Technical catalogue TK 501/15 en

ZX1.2
Gas-insulated medium voltage switchgear

Power and productivity
for a better world™

Contents

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1 Introduction

Switchgear systems and their components rank among the most important facilities for electrical power transmission and distribution. Their versatile functions and the opportunities they provide contribute on the one hand to safety in general, and on the other hand they secure the availability of electrical energy.

Our ZX product family, consisting of panel types

ZX0:	**... 24 kV**	**... 1250 A**	**... 25 kA**
ZX0.2:	**... 36 kV**	**... 2500 A**	**... 31.5 kA**
ZX1.2:	**... 40.5 kV**	**... 2500 A**	**... 31.5 kA**
ZX2:	**... 40.5 kV**	**... 2500 A**	**... 40 kA**

covers the entire spectrum of primary distribution applications.

Flexible combination, reliability, availability and economy are the attributes that make it easy for our clients in industry and utilities to decide in favor of products from the ZX series. Together with complete conventional solutions, the use of digital protection and control technology, sensor systems and plug-in connections makes ZX systems unrestrictedly fit for the future, and the primary function of reliable power distribution is fulfilled with no ifs and buts. This is ensured by ABB's uncompromising approach to quality, which leaves no customer's wishes unfulfilled. Aligned to each need, the panel types of the ZX family offer a solution for each requirement. In over 70 countries the customers rely on gas-insulated switchgears from ABB.

The ZX series leave our works as tested panels and, as SF_6 switchgear, are exemplary in terms of safety, economy and availability. Their compact design permits installation in even the most constricted spaces. The hermetically sealed enclosures make the systems shockproof and protect the high voltage components from all environmental influences.

ABB AG's Calor Emag Medium Voltage Products division develops, manufactures and installs switchgear systems and components for electrical power distribution in the medium voltage range. Based in Ratingen, Germany, we have the know-how, global project experience and local partners for the supply of panels and turnkey medium voltage switchgear systems.

2 Applications

Power supply companies

- Power stations
- Transformer substations
- Switching substations

Industry

- Steel works
- Paper manufacture
- Cement industry
- Textiles industry
- Chemicals industry
- Foodstuffs industry
- Automobile industry
- Petrochemicals
- Raw materials industry
- Pipeline systems
- Foundries
- Rolling mills
- Mining

Marine

- Platforms
- Drilling rigs
- Offshore facilities
- Supply vessels
- Ocean liners
- Container vessels
- Tankers
- Cable laying ships
- Ferries
- Wind farms

Transport

- Airports
- Harbours
- Railways
- Underground railways

Services

- Supermarkets
- Shopping centres
- Hospitals

3 Characteristics

Basic characteristics

- SF_6 - gas-insulated with hermetically sealed pressure system
- Rated voltages up to 36 kV (40.5 kV)
- Up to 2500 A and 31.5 kA
- Single busbar design
- Stainless steel encapsulation, manufactured from laser cut sheet material
- Modular structure
- Switchgear with a leakage rate of less than 0.1 % per annum
- Integrated leakage testing
- Indoor installation
- Panel widths 400 mm, 600 mm and 800 mm

Panel variants

- Incoming and outgoing feeder panels
- Cable termination panels
- Termination panels for fully insulated bars
- Sectionaliser
- Riser
- Metering panels
- Double feeder panels
- Cable in – cable out panels
- Panels for wind farm applications
- Customised panel versions

Circuit-breaker and three position disconnector

- Vacuum circuit-breaker
- Disconnector/earthing switch (three position disconnector) with functions for
  - busbar connection
  - disconnection
  - earthing

Connections

- Inner cone cable plug system in sizes 2 and 3
- Connection facility for surge arresters
- Connection facility for fully insulated bars

Current and voltage metering

- Instrument transformers and sensors

Protection and control

- Combined protection and control devices
- Discrete protection devices with conventional control

Protection against maloperation

- Electrical switch interlocks
- Additional mechanical interlocks

Pressure relief

- Via plasma diverters into the switchroom, or
- via pressure relief ducts into the switchroom, or
- via pressure relief ducts to the outside

Installation

- Panels joined together by plug-in connectors

4 Your benefit

Maximum operator safety

- All live components are enclosed to prevent accidental contact.
- As the high voltage compartments are independent of external influences (degree of protection IP65), the probability of a fault during operation is extremely low.
- As evidenced by arc fault testing, our switchgear systems are notable for maximum operator safety.
- A further increase in operator safety can be achieved by providing pressure relief to outside the switchgear room.

Minimum overall costs

- The compact design of the panels reduces the space required and therefore the size of the station. The result is a lower investment requirement.
- Freedom from maintenance is achieved by constant conditions in the high voltage compartments in conjunction with the selection of suitable materials. The injurious influences of dust, vermin, moisture, oxidation and contaminated air in the high voltage compartments are precluded, as the gas-tight compartments are filled with inert gas.
  As a rule, therefore, isolation of the switchgear to perform maintenance work is not required.
- The panels are designed for an expected service life of over 40 years.
- The systematic selection during the development process of the materials used provides for complete recycling or reuse of those materials at the end of the service life.
- The panels only leave our production facilities after documented routine testing. Thanks to the plug-in technology applied in the areas of the busbars, cables and secondary systems, extremely short installation times are possible.
- No gas work is required as a rule at site. There is thus no need to evacuate and fill the high voltage compartments, test them for leakage and measure the dewpoint of the insulating gas at site.

Maximum availability

- The plug-in busbar technology without screw couplings permits simple and therefore safe assembly.
- In spite of the extremely low failure probability of the ZX switchgear systems, replacement of components in the gas compartments and therefore a rapid return to service after repairs is possible.
- In gas-insulated switchgear, earthing of switchgear sections is performed by a high quality vacuum circuit-breaker. The circuit-breaker can close onto a short-circuit significantly more frequently and reliably than a positively making earthing switch.

5 Technical data

5.1 Technical data of the panel

Table 5.1.1: Technical data of the panel

				IEC-ratings			Special ratings
All panels except double feeder panels	Rated voltage	U_r	kV	12	24	36	40.5
	Maximum operating voltage		kV	12	24	36	40.5
	Rated power frequency withstand voltage	U_d	kV	28	50	70	85
	Rated lightning impulse withstand voltage	U_p	kV	75	125	170	185 [1]
	Rated normal current [2]	I_r	A	...2500			
	Rated short-time withstand current	I_k	kA	...31.5			
	Rated peak withstand current	I_p	kA	...80			
	Rated duration of short-circuit	t_k	s	...3			
Double feeder panels, panel width 2 x 400 mm	Rated voltage	U_r	kV	12	24		
	Maximum operating voltage		kV	12	24		
	Rated power frequency withstand voltage	U_d	kV	28	50		
	Rated lightning impulse withstand voltage	U_p	kV	75	125		
	Rated normal current [2]	I_r	A	...630 (...800) [3]			
	Rated short-time withstand current	I_k	kA	...25			
	Rated peak withstand current	I_p	kA	...62.5			
	Rated duration of short-circuit	t_k	s	...3			
Rated frequency [4]		f_r	Hz	50			
Rated normal current of busbars [2]		I_r	A	...2500			
Insulating gas system [5] [6]							
Alarm level for insulation		p_{ae}	kPa [7]	120			
Rated filling level for insulation		p_{re}	kPa	130			
Degree of protection for gas filled compartments				IP65			
Degree of protection of low voltage compartment [8]				IP4X			
Ambient air temperature, maximum [9]			°C	+40			
Ambient air temperature, maximum 24 hour average [9]			°C	+35			
Ambient air temperature, minimum			°C	-5			
Site altitude [10]			m	...1000			

1) Higher levels to international standards on request
2) Rated current for 60 Hz on request, higher operating current on request
3) See chapter "Double feeder panels"
4) 60 Hz on request
5) Insulating gas: SF_6 (sulphur hexafluoride)
6) All pressures stated are absolute pressures at 20° C
7) 100 kPa = 1 bar
8) Higher degrees of protection on request
9) Higher ambient temperature on request
10) Higher site altitude on request

Internal arc classification

The panels are arc fault tested in accordance with IEC 62271-200.

Table 5.1.2: Internal arc classification of the switchgear in accordance with IEC 62271-200 [1)]

Pressure relief system		
1	Switchgear with plasma diverters (Fig. 7.13.1)	Classification IAC AFL Internal arc 31.5 kA 1 s
2	Switchgear with pressure relief duct (discharging into the switchroom, Fig. 7.13.2)	Classification IAC AFLR Internal arc 31.5 kA 1 s
3	Switchgear with pressure relief duct (discharging to the outside, Fig. 7.13.3)	Classification IAC AFLR Internal arc 31.5 kA 1 s
4	Cable in – cable out panel version 1 (section 8.6.3.1) with endcovers for pressure relief at both sides (width 250 mm each) with pressure relief duct discharging to the outside	Classification IAC AFLR Internal arc 25 kA 1 s

Key to table 5.1.2:

IAC — Internal arc classification
AFLR
- R: Accessibility from the rear (R - rear)
- L: Accessibility from the sides (L - lateral)
- F: Accessibility from the front (F- front)
- A: Switchgear installed in closed rooms with access restricted to authorised personnel only

The following applies to variants 1-3 in table 5.1.2: The IAC qualification relies on a system consisting of at least three panels.

[1)] IEC 62271-200 corresponds to DIN EN 62271-200 and VDE 0671 Part 200

Loss of Service Continuity to IEC 62271-200

The various LSC categories of the standard define the possibility to keep other compartments and/or panels energised when opening a main circuit compartment.
Gas-filled compartments cannot be opened, as they would then lose their functionality. This means that there is no criterion for loss of service continuity of inaccessible compartments.

Table 5.1.3: Loss of Service Continuity of the switchgear

Loss of Service Continuity of the switchgear	LSC2A

Key to table 5.1.3:

LSC2A: On access to the cable terminations of a panel, the busbar and all other panels can remain energized.

Note from VDE 0671-200:2012-08 / IEC 62271-200 Edition 2.0:

„The LSC category does not describe ranks of reliability of switchgear and controlgear.“

Partition class to IEC 62271-200

The partition class to IEC 62271-200 defines the nature of the partition between live parts and an opened, accessible compartment.

Table 5.1.4: Partition class in accordance with IEC 62271-200

Partition class	PM

Key to table 5.1.4:

PM: partition of metal

Panels of partition class PM provide continuous metallic and earthed partitions between opened accessible compartments and live parts of the main circuit.

5.2 Technical data of the circuit-breaker

Table 5.2.1: Technical data of the circuit-breaker

			IEC-ratings			Special ratings
Rated voltage	U_r	kV	12	24	36	40.5
Maximum operating voltage		kV	12	24	36	40.5
Rated power frequency withstand voltage [1]	U_d	kV	28	50	70	85
Rated lightning impulse withstand voltage [1]	U_p	kV	75	125	170	185
Rated frequency [2]	f_r	Hz	50			50
Rated normal current [3]	I_r	A	...2500			...2500
Rated short-circuit breaking current	I_{sc}	kA	...31.5			...31.5
Rated short-circuit making current	I_{ma}	kA	...80			...80
Rated short-time withstand current	I_k	kA	...31.5			...31.5
Rated duration of short-circuit	t_k	s	...3			...3
Operating sequence			O - 0.3 s - CO - 3 min - CO [4]			
Closing time	t_{cl}	ms	approx. 60			
Rated opening time	t_3	ms	≤ 45			
Rated break time	t_b	ms	≤ 60			
Rated auxiliary voltage		V DC	60, 110, 220 [5]			
Power consumption of charging motor		W	max. 260			
Power consumption of closing coil		W	250 - 310			
Power consumption of opening coil		W	250 - 310			
Power consumption of blocking magnet		W	10			
Power consumption of undervoltage release		W	11			
Power consumption of indirect overcurrent release		W	15			

Permissible numbers of operating cycles of the vacuum interrupters
20000 - 30000 [6] x I_r (I_r = Rated normal current)
50 x I_{SC} (I_{SC} = Rated short-circuit breaking current)

1) Higher levels to international standards on request
2) Rated current for 60 Hz on request
3) Higher operating current on request
4) Different operating sequences on request
5) Different auxiliary voltages on request
6) Dependent on the vacuum interrupter type

5.3 Technical data of the three position disconnector

Table 5.3.1: Technical data of the three position disconnector

			IEC-ratings			Special ratings
Rated voltage	U_r	kV	12	24	36	40.5
Maximum rated voltage		kV	12	24	36	40.5
Rated power frequency withstand voltage across the isolating distance		kV	32	60	80	[1]
Rated lightning impulse withstand voltage across the isolating distance		kV	85	145	195	[1]
Rated normal current [2]	I_r	A	...2500			...2500
Rated short-time withstand current	I_k	kA	...31.5			...31.5
Rated peak withstand current	I_p	kA	...80			...80
Rated duration of short-circuit	t_k	s	3			3
Rated auxiliary voltage	U_a	V DC	60, 110, 220 [3]			
Rated normal current		A	...1250	...2500		
Power consumption of mechanism motor		W	approx. 180			
Motor running time on opening or closing the disconnector [4]		s	approx. 18	approx. 20		
Motor running time on opening or closing the earthing switch [4]		s	approx. 18	approx. 20		

1) On request
2) Higher operating current on request
3) Different auxiliary voltages on request
4) At rated auxiliary voltage

6 Fundamental structure of the panels

Fig. 6.1: Outgoing cable panel 800 A, with plasma diverter

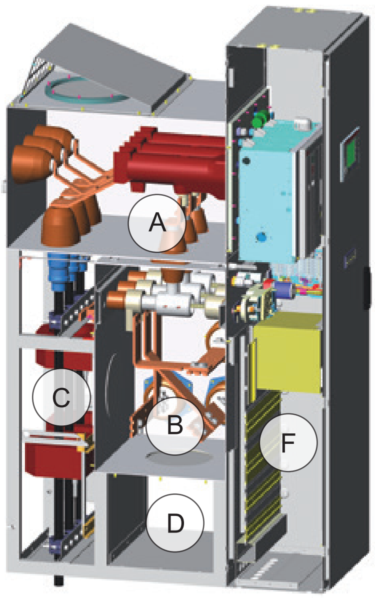
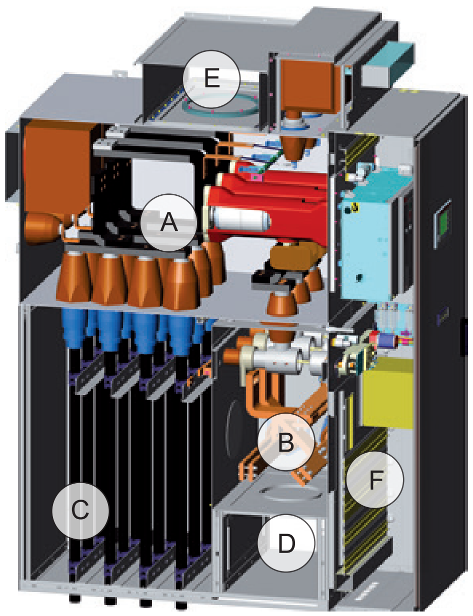


Fig. 6.2: Outgoing cable panel 2000 A, with pressure relief duct



Modular structure

Each feeder panel consists of the circuit-breaker compartment (A), the busbar compartment (B), the cable termination compartment (C), the lower pressure relief duct (D), the pressure relief system for the circuit-breaker compartment (E) and the low voltage compartment (F). The circuit-breaker compartment and the busbar compartment are filled with gas. There are no gas connections between the two compartments or to gas compartments in adjacent panels.

The circuit-breaker compartment (A)

The cable (1.3) and test plug sockets (1.4) and the circuit-breaker poles (1.1) are located in the circuit-breaker compartment (fig. 6.3 and 6.4).

The current-carrying connection between the circuit-breaker and the three position disconnector in the busbar compartment is effected via single pole cast resin bushings (1.12).

There are two basic versions of circuit-breaker compartments available:

- Current metering by ring core current transformers or sensors outside the gas compartment (figs. 6.3 and 6.6)
- Current metering and/or voltage metering by block-type transformers or sensors (1.9) in the gas compartment (fig. 6.4)

For currents > 1250 A, block-type transformers or sensors are generally located in the circuit-breaker compartment.

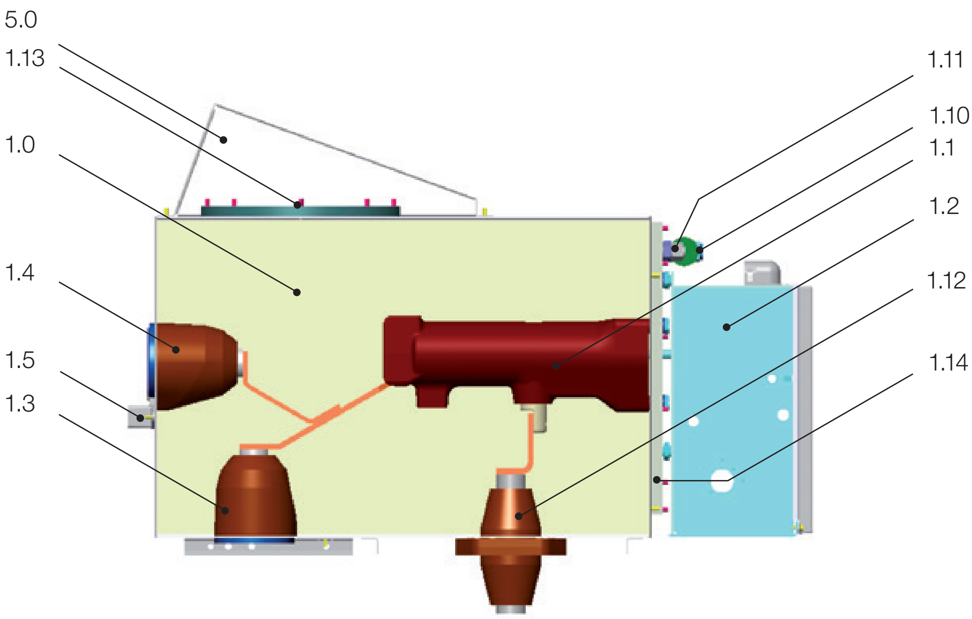
Voltage measurement at the feeder panel (fig. 6.4) can be implemented with plug-in voltage transformers (1.8). The optional, isolatable sockets (1.6) for plug-in voltage transformers are located above the circuit-breaker poles (1.1). Manual operation of the isolating system (1.7) for the plug-in voltage transformers is performed in the low voltage compartment with the door open.

The pressure relief disk (1.13) for the circuit-breaker compartment is located in the roof plate of the enclosure. The capacitive voltage indicator system (1.5) is fitted to the rear wall of the enclosure below the test sockets (1.4). The circuit-breaker operating mechanism (1.2), the gas density sensor (1.10) and the filling valve (1.11) are located on the mounting plate for the circuit-breaker (1.14), which is bolted to the front wall of the enclosure.

The seals of the components are o-ring seals which are not exposed to any UV radiation.

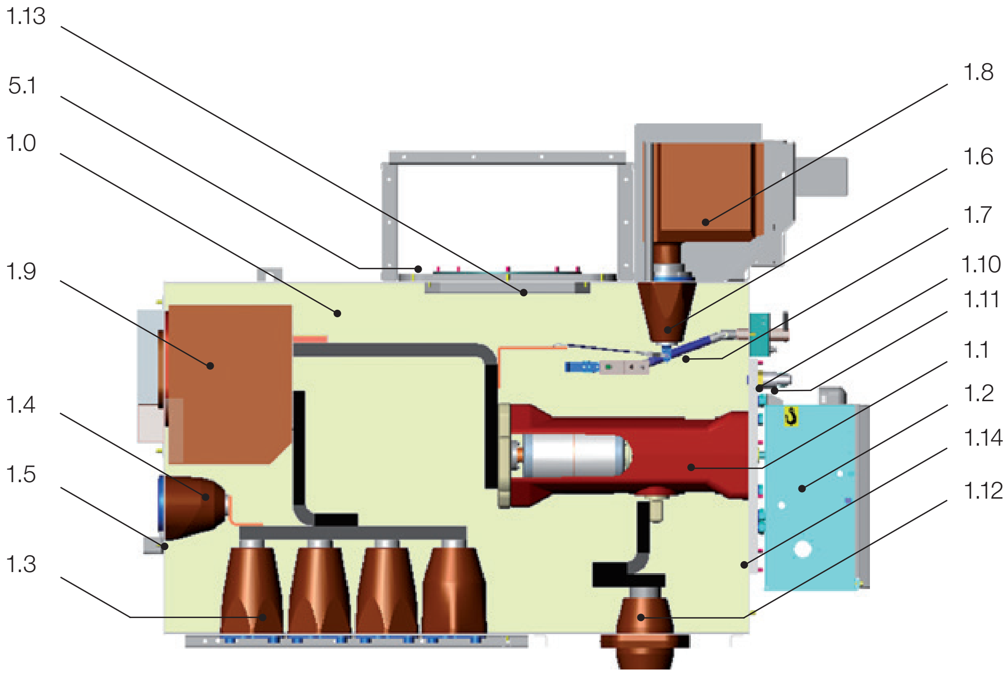
The circuit-breaker compartments in systems consisting of several panels have no gas connections to the neighbouring panels, nor is there any gas connection to the busbar compartments located below the circuit-breaker compartments.

Fig. 6.3: Circuit-breaker compartment (A), 800 A



1.0	Circuit-breaker compartment (enclosure)	1.11	Filling valve for circuit-breaker compartment
1.1	Circuit-breaker pole	1.12	Cast resin bushing to busbar
1.2	Circuit-breaker mechanism	1.13	Pressure relief disk
1.3	Cable socket	1.14	Mounting plate
1.4	Test socket	5.0	Plasma diverter (example)
1.5	Capacitive voltage indicator system		
1.10	Gas density sensor for circuit-breaker compartment		SF_6 insulating gas

Fig. 6.4: Circuit-breaker compartment (A), 2000 A



1.0	Circuit breaker compartment (enclosure)
1.1	Circuit-breaker pole
1.2	Circuit-breaker mechanism
1.3	Cable socket
1.4	Test socket
1.5	Capacitive voltage indicator system
1.6	Sockets for voltage transformers
1.7	Isolating system for voltage transformers
1.8	Voltage transformer
1.9	Block-type transformer or sensor
1.10	Gas density sensor for circuit-breaker compartment
1.11	Filling valve for circuit-breaker compartment
1.12	Cast resin bushing to busbar
1.13	Pressure relief disk
1.14	Mounting plate
5.1	Pressure relief duct, top (example)

SF_6 insulating gas

The busbar compartment (B)

The busbar compartment (fig. 6.5) contains the busbar system (2.1), which is connected to the single pole cast resin bushings (1.12) located at the top via flat conductors (2.8) and the three position disconnector (2.3).

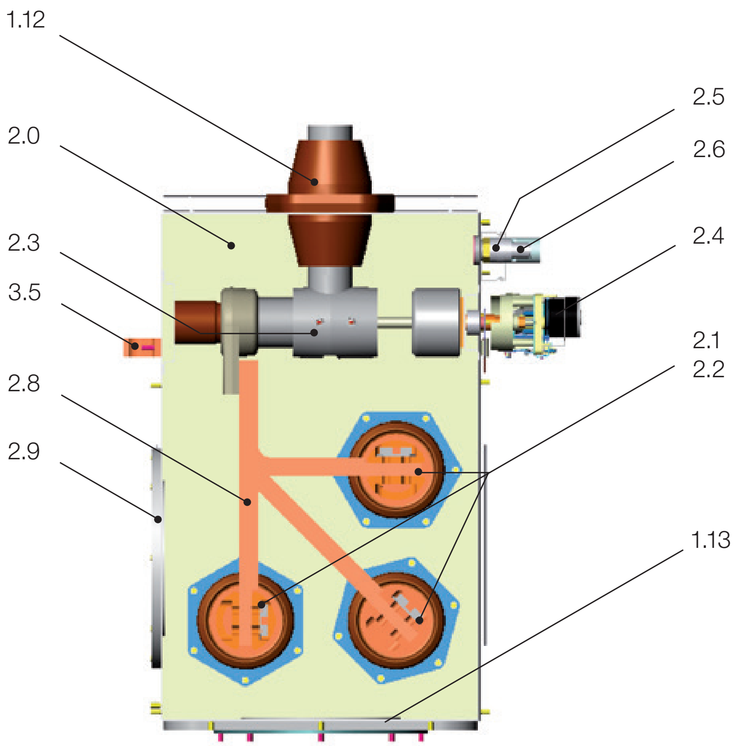
The pressure relief disk (1.13) for the busbar compartment is located in the floor plate of the enclosure. An assembly opening in the rear enclosure wall permits assembly of the components inside the enclosure at the works. The main earthing bar (3.5) of the panel is bolted to the enclosure above the access cover (2.9).

The operating mechanism for the three position disconnector (2.4) and the gas density sensor (2.5) and the filling valve (2.6) are located on the front plate of the enclosure.

As with the circuit-breaker compartment, the seals on the components are o-ring seals which are not exposed to any UV radiation.

The busbar connection to the adjacent panels is effected by plug-in connectors (2.2) located at either side of the enclosure. The busbar compartments in switchgears consisting of several panels have no gas connections with the neighbouring panels, nor is there any gas connection to the circuit-breaker compartment located above the busbar compartment.

Fig. 6.5: Busbar compartment (B), 2000A



- 1.12 Cast resin bushing
- 1.13 Pressure relief disk
- 2.0 Busbar compartment (enclosure)
- 2.1 Busbar system
- 2.3 Three position disconnector
- 2.4 Three position disconnector operating mechanism
- 2.5 Gas density sensor for busbar compartment
- 2.6 Filling valve for busbar compartment
- 2.8 Flat conductor
- 2.9 Access cover
- 3.5 Main earthing bar

SF_6 insulating gas

The cable termination compartment (C) and the lower pressure relief duct (D)

The cable termination compartment (fig. 6.6) and the lower pressure relief duct constitute a support frame for the panel manufactured from special aluminium sections.

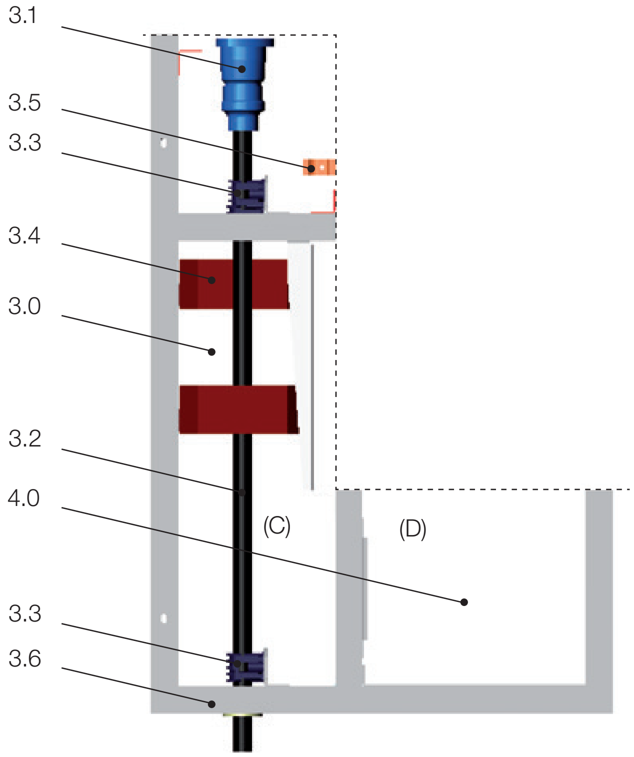
The cable termination compartment contains the main earthing bar (3.5), the high voltage cables (3.2) with fitted cable plugs (3.1), and cable fasteners (3.3) and, where appropriate, surge arresters. Optionally, the cable termination compartment may contain ring core current transformers or current sensors (3.4) when one cable per phase is used, or ring core current transformers when two cables are used.

An antimagnetic floor plate (3.6), split for cable installation, serves to partition the cable termination compartment off from the cable basement. The cable termination compartment can be fitted with partition plates at the sides and rear.

The cable termination compartment is shockproof.

In the unlikely event of an internal arc fault in the busbar compartment and the optionally partitioned cable termination compartment, the pressure is discharged through the lower pressure relief duct (4.0).

Fig. 6.6: Cable termination compartment (C) and lower pressure relief duct (D) (Example: unpartitioned, with ring core current transformers)



- 3.0 Cable termination compartment (C)
- 3.1 Cable plug
- 3.2 High voltage cable
- 3.3 Cable fastener
- 3.4 Ring core transformer or sensor
- 3.4 Main earthing bar (mounted to the busbar enclosure)
- 3.6 Floor plate
- 4.0 Pressure relief duct, bottom (D)

The pressure relief system for the circuit-breaker compartment (E)

The upper pressure relief system serves to discharge the pressure in the unlikely event of an internal arc fault in the circuit-breaker compartment.

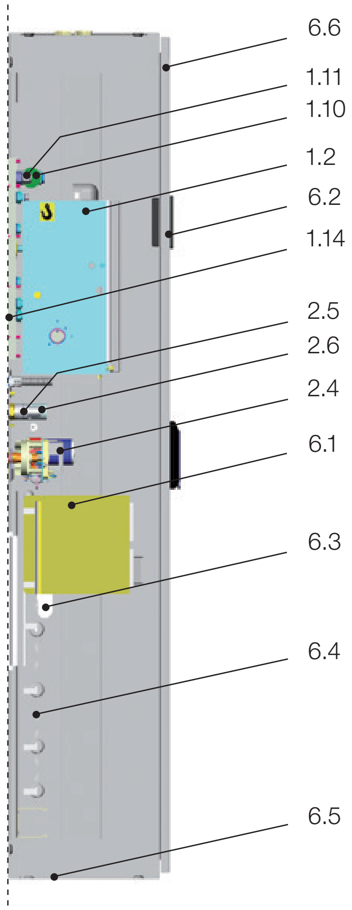
The low voltage compartment (F)

The operating mechanism for the circuit-breaker (1.2), the mechanism for the three position disconnector (2.4), sensors for gas density monitoring in the gas compartments (1.10, 2.5), protection devices and further secondary devices and their wiring are located in the low voltage compartment (fig. 6.7).

The entry for external secondary cables (6.5) is located in the base plate of the low voltage compartment.

As a rule the low voltage compartment depth amounts to 500 mm.

Fig. 6.7: Low voltage compartment



1.2 Circuit-breaker operating mechanism
1.10 Gas density sensor for circuit-breaker compartment
1.11 Filling valve for circuit-breaker compartment
1.14 Mounting plate for circuit-breaker
2.4 Three position disconnector mechanism
2.5 Gas density sensor for busbar compartment
2.6 Filling valve for busbar compartment
6.0 Low voltage compartment
6.1 Central unit of a combined protection and control device
6.2 Human-machine interface of a combined protection and control device
6.3 Opening for loop lines
6.4 Wiring section
6.5 Secondary cable entry
6.6 Low voltage compartment door

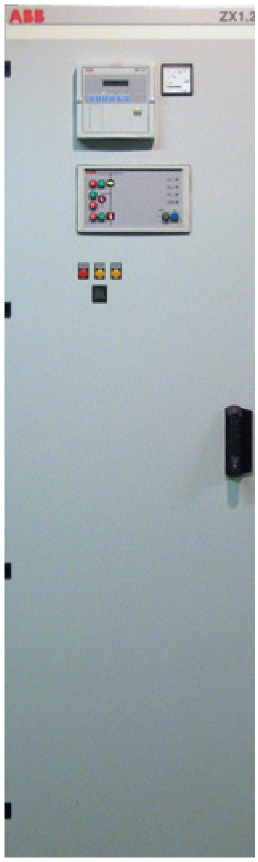
Either combined protection and control units such as ABB's RE_ family or a combination of any separate protection devices with conventional control systems can be used (cf. Chapter 5).

Fig. 6.8 shows a panel door fitted with the RE_ protection and control unit. Control of the primary side switching devices is effected by selecting the appropriate switch symbol on the control panel of the combined protection and control unit. The available measured values can be called up on the display of the RE_.

Fig. 6.9 shows the structure of a low voltage compartment door for the use of a conventional control system. Operation is effected using the control and display unit in the door, and the switch positions are displayed by bar indicators integrated in the single line diagram on the control and display unit. Signals are displayed by devices fitted in the door (e.g. signal lamps, drop indicator relays etc.). Display of measurements requires the use of discrete measuring instruments. Protection is performed by a separate protection device (shown in the example as a door-mounted unit).

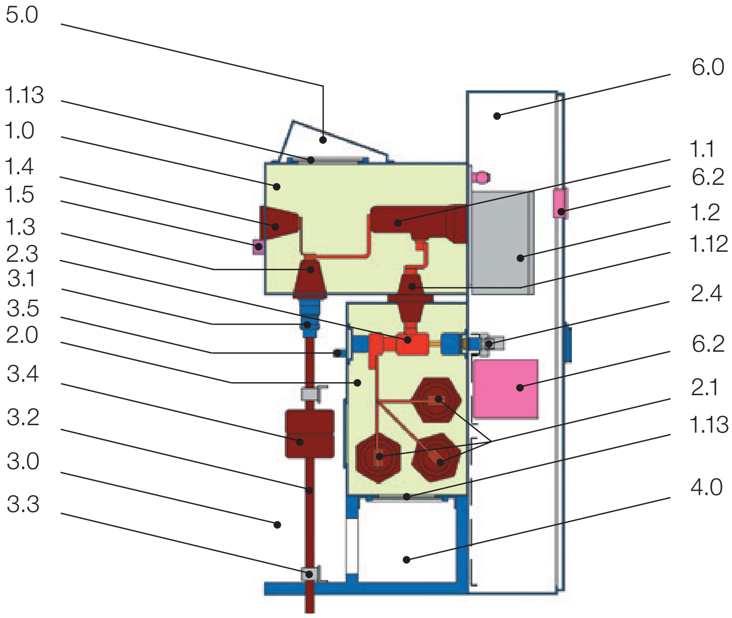
Fig. 6.8: Front view of low voltage compartment door with RE_

Fig. 6.9: Front view of low voltage compartment door with third party protection device and conventional control units



7 Components

Fig. 7.1: Outgoing cable panel 800 A with plasma diverter



1.0 Circuit-breaker compartment
1.1 Circuit-breaker pole
1.2 Circuit-breaker operating mechanism
1.3 Cable sockets
1.4 Test sockets
1.5 Capacitive voltage indicator system
1.6 Sockets for voltage transformers
1.7 Isolating system for voltage transformers
1.8 Voltage transformer
1.9 Block-type transformer or sensor
1.12 Bushing, circuit-breaker/busbar compartment
1.13 Pressure relief disk

2.0 Busbar compartment
2.1 Busbar system
2.3 Three position disconnector
2.4 Three position disconnector mechanism

3.0 Cable termination compartment
3.1 Cable plug
3.2 High voltage cable
3.3 Cable fastener
3.4 Ring core transformer or sensor
3.5 Main earthing bar

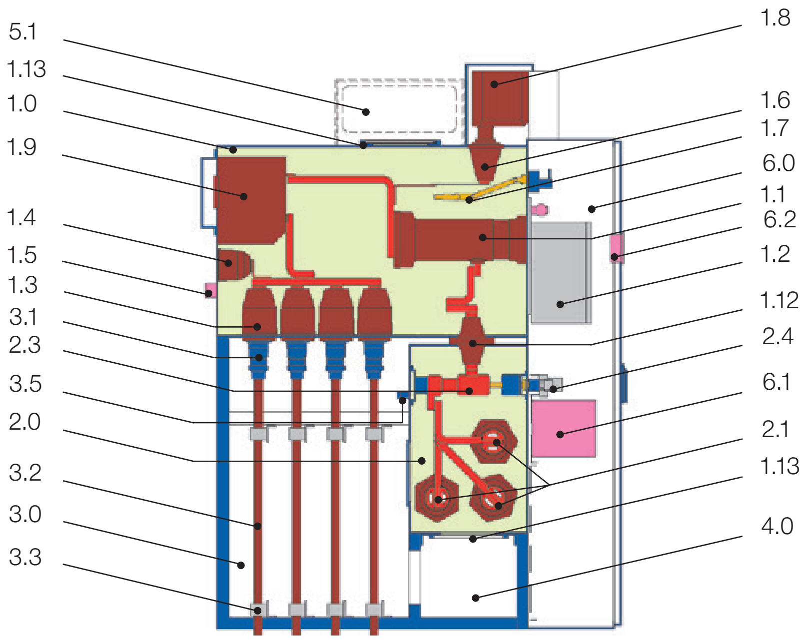
4.0 Pressure relief duct, bottom

5.0 Plasma diverter
5.1 Pressure relief duct, top

6.0 Low voltage compartment
6.1 Central unit of a combined protection and control device
6.2 Human-machine interface of a combined protection and control device

Insulating gas SF_6

Fig. 7.2: Incoming Panel 2000 A, with pressure relief duct



7.1 Vacuum circuit-breaker

The fixed mounted vacuum circuit-breakers (fig. 7.1.1) are three phase switching devices and fundamentally consist of the operating mechanism and the three pole parts. The pole parts contain the switching elements proper, the vacuum interrupters.

The pole parts are installed on a common mounting plate. The operating mechanism is on the opposite side from the mounting plate. In this way, the pole parts, mounting plate and operating mechanism form a single assembly. The mounting plate for this assembly is screwed to the front wall of the circuit-breaker compartment in a gas-tight manner at the works.

The pole parts are located in the circuit-breaker compartment which is filled with SF_6, and are therefore protected from external influences. The operating mechanism is located in the low voltage compartment and is therefore easily accessible.

Functions of the vacuum circuit-breaker

- Switching operating current on and off
- Short-circuit breaking operations
- Earthing function in conjunction with the three position disconnector

For earthing, the three position disconnector prepares the connection to earth while in the de-energised condition. Earthing proper is performed by the circuit-breaker. A circuit-breaker functioning as an earthing switch is of higher quality than any other earthing switch.

Vacuum interrupter

The outer casing of the vacuum interrupter (fig. 7.1.2) consists of ceramic insulators (1), whose ends are sealed off by stainless steel lids (2). The contacts (4 and 5) surrounded by the potential-free centre screen (3) are made of copper/chromium composite. As a consequence of the extremely low static pressure of less than 10^{-4} to 10^{-8} hPa inside the interrupter chamber, only a relatively small contact gap is required to achieve a high dielectric strength. The switching motion is transmitted into the enclosed system of the vacuum interrupter via a metal bellows (6). An anti-rotation element (7) is fitted to protect the metal bellows from torsion and to guide the conductor leading to the moving contact. The connection to the operating mechanism is effected by a threaded pin (8) fastened in the feed conductor.

If contacts through which current is flowing are opened in a vacuum, a metal vapour arc arises under short-circuit conditions. This arc creates the charge carriers required to conduct the current inside the vacuum interrupter. The arc is extinguished at the first natural zero of the alternating current after switch-off, i.e. after separation of the contacts. With the rapid reestablishment of the contact gap in the vacuum, the current flow is then securely interrupted.

Fig. 7.1.1: Vacuum circuit-breaker

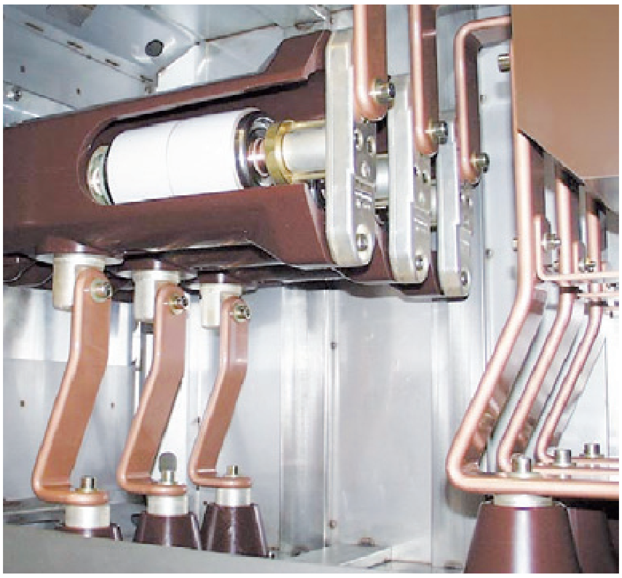
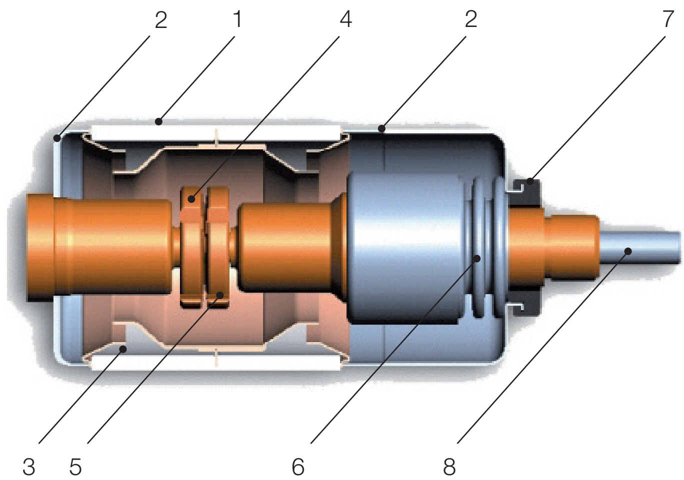


Fig. 7.1.2: Vacuum interrupter



Pole parts

The interrupter (9) inside the pole part is embedded in cast resin or located in a cast resin pole tube (10). With the breaker closed, the current flows from breaker terminal (11) to the fixed contact in the vacuum interrupter, and from there via the moving contact to breaker terminal (12). The operating motions are effected by insulated actuating rods (8).

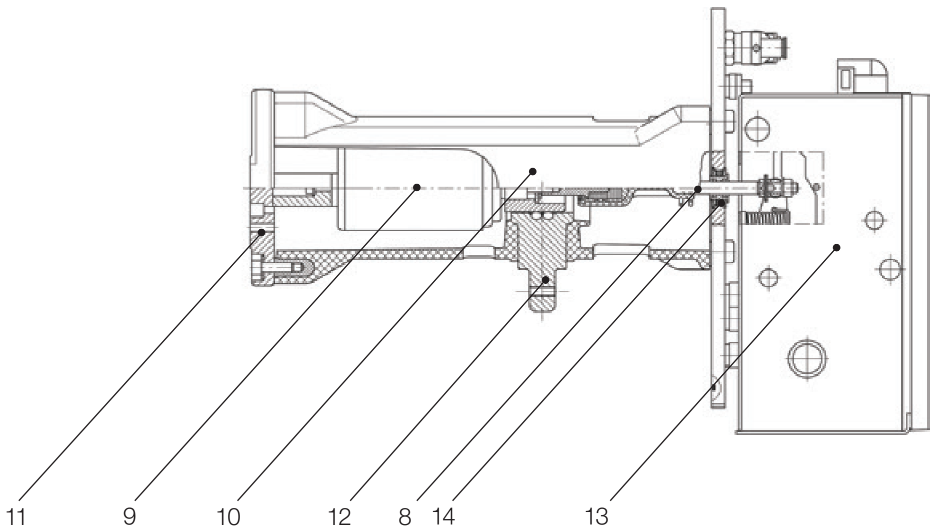
Circuit-breaker operating mechanism

The circuit-breaker operating mechanism (fig. 7.1.3, item 13) is connected to the pole parts via gas-tight thrust bushings (14).

The circuit-breaker is equipped with a mechanical stored-energy spring mechanism. The stored-energy spring can be charged either manually or by a motor. Opening and closing of the device can be performed by means of mechanical push-buttons or by electrical releases (closing, opening and undervoltage releases).

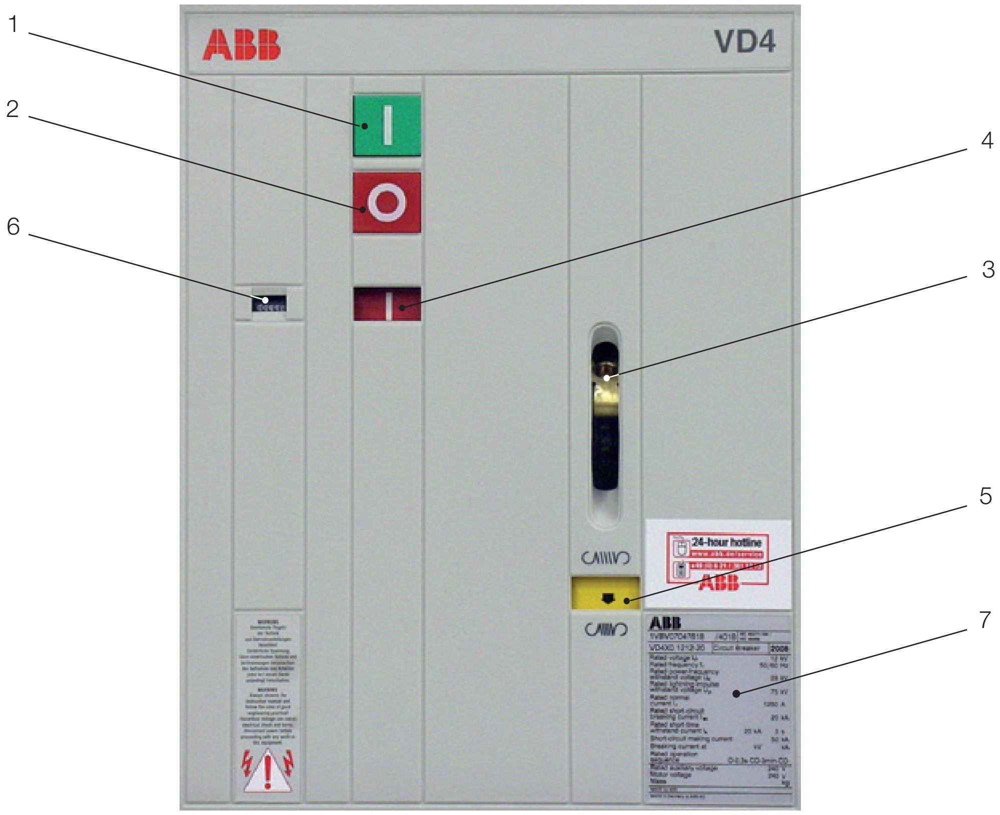
The operating mechanism can be configured for autoreclosing and, with the short motor charging times involved, also for multi-shot autoreclosing.

Fig. 7.1.3: Pole part and operating mechanism



The front of the operating mechanism (fig. 7.1.4) accommodates the mechanical on (1) and off (2) pushbuttons, the receptacle for manual charging of the stored-energy spring (3), the mechanical indicators for “Circuit-breaker ON” “Circuit-breaker OFF” (4), “Stored-energy spring charged”, “Stored-energy spring discharged” (5), an operating cycle counter (6) and the name plate for the circuit-breaker (7).

Fig. 7.1.4: Controls for the circuit-breaker operating mechanism



The mechanical push-buttons can optionally be fitted with a locking device (figure 7.1.5). When this option is selected, both buttons can be secured separately with padlocks.

Fig. 7.1.5: Optional locking device for mechanical push-buttons on the circuit-breaker

Example: OFF button secured

Example: OFF button enabled for operation

Secondary equipment for the circuit-breaker mechanism

Table 7.1.1 shows the secondary equipment for the circuit-breaker operating mechanism in an outgoing feeder panel. The “Standard” column indicates the equipment necessary for control of the panel. Over and above this, the use of further devices such as additional auxiliary switches is possible as an option to meet your specific requirements.

Table 7.1.1: Secondary equipment for the circuit-breaker mechanism in feeder panels

IEC designation	VDE designation	Equipment	Standard	Option
-MAS	-M0	Charging motor for spring mechanism	●	
-BGS1 1)	-S1	Auxiliary switch “Spring charged”	●	
-MBO1	-Y2	Shunt release OFF	●	
-MBC	-Y3	Shunt release ON	●	
-BGB1	-S3	Auxiliary switch “CB ON/OFF”	●	
-BGB2 2)	-S3	Auxiliary switch “CB ON/OFF”	●	
-BGB3 2)	-S3	Auxiliary switch “CB ON/OFF”		●
-KFN	-K0	Anti-pumping device	●	
-RLE1	-Y1	Blocking magnet “CB ON”	●	
-BGL1	-S2	Auxiliary switch for blocking magnet	●	
-BGB4	-S7	Fleeting contact ≥ 30 ms for C.B. tripped indication		●
-MBU 3)	-Y4	Undervoltage release		●
-MBO3 3)	-Y7	Indirect overcurrent release		●
-MBO2	-Y9	2nd shunt release OFF		●

1) For certain versions of the circuit-breaker, auxiliary switches BGS1.1...1.5 are used.
2) For certain versions of the circuit-breaker, the auxiliary switch may not be required. In such cases the function is performed by auxiliary switch -BGB1.
3) Combination of -MU with -MO3 is not possible

7.2 Three position disconnector

The three position disconnectors are combined disconnectors and earthing switches. The three switch positions, connecting, disconnecting and earthing, are clearly defined by the mechanical structure of the switch. Simultaneous connection and earthing is therefore impossible.

The three position disconnectors are motor-operated rod-type switches whose live switching components are located in the busbar compartment filled with SF_6, while the mechanism block is easily accessible in the low voltage compartment.

The switch (fig. 7.2.1) has its disconnected position in the central position. In the disconnector ON and earthing switch ON limit positions, the moving contact (sliding part) driven by an insulating spindle reaches the fixed contacts (disconnector contact or earthing contact) which are fitted with one or two spiral contacts.

Series connected, optional reed contacts (= switches operated by permanent magnets) detect the correct positions of the three contacts in the earthing switch ON position (figs. 7.2.2 and 7.2.3).

Three position disconnector operating mechanism

The operating mechanism block for the three position disconnector consists of the following functional groups (figs. 7.2.4 to 7.2.6):

- Drive motor
- Functional unit with micro switches and auxiliary switches for position detection
- Mechanical position indicator
- Mechanical access interlock for emergency manual operation
- Hand crank receptacle for emergency manual operation

The various options for secondary equipment in the mechanism variants can be found in table 7.2.1.

Fig. 7.2.1: Three position disconnector in disconnector ON position

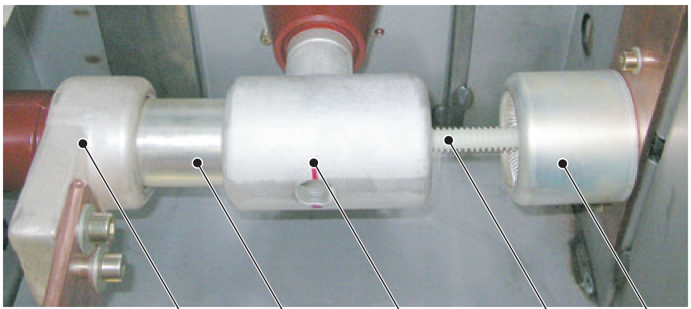


Fig. 7.2.2: Partial view of the three position disconnector in the earthing switch ON position (reed contact switched on by permanent magnet)

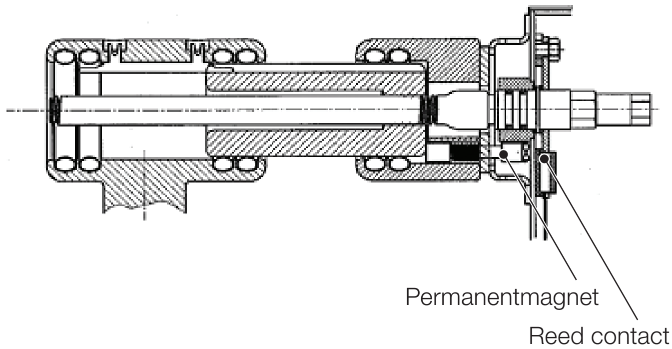


Fig. 7.2.3: Partial view of the three position disconnector in the central position

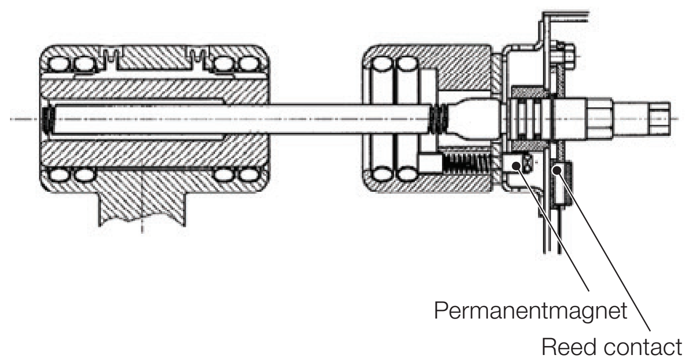


Fig. 7.2.4: Three position disconnector operating mechanism

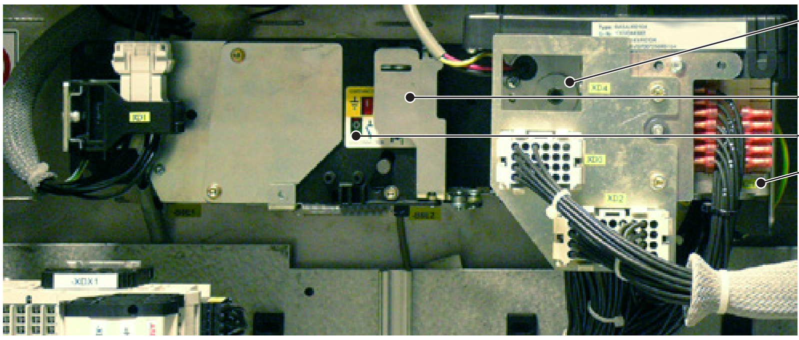


Fig. 7.2.5: Closed mechanical access interlock for emergency manual operation

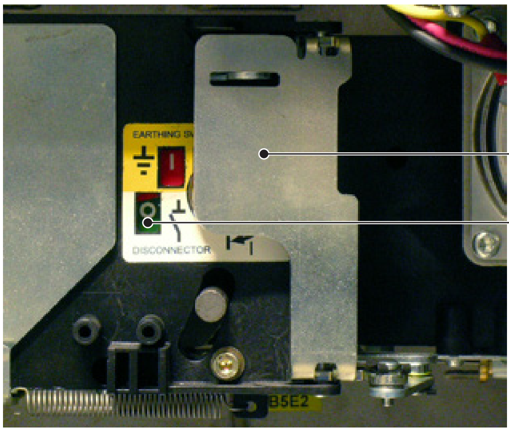
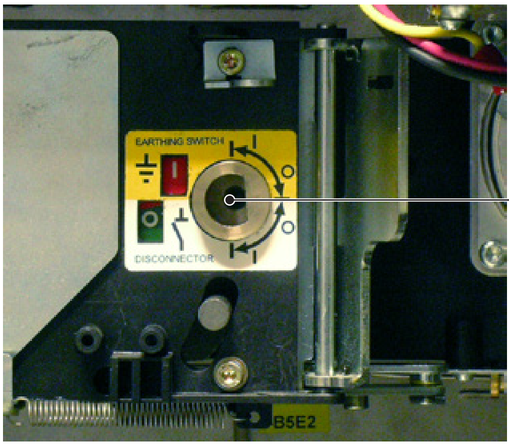


Fig. 7.2.6: Opened mechanical access interlock for emergency manual operation



Secondary equipment for the three position disconnector operating mechanism

Table 7.2.1 shows the secondary equipment for the three position disconnector operating mechanism in an outgoing feeder panel. The “Standard” column indicates the equipment necessary for control of the panel. Over and above this, the use of further devices such as additional auxiliary switches is possible as an option to meet your specific requirements.

Table 7.2.1: Secondary equipment for the three position disconnector mechanism in feeder panels

IEC designation	VDE designation	Equipment	Standard	Option
-MAD	-M1	Drive motor	•	
-BGI15	-S15	Microswitch to detect switch position “Disconnector OFF”	•	
-BGI16	-S16	Microswitch to detect switch position “Disconnector ON”	•	
-BGE57	-S57	Microswitch to detect switch position “Earthing switch OFF”	•	
-BGE58	-S58	Microswitch to detect switch position “Earthing switch ON”	•	
-BGI1	-S11	Auxiliary switch to detect switch position “Disconnector OFF”	•	
-BGI1	-S12	Auxiliary switch to detect switch position “Disconnector ON”	•	
-BGI5	-S51	Auxiliary switch to detect switch position “Earthing switch OFF”	•	
-BGI5	-S52	Auxiliary switch to detect switch position “Earthing switch ON”	•	
-BGE3.1/2/3	-B5E1/2/3	Reed contacts to detect the “Earthing switch ON” switch position		•
-BGL1 -BGL2	-S151 -S152	Microswitch for access blocking of hand crank receptacle for emergency manual operation		•

7.3 Busbar

The busbars, located in the gas compartment of the panels, are connected together by plug-in busbar connectors (figs. 7.3.1 to 7.3.3). The busbar connection consists of the cast resin busbar socket (1) mounted in the busbar compartment from the inside, the silicone insulating part (2), the contact tube (3) and the spiral contacts (4).

The electrically conductive connection from the embedded part of the cast resin busbar socket to the contact tube is established by one or two spiral contacts, depending on the rated busbar current. The silicone insulating part isolates the high voltage potential from earth potential. The surfaces of all electrically conductive components (embedded part, spiral contact and contact tube) which are accessible from the outside are silver plated. As the contact tubes are axially movable, no further compensation for expansion in the busbars running through a switchgear system is necessary.

The circuit-breaker and busbar compartments are separate chambers in the gas system. Busbar operation therefore continues to be possible in the event of a fault in the circuit-breaker compartment of an outgoing feeder panel. The gas systems of adjacent busbar compartments are also not connected to each other (exception: double feeder panels).

The plug connector system on the one hand facilitates the delivery of panels tested at the works for leakage and dielectric strength, and on the other hand no gas work during installation at site is necessary for rated currents up to 2000 A.

Fig. 7.3.1: Busbar socket (1) with insulating part (2), contact tube (3) and spiral contacts (4)

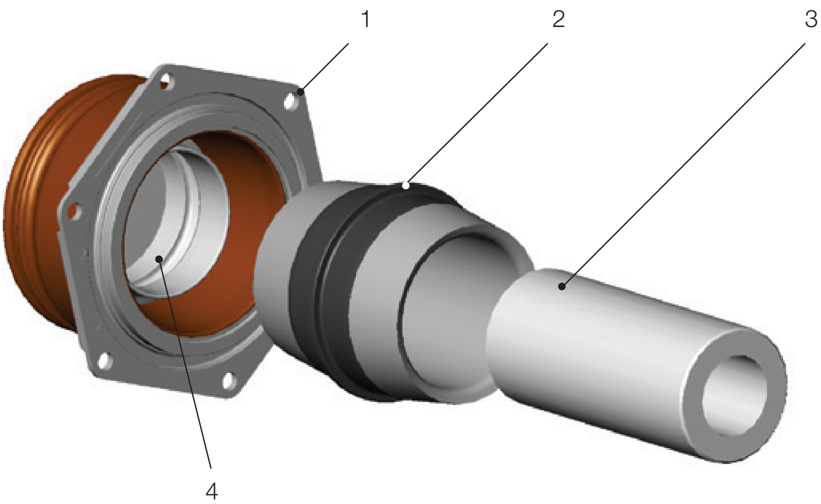


Fig. 7.3.2: Busbar connection, plugged in at one end

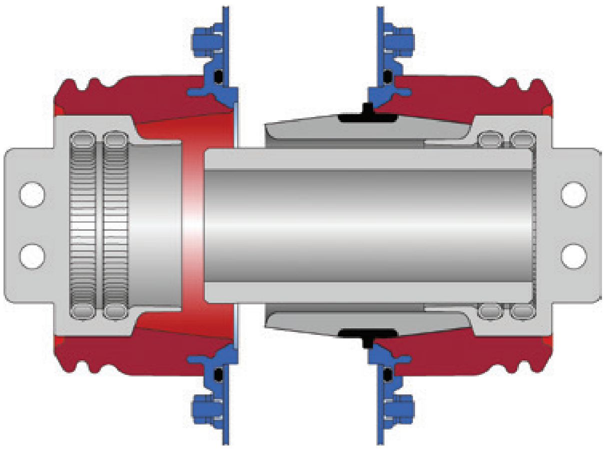
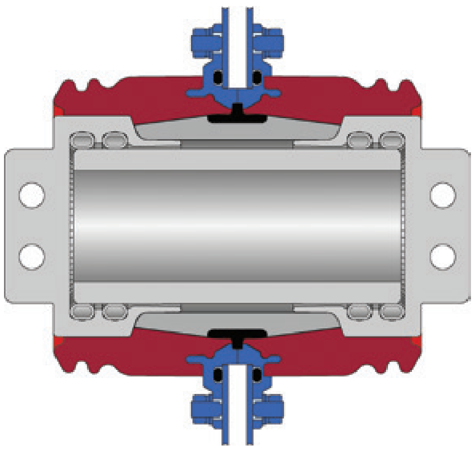


Fig. 7.3.3: Busbar connection, between the panels



End panels

End panels are available in versions which permit extension. In these versions, the busbar sockets (fig. 7.3.4) are dielectrically sealed off with blanking plugs. If extension is definitely not necessary, busbar end insulators (fig. 7.3.5) are used in place of the conventional busbar sockets.

Removal of intermediate panels

The busbar connection with busbar socket, insulating part and contact tube can be dismantled when the busbar is earthed, the SF_6 properly pumped out and the busbar compartment opened. It is therefore possible to remove any panel from the middle of a switchgear installation.

The busbar interrupted by removal of the panel can be temporarily bridged with the aid of a coupler box.

Direct connection of fully insulated bars to the busbar

Fully insulated bars can be connected with special busbar sockets in an end panel (fig. 7.3.6).

Fig. 7.3.4: Busbar enclosure with busbar sockets (1)

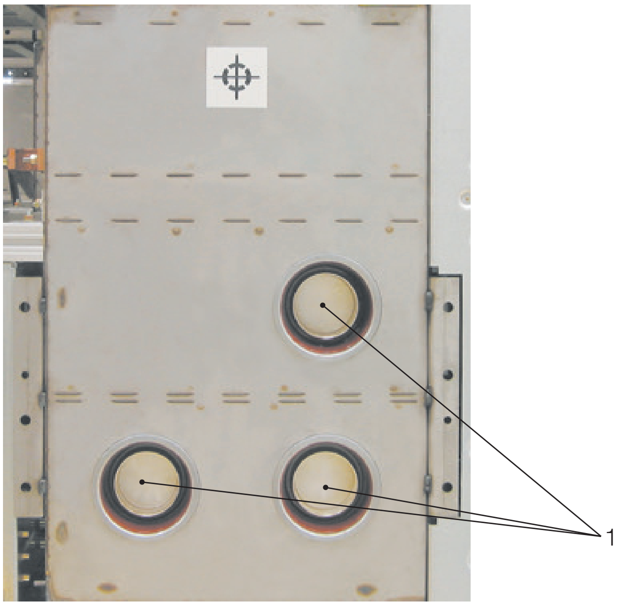


Fig. 7.3.5: Busbar enclosure with busbar end insulators (2)

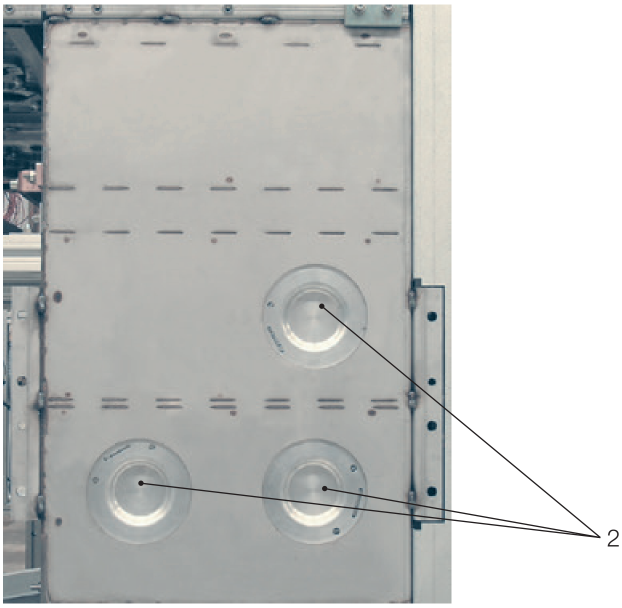
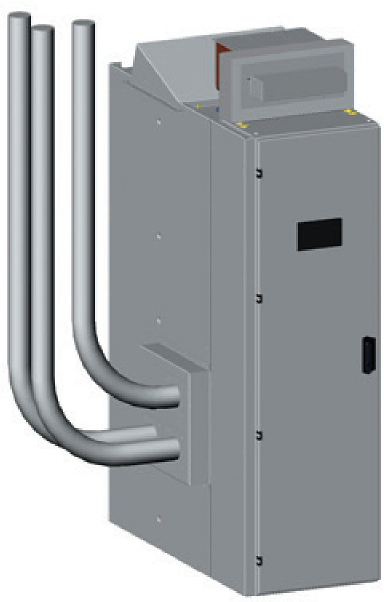


Fig. 7.3.6: Direct connection of fully insulated bars to the busbar



7.4 Inner cone termination system

Inner cone sockets (fig. 7.4.1 - size 2 or 3) fitted in a gas-tight manner in the floor plate of the circuit-breaker compartment facilitate facilitate the connection of cables (fig. 7.4.1.1), fully insulated bars (7.4.2.1) or surge arresters (7.4.3.1).

The inner cone termination system is above all notable for its total insulation and the associated protection against accidental contact. The termination height of 1.25 m ensures good accessibility during installation of the cables.

7.4.1 Connection of cables

An overview of the maximum cross-sections of the cables to be connected and the cable plugs usable in various installation situations can be found in table 7.6.1.1. As the assignment of plug sizes to the actual cable used can depend on further cable data, these are to be discussed with the plug supplier.

The current carrying capacity of the panels as stated is achieved when all the sockets in the panel are evenly fitted with cables.

Table 7.6.1.1: Cable plugs usable in various installation situations

Manufacturer	Plug size	Cable cross section [mm^2]
ABB	2	185
AB srl.		400
nkt		300
Pfisterer		400
Südkabel		300
Tyco / Raychem		400
ABB	3	630
nkt		630 (800 RE) [1)]
Südkabel		630
Tyco / Raychem		630

Fig. 7.4.1: View into the gas-insulated circuit-breaker compartment with inner cone sockets

Fig. 7.4.1.1: View into the cable termination compartment in air with cable connectors and cables

[1)] RE: round single-wire

7.4.2 Connection of fully insulated bars

Connection of fully insulated bars (fig. 7.4.2.1) in place of cables is possible using sockets of size 3 (up to 1250 A) or special sockets (up to 2500 A).

7.4.3 Connection of surge arresters

Connection of plug-in surge arresters of sizes 2 (12- 36 kV) and 3 (24 – 36 kV) in place of cables is possible (fig. 7.4.3.1).

ABB-Polim® surge arresters are to be used. The surge arresters consist of zinc oxide varistors, which provide optimum protection from hazardous overvoltages. The varistors are located in an aluminium casing and embedded in silicone.

Fig. 7.4.2.1: Connection of a fully insulated bar using plug size 3

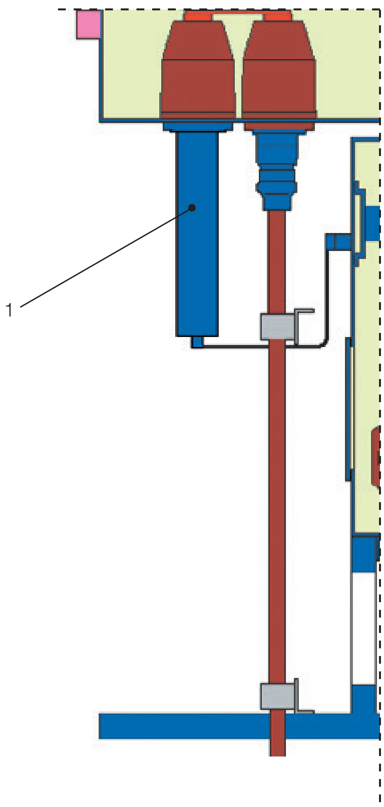
7.5 Main earthing bar

The main earthing bar of the switchgear system runs through the cable termination compartments of the panels. The earthing bars in the individual panels are connected together during installation at site.

The cross-section of the main earthing bar is 300 mm^2 (ECuF30 30 mm x 10 mm).

Details on earthing the switchgear can be found in section 10.8.

Fig. 7.4.3.1: Connection of surge arresters (1)



7.6 Test sockets

Incoming and outgoing cable panels are equipped with test sockets (figs. 7.6.1 and 7.6.2) at the rear. The test sockets are used for cable tests, for insulation testing on the panels, for testing of the protection systems by primary current injection and for maintenance earthing of the relevant feeder panel. Suitable testing and earthing sets are available for this purpose (figs. 7.6.3 to 7.6.5).

The test sockets must be closed off with blanking plugs of high dielectric strength during normal operation of the panel.

Fig. 7.6.1: View into the circuit-breaker compartment: test sockets

Fig. 7.6.2: Test sockets (above the capacitive voltage indicator system), access prevented by high dielectric strength blanking plugs

Fig. 7.6.3: Current test plug

Fig. 7.6.4: Voltage test plug

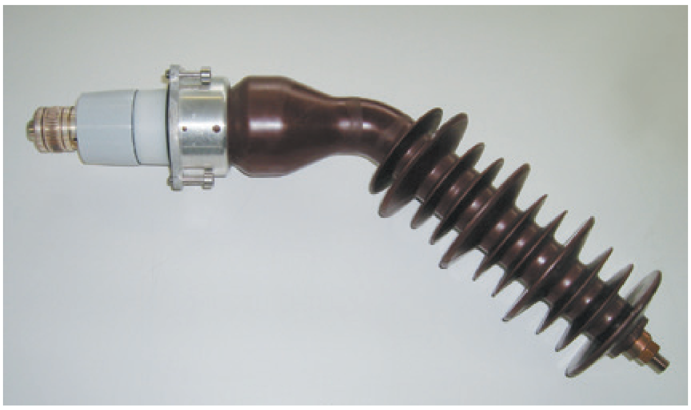
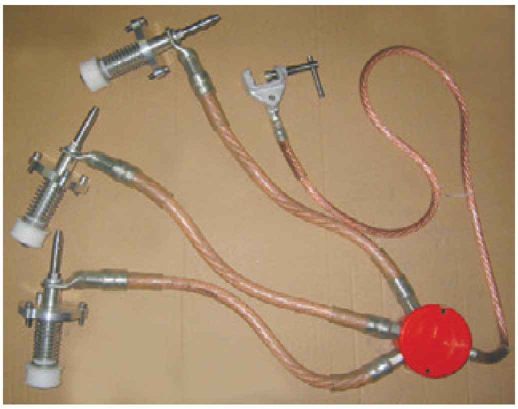


Fig. 7.6.5: Earthing set



7.7 Capacitive voltage indicator systems

Two types of capacitive, low impedance voltage indicator systems are available for checking of the off-circuit condition of a feeder. The coupling electrode is integrated in the test sockets or in the sensors and – when an additional capacitive voltage indicator system is fitted in the panel door – in the cable sockets. The capacitive voltage indicator system is located at the rear of the panel. A further system in the low voltage compartment door can also be used.

Both systems used are voltage detection systems (VDS) according to IEC 61243-5.

The systems used permit phase comparison with the aid of an addition, compatible phase comparator.

System WEGA 1.2 C (Fig. 7.7.1)

- LC-Display
- Three phase
- No additional indicator unit required
- Auxiliary voltage not required
- Maintenance-free with integrated self-test in built-in condition:
- Phase-selective overvoltage indication
- Three phase symbolic display:
  - Voltage present / no voltage present (Threshold value for voltage presence indication: 0.1 - 0.45 x U_N)
  - Integrated maintenence test passed
  - Voltage signal too high (Overvoltage indication)

System WEGA 2.2 C (Fig. 7.7.2)

As system WEGA 1.2 C, but:
- Two integrated relay contacts (changeover contacts) for signals/interlocks
- Auxiliary voltage for relay function required (LC-Display function via measuring signal)
- LED indication
  - green for U = 0
  - red for U ≠ 0

Fig. 7.7.1: System WEGA 1.2 C

Fig. 7.7.2: System WEGA 2.2 C

7.8 Current and voltage detection devices

The areas of application for current and voltage detection devices are

- Protection applications
- Measurement
- Billing metering

Conventional current and voltage transformers and/or current and voltage sensors may optionally be used.

Current transformers

The inductive transmission principle of a current transformer is based on the use of a ferromagnetic core. Irrespective of its structure as a bushing or block-type transformer, bar-primary or wound-primary transformer, a current transformer is in principle subject to hysteresis and saturation. In the rated current range, the primary and secondary currents are proportional and in phase.

Current sensors

The current sensor functions on the principle of the Rogowski coil. This is a coil consisting of a uniform winding on an enclosed, non-magnetic core of constant cross-section. The voltage induced in the secondary circuit is proportional to the change in time of the primary current. The current sensor signal therefore has a phase shift of 90°, which has to be compensated for by integration in the subsequent processing.

Voltage transformers

Inductive voltage transformers are low capacity transformers in which the primary and secondary voltage is proportional and in phase. The primary and secondary windings are electrically isolated from each other.

Voltage sensors

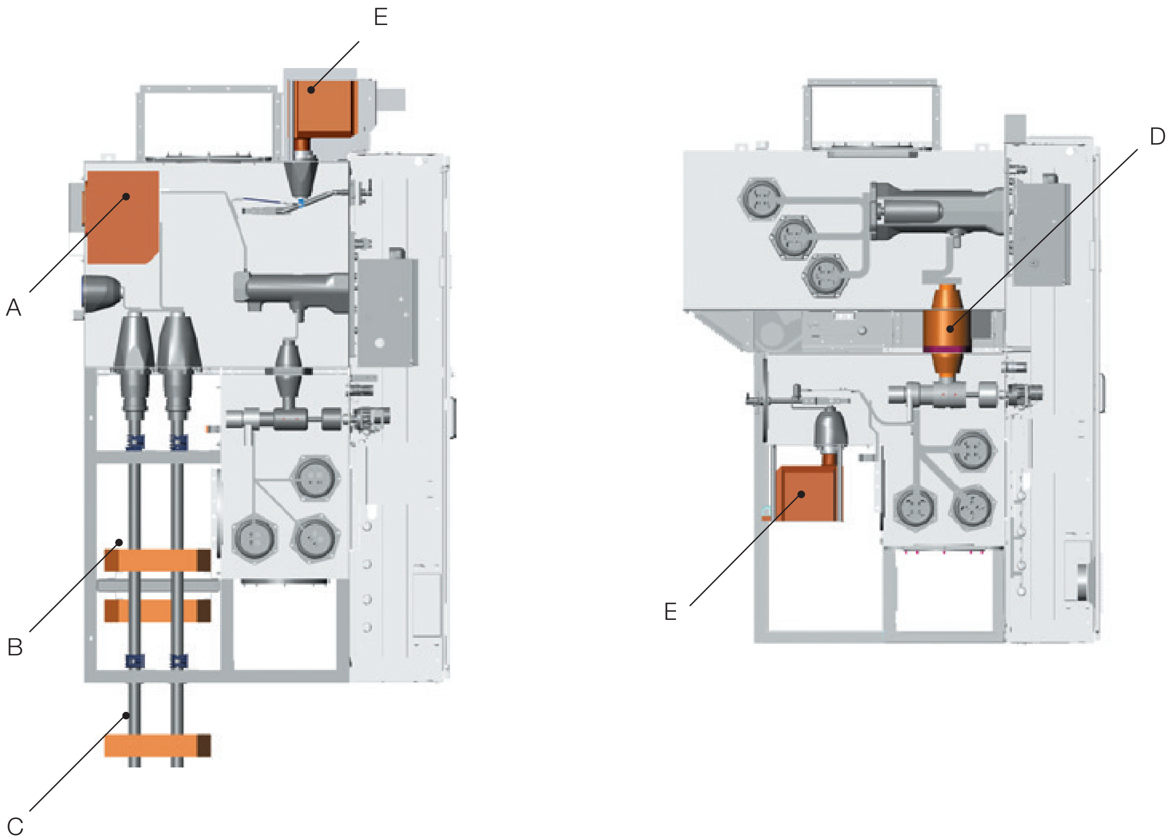
The voltage sensor functions on the principle of a potentiometer-type resistor. The output signal from the voltage sensor is proportional to the primary voltage and linear throughout the working range.

The following current and voltage detection devices can be used (see fig. 7.8.3):

- Device A: Block-type transformer, block-type sensor or combined block-type transformer/sensor in the circuit-breaker compartment
- Device B: for current detection: Ring core transformer or ring core sensor (1 cable per phase) in the cable termination compartment
- Device C: Ring core transformer for earth fault detection below the panel (in the cable basement)
- Device D: Optional current trans-former between the three position disconnector and circuit-breaker in a sectionaliser and riser panel
- Device E: Voltage transformer (outside the gas compartment only, plug-in type and isolatable in the earthed condition)

Conventional current and voltage transformers are certifiable.

Fig. 7.8.3: Current and voltage detection devices



7.8.1 Block-type transformers and block-type sensors

The block-type transformer or block-type sensor (fig. 7.8.1.1 and 7.8.1.2) consists of cast resin in which the corresponding components are embedded. It is located in the gas compartment, and is therefore protected from external influences.
The terminal board is easily accessible from the outside. The cross-section of the connecting wires is 2.5 mm² (larger cross-sections on request).
The terminal board is sealable. The advantage of the block-type transformer over ring core transformers is that only one transformer is required when several cables per phase are used. No provision has to be made for ring core transformers during cable installation.

The possible combinations of current sensors, current transformers and voltage sensors can be seen in table 7.8.1.

Current sensor

The current sensor for rated currents up to 1250 A has three taps. The sensors can be adjusted to suit the working range by corresponding connection of the secondary wiring at the terminal board (see fig. 7.8.1.3).

The current sensor for rated currents up to 2500 A has one tap (see fig. 7.8.1.4).

The measurement accuracy is better than 1%.

Voltage sensor

The voltage sensor for operating voltages up to 6 kV has a ratio of 5000 : 1, for up to 24 kV a ratio of 10000 : 1, and for 36 kV a ratio of 20000 : 1 (see figs. 7.8.1.3 and 7.8.1.4).
The measurement accuracy is better than 1%.

Current transformer

When only current transformer cores are used, the device can contain up to 3 cores in a 600 mm wide panel and up to 5 cores in an 800 mm wide panel (see also section 7.8.3).

Fig. 7.8.1.1: Block-type transformer or block-type sensor

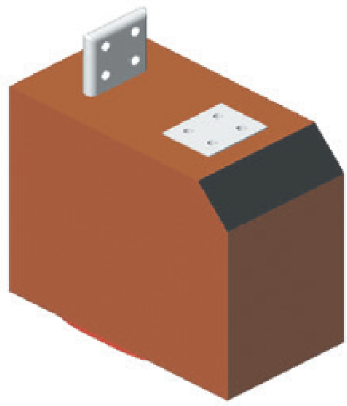
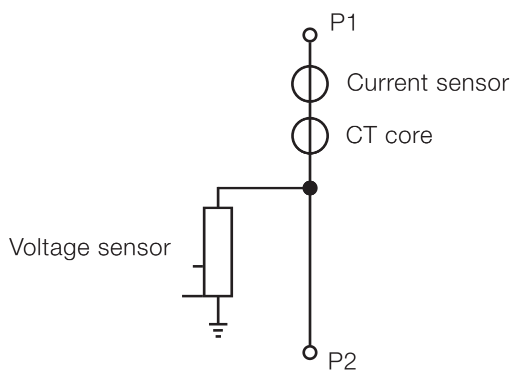


Fig. 7.8.1.2: Circuit diagram of the block-type transformer/sensor (example)



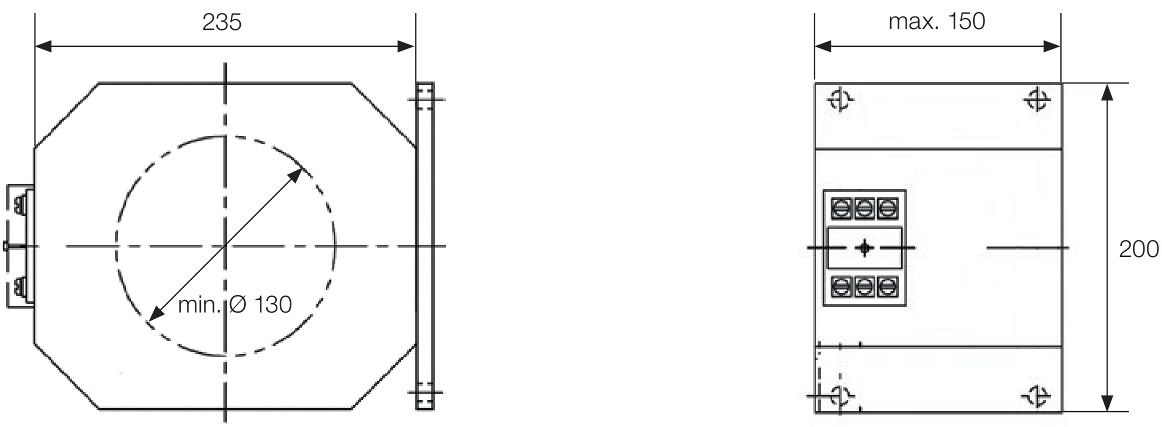
7.8.2 Ring core current transformers

The winding of the ring core transformer is located in a cast resin casing. The transformer has a terminal board with the winding taps or embedded connecting cables. The cross-section of the connecting wires is 2.5 mm² (larger cross-sections on request). Depending on the primary current, up to 3 cores can be accommodated in a ring core transformer. Typically, one current transformer is used per phase.

Fig. 7.8.2.1: Ring core current transformer

The following models are available:

Fig. 7.8.2.2: Ring core current transformer (one cable per phase, plug size 2)



In the models shown, the primary cable with fitted plug can be threaded through the transformer. Further types of ring core current transformer (e.g. with smaller internal diameter or greater overall height) are available and up to two transformers per phase can be used on request.

Earth fault transformers

Earth fault transformers are special ring core transformers. As all the power cables in a panel are routed through the transformer, the opening in the transformer has to be correspondingly large. As a result of their size, earth fault transformers are installed in the cable basement below the panel.

Fig. 7.8.2.3: Ring core current transformer (one cable per phase, up to plug size 3)

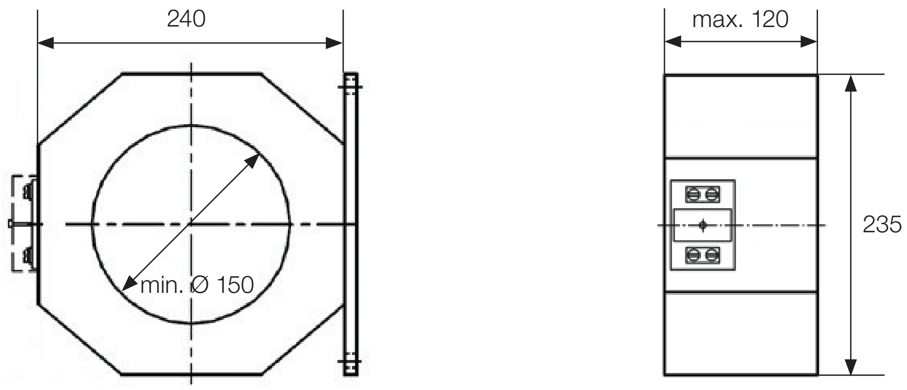


Fig. 7.8.2.4: Ring core current transformer (two cables per phase, up to plug size 2)

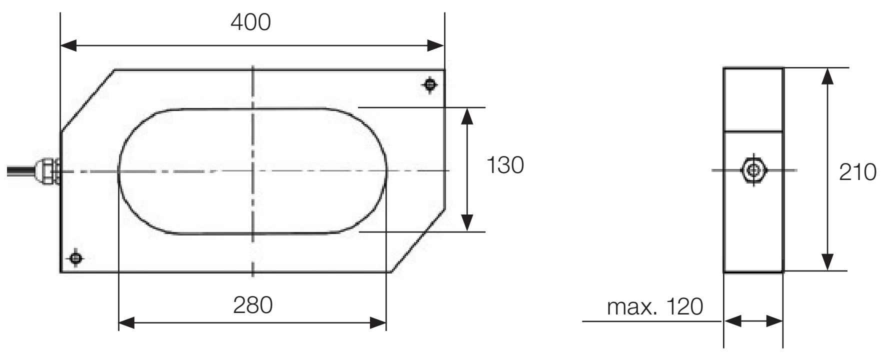
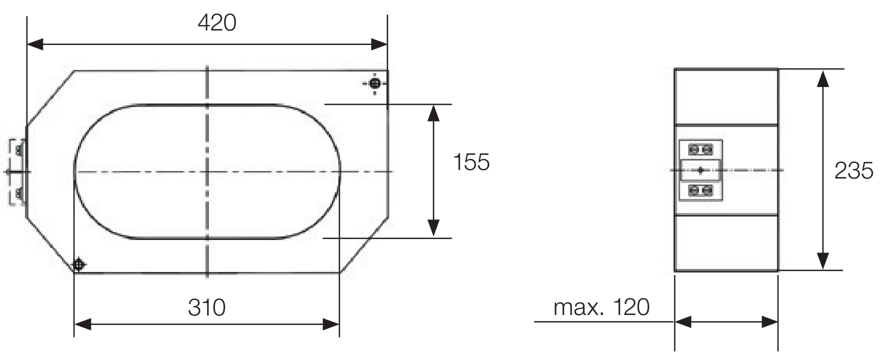


Fig. 7.8.2.5: Ring core current transformer (two cables per phase, up to plug size 3)



7.8.3 Dimensioning of current transformers

The stipulations and recommendations of IEC 61936, section 6.2.4.1 “Current transformers” and IEC 61869-2 are to be observed in the design of current transformers. The rated overcurrent factor and rated burden of current transformer cores are to be selected in such a way that protection devices can function correctly and measuring systems are not damaged in the event of a short-circuit.

Protection purposes

Protection cores are, logically, operated at above rated current. The function of the selected protection system is essentially determined by the connected current transformer. The requirements to be fulfilled by the current transformers for the selected protection or combination device can be found in the documentation from the protection equipment supplier. For an accurate switchgear proposal, these current transformer data are to be provided with the product enquiry and then finally agreed by the operator and manufacturer in the order.

The direct path to the right current transformers is via the technical documentation of the selected protection device. The current transformer requirements of the relay can be found there.

Measuring purposes

In order to protect measuring and metering devices from damage in the case of a fault, they should go into saturation as early as possible. The rated burden of the current transformer should be approximately the same as the operating burden consisting of the measuring instrument and cable. Further details and designations can be found in IEC 61869-2.

Recommendations

In principle, we recommend a rated secondary current of 1 A. The current transformer ratings for ABB protection devices are known. The transformer data can be selected to suit the protection application and the network parameters. If, however, third party devices are to be connected, we recommend a review by our engineers at an early stage. Taking account of the burdens and overload capacities, our experts can examine the entire current transformer requirements of the third party protection devices on request.

Further information for different protection systems

If the current transformers to be used in the network concerned (e.g. on the opposite side of the network) have already been specified, early coordination of the switchgear configuration is advisable. This requires, but is not limited to, the provision of data on the ratio, rated capacity, accuracy class, and the resistance of the secondary winding and secondary wiring. Further configurations for the particular application can then be requested.

Table 7.8.3.1: Technical data of a block-type current transformer (Device A)

Rated voltage		kV	24	36
Max. operating voltage		kV	24	40.5
Rated short duration power-frequency withstand voltage	U_d	kV	50	70 (85)
Rated lightning impulse withstand voltage	U_p	kV	125	170 (185)
Rated frequency	f_r	Hz	50 [1]	
Rated thermal short-time current	I_{therm}		100/250 x I_r, max. 31.5 kA / 3 s	
Rated impulse current	I_p	kA	80	

Table 7.8.3.2: Core data (Device A)

Panel width			mm	600	800	
Rated primary current		I_r	A	...1250	...1250	...2500
Rated secondary current			A	1 or 5		
Max. number of cores				3	5	5
Measuring cores	Capacity [2]		VA	2.5 to 15		
	Class [2]			0.2 / 0.5 / 1		
Protection cores	Capacity [2]		VA	2.5 to 30		
	Class [2]			5P to 10P		
	Overcurrent factor [2]			10 to 20		

[1] 60 Hz on request

[2] Dependend on rated primary current

7.8.4 Ring core sensors

The Rogowski coil of the ring core sensor (fig. 7.8.4.1) is enclosed in a cast resin casing. The sensor has a terminal board with three winding taps. The working range of the sensor is set on the terminal board. The secondary wiring connected there is led uncut up to the protection device.
Ring core sensors can be used in panels with one cable per phase.

The cable plugs are to be fitted after the cables have been passed through the relevant sensors.

The weight of the ring core sensor is approx. 2.5 kg.

Fig. 7.8.4.1: Ring core sensors

7.8.5 Voltage transformers

The voltage transformers (fig. 7.8.5.1) are always located outside the gas compartments. They are of the plug-in type (plugs size 2 to DIN 47637 and EN 50181). Isolating systems in the gas compartments (fig. 7.8.5.2) are connected in series with the sockets. The voltage transformers can therefore be isolated for testing purposes in the earthed condition, and it is not necessary to remove them for testing. The isolating system for the voltage transformer sockets in bus bar meterings also provide an earthing function for the isolated transformers.

The panel widths required for various rated voltages and the technical data can be found in table 7.8.5.1 and 7.8.5.2.

Fig. 7.8.5.1: Voltage transformers on a cable termination panel

Fig. 7.8.5.2: Sockets for voltage transformers with series isolating systems

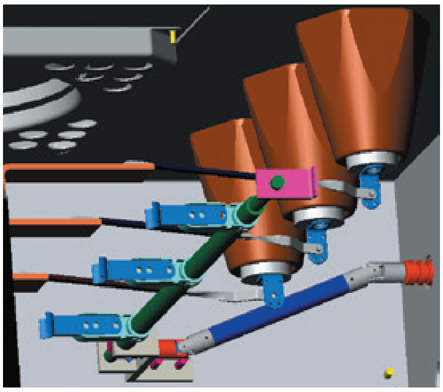


Table 7.8.5.1: Technical data of the voltage transformers

Rated voltage [kV]	Panel width [mm]	Max. capacity [VA]	Class	Rated secondary voltage of the metering winding [V]	Rated secondary voltage of the earth fault winding [V]	Rated thermal current limit of the metering winding with rated voltage factor 1.2 / continuous [A]	Rated thermal long duration current of the earth fault winding with rated voltage factor 1.9 / 8 h [A]
Up to 24 kV	600	15	0.2	100 / √3 110 / √3	100 / 3 110 / 3	4	4
		45	0.5				
		100	1				
	800	30	0.2	100 / √3 110 / √3	100 / 3 110 / 3	6	6
		75	0.5				
		150	1				
> 24 to 36 kV	800	30	0.2	100 / √3 110 / √3	100 / 3 110 / 3	6	6
		75	0.5				
		150	1				

Table 7.8.5.2: Rated power frequency withstand voltage of voltage transformers

Rated voltage [kV]	Rated power frequency withstand voltage (1 min) [kV]
< 6	5 x U_r
6 to 12	28
> 12 to 17.5	38
> 17.5 to 24	50
> 24 to 36	70

7.9 Protection and control units

ABB provides the right protection and automation solution for every application. Table 7.9.1 below provides an overview of the most important protection devices with notes on their range of applications. Further information can be obtained in the Internet (http://www.abb.de/mediumvoltage) or from the responsible ABB contact for you.

7.10 Sulphur hexafluoride

This product contains Sulphur hexafluoride (SF_6). [1)]

Sulphur hexafluoride (chemical symbol SF_6) is non-toxic, non-combustible, chemically inactive gas with a high dielectric strength.

Its unique electrical and thermal properties have made the design of new, more efficient switchgear possible. The change from conventional insulation to the non-flammable, chemically inactive and non-toxic heavy gas sulphur hexafluoride has led to significant savings in space and materials, and to greater safety of the installations. Switchgear systems insulated with sulphur hexafluoride have become highly successful especially in applications where space is constricted and compact design is required. On account of their insensitivity to airpollution, enclosed SF_6 systems are also used in the chemicals industry, in desert areas and at coastal locations.

SF_6 has been used in HV-switchgear since 1960.

Table 7.9.1: Application of protection and control units

Unit designation	REF620	RET620	REM620	REX640	REF615	RET615	REM615	RED615
Application								
Main protection	•	•	•	•				
Backup protection					•	•	•	•
Feeder protection	•			•	•			
Transformer protection		•		∘		•		
Motor protection			•	∘			•	
Cable differential protection				∘				•
Busbar differential protection				∘				
Communication protocols								
DNP 3.0	•	•	•	•	•	•	•	•
IEC 60870-5-103	•	•	•	•	•	•	•	•
IEC 60870-5-104				•				
IEC 61850 Ed.1	•	•	•	•	•	•	•	•
IEC 61850 Ed.2 (inc. SMV)	•	•	•	•	•	•	•	•
Modbus	•	•	•	•	•	•	•	•

• Function supported
∘ Function available as option

1) SF_6 is a fluorinated greenhouse gas with a GWP of 22800.
The maximum quantity per panel is 12 kg, divided into two gas compartments
That corresponds to a CO_2 equivalent of 274 t.
Each gas compartment has a gas leakage monitor, and therefore regular leakage testing (to Fluorinated Gas Regulation 517/2014) is not required.

7.11 Gas system in the panels

SF_6 is used as the insulating medium.

The gas compartments are designed as hermetically seale d pressure systems. As they are filled with SF_6, constant ambient conditions are permanently ensured for the entire high voltage area of the panel. It is not necessary to top up the insulating gas during the expected service life of the system. Under normal operating conditions, no checks on the insulating gas are necessary. The insulating gas is maintenance-free.

The circuit-breaker compartment and the busbar compartment in each panel are separate gas compartments with their own gas filling connectors (fig. 7.11.1). The gas compartments of the individual panels in a row are not connected together (exception: double feeder panels).
Each panel has gas filling connectors (fig 7.11.1 - see also section 6), through which the gas compartments can be filled with gas, for instance in the case of repairs.
The service pressure in the individual gas compartments is monitored by separate density sensors (temperature-compensated pressure sensors, fig. 7.11.2). Any drop below the insulation warning level (120 kPa) in a gas compartment is displayed on the protection and control unit or by a signal lamp. Temporary operation of the panel at atmospheric pressure (> 100 kPa) is possible in principle if the SF_6 content of the insulating gas is at least 95 % (exceptions: 120 kPa required for rated voltage > 36 kV, and 110 kPa for operation of a double feeder panel with rated voltage > 17.5 kV).

As an option, the thermal effects of an internal arc fault can be limited by an I_{th} protection function. For this purpose, the signal from an additional switching contact for all the gas density sensors (threshold 190 kPa) is logically linked to an overcurrent excitation system and used to trip defined circuit-breakers. The logic operation is performed by the combined protection and control unit RE_, and reduces the breaking time to only approx. 100 ms.

Leakage testing of the gas compartments during manufacturing process

The leakage rate of the gas compartments is determined by integral leakage testing.
Inside a pressure test cabin, following evacuation of the gas compartments, the panel is filled with helium. The leakage rate of the gas compartments is determined by measurement of the proportion of helium in the test cabin. The helium is then recovered as the gas compartments in the panel are evacuated again. Thereafter, the gas compartments are filled with insulating gas at the rated filling pressure.
A successful leakage test is therefore the necessary condition for filling of the systems with insulating gas.

Fig. 7.12.1: Gas filling connector

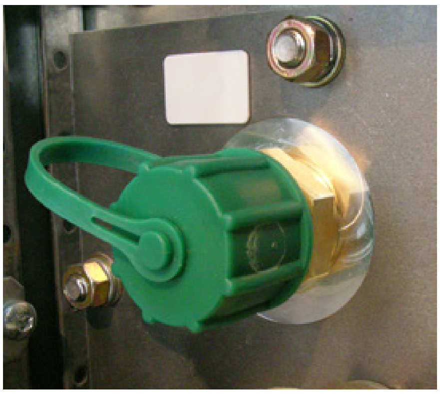


Fig. 7.12.2: Density sensor

7.12 SF$_6$ density sensor

Fig. 7.12.1 shows the function of the SF$_6$ density sensor. Between the measuring chamber and a reference chamber there is a moving mounting plate which operates electrical contacts.

Temperature compensation

The pressure in the monitored gas compartment rises with increasing temperature. As, however, the temperature in the reference chamber and thus the pressure of the reference volume increases to the same extent, this does not lead to any movement of the mounting plate.

Self-supervision

A drop in pressure of the reference volume results in a movement of the mounting plate (to the right in fig. 7.15.1). The self-supervision contact is operated. As the system is designed as a closed circuit, both wire breakages and defective plug and terminal connections are signalled as faults.

Gas losses

A loss of gas in the monitored gas compartment results in a drop in pressure in the measuring volume and thus a movement of the mounting plate (to the left in fig. 7.12.1). The contact for the pressure loss signal is operated.

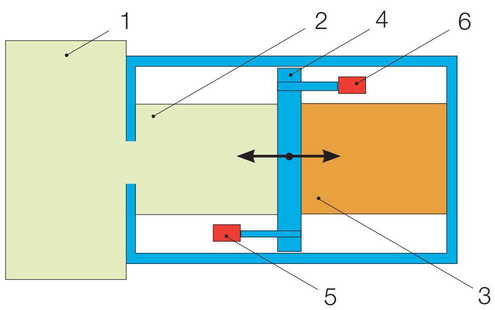
Two versions of SF$_6$ density sensors

Two versions of the density sensors (figs. 7.12.2 and 7.12.3) are used.

1. A common indication for gas loss, wire breakage, defective plug connection and defective pressure sensor for the reference volume.

2. Separate indications for a) gas loss, wire breakage and defective plug connection, and b) defective pressure sensor for the reference volume, wire breakage and defective plug connection.

Fig. 7.12.1: Schematic diagram of the function of the SF$_6$ density sensor



1	Monitored gas compartment
2	Measuring volume
3	Enclosed volume for temperature compensation (reference volume)
4	Mounting plate moved by interaction of forces (pressure of measuring volume against pressure of reference volume)
5	Contact for self-supervision ($p > 150$ kPa)
6	Contact for gas loss ($p < 120$ kPa)

Fig. 7.12.2: Version 1 of the SF$_6$ density sensor

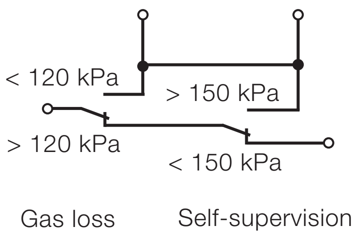
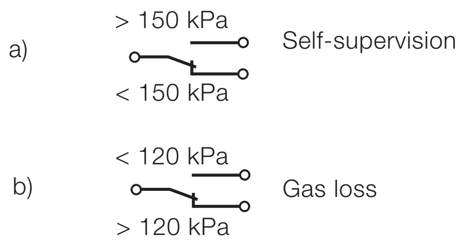


Fig. 7.12.3: Version 2 of the SF$_6$ density sensor



7.13 Pressure relief systems

In the unlikely event of an internal arc fault in the gas compartment, the relevant pressure relief disk opens.

There are facilities for panel by panel pressure relief, or for pressure relief into the switchroom or to the top via pressure relief ducts and an absorber. The use of pressure relief ducts requires metal-clad cable termination compartments.

Panel by panel pressure relief (fig. 7.13.1)

The pressure in the busbar compartment is discharged through the lower pressure relief duct, preferably up to a sectionaliser, riser or metering panel. There, a pressure relief flap opens to the rear.

Pressure from the circuit-breaker compartment is discharged to the rear via plasma diverters.

Pressure relief via pressure relief ducts and absorbers into the switchroom (fig 7.13.2)

As an option, the pressure from the metal-clad cable termination compartment can be discharged to the lower pressure relief duct via an upper pressure relief duct designed as a broad end cover at the end of the switchgear block. The upper and lower ducts are connected at an absorber duct at the end of the switchgear installation. The pressure wave is cooled and discharged into the switchroom by means of (plasma) absorbers.

Pressure relief to the outside via pressure relief ducts and absorbers (fig. 7.13.3)

Discharge of the pressure takes place in principle in the same way as pressure relief via absorbers. The pressure is discharged into the open air by means of a customised pressure relief duct extension leading to an opening in the outside wall of the switchroom.

The building wall through which the pressure relief duct is led to the outside must not contain any combustible materials. The area outside below the pressure relief discharge opening is to be fenced off and marked with warning signs. There must not be any accessible areas such as stairs or walkways above the pressure relief opening. Storage of combustible materials in the areas mentioned is prohibited. The dimensions of the hazardous area can be found in the section entitled “Hazardous area for pressure relief to the outside”.

Fig. 7.13.1: Panel by panel pressure relief

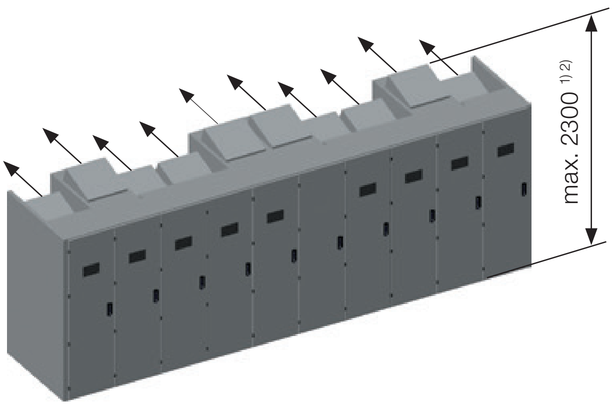


Fig. 7.13.2: Pressure relief duct (discharging into the switchroom)

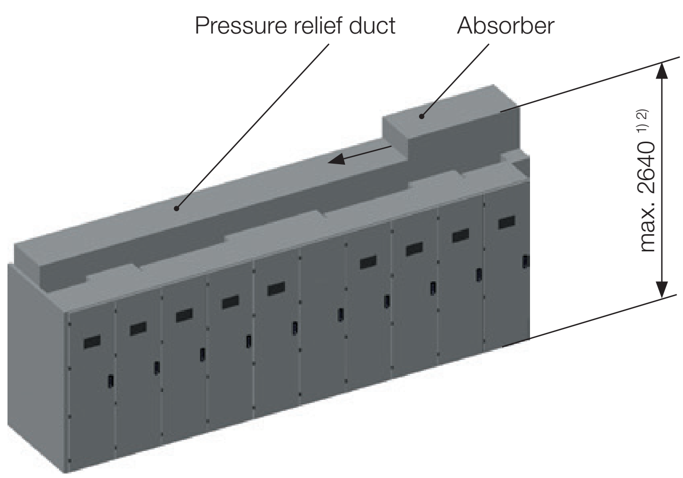
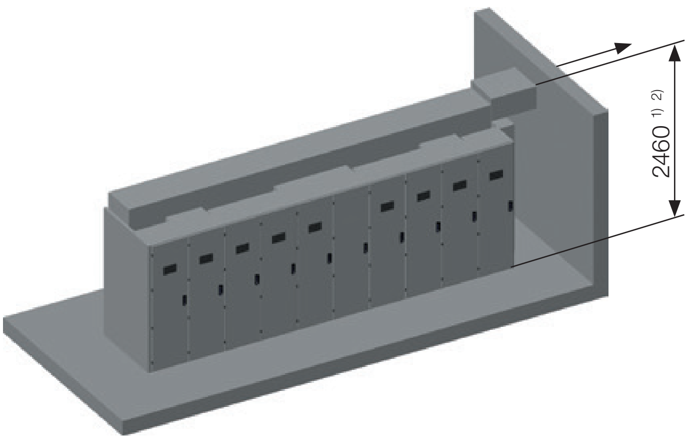


Fig. 7.13.3: Pressure relief duct (discharging to the outside)



1) Dimensions for switchgear with at least one panel for capacitor switching (ZX1.2 - C) on request
2) Without consideration of heat dissipation unit or voltage transformers on the top of circuit-breaker compartments

7.14 Surface

The gas-tight enclosures of the panels consist of stainless steel sheets. The cable termination compartments, low voltage compartments, pressure relief ducts and plasma diverters are manufactured from galvanised sheet steel.
The end covers at the sides of the switchgear system and the low voltage compartment doors are coated with a powder stove enamel in RAL 7035 (light grey).
Other colours for the painted components are available on request.

8 Range of panels

The following panel variants are available:

- Incoming and outgoing feeder panels
- Cable termination panels
- Termination panels for fully insulated bars
- Sectionaliser
- Riser
- Metering panels
- Double feeder panels
- Cable in – cable out panels
- Panels for wind farm applications
- Customised panel versions

Please note: The stated panel depths refer to a low voltage compartment depth of 500 mm.

8.1 Feeder panels

8.1.1 Incoming and outgoing feeder panels

Fig. 8.1.1.1: Outgoing feeder panel, 1250 A, with ring core CTs

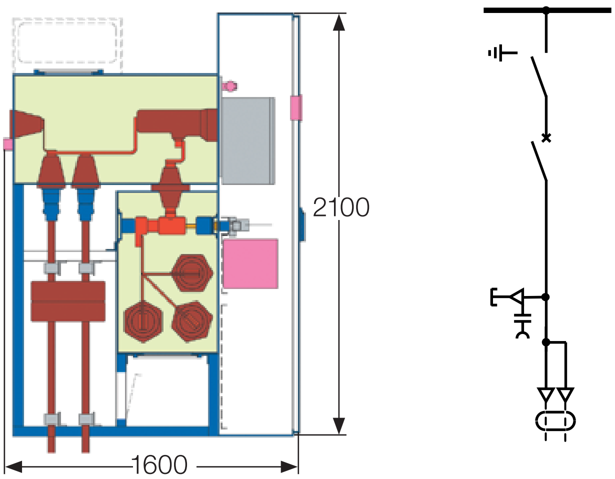


Fig. 8.1.1.2: Outgoing feeder panel, 800 A, with ring core CTs or sensors

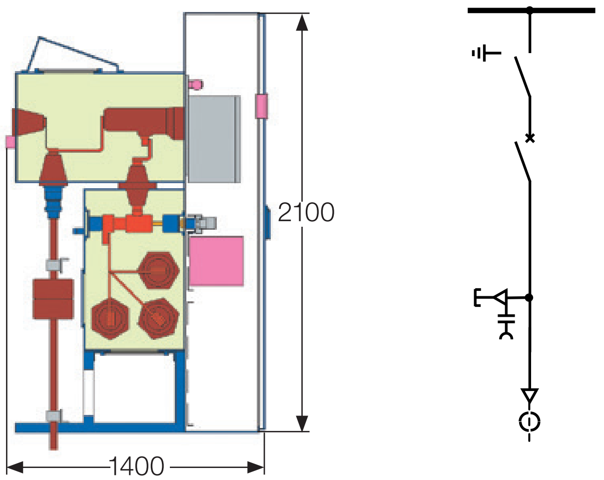


Fig. 8.1.1.3: Incomer feeder panel 2000 A

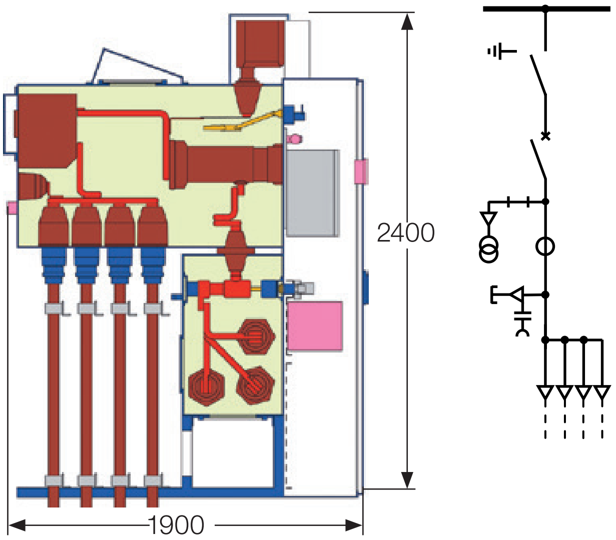


Fig. 8.1.1.4: Incoming feeder panel 1250 A

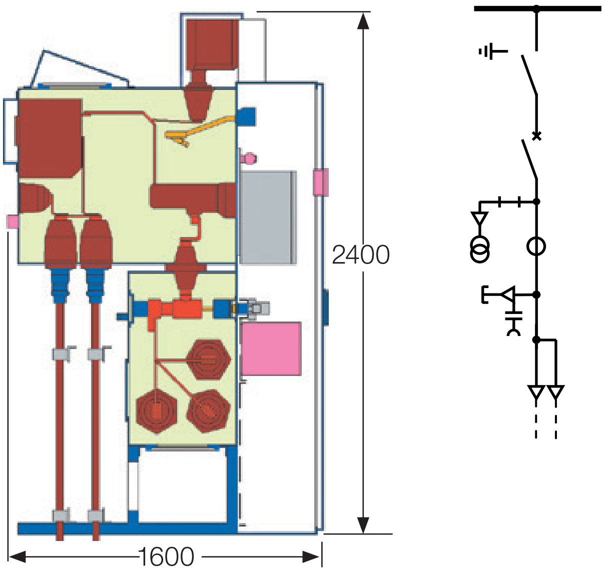


Fig. 8.1.1.5: Incoming feeder panel 2500 A, cooling by fan

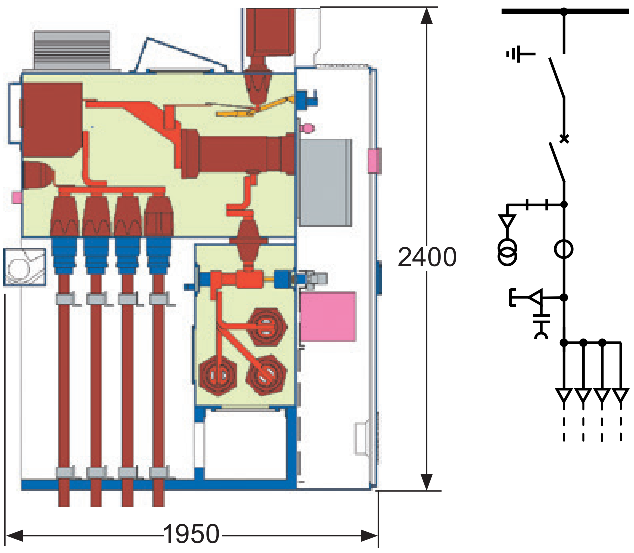
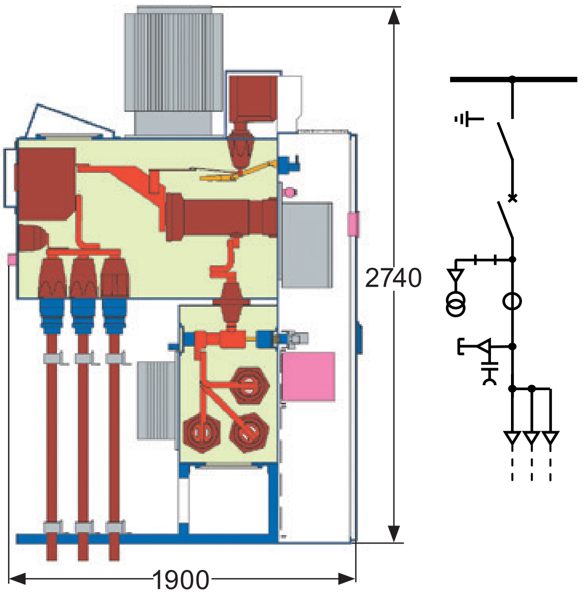


Fig. 8.1.1.6: Incoming feeder panel 2500 A, cooling by heat sinks



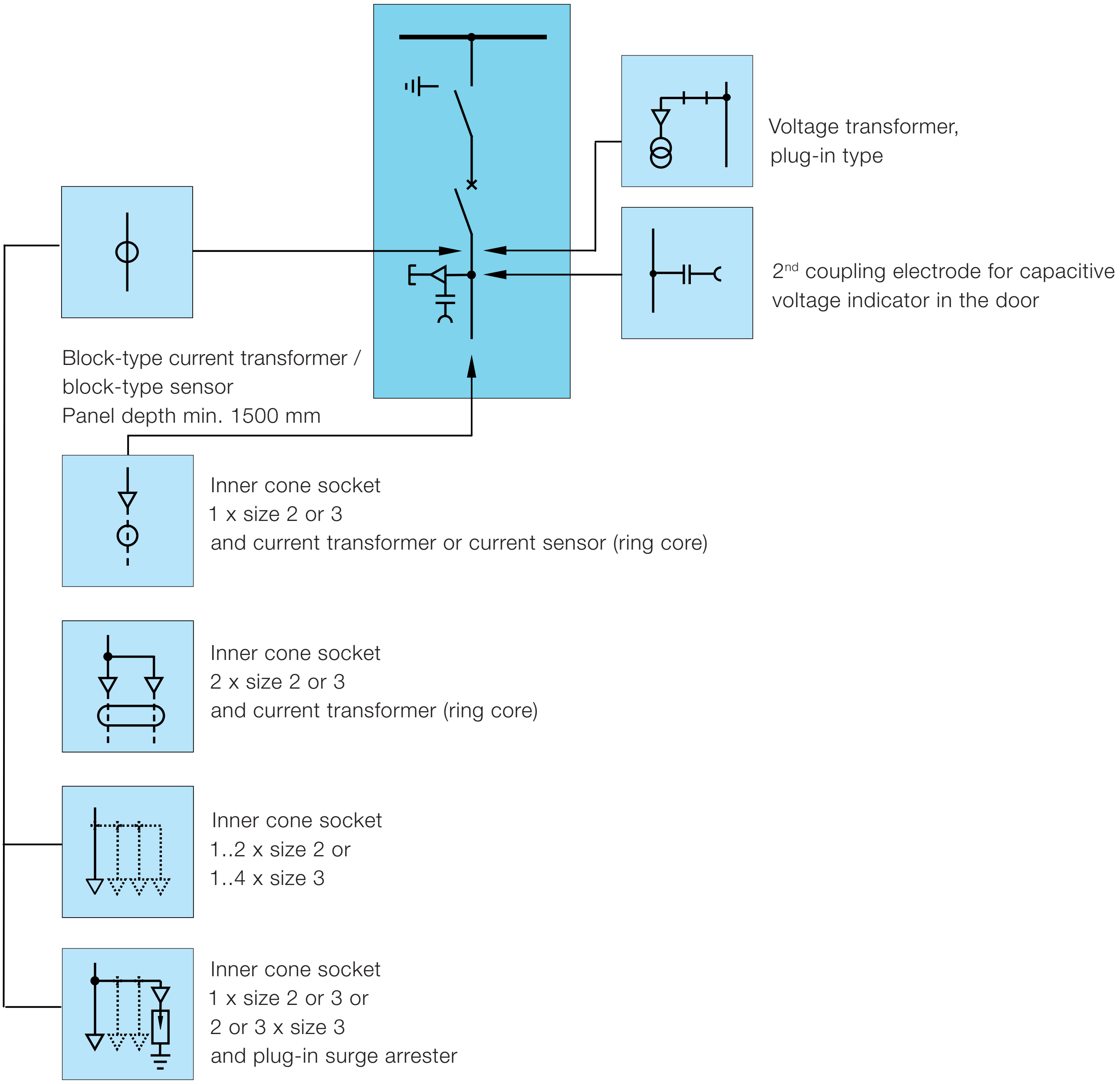


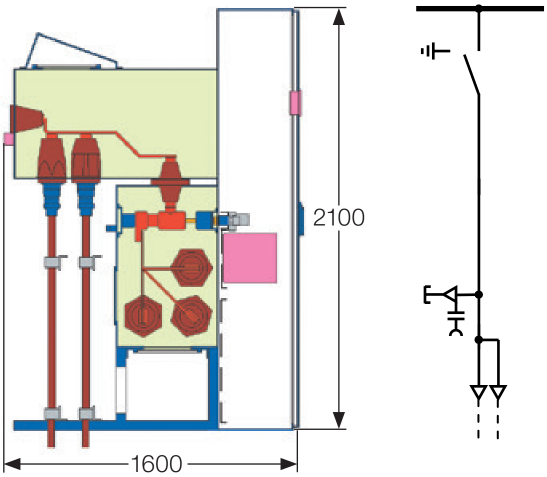
Table 8.1.1.1: Overview of variants for incoming and outgoing feeder panels

Panel width 600 mm:	U_r:	...24 kV (with voltage transformer)	
		> 24 kV (without voltage transformers)	
	I_r:	...1250 A	
	I_p:	...31.5 kA [1]	
Panel width 800 mm:	U_r:	...36 kV (with voltage transformer)	
	I_r:	...2500 A	
	I_p:	...31.5 kA [1]	
Panel depth 1400 mm:	I_r:	... 800 A	1 socket per phase
Panel depth 1600 mm:	I_r:	...1250 A	2 sockets per phase
Panel depth 1950 mm:	I_r:	...2500 A	4 sockets per phase, forced ventilation (fan)
Panel depth 1900 mm:	I_r:	...2500 A	3 sockets per phase, static cooling (heat sink)

[1] When using socket size 2: At least two sockets are required

8.1.2 Cable termination panels

Fig. 8.1.2.1: Cable termination panel 1250 A



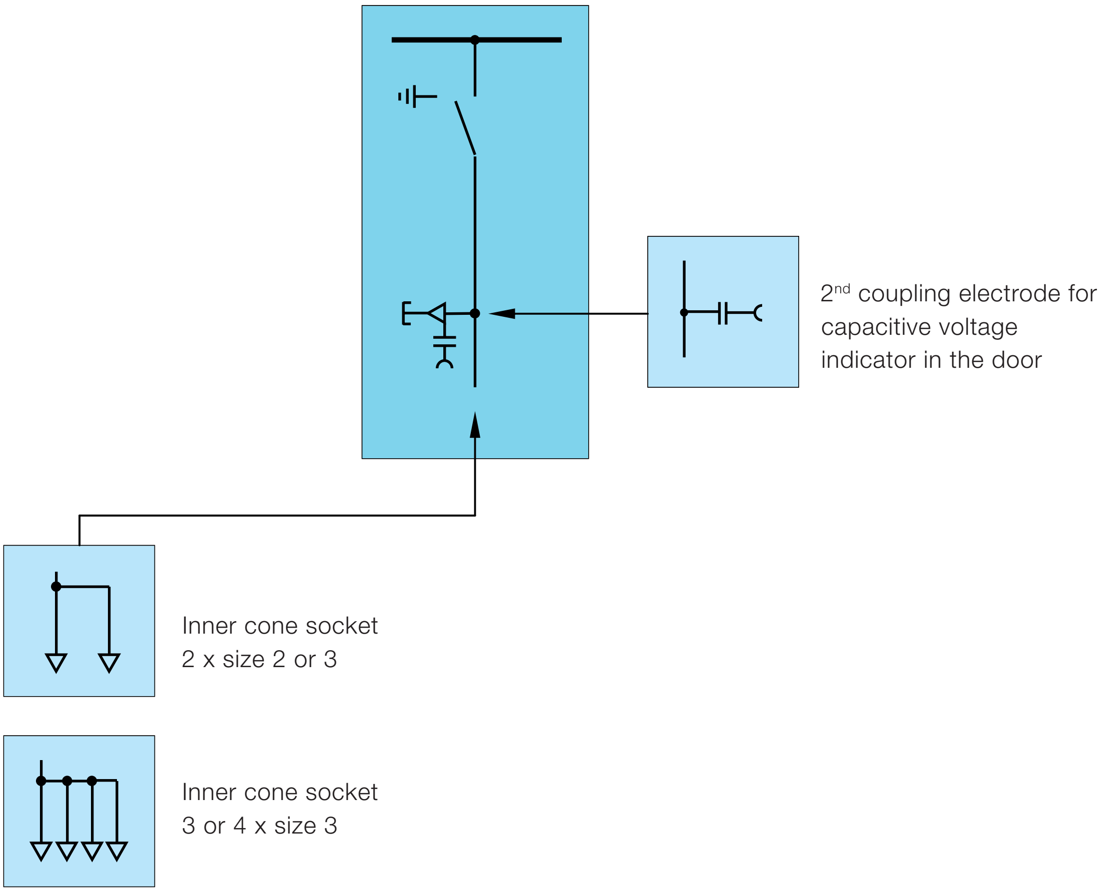


Table 8.1.2.1: Overview of variants for cable termination panels

Panel width 600 mm:	U_r:	...36 kV	
	I_r:	...1250 A	
	I_p:	...31.5 kA	
Panel width 800 mm:	U_r:	...36 kV	
	I_r:	...2500 A	
	I_p:	...31.5 kA	
Panel depth 1600 mm:	I_r:	...1250 A	2 sockets per phase
Panel depth 1900 mm:	I_r:	...2000 A	3 and 4 sockets per phase
Panel depth 1950 mm:	I_r:	...2500 A	4 sockets per phase, forced ventilation (fan) - on request
Panel depth 1900 mm:	I_r:	...2500 A	3 sockets per phase, static cooling (heat sink)

8.2 Busbar sectionaliser and riser panels

A sectionaliser panel and a riser panel are required for the implementation of bus couplings.

Bus couplings can be integrated in a switchgear block. The busbar connections and coupling connections are of the plug-in type, using busbar sockets. Couplings between two system blocks can be effected by means of cables or connections with fully insulated trunking bars.

Integration of busbar voltage transformers is possible as an option.

8.2.1 Couplings within a switchgear block

Together with the three position disconnector, the sectionaliser panel contains the circuit-breaker and, where appropriate, a current transformer between the three position disconnector and the circuit-breaker. The riser panel contains a block-type current transformer or sensor.

Installation variants “sectionaliser left – riser right” and vice versa are possible.

Fig. 8.2.1.1: Sectionaliser panel, 2000 A, with busbar voltage measurement

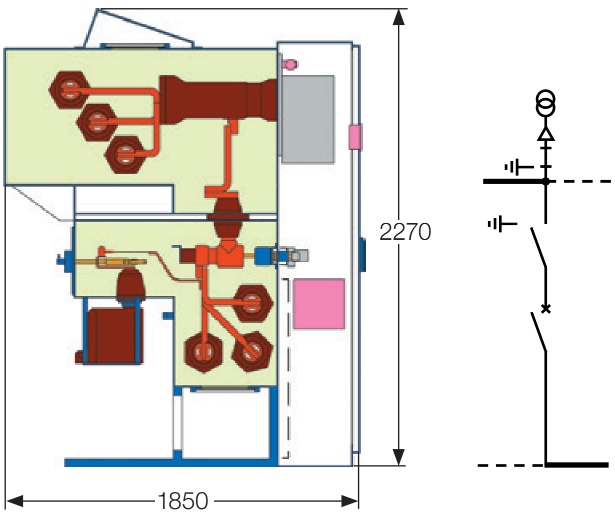
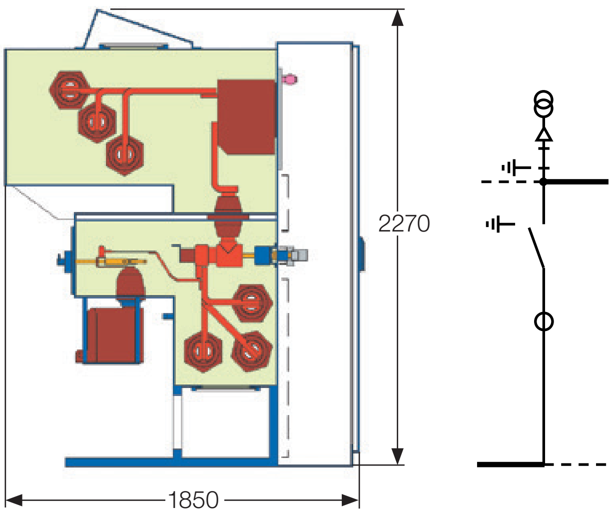


Fig. 8.2.1.2: Riser panel, 2000 A, with busbar voltage measurement



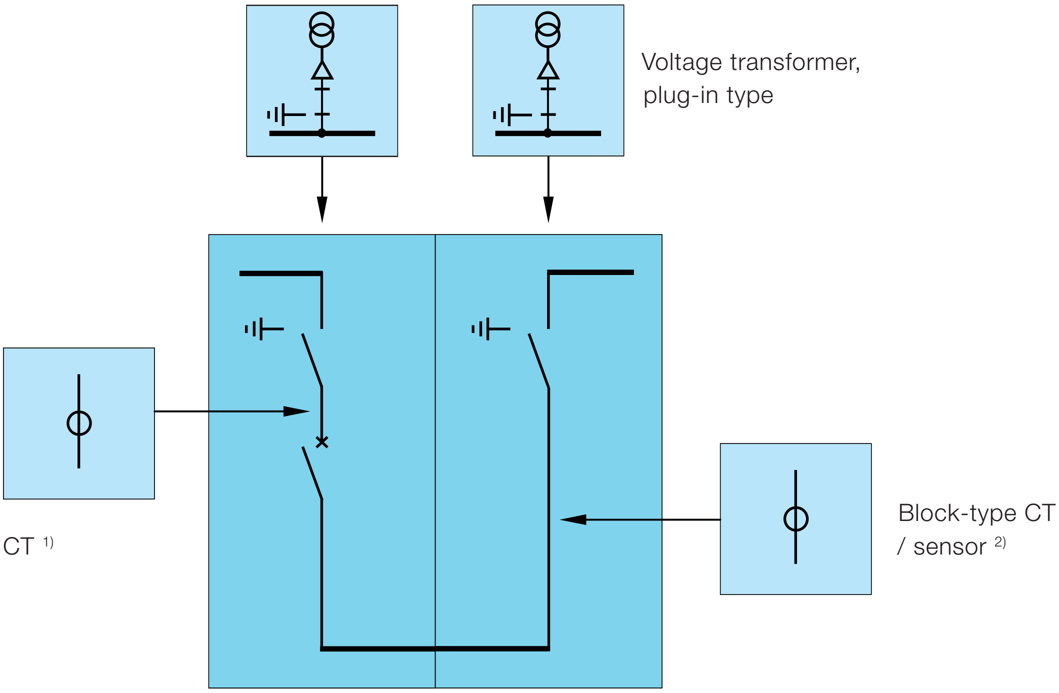


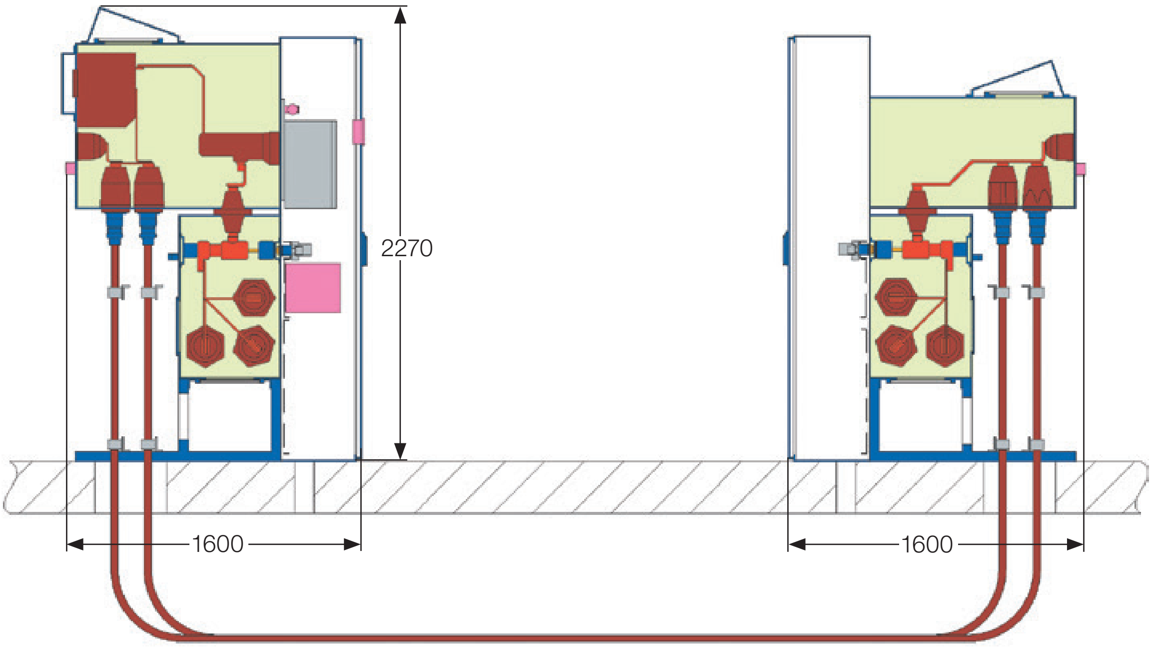
Table. 8.2.1.1: Overview of variants for sectionaliser and riser panels for installation within a switchgear block		
Panel width 600 mm:	U_r:	...24 kV (with voltage transformer)
		> 24 kV (without voltage transformer)
	I_r:	...1250 A
	I_p:	...31.5 kA
Panel width 800 mm:	U_r:	...36 kV (with voltage transformer)
	I_r:	...2500 A
	I_p:	...31.5 kA
Panel depth 1350 mm:	I_r:	...1250 A (without voltage transformer)
Panel depth 1550 mm:	I_r:	...1250 A (with voltage transformer)
Panel depth 1850 mm:	I_r:	...2500 A

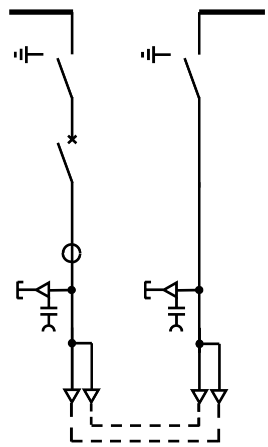
1) Available for 2000 A and 2500 A variants
2) Block-type current transformer or sensor

8.2.2 Couplings using cables (connection of two system blocks)

The overview of variants can be found in sections 8.1.1 and 8.1.2.

Fig. 8.2.2.1: Coupling by cables, 1250 A





8.3 Metering panels

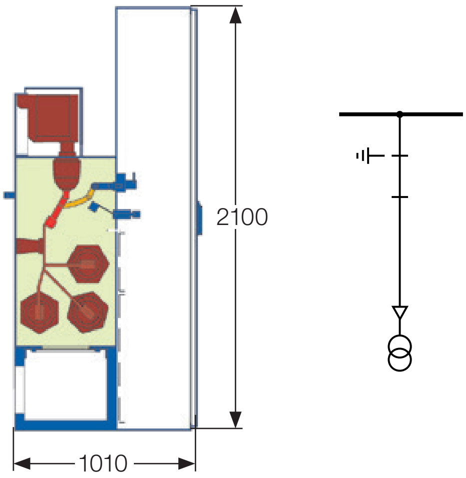


Table 8.3.1: Schedule of variants for metering panels		
Panel width 600 mm:	U_r:	...24 kV
Panel width 800 mm:	U_r:	...36 kV
Panel depth 1010 mm:	All variants	

8.4 Feeder panels with integrated busbar metering

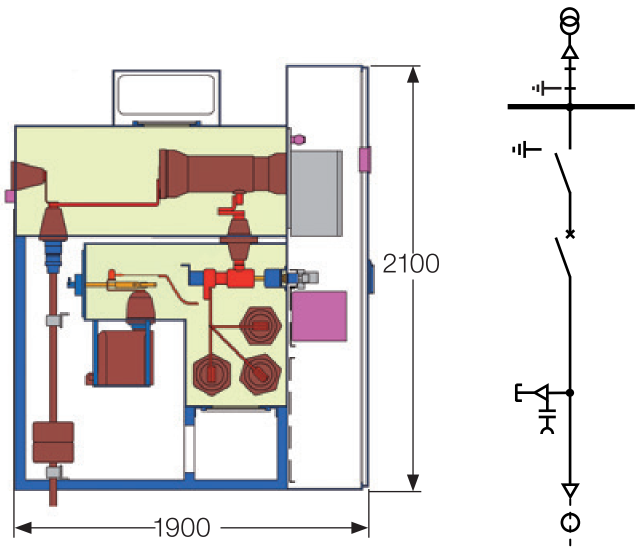


Table 8.4.1: Schedule of variants for feeder panels with integrated busbar metering		
Panel width 800 mm:	U_r:	...36 kV
	I_r:	...800 A
	I_p:	...31.5 kA
Panel depth 1900 mm:	1 socket size 2 or 3 per phase	

8.5 Double feeder panels

The structure of the double feeder panel deviates from that of a conventional outgoing feeder panel as described below.

- The width (= transport width) of a double feeder panel is 800 mm, with two outgoing feeders of 400 mm width grouped together in the double panel.
- The busbar compartment for the two feeders in a double feeder panel is a continuous gas compartment extending over the panel width of 800 mm.
- The two circuit-breaker compartments in a double feeder panel are two independent units.
- Only the inner cone plug system size 2 (1 or 2 x per phase) to EN 50181 is used.
- Only ring core current transformers (for one or two cables per phase) or ring core sensors (for one cable per phase) are used. The cable plugs are to be fitted after the cables have been threaded through the relevant transformers or sensors.
- Two separate low voltage compartment doors (width 400 mm) are fitted.
- Technical data which deviate from the conventional panel (compare section 4):

U_r:	... 24 kV
I_k:	... 25 kA
I_r (feeder):	... 630 A (800 A) [1)]
I_r (busbar):	... 2500 A

Internal arc classification to IEC 62271-200

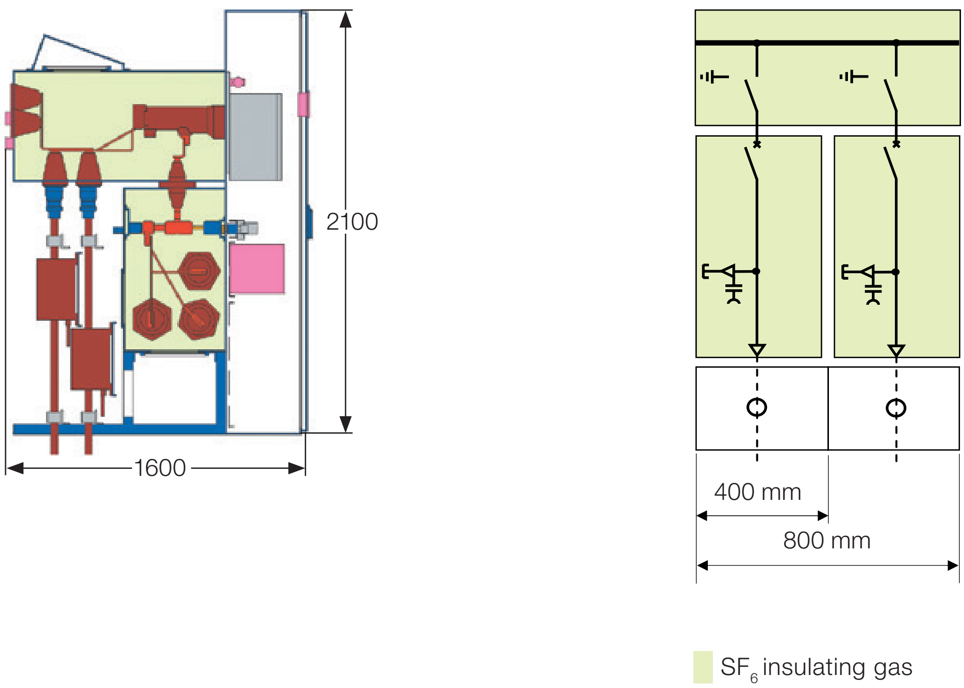
Switchgear with pressure relief duct:

Classification IAC	AFLR
Internal arc	25 kA 1 s

Switchgear with plasma diverters:

Classification IAC	AFL
Internal arc	25 kA 1 s

Fig. 8.5.1: Double feeder panel, version with 1 cable per phase



1) 630 A: Panel with pressure relief duct (partitioning of the cable termination compartment), cable cross-section at least 1 x 300 mm²,
800 A: Panel with plasma diverter (without partitioning of the cable termination compartment), at least 2 cables/phase with a minimum cross-section of 300 mm² each.

8.6 Design to order panels

The panel variants presented in sections 8.1 to 8.5 are standard panels. Should you require panel variants which are not listed there when planning your switchgear, please contact the ABB office responsible for your area.

Our design team will be pleased to submit and implement technical proposals to fulfil your requirements.

Find some examples for design to order panels in the following subchapters.

IAC qualification according to IEC 62271-200 of special panels may not be possible in all cases..

8.6.1 Termination panels for fully insulated bars

Depending on the panel version, fully insulated bars can be connected to the panel from the top or from the bottom.

Fig. 8.6.1.1: Termination panel for fully insulated bars, 2000 A, bar connection at top.

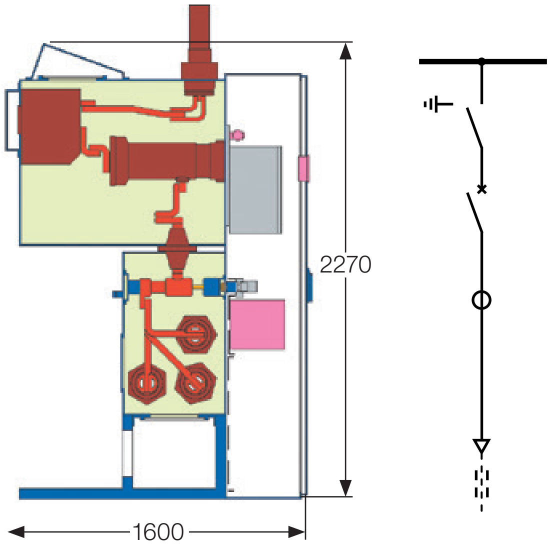
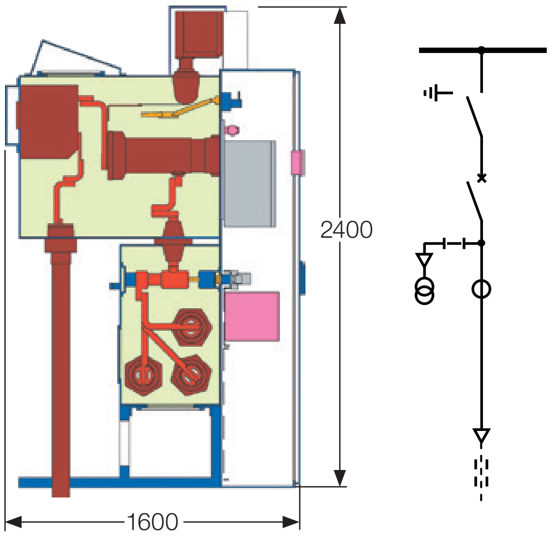


Fig. 8.6.1.2: Termination panel for fully insulated bars, 2000 A, with voltage transformer on outgoing feeder, bar connection at bottom.



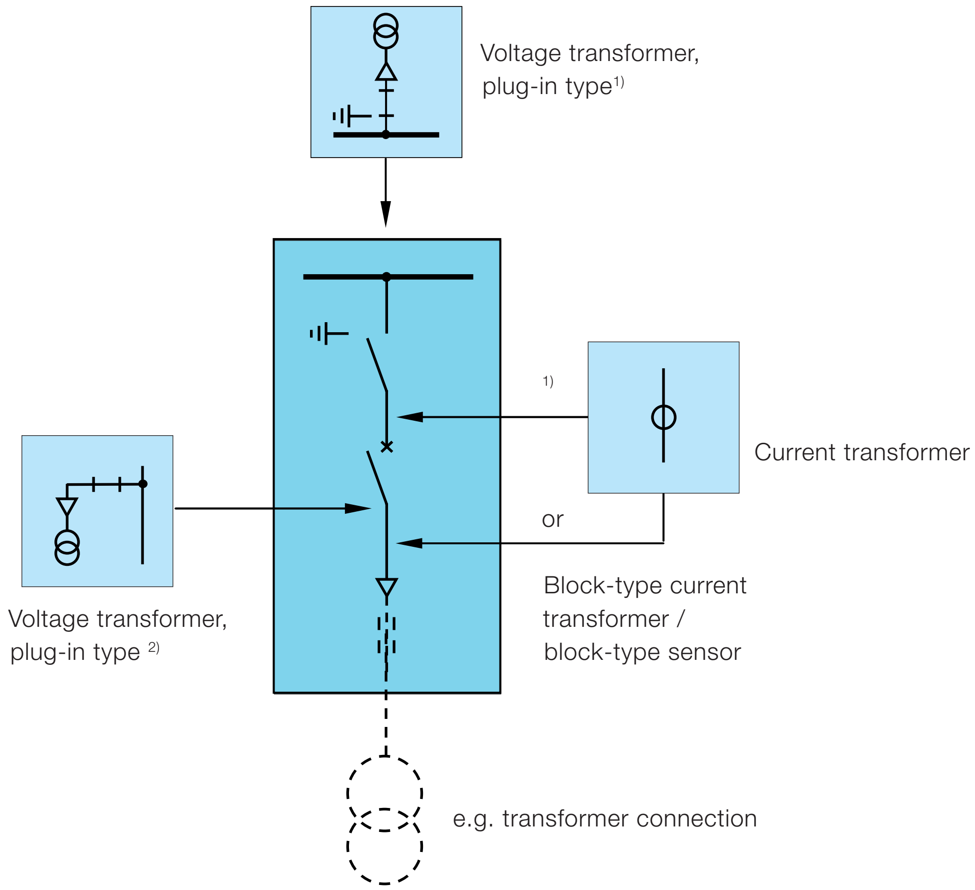


Table 8.6.1.1: Overview of variants for termination panels for fully insulated bars

Panel width 600 mm:	U_r:	...24 kV (with voltage transformer)
		> 24 kV (without voltage transformer)
	I_r:	...1250 A
	I_p:	...31.5 kA
Panel width 800 mm:	U_r:	...36 kV
	I_r:	...2500 A
	I_p:	...31.5 kA
Panel depth 1600 mm:	I_r:	...2000 A
Panel depth 1660 mm:	I_r:	...2500 A, Forced ventilation (fan)
Panel depth 1850 mm:	I_r:	...2500 A, Static cooling (heat sink)

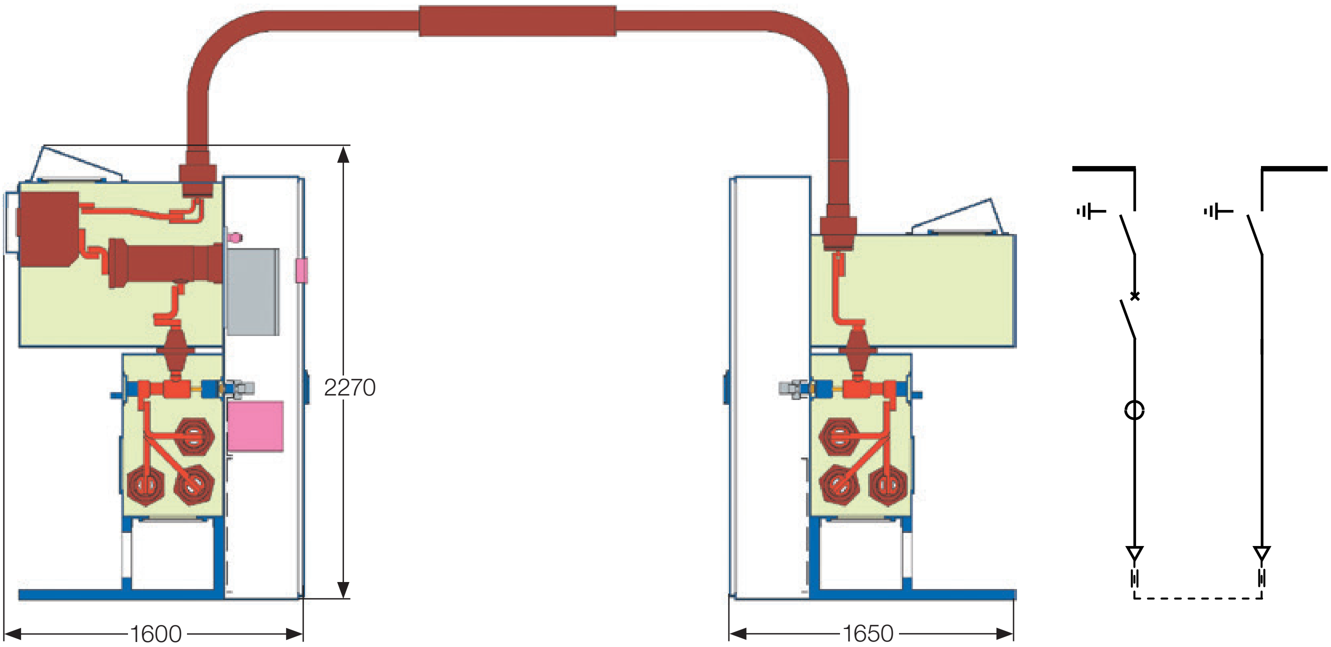
1) For 2500 A – Variant with bar connection from above available
2) For 2000 A – Variant with bar connection from below available

8.6.2 Couplings using fully insulated bars (connection of two system blocks)

Panels with bar connections from above or below are available. The fully insulated bars can therefore be routed above the panels or through the cable basement. The bars are fastened to the ceiling of the station room or to the floor of the cable basement.

When the two switchgear blocks are installed opposite each other as mirror images and the fully insulated, three-phase bar system is routed in parallel, a phase reversal at the connections on the sectionaliser or riser panel is necessary. For this purpose, the connecting bars for L1 and L3 in the busbar compartment between the busbar and three position disconnector are exchanged at the works. The phase relation in the busbar system in the panels is preserved by this procedure.

Fig. 8.6.2.1: Coupling by fully insulated bars (connection of two switchgear blocks), 2000 A (Example: Bars routed above the panels)



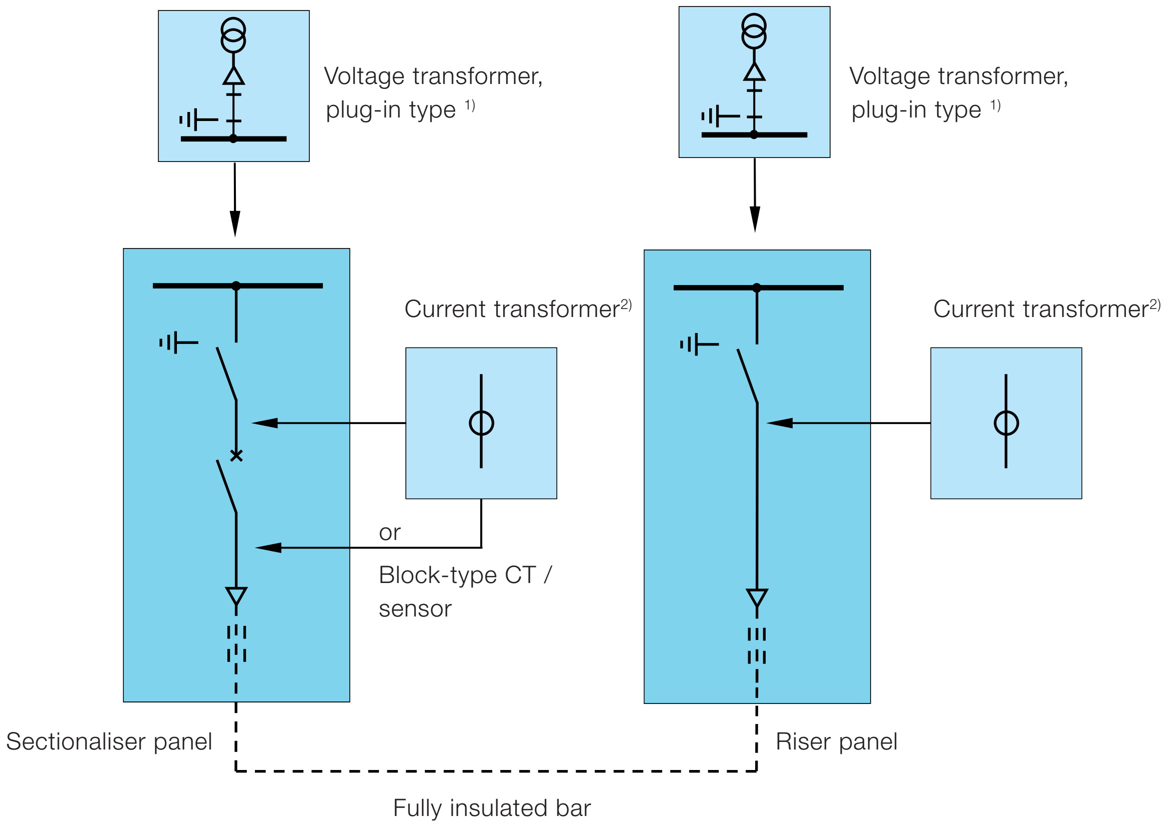


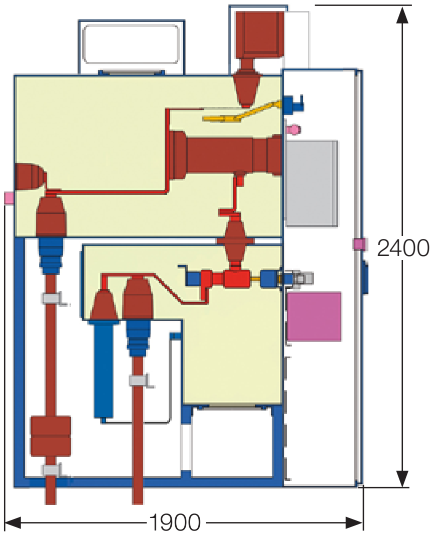
Table 8.6.2.1: Overview of variants for couplings with fully insulated bars (connection of two system blocks

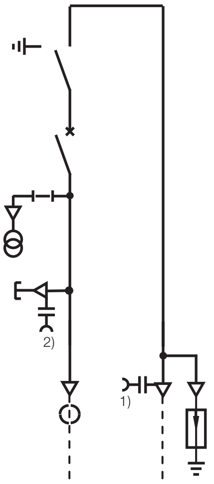
Panel width 600 mm:	U_r:	...24 kV (with voltage transformer)
		> 24 kV (without voltage transformer)
	I_r:	...1250 A
	I_p:	...31.5 kA
Panel width 800 mm:	U_r:	...36 kV
	I_r:	...2500 A (connection from above)
	I_p:	...31.5 kA
Panel depth 1350 mm:	I_r:	...1250 A riser panel
Panel depth 1600 mm:	I_r:	...1250 A sectionaliser panel
Panel depth 1550 mm:	I_r:	...2000 A riser panel
Panel depth 1600 mm:	I_r:	...2000 A sectionaliser panel
Panel depth 1660 mm:	I_r:	...2500 A forced ventilation (fan)
Panel depth 1650 mm:	I_r:	...2500 A static cooling (heat sink)

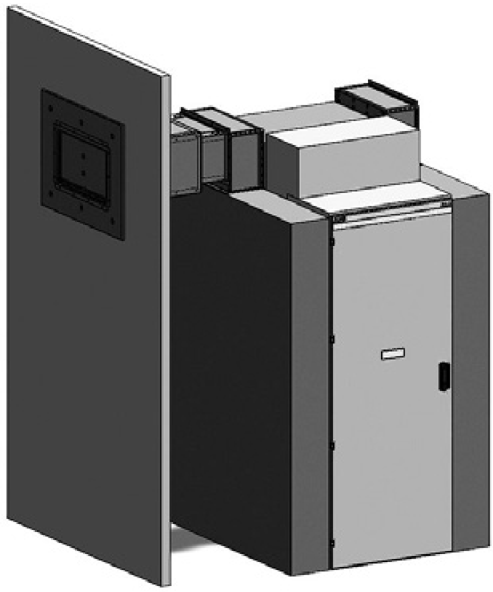
1) For 2000 A and 2500 A – Variants with bar connection from above available
2) For 2500 A – Variants with bar connection from above available

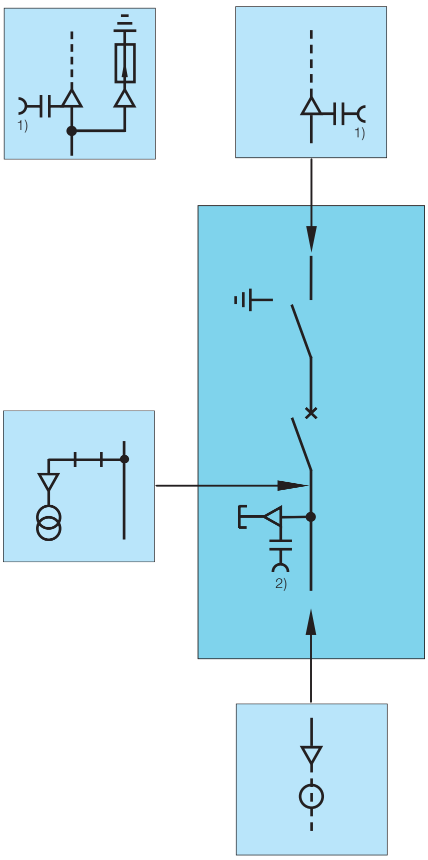
8.6.3 Cable in – cable out panels

8.6.3.1 Cable in – cable out panels, version 1









Inner cone socket
1 x size 2 or 3
and optional surge arrester (plug size 2)

Voltage transformer,
plug-in type

Inner cone socket
1 x size 2 or 3
and current transformer or current sensor (ring core)

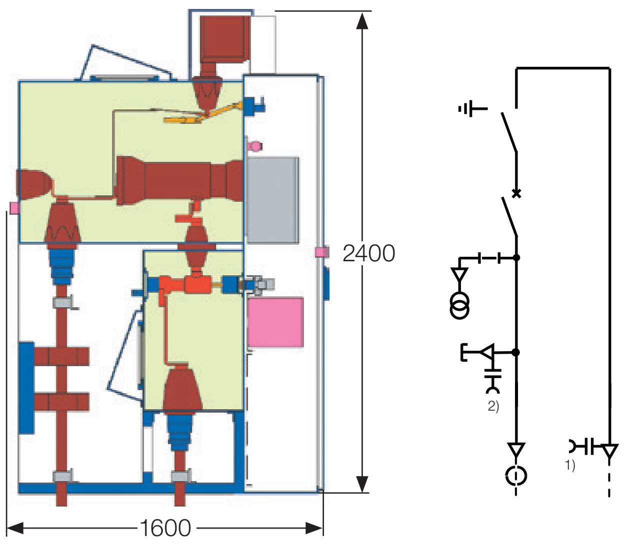
An IAC qualification to IEC 62271-200 is available for the cable in – cable out panel with Ipmax = 25 kA fitted with end covers of 250 mm width on both sides and pressure relief via a duct to the outside.

Table 8.6.3.1.1: Schedule of variants for cable in – cable out panels, version 1

Panel width 800 mm (Over all width 1300 mm)	U_r:	...36 kV
	I_p:	...25 kA
	I_r:	...800 A

1) Capacitive voltage indicator system inside the low voltage compartment door
2) Capacitive voltage indicator system at the rear side of the panel

8.6.3.2 Cable in – cable out panels, version 2



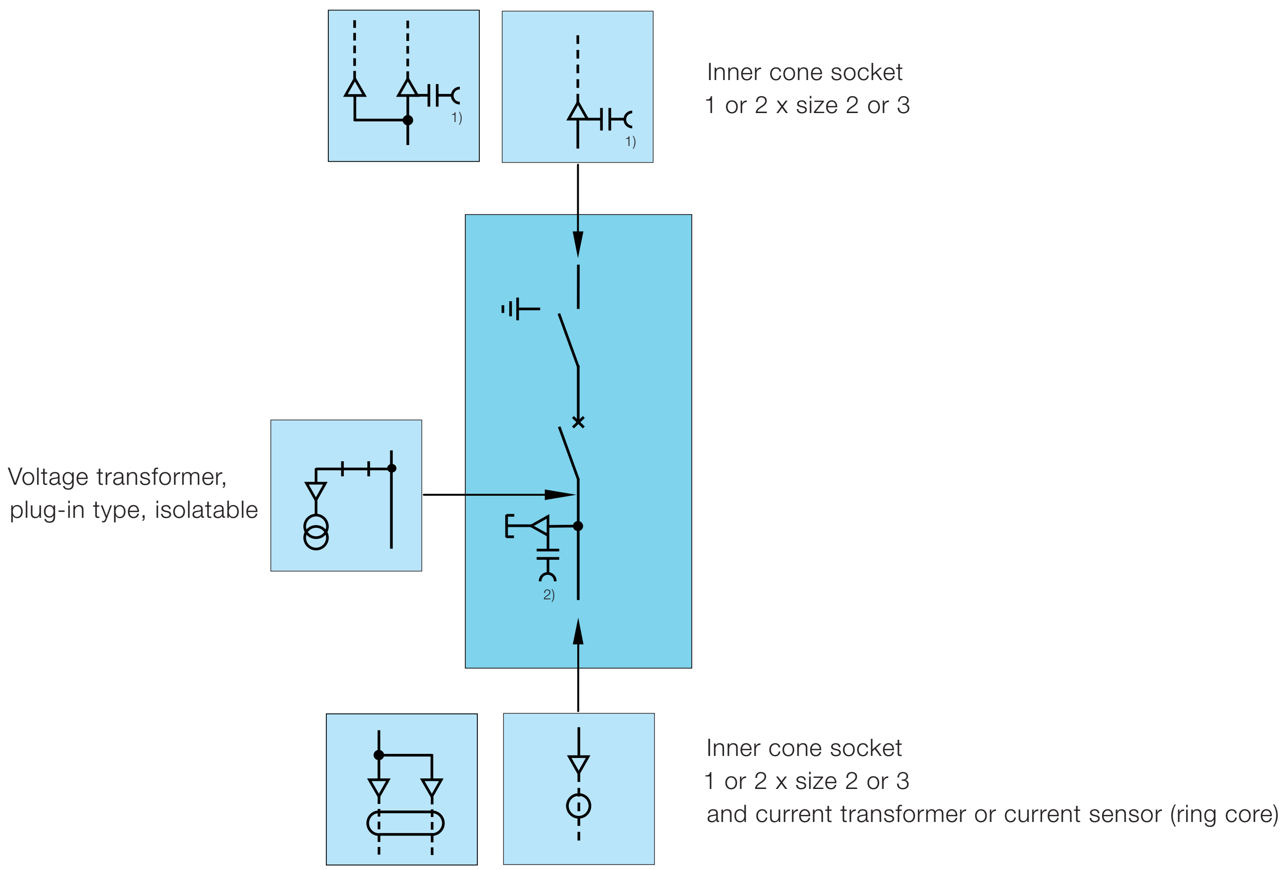


Table 8.6.3.2.1: Schedule of variants for cable in – cable out panels, version 2

Panel width 800 mm	U_r:	...36 kV
	I_p:	...31.5 kA
Panel depth 1600 mm:	I_r:	...800 A (1 socket per phase, size 2 or 3)
Panel depth 1900 mm:	I_r:	...1250 A (2 sockets per phase, size 2 or 3)

[1] Capacitive voltage indicator system inside the low voltage compartment door
[2] Capacitive voltage indicator system at the rear side of the panel

8.6.4 Further design to order panels

Find further examples for design to order panels in the following figures.

Fig. 8.6.4.1: Panel with inner cone sockets, 1 x size 4 per phase (36 kV, 31.5 kA, 2500 A), panel width 800 mm

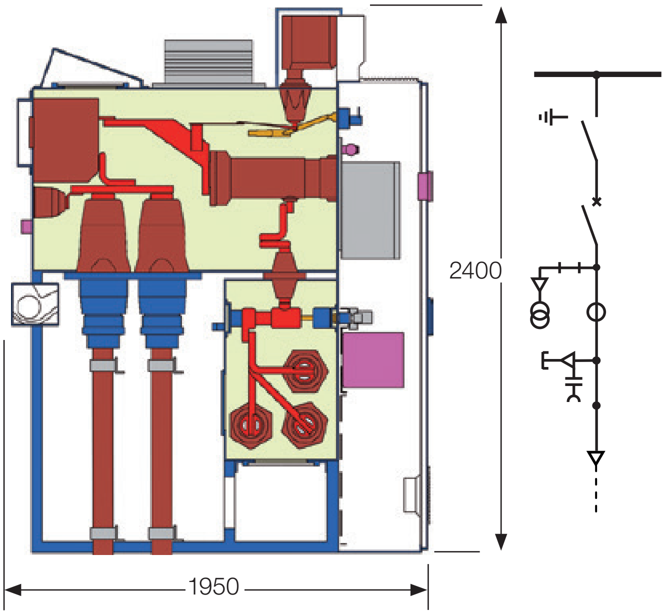
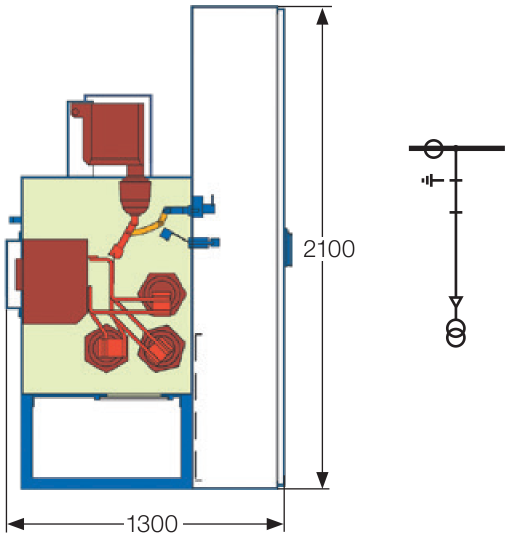


Fig. 8.6.4.2: Supply metering (12 kV, 16 kA, 630 A)



8.7 Panels for wind farm applications

A fundamental aspect in the planning of wind farms is the availability of the system as a whole in the event of a fault (e.g. in a submarine cable). The use of circuit-breakers in place of switch-disconnectors is highly advantageous, as circuit-breakers can switch short-circuit currents several times.

It is appropriate to configure the system as a ring network. Maximum availability is achieved by installing three circuit-breakers for each generator. In the case of a cable fault, only the faulty cable is then isolated in response to the protection devices. All the generators continue to be connected to the part of the system which remains functional.

A reduction in the number of circuit-breakers has the consequence that larger system sections are isolated in the case of a fault and, in extreme cases, the entire ring has to be disconnected from the grid.

Fig. 8.7.1: Availability under fault conditions using three circuit-breakers per generator

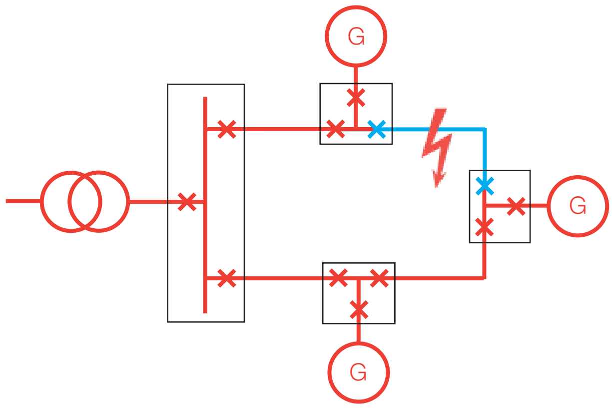


Fig. 8.7.2: Direct connection to the ring

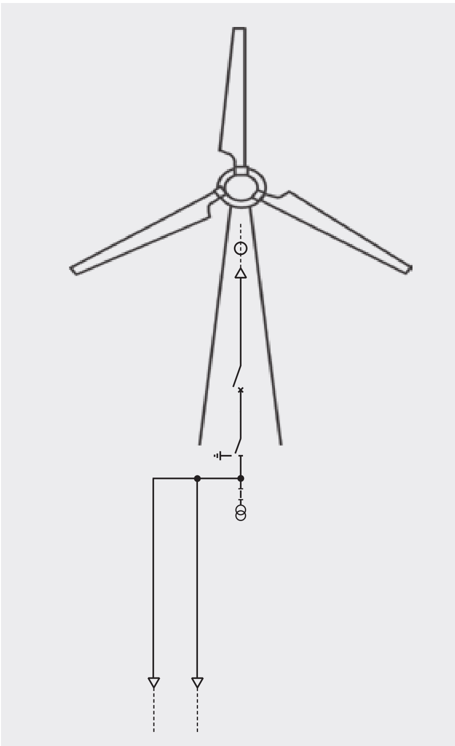


Fig. 8.7.3: Connection to the ring via a circuit-breaker

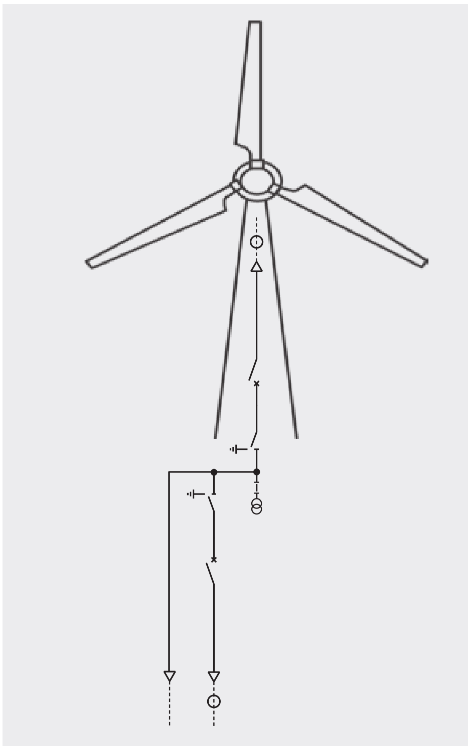
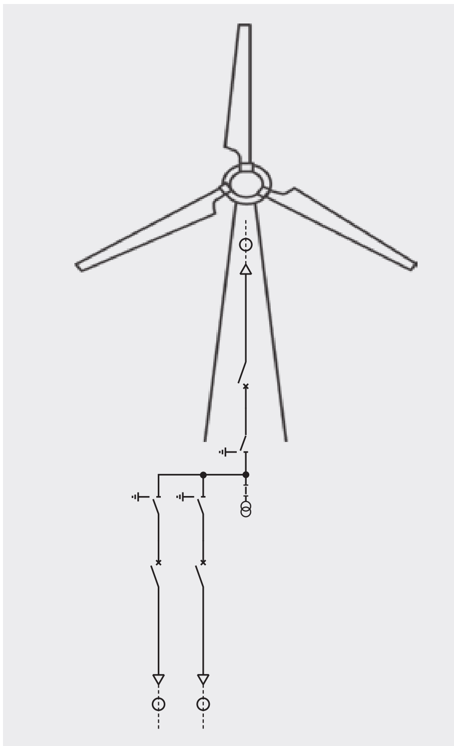


Fig. 8.7.4: Optimised connection to the ring via two circuit-breakers



Further benefits from the use ZX1.2 panels

- Connection of submarine cables with cross-sections up to 1600 mm²
- Hermetically sealed with IP65 protection for the high voltage section
- Complete remote control capability
- Rated currents 1250 A to 2500 A
- Prepared for all protection systems
- Suitable for connection of wind turbines with output even greater than 5 MW
- Suitable for operation on open or closed ring networks
- Vacuum circuit-breakers for reliable and maintenance-free connection of the wind turbine to the open or closed ring

8.8 Panels with rated currents > 2000 A

At a maximum ambient air temperature of 40 °C, a maximum 24 h average ambient air temperature of 35 °C and a rated frequency of 50 Hz (standard operating conditions), no cooling facilities are required for a rated current of up to 2000 A.

For standard operating conditions and rated currents > 2000 A (max. 2500 A), two cooling methods are available as alternatives:

Use of the plasma diverter

- Static cooling by means of one or more heat sinks
- Forced cooling by fan, combined if necessary with heat sinks

Use of the pressure relief duct

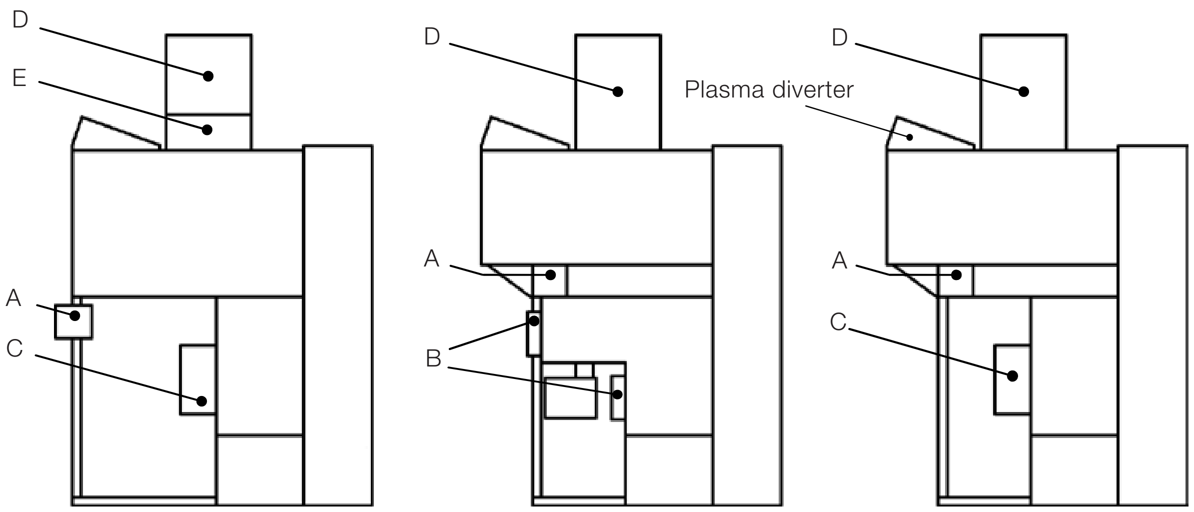
- Forced cooling by fans only, combined if necessary with heat sinks

The positions of the corresponding fans and heat sinks are shown in the following illustrations, where

A: Ventilator with radial flow fan
B: Small heat sinks on the busbar compartment
C: Large heat sink on the busbar compartment
D: Tall heat sink on the circuit-breaker compartment
E: Short heat sink on the circuit-breaker compartment

The cooling methods for the various panel types are shown in tables 8.8.1 and 8.8.2. Please observe the number of cables required and the minimum cable cross-sections.

Fig. 8.8.1: Cooling methods for pressure relief with plasma diverter (open cable termination compartment)



Incoming feeder

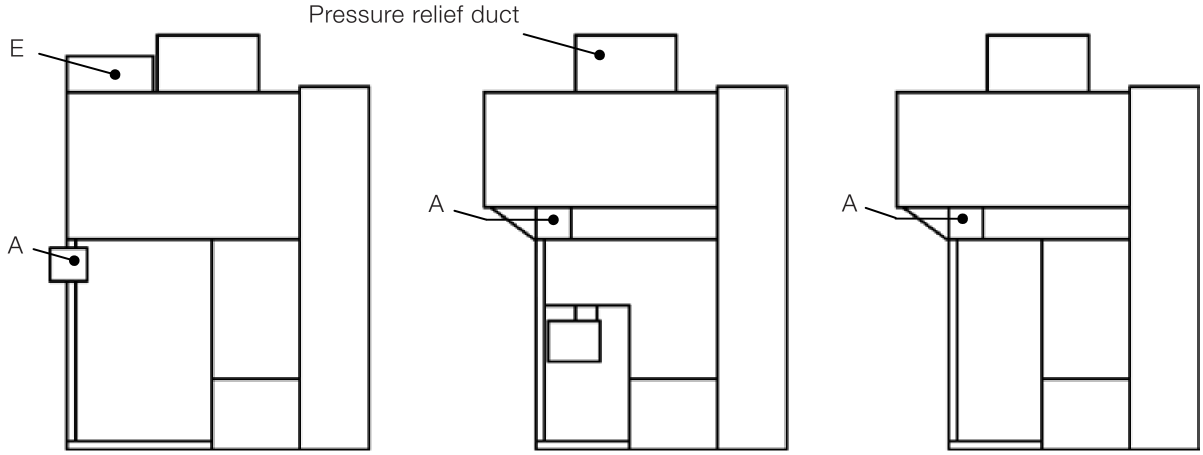
Sectionaliser or riser with voltage transformer (busbar measurement)

Sectionaliser or riser without voltage transformer

Table 8.8.1: Cooling methods for pressure relief with plasma diverter (IAC: AFL)

Type of cooling	Panel type	Cooling method	Required number of cables and required minimum cable cross-sections
Static cooling	Incomer panel	C + D	3 x 500 mm²
	Cable termination panel	C	3 x 500 mm²
	Sectionaliser and riser panel with busbar voltage metering	B + D	-
	Sectionaliser and riser panel without busbar voltage metering	C + D	-
Forced cooling	Incomer panel	A + E	4 x 300 mm²
	Cable termination panel	A	4 x 300 mm²
	Sectionaliser and riser	A	-

Fig. 8.8.2: Cooling methods for pressure relief via pressure relief ducts (closed cable termination compartment)



Incoming feeder

Sectionaliser or riser with voltage transformer (busbar measurement)

Sectionaliser or riser without voltage transformer

Table 8.8.2: Cooling methods for pressure relief duct (IAC: AFLR)

Type of cooling	Panel type	Cooling method	Required number of cables and required minimum cable cross-sections
Forced cooling	Incomer panel	A + E	4 x 300 mm²
	Cable termination panel	A	4 x 300 mm²
	Sectionaliser and riser panel (with or without busbar voltage metering)	A	-
Static cooling	Not applicable		

The cooling facilities required at

- higher ambient air temperatures and/or
- higher rated currents and/or
- a rated frequency of 60 Hz

may deviate from the cooling methods stated above.
Such special cases can be investigated on request.

9 Busbar earthing

This section outlines the ways in which the busbar can be earthed. The details of these operations can be found in the relevant instruction manuals.

9.1 Earthing the busbar by means of an earthing set

With the outgoing feeder earthed, the test sockets can be fitted with an earthing set (fig. 7.6.5) connected to the main earthing bar. Earthing of the busbar is effected via the closed feeder disconnector and subsequently closed circuit-breaker (see fig. 9.1.1).

9.2 Earthing the busbar by means of a sectionaliser and riser

Earthing is effected by the three position disconnector and circuit-breaker in the sectionaliser/riser (see fig. 9.2.1).

Fig. 9.1.1: Busbar earthing by earthing set

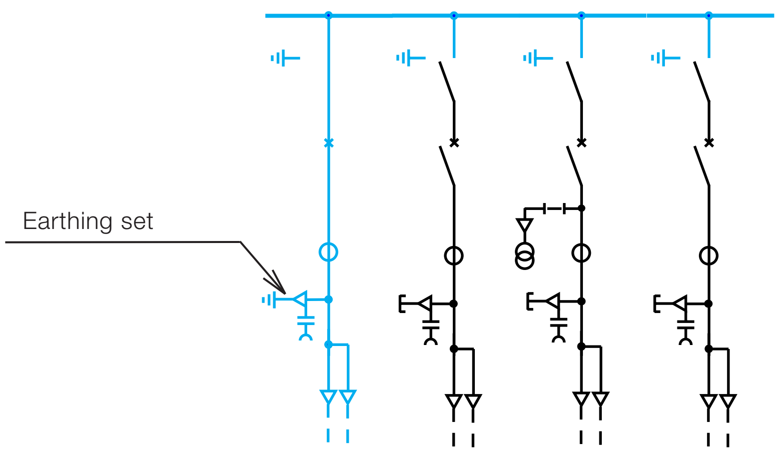
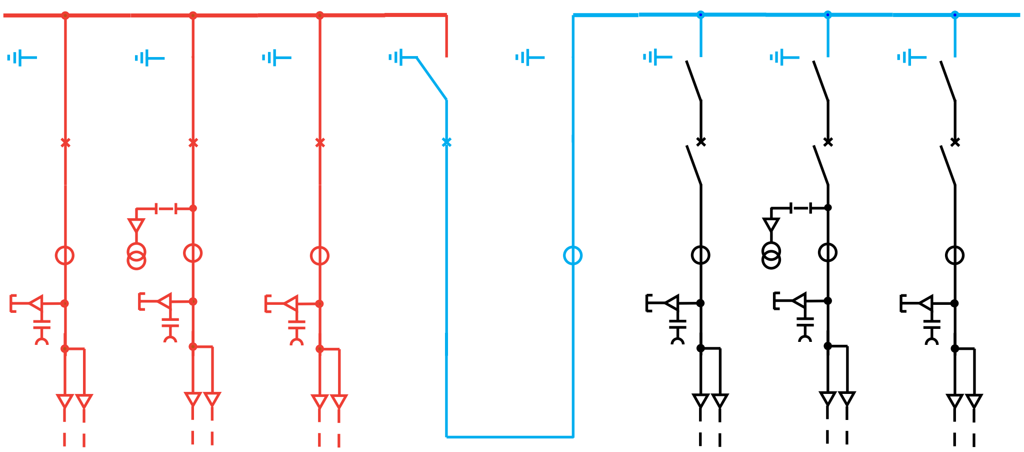


Fig. 9.2.1: Busbar earthing by earthing set



10 Building planning

10.1 Site requirements

The switchgear can be installed

- on a concrete floor, or
- on a raised false floor.

Concrete floor

A concrete floor requires a foundation frame set into the floor topping. The evenness and straightness tolerances for the base of the switchgear system are ensured by the foundation frame. The foundation frame can be supplied by ABB.
Floor openings for power and control cables can be configured as cutouts for each panel, as continuous cutouts (one each for power and control cables) or as drill holes. The floor openings are to be free from eddy currents (drill holes for power cables three phase – without ridges in between).

False floor

Below the switchgear, the supporting sections of the raised false floor serve as a base for the panels. A foundation frame is not as a rule necessary.

Pressure stress on the switchroom

With pressure relief inside the switchroom, a pressure rise in the room can be expected in the – highly unlikely – event of an internal arc fault. This is to be taken into account when planning the building. The pressure rise can be calculated by ABB on request. Pressure relief openings in the switchroom may be necessary.

Ventilation of the switchroom

Lateral ventilation of the switchroom is recommended.

Service conditions

The service conditions according to IEC 62271-1 for indoor switchgear are to be ensured.

The ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapours or salt.

The conditions of humidity are as follows:

- the average value of the relative humidity, measures over a period of 24 h, does not exceed 95 %;
- the average value of the water vapour pressure, over a period of 24 h, does not exceed 2.2 kPa;
- the average value of the relative humidity, over a period of one month, does not exceed 90 %;
- the average value of the water vapour pressure, over a period of one month, does not exceed 1.8 kPa.

Heaters are to be fitted in the low voltage compartments to preclude condensation phenomena (outside the gas-tight enclosures) resulting from major rapid temperature fluctuations and corresponding humidity. The specified temperature conditions according to IEC 62271-1 (> -5 °C) are also to be ensured by means of room heating.

10.2 Space required

Planning of the space required for the switchgear must take account of the
- escape routes,
- the possibility of inserting panels into an existing row,
- the boundary conditions for IAC qualification, and
- space required for dismantling and assembly of voltage transformers.

Fig. 10.2.1: Example of a single row installation (dimensions in mm)

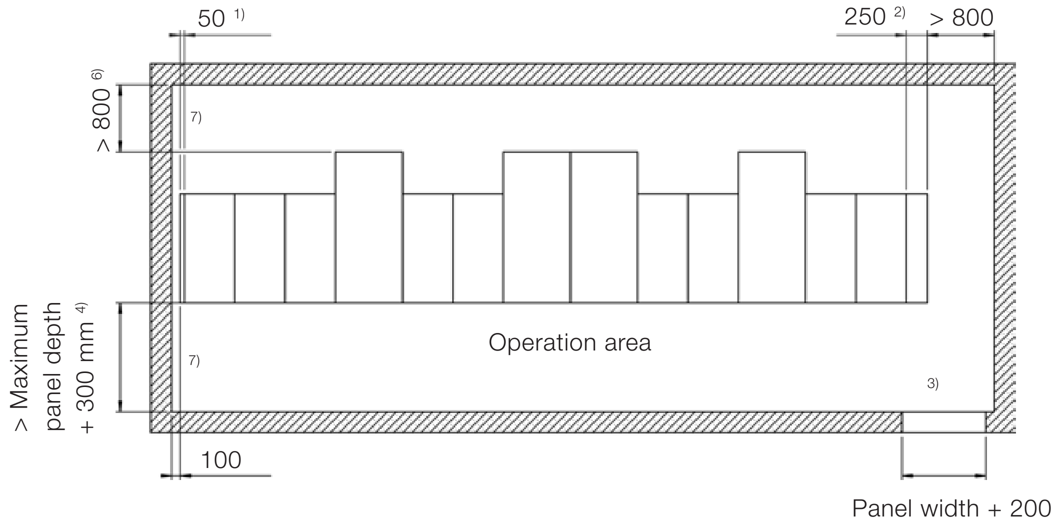
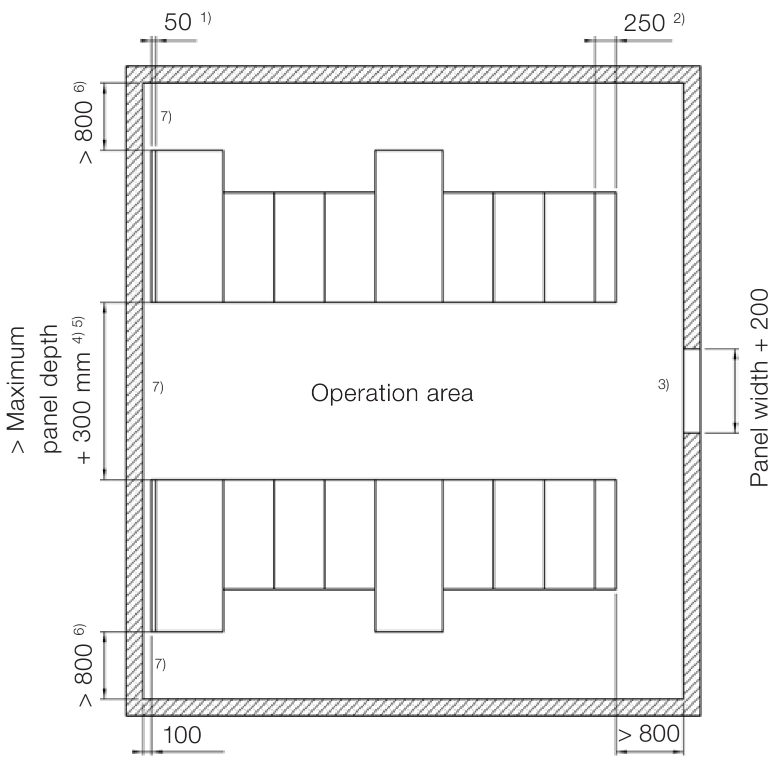


Fig. 10.2.2: Example of a double row installation (dimensions in mm)



1) End cover
2) Pressure relief duct at end (when a pressure relief duct on top of the switchgear block is used; otherwise 50 mm wide end cover)
3) Door height dependent on the transport height of the panel (the transport height of the panel is normally 2100 mm without pallet – exceptions: ZX1.2-C or transport with heat sinks fitted).
4) Recommended dimension taking account of the insertion of panels into an existing row (can possibly be reduced as stated in section 10.3)
5) Take the required door width of the switchroom and the area defined in section “Hasardous area for pressure relief to the outside” for determining the aisle width between two switchblocks into account.
6) Recommended dimension; can be reduced under certain circumstances as stated in section 10.3.
7) Observe the notes on escape routes in section 10.3.

10.3 Aisle widths and emergency exits

The aisle width in front of the switchgear is to be planned with attention to the need to remove panels from or insert panels into existing rows, and to the requirements of the relevant standards (see IEC 61936 and IEC 62271-200). The minimum and recommended minimum aisle widths can be found in table 10.3.1.

"Aisles shall be at least 800 mm wide. ... Space for evacuation shall always be at least 500 mm, even when removable parts or open doors, which are blocked in the direction of escape, intrude into the escape routes. ... Exits shall be arranged so that the length of the escape route within the room ... does not exceed ... 20 m. ... If an operating aisle does not exceed 10 m, one exit is enough. An exit or emergency possibilities shall be provided at both ends of the escape route if its length exceeds 10 m. ... The minimum height of an emergency door [possibly the 2nd door] shall be 2 000 mm [clear height] and the minimum clear opening 750 mm." [1)]

Table 10.3.1: Restrictive conditions on minimizing the aisle widths in front of the switchgear [2)]

		Minimum aisle width (Doors close in the direction of the escape route) [mm]	Recommended aisle width taking no account of removal or insertion of panels [mm]	Aisle width required for removal and insertion of panels [mm]
Single row installation	Panel blocks consisting exclusively of panels of 400 and/or 600 mm in width	> 800	> 1100	> maximum panel depth + 300
	Panel block with at least one panel of 800 mm in width	> 1000	> 1300	
		Minimum aisle width [mm]	**Recommended aisle width taking no account of removal or insertion of panels [mm]**	**Aisle width required for removal and insertion of panels [mm]**
Double row installation (with operator aisle between the system blocks)	Panel blocks consisting exclusively of panels of 400 and/or 600 mm in width	> 1400	> 1700	> maximum panel depth + 300
	Panel blocks with at least one panel of 800 mm in width	> 1800	> 2100	

1) IEC 61936
2) Enlarging the aisle width might be required due to the area defined in section "Hasardous area for pressure relief to the outside"

Installation and maintenance areas behind and to the side of the switchgear

The handling of test plugs and test cables behind the switchgear requires sufficient distance between the switchgear and the wall at the rear. Table 10.3.2 shows these minimum dimensions.

The handling of test plugs and test cables behind the switchgear requires sufficient distance between the switchgear and the wall at the rear. Table 10.3.2 shows these minimum dimensions.

Use of test cables [mm]	Use of test plugs [mm]
> 600	> 700

When **plasma diverters** are used, the dimensions stated in table 10.3.3 are to be maintained to fulfil the IAC qualification AFL.

Table 10.3.3: Wall distance behind the switchgear when plasma diverters are used, in relation to the panel depth

Panel width [mm]	Wall distance behind the switchgear [mm]	IAC-Qualification
nur 1400	> 800	AFL
1400, 1550,1600	> 800	
1850, 1900, 1950	> 600	

When a **pressure relief duct** relieving the pressure **to the outside** is used, only the minimum dimensions behind the switchgear required for testing instruments as set out in table 10.3.2 are to be maintained. The IAC qualification in this case is AFLR.On use of a pressure relief duct relieving the pressure **into the switchgear room**, the distance behind the switchgear can be reduced in accordance with tables 10.3.2 and 10.3.4, with a reduction in the IAC qualification. Reducing the wall distance at the side of the switchgear from 800 mm to a minimum of 500 mm reduces the IAC qualification as shown in table 10.3.4.

Table 10.3.4: IAC qualification on reduction of the wall distance behind the switchgear and of the wall distance at the side when using a pressure relief duct with relief into the switchgear room

	Wall distance behind the switchgear [mm]	Wall distance at the side of the switchgear (on one or both sides of the switchgear) [mm]	IAC-Qualification
Test cables	> 800	> 800	AFLR
	> 600	> 800	AFL
	> 800	> 500	AFR
	> 600	> 500	AF
Test plugs	> 800	> 800	AFLR
	> 700	> 800	AFL
	> 800	> 500	AFR
	> 700	> 500	AF

10.4 Minimum room heights

Table 10.4.1: Minimum room heights

		[mm]
System with tall heat sinks on at least one circuit-breaker compartment		3250
System without ZX1.2 - C (with or without voltage transformers on the circuit-breaker compartment)	Pressure relief duct with discharge to the outside	2700
	System with plasma diverters	2800
	Pressure relief duct with discharge into the switchgear room	2950
System with ZX1.2 - C (with or with voltage transformers on the circuit-breaker compartment)	System with plasma diverters	3000
	Pressure relief duct with discharge to the outside (ZX1.2 - C not at the end of the system)	
	Pressure relief duct with discharge to the outside (ZX1.2 - C at the end of the system)	3200
	Pressure relief duct with discharge into the switchgear room	

[1] IEC 61936
[2] Internal arc classification according to IEC 62271-200: IAC AFL

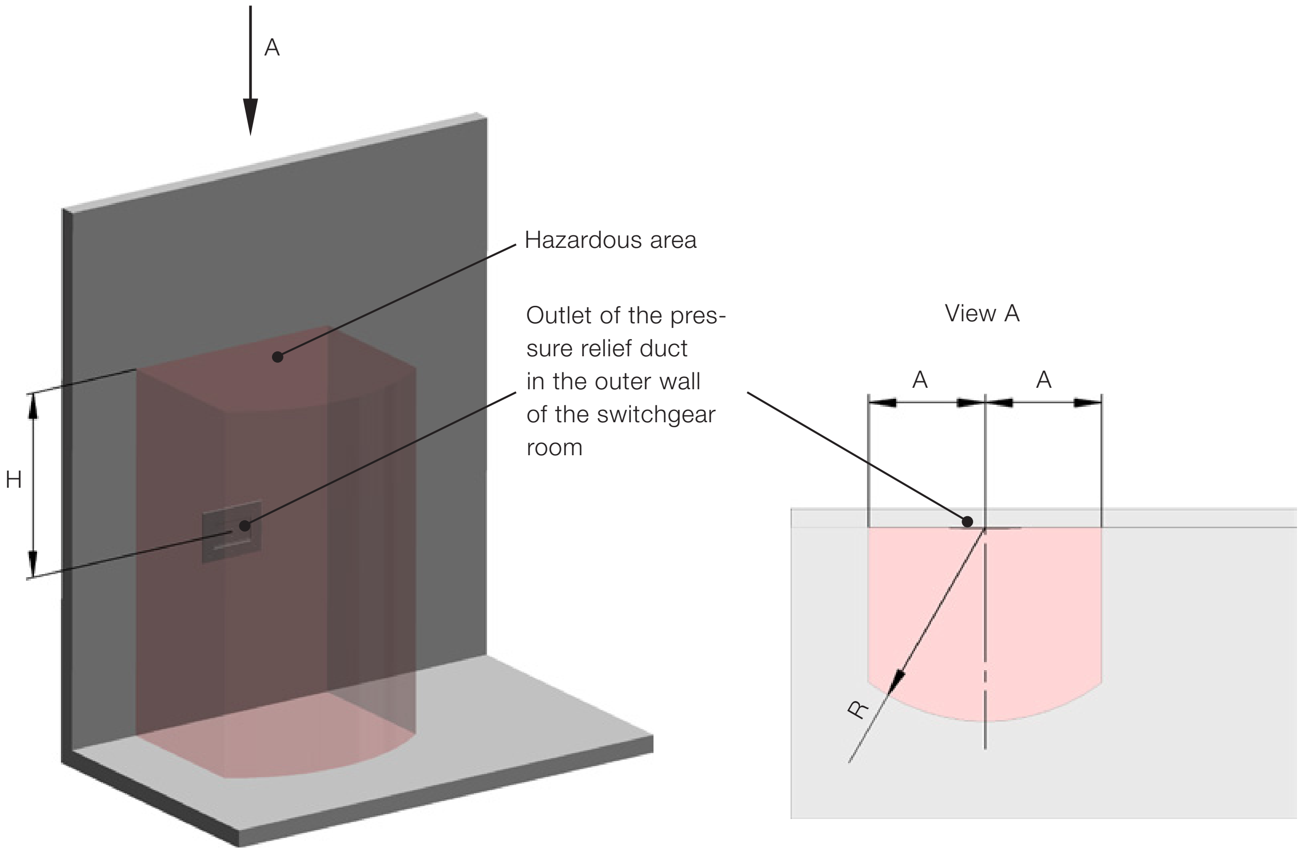
10.5 Hazardous area for pressure relief to the outside

In the case of an internal arc fault, hot gases can suddenly emerge from the outlet of the pressure relief duct. The area around the outlet of a pressure relief duct for relief to the outside constitutes a hazardous area which must be fenced off by the switchgear operator to prevent persons from entering that area.
The size of the hazardous area depends on the level of the expected short-circuit current. Please consult figure 10.5.1 and table 10.5.1 for the dimensions of the hazardous area.

Table 10.5.1: Dimensions of the hazardous area

Short-circuit current [kA]	A (distance to the side) [m]	R (distance to the front) [m]	H (distance to the top) [m]
20 / 25	1.0	2.0	2.0
31.5	1.5	2.5	2.5

Fig. 10.5.1: Dimensions of the hazardous area for pressure relief to the outside



10.6 Floor openings and cable axes

Fig. 10.6.1: Feeder panel, panel width 600 mm, panel depth 1400 mm

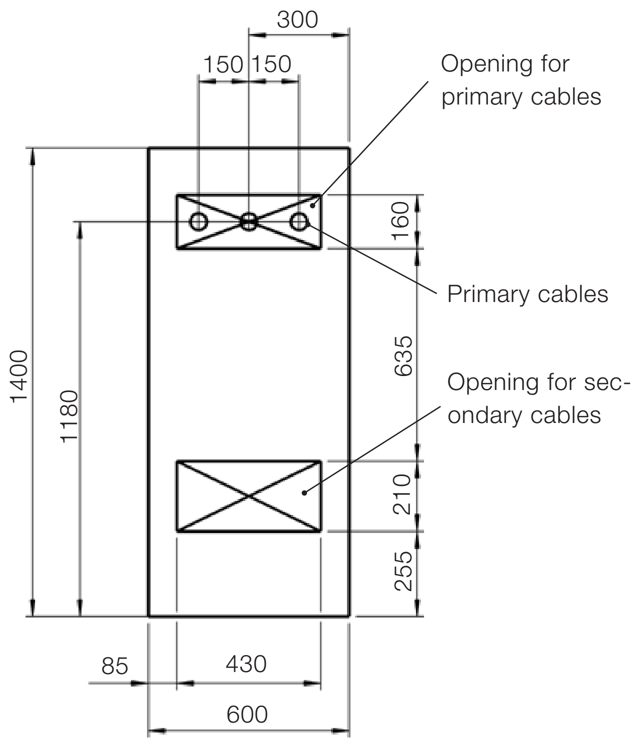


Fig. 10.6.2: Feeder panel, panel width 800 mm, panel depth 1400 mm

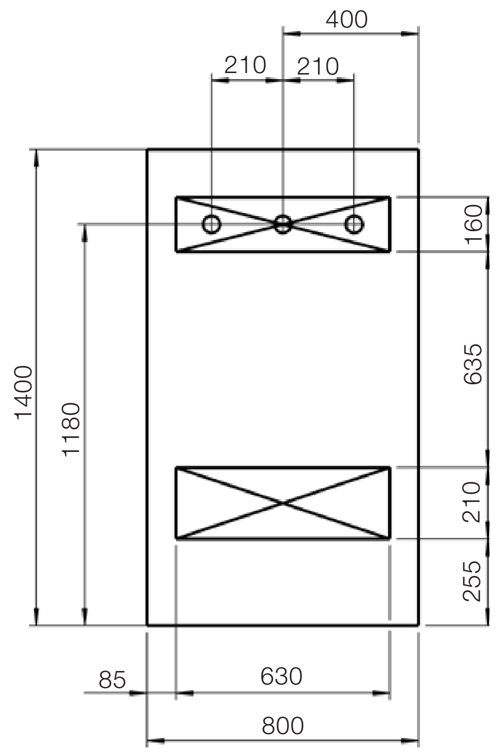


Fig. 10.6.3: Feeder panel and cable termination panel, panel width 600 mm, panel depth 1600 mm

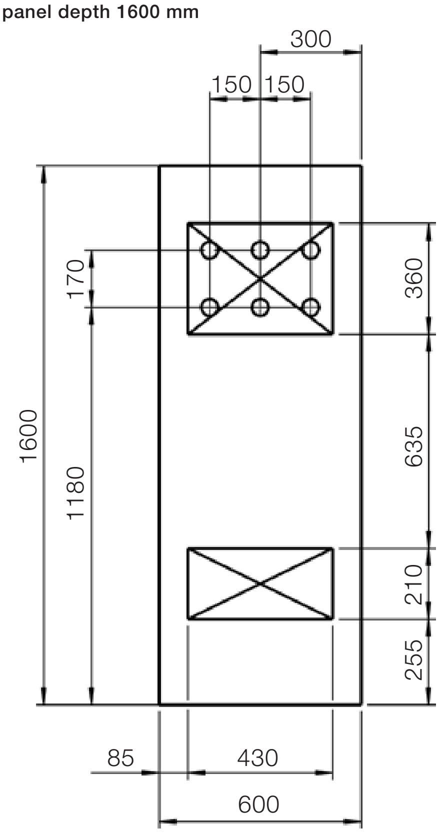


Fig. 10.6.4: Feeder panel, panel width 800 mm, panel depth 1600 mm

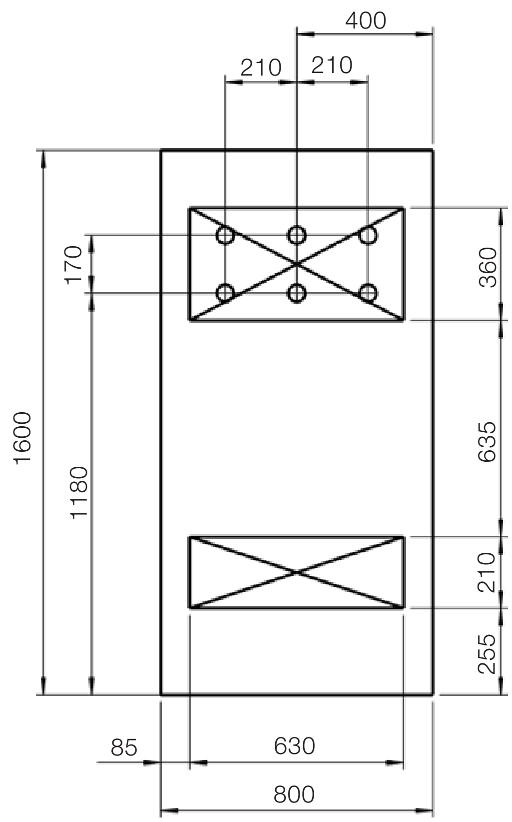


Fig. 10.6.5: Feeder panel and cable termination panel, panel width 800 mm depth 1900 mm (1950 mm with fan cooling)

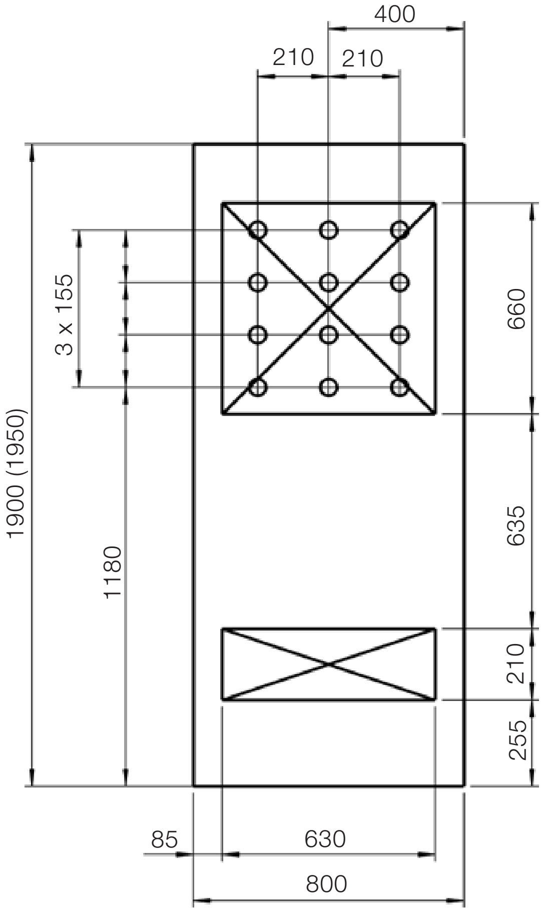


Fig. 10.6.6: Panel for capacitor switching (ZX1.2-C)

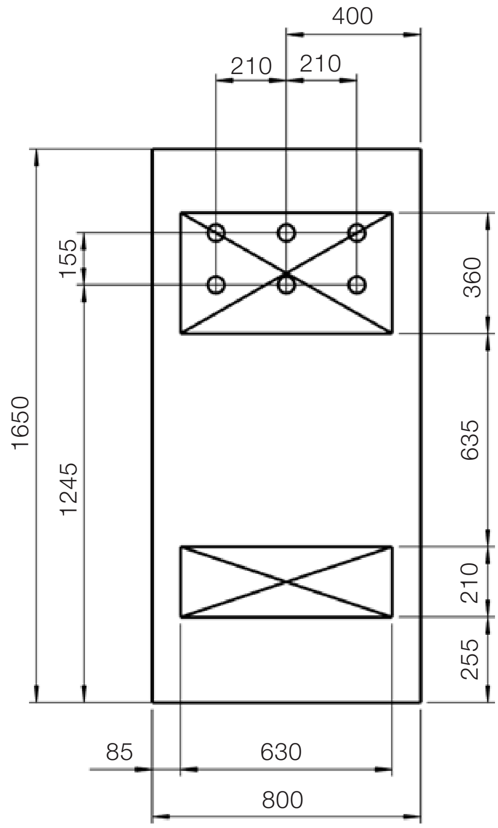


Fig. 10.6.7: Double feeder panel with one cable per phase

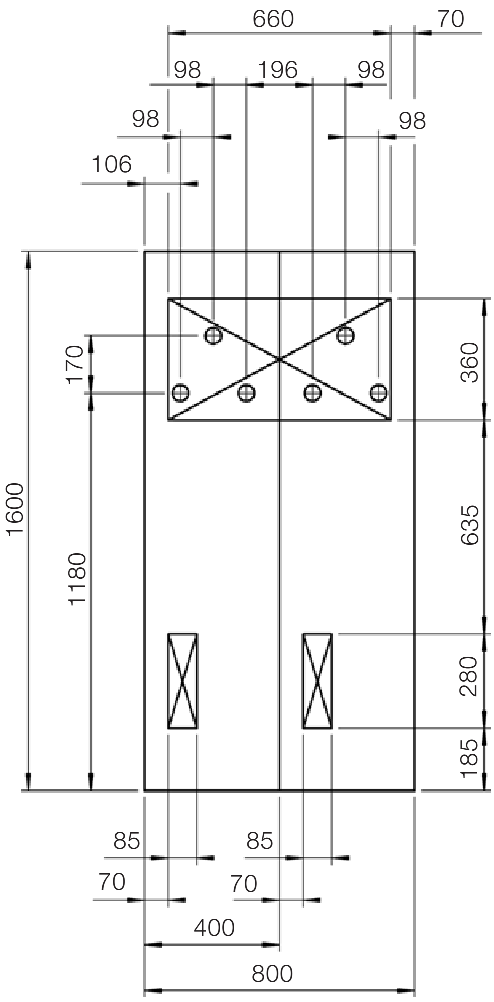


Fig. 10.6.8: Double feeder panel with two cables per phase

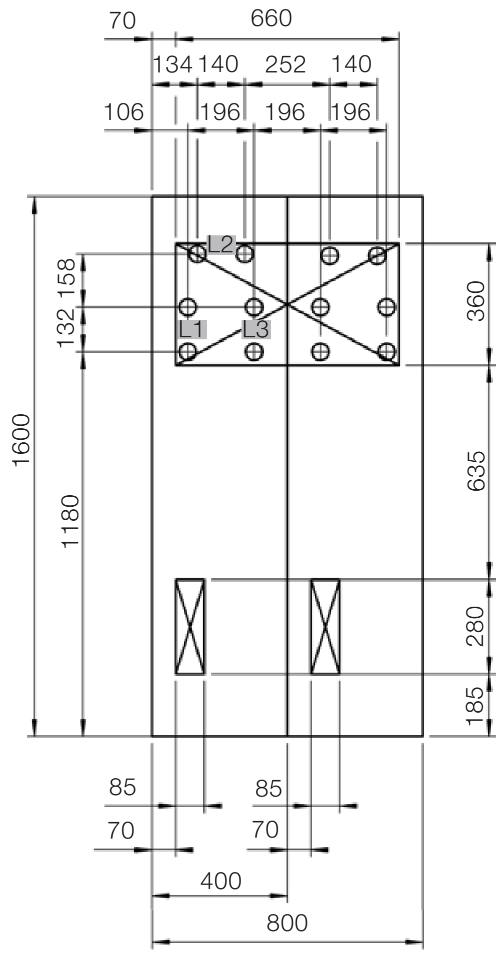


Fig. 10.6.9: Cable in – cable out panel, version 1

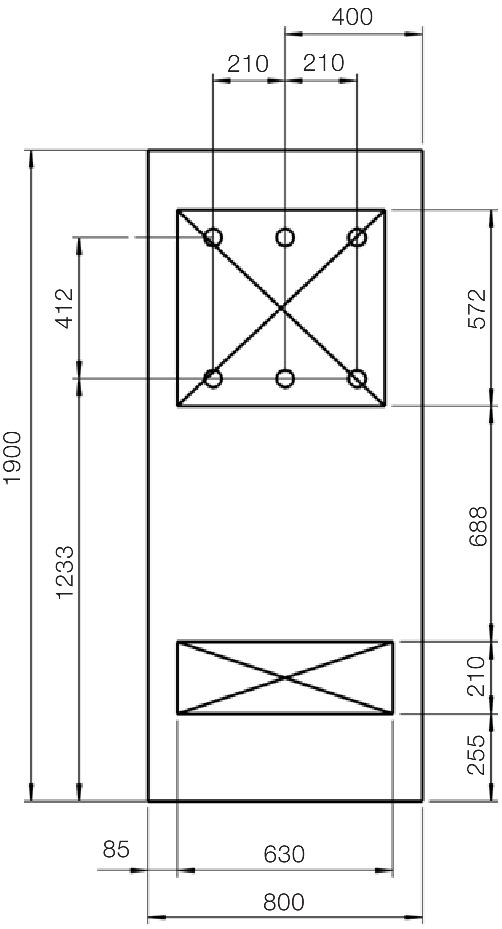


Fig. 106.10: Cable in – cable out panel, version 2, 1 cable per phase

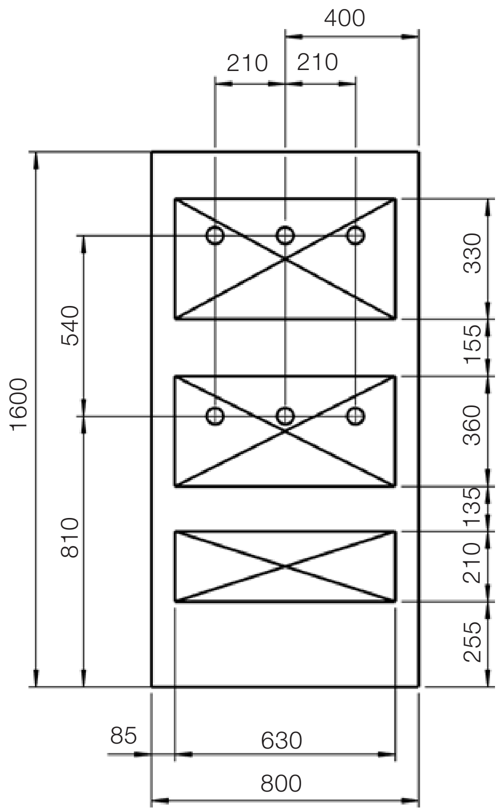
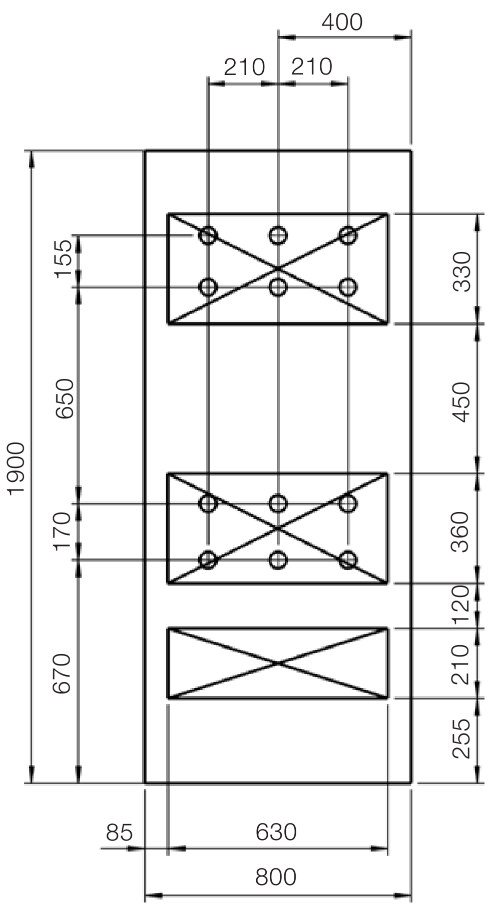


Fig. 10.6.11: Cable in – cable out panel, version 2, 2 cables per phase



Details of floor openings for termination panels for fully insulated bars with connections from below are available on request.

For the following panels, only the openings for secondary cables in the concrete floor are required:

- Termination panels for fully insulated bars with bar connection from above
- Sectionaliser and riser panels
- Metering panels

The relevant panel depths can be found in section 8.

Fig. 10.6.12: Opening for secondary cables, panel width 600 mm,

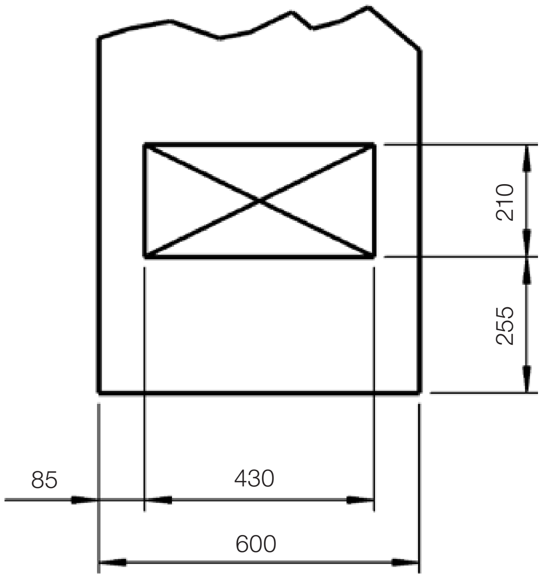
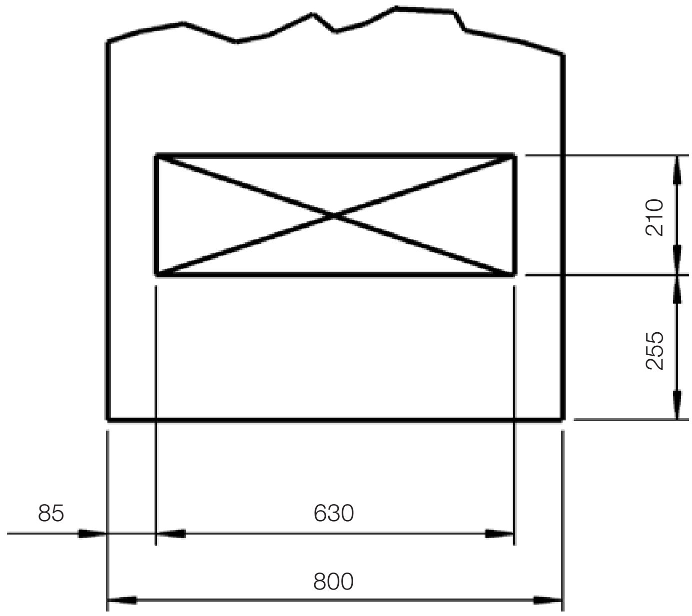


Fig. 10.6.13: Opening for secondary cables, panel width 800 mm



10.7 Foundation frames

The optional foundation frames consist of aluminium sections. They are supplied pre-assembled as single panel units. The dimensions of the foundation frames correspond to the panel width and depth. Frames of 800 mm width are available for double panels of 400 mm width.

The position of the foundation frame relative to the panel can be seen in figure 10.7.1.

The foundation frames are to be fastened to the concrete floor and embedded in the floor topping. When installing the foundation frames at site, please observe the form and position tolerances stated in the order documents.

Fig. 10.7.1: Example of a foundation frame for a panel with a width of 600 mm and a depth of 1600 mm

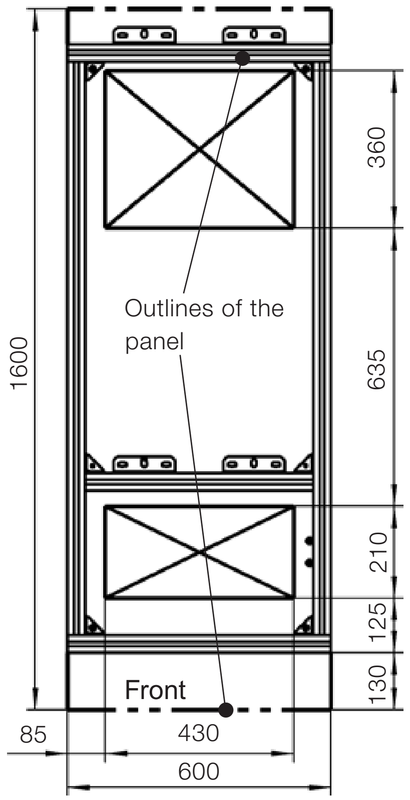
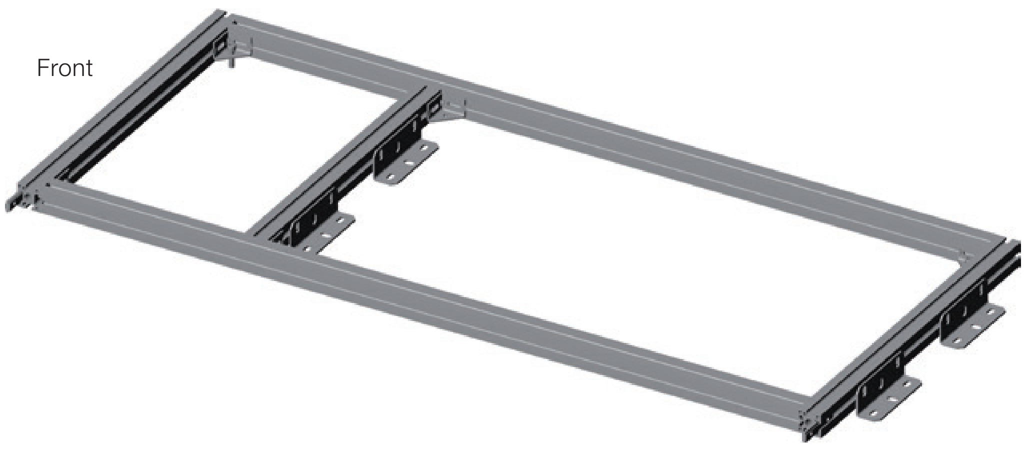


Fig. 10.7.2: Foundation frame, two panel version

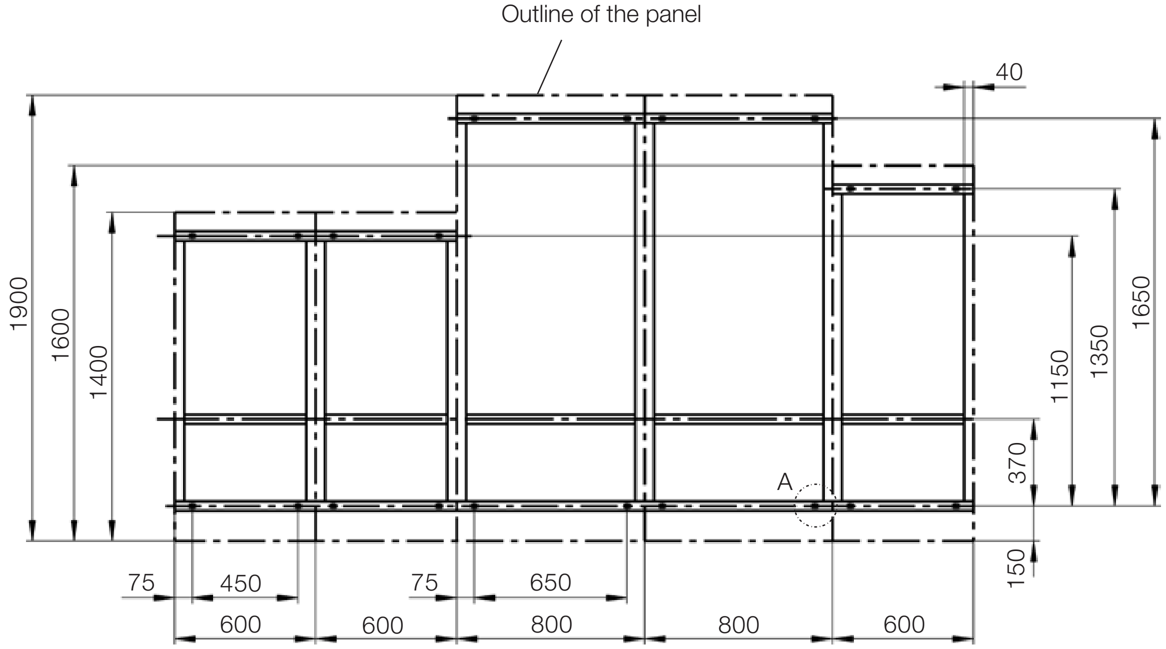


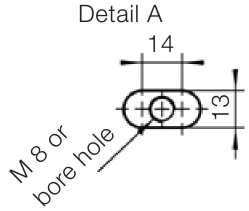
10.8 False floor

Fig. 10.8.1 is an aid to planning of the false floor.

The floor plates of the panels have L13 x 14 slots for fastening the panels to the frame sections. Provide M 8 threads or bore holes for screws M 8 in the frame sections at the positions of the slots.

Fig. 10.8.1: Example of a false floor in the area of a five-panel ZX1.2 switchgear system as an aid to planning (plan view, dimensions in mm).





- L 13 x 14 slot in the floor plate of the panel
- M 8 thread or bore hole for screw M 8 in the frame section of the false floor

10.9 Earthing of the switchgear

10.9.1 Design of earthing systems with regard to touch voltage and thermal stress

The earthing system for the station building and the earthing system for the switchgear are to be designed in accordance with IEC 61936.
The switchgear system is to be fitted with a continuous copper earthing bar with a cross-section of 300 mm^2 (ECuF30, 30 mm x 10 mm). The connection of this earthing bar to the station earthing system is to be effected in accordance with the above standards.

10.9.2 EMC-compliant earthing of the switchgear

Observe IEC 61000-5-2 and IEC 61000-6-5 to project the earthing system for the station building and the design, laying and connection of external control cables.

Establish the switchgear earthing due to the guidelines in the following section.

10.9.3 Recommendations on configuration of the switchgear earthing

We recommend that the switchgear be earthed as shown in figures 10.9.3.1 and 10.9.3.2.

A ring consisting of 80 mm x 5 mm copper strip is to be located beneath the switchgear and connected at several points with a maximum spacing of 5 m to the earthing system of the building. The foundation frame, the main earthing bar in the panels and the earthing bar in the low voltage compartments are to be connected at multiple points to the ring located beneath the switchgear. Details on the use of materials and the number of connections can be found in figure 10.9.3.1 and 10.9.3.2.

Fig. 10.9.3.1: Earthing recommendation, shown schematically as a sectional elevation of the lower part of a panel including the concrete floor

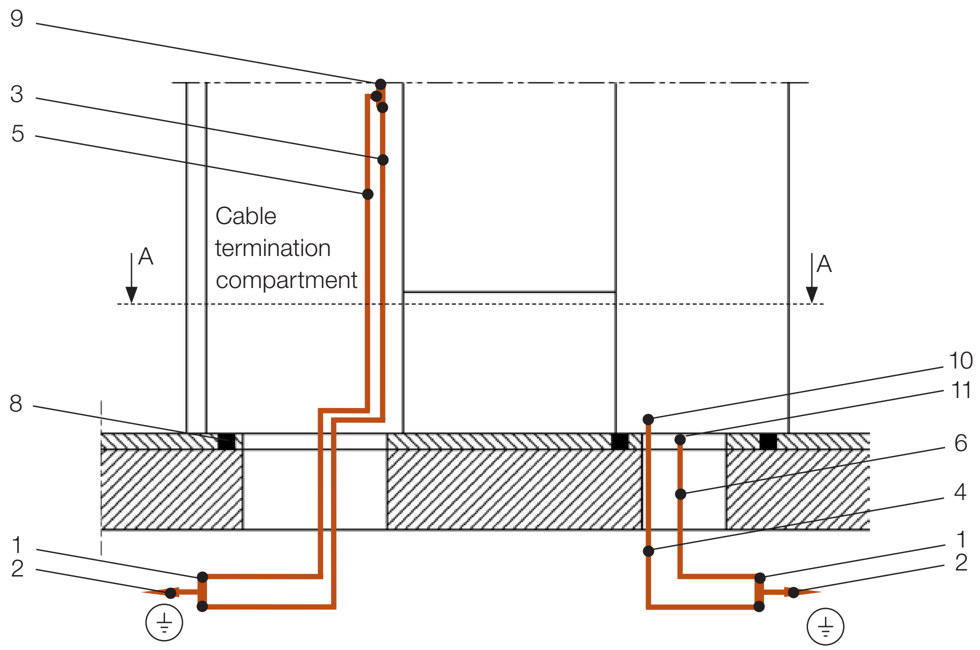
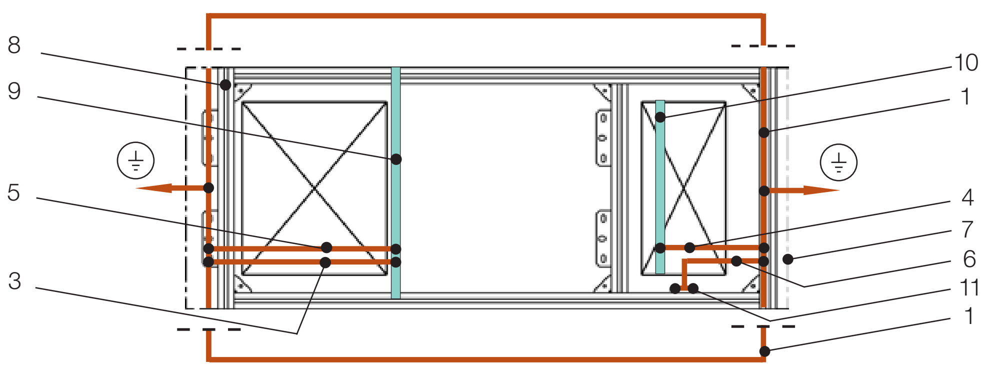


Fig. 10.9.3.2: Earthing recommendation, plan view (section A-A of figure 10.9.3.1)



Legend to figures 10.9.3.1 and 10.9.3.2

1 Ring below the switchgear, material ECuF30, cross-section 80 mm x 5 mm
2 Several connections from (1) to the building earth at distances of max. 5 m, material ECuF30, cross-section 80 mm x 5 mm
3 Short-circuit proof earthing of the switchgear in both end panels and at least every third panel, material: ECuF30, cross-section: 30 mm x 10 mm
4 Low impedance earthing of the earthing bar in the low voltage compartment of each panel, material: tinned copper braid, cross-section: 20 mm x 3 mm
5 Low impedance earthing of the switchgear in each panel, material: tinned copper braid, cross-section: 20 mm x 3 mm
6 Earthing of the foundation frame, at least every third foundation frame, material: galvanised steel strip, cross-section: 30 mm x 3.5 mm
7 Outline of the panel
8 Foundation frame
9 Main earthing bar
10 Earthing bar in the low voltage compartment
11 Earthing point on the foundation frame

10.10 Panel weights

Table 10.10.1: Panel weights

800 – 1250 A panel variants [1]	From approx. 550 kg to approx. 1000 kg
2500 A – panel variants [2]	Up to 1650 kg

[1] Weights dependent on variant, design, panel width and equipment fitted.
[2] Weights dependent on variant, design and equipment fitted.

11 Non-standard operating conditions

Non-standard operating conditions may require special action. Our design team will be pleased to propose and implement technical solutions to meet your requirements.

The non-standard operating conditions include in particular

- Site altitudes > 1000 m above sea level,
- Higher ambient air temperature (maximum > 40 °C and maximum 24 h average > 35°C) (see fig. 11.1).
- Ambient air contaminated by dust, smoke, corrosive or flammable gases or salt.

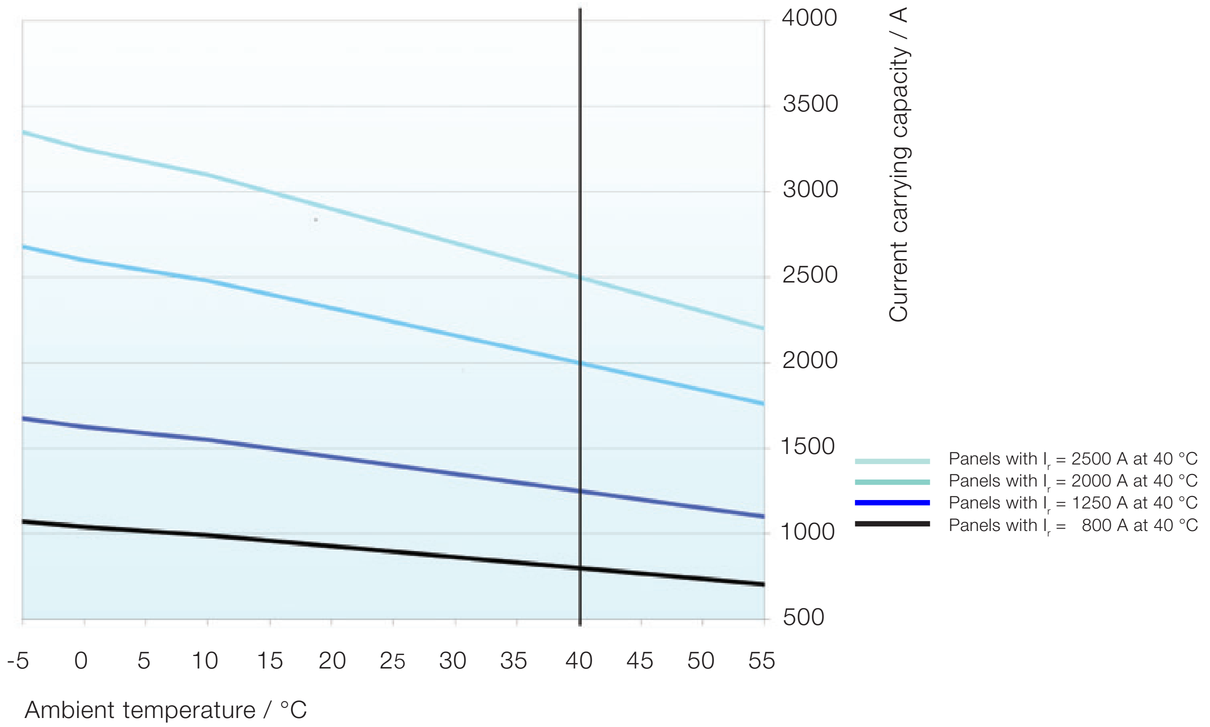
Seismic withstand capability

The panels are tested to IEEE Std. 693. [1)]

Climate

With high humidity and/or major rapid temperature fluctuations, electrical heaters must be fitted in the low voltage compartments.

Fig. 11.1: Relationship between ambient air temperature and current carrying capacity



[1)] Additional measures required (on request)

Notes

Contact us

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