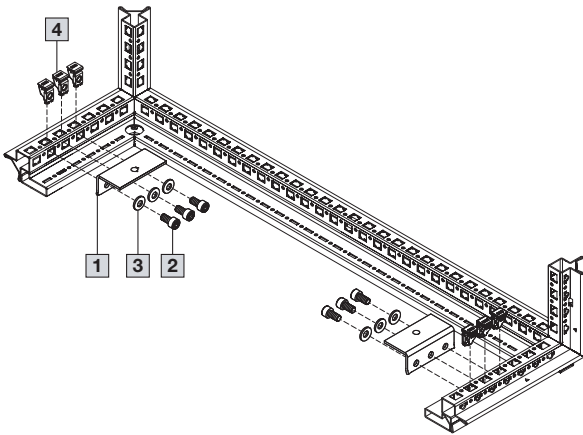


- 1 PE conductor with ring terminal
- 2 Contact washer 2335.000
- 3 Threaded block M8 4163.000
- 4 Frame
- 5 Plain washer A8.4
- 6 Hex screw M8

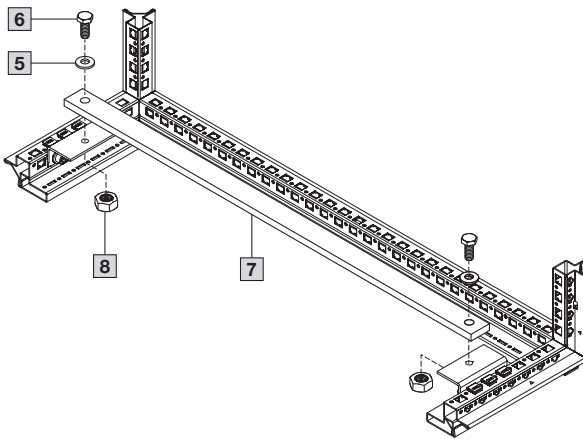
Rated surge current resistance	$I_p = 13.5 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 8.3 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 3.6 \cdot 10^6 \text{ A}^2 \text{ s}$
Recommended tightening torque	$M_A = 10 - 12 \text{ Nm}$

2. Earthing connection points

2.3 PE/PEN combination – Angle bracket, busbar



- 1 Angle bracket PE/PEN 9686.350
- 2 Hex screw M8
- 3 Spring washer A8.4
- 4 Captive nut M8 4165.500
- 5 Spring washer A10.5
- 6 Hex screw M10
- 7 PE/PEN busbar 9686.5XX
- 8 Hex nut M10



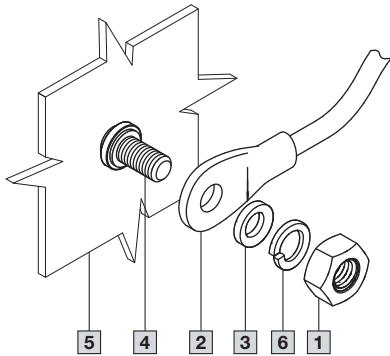
Rated surge current resistance	$30 \times 5 I_p = 36.0 \text{ kA}$
	$30 \times 10 I_p = 63.0 \text{ kA}$
	$80 \times 10 I_p = 138.0 \text{ kA}$
Rated transient current resistance	$30 \times 5 I_{cw} = 18.0 \text{ kA (1 s)}$
	$30 \times 10 I_{cw} = 30.0 \text{ kA (1 s)}$
	$80 \times 10 I_{cw} = 61.7 \text{ kA (1 s)}$

VX SE enclosure system

PE conductor connection

2. Earthing connection points

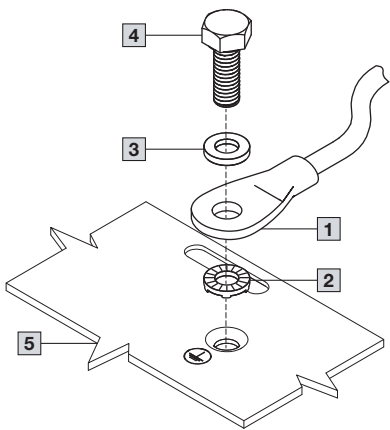
2.4 Panels



- 1 Hex nut M8
- 2 PE conductor with ring terminal
- 3 Plain washer A8.4
- 4 Welded stud M8
- 5 Panel
- 6 Spring lock washer A8

Rated surge current resistance	$I_p = 32.6 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 16.1 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 16.1 \cdot 10^6 \text{ A}^2 \text{ s}$
Recommended tightening torque	$M_A = 8 - 10 \text{ Nm}$

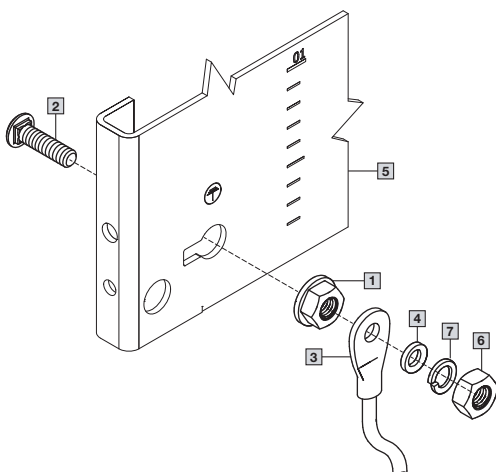
2.5 Gland plate



- 1 PE conductor with ring terminal
- 2 Contact washer 2335.000
- 3 Plain washer A8.4
- 4 Self-tapping hex screw M8
- 5 Gland plate

Rated surge current resistance	$I_p = 27.0 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 13.4 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 11.1 \cdot 10^6 \text{ A}^2 \text{ s}$
Recommended tightening torque	$M_A = 10 - 12 \text{ Nm}$

2.6 Mounting plate



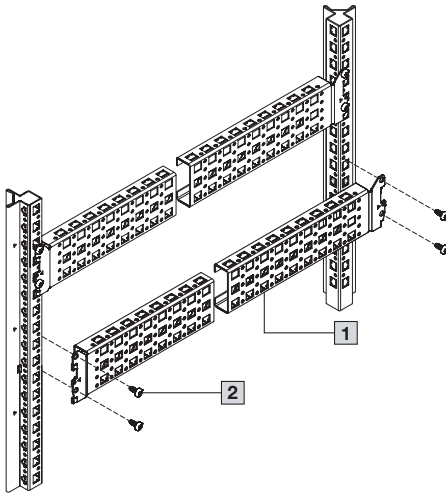
- 1 Self-locking nut M8, DIN 6923
- 2 Carriage bolt M8, DIN 603
- 3 PE conductor with ring terminal
- 4 Plain washer A8.4
- 5 Mounting plate
- 6 Hex nut M8
- 7 Spring lock washer A8

Rated surge current resistance	$I_p = 53.6 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 25.3 \text{ kA} (T_k = 150 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 105 \cdot 10^6 \text{ A}^2 \text{ s}$
Recommended tightening torque	$M_A = 10 - 12 \text{ Nm}$

3. Current carrying capacity and short-circuit resistance

3.1 Current carrying capacity of system accessories

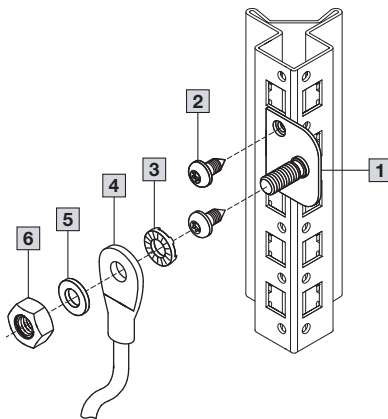
3.1.1 Frame – Punched section with mounting flange



- 1 Punched section with mounting flange
8100.730 – 8100.733
8617.000 – 8617.060
8617.100 – 8617.210
- 2 Screw 5.5 x 13

Rated surge current resistance	$I_p = 61.1 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 29.2 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 47.7 \cdot 10^6 \text{ A}^2 \text{ s}$

3.1.2 Frame – Central earthing point



- 1 Central earthing point 7829.200
- 2 Screw 5.5 x 13
- 3 Contact washer M8 2335.000
- 4 PE conductor with ring terminal
- 5 Plain washer A8.4
- 6 Hex nut M8

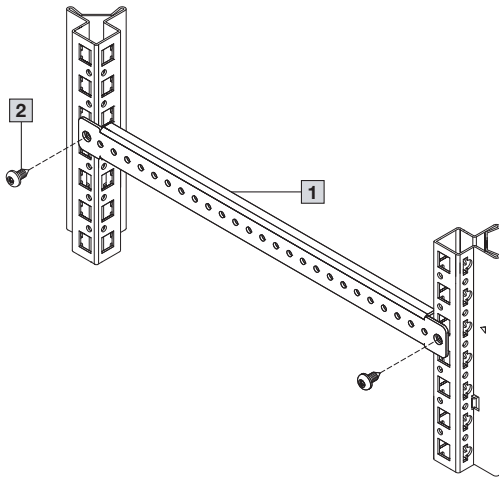
Rated surge current resistance	$I_p = 14.7 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 9.1 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 3.92 \cdot 10^6 \text{ A}^2 \text{ s}$

VX SE enclosure system

Current carrying capacity

3. Current carrying capacity and short-circuit resistance

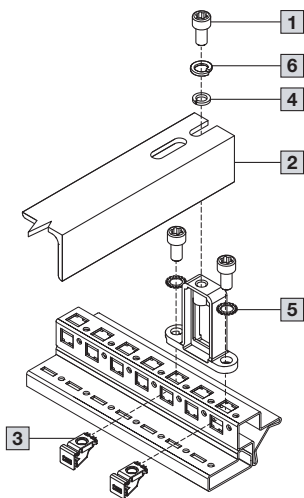
3.1.3 Frame – Support strip



- 1 Support strip 4694.000 – 4697.000
- 2 Screw 5.5 x 13

Rated surge current resistance	$I_p = 26.4 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 13.0 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 10.3 \cdot 10^6 \text{ A}^2 \text{ s}$

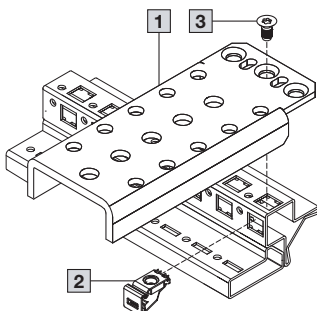
3.1.4 Frame – Bracket, cable clamp rail



- 1 Allen screw M8
- 2 Cable clamp rail 8619.400 – 8619.460
- 3 Captive nut M8 4165.500
- 4 Plain washer A8.4
- 5 Serrated washer A8.4
- 6 Spring lock washer A8

Rated surge current resistance	$I_p = 51.3 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 35.2 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 49.6 \cdot 10^6 \text{ A}^2 \text{ s}$

3.1.5 Frame – Support rail 75 x 20 mm

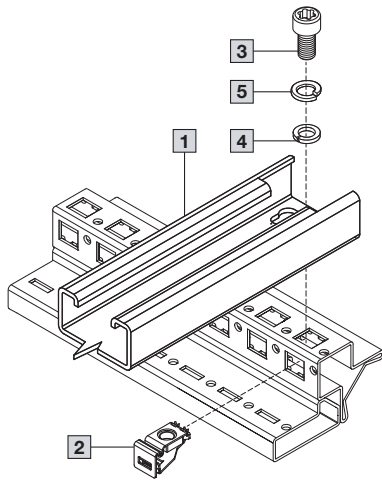


- 1 Support rail 75 x 20 mm 4394.000 – 4398.000
- 2 Captive nut M8 4165.500
- 3 Posidrive raised countersunk screws M8

Rated surge current resistance	$I_p = 50.6 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 35.8 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 51.3 \cdot 10^6 \text{ A}^2 \text{ s}$

3. Current carrying capacity and short-circuit resistance

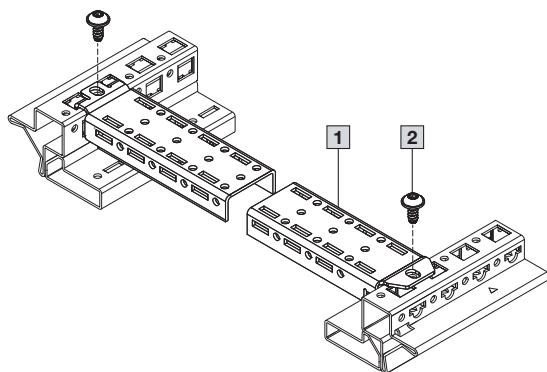
3.1.6 Frame – Support rail 48 x 26 mm



- 1 Support rail 48 x 26 mm
8617.800 – 8617.830
- 2 Captive nut M8 4165.500
- 3 Allen screw M8
- 4 Plain washer A8.4
- 5 Spring lock washer A8

Rated surge current resistance	$I_p = 30.0 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 21.1 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 17.8 \cdot 10^6 \text{ A}^2 \text{ s}$

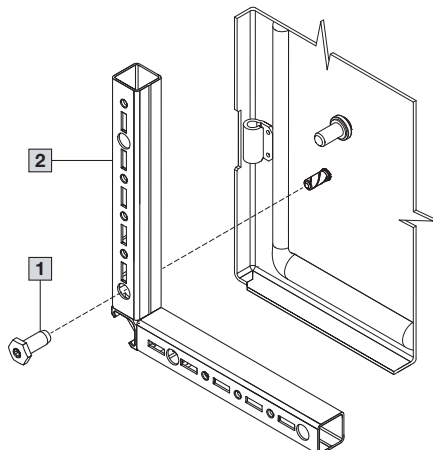
3.1.7 Frame – Punched rail 18 x 39 mm



- 1 Punched rail 18 x 39 mm (mounting plate slide rail)
8617.700 – 8617.730
- 2 Screw 5.5 x 13

Rated surge current resistance	$I_p = 21.4 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 10.6 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 6.9 \cdot 10^6 \text{ A}^2 \text{ s}$

3.1.8 Door – Sleeve screw, tubular door frame



- 1 Sleeve screw M6
- 2 Tubular door frame

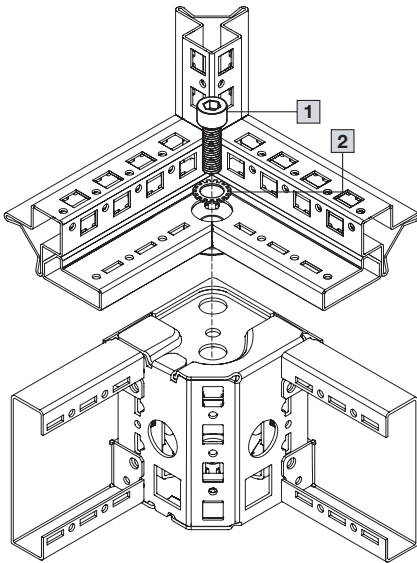
Rated surge current resistance	$I_p = 30.0 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 21.0 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 17.6 \cdot 10^6 \text{ A}^2 \text{ s}$

VX SE enclosure system

Current carrying capacity

3. Current carrying capacity and short-circuit resistance

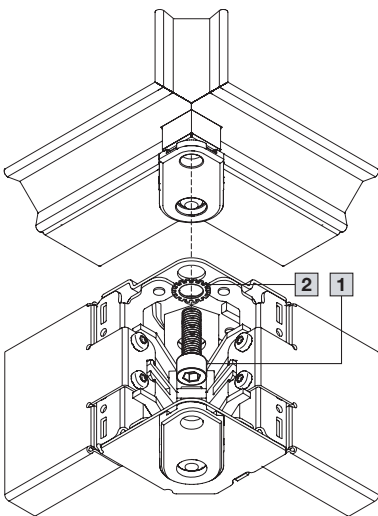
3.1.9 Base frame – Base/plinth



- 1 Allen screw M12
- 2 Serrated washer A13

Rated surge current resistance	$I_p = 40.7 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 27.4 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 30.0 \cdot 10^6 \text{ A}^2 \text{ s}$

3.1.10 Frame (corner piece) – Base/plinth



- 1 Allen screw M12
- 2 Serrated washer A13

Rated surge current resistance	$I_p = 40.8 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 27.7 \text{ kA} (T_k = 40 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 30.7 \cdot 10^6 \text{ A}^2 \text{ s}$

3.2 Current carrying capacity of the automatic contacting

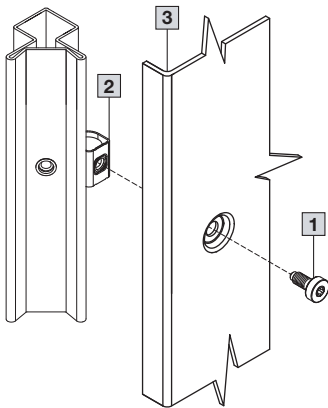
The automatic contacting system of the VX SE ensures a conducting connection between all panel elements.
The results of our tests and measurements confirm that the connections possess a contact resistance of less than 0.1Ω , as demanded in IEC/DIN EN 62 208.

With regard to the inclusion of the door in the protection measures for "Protection in case of indirect contact" we recommend connection of a separate earth conductor to the door, as a permanent conducting connection cannot be guaranteed (paint, oil, contamination, etc.). The designer must determine whether or not the automatic contacting is sufficient for the earthing system.
Attention is here drawn to point 1.2 (Notes on design) and to the relevant directives and standards (see 1.3).

Note:

The following values are based on a standard spray finish. Where special paints are used, contact conditions may vary. The design allows for automatic potential equalisation from the rear panel, roof plate and side panel (accessories) to the basic enclosure, and from the gland plates to the basic enclosure. For the installation or surface mounting of electrically powered Rittal accessories (cooling units, fan-and-filter units etc.) in or on the side panel, rear panel or roof plate, the mechanical attachment already provides adequate PE conductor connection. One assembly component should be marked with a PE conductor symbol to label its function as a PE conductor. An additional PE conductor connection is not required.

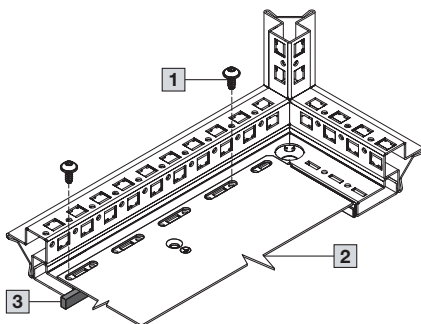
3.2.1 Frame – Rear panel



- 1 Panhead screw M6 x 16
- 2 Enclosure panel fastener with contact spring
- 3 Rear panel

Rated surge current resistance	$I_p = 15 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 7.5 \text{ kA} (T_k = 50 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 3.52 \cdot 10^6 \text{ A}^2 \text{ s}$

3.2.2 Base frame – Gland plate



- 1 Screw 5.5 x 13
- 2 Gland plate
- 3 Seal

Rated surge current resistance	$I_p = 15.3 \text{ kA}$
Thermal equivalent short-time current	$I_{th} = 7.7 \text{ kA} (T_k = 33 \text{ ms})$
Joule heat value	$I^2t \text{ value} = 0.4 \cdot 10^6 \text{ A}^2 \text{ s}$

VX SE enclosure system

Current carrying capacity

3.3 Permissible symmetrical short-circuit current of earthing straps

3.3.1 Earthing straps, PVC insulated

Permissible symmetrical short-circuit current of earthing straps (PE conductors) Cu (PVC insulated) in relation to a short-circuit duration of 0.04 s; 0.2 s; 0.5 s; 1 s and 5 s.

Permissible symmetrical short-circuit current

Break time of protective device	Cross-section of PE conductor (PVC insulation)				
	4 mm ² (Cu)	10 mm ² (Cu)	16 mm ² (Cu)	25 mm ² (Cu)	35 mm ² (Cu)
0.04 s	2.86 kA	7.15 kA	11.44 kA	17.88 kA	25.03 kA
0.2 s	1.28 kA	3.20 kA	5.12 kA	8.00 kA	11.20 kA
0.5 s	0.81 kA	2.02 kA	3.23 kA	5.05 kA	7.07 kA
1.0 s	0.57 kA	1.43 kA	2.29 kA	3.58 kA	5.01 kA
5.0 s	0.26 kA	0.64 kA	1.02 kA	1.60 kA	2.24 kA

Basis of calculation EN 61 439-1, appendix B (VDE 0660, part 600-1)

$$S_p = \frac{\sqrt{I^2 \cdot t}}{k} \quad I = S_p \cdot k \cdot \sqrt{1/t}$$

I = permissible symmetrical short-circuit current in A

where:

Cross-section of conductor SP = 4, 10, 16, 25, 35 mm²

Break time t = 0.04; 0.2; 0.5; 1; 5 s

Material coefficient k = 143 A · √s/mm²

3.3.2 Earthing straps, bare conductors

Permissible symmetrical short-circuit current of earthing straps (PE conductors) Cu (bare conductors) in relation to a short-circuit duration of 0.04 s; 0.2 s; 0.5 s; 1 s and 5 s.

Permissible symmetrical short-circuit current

Break time of protective device	Cross-section of PE conductor (bare)				
	4 mm ² (Cu)	10 mm ² (Cu)	16 mm ² (Cu)	25 mm ² (Cu)	35 mm ² (Cu)
0.04 s	3.52 kA	8.79 kA	14.07 kA	21.99 kA	30.79 kA
0.2 s	1.57 kA	3.93 kA	6.30 kA	9.84 kA	13.78 kA
0.5 s	1.00 kA	2.48 kA	3.97 kA	6.21 kA	8.70 kA
1.0 s	0.70 kA	1.76 kA	2.82 kA	4.40 kA	6.16 kA
5.0 s	0.32 kA	0.79 kA	1.25 kA	1.97 kA	2.76 kA

Basis of calculation EN 61 439-1, appendix B (VDE 0660, part 600-1)

$$S_p = \frac{\sqrt{I^2 \cdot t}}{k} \quad I = S_p \cdot k \cdot \sqrt{1/t}$$

I = permissible symmetrical short-circuit current in A

where:

Cross-section of conductor SP = 4, 10, 16, 25, 35 mm²

Break time t = 0.04; 0.2; 0.5; 1; 5 s

Material coefficient k = 176 A · √s/mm²

4. Test methods and evaluation

Rittal has commissioned one of the largest German test institutes – IPH in Berlin – to perform an elaborate series of experiments to test the earthing connections of the VX SE enclosure. These experiments were to investigate both connections between the housing elements and earth conductor terminal points with regard to their proper electrical continuity (in accordance with IEC/DIN EN 62 208) and thermal short-circuit resistance (following IEC/DIN EN 61 439-1). The objective of the tests was to confirm the continuity between the individual housing elements and to obtain values for the short-circuit resistance. Both the surge current resistance and the Joule heat value (I^2t value) were determined and documented.

4.1 Test methods

- The test specimens were connected to a heavy current generator via a power transformer and subjected to a short-circuit current over a defined period of time.
- Before and after the short-circuit, the contact resistance was measured using the ammeter-voltmeter method and recorded.
- The surge current was gradually increased until the connection was destroyed or until the permissible contact resistance was exceeded.
- The curve patterns of the current and the voltage were recorded, and the surge current, the symmetrical short-circuit current (r.m.s. value), the short-circuit duration and the Joule integral (I^2t value) were determined.
- The condition of the connections before and after the individual phases of the experiment were recorded as photographs.

4.2 Notes of evaluation

The tests were evaluated in that the electrical connection was examined visually and through measurement of the resistance. It must be mentioned that a certain level of crackle remains permissible, provided the electrical connection is not adversely affected and neighbouring inflammable components are not ignited (in accordance with IEC/DIN EN 61 439-1, item 10.11.5.6.2 note 1). It is thus recommended to carry out appropriate individual testing, depending on the specific configuration.

The tests provide a value for the Joule heat (I^2t value), which can be converted by the designer to take into account the possible loads arising at the actual point of installation (see IEC/DIN EN 61 439-1). It follows herefrom that the Joule heat I^2t is practically constant across the whole range of short durations. This means that the product of the known break time T_k and the permissible thermal short-time current I_{th} must not exceed the specified current carrying capacity (I^2t value).

$$I^2 \cdot t = I_{th}^2 \cdot T_k = \text{const.}$$

It should be noted further, that the given values refer only to the tested structural elements and connections.

With regard to the dynamic short-circuit resistance, in particular, it is not possible to specify generally applicable values. When applying the specified values for rated surge current resistance, it must be noted that the layout of the connecting cables and the installations of the enclosure are decisive factors determining the arising current forces.

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