ZX2

Gas-insulated medium voltage switchgear

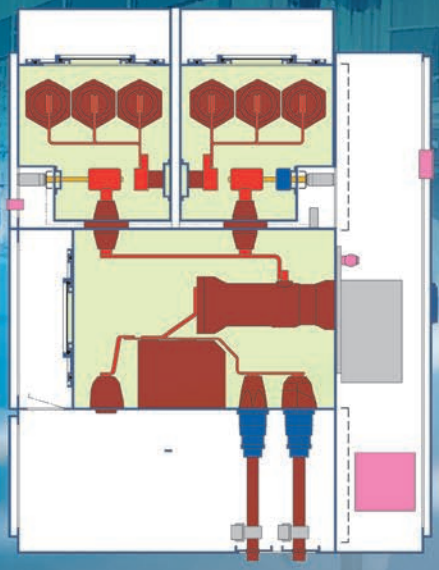
Technical catalogue TK 502/04 E

ZX0

...24 kV

...1250 A

...25 kA

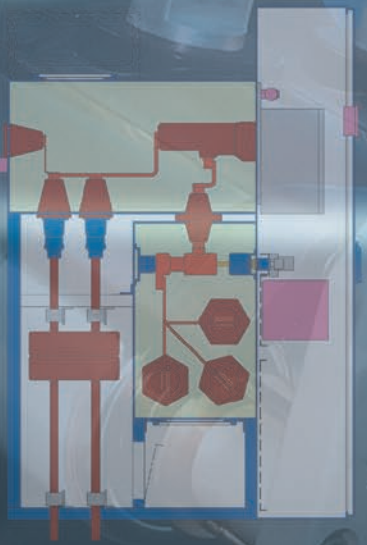


ZX2

...40.5 kV

...2500 A

...40 kA



ZX1.2

...40.5 kV

...2500 A

...31.5 kA

Foreword

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.

Gas-insulated switchgear (GIS) has been in service since the 1960s, establishing itself both in high voltage (> 52 kV) and medium voltage (≤ 52 kV) applications.

Within the ABB Group, the German production location at Ratingen is responsible for the manufacture and worldwide supply of gas-insulated medium voltage switchgear. At its Focussed Feeder Factory, ABB AG not only manufactures the complete ZX product range

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

but also possesses the know-how, global project experience and local partners required for the supply of panels and turnkey medium voltage switchgear systems.

The ZX series leave our works as completely 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.

This technical catalogue is intended to provide you with basic information on our products. It is our aim to provide you with a clear overview of the existing know-how that has been contributed to our products in many years of advanced research. The technical catalogue is not a general reference work on electrical engineering or the principles of switchgear, but rather deals with the details of the ZX range of gas-insulated switchgear. For general principles, we would draw your attention to the well-known Asea Brown Boveri publication “Switchgear Manual” (ISBN 13: 978-3-589-24112-5).

Ratingen, January 2008

Andreas Reimüller
Head of Product Management

Michael Müller
Technical Author

ABB AG
Calor Emag Medium Voltage Products
Oberhausener Straße 33
40472 Ratingen

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2. Characteristics

Basic characteristics

- SF_6 gas-insulated
- Rated voltages from 12 kV up to 36 kV (40.5 kV)
- Up to 2500 A and 40 kA
- Single and double busbar design
- Laser welded stainless steel encapsulation, manufactured from laser cut sheet material
- Modular structure
- Busbar compartments as hermetically sealed pressure systems
- Circuit-breaker compartment as a hermetically sealed pressure system
- Switchgear with a leakage rate of less than 0.1 % per annum
- Integrated leakage testing of the panels
- Indoor installation

Panel variants

- Incoming and outgoing feeder panels
- Cable termination panels
- Termination panels for fully insulated bars
- Sectionaliser
- Riser
- Metering panels
- Double feeder panels
- Customised panel versions

Circuit-breaker, disconnector and three position disconnector

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

Connections

- Inner cone cable plug system to EN 50181 and DIN 47637, in sizes 2 and 3
- Outercone cable plug system to EN 50181 and DIN 47637 (double feeder panel only)
- Connection facility for surge arresters

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
- Optional: additional mechanical interlocks

Pressure relief

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

Installation

- Panels joined together by plug-in connectors

3. Technical data

3.1 Technical data of the panel

Electrical data			IEC ratings			Special ratings
Rated voltage / maximum operating voltage	U_r	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 of busbars [3]	I_r	A		...2500		...2500
Rated normal current [4]	I_r	A		...2500		...2500
Rated short-time withstand current	I_k	kA		...40		...40
Rated peak withstand current	I_p	kA		...100		...100
Rated duration of short-circuit	t_k	s		...3		...3
Insulating gas system [5] [6]						
Minimum functional level for insulation	p_{me}	kPa [7]		100 [8]		120
Alarm level for insulation	p_{ae}	kPa		120		120
Rated filling level for insulation	p_{re}	kPa		130		130

Degree of protection for parts under high voltage		IP65
Degree of protection of panel with low voltage compartment door closed [9]		IP4X
Ambient air temperature, maximum	°C	+40
Ambient air temperature, maximum 24 hour average [10]	°C	+35
Ambient air temperature, minimum	°C	-5
Site altitude [11]	m	...1000

Table 3.1.1: Technical data of the panel

1) Higher levels to international standards on request
2) Rated current for 60 Hz on request
3) Higher rated currents on request
   Single busbar systems up to 4000 A on request
4) Higher rated currents 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) 110 kPa when double feeder panel is used at U_r > 17.5 kV
9) Higher degrees of protection on request
10) Higher ambient air temperature on request
11) Higher site altitude on request

Internal arc classification to IEC 62271-200 [1)]

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

Internal arc classification	Classification IAC AFLR Internal arc 40 kA 1 s
Rated short-time current and duration of an arc fault in the cable termination compartment	0.87 x 40 kA 1 s [2)]

Table 3.1.2: Internal arc classification of the switchgear in accordance with IEC 62271-200

Key to table 3.1.2:

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

The arrangement of the pressure relief duct means that at least four panels are required. As a result, the IAC qualification relies on a system consisting of at least four panels.

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.

Loss of Service Continuity	Cable compartments:	LSC2B
	Gas compartments:	Gas compartments are not to be opened under service conditions, and therefore an LSC qualification is not applicable.

Table 3.1.3: Loss of Service Continuity of the switchgear in accordance with IEC 62271-200

Key to table 3.1.3:

LSC2B
- Loss of Service Continuity
- Other panels and all cable compartments may remain energised.

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

[2)] According to IEC 62271-200, section A.5.2.1 (page 127) three-phase faults do not generally develop in cable compartments with plug-in connectors. “That means the actual current value … is reduced to approximately 87 % of the specified internal arc withstand current.”

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.

Partition class	PM

Table 3.1.4: Partition class in accordance with IEC 62271-200

Key to table 3.1.4:

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.

3.2 Technical data of the circuit-breaker

Electrical data			IEC ratings			Special ratings
Rated voltage / maximum operating voltage	U_r	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	...40			...40
Rated short-circuit making current	I_{ma}	kA	...100			...100
Rated short-time withstand current	I_k	kA	...40			...40
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	ca. 60			[5]
Rated opening time	t_3	ms	≤ 45			[5]
Rated break time	t_b	ms	≤ 60			[5]
Rated auxiliary voltage		V dc	48, 60, 110, 220 [6]			
Power consumption of charging motor		W	max.240			
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 [7] x I_r (I_r = Rated normal current)
50 x I_{SC} (I_{SC} = Rated short-circuit breaking current)

Table 3.2.1: Technical data of the circuit-breaker

1) Higher levels to international standards on request
2) Rated current for 60 Hz on request
3) Higher rated currents on request
4) Different operating sequences on request
5) Times for 40.5 kV, 40 kA circuit-breakers on request
6) Different auxiliary voltages on request
7) Dependent on the vacuum circuit-breaker

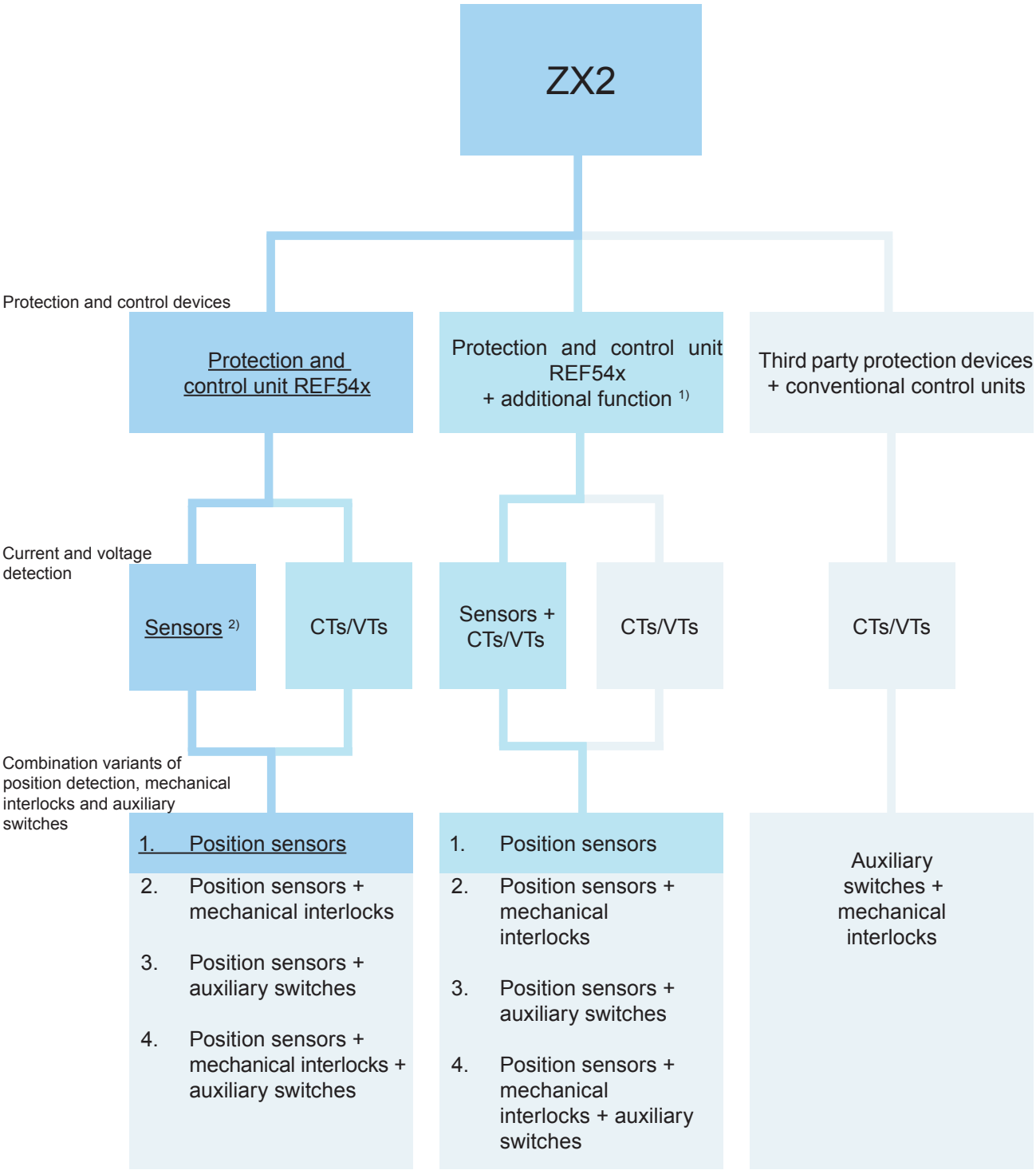
3.3 Technical data of the disconnector and three position disconnector

Electrical data			IEC ratings			Special ratings
Rated voltage / maximum rated voltage	U_r	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	...40			...40
Rated peak withstand current	I_p	kA	...100			...100
Rated duration of short-circuit	t_k	s	3			3
Rated auxiliary voltage	U_a	V dc	48, 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

Table 3.3.1: Technical data of the disconnector and the three position disconnector

[1] On request
[2] Higher rated currents on request
[3] Different auxiliary voltages on request
[4] At rated auxiliary voltage

4. Alternative protection and control concepts



4.1: Alternative protection and control concepts (preferred variants are marked)

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1) The additional functions are, for example:
- Billing metering
- Transient earth fault
- Differential protection
- Backup protection

2) Voltage measurement covering all panels (busbar metering) is effected by means of conventional voltage transformers

5. Fundamental structure of the panels

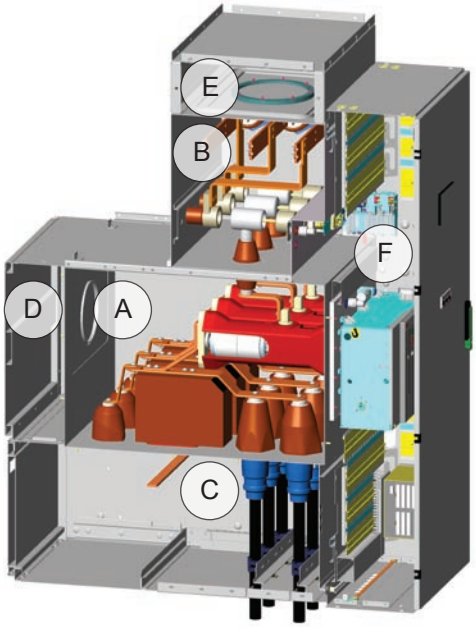


Fig. 5.1: Outgoing cable panel 1250 A with block-type transformer/sensor, single busbar at front

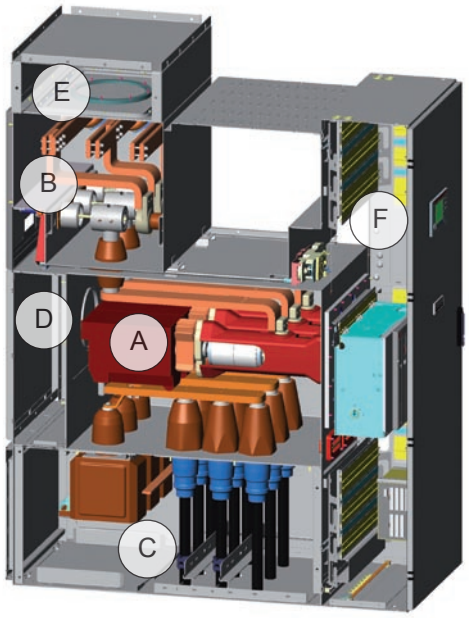


Fig. 5.2: Outgoing cable panel 2000 A with current and voltage transformer , single busbar at rear

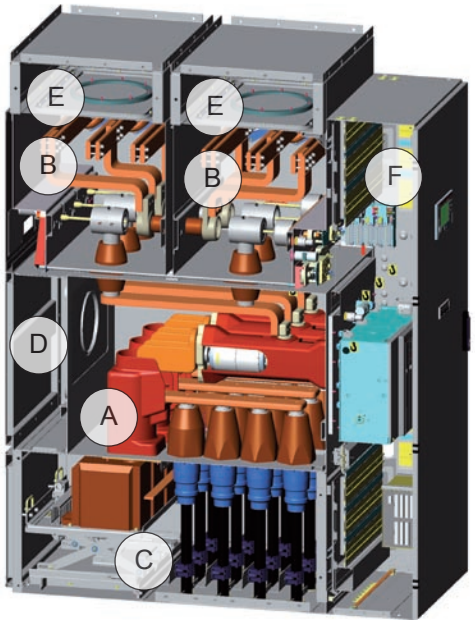


Fig. 5.3: Outgoing cable panel 2000 A with sensor and voltage transformer, double busbar

Modular structure

Each feeder panel consists of the circuit-breaker compartment (A), one or two busbar compartments (B), the cable termination compartment (C), the pressure relief duct for the circuit breaker compartment and for the cable termination compartment (D), one or two pressure relief ducts for the busbar compartments (E) and the low voltage compartment (F). The circuit-breaker compartment and the busbar compartments are filled with gas. There are no gas connections between the two or three 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 (1.0).

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

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

- Current detection by blocktype transformers or sensors (fig. 5.4) with max. two cable sockets per phase
- Current detection by current transformer (fig. 5.5)
- Current detection by sensors or combination of sensor/current transformers (fig. 5.6).

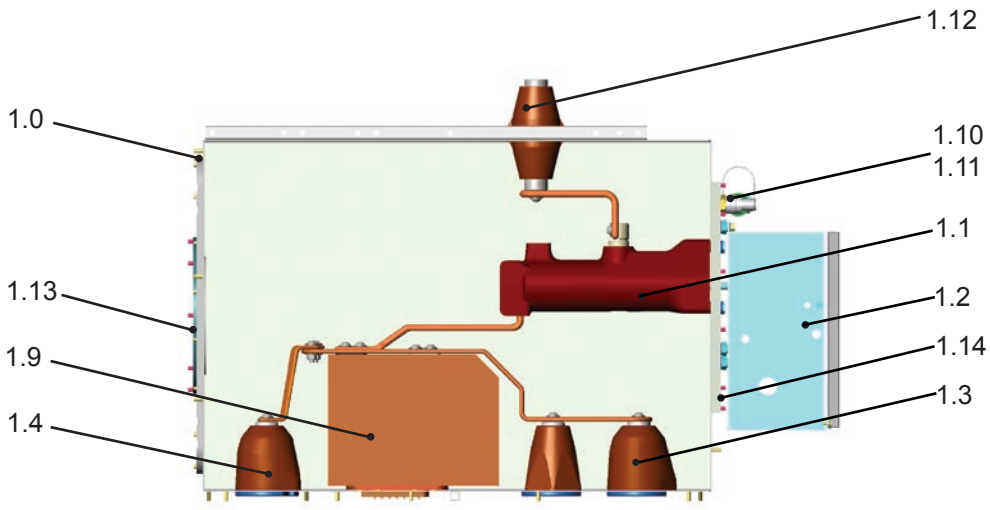
Sockets (1.4) for plug-in voltage transformers or sensors are located underneath the circuit-breaker compartment. In the version shown in fig. 5.6 the sockets are integrated in the sensor unit (1.17). When voltage transformers/sensors are removed the sockets can be used as test sockets. If no voltage transformers or sensors are used the sockets are sealed and insulated with blanking plugs.

The pressure relief disk (1.13) of the circuit-breaker compartment is located in the rear wall of the enclosure. The circuit-breaker operating mechanism (1.2), the gas leakage sensor (1.10) and the filling valve (1.11) are located on the mounting plate of the circuit-breaker (1.14) which is bolted to the front wall of the enclosure.

The main earthing bar (3.5) of the panel is bolted to the floor plate of the enclosure.

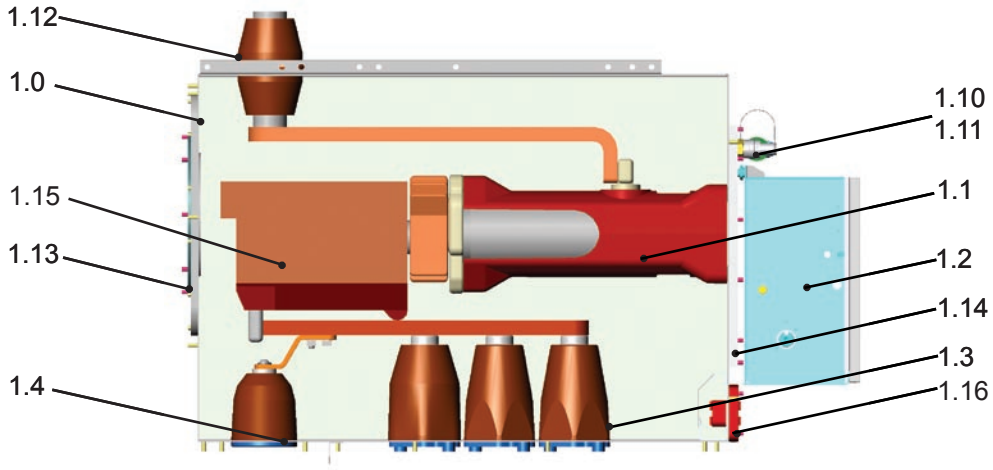
The seals of the components are o-ring seals which are not exposed to any UV radiation.

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 above the circuit-breaker compartments.



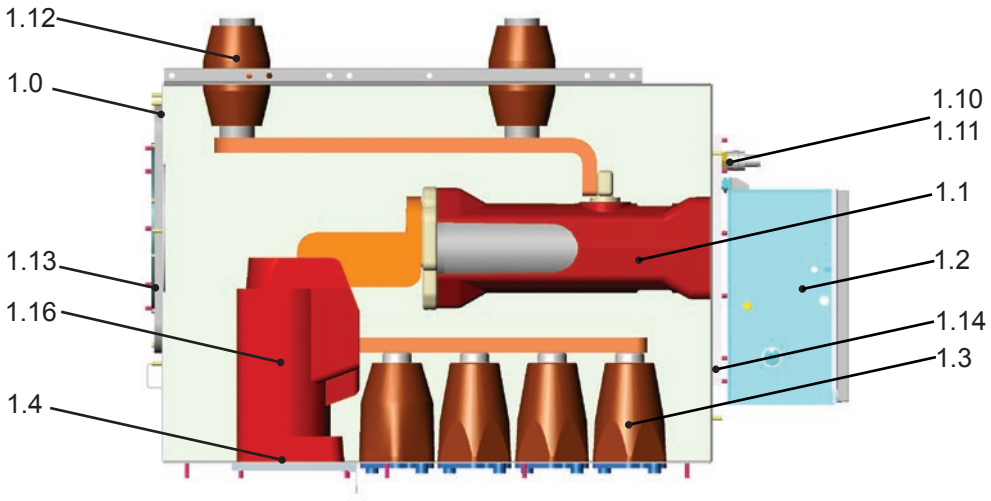
1.0	Circuit-breaker compartment (enclosure)	1.10	Gas density sensor for circuit-breaker compartment
1.1	Circuit-breaker pole	1.11	Filling valve for circuit-breaker compartment
1.2	Circuit-breaker mechanism	1.12	Cast resin bushing to busbar
1.3	Cable socket	1.13	Pressure relief disk
1.4	Test socket (also for use with other plug-in devices).	1.14	Mounting plate
1.9	Block-type transformer		Insulating gas SF_6

Fig. 5.4: Circuit-breaker compartment with block type transformer, 1250 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 (also for use with other plug-in devices).	1.15	Current transformer
1.10	Gas density sensor for circuit-breaker compartment	1.16	Bushing for secondary transformer wiring
			Insulating gas SF_6

Fig. 5.5: Circuit-breaker compartment with current transformer, 2000 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 (also for use with other plug-in devices).	1.17	Combination sensor
1.10	Gas density sensor for circuit-breaker compartment		Insulating gas SF_6

Fig. 5.6: Circuit-breaker compartment with sensor, 2000 A

The busbar compartment (B)

The busbar compartment (figs. 5.7 and 5.8) consists of the busbar system (2.1), which is connected to the single-pole cast resin bushings (1.12) below via flat conductors (2.10) and the three position disconnector (2.3) or disconnector (2.4).

The pressure relief disk (1.13) of the busbar compartment is located in the roof of the enclosure.

Front busbar compartment

The operating mechanism (2.5) of the three position disconnector (2.3), the gas leakage sensor (2.7) and the filling valve (2.8) are located on the front wall of the enclosure.

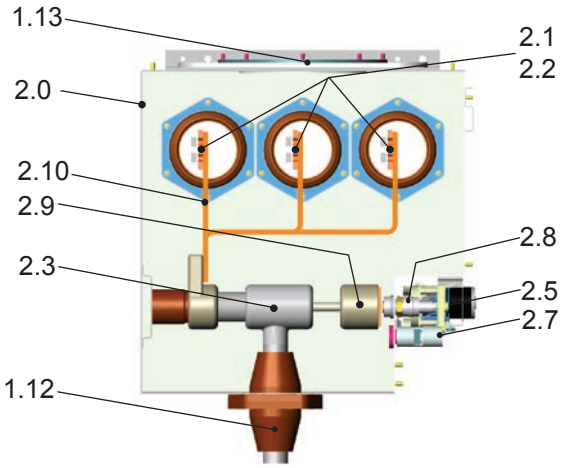
Rear busbar compartment

The operating mechanism (2.5) of the disconnector (2.4), the gas leakage sensor (2.7) and the filling valve (2.8) are located on the rear wall of the enclosure. Emergency manual operation of the disconnector is effected from the low voltage compartment.

As a rule, the front busbar compartment contains a three position disconnector (with earthing function). The rear busbar compartment of the single busbar version also contains a three position disconnector. In the double busbar version the rear busbar compartment of cable termination panels contains a disconnector with no earthing function.

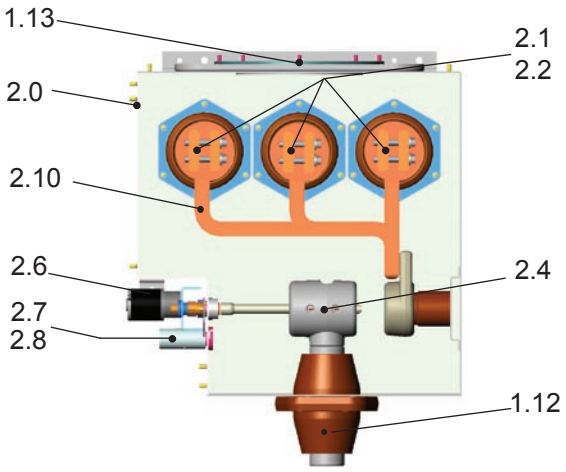
As with the circuit-breaker compartment, the seals on the components are o-ring seals which are not exposed to any UV radiation.

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 below the busbar compartments.



1.12	Cast resin bushing	2.7	Gas density sensor for busbar compartment
1.13	Pressure relief disk		
2.0	Busbar compartment (enclosure)	2.8	Filling valve for busbar compartment
2.1	Busbar system	2.9	Earthing contact
2.2	Plug-in busbar connector	2.10	Flat conductor
2.3	Three position disconnector		
2.5	Three position disconnector operating mechanism		Insulating gas SF_6

Fig. 5.7: Front busbar compartment (B), 1250 A



1.12	Cast resin bushing	2.6	Disconnector operating mechanism
1.13	Pressure relief disk	2.7	Gas density sensor for busbar compartment
2.0	Busbar compartment (enclosure)		
2.1	Busbar system	2.8	Filling valve for busbar compartment
2.2	Plug-in busbar connector	2.10	Flat conductor
2.4	Disconnector		
			Insulating gas SF_6

Fig. 5.8: Rear busbar compartment (B), Double busbar, 2000 A

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

The cable termination compartment (fig.5.6) constitutes a support frame for the panel manufactured from bended zinc-plated sheet metal.

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 or voltage transformers.

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 is metal-enclosed on all sides and protected against accidental contact. The installation access at the rear of the cable termination compartment is closed off by a detachable plate.

In the unlikely event of an arc fault in the cable termination or circuit-breaker compartments, pressure is relieved through the rear pressure relief duct (4.0).

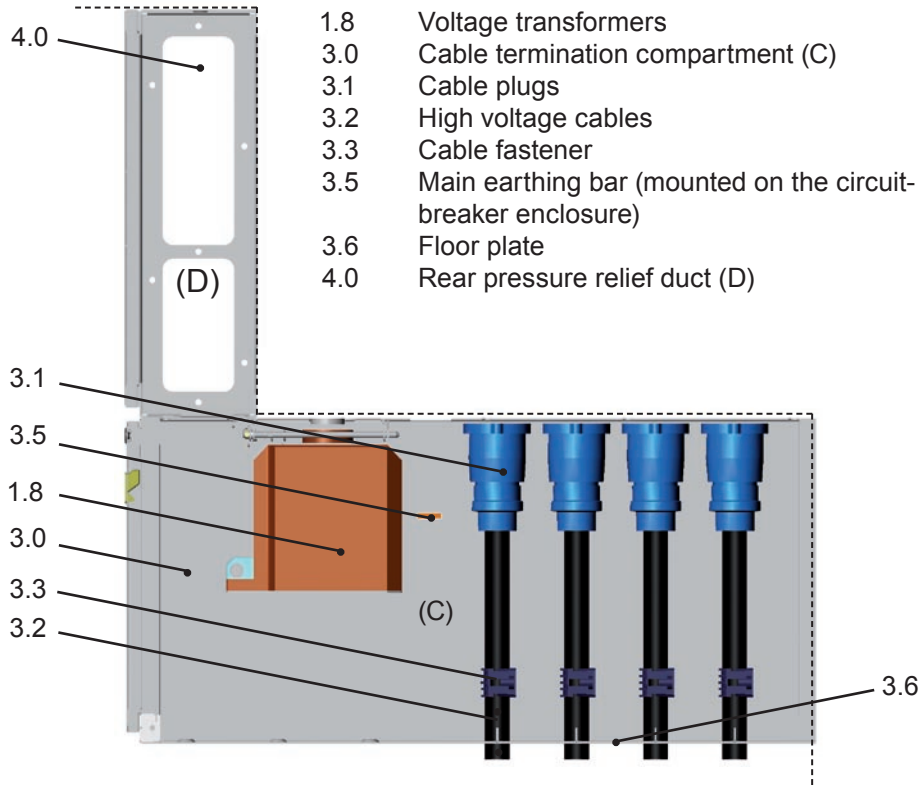


Fig. 5.9: Cable termination compartment (C) and rear pressure relief duct (D)

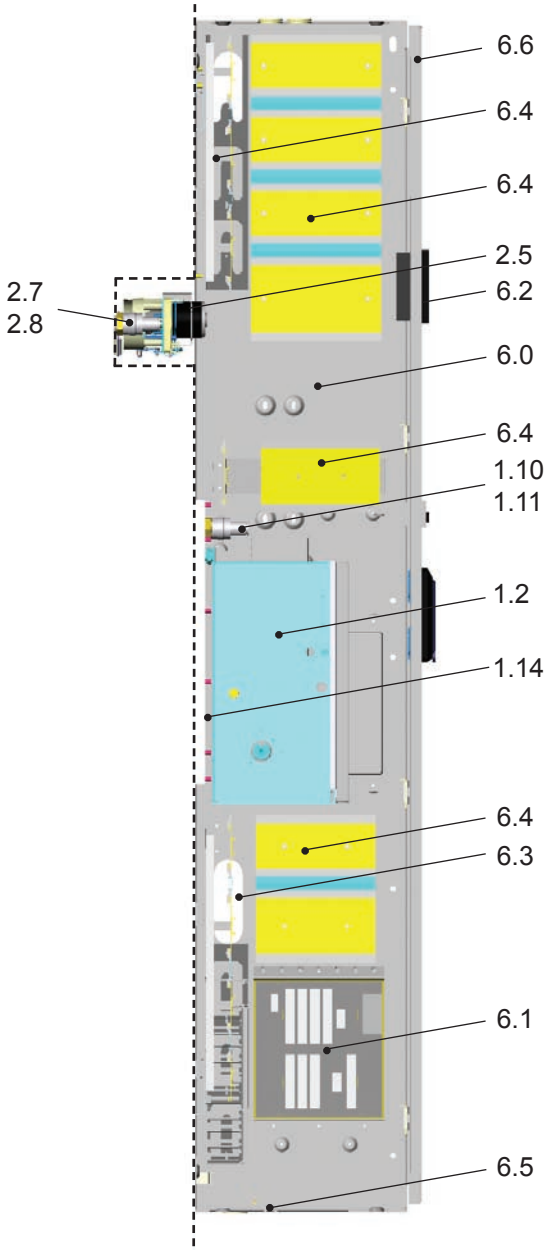
The pressure relief system for the busbar-compartment (E)

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 and 2.7), protection devices and further secondary devices and their wiring are located in the low voltage compartment (fig. 5.7). When the multifunctional protection and control unit REF 542plus is used, the depth of the low voltage compartment is 400 mm. A 100 mm deeper low voltage compartment, for example for use in connection with conventional control systems with separate protection devices, is available.

The entry for external secondary cables (5.5) is located in the base plate of the low voltage compartment.



1.2	Operating mechanism for the circuit-breaker
1.10	Sensors for gas density monitoring for Circuit-breaker compartment
1.11	Filling valve for circuit-breaker compartment
1.14	Mounting plate for circuit-breaker
2.5	Three position disconnector mechanism
2.7	Gas density sensor for front busbar compartment
2.8	Filling valve for front 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

Fig. 5.10: Low voltage compartment (F)

6. Components

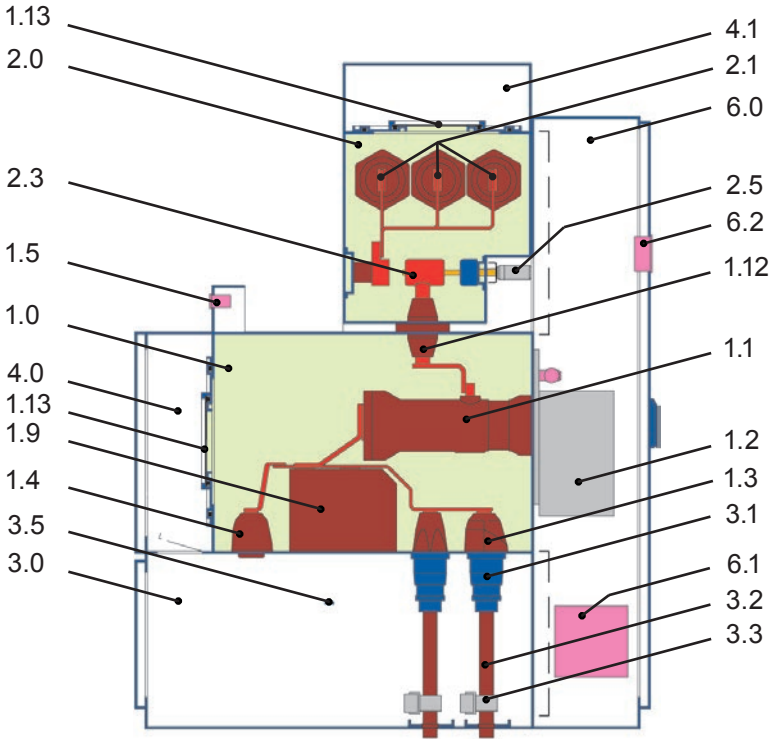


Fig. 6.1: Feeder Panel 1250 A, Single busbar

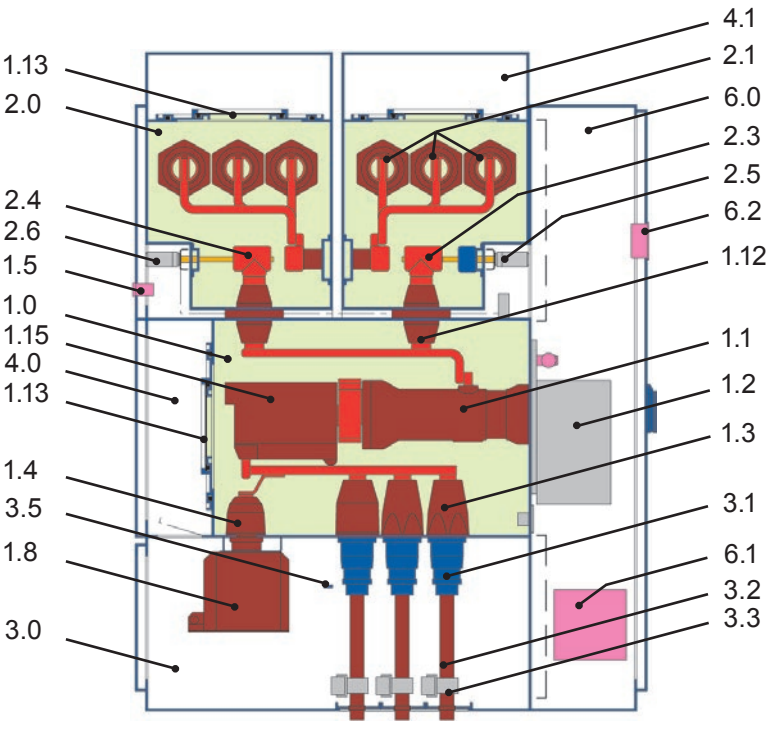


Fig. 6.2: Feeder Panel 2000 A, Double busbar

1.0 Circuit-breaker compartment
1.1 Circuit-breaker pole
1.2 Circuit-breaker operating mechanism
1.3 Cable socket
1.4 Test socket (also for use with other plug-in devices)
1.5 Capacitive voltage indicator system
1.8 Voltage transformer
1.9 Block-type transformer or sensor
1.12 Bushing, circuit-breaker/busbar compartment
1.13 Pressure relief disk
1.15 Current transformer

2.0 Busbar compartment
2.1 Busbar system
2.3 Three position disconnector
2.4 Disconnector
2.5 Three position disconnector mechanism
2.6 Disconnector mechanism

3.0 Cable termination compartment
3.1 Cable plug
3.2 High voltage cable
3.3 Cable fastener
3.5 Main earthing bar

4.0 Pressure relief duct, rear (for circuit-breaker compartment and cable termination compartment)
4.1 Pressure relief duct, top (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

Insulating gas SF_6

6.1 Vacuum circuit-breaker, type VD4X

The fixed mounted vacuum circuit-breakers (fig. 6.1.1) 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. 6.1.2) 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.

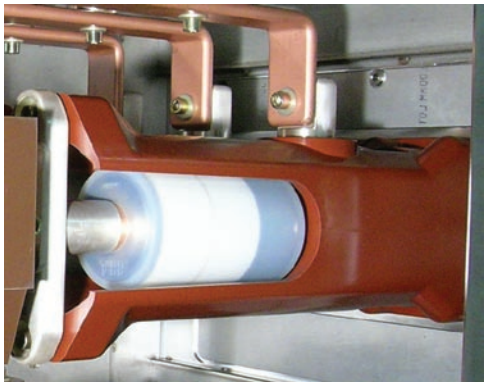


Fig.. 6.1.1: Vacuum circuit-breaker

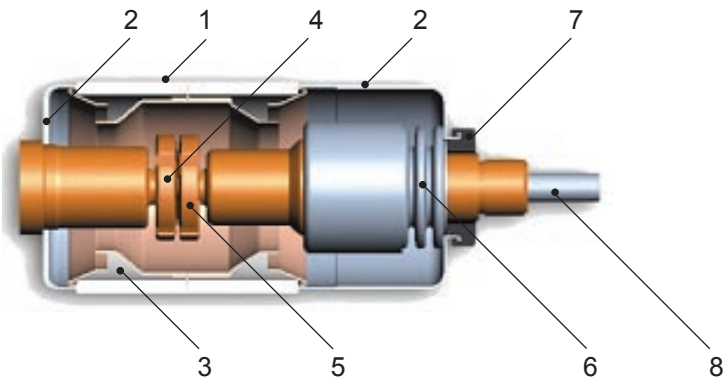


Fig. 6.1.2: Vacuum interrupter

Pole parts

The interrupter (1) inside the pole part is embedded in cast resin or located in a cast resin pole tube (2). With the breaker closed, the current flows from breaker terminal (3) to the fixed contact in the vacuum interrupter, and from there via the moving contact to breaker terminal (4). The operating motions are effected by insulated actuating rods (5).

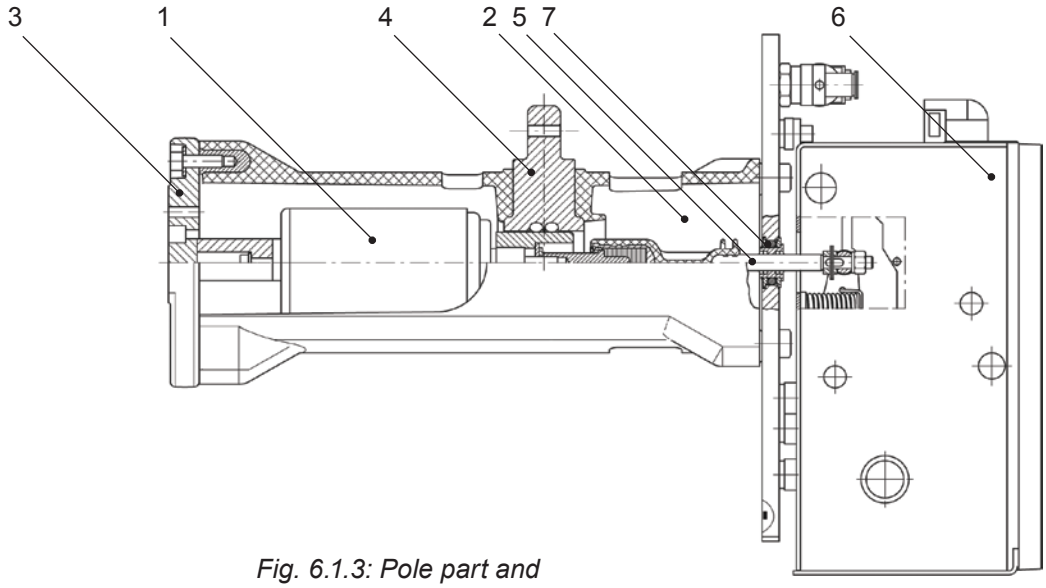


Fig. 6.1.3: Pole part and operating mechanism

Circuit-breaker operating mechanism

The circuit-breaker operating mechanism (fig. 6.1.3, item 6) is connected to the pole parts via gas-tight thrust bushings (7).

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 pushbuttons 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.

The front of the operating mechanism (fig. 6.1.4) 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).

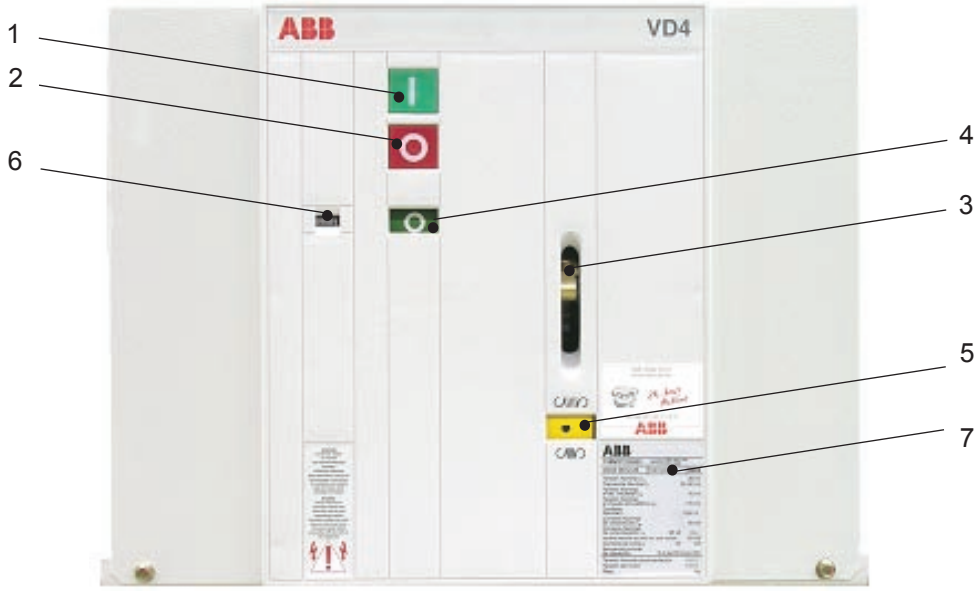


Fig. 6.1.4: Controls for the circuit-breaker operating mechanism

Mechanism variants

When digital secondary systems, e.g. the multifunctional protection and control unit REF 542plus, are used, sensors are used to detect the switch positions. The operating mechanism can be equipped with auxiliary switches for conventional secondary systems, or with a combination of sensors and auxiliary switches. The various options for secondary equipment in the mechanism variants can be found in table 6.1.1.

			Protection and control concepts					
			Protection and control unit REF 54x		Protection and control unit REF 54x + additional functions		Separate protection + conventional control	
			Standard	Option	Standard	Option	Standard	Option
-MS	(-M0)	Charging motor for spring mechanism	•		•		•	
-BS1	(-B0S)	Sensor “Stored-energy spring charged”	•					
-BS1	(-S1)	Auxiliary switch “Spring charged”			•		•	
-MO1	(-Y2)	Shunt release OFF	•		•		•	
-MC	(-Y3)	Shunt release ON	•		•		•	
-BB1	(-B0A)	Sensor “Circuit-breaker OFF”	•		•			
-BB2	(-B0E)	Sensor “Circuit-breaker ON”	•		•			
-BB3	(-S3)	Auxiliary switch “CB ON/OFF”			•		•	
-BB6	(-S4)	Auxiliary switch “CB ON/OFF”			•		•	
-BB7	(-S5)	Auxiliary switch “CB ON/OFF”				•	•	
-KN	(-K0)	Antipumping relay					•	
-RL1	(-Y1)	Blocking magnet “CB ON”		•		•	•	
-BL1	(-S2)	Auxiliary switch for blocking magnet		•		•	•	
-BB4	(-BB4)	Auxiliary switch for fault signal (impulse time 35 ms)					•	
-MU [1)]	(-Y4)[1)]	Undervoltage release		•		•		•
-MO3 [1)]	(-Y7)[1)]	Indirect overcurrent release		•		•		•
-MO2	(-Y9)	2nd shunt release OFF		•		•		•

Table 6.1.1: Secondary equipment options for the circuit-breaker operating mechanism variants

[1)] Combination of –MU with –MO3 is not possible.

6.2 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. 6.2.1) has its disconnected position in the central position. In the disconnector ON and earthing switch ON limit positions, the moving contact (sliding part) (2) driven by an insulating spindle (1) reaches the fixed contacts (disconnector contact (3) or earthing contact (4)) which are fitted with one or two spiral contacts.

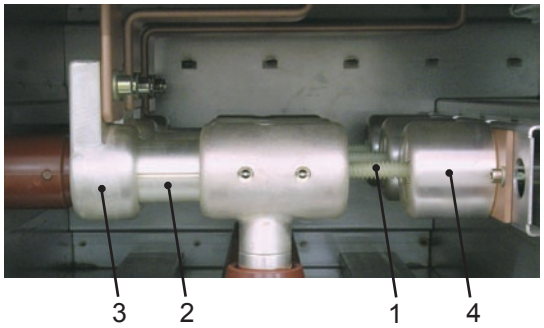


Fig. 6.2.1: Three position disconnector in disconnector ON position

Series connected reed contacts (= switches operated by permanent magnets) detect the correct positions of the three contacts in the earthing switch ON position (Figs. 6.2.2 and 6.2.3).

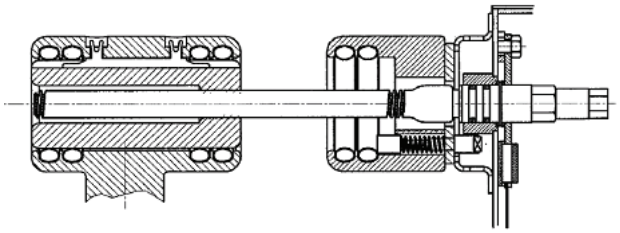


Fig. 6.2.2: Three position disconnector in the central position

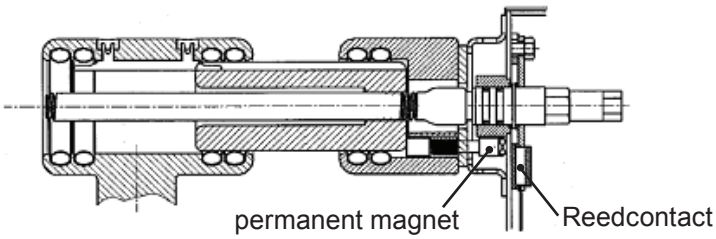


Fig. 6.2.3: Three position disconnector in the earthing switch ON position (reed contact switched on by permanent magnet)

Three position disconnector operating mechanism

The operating mechanism block for the three position disconnector consists of the following functional groups (figs. 6.2.4 to 6.2.7):

- Drive motor (1)
- Position detection with position sensors (2) or auxiliary switches (3)
- Integrated LED for position indication when sensors are used
- Mechanical position indicator (4)
- Hand crank receptacle for emergency manual operation (5)
- Mechanical access interlock for emergency manual operation (6) when the circuit-breaker is closed (optional with position sensors)

The various options for secondary equipment in the mechanism variants can be found in table 6.2.1.

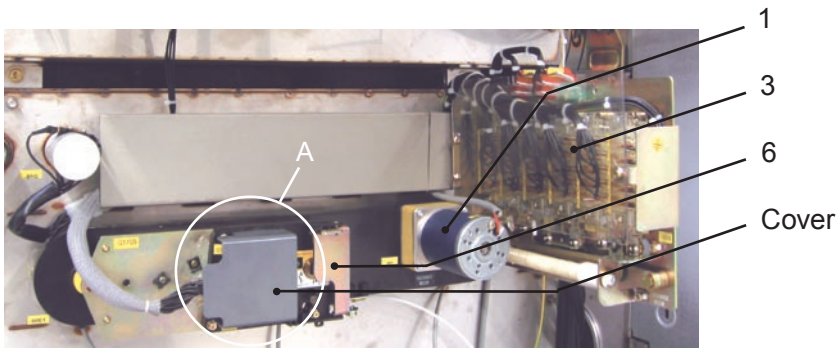


Fig. 6.2.4: Three position disconnector mechanism with auxiliary switches (3) and mechanical access interlock for emergency manual operation (6)

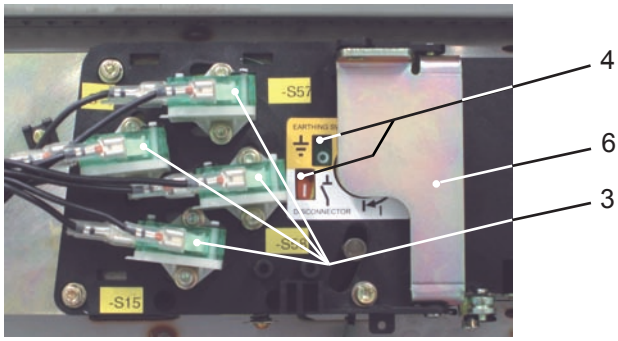


Fig. 6.2.5: (Detail A in fig. 6.2.4 – without cover) Auxiliary switches for switch position detection (3) and mechanical access interlock (closed) for emergency manual operation (6)

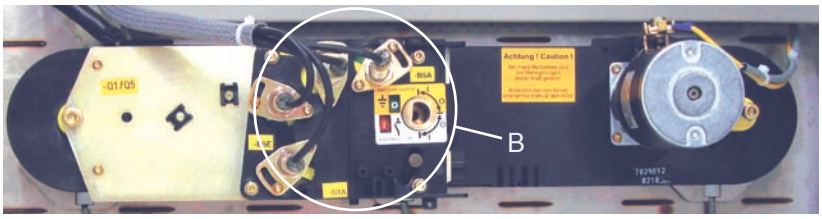


Fig. 6.2.6: Three position disconnector mechanism with sensors for switch position detection

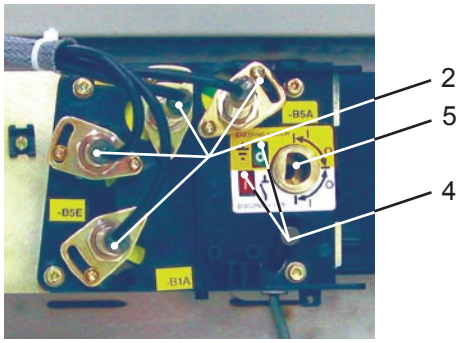


Fig. 6.2.7: (Detail B in fig. 6.2.6) Sensors (2) for switch position detection (Optional with auxiliary switches (3 in fig. 6.2.4) and access interlock for emergency manual operation (6 in fig. 6.2.5))

			Protection and control concepts					
			Protection and control unit REF 54x		Protection and control unit REF 54x + add. functions		Separate protection + conventional control	
			Standard	Option	Standard	Option	Standard	
-MI	(-M1)	Drive motor	•		•		•	
-BI1	(-B1A)	Sensor to detect switch position “Disconnector OFF”	•		•			
-BI2	(-B1E)	Sensor to detect switch position “Disconnector ON”	•		•			
-BE8	(-B5A)	Sensor to detect switch position “Earthing switch OFF”	•		•			
-BE9	(-B5E)	Sensor to detect switch position “Earthing switch ON”	•		•			
-BI1	(-S15)	Microswitch to detect switch position “Disconnector OFF”					•	
-BI2	(-S16)	Microswitch to detect switch position “Disconnector ON”					•	
-BE8	(-S57)	Microswitch to detect switch position “Earthing switch OFF”					•	
-BE9	(-S58)	Microswitch to detect switch position “Earthing switch ON”					•	
-BI1	(-S11)	Auxiliary switch “Disconnector OFF”			•		•	
-BI2	(-S12)	Auxiliary switch “Disconnector ON”			•		•	
-BE1	(-S51)	Auxiliary switch “Earthing switch OFF”			•		•	
-BE2	(-S52)	Auxiliary switch “Earthing switch ON”			•		•	
-BE5/6/7	(-B5E1,2,3)	Reed contacts to detect the “Earthing switch ON” switch position	•		•		•	
-BL1, -BL2	(-S151), (-S152)	Microswitch for (optional) access blocking of hand crank receptacle for emergency manual operation		•		•	•	

Table 6.2.1: Secondary equipment options for the three position disconnector operating mechanism variants in a feeder panel

6.3 Disconnector

Except for the lack of an earthing contact the design of the disconnector is the same as that of the three position disconnector. Accordingly the two switch positions are “connect” and “disconnect”.

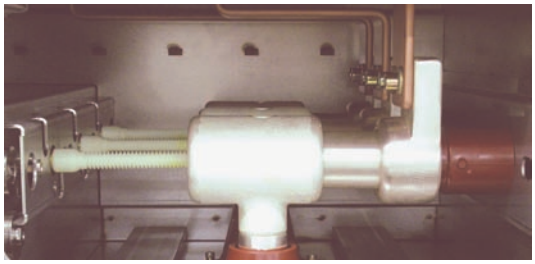


Fig. 6.3.1: Disconnector in ON position

The two-part operating mechanism of the disconnector consists of the following functional groups (figs. 6.3.2 to 6.3.5):

- Drive motor (1)
- Position detection with position sensors (2) or auxiliary switches
- Integrated LED for position indication when sensors are used
- Mechanical position indicator (4)
- Hand crank receptacle for emergency manual operation (5)
- Mechanical access interlock for emergency manual operation (6) when the circuit-breaker is closed (optional with position sensors)

The various options for secondary equipment in the mechanism variants can be found in table 6.3.1.

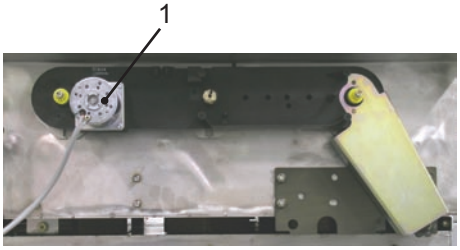


Fig. 6.3.2: Rear part of the disconnector operating mechanism with motor (1) on the back of the panel

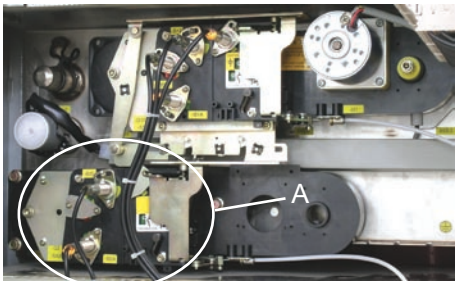


Fig. 6.3.3: Front part of the disconnector operating mechanism in the low voltage compartment. The operating mechanism of the three position disconnector is located above the disconnector operating mechanism.

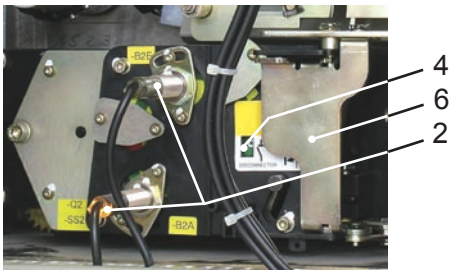


Fig. 6.3.4: (Detail A in fig. 6.3.3) Sensors (2) for switch position detection (Optional with auxiliary switches) and access interlock (6) for emergency manual operation

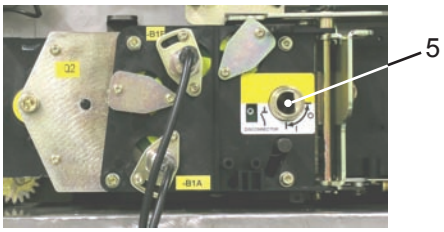


Fig. 6.3.5: Mechanical access interlock for emergency manual operation (5)

			Protection and control concepts					
			Protection and control unit REF 54x		Protection and control unit REF 54x + add. unctions		Separate protection + conventional control	
			Standard	Option	Standard	Option	Standard	
-MI	(-M1)	Drive motor	•		•		•	
-BI1	(-B1A)	Sensor to detect switch position “Disconnector OFF”	•		•			
-BI2	(-B1E)	Sensor to detect switch position “Disconnector ON”	•		•			
-BI1	(-S15)	Microswitch to detect switch position “Disconnector OFF”					•	
-BI2	(-S16)	Microswitch to detect switch position “Disconnector ON”					•	
-BI3	(-S11)	Auxiliary switch “Disconnector OFF”			•		•	
-BI4	(-S12)	Auxiliary switch “Disconnector ON”			•		•	
-BL41, -BL42	(-S151), (-S152)	Microswitch for (optional) access blocking of hand crank receptacle for emergency manual operation		•		•	•	

Table 6.3.1: Secondary equipment options for the disconnector operating mechanism variants in a feeder panel

6.4 Busbar

The busbars, located in the gas compartment of the panels, are connected together by plug-in busbar connectors (figs. 6.4.1 to 6.4.3). 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) 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, see page 56 and 63).

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.

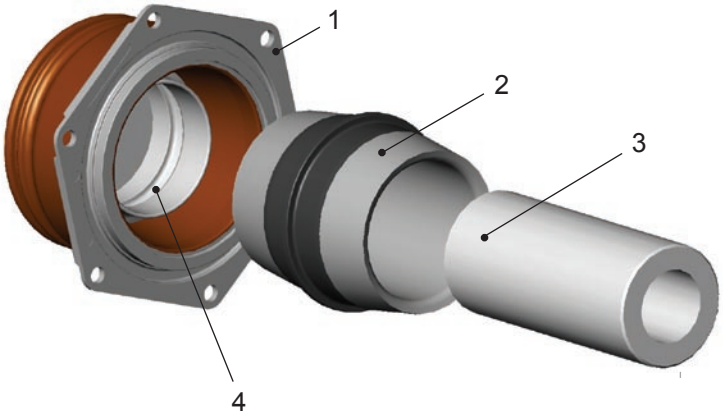


Fig. 6.4.1: Busbar socket (1) with insulating part (2), contact tube (3) and spiral contacts (4)

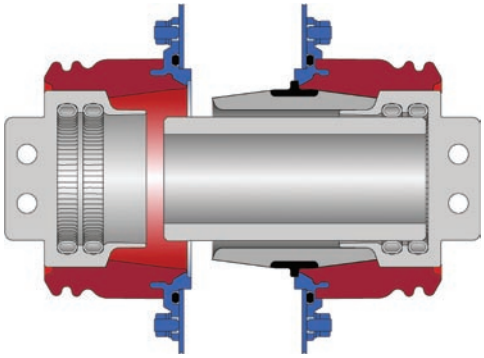


Fig. 6.4.2: Busbar connection, plugged in at one end

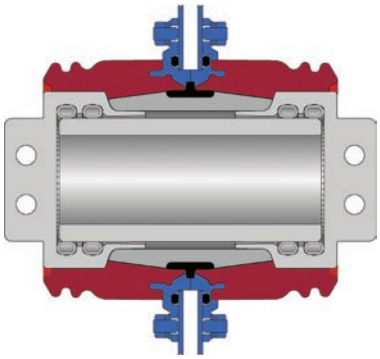


Fig. 6.4.3: Busbar connection between the panels

End panels

End panels are available in versions which permit extension. In these versions, the busbar sockets are dielectrically sealed off with blanking plugs. If extension is definitely not necessary, busbar end insulators (fig. 6.4.4) 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. 6.4.5).

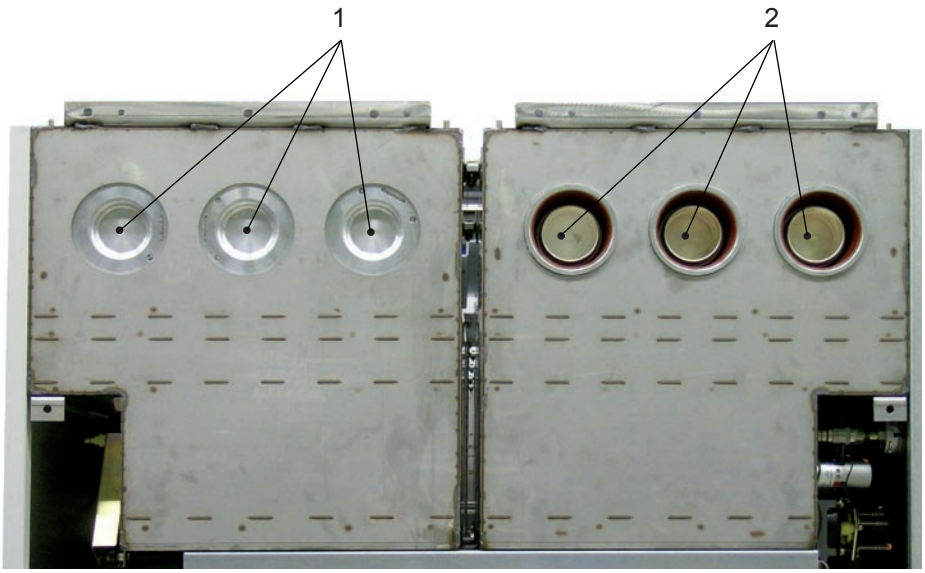


Fig. 6.4.4: Busbar enclosures with busbar end insulators (1) and busbar sockets (2)

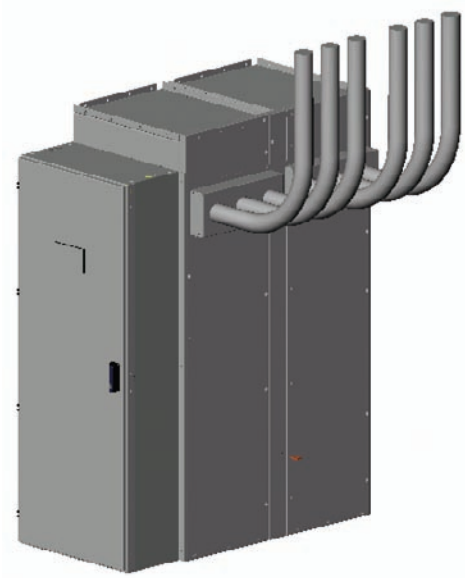


Fig. 6.4.5: Direct connection of fully insulated bars to the busbar

6.5 Inner cone termination system

Inner cone sockets to EN 50181 (size 2 or size 3) fitted in a gas-tight manner in the floor plate of the circuit-breaker compartment facilitate plug-in connection of cables, fully insulated bars or surge arresters.

The inner cone termination system is above all notable for its total insulation and the associated protection against accidental contact.

6.5.1 Connection of cables

An overview of the cross-sections of the cables to be connected is presented in table 6.5.1.1. 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.
Up to four cables per phase can be used, depending on the panel design.

Rated voltage [kV]	Plug size	Cable cross-section [mm²]
12	2	95 - 300
	3	240 - 630
24	2	50 - 300
	3	150 - 630
36	2	50 - 240
	3	95 - 630

Table 6.5.1.1: Assignment of cable cross-sections

6.5.2 Connection of fully insulated bars

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

Fig. 6.5.1: View into the gas-insulated circuit-breaker compartment with inner cone sockets

Fig. 6.5.1.1: View into the cable termination compartment in air with cable plugs and cables

Fig. 6.5.2.1: Connection of a fully insulated bar using plug size 3

6.5.3 Connection of surge arresters

Connection of plug-in surge arresters (fig. 6.8.6, Page 39) of sizes 2 (12- 36 kV) is possible (fig. 6.5.3.1).

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.

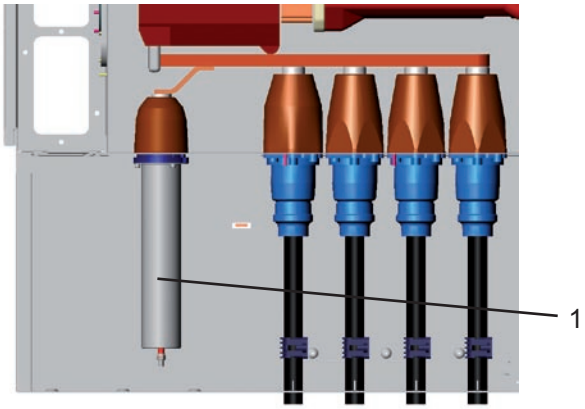


Fig. 6.5.3.1: Connection of surge arresters (1)

6.6 Outer cone termination system

Outer cone termination systems are used only in 2 x 400 mm double feeder panels.

Cable plug systems protected against accidental contact must be used. A selection of suitable plug types is given in Table 6.6.1.

Manufacturer	Cable plug type	
	one cable	two cables
Euromold	K 440 TB	-
NKT	CB	CB
Südkabel GmbH	SEHDT 23 SEHDT 23.1	SEHDT 23.1 -

Table 6.6.1: Selection of suitable plug types

6.7 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. It is recommended to connect the main earthing bar of the switchgear system to the main station earth as often as possible (at the first and last panel of the switchgear installation and at every second or third panel in between).

The cross-section of the main earth bar is 400 mm^2 (ECuF30 40 mm x 10 mm).

6.8 Test sockets

Outgoing cable panels and cable termination panels are equipped with test sockets (figs. 6.8.1 and 6.8.2). The test sockets are accessible in the cable termination compartment, and are used to accommodate surge arresters (fig. 6.8.6), for cable tests, for insulation testing of the panels, for testing of the protection systems by primary current injection and for maintenance earthing of the relevant outgoing feeder panel. Suitable testing and earthing sets are available for these purposes (figs. 6.8.3 to 6.8.5).

When sensors are used, these sensors contain the test sockets.
The test sockets must be closed off with blanking plugs of high dielectric strength during normal operation of the panel.

Fig. 6.8.1: View into the circuit-breaker compartment: test sockets

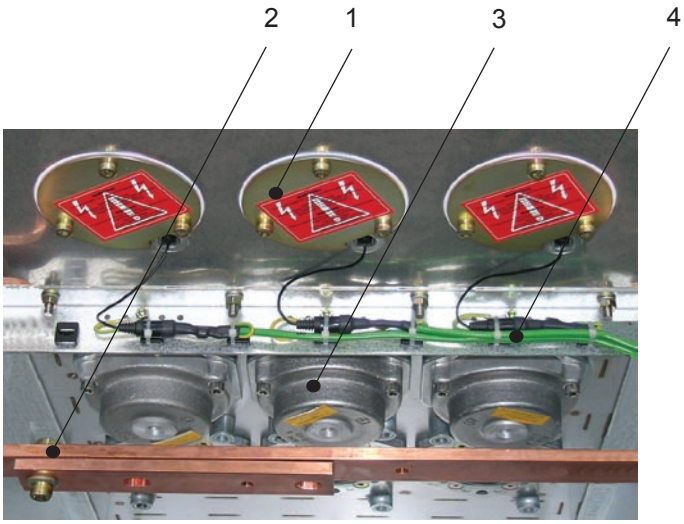


Fig. 6.8.2: View from the rear into the cable termination compartment: Test sockets (1) – access blocked by insulating blanking plugs; main earthing bar (transport condition) (2); cable blanking plug (3) for unused cable sockets, and wiring for capacitive indicator unit (4).

Fig. 6.8.3: Current test plug

Fig. 6.8.4: Voltage test plug

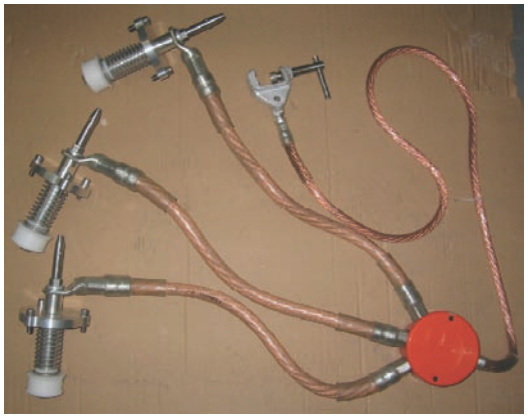


Fig. 6.8.5: Earthing set

Fig. 6.8.6: Surge arrester

6.9 Capacitive voltage indicator systems

Various capacitive, low impedance voltage indicator systems are available for checking of the off-circuit condition of a feeder. The high voltage capacitor 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.

All systems used comply with IEC 61243-5.

LRM-system (Fig. 6.9.1)

- Additional indicator unit (fig. 6.9.2) required
- Repeat testing necessary

KVDS-system (Fig. 6.9.3)

- LC-display
- Three phase
- No additional indicator unit required
- Maintenance-free with integrated self-test:
  - No symbol visible: De-energised
  - Half lightning arrow displayed: Voltage applied
  - Full lightning arrow displayed: Voltage applied and self-test passed

Fig. 6.9.1: Three phase LRM system

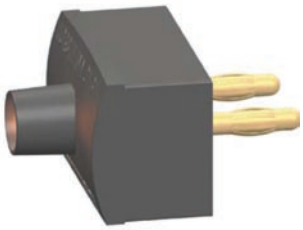


Fig. 6.9.2: Indicator unit for LRM systems

Fig. 6.9.3: KVDS-system

CAVIN-system (Fig. 6.9.4)

As the KVDS system, but:

- Two integrated relay contacts for signals/interlocks
- LED display of relay status:
  - No Error: Relay 1 closed (All three conductors have the same voltage state and auxiliary voltage is available.)
  - Error: Relay 1 open (The three conductors are carrying different voltages, or the auxiliary voltage has failed.)
  - HV OFF: Relay 2 closed (UL1 = UL2 = UL3 < phase to earth voltage when the response voltage is reached.)
  - HV ON: Relay 2 open (In at least one phase, U / √3 > phase to earth voltage when the response voltage is reached, or auxiliary voltage has failed.)
- Auxiliary voltage required for the relays

Fig. 6.9.4: CAVIN-system

System	Technical characteristics		Installation point: panel rear	Installation point: panel door	Additional indicator unit required	LC-display	Integrated self-test	Two relay contacts	Auxiliary voltage required for relays
LRM	Three phase	Low impedance	Standard	Option	•				
KVDS			Option	Option		•	•		
CAVIN			-	Option		•	•	•	•

Table 6.9.1: Scope of function of the capacitive voltage indicator systems

6.10 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.

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.

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.

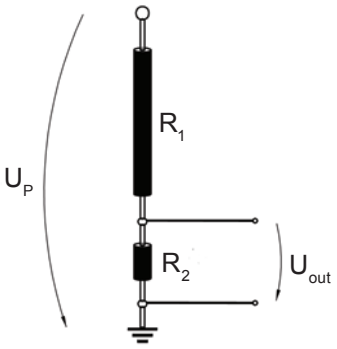


Fig. 6.10.1: Principle of the voltage sensor

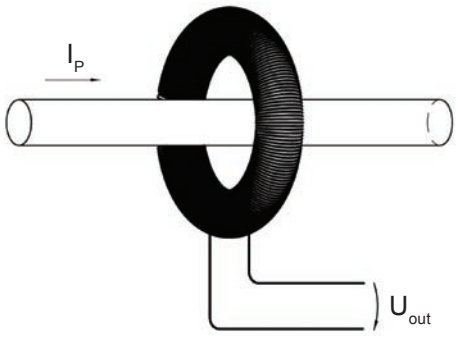


Fig. 6.10.2: Principle of the current sensor

Advantages of sensor technology

- Usable for protection and metering
- Size: Sensors are significantly smaller than inductive instrument transformers
- Large dynamic range (amplitude and frequency bandwidth)
- Sensors are insensitive to ferro-resonance and DC voltage components
- The output signal transmitted is a low-level signal – even at maximum short-circuit currents and voltag
- Short-circuit proof
- Versatile in service
- AC and DC test voltage proof components
- High reliability and availability
- No hazard from exposed terminals
- Lower temperature rise

The following current and voltage detection devices can be used (see fig. 6.10.3):

- Device A: Block-type transformer, block-type sensor or combined block-type transformer/sensor in the circuit-breaker compartment
- Device B: Current transformer in the circuit breaker compartment
- Device C: Current sensor in the circuit breaker compartment
- Device D: Ring core transformer for earth fault detection below the panel (in the cable basement)
- Device E: Optional bushing.type current transformer between the three position disconnector and circuit-breaker in a sectionaliser and riser panel
- Device F: Voltage transformer (outside the gas compartment only, plug-in type)

Conventional current and voltage transformers are certifiable.

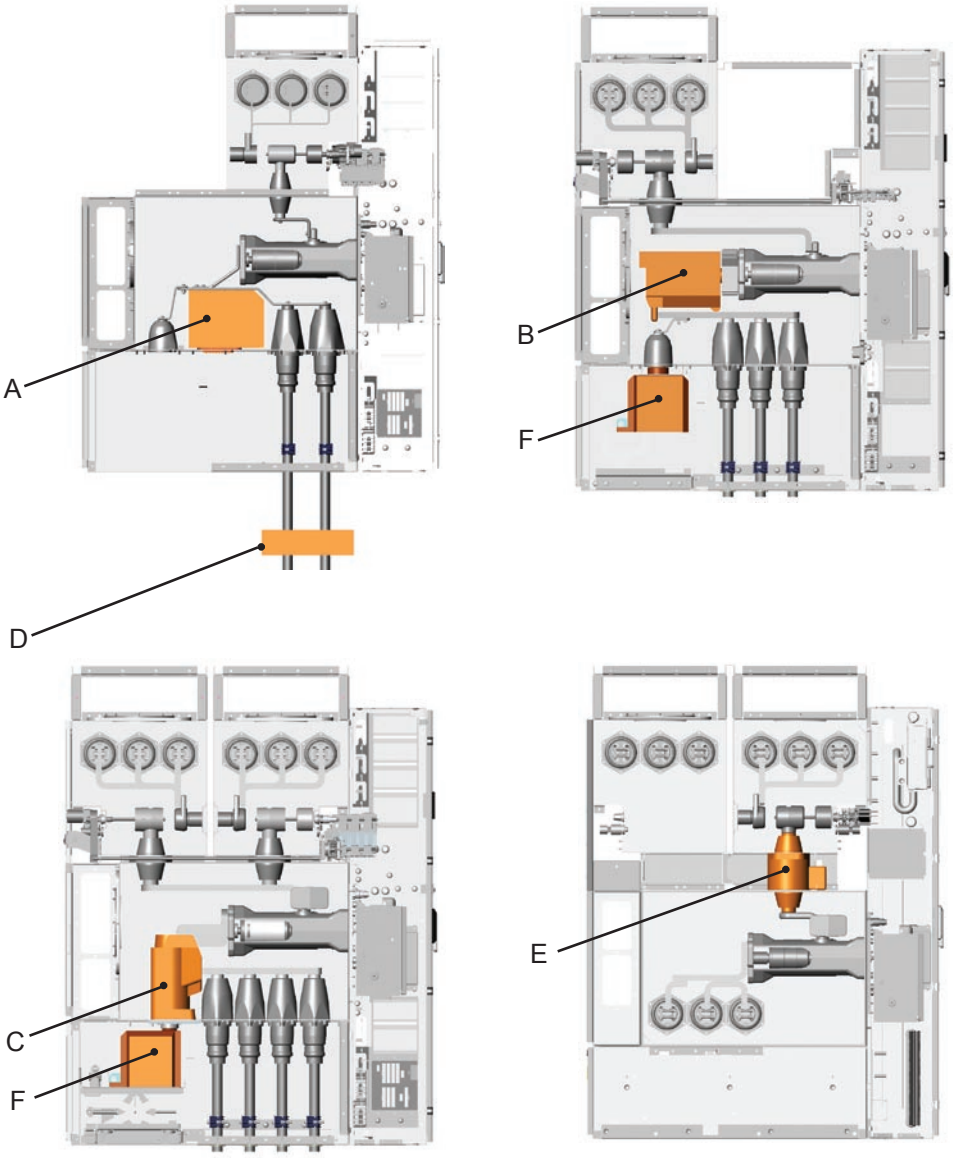


Fig. 6.10.3: Current and voltage detection devices

		Protection and control concept		
Device	Contents	Protection and control unit REF 54x	Protection and control unit REF 54x + additional functions [1)]	Third party protection devices + conventional control units
A	Current sensor	•		
	Current sensor + current transformer core		•	
	Several current transformer cores		•	•
	Current sensor + voltage sensor	•		
	Current sensor + current transformer core + voltage sensor		•	
B	Current transformer	•	•	•
C	Current sensor	•		
D	Current transformer	•	•	•
E	Current transformer		•	•
F	Voltage transformer	•	•	•

Table 6.10.1: Use of current and voltage detection devices with various protection and control concepts (see also section 4, page 15)

[1)] The additional functions are, for example:

- Billing metering
- Transient earth fault
- Differential protection
- Backup protection

6.10.1 Block-type transformers and block-type sensors

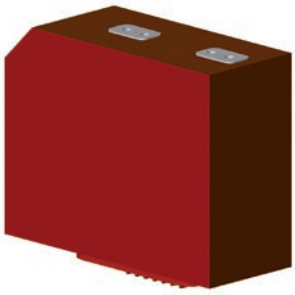


Fig. 6.10.1.1: Block-type transformer or block-type sensor, device A

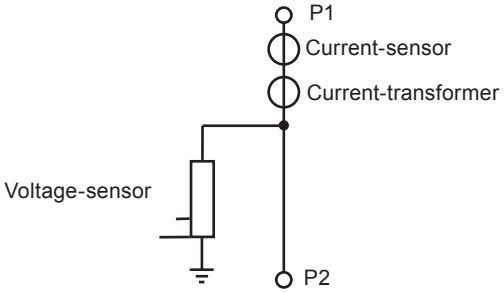


Fig. 6.10.1.2: Circuit diagram of the block-type transformer/sensor (example)

The block-type instrument transformer or block-type sensor is used in outgoing feeder panels for rated currents up to 1250 A [1)] and in various bus tie panels for rated currents up to 2500 A.

The block-type transformer or block-type sensor 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 lead-sealable. The possible combinations of current sensors, current transformers and voltage sensors can be seen in table 6.10.1 (Page 43).

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. 6.10.1.3). The current sensor for rated currents up to 2500 A has one tap (see fig. 6.10.1.4). 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. 6.10.1.3). The measurement accuracy is better than 1%.

Current transformer

When only current transformers are used, the device can contain up to 3 current transformer cores in a 600 mm wide panel and up to 5 current transformer cores in an 800 mm wide panel.

[1)] > 1250 A see section 6.10.2 Current transformer and 6.10.3 Current sensor

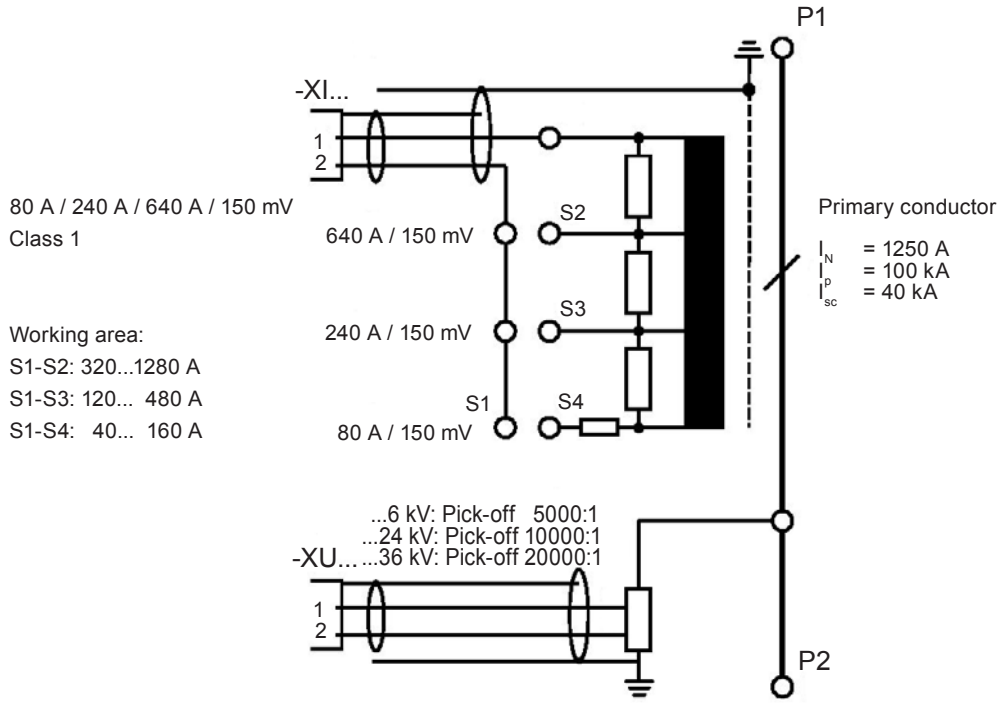


Fig. 6.10.1.3: Circuit diagram of the block-type transformer or block-type sensor, example with current and voltage sensor, 1250 A

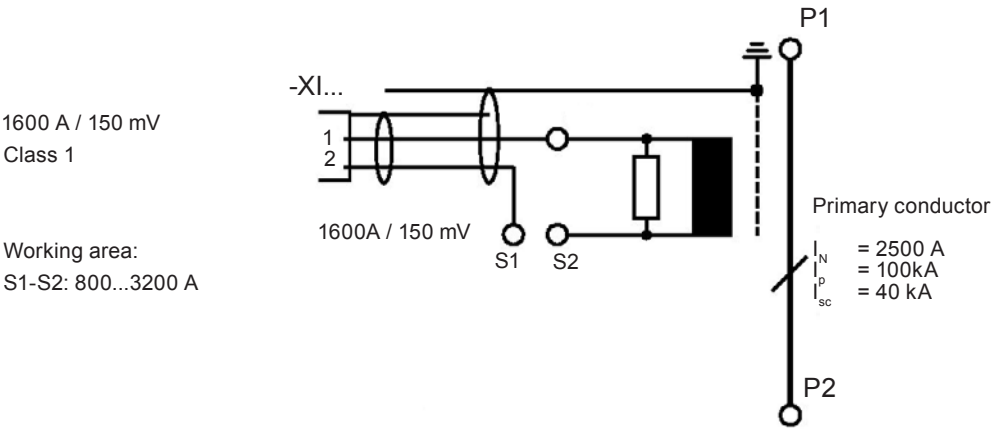


Fig. 6.10.1.4: Circuit diagram of the current sensor, 2500 A

6.10.2 Current transformers

When only current transformer cores are used, with outgoing feeder currents > 1250 A, the current transformers used are as shown in fig. 6.10.2.1.
Depending on the primary current, up to 5 cores can be accommodated in a single current transformer.
The secondary wiring of the current transformer is routed out of the gas compartment into the low voltage compartment via secondary bushings below the circuit-breaker. The cross-section of the connecting wires is 2.5 mm² (larger cross-sections on request).

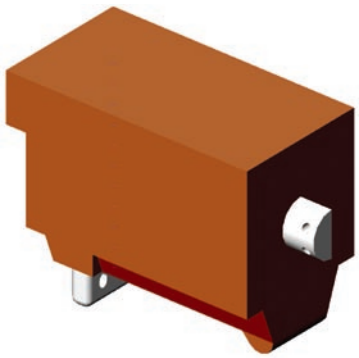


Fig. 6.10.2.1: Current transformer, device B

6.10.3 Current sensors

When a sensor is used and with outgoing feeder currents > 1250 A, the devices used are as shown in fig. 6.10.3.1.
The ratio of the current sensor is generally 1600 A / 150 mV. The current has one tap (see fig. 6.10.1.4, Page 47).The measuring accuracy is better than 1 %.

The device can contain a current transformer core in addition to the current sensor.

An integrated socket of size 2 to DIN 47637 and EN 50181 is used for test purposes or for the connection of further equipment (voltage sensors, voltage transformers or surge arresters). When not in use, the socket is to be sealed off with an insulating cover during operation.

The sensor has embedded connecting leads. The cross-section of the connecting leads is 2.5 mm² (larger cross-sections on request).

Fig. 6.10.3.1: Current sensor, device C

6.10.4 Earth fault transformers

Earth fault transformers (device D) 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.

6.10.5 Dimensioning of current transformer cores

Dimensioning of current transformer cores is order-related, taking the following factors into account:

- Application (protection, measuring or billing metering)
- Primary and secondary variables (rated, short-circuit and secondary current)
- Accuracy and transmission behaviour
- Transformer capacity

Rated voltage	U_r	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. 40 kA - 3 s	
Rated impulse current	I_p	kA	100	

Table 6.10.5.1: Technical data of the current transformers (primary data)

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

Table 6.10.5.2: Core data

[1] 60 Hz on request
[2] dependent on rated primary current

6.10.6 Voltage transformer

The voltage transformers are always located outside the gas compartments. They are of the plug-in type (plug size 2 to EN 50181 and DIN 47637). The voltage transformers can be dismantled for test purposes.

In metering panels isolating systems in combination with an earthing function are connected in series with the voltage transformer sockets.

The panel widths required for various rated voltages and the electrical data can be found in table 6.10.6.1.

Voltage transformers in feeders with a width of 600 mm are applicable for a power frequency withstand voltage up to 70 kV and a lightning impulse withstand voltage up to 170 kV.

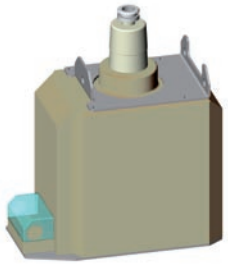


Fig. 6.10.6.1: Plug-in type voltage transformer, device F

Rated voltage [kV]	Panel width of feeder panels [1] [mm]	max. output [VA]	class	Rated thermal current limit [A]	Rated thermal long-duration current of the earth fault winding at 1.9 x U_N / 8 h [A]
12	600	15 45 100	0.2 0.5 1	4	4
	800	30 75 150	0.2 0.5 1	6	6
24	600	15 45 100	0.2 0.5 1	4	4
	800	30 75 150	0.2 0.5 1	6	6
36	600	12,5 25 50	0.2 0.5 1	4	4
	800	30 75 150	0.2 0.5 1	6	6

Table 6.10.6.1: Technical data of the voltage transformers

6.10.7 Voltage sensor

When a current sensor as shown in fig. 6.10.3.1 (Page 48) is used, the voltage at the outgoing feeder can be picked off by means of a plug-in voltage sensor as shown in fig. 6.10.7.1. The voltage sensor has a ratio of 5000:1 for operating voltages up to 6 kV, 10000:1 for up to 24 kV, and 20000:1 for 36 kV. The measuring accuracy is better than 1%.

Fig. 6.10.7.1: Plug-in type voltage sensor

[1] • Panel width of the panels with integrated busbar measurement: 800 mm
• Panel width of the metering panels: 600 mm

6.11 Protection and control units

ABB provides the right protection and automation solution for every application.
Table 6.11.1 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.

			Incomer	Feeder	Metering panel	Bay control and measurement	Capacitor bank protection	Motor protection	Generator protection	Transformer protection	Voltage regulation	I_{th} protection (see section 6.13)	Back-up protection	Feeder automation
Basic Range	SPAM 150 C							●						
	SPAJ 140 C		●	●									●	
	SPAJ 160 C						●							
	SPAU 130 C		●	●										
	SPAU 140 C		●	●										
	SPAF 140 C							●	●					
	REC 501													●
	REU 610		●	●										
	REM 610							●						
	REF 610		●	●									●	
Middle Range	SPAU 341 C										●			
	SPAD 346 C							●	●	●				
	REX 521B01		●	●										
	REX 521B02		●	●										
	REX 521M01		●	●										
	REX 521M02		●	●										
	REX 521H01		●	●										
	REX 521H02		●	●										
	REX 521H03		●	●										
	REX 521H04		●	●										
	REX 521H05		●	●						●				
	REX 521H06				●									
	REX 521H07							●						
	REX 521H08		●	●										
	REX 521H09		●	●										
	REX 521H50		●	●										
	REX 521H51							●						
High Range	REM 543	Motor						●						
		Generator						●	●					
	REM 545	Motor						●						
		Generator						●	●					
	RET 541	Control									●			
	RET 543	Basic								●	●			
	RET 545	Multi								●	●			
	REF 541	Control				●						●		
	REF 543	Basic	●	●	●	●	●	●				●	●	
	REF 545	Multi	●	●	●	●	●	●				●	●	
	REC 523													●
	REF 542plus	Basic low	●	●	●	●						●		
		Basic	●	●	●	●						●		
		Multi low	●	●	●	●						●		
		Multi	●	●	●	●	●	●				●		
		Differential				●				●		●		
		Distance	●	●	●	●	●	●		●		●	●	

Table 6.11.1: Overview of protection and control units

6.12 Sulphur hexafluoride

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

Its ununique 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.

6.13 Gas system in the panels

SF_6 is used as the insulating medium.

The gas compartments are designed as hermetically sealed 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. 6.13.1). The gas compartments of the individual panels in a row are not connected together (exception: double feeder panels, see page 56 and 63).

The service pressure in the individual gas compartments is monitored by separate density sensors (temperature-compensated pressure sensors, fig 6.13.1). 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. Operation of the panel at atmospheric pressure (≈ 100 kPa) is possible (exceptions: 1st: Rated voltage > 36 kV: 120 kPa and 2nd:double feeder panel: 110 kPa for U_r > 17.5 kV) if the SF_6 content of the insulating gas is at least 95 %.

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 REF 542plus, 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:
The panel is placed in a test chamber. The panel and the test chamber are evacuated. The gas compartments in the panel are filled with helium. In this condition, the leakage rate is determined by measurement of the helium content in the test chamber. The helium is recovered after measurement, and the gas compartments in the panel simultaneously evacuated. They are then filled with SF_6 at the rated filling pressure for insulation (130 kPa at 20 °C). This means that systems are only filled with SF_6 when they have successfully passed the leakage test.

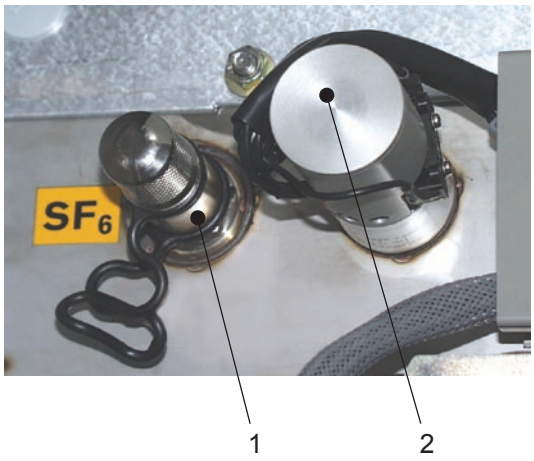


Fig. 6.13.1: Gas filling connector (1) and density sensor (2)

6.14 Pressure relief systems

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

There is an opportunity to discharge pressure via pressure relief ducts and an absorber into the switchgear room or to the outside.

Pressure relief via pressure relief ducts and absorbers into the switchroom (fig. 6.14.1)

Discharge of pressure from the circuit-breaker compartments and cable termination compartments is effected via the rear pressure relief duct, and then through a pressure relief duct designed as a broad end cover at the side of the switchgear block into the upper duct. Discharge of pressure from the busbar compartments is directed into the upper pressure relief duct. The pressure surge is cooled in the (plasma) absorber located above the upper duct and released into the switchgear room.

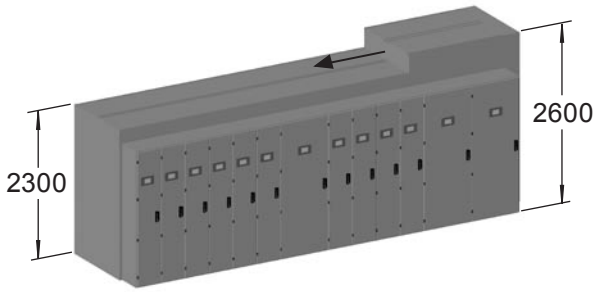


Fig. 6.14.1: Pressure relief duct (discharging into the switchroom)

Pressure relief to the outside via pressure relief ducts and absorbers (fig. 6.14.2)

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

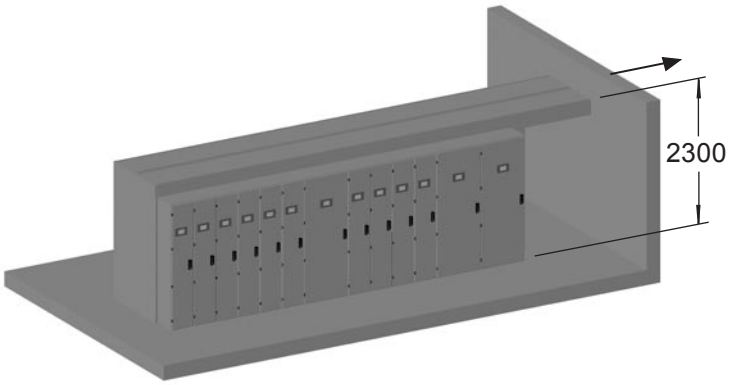


Fig. 6.14.2: Pressure relief duct (discharging to the outside)

7. Range of panels

The following panel variants are available in single and double busbar versions:

- Incoming and outgoing feeder panels
- Cable termination panels
- Sectionaliser panels
- Metering panels
- Double feeder panels
- Special panels

7.1 Panels in single busbar design

7.1.1 Feeder panels

7.1.1.1 Incoming and outgoing feeder panels

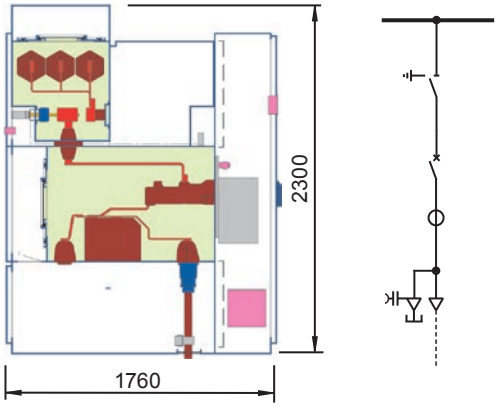


Fig. 7.1.1.1.1: Feeder panel 800 A with block-type transformer or sensor and one cable per phase

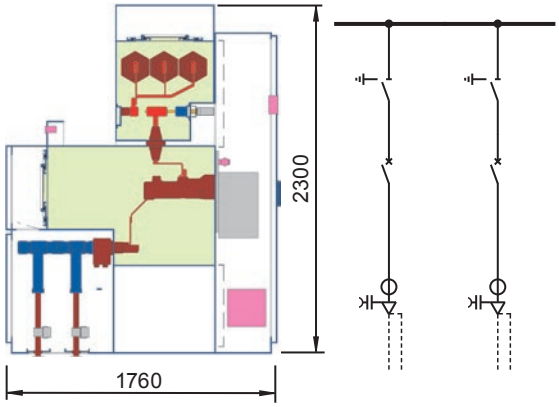


Fig. 7.1.1.1.2: Double feeder panel 24 kV, 630 A with two cables per phase (see also Page 56)

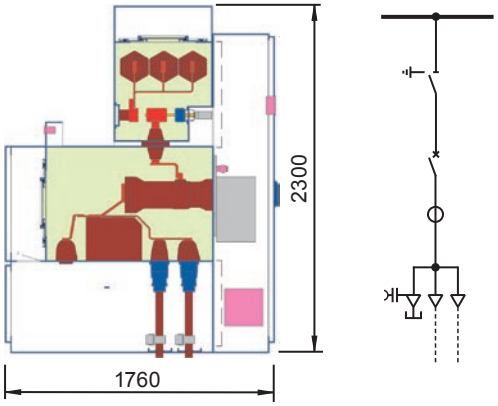


Fig. 7.1.1.1.3: Feeder panel 1250 A with block-type transformer or sensor and two cables per phase

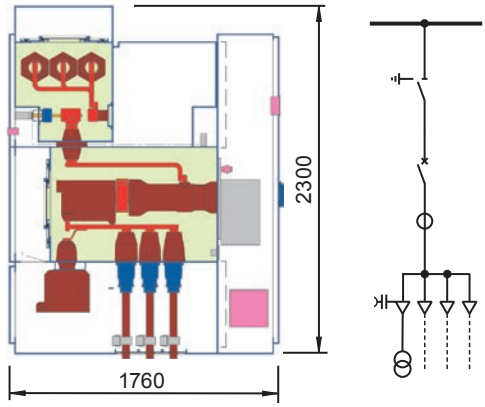


Fig. 7.1.1.1.4: Feeder panel 2000 A with current and voltage transformer and three cables per phase

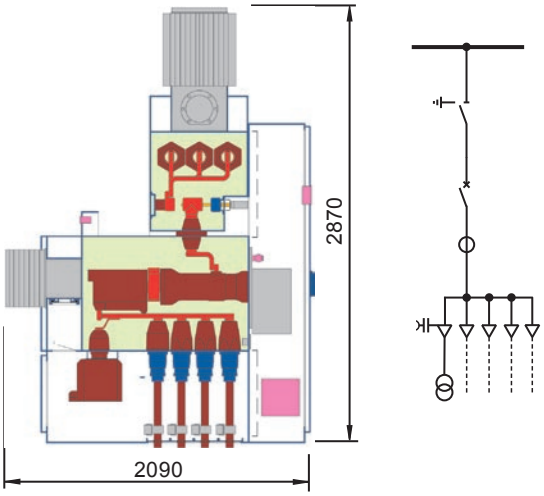


Fig. 7.1.1.1.5: Feeder panel 2500 A with current and voltage transformer and four cables per phase, cooling by heat sinks

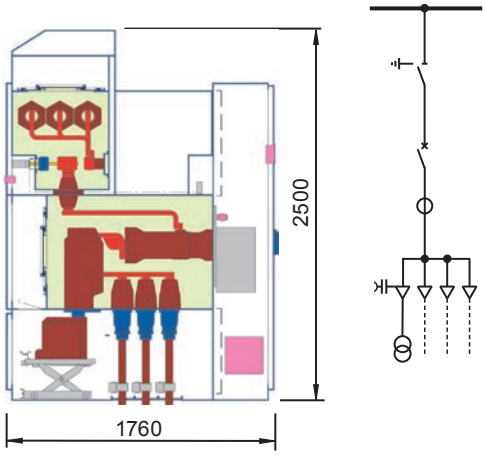
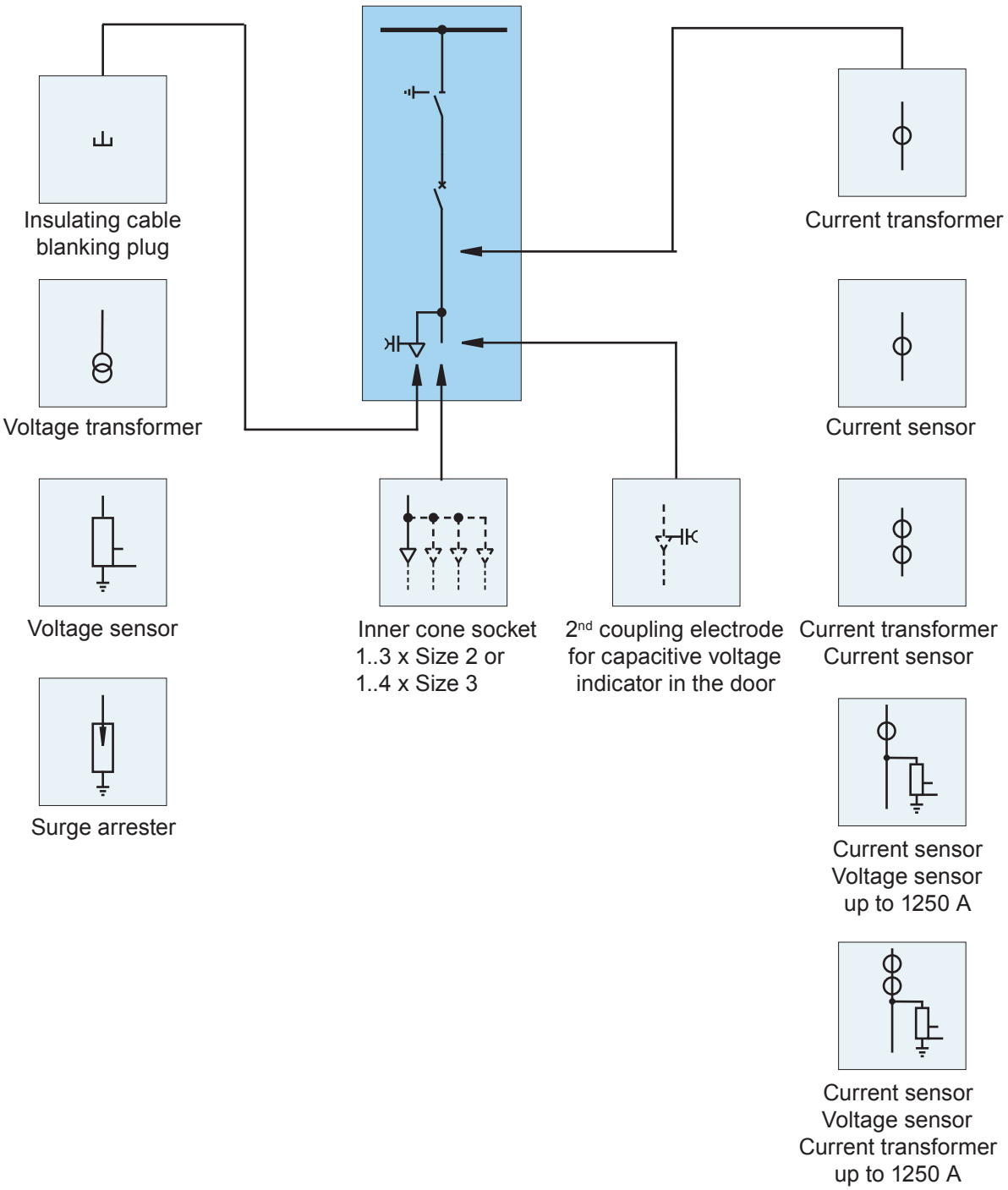


Fig. 7.1.1.1.6: Feeder panel 2500 A with current and voltage transformer and three cables (630 mm²) per phase, cooling by fan



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 800 A (1 x size 2) I_r: ... 1250 A (1 .. 3 x size 2 and 1 .. 2 x size 3) [1)] I_p: ... 31.5 kA (U_r = 36 kV) ... 40 kA (U_r = 17.5 kV)
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 800 A (1 x size 2) I_r: ... 1250 A (1 .. 2 x size 2 and 1 .. 3 x size 3) [1)] I_r: ... 2500 A (3 or 4 x size 3) I_p: ... 40 kA

Table 7.1.1.1.1: Overview of variants of incoming and outgoing feeder panels with inner cone termination system

[1)] Three sockets per phase only in conjunction with current transformers to fig. 6.10.2.1

Deviations for double feeder panels

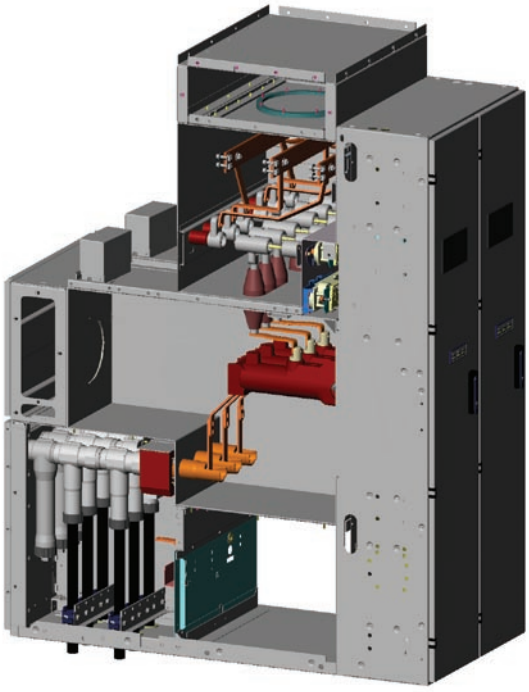
The structure of the double feeder panel deviates from that of a conventional outgoing feeder panel as described below.

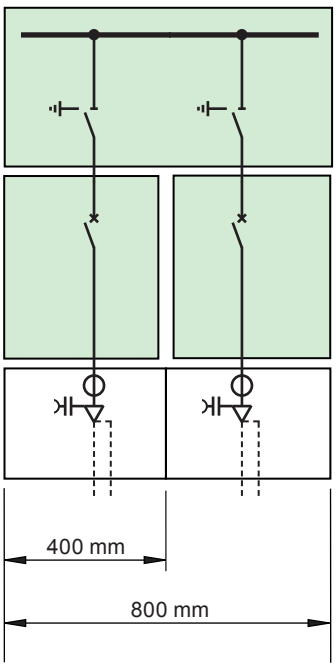
- The double panel facilitates even more compact station planning for systems up to 24 kV.
- The width (= transport width) of a double feeder panel is 800 mm, with two outgoing feeders of 400 mm width grouped together in the double panel.
- The busbar compartment for the two feeders in a double feeder 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 outer cone plug system (one or two cables per phase) to DIN 47636 is used.
- Only ring core current transformers or ring core sensors are used.
- Two separate low voltage compartment doors (width 400 mm) are fitted.
- Technical data which deviate from the conventional panel (compare section 3, page 10):

U_r:	...24 kV
I_k:	...25 kA
I_r (feeder):	...630 A
I_r (busbar):	...2500 A
p_{me} (U_r > 17.5 kV):	110 kPa

Internal arc classification according to IEC 62271-200

Classification IAC	AFLR
Internal arc	25 kA 1 s





: Insulating gas SF_6

Fig.. 7.1.1.1.7: Double feeder panel: version with busbar at the front, two cables per phase and surge arresters

7.1.1.2 Cable termination panels

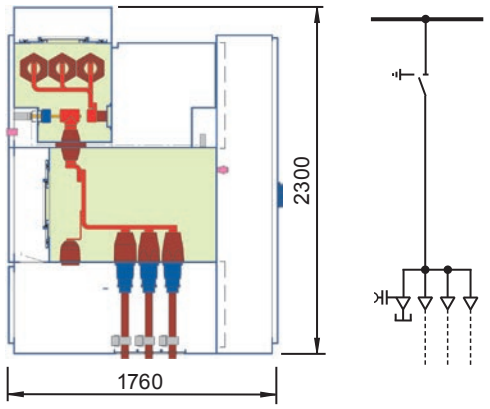


Fig. 7.1.1.2.1: Cable termination panel 2000 A

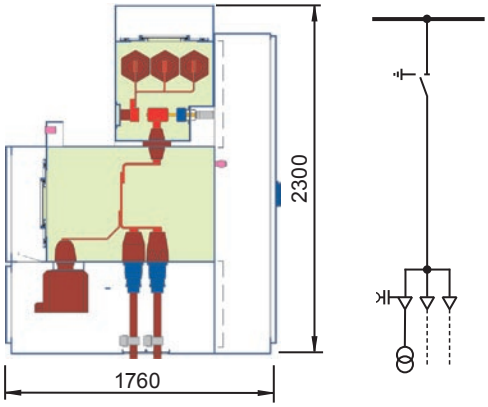
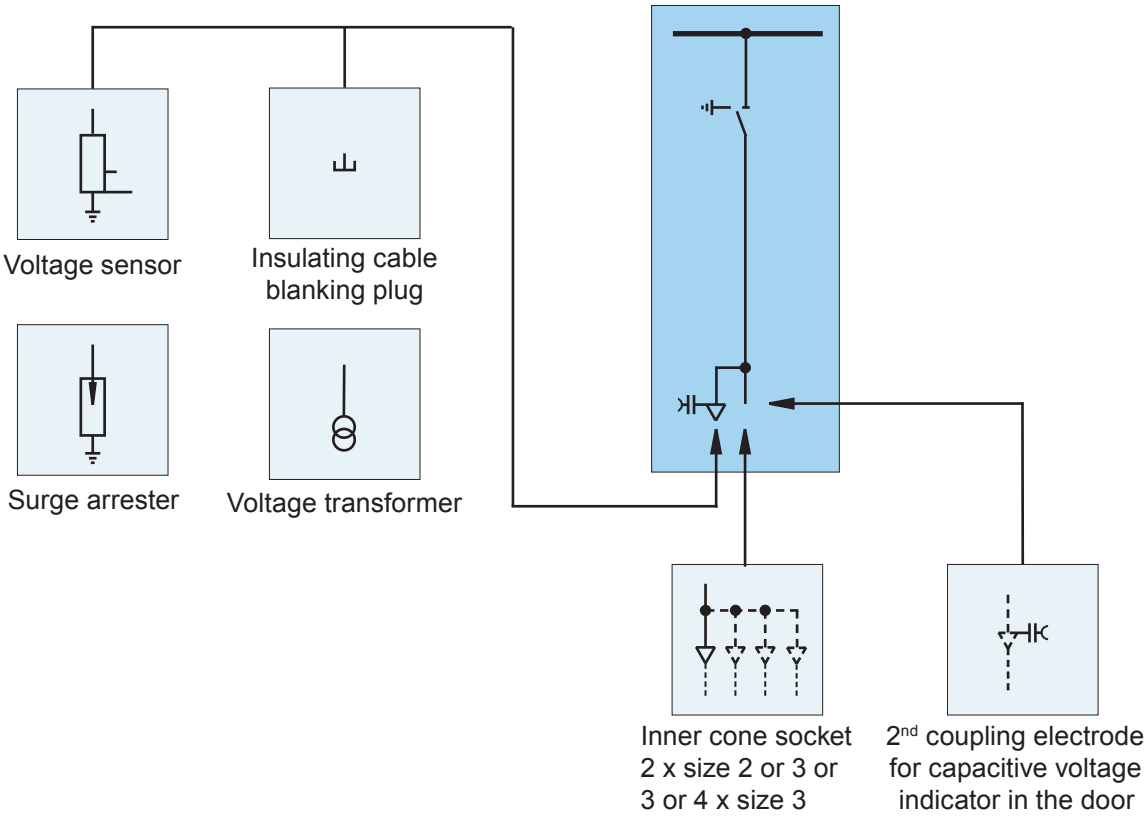


Fig. 7.1.1.2.2: Cable termination panel 1250 A with voltage transformer at the cable



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 1250 A (2 sockets size 2 or 3) I_p: ... 40 kA
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 2500 A (3 or 4 sockets size 3) I_p: ... 40 kA

Table 7.1.1.2.1: Overview of variants for cable termination panels

7.1.2 Busbar sectionaliser panels

7.1.2.1 Sectionaliser within a switchgear block

The sectionaliser panel contains the circuit-breaker, two three position disconnectors and a block-type current transformer or current sensor.
In addition, sectionalisers can be fitted with current transformers between the circuit-breaker and the three position disconnectors. In the sectionaliser panel, the position of the busbar changes from front to rear or vice versa.

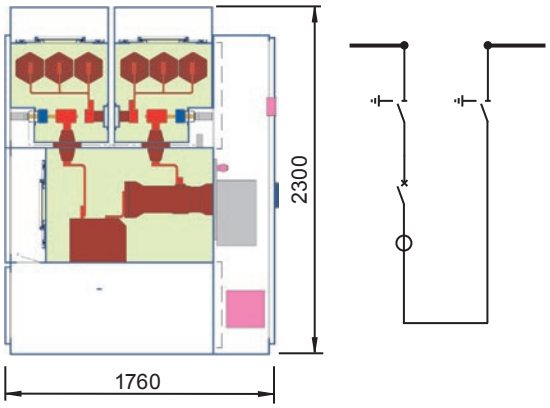


Fig. 7.1.2.1.1: Sectionaliser panel 1250 A with block-type CT or sensor

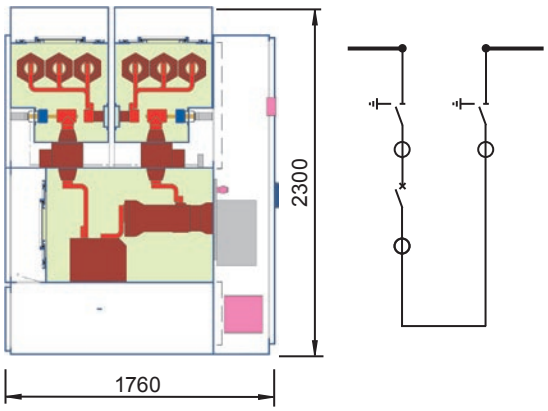
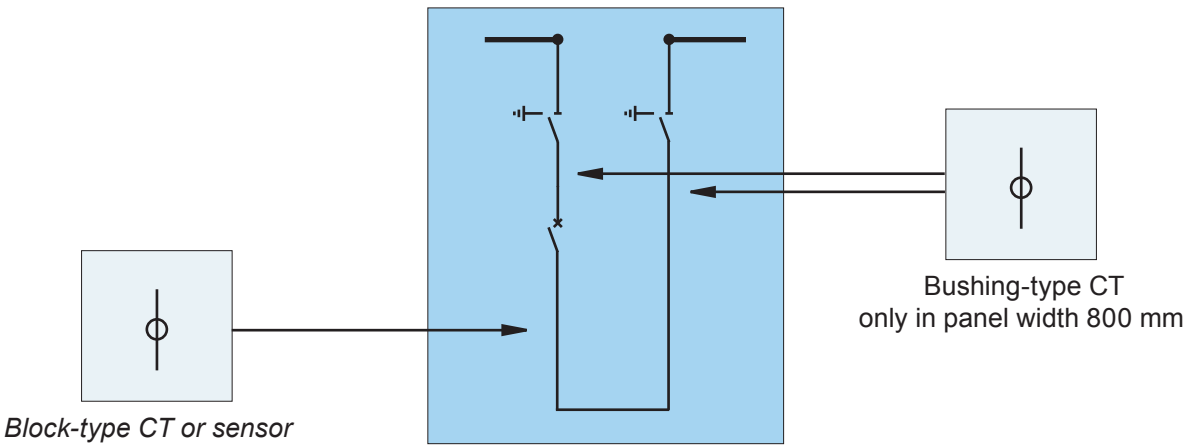


Fig. 7.1.2.1.2: Sectionaliser panel 2000 A with current transformers



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 1250 A I_p: ... 40 kA (U_r = 17.5 kV)	2 variants: • without transformers • Block-type CT or sensor
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 1250 A oder ...2500 A I_p: ... 40 kA	4 variants: • without transformers • Block-type CT or sensor • Bushing-type CT • Block-type CT or sensor + Bushing-type CT

Table 7.1.2.1.1: Overview of variants for sectionaliser panels

7.1.2.2 Sectionaliser using cables (connection of two system blocks)

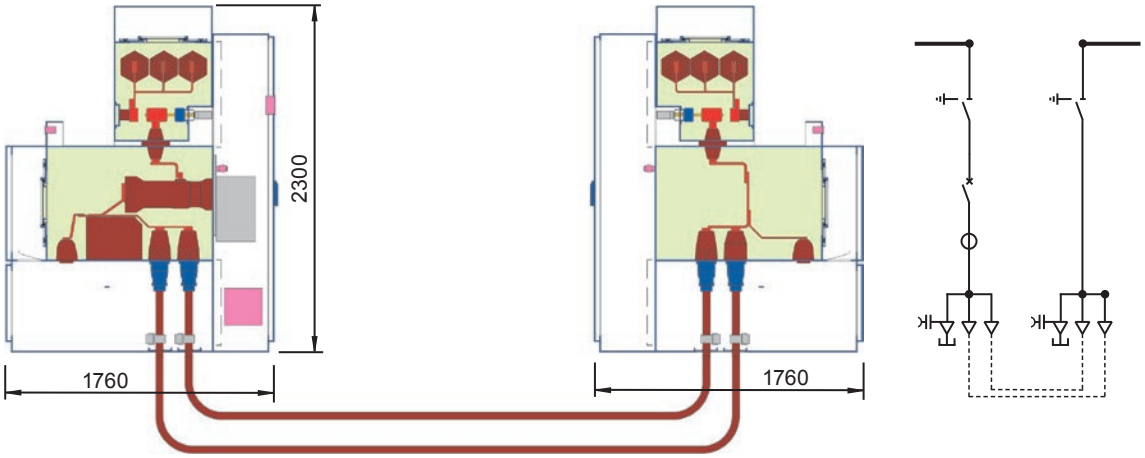


Fig. 7.1.2.2.1: Sectionaliser by cables, 1250 A

The overview of variants can be found in sections 7.1.1.1 (feeder panels) and 7.1.1.2 (cable termination panels).

7.1.3 Metering Panels

Two methods of busbar measurement are available:

The metering panel

The metering panel with a width of 600 mm contains isolatable voltage transformers. Operation of the isolating system is performed at the low voltage compartment.

Integrated metering

Sockets for plug-in voltage transformers are provided above the busbar compartment in outgoing feeder panels with integrated measurement. The following limitations to the use of integrated measurement must be taken into account at the planning stage:

- For 800 mm wide panels including double feeder panels.
- For panels without cooling systems.
- Not for sectionaliser panels.
- The distance from the end of the system must be three panel widths to the side pressure relief duct.
- The ceiling height must be at least 3000 mm
- The transport unit height is 2300 mm

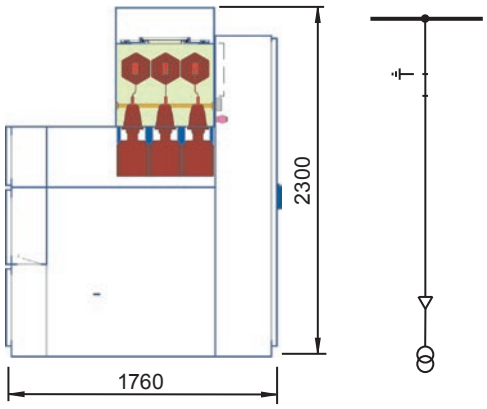


Fig. 7.1.3.1: Metering panel (Example: Measurement of the front busbar)

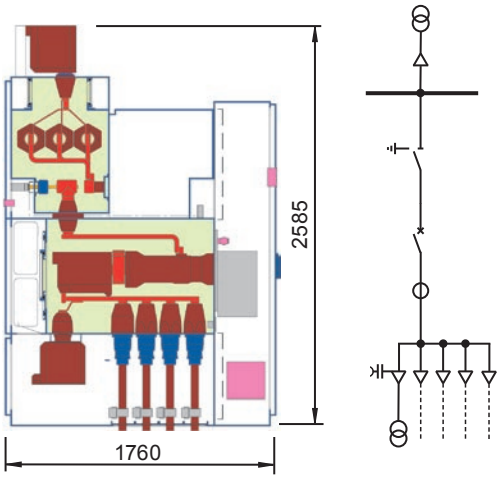


Fig. 7.1.3.2: Integrated busbar measurement (example for measurement of the rear busbar)

Panel width 600 mm:	U_r: ... 36 kV	Metering panel
Panel width 800 mm:	U_r: ... 36 kV	integrated busbar measurement

Table 7.1.3.1: Overview of variants of metering panels

7.2 Panels in double busbar design

7.2.1 Feeder panels

7.2.1.1 Incoming and outgoing feeder panels

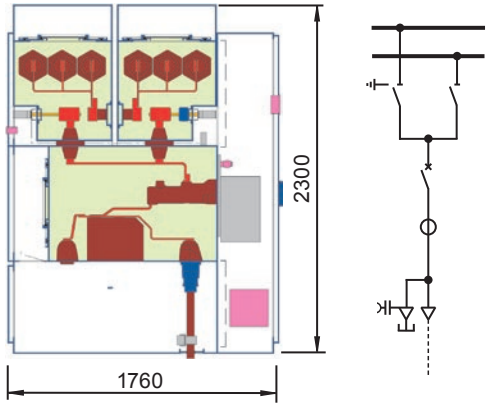


Fig. 7.2.1.1.1: Feeder panel 800 A with block-type transformer or sensor and one cable per phase

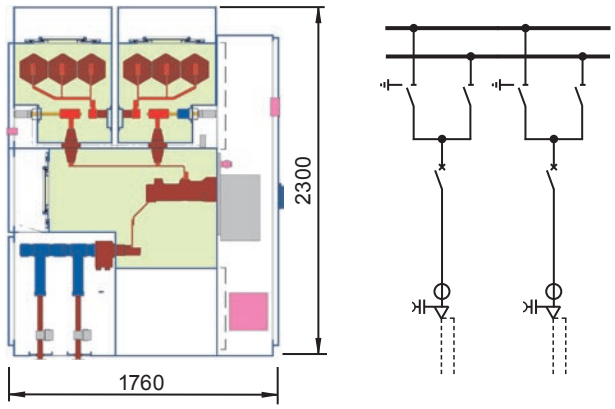


Fig. 7.2.1.1.2: Double feeder panel 24 kV, 630 A with two cables per phase (see also page 63)

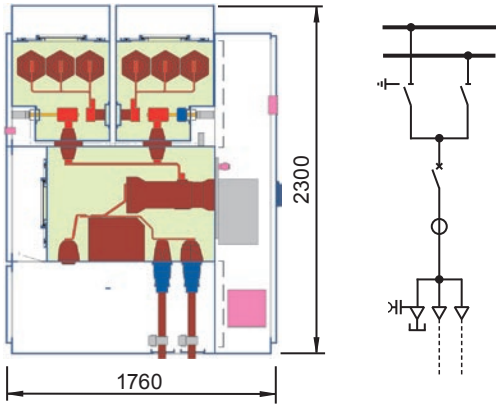


Fig. 7.2.1.1.3: Feeder panel 1250 A with block-type transformer or sensor and two cables per phase

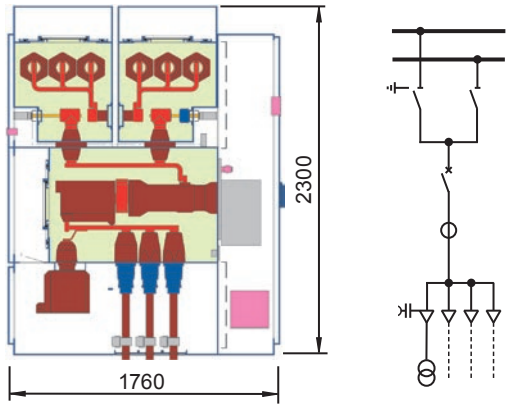


Fig. 7.2.1.1.4: Feeder panel 2000 A with current and voltage transformer and three cables per phase

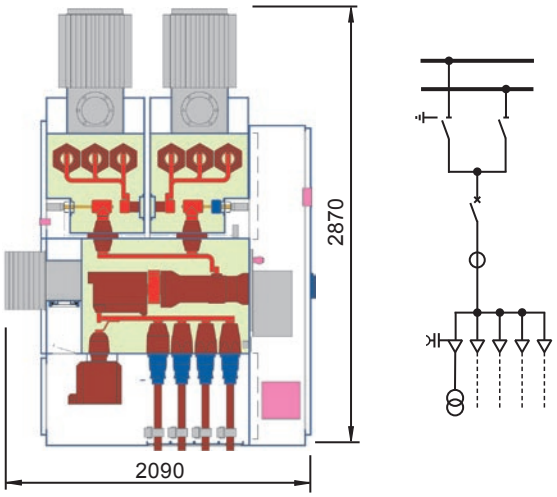


Fig. 7.2.1.1.5: Feeder panel 2500 A with current and voltage transformer and four cables per phase, cooling by heat sink

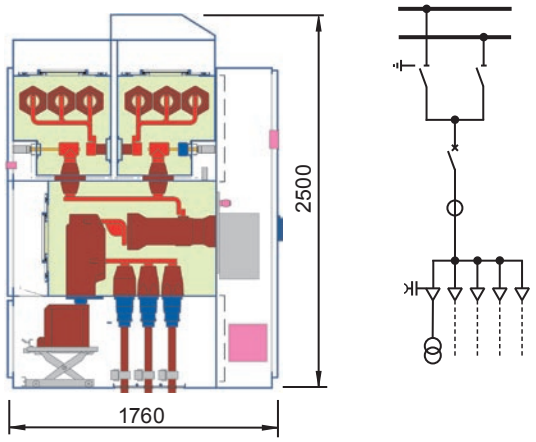
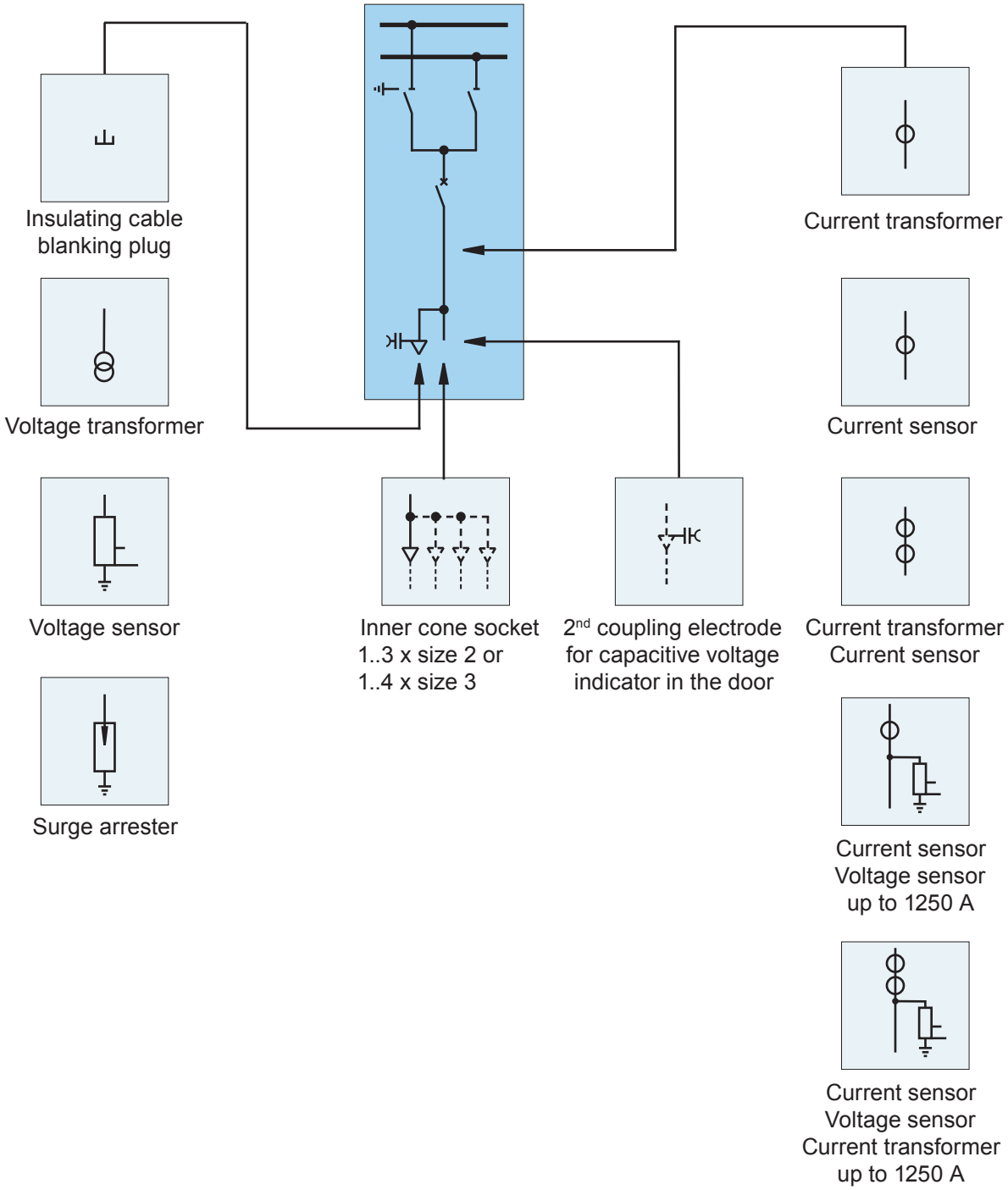


Fig. 7.2.1.1.6: Feeder panel 2500 A with current and voltage transformer and three cables (630 mm²) per phase, cooling by fan



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 800 A (1 x size 2) I_r: ... 1250 A (1 .. 3 x size 2 and 1 .. 2 x size 3) [1)] I_p: ... 31.5 kA (U_r = 36 kV) ... 40 kA (U_r = 17.5 kV)
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 800 A (1 x size 2) I_r: ... 1250 A (1 .. 2 x size 2 and 1 .. 3 x size 3) [1)] I_r: ... 2500 A (3 or 4 x size 3) I_p: ... 40 kA

Table 7.2.1.1.1: Overview of variants of incoming and outgoing feeder panels with inner cone termination system

[1)] Three sockets per phase only in conjunction with current transformers to fig. 6.10.2.1

Deviations for double feeder panels

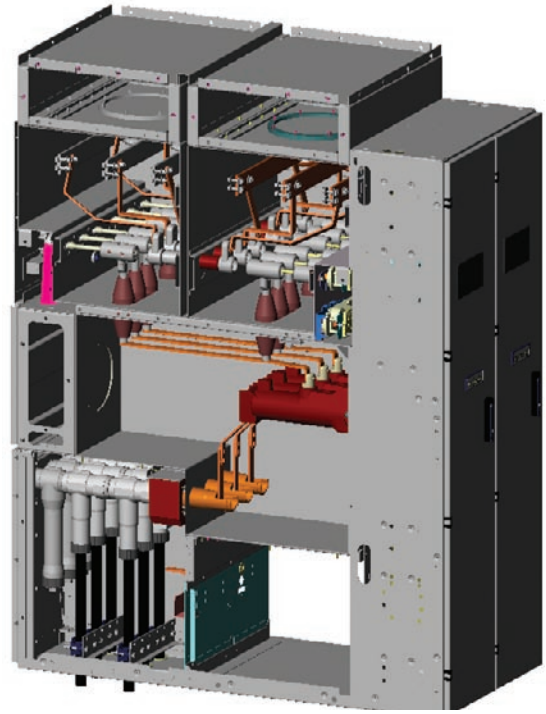
The structure of the double feeder panel deviates from that of a conventional outgoing feeder panel as described below.

- The double panel facilitates even more compact station planning for systems up to 24 kV.
- 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 outer cone plug system (one or two cables per phase) to DIN 47636 is used.
- Only ring core current transformers or ring core sensors are used.
- Two separate low voltage compartment doors (width 400 mm) are fitted.
- Technical data which deviate from the conventional panel (compare section 3, page 10):

U_r:	...24 kV
I_k:	...25 kA
I_r (feeder):	...630 A
I_r (busbar):	...2500 A
p_{me} (U_r > 17.5 kV):	110 kPa

Internal arc classification according to IEC 62271-200

Classification IAC	AFLR
Internal arc	25 kA 1 s



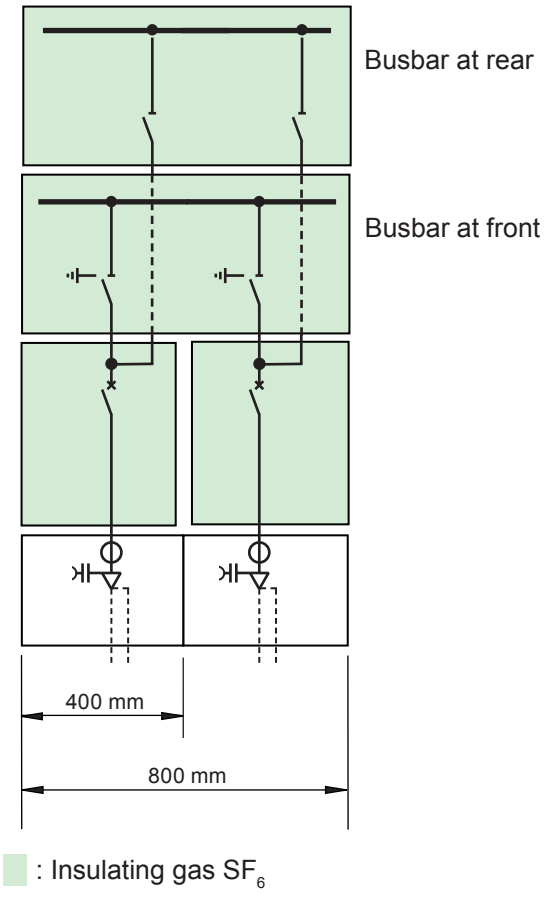


Fig.. 7.2.1.1.7: Double feeder panel: version with two cables per phase and surge arresters

7.2.1.2 Cable termination panels

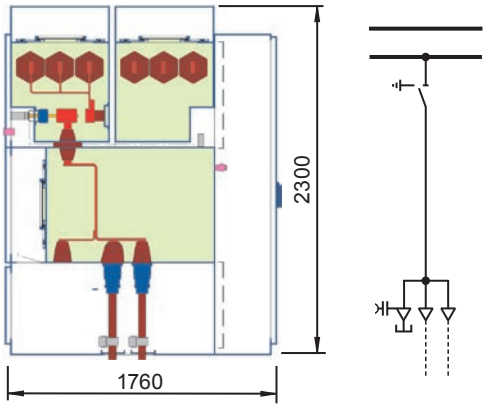


Fig. 7.2.1.2.1: Cable termination panel 1250 A (Example with continuous busbar at the front)

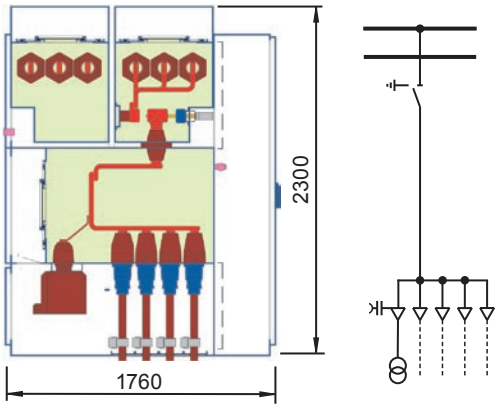
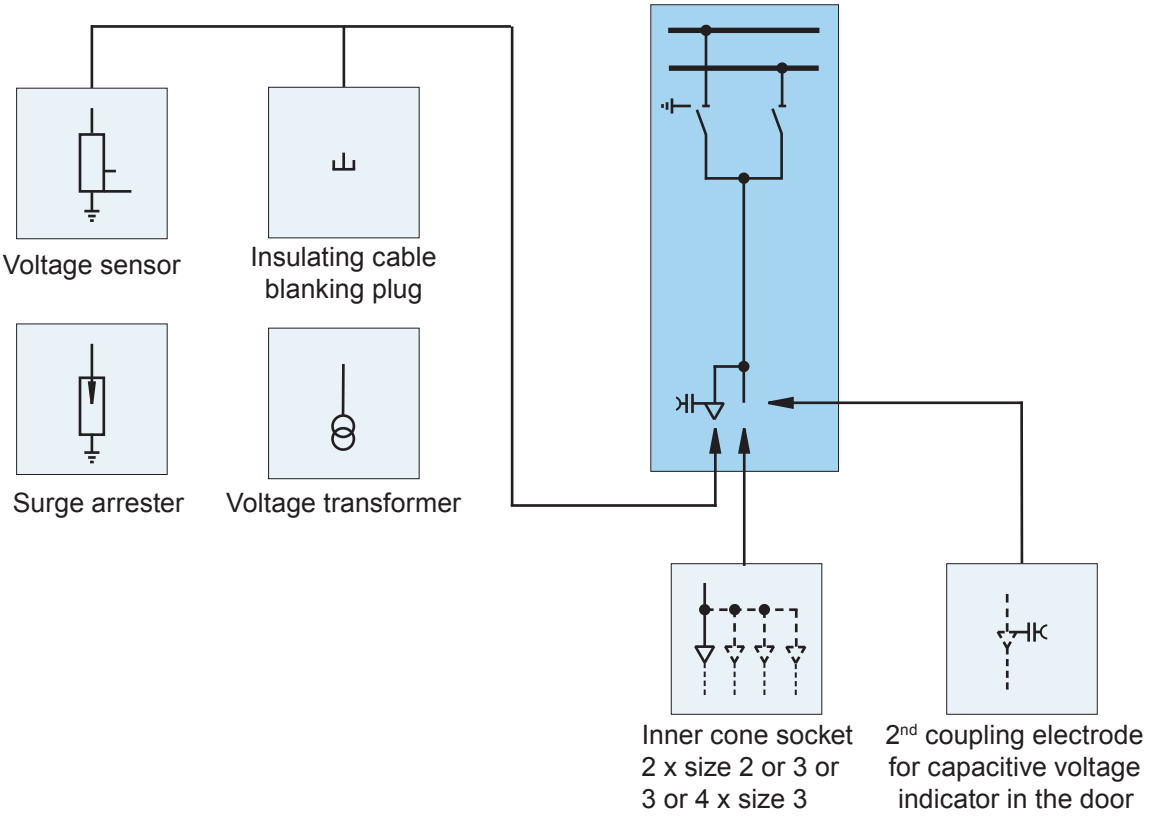


Fig. 7.2.1.2.2: Cable termination panel 2000 A (Example with continuous busbar at the rear and voltage transformer on the outgoing feeder)



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 1250 A (2 sockets size 2 or 3) I_p: ... 40 kA
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 2500 A (3 or 4 sockets size 3) I_p: ... 40 kA

Table 7.2.1.2.1: Overview of variants for cable termination panels

7.2.2 Coupling panels

7.2.2.1 Sectionaliser within a switchgear block

Two panels are required for a complete busbar sectionaliser. The sectionaliser panel contains the circuit-breaker and a three position disconnector. The riser panel contains a three position disconnector. Installation variants “sectionaliser left – riser right” and vice versa are possible.

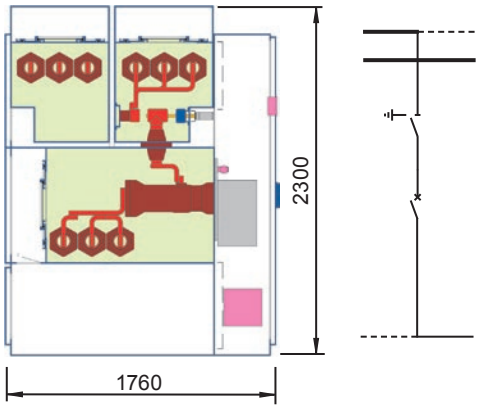


Fig.: 7.2.2.1.1: Sectionaliser panel for the front busbar, 2000 A

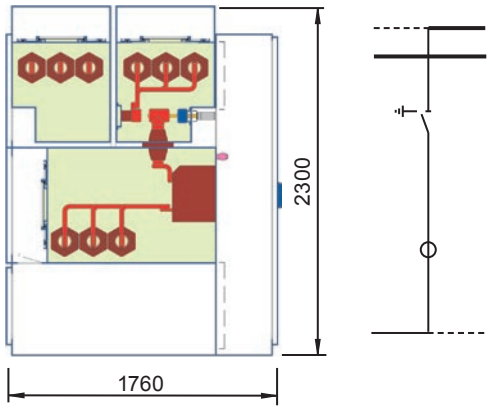
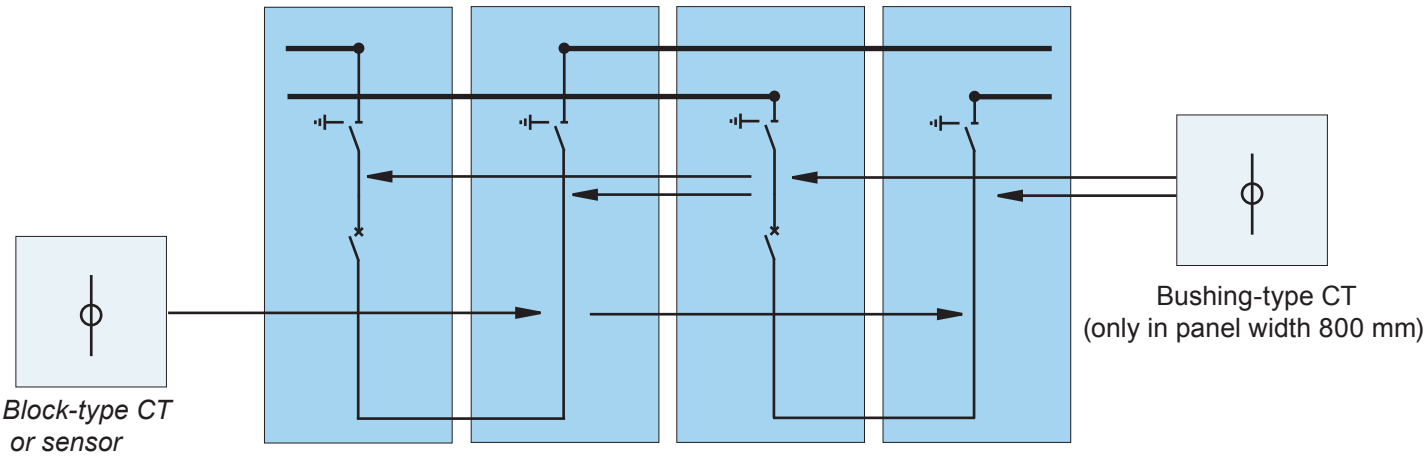


Fig.: 7.2.2.1.2: Riser panel for the front busbar, 2000 A



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 1250 A I_p: ... 40 kA (U_r = 17.5 kV)	Sectionaliser panel: without CTs Riser panel: with block-type CT or sensor
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 1250 A, 2000 A or ...2500 A I_p: ... 40 kA	Sectionaliser panel: without CTs or with bushing-type CTs Riser panel: without CTs, with block-type CT/sensor or block-type CT/sensor + bushing-type CT

Table 7.2.2.1.1: Overview of variants for couplings within a switchgear block

7.2.2.2 Sectionaliser using cables (connection of two system blocks)

Two panels are required for a complete busbar sectionaliser. The sectionaliser panel contains the circuit-breaker and a three position disconnector. The riser panel contains a three position disconnector.

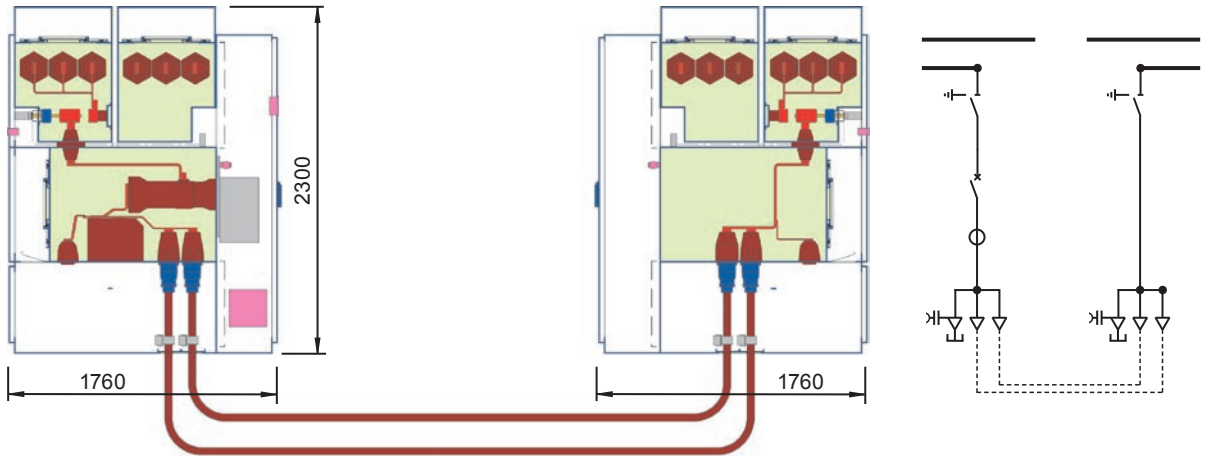


Fig. 7.2.2.2.1: Connection of two system blocks using cables (bus sectionaliser), 1250 A

The overview if variants can be found in sections 7.2.1.1 (incoming and outgoing feeder panels and 7.2.1.2 (cable termination panels).

7.2.2.3 Bus coupler

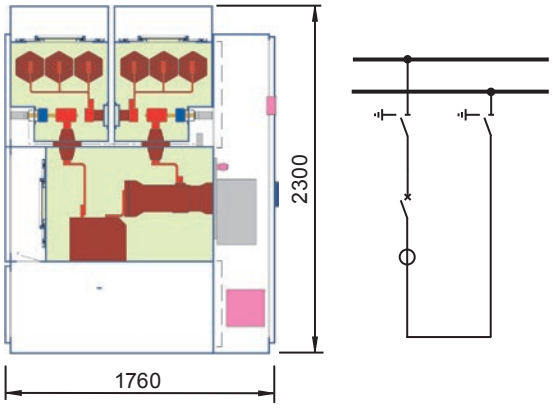


Fig. 7.2.2.3.1: Bus coupler, 1250 A with block-type CTs or sensors

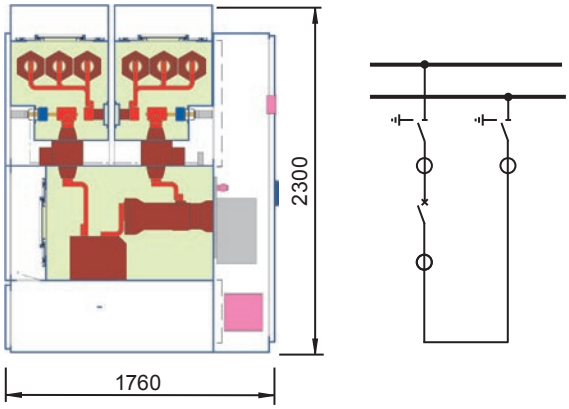
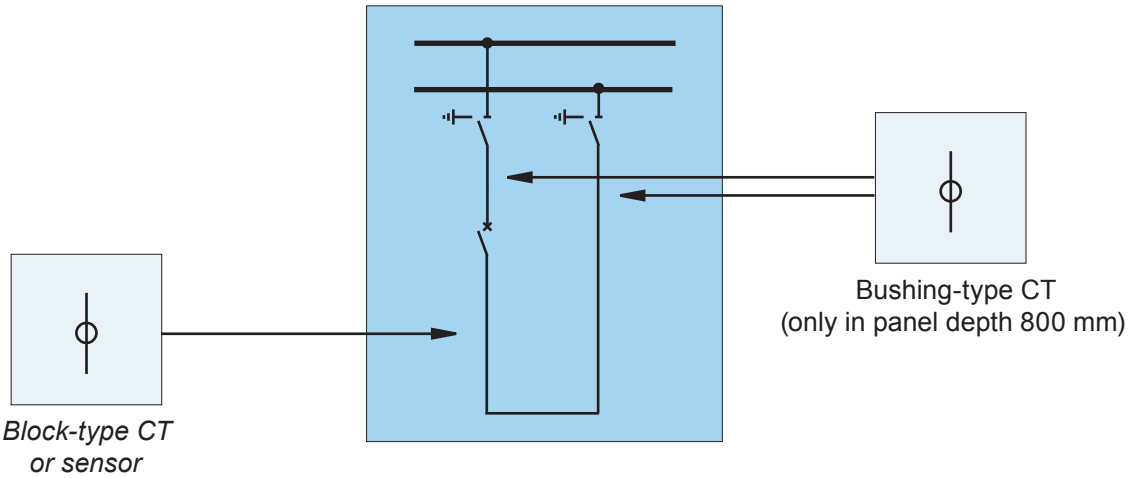


Fig. 7.2.2.3.2: Bus coupler, 2000 A with CTs



Panel width 600 mm:	U_r: ... 36 kV I_r: ... 1250 A I_p: ... 40 kA (U_r = 17.5 kV)	2 variants: • without CTs • Block-type CT or sensor
Panel width 800 mm:	U_r: ... 36 kV I_r: ... 1250 A or ...2500 A I_p: ... 40 kA	4 variants: • without CTs • block-type CT or sensor • bushing-type CT • block-type CT or sensor + bushing-type CT

Table 7.2.2.3.1: Overview of variants for bus coupler panels

7.2.3 Bus coupler without circuit-breaker

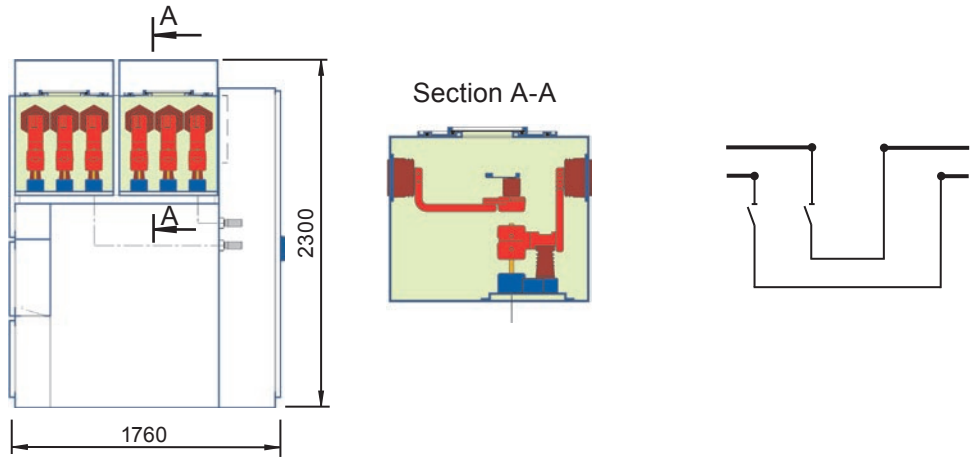


Fig. 7.2.3.1: Bus coupler without circuit-breaker 2000 A

Panel width 800 mm:	U_r: ... 36 kV I_r: ....2000 A or I_r: ... 2500 A (cooling only with heat sinks) I_p: ....40 kA

Table 7.2.3.1: Overview of variants for the bus coupler panels without circuit-breaker

7.2.4 Metering Panels

Two methods of busbar measurement are available:

The metering panel

The metering panel with a width of 600 mm contains isolatable voltage transformers. Operation of the isolating system is performed at the low voltage compartment.

Integrated measurement

Sockets for plug-in voltage transformers are provided above the busbar compartment in outgoing feeder panels with integrated measurement. The following limitations to the use of integrated measurement must be taken into account at the planning stage:

- For 800 mm wide panels including double feeder panels.
- For panels without cooling systems.
- The distance from the end of the system must be three panel widths to the side pressure relief duct.
- The ceiling height must be at least 3000 mm.
- The transport unit height is 2300 mm.

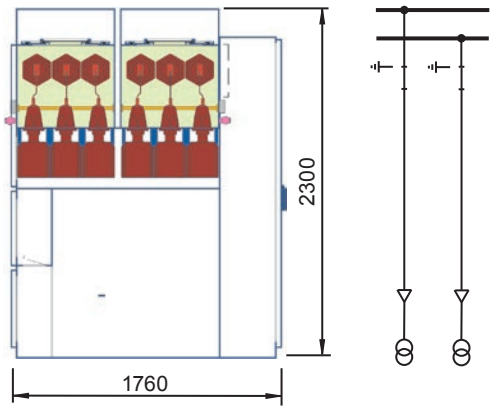


Fig. 7.2.4.1: Metering Panel

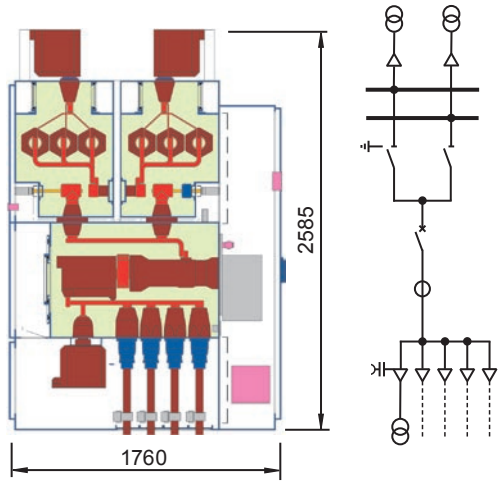


Fig. 7.2.4.2: Integrated Metering

Panel width 600 mm:	U_r: ... 36 kV	Metering panel
Panel width 800 mm:	U_r: ... 36 kV	Integrated metering

Table 7.2.4.1: Overview of variants for metering panels

7.3 Design to order panels

The panel variants presented in sections 7.1 to 7.2 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.

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

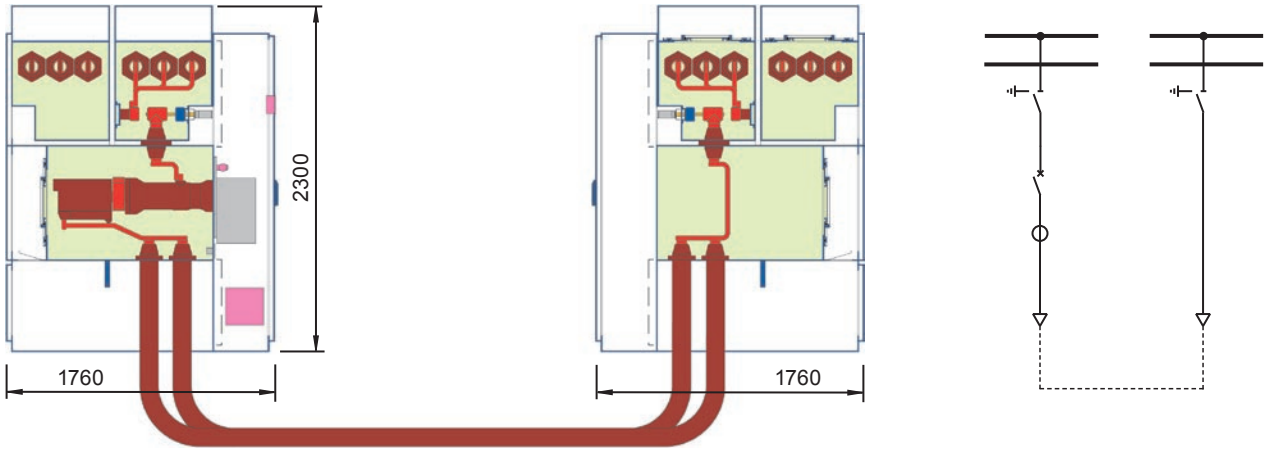


Fig. 7.3.1: Termination panels for fully insulated bars (Example: connection of two system blocks, 36 kV, 40 kA, 2000 A)

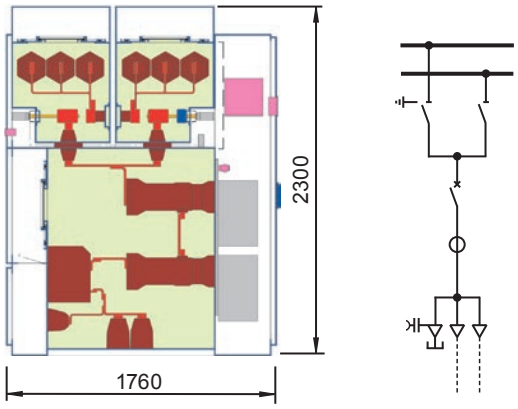


Fig. 7.3.2: Panel for capacitor switching (36 kV, 40 kA, 800 A)

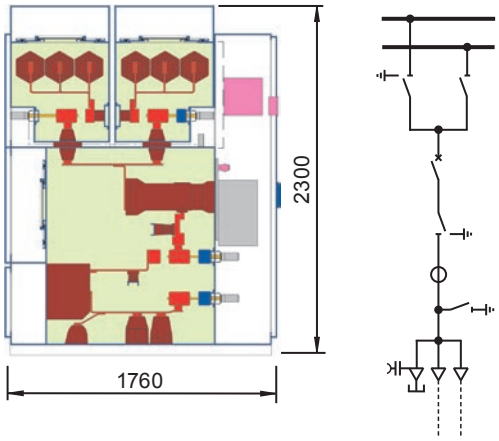


Fig. 7.3.3: Panel with additional three-position disconnector and cable earthing switch (36 kV, 40 kA, 1250 A)

7.4 Panels with rated currents > 2000 A

At a maximum ambient air temperature of 40 °C, a maximum 24 h average , 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.

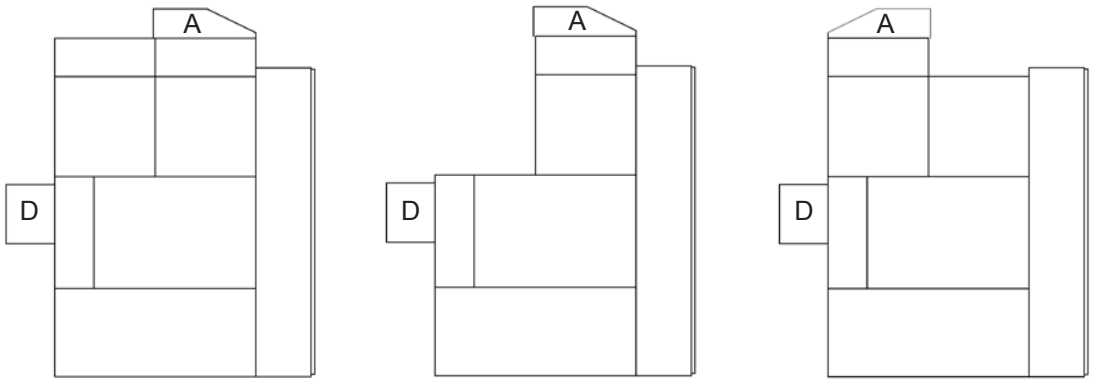
For standard operating conditions and rated currents > 2000 A (max. 2500 A), two cooling methods are available as alternatives:

- Forced ventilation by fans, combined with heat sinks if necessary.
- Static cooling by heat sinks.

The positions of the relevant fans and heat sinks are shown in the illustrations below.

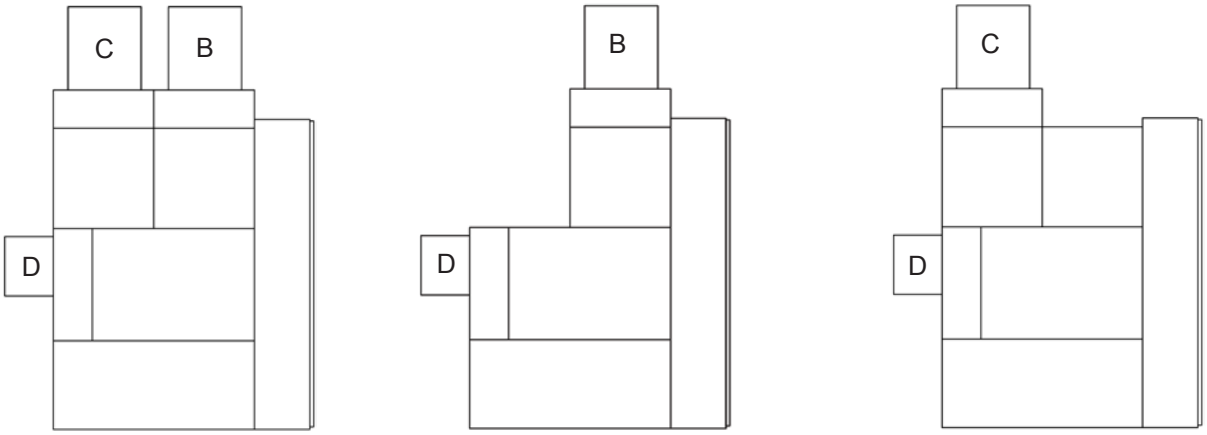
A: Radial flow fan
B, C: Heat sink on the busbar compartment
D: Heat sink on the circuit-breaker compartment

The cooling of the sectionaliser panel without circuit breaker (section 7.2.3.1, page 68) for rated currents > 2000 A is effected only with heat sinks.



Double busbar *Single busbar at the front* *Single busbar at the rear*

Fig. 7.4.1: Cooling with fan and heat sinks



Double busbar *Single busbar at the front* *Single busbar at the rear*

Fig. 7.4.2: Cooling with heat sinks

Method of current detection	Panel type	Fan and heat sinks	Heat sinks
Sensors	Double bus bar	A	B + C + D
	Single busbar at the front	A	B + D
	Single busbar at the rear	A	C + D
Current transformers	Double bus bar	A + D	B + C + D
	Single busbar at the front	A + D	B + D
	Single busbar at the rear	A + D	C + D

Table 7.4.1: Cooling methods

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.

8 Arrangement of panels with cooling facilities and panels with integrated bus bar measurement

The following is to be observed when installing panels with cooling facilities and panels with busbar measurement:

- Panels with heat sinks (B or C, section 6.7) or with busbar measurement can be positioned from the fourth panel at the absorber end onwards (section 6.14). (The distance from the absorber must be at least one panel width.)

- Panels with fans can be positioned as the first, second, and anywhere from the fourth panel at the absorber end.

- A panel with heat sink B and/or C (section 7.4) must have at least one free side (without heat sink or busbar measurement).

- Absorbers and a pressure relief duct at the side are required at both ends of the system when

  - more than two panels with heat sinks C or B (section 7.4) and/or busbar measurement are installed in the system

  or when

  - more than two heat sinks D (section 7.4) are installed in the system.

Further conditions for the use of integrated busbar measurement can be found in sections 7.1.3 and 7.2.4.

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 (see page 30), the test sockets can be fitted with an earthing set (fig. 6.8.5, page 39) 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 or bus coupler

Earthing is effected by the three position disconnector and the circuit-breaker in a bus coupler (see fig. 9.2.1) or bus sectionaliser.

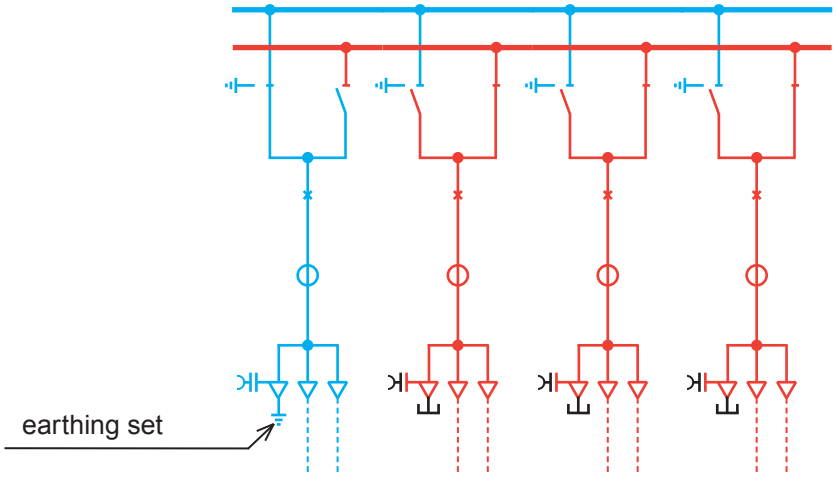


Fig. 9.1.1: Busbar earthing by earthing set

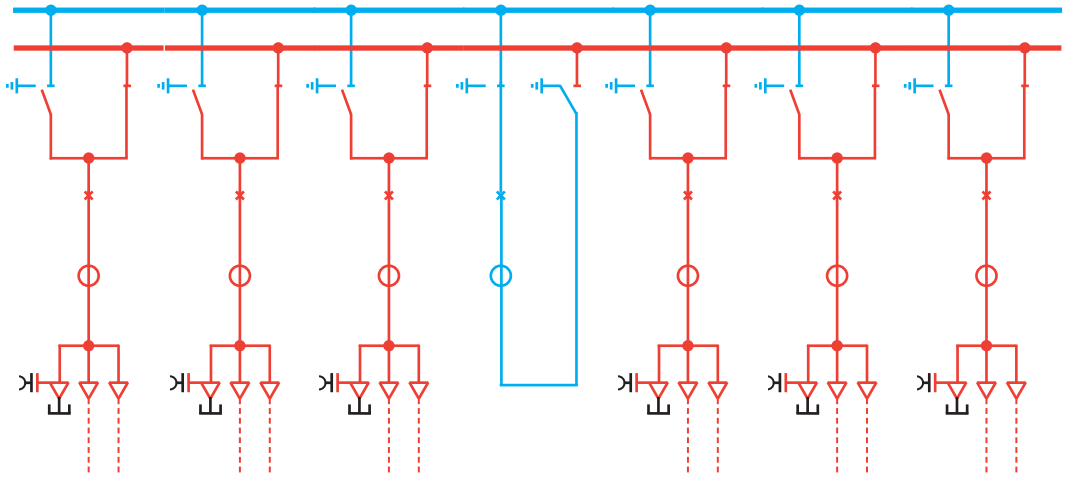


Fig. 9.1.2: Busbar earthing by bus coupler

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.

Earthing of the frames

We recommend connecting the foundation frame (or raised false floor frame) in as closely meshed a manner as possible (front and rear at spacings of max. 3 m) to the main building

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.

Climate

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

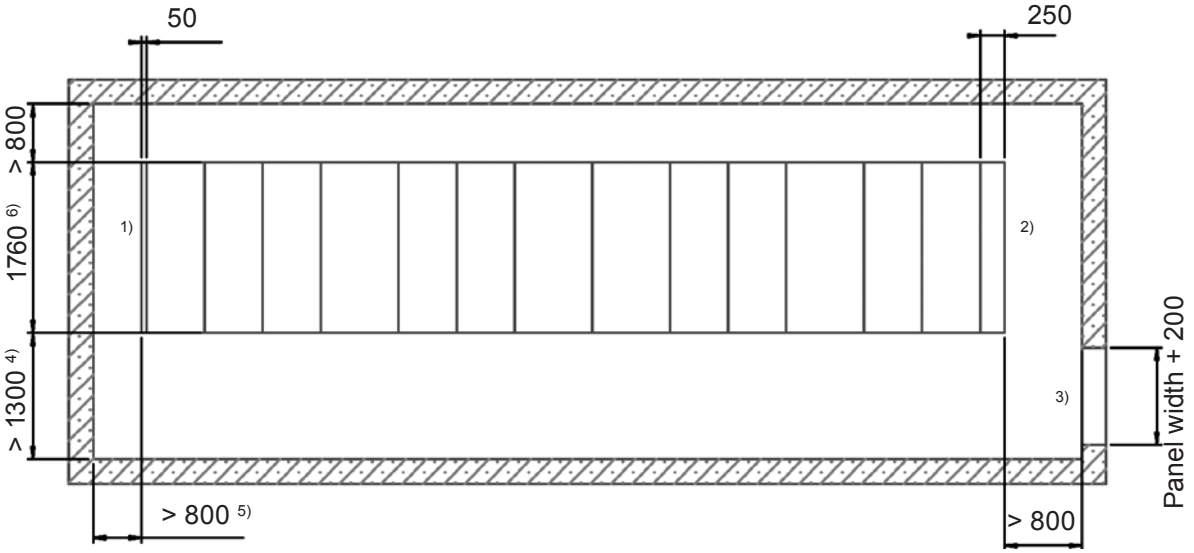


Fig. 10.2.1: Example of a single row installation
(Top view, dimensions in mm)

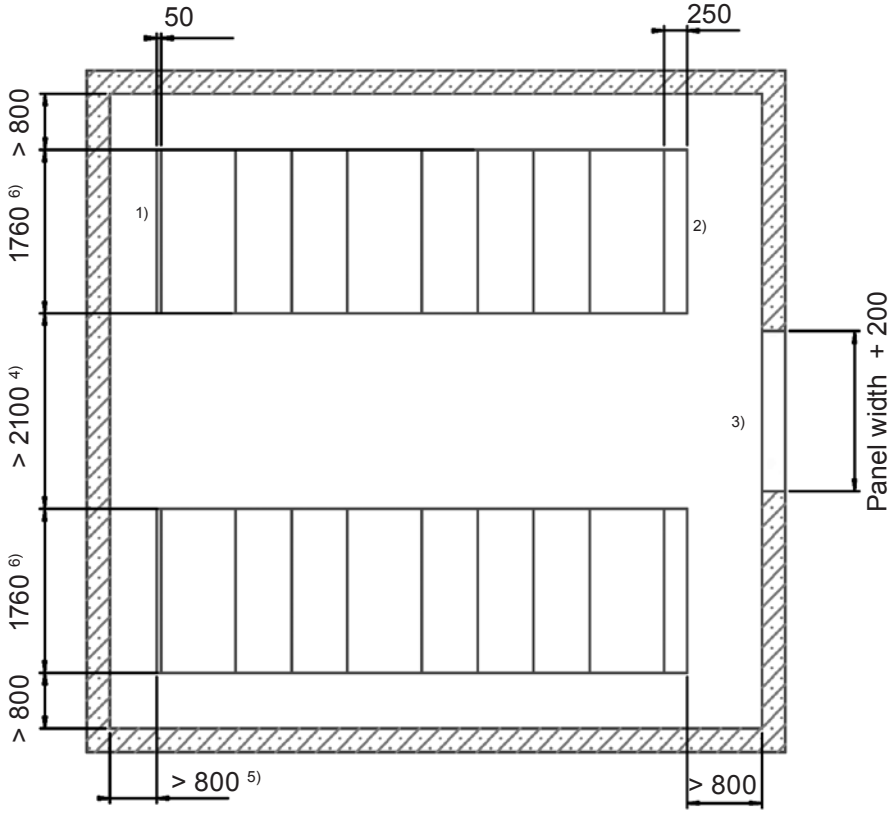


Fig. 10.2.2: Example of a double row installation
(Top view, dimensions in mm)

1) End cover
2) Lateral pressure relief duct
3) Door height: > 2300 mm (with integrated measurement: > 2500 mm)
4) Recommended dimension (permitted reduction in accordance with section 10.3)
5) Permitted reduction to min. 100 mm in accordance with section 10.3
6) With heat sinks at the circuit-breaker compartment: 2090 mm

10.3 Minimum aisle widths and emergency exits

	Aisle width in front of the system, single row installation	Aisle width between the system blocks, double row installation	Remaining aisle width in front of the system with the doors open
	[mm]	[mm]	[mm]
Panel width 600 mm only	> 1100	> 1700	> 500
Block, consisting of panels of widths 600 mm and 800 mm and 800 mm only	> 1300	> 2100	> 500

Table 10.3.1: Minimum aisle widths (recommended) in front of the switchgear

Requirement for removal/installation of a panel in an existing row: Minimum aisle width = maximum panel depth + 300 mm

"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)]

10.4 Minimum room heights

Pressure relief duct to the outside	Pressure relief into the switchgear room (absorber)	Pressure relief into the switchgear room (absorber) with a fan on at least one panel	Integrated metering on at least one panel	Heat sink on at least one panel
[mm]	[mm]	[mm]	[mm]	[mm]
> 2800	> 2800	> 3000	> 3000	> 3200

Table 10.4.1: Minimum room heights

1) IEC 61936, section 7.5.4 and 7.5.5

10.5 Floor openings and cable axes

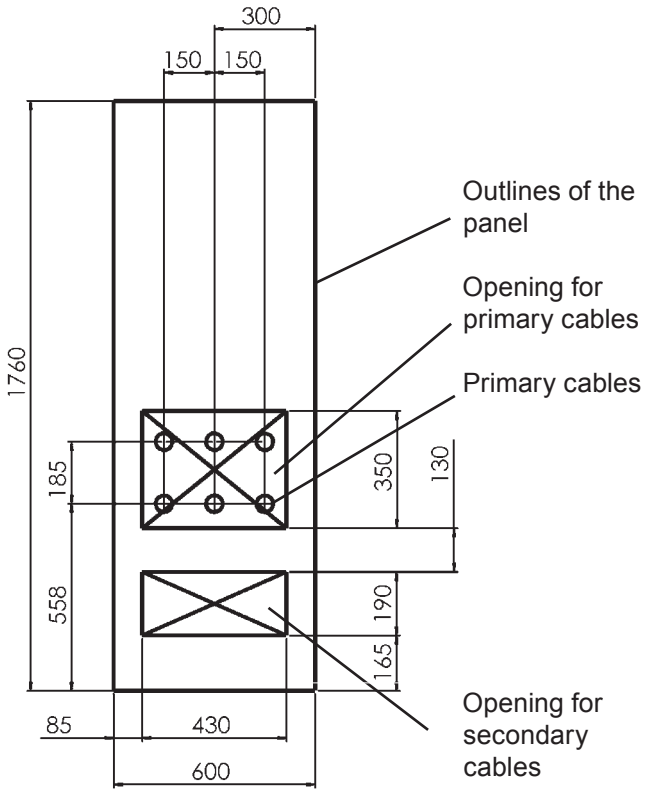


Fig. 10.5.1: Feeder Panel with block-type CT or sensor, panel width 600 mm

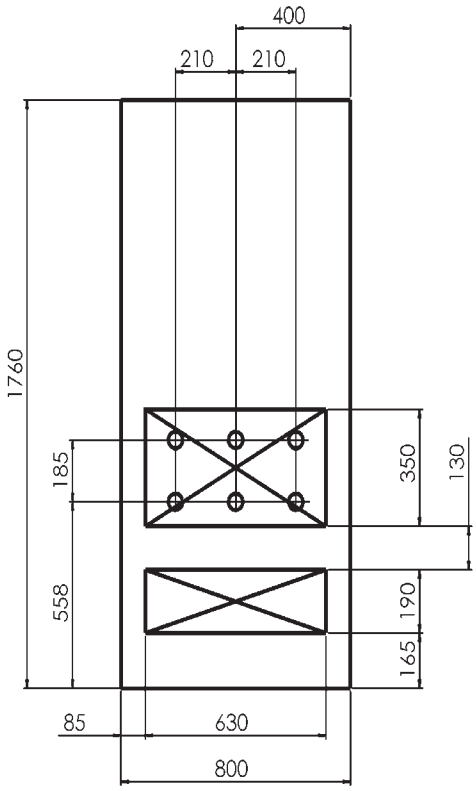


Fig. 10.5.2: Feeder Panel with block-type CT or sensor, panel width 800 mm

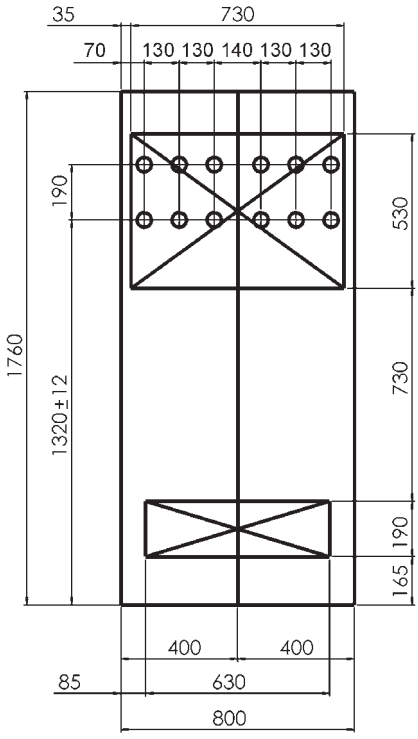


Fig. 10.5.3: Double feeder panel, panel width 2 x 400 mm

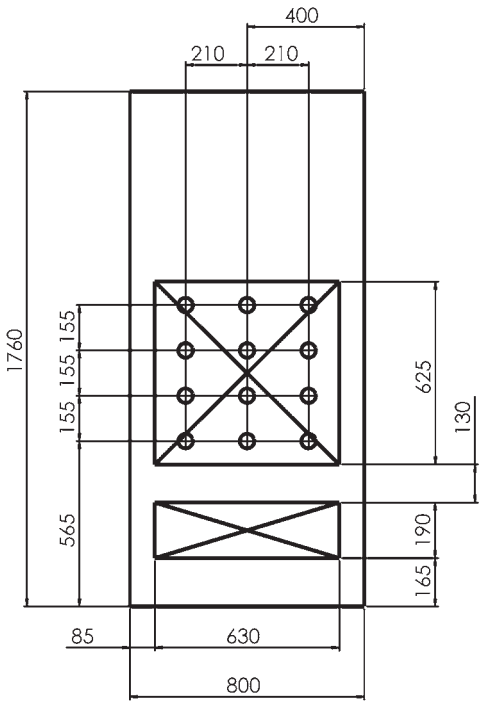


Fig. 10.5.4: Feederpanel with CT or sensor, Panel width 800 mm

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

- Sectionaliser and riser panels [1)]
- Bus coupler [1)]
- Sectionaliser panels without circuit breaker
- Metering panels (not integrated metering)

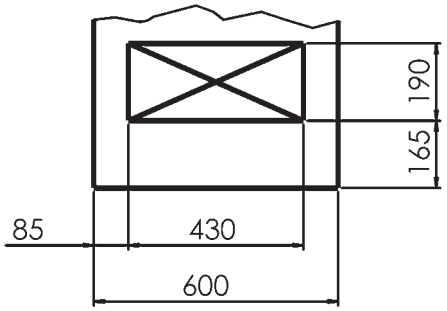


Fig. 10.5.5: Opening for control cables, panel width 600 mm

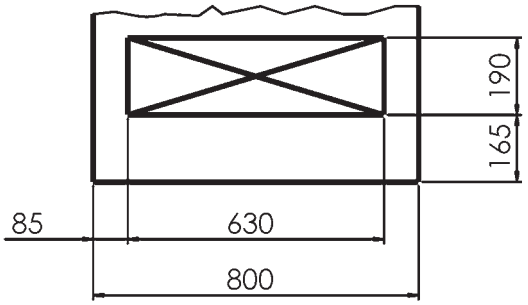


Fig. 10.5.6: Opening for control cables, panel width 800 mm

Low voltage compartment depth 500mm

The dimensions in figs. 10.5.1 to 10.5.6 refer to a low voltage compartment depth of 400 mm (standard). When the 500 mm deep low voltage compartment (optional) is used, the panel depth is increased by 100 mm at the front (see also figs. 10.5.7 and 10.5.8).

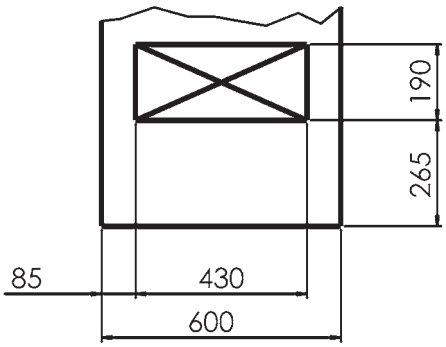


Fig. 10.5.7: Opening for control cables, panel width 600 mm, depth of low voltage compartment: 500 mm

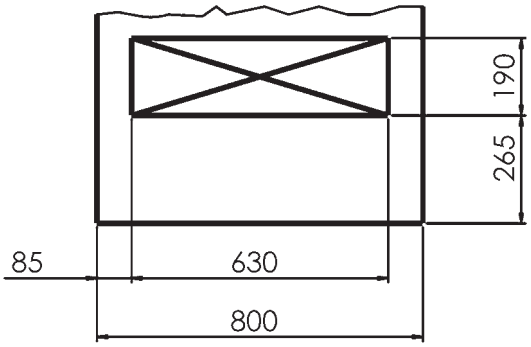


Fig. 10.5.8: Opening for control cables, panel width 800 mm, depth of low voltage compartment: 500 mm

1) Within in switchgear block

10.6 Foundation frames

The optional foundation frames consist of aluminium sections. They are supplied pre-assembled for one panel each. Foundation frames of 600 mm or 800 mm in width are used, depending on the panel width. 800 mm wide frames are available for double panels of 400 mm width. The foundation frames are fastened to the concrete floor and embedded in the floor topping.

When the 500 mm deep low voltage compartment (optional) is used, the panel depth is increased by 100 mm at the front (see figs. 10.6.1 and 10.6.2).

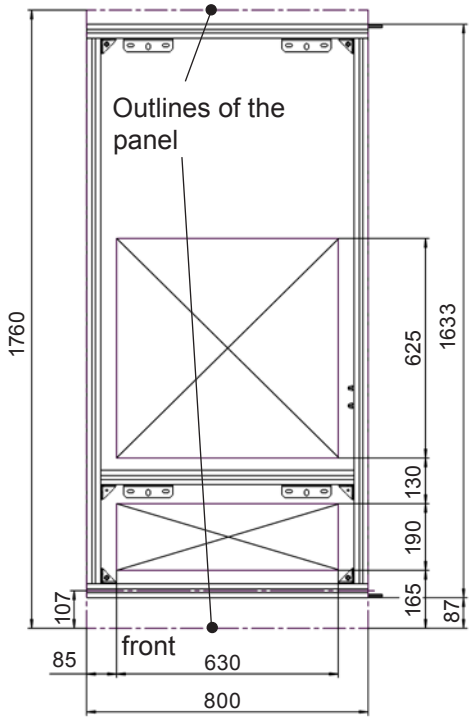


Fig. 10.6.1: Foundation frame, panel with a LV compartment depth of 400 mm (standard), panel width 800 mm

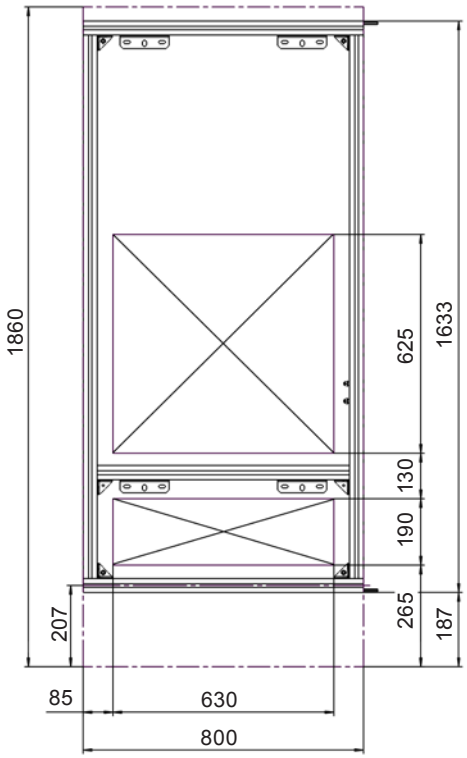


Fig. 10.6.2: Foundation frame, panel with a LV compartment depth of 500 mm (option), panel width 800 mm

Fig. 10.6.3: Foundation frame for the panel width 800 mm

10.7 Earthing of the switchgear

10.7.1 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 400 mm2 (ECuF30, 40 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.

The earthing system described in this section does not represent EMC-compliant earthing of the switchgear (EMC = electromagnetic capability). EMC-compliant earthing is achieved by additional measures which are explained in the following section.

10.7.2 EMC-compliant earthing of the switchgear

Electromagnetic compatibility (EMC) is to be planned from quantitative points of view. The interface requirements regarding emissions and immunity are to be stipulated for delimited areas (EMC zones). In the best possible case, these requirements can be met directly, i.e. with no additional action. If, however, the requirements are not fulfilled, additional action is necessary, and is in principle to be applied in the order of the interference source, coupling path and interference sink. It is useful to assess the hierarchical elements of a system, such as the complete plant equipment, room, cubicle assembly, rack assembly, circuit board, circuit section and component, with respect to their electromagnetic environments on the various levels.

The design of the earthing system for the switchgear is of decisive importance for the EMC of the secondary equipment in the switchgear installation. Information on this can be found in IEC 61936 standard, section 9.5. According to IEC 62271-1, the secondary equipment in the switchgear system must satisfy the requirements of section 6.9.

It is then ensured that interference which is permissible under the terms of the standard does not impair the immunity to noise of the secondary equipment (see also Annex J of the standard IEC 62271-1). The measures are to be implemented in addition to the earthing system described in section 10.7.1.

Limitation of the interference level within the switchgear system is supported by suitable measures as listed below.

- Separate laying of power, signal and control cables.
- Suitable screening and earthing of the equipment.
- Potential isolation: Galvanic isolation of the signal circuits at the system boundary.
- Equipotential bonding: For low-impedance connection of system or circuit sections between which the potential difference should be as low as possible.
- The earthing conductors of the cable screens should always be routed to the earthing bar in the shortest possible distance.
- The lengths of the external control cables should not exceed 200 m. With greater lengths, use for example interposing relays or optical fibre cables.

10.7.3 Recommendations on configuration of the switchgear earthing

We recommend that the switchgear be earthed as shown in figures 10.7.3.1 and 10.7.3.2.
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 10.7.3.1 and 10.7.3.2. When planning the switchgear earthing, please observe the notes in sections 10.7.1 and 10.7.2.

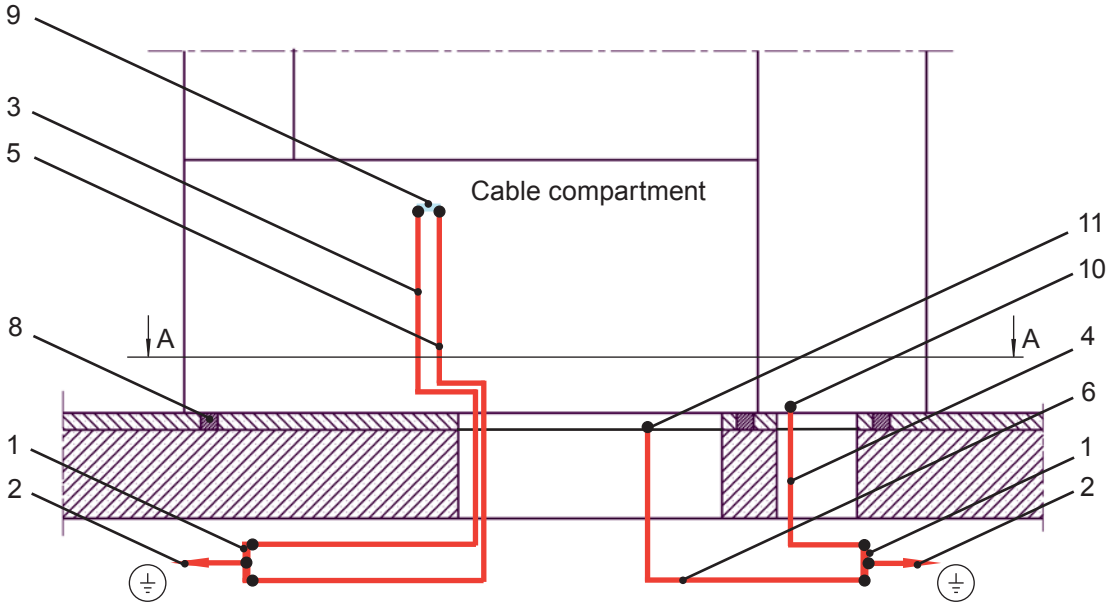


Fig. *10.7.3.1: Earthing recommendation, shown schematically as a sectional elevation of the lower part of a panel including the concrete floor*

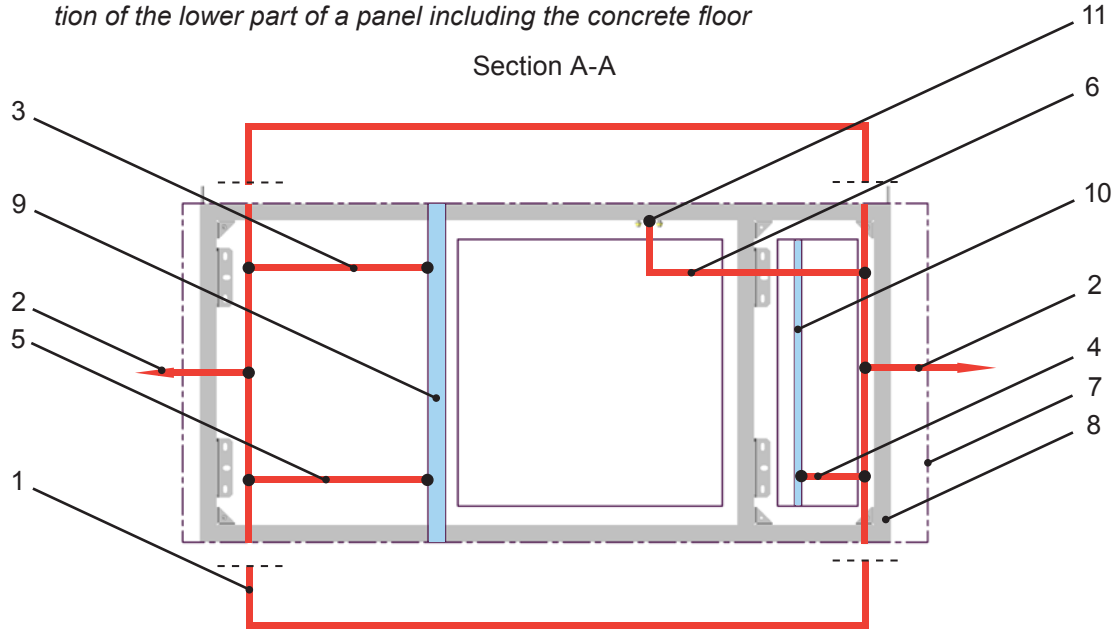


Fig. 10.7.3.2: Earthing recommendation, plan view (section A-A of figure 10.7.3.1)

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: 40 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

Legend to figures 10.7.3.1 and 10.7.3.2

10.8 Panelweights

Panel type	Panel width [mm]	Rated current [A]	Weight, max. [kg]
Double feeder panel, single busbar	2 x 400	≤ 630	1050
Single busbar	600	≤ 1250	1100
Single busbar	800	≤ 2000	1550
Single busbar	800	≤ 2500	1650
Double feeder panel, double busbar	2 x 400	≤ 630	1300
Double busbar	600	≤ 1250	1250
Double busbar	800	≤ 2000	1800
Double busbar	800	≤ 2500	1900

Table 10.8.1: Panelweights

11 Non-standard operating conditions

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 Draft 6; 1997.

Climate

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

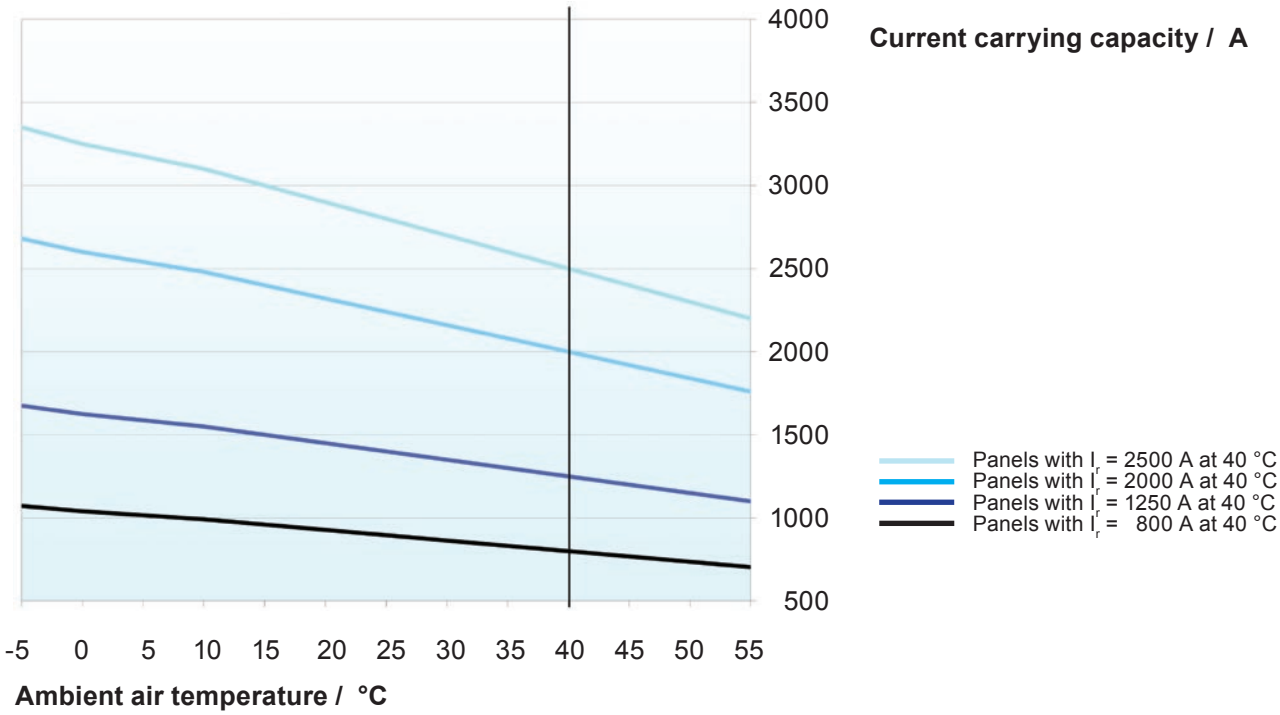


Fig. 11.1: Relationship between ambient air temperature and current carrying capacity

Notes

Notes

ABB AG

Calor Emag Medium Voltage Products

Germany

Ratingen Factory

Technical catalogue no. 1VBA 680 502 P0102 (January 2008 - 500)

ABB AG
Calor Emag Medium Voltage Products
Oberhausener Straße 33
40472 Ratingen
DEUTSCHLAND

Petzower Straße 8
14542 Werder (Havel) OT Glindow
DEUTSCHLAND

Tel: +49(0)21 02/12-0 Fax: +49(0)21 02/12-17 77
E-mail: powertech@de.abb.com
Internet: http//www.abb.de/mediumvoltage

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