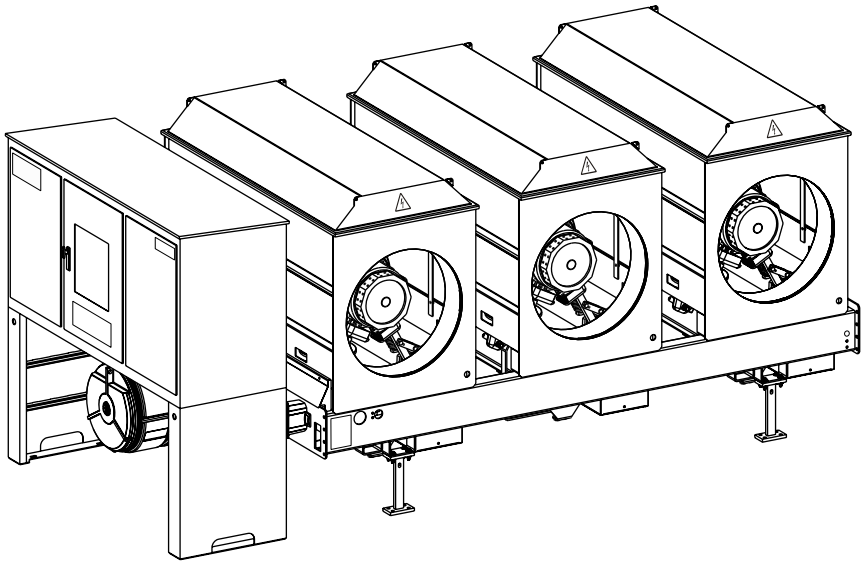
1HC0066311 AA E01 en

Operating Manual

Generator Circuit-Breaker System HECS-100M



© Copyright 2008 ABB. All rights reserved.

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

Table of contents

1 General

This section is addressed to all target groups and contains general and introductory information about the manufacturer and this document.

1.1 Manufacturer and customer support

1.1.1 Manufacturer

ABB Switzerland Ltd, High Voltage Products, hereafter named manufacturer. The address follows hereafter and is mentioned additionally on the last page of this document.

ABB Switzerland Ltd
High Voltage Products, High Current Systems
Brown-Boveri-Strasse 5
CH-8050 Zurich/Switzerland

www.abb.ch

1.1.2 Customer support

If you need to contact the manufacturer‘s customer support you will need additional information about the product at your premises:

– Section 2.2 Product data, page 27

24-hour call centre	+41 (0)844 845 845
Service fax	+41 (0)58 588 18 22
Service mail	gcb_service@ch.abb.com

1.2 Target groups

The operation and handling of the product:

- has to be carried out by certified technicians
- has to be carried out under observance of the valid standards and national directives

The plant officer/operating company is responsible for the assignment of certified and skilled technicians and the observance of all valid standards.

This document addresses plant officers/operating companies, certified and skilled technicians respectively.

It is incumbent on the plant officers/operating companies, to prompt further measures for the operation and handling of the product.

1.2.1 Definition

Plant officer/ operating company

A person and/or company respectively who is authorised to bear the direct responsibility for the operation of the plant. If necessary, some obligations as a consequence of this responsibility may be assigned to other persons.

Work officer

A person who is authorised to bear the direct responsibility for the work. If necessary; some obligations as a consequence of this responsibility may be assigned to other persons.

Certified technician

A person who has been trained at the manufacturer's premises for the respective type of the product and which has obtained a certificate after the successful finishing of the training. Certified technicians are trained and audited at regular intervals by the manufacturer.

The manufacturer offers appropriate training modules for the various possible works on the product. The levels are:

- operator
- certified commissioner
- certified overhauler
- certified supervisor

See summary in Tab. 1-1 Overview training modules, page 15.

Skilled technician	A person with suitable technical training, knowledge, and experience, enabling the person to recognise and avoid dangers arising from the product.
Instructed labourer	A person who has been sufficiently trained by skilled technicians, in order to avoid dangers arising from the product.
Layperson	A person who does not belong to one of the above groups and who has not been trained to avoid dangers arising from the product.

1.2.2 Training modules

The following training modules are available:

Modules and qualification as	**Certificate**	**Qualification per training module and product type**
Operator	Confirmation of participation in a course	Can assume control from the main control desk and from local and is able to carry out maintenance work as defined in this document.
Commissioner	Certificate “Commissioner” valid for 24 months	After an assigned number of commissionings performed under survey of a supervisor, the commissioner can perform further commissionings in own responsibility.
Overhauler	Certificate “Overhauler” valid for 24 months	After an assigned number of revisions performed under survey of a supervisor, the overhauler can perform further revisions and re-commissionings in own responsibility.
Supervisor	Certificate “Commissioner” and/or “Overhauler” with 5 years experience	Possesses “Commissioner” and/or “Overhauler” certificate with 5 years experience. Can supervise and advise “Commissioner” and/or “Overhauler”.

Tab. 1-1 Overview training modules

1.3 Document

This document gives information about the product and provides safety instructions for persons, product and environment. Plant specific executions of the product are not described herein:

– Section 1.3.6 Additional documents, page 21.

1.3.1 Identification

Title, product, and product type are shown in the header:

–	Title	Operating Manual
–	Product	Generator Circuit-Breaker System
–	Type	HECS-100M

The document identification is shown in the footer:

–	Document ID	1HC0066311
–	Revision index	AA
–	Language	E01 en

1.3.2 Validity

The document is valid for the described product at the date of delivery.

1.3.3 Purpose

The document describes the product. The document is an aid for the target groups addressed in the itemised sections. It is not a substitute for the training on the product.

The document shall enable the target group:

– to plan the work and the deployment of manpower

– to perform work safely and properly

The document must be read and understood by the addressed target groups.

1.3.4 Contents overview

The sections in the document are structured according to the life cycle of the product during its utilisation. Each section is assigned to certain target groups. The addressed target groups are mentioned at the beginning of the section.

Section title	Content
General	General and introductory information about the manufacturer, target group and document
Product description	General introductory information about the product, equipment options and product data
Safety instructions	Summary of the general valid safety regulations
Design and function	Information about the product, its design and function
Operating and indicating elements	Operating modes and basics on the operating and indicating elements
Erection	Information for first-time erection
Operation	Operating modes and fault signals are described.
Maintenance	Maintenance schedule and maintenance work are described, by indicating which activities are due at which intervals.
Packaging	Basics on packaging
Storage	Basics on storage
Transport	Basics on transportation
Disposal	Basics on disposal

Tab. 1-2 Contents overview

The following stages of the product life cycle are supervised by certified commissioners, overhaulers or supervisors and are not covered by this document:

– commissioning
– service
– overhaul
– decommissioning

1.3.5 Presentation conventions

1.3.5.1 Orientation guide

The header gives text elements, which shall assist the user as an orientation when reading.

The header shows at the inside margin:

– document title
– product name and type

The header shows at the outside margin:

– section, level 1
– section, level 2

The footer shows, read from inside to outside margin:

– ABB wordmark®
– document identification, revision index and language code
– page number

1.3.5.2 Text elements

Continuous text, lists and action sequences are considered text elements.

Lists

Lists are marked with bullets or dashes. Items of the list placed on the same level are of equal importance.

Example: Section 1.3.5.1 Orientation guide, page 18.

Action sequences

Action sequences describe the procedures to perform complex tasks, for example in maintenance. An action sequence typically comprises a group of single action steps, help for orientation, and intermediate information. The individual steps of an action sequence are numbered. An action step may be composed of handling procedures.

Reading and understanding action sequences

An introduction may give an orientation prior to action steps that are to be carried out.

1. First action step

   Result of the action step

   – or –

   Orientation prior to the next action step to be carried out.

2. Second action step consisting of:

   a) Handling procedure a)

   b) Handling procedure b)

3. Third action step

Record the tasks carried out in the maintenance report form.

Fig. 1-1 Example of an action sequence

1.3.5.3 Cross references and markups

The document contains cross references. Cross references are marked blue and are visible in colour print and on screen. In electronic documents, e.g. in the file format “pdf”, the target of a cross reference can be accessed by clicking the cross reference with the mouse key. The following types of cross references are used:

– Section 1 General, page 13
  refers to a main or sub-section within the document starting on the indicated page.
– Fig. 1-1 Example of an action sequence, page 19 or Fig. 1-1, page 19
  refers to an image or figure. “Fig.” stands for figure.
– Tab. 1-2 Contents overview, page 17 or Tab. 1-2, page 17
  refers to information represented in tabular form. “Tab.” stands for table.

1.3.5.4 Illustrations

Illustrations are commented in legends following the illustration. Illustrations are not to scale.

1.3.5.5 Values and units

Values above 1000 are displayed without dividers for thousands. A dot “.” is used as the decimal point.

Units are presented according to the International System of Units, SI. Base units, their multiples or sub-units are used.

1.3.5.6 Residual risks and safety instructions

Despite technical and design measures, residual risks remain which are not shown on the product. These residual risks are pointed out in this document.

Safety instructions are placed above the description of the relevant situation. A symbol associated with a signal word classifies the residual risk.

Each safety instruction contains:

– a brief description of the residual risk
– instructions to avoid the risk

The following classes of safety instructions are distinguished:

CAUTION
The symbol shown on the left with the signal word CAUTION is used to indicate a general hazardous situation which may cause damage to property.

WARNING
The symbol shown on the left with the signal word WARNING is used to indicate a general hazard that may cause injuries and damage to property.

DANGER
The symbol shown on the left with the signal word DANGER is used to indicate an imminent hazardous situation which, if not avoided, will result in death or serious injury and damage to property.

ENVIRONMENT
The symbol shown on the left with the signal word ENVIRONMENT is used to indicate a potential environmental hazard.

1.3.5.7 Helpful or important information

NOTE

The symbol on the left with the signal word NOTE points out helpful or important information.

1.3.6 Additional documents

There is a separate document for:

- the hydraulic spring operating mechanism
- transport instructions

NOTE

There are differences between some instructions given in this document and corresponding instructions in the document for the hydraulic spring operating mechanism. The differences particularly concern the intervals of scheduled maintenance.

- The instructions given in this document override the instructions in the document for the hydraulic spring operating mechanism.

1.3.6.1 Plant specific documents

NOTE

Plant specific information is not covered by this document. Details of the specific product installed are covered by plant specific documents. Refer to the plant officer/operating company for these documents:

- list of plant specific documents
- outline drawings
- control schematic, typically including:
  - mimic diagram
  - interlocking diagram
  - wiring diagram
  - interface description
  - list of components and devices
- test reports
- packing list

1.3.6.2 Safekeeping of documents

The plant officer/operating company is bound to have the necessary documents and documentation readily available in close vicinity of the product.

1.4 Trademarks

The company and brand names mentioned in this document, as well as the product and type designations are property of the particular holder and are subject to protection by company, brand, and patent and competition laws.

2 Product description

This section is addressed to all target groups.

2.1 Introduction

This section contains technical data of the product.

NOTE

The plant specific layout and the plant specific documents are decisive for the product. See Section 1.3.6.1 Plant specific documents, page 21.

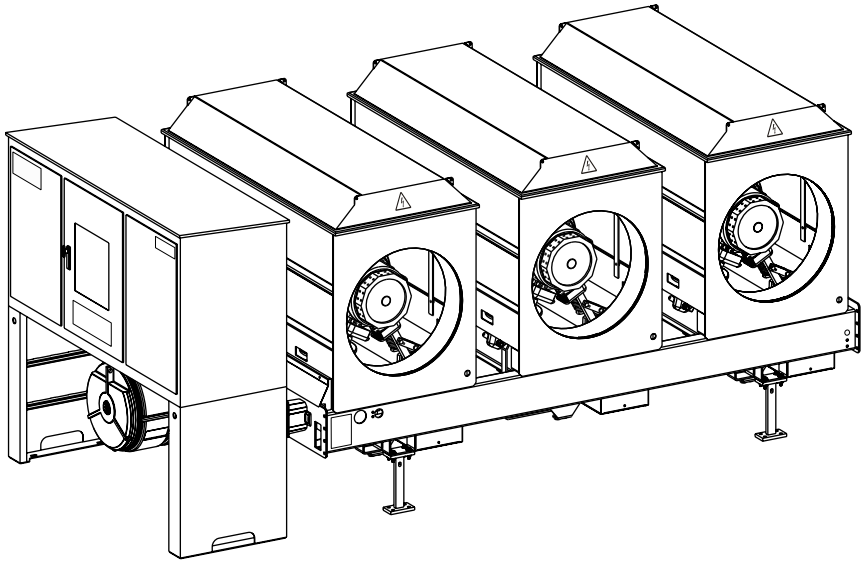


Fig. 2-1 Generator Circuit-Breaker System HECS-100M

2.1.1 Intended use

The product has to be used solely within high current applications, such as power plants in the area as agreed upon.

The product has to be operated and maintained within the limits as set out throughout this document. It is not allowed to modify the product.

All other use without previous written consent by means of a special technical release by the manufacturer is considered as misuse.

2.1.2 Conformity and safety

The product has been designed and assembled by the manufacturer according to state-of-the-art technology. The product consists of enclosed units. The units are touch proof regarding the live components. Health and safety concerns – as governed by laws, ordinances, and directives – have been taken into consideration, in particular in the area of:

- fire hazards
- gas emissions
- noise emissions
- electromagnetic compatibility (EMC)

More details on specific safety measures can be found in Section 3 Safety instructions, page 51 and in the other relevant sections of this document.

The ruling applicable international standards for performance, conformity, and safety of the product, assemblies and components are listed below:

Generator circuit-breaker system

– IEC 62271-1 (replaces IEC 60694) High-voltage switchgear and controlgear - Part 1: Common specifications

Circuit-breaker

– IEEE C37.013 IEEE standard for AC high-voltage generator circuit breakers rated on a symmetrical current basis

– IEC 62271-100 High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers

Disconnector and earthing switches

– IEC 62271-102 High-Voltage Switchgear and Controlgear - Part 102: Alternating current disconnectors and earthing switches

Capacitor

– IEC 60358 Coupling capacitors and capacitor dividers

Current and voltage transformers

– IEEE C57.13 Requirements for Instrument Transformers
– IEC 60044-1 Instrument transformers - Part 1: Current transformers
– IEC 60044-2 nstrument transformers - Part 2: Inductive voltage transformers

Surge arrester

– IEEE C62.11 IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV)
– IEC 60099-4 Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems

SF6 gas

– IEC 60376 Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
– IEC 60480 Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use

Enclosure protection

– IEC 60529 Degrees of Protection Provided by Enclosures (IP Code)

2.1.3 Product labelling

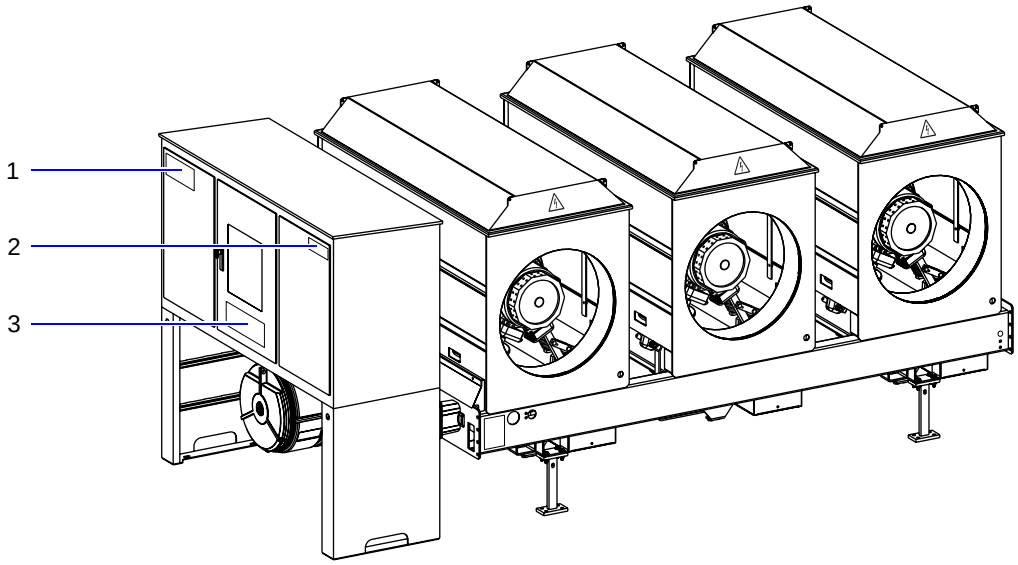


Fig. 2-2 Labelling on a Generator Circuit-Breaker System HECS-100M

1 Manufacturer logo
2 Product name
3 Rating plate

2.2 Product data

NOTE

The product data is indicated on the rating plate.

– Section 2.1.3 Product labelling, page 26

Whenever you contact the customer support you will be asked for additional information about the specific product.

1. Copy the relevant data into the table below to have them available whenever needed.

Product	**Data rating plate**
Name	
Type	
Year	
ABB Order no.	
Serial number(s)	1HC2 . . .

Tab. 2-1 Product data according to rating plate

2.2.1 Dimensions

For data of dimensions see:

– Section 1.3.6.1 Plant specific documents, page 21

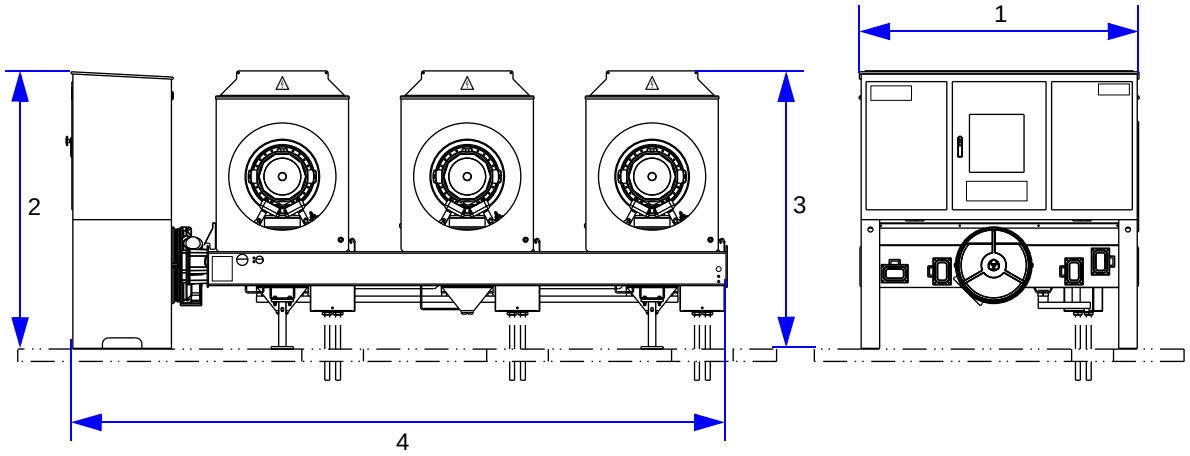


Fig. 2-3 Dimensions of the product, front and side view

1 Depth
2 Height of control cubicle
3 Height of product enclosure and pole frame
4 Width

2.2.2 Weights

Total weight can be taken from the rating plate. Additional data on weights are contained in the shipping / transportation documents:

– Section 1.3.6.1 Plant specific documents, page 21.

2.3 Performance characteristics and technical data

Hereafter, only the performance characteristics of the product are given.

Performance characteristics of the product may vary according to the plant specific configuration of assemblies and optional components.

For the plant specific performance characteristics of the product see rating plate.

– Section 2.1.3 Product labelling, page 26

2.3.1 Generator circuit-breaker system

Rated frequency	50/60	Hz
Rated normal current at 40 °C		
at 50 Hz rated frequency	10.5	kA
at 60 Hz rated frequency	10.3	kA
Rated voltage	25.3	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak
Rated short-time withstand current	100	kA
Rated peak withstand current	300	kA peak
Rated duration of short-circuit	3	s
Insulating medium	air	
Pressure	atmospheric	

2.3.1.1 Circuit-breaker

Technical data according to IEEE C37.013.

Serial number, refer to the rating plate	1HC2 ....-10	
Rated frequency	50/60	Hz
Rated normal current at 40 °C		
at 50 Hz rated frequency	10.5	kA
at 60 Hz rated frequency	10.3	kA
Rated voltage	25.3	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak
Rated short-circuit current, symmetrical	100	kA
DC component	75	%
Rated short-time withstand current	100	kA
Rated peak withstand current	300	kA peak
Rated duration of short-circuit	3	s
Assigned out-of-phase switching current	50	kA
Rated interrupting time	≤67	ms
Insulating and quenching medium	SF6 gas	

Operating mechanism of circuit-breaker:

– Section 2.3.1.3 Hydraulic spring operating mechanism, page 32

2.3.1.2 Gas and gas equipment

Gas

Technical data according to IEC 60376 and IEC 60480.

Insulating and quenching medium	SF6 gas	
Quantity for 3 phases	11	kg
Density settings for operation and insulation:		
Rated filling density	40.7	kg/m^3
Alarm density	36.1	kg/m^3
Minimum functional density	34.7	kg/m^3
Corresponding pressure settings for operation and insulation at 20 °C:		
Rated filling pressure at 20 °C	620	kPa (abs)
Alarm pressure at 20 °C	560	kPa (abs)
Minimum functional pressure at 20 °C	540	kPa (abs)

Micro switch terminals of density monitoring switch

Three micro switches are factory-set at dropping density and must be evaluated for switchgear interlocking:

Micro switch	Meaning	Signal name
Number 1 [a]	Density fallen below minimum functional density	`SF6 BLOCKING CLOSE / TRIP I`
Number 2	Density fallen below alarm density	`SF6 LOW DENSITY`
Number 3 [a]	Density fallen below minimum functional density	`SF6 BLOCKING TRIP II`

a: For safety reasons minimum functional density is monitored by two independent micro switches, `SF6 BLOCKING CLOSE / TRIP I` and `SF6 BLOCKING TRIP II`

Density indicator

Measuring gauge of class 1.0 if the following conditions are fulfilled:

Temperature range:	-20…+70	°C

No temperature differences between:
interrupting chamber and density indicator

2.3.1.3 Hydraulic spring operating mechanism

Type	HMB 4.5	
Serial number, refer to the rating plate	1HC2 . . . . -11	
Trip coils, variant 1:		
Rated voltage	110–125	V DC
Resistance	36	Ω
Motor, variant 1:		
Rated voltage	110–125	V DC
Peak current	30	A peak
Operating current	6	A
Trip coils, variant 2:		
Rated voltage	220–250	V DC
Resistance	154	Ω
Motor, variant 2:		
Rated voltage	220–250	V DC
Peak current	20	A peak
Operating current	3	A

See Section 1.3.6 Additional documents, page 21.

Safety relevant micro switch terminals

The following micro switches must be evaluated for switchgear interlocking:

Spring travel	Meaning	Signal name
S1 (23 - 24)	Spring travel of the disc springs below closing threshold	BLOCKING C
S1 (03 - 04) [a]	Spring travel of the disc springs below opening threshold	BLOCKING O TRIP I
S1 (13 - 14) [a]	Spring travel of the disc springs below opening threshold	BLOCKING O TRIP II

a: For safety reasons the blocking range of spring travel is monitored by independent micro switches for TRIP I and TRIP II.

Auxiliary switch	Meaning	Signal name
S0 (01 - 02)	Circuit-breaker: switching position OPEN	OPEN
S0 (03 - 04)	Circuit-breaker: switching position CLOSE	CLOSE TRIP I
S0 (13 - 14)	Circuit-breaker: switching position CLOSE	CLOSE TRIP II

2.3.1.4 Capacitor

Type: BIORIPHASO, TF AT 0.13/36

Layout: Aluminium foil/polypropylene film.

Technical data: Ratings according to IEC 60358.

Rated capacitance	130	nF
Rated voltage	36	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak

2.3.1.5 Disconnector

Technical data according to IEC 62271-102.

Serial number, refer to the rating plate	1HC2 ....-20	
Rated frequency	50/60	Hz
Rated normal current at 40 °C		
at 50 Hz rated frequency	10.5	kA
at 60 Hz rated frequency	10.3	kA
Rated voltage	36	kV
Rated short-duration power-frequency withstand voltage, common value	80	kV
Rated short-duration power-frequency withstand voltage, across the insulating distance	88	kV
Rated lightning impulse withstand voltage, common value	150	kV peak
Rated lightning impulse withstand voltage, across the insulating distance	165	kV peak
Rated short-time withstand current	100	kA
Rated peak withstand current	300	kA peak
Rated duration of short-circuit	3	s
Insulating medium	air	
Pressure	atmospheric	
Electrical switching capability	none	

Drive of disconnector:

– Section 2.3.1.6 SDM drive, page 35

2.3.1.6 SDM drive

Type: HF 710 4 B5

Layout: 3 phase asynchronous motor

Technical data

Rated frequency	50/60	Hz
Rated voltage	400	V AC
Peak current	20	A peak
Operating current	2	A
Operating time	2	s

Safety relevant micro switch terminals

The following micro switches must be evaluated for switchgear interlocking:

Meaning	**Signal name**[a]
Connected switching element CLOSE	QXX CLOSE
Connected switching element OPEN	QXX OPEN
Access key removed	QXX NOT OPERATED BY KEY

a: QXX represents the connected switching element:
Q9 disconnector, Q81 and Q82 earthing switches, and Q91 starting switch

2.3.1.7 Control cubicle

The control cubicle is equipped with standard units for electric and electronic control and monitoring of the switching elements. For connective wiring standard terminal blocks are provided.

2.3.1.8 Earthing switch – optional

Technical data according to IEC 62271-102.

Serial number, refer to the rating plate	1HC2 ....-30 1HC2 ....-40	
Rated frequency	50/60	Hz
Rated voltage	36	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak
Rated short-time withstand current	130	kA
Rated peak withstand current	360	kA peak
Rated duration of short-circuit	1	s
Insulating medium	air	
Pressure	atmospheric	
Electrical switching capability	none	

Drive of earthing switch:

– Section 2.3.1.6 SDM drive, page 35

2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional

Technical data according to IEC 62271-102.

Serial number, refer to the rating plate	1HC2 ....-30	
Rated frequency	50/60	Hz
Rated normal current at 40 °C	2.5	kA
Short-time current, 5 min	9.5	kA
Rated voltage	36	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak
Rated short-duration power-frequency withstand voltage during operation as short-circuiting connection	2.5	kV
Rated short-time withstand current	130	kA
Rated peak withstand current	360	kA peak
Rated duration of short circuit	1	s
Insulating medium	air	
Pressure	atmospheric	
Maximum temperature of short-circuiting connection	200	°C
Breaking capability at 0.5 Hz and 10 V	100	A
Making capability at 0.5 Hz and 10 V	5250	A
Breaking capability at rated frequency and 500 V	100	A
Making capability at rated frequency and 500 V	5250	A

Drive of earthing switch with motor operated short-circuiting connection:

– Section 2.3.1.6 SDM drive, page 35

2.3.1.10 Starting switch – optional

Technical data according to IEC 62271-102.

Serial number, refer to the rating plate	1HC2 ....-50	
Rated frequency	50/60	Hz
Rated normal current at 40 °C	1.8	kA
Short-time current, 30 min	3.2	kA
Rated voltage	7.2	kV
Rated short-duration power-frequency withstand voltage	20	kV
Rated lightning impulse withstand voltage	40	kV peak
Rated short-time withstand current	104	kA
Rated peak withstand current	285	kA peak
Rated duration of short circuit	1	s
Insulating medium	air	
Pressure	atmospheric	
Capacitive switching capability	0.5	A

Drive of starting switch:

– Section 2.3.1.6 SDM drive, page 35

2.3.2 Optional components

2.3.2.1 Current transformer

Type: IORAZN

Layout: Primary winding: Main conductor of product.
Secondary winding: Ring core current transformer with a maximum of three cores.

Technical data: Ratings according to IEC 60044-1 and/or IEEE C57.13.

Rated insulation level for primary winding:

Highest voltage for equipment	36	kV
Rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak

2.3.2.2 Voltage transformer

Types:

Without fuse	EPR 20Z, EPR 20ZA, EPR 30Z
With fuse	EPR 20FB

Layout: Inductive voltage transformer with a maximum of two secondary windings

Technical data: Ratings according to IEC 60044-2 and/or IEEE C57.13.

Rated insulation level for types EPR 20Z, EPR 20ZA, EPR 20FB:

Highest system voltage	24	kV
Maximum rated short-duration power-frequency withstand voltage	60	kV
Rated lightning impulse withstand voltage	125	kV peak

Rated insulation level for type EPR 30Z:

Highest system voltage	36	kV
Maximum rated short-duration power-frequency withstand voltage	80	kV
Rated lightning impulse withstand voltage	150	kV peak

2.3.2.3 Surge arrester

Types	Polim-H..N		
Layout	Metal-oxide surge arrester with silicon housing		
Technical data	Ratings according to IEC 60099-4 and/or IEEE C62.11.		
	Nominal discharge current I_n (8/20 μs)	20	kA
	High current impulse I_{hc} (4/10 μs)	100	kA
	Energy absorption capacity	13.3	kJ/kV$_{Uc}$
	Long duration current impulse (2 ms)	1350	A
	Rating ranges:		
	Continuous operating voltage U_c	4–36	kV
	Rated voltage U_r	5–45	kV
	Residual voltage at I_n	13–115	kV

2.4 Power supply, interfaces, connections

See Section 1.3.6.1 Plant specific documents, page 21.

2.4.1 Control cubicle

Power supply

- Power supply for the control cubicle is provided by the operating company.

Interfaces

- The control cubicle is equipped with terminal blocks as interfaces for direct wiring.

Connections

- The control cubicle is connected to the main control desk.
- According to the plant specific configuration it is connected to the following elements of the product:
  - Density monitoring switch
  - Hydraulic spring operating mechanism
  - SDM drives
  - Optional components:
    - Current transformers
    - Voltage transformers

2.4.2 Density monitoring switch

Power supply

- The control circuits are supplied by the control cubicle.

Connections

- Multicore, screened cable.

2.4.3 Hydraulic spring operating mechanism

Power supply

- The pump motor and the control circuits are supplied by the control cubicle.

Connections

- Multicore, screened cables with plug connectors.

2.4.4 SDM drives

Power supply

- Motor and control circuits are supplied by the control cubicle.

Connections

- Multicore, screened cable with plug connector.

2.4.5 Optional components

Current transformers and voltage transformers components must be connected in accordance with the plant specific documents.

2.5 Ambient conditions

2.5.1 Indoor installation

The operating conditions comply with indoor installation of switchgear and controlgear according to IEC 62271-1.

Ambient air temperature without reduction of rated normal current,		
without SF6-heaters	-25…+40	°C
with SF6-heaters	-40…+40	°C
Maximum ambient air temperature		
with reduction of rated normal current	+50	°C
Maximum altitude above sea level		
without reduction of insulating levels	1000	m
Air pollution level according to IEC 60815:		
(I - Light, II - Medium, III - Heavy, IV - Very Heavy)		
without special technical release:	I	
with special technical release:	II, III, IV	
Relative humidity		
monthly average	≤90	%
24 hours average	≤95	%

2.5.2 Outdoor installation

The operating conditions comply with outdoor installation of switchgear and controlgear according to IEC 62271-1.

Ambient air temperature without reduction of rated normal current,		
without SF6-heaters	-25…+40	°C
with SF6-heaters	-40…+40	°C
Maximum ambient air temperature		
with reduction of rated normal current	+50	°C
Maximum solar radiation		
with reduction of rated normal current	1000	W/m^2
Maximum altitude above sea level		
without reduction of insulating levels	1000	m
Air pollution level according to IEC 60815:		
(I - Light, II - Medium, III - Heavy, IV - Very Heavy)		
without special technical release:	II	
with special technical release:	III, IV	
Maximum ice coating	20	mm
Maximum wind speed	50	m/s
Maximum snow load	2.7	kPa

2.5.3 Seismic qualification

Classification on the basis of the guides for seismic qualification of high voltage alternating current circuit-breakers, IEC 61166 and IEC 62271-2:

Qualification level	AF5

2.5.4 During storage

Corrosion protection must be considered, see Section 9.3.3 Temporary corrosion protection, page 212.

Maximum ambient air temperature	+80	°C
Minimum ambient air temperature	-50	°C

Packed, see Section 9 Packaging, page 209

Relative humidity	≤100	%

Unpacked

Relative humidity		
monthly average	≤90	%
24 hours average	≤95	%

Air pollution level according to IEC 60815:
(I - Light, II - Medium, III - Heavy, IV - Very Heavy)

indoor installation	
without special technical release	I
with special technical release	II, III, IV
outdoor installation	
without special technical release	II
with special technical release	III, IV

2.5.5 During transport

Corrosion protection must be considered, see Section 9.3.3 Temporary corrosion protection, page 212.

Maximum ambient air temperature	+80	°C
Minimum ambient air temperature	-50	°C

Packed, see Section 9 Packaging, page 209

Relative humidity	≤100	%
Acceleration		
value	≤150	m/s^2
duration	≤10	ms

Unpacked

Relative humidity		
monthly average	≤90	%
24 hours average	≤95	%

Air pollution level according to IEC 60815:
I - Light, II - Medium, III - Heavy, IV - Very Heavy

indoor installation	
without special technical release	I
with special technical release	II, III, IV
outdoor installation	
without special technical release	II
with special technical release	III, IV

Acceleration		
value	≤50	m/s^2
duration	≤10	ms

2.5.6 Gas containers

Containers are used for storage and transportation of SF6 gas. It is the responsibility of the SF6 supplier to provide gas in appropriate containers, according to local regulations and international transport regulations.

The mass of SF6 content has to be stated on each container.

1. Observe the supplier’s safety data sheets and safety instructions.

2.6 Resistivity

2.6.1 Protection class

Degree of protection according to IEC 60529:

	Protection class:
Enclosure of the product	IP 65
Control cubicle	IP 55
Hydraulic spring operating mechanism	IP 54
SDM drive	IP 54
Terminal box of starting switch	IP 43

2.6.2 Immissions

Connection of additional electrical elements in the grid of the operating company may influence the performance of the product.

Please contact the manufacturer for feasibility and clarification. Any connection of additional elements requires a special technical release by the manufacturer.

For further information refer to:

– Section 1.3.6 Additional documents, page 21
– Section 2.1.2 Conformity and safety, page 24
– Section 2.5 Ambient conditions, page 43

2.6.3 Emissions

With regard to emissions, please refer to

– Section 1.3.6 Additional documents, page 21
– Section 2.1.2 Conformity and safety, page 24

2.7 Scope of delivery

Quantity and type of equipment vary in accordance with plant specific configuration.

– Section 6.2.2.1 Standard accessories, page 127
– Section 1.3.6.1 Plant specific documents, page 21

Equipment of the product

Maximum permissible number of individual assemblies and components:

– Tab. 2-2 Possible equipment options, page 49

If surge arresters are built-in, the possible number of voltage transformers varies:

– Tab. 2-3 Combinations of surge arresters and voltage transformers, page 50

Assemblies, components	**per generator circuit-breaker system**	**per phase**
Circuit-breaker	1	
Hydraulic spring operating mechanism HMB 4.5	1	
Disconnector	1	
Control cubicle	1	
Earthing switches [a]	0–2	
Starting switch	0–1	
SDM drives	1–4	
Capacitors – Type BIORIPHASO/TF AT 0.13/36		2
Current transformers – Type IORAZN		0–2
Voltage transformers [b, c] – Type EPR 20Z – Type EPR 20ZA – Type EPR 20FB with fuse – Type EPR 30Z		 0–6 0–6 0–4 0–4
Surge arresters [b] – Type Polim H..N		 0–2
Sets of flexible connections		2

Tab. 2-2 Possible equipment options

a: As a variant, the earthing switch on the generator side of the product can be replaced by an earthing switch with short-circuiting connection.

b: If surge arresters are built-in, the possible number of voltage transformers varies according to Tab. 2-3 Combinations of surge arresters and voltage transformers, page 50.

c: Voltage transformers are always of one type within a generator circuit-breaker system.

	Quantity of voltage transformers per phase			
Quantity of surge arresters per phase	**EPR 20Z**	**EPR 20ZA**	**EPR 20FB with fuse**	**EPR 30Z**
1	0–5	0–5	0–3	0–3
2	0–4	0–4	0–2	0–2

Tab. 2-3 Combinations of surge arresters and voltage transformers

3 Safety instructions

This section is addressed to all target groups. The safety instructions must be read and understood by all target groups.

3.1 Introduction

This section contains a summary of the safety instructions. Further safety instructions are assigned to the sections, where they are applicable in the respective context.

NOTE

Observe safety standards

Legislatory regulations, international standards and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

3.2 Product safety

The production of the product complies with valid international standards, dangerous situations might nevertheless arise. The product must only be used in a faultless condition, under consideration of the plant specific documents.

Operation and operating of the product must be carried out by certified technicians.

Refer also to:

– Section 1.2 Target groups, page 14.
– Section 1.3.6 Additional documents, page 21.
– Section 2.1.1 Intended use, page 24.
– Section 2.1.2 Conformity and safety, page 24.
– Section 3.7 Obligations of the plant officer/operating company, page 67.

3.3 Product protection

CAUTION

Keep off the equipment

The equipment or parts thereof may be damaged by your weight.

1. Do not step on protruding parts of the equipment.
2. Do not step on any components inside the enclosure.

CAUTION

Do not operate the circuit-breaker with insufficient SF6 gas filling density

In addition to insulating and quenching functions an adequate gas density is necessary to absorb mechanical forces. Operations with insufficient gas filling density damage the mechanics of the circuit-breaker even if no currents are switched.

1. Only operate the circuit-breaker if the filling density of SF6 gas is in the range GREEN, see Section 5.2.1 Density indicator SF6, page 108.

CAUTION

Protect the product against pollutants and moisture

Pollutants and moisture might damage the product.

1. Do not expose the product to environmental conditions incompatible with those specified in Section 2.5 Ambient conditions, page 43.
2. Do not unpack the product unless adequate environmental conditions can permanently be provided.
3. Pack the product if it is already unpacked and adequate environmental conditions cannot permanently be provided,
   see Section 9 Packaging, page 209.

3.4 Product safety signs

3.4.1 Protective earth sign

The sign for protective earth connection indicates possible earthing points. The following earthing points are marked:

- 2 earthing points on the pole frame
- 2 earthing points on the control cubicle

Both, the pole frame and the control cubicle must be earthed separately.

Correct earthing of the product:

- Only one (1) earthing point of the control cubicle must be connected to protective earthing.
- Only one (1) earthing point of the pole frame must be connected to protective earthing.

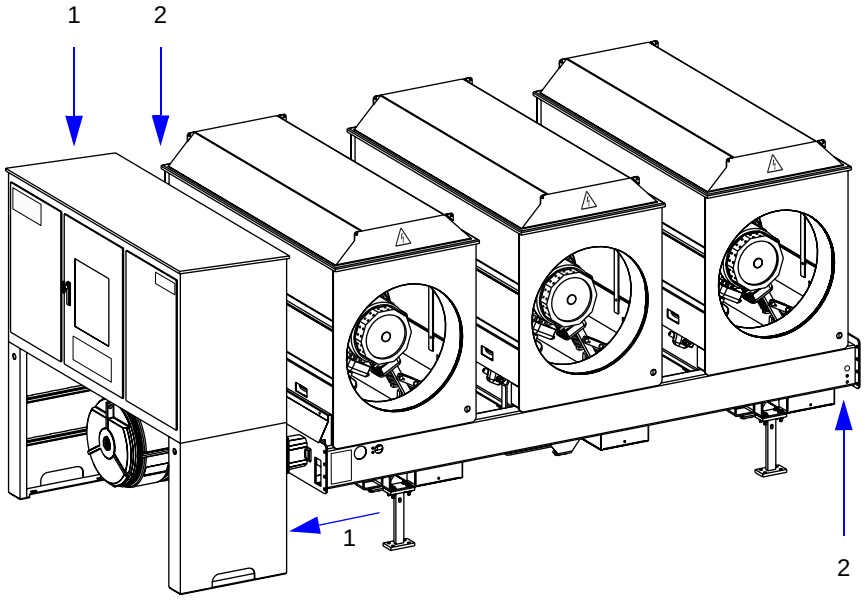


Fig. 3-1 Possible protective earth connections

1 Protective earth signs on the control cubicle
2 Protective earth signs on the pole frame

3.4.2 Hazardous voltages

DANGER

Electrocution

High voltage symbols indicate that hazardous voltages are present inside of the product enclosure. If parts of the enclosure are opened or removed, electric flashover to personnel and objects may lead to death.

1. Do not open or remove any parts of the enclosure:
   - if the generator side is energised
   - if the transformer side is energised
   - with optional starting switch:
     if the static frequency converter is energised
   - if the product is in operation

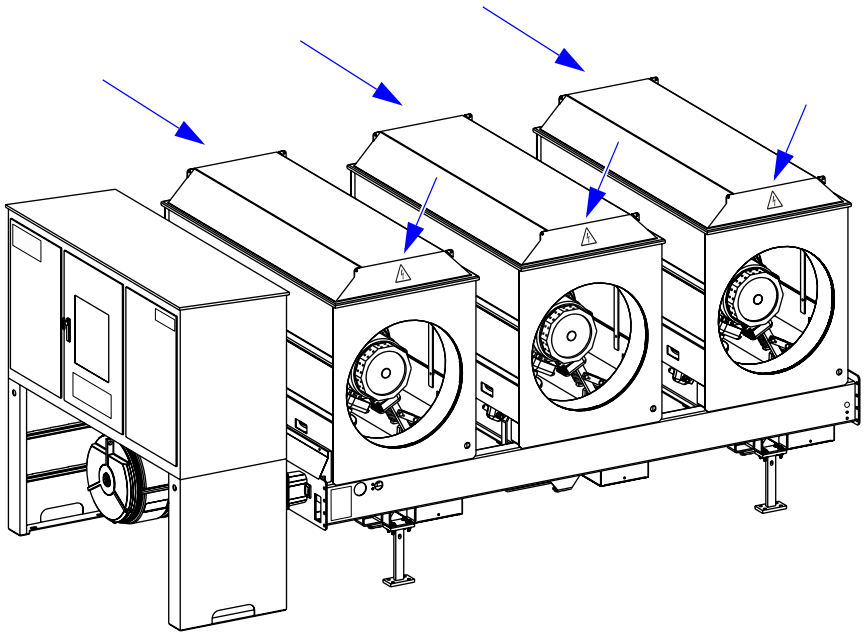
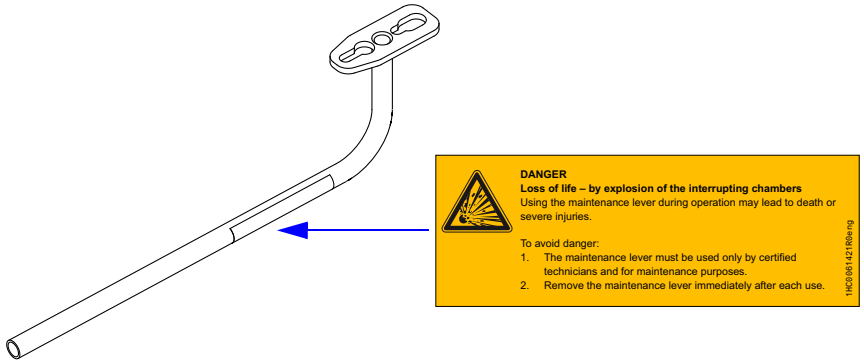


Fig. 3-2 Hazardous voltages

3.4.3 Remove maintenance lever

The maintenance lever can be used to manually actuate the circuit-breaker for maintenance purposes. The lever must not be used during operation.

The label is also attached to the pole frame.



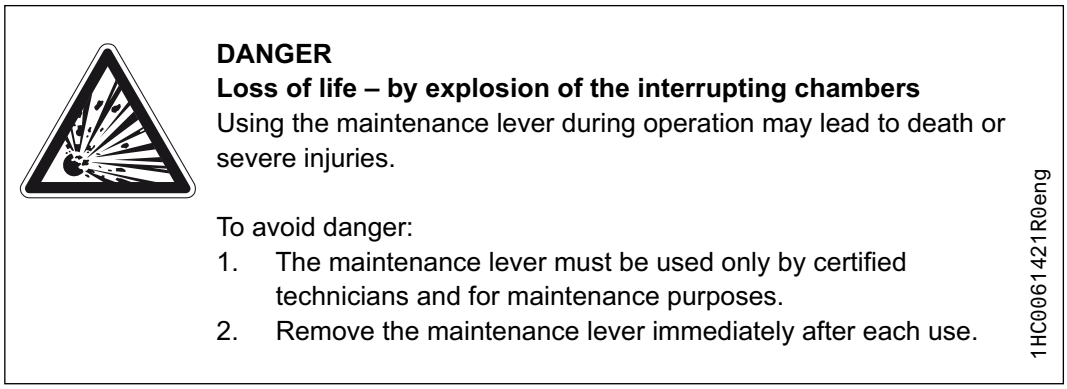


Fig. 3-3 Label “Remove maintenance lever”

3.4.4 Danger, read operating manual

DANGER

Unauthorised use of hand crank

Unauthorised use of hand crank may cause explosion of the switching element connected to an SDM drive:

- Make sure that the hand crank is secured against misuse and loss by means of securing pin and padlock.
- The hand crank may only be used for maintenance purposes.
- Before using hand crank read:
  - Section 5 Operating and indicating elements, page 107
  - Section 7 Operation, page 157

The labels are attached to the pole frame, next to the holding device for the hand crank.

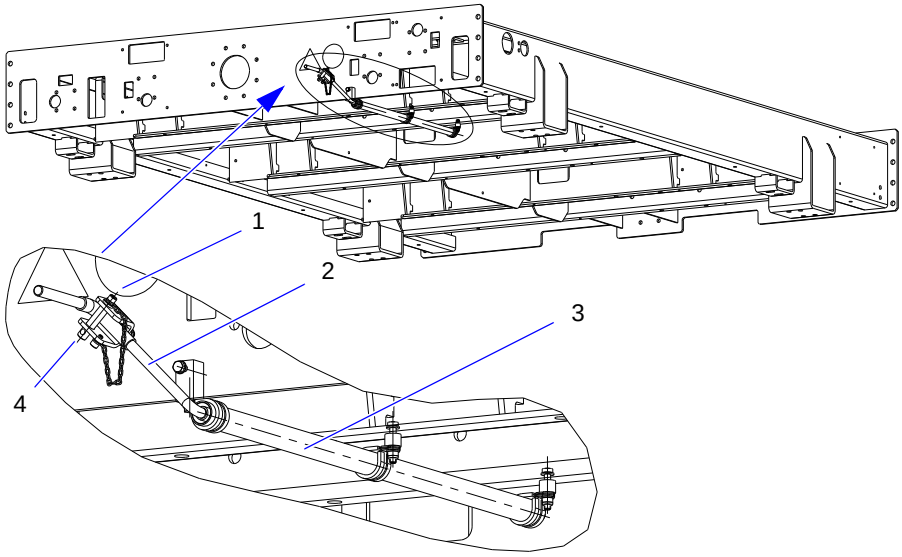


Fig. 3-4 Holding device for hand crank, overview and detail

1 Securing pin with chain
2 Hand crank
3 Tube
4 Hole for padlock

3.5 Hazardous areas

The extent of hazardous areas varies during the product life cycle according to:

- the respective location of the product,
- the energisation status of the product.

Hazardous areas are not only defined by their dimensions but also by the life cycle itself, e.g. hazard areas during operation differ from hazard areas during maintenance.

During operation the operating linkages underneath the pole frame might switch at any time.

During operation protective covers must not be removed. Special attention must be paid to following parts:

- product enclosures
- cover of the hydraulic spring operating mechanism
- covers of the SDM drives

3.5.1 Product specific hazards

The following table summarises the existing hazards during the product life cycle. Non-observance of the hazards may cause harms covering the range from small injuries to explosion.

Due to plant specific conditions the resultant risks cannot generally be specified and the risks may vary from plant to plant.

Residual hazards during product life cycle	Hazard							Target group				
	Electrocution	Electric shock	Explosion	Noise	Temperature	Bruises	Suffocation	Plant officer/Operating company	Operator	Commissioner	Overhauler	Supervisor
General								x	x	x	x	x
Product description								x	x	x	x	x
Safety instructions								x	x	x	x	x
Design and Function								x	x	x	x	x
Operating and indicating elements								x	x	x	x	x
Erection		x			x	x		x				
Commissioning	x	x	x	x	x	x	x			x	x	x
Operation	x		x	x	x	x	x	x	x	x	x	x
Maintenance	x	x	x	x	x	x	x	x	x		x	x
Overhaul	x	x	x	x	x	x	x				x	x
Packaging						x		x				
Storage						x		x				
Transport						x		x				
Decommissioning	x		x	x	x	x	x				x	x
Disposal						x		x				

Tab. 3-1 Residual hazards during product life cycle and respective target groups addressed

Documentation of the individual phases of the product life cycle is addressed to target groups with special training and product knowledge.

Reading and understanding the corresponding documents by the respective target groups effectively reduces the residual risk.

To avoid or reduce each individual hazard there are basic and easy to follow safety rules described below.

DANGER

Electrocution – power installation

Hazardous voltages are present inside of the product enclosure. Electric flashover to personnel and objects may lead to death.

1. Do not open or remove any parts of the enclosure:
   - if the generator side is energised
   - if the transformer side is energised
   - with optional starting switch:
     if the static frequency converter is energised
   - if the product is in operation
2. Prerequisites to open the enclosure:
   - generator disconnected or shut down
   - transformer disconnected or earthed
   - with optional starting switch:
     static frequency converter disconnected or earthed
   - conductors of isolated-phase bus earthed
   - power supply and control voltage of product disconnected

DANGER

Explosion during operation

Any switching operation with insufficient gas filling density may cause explosion of an interrupting chamber.

1. Only operate the circuit-breaker if the filling density of SF6 gas is in the range GREEN, see Section 5.2.1 Density indicator SF6, page 108.

If the number and/or nature of switching operations exceed the limits given within this document any further operation may cause explosion of an interrupting chamber.

1. Be aware of the consequences resulting from switching operations.
2. Observe the maintenance schedule to keep the product in its functional condition. See Section 8 Maintenance, page 175.

DANGER

Explosion hazard

Operation of the drive for the disconnector:

1. Ensure that the circuit-breaker is open if the drive for the disconnector is operated.
   – Section 4.4.3.3 Operation of the disconnector, page 102

Operation of the drives for earthing switches:

1. Ensure that earthing switches are not closed towards live conductors.

Operation of the drive for an earthing switch with short-circuiting connection:

1. Ensure that the earthing switch does not switch currents exceeding the values specified:
   – Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

The hand crank must only be used by certified technicians for maintenance purposes!

DANGER

Electric shock – hazardous supply voltages

Assemblies of the product are energized with hazardous voltages.

Contact with live parts may lead to severe injuries or possible death.

1. Do not remove any protective covers if an assembly is energized.

WARNING

Noise along with switching operations

The hydraulic spring operating mechanism may switch at any time. Unexpected switching operations may cause hearing damages.

1. Protect your ears by wearing ear protection during operation.

WARNING

Bruises

Unexpected switching operations may cause injuries by movements of operating linkage.

1. Never stay underneath the pole frame:
   – during operation
   – during commissioning, maintenance and overhaul, if the hydraulic spring operating mechanism is charged and/or if a SDM drive is in the motorised operation mode

3.5.2 Working with SF6 gas

It must be avoided that solid and/or gaseous products of decomposition are released into the environment. The recommendations given in IEC 60376, IEC 60480, and IEC 61634 should be followed to prevent any incidents.

Observe safety concepts and legislatory regulations:

– Section 3.7 Obligations of the plant officer/operating company, page 67

DANGER

Unconsciousness and suffocation

SF6 gas is heavier than air and can accumulate in lower lying, unventilated rooms where it will displace atmospheric air, with the result that people entering these rooms may be endangered by unconsciousness and suffocation.

Gas masks do not protect against shortage of oxygen!

1. Check rooms which can be contaminated with SF6 gas before entering.
2. If the safety of the room atmosphere cannot be established, self-contained breathing equipment must be used.

DANGER

Solid and gaseous products of decomposition

In SF6 gas switching operation induced arcing leads to the formation of solid and gaseous products of decomposition. The solid decomposition products form aggressive acids when coming into contact with atmospheric humidity or water and on contact with the body, especially skin and eyes.

Because products of decomposition may be present, used gas must be considered as potentially toxic and corrosive.

1. Observe the procedures for storage, transportation, and the use of filling equipment.
2. Wear the personal protective equipment:
   - respirator mask, self-contained breathing apparatus if necessary
   - protective clothing consisting of:
     - protective overall
     - protective gloves
     - safety shoes
   - safety glasses

DANGER

Explosion of pressurised gas containers during storage and transport

Excessive warming of pressurised gas containers can result in explosion.

Follow the supplier’s instructions and observe the following conditions for storage and transportation:

1. Store in a dry, well-ventilated room.
2. Store separately from inflammable or explosive materials.
3. Do not expose to direct sunlight.
4. Observe the maximum ambient temperature to which the containers can be subjected.
   - Take into account the design pressure and the filling density.
5. Always secure the valve with a protective cap or protective shroud.
6. Store the pressurised container above floor level to avoid contact with moisture.
7. If the pressurised container is stored upright:
   - The valve must be at the top.
   - Secure against falling.

WARNING

Frostbite during filling and reclaiming

Contact with expanding gas may result in frostbite.

1. Carefully observe the instructions for storage, transportation and the use of filling equipment.
2. Wear the personal protective equipment.

ENVIRONMENT

Greenhouse gas

SF6 gas has a severe greenhouse effect.

1. Observe the instructions for handling and storage.
2. Avoid the escape of SF6 gas into the atmosphere.

ENVIRONMENT

Products of decomposition

The gaseous decomposition products are largely adsorbed by the installed filters within a few hours of normal operation.

The solid decomposition products, so-called switching dust, mainly metal fluorides and tungsten oxifluorides, form aggressive acids when coming into contact with atmospheric humidity or water.

Switching dust and its products of reaction:

– must not escape into the environment
– must be appropriately disposed, if necessary by a professional company

3.6 Safety recommendations and standard procedures

To avoid hazardous situations the manufacturer recommends to install standard procedures such as a suitable “permit to work system” with regular reviews and audits.

To avoid electrical hazards the manufacturer recommends to comply with the “seven safety rules”.

3.6.1 Permit to work system

The permit to work system represents a written and formalised process to reduce risks. The permit itself should at least specify:

– the persons responsible for the overall permit and for individual steps of the permit to work
– the time for which the permit is valid
– any permitted time extension to complete the work
– details of the work to be carried out
– where the work must be carried out
– any limitations on the work, the work location, or the equipment
– details of the controls/precautions required
– emergency procedures
– the individual responsibilities
– how the permit is to be cancelled

The permit to work summarises:

• the precautions that have been taken to create a safe working area

The permit to work requires duly signed confirmations by:

• the plant officer/operating company who issues the permit to work.
  The approved signatory confirms with signature that:
  – the equipment is handed over in a safe condition
• the person who is responsible for carrying out the work.
  The approved signatory confirms with signature that:
  – he/she has understood the content
  – he/she now is responsible to keep a safe work location

Clearance and cancellation require duly signed confirmations by:

- the person who is responsible for carrying out the work.
  The approved signatory confirms with signature that:
  - he/she has withdrawn all assisting persons
  - he/she has informed all assisting persons that the permit to work is cleared
  - the work has been completed
  - the working area has been restored to safety
- the plant officer/operating company who issued the permit to work.
  The approved signatory confirms with signature that:
  - the permit to work is cancelled

3.6.2 The seven safety rules

1. Clearly identify the work location.
   a) The location for working has to be clearly identified for each step of the working sequence.
2. Disconnect and secure against reconnection.
   a) Disconnect from all possible points of supply.
   b) Secure by means of locking mechanisms marked with appropriate tags.
3. Protect against any other live parts.
   a) Exposed live equipment must be protected by additional physical barriers (locks, insulating screens, etc.).
   b) Attach warning notices to all possible working places that must not be touched, even if you are not going to work on these working places.
   c) Check again that the correct work location has been identified; maintain step 1.
4. Take special precautions when being close to bare conductors.
   a) Slips or accidental movements might result in contact.
   Even distances of more than a metre might not always be safe.
   b) When opening a cover:
   Beware of bare conductors under the cover.
   c) Wear insulating gloves.

5. Check the installation is dead.
   a) Use a proper test instrument.
   b) Check the test instrument before testing.
   c) During the test: Take precautions to keep clear of the connections.
   d) Recheck the test instrument after the test.
6. Carry out earthing.
   a) Earthing ensures the equipment is free of any residual charge or induced voltages.
7. Issue a permit to work, see Section 3.6.1 Permit to work system, page 64.
   a) The plant officer/operating company signs the permit to prove:
      – that the equipment is handed over in a safe condition
   b) The person receiving the permit (work officer, certified technician) signs the permit to confirm that:
      – he/she has understood the content
      – he/she is responsible to keep a safe work location; see step 1
   c) The permit to work only expires after it is cancelled.
      – Clearance and cancellation must be signed by the person receiving the permit and the plant officer/operating company.

3.7 Obligations of the plant officer/operating company

Legislatory regulations and guidelines of the plant officer/operating company regarding work safety and accident prevention must be strictly observed.

The plant officer/operating company must ensure that all valid safety requirements are met at any time. The observation of the valid applicable standards must be ensured.

The allocation of rights and duties for self dependent realisation of tasks is the responsibility of the plant officer/operating company.

Operation and operating of the product must be carried out by certified technicians in line with Section 1.2 Target groups, page 14.

The plant officer/operating company is not allowed to modify the product. The manufacturer must be informed about malfunctions and damages of his product:

– Section 1.1 Manufacturer and customer support, page 13

3.7.1 Minimisation of residual risks

Despite technical and design measures residual risks remain. The manufacturer recommends to establish a standard procedure by implementing an access authorisation scheme, including:

- physical means, such as:
  - barriers with warning signs
- systematic means, such as:
  - permit to work
  - safety precautions
  - the seven safety rules
- personnel means, such as:
  - personal protective equipment
  - training, skills, knowledge

3.7.1.1 Safety precautions

DANGER

Electromagnetic radiation

Persons wearing heart pace makers and/or hearing aids must be warned:

- Persons wearing heart pace makers must not be admitted.
- Persons wearing hearing aids must turn off the hearing device.

The manufacturer recommends to establish an access authorisation scheme.

Access:

- for authorised personnel only
- for reasons of health:
  Persons with devices sensitive to electromagnetic interference (cardiac pace makers, hearing aids, etc.) must not stay nearby the product.

3.7.1.2 Safety measures

The manufacturer recommends to establish a standard procedure by implementing safety requirements and precautions. The standard procedure should include regular and repeated training of personnel.

3.7.1.3 Personnel instructions

The allocation of rights and duties for self dependent realisation of tasks is the responsibility of the plant officer/operating company.

The operating manual must be read and understood.

3.7.1.4 Personnel protection

The plant officer/operating company must provide personal protective equipment, such as:

- respirator mask, self-contained breathing apparatus if necessary
- protective clothing consisting of:
  - protective overall
  - protective gloves
  - safety shoes
- safety glasses
- ear protection
- safety system for work at height

3.7.2 Emergency information

Legislatory regulations and the guidelines of the plant officer/operating company regarding occupational health and safety apply.

First aid

The directives of the plant officer/operating company for first-aid-measures are effective.

4 Design and function

This section is addressed to all target groups.

4.1 Introduction

This section describes design and function of the product, its assemblies and components. The single-line diagram shows one phase of a fully equipped 3-phase system, see Fig. 4-1, page 71.

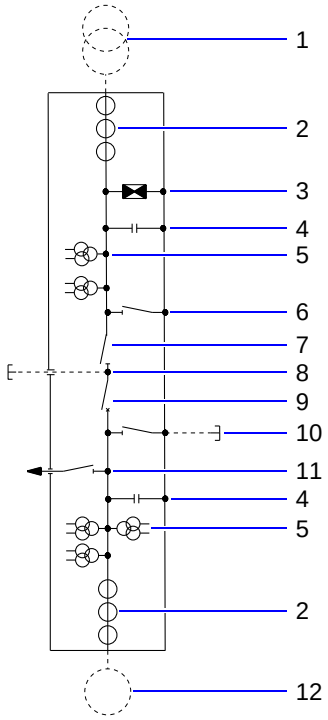


Fig. 4-1 Single-line diagram

1 Step-up transformer
2 Current transformer
3 Surge arrester
4 Capacitor
5 Voltage transformer
6 Earthing switch on transformer side
7 Disconnector
8 Manual short-circuiting connection
9 Circuit-breaker
10 Earthing switch on generator side
– or
Earthing switch with short-circuiting connection
11 Starting switch
12 Generator

Switching element	DIN 40719-2	DIN EN 61346
Circuit-breaker	Q0	QA1
Disconnector	Q9	QB9
Earthing switch on generator side	Q81	QC91
Earthing switch on transformer side	Q82	QC92
Starting switch	Q91	QB91

Tab. 4-1 Definitions of switching elements

This operating manual uses the naming conventions of DIN 40719-2.

4.2 Design

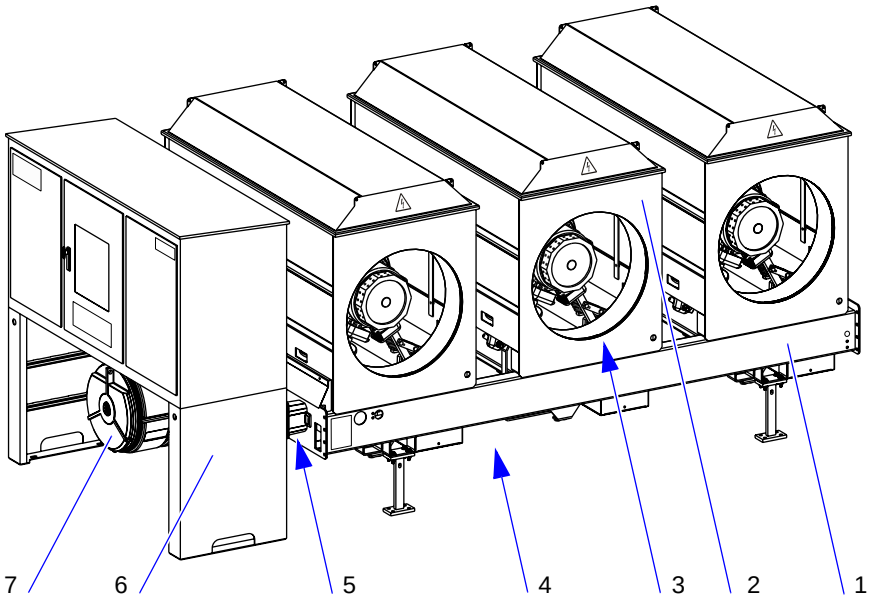


Fig. 4-2 Exterior view of generator circuit-breaker system

1 Pole frame on pole frame supports
2 Enclosure with cover
3 Each enclosure includes:
- 1 interrupting chamber of circuit-breaker
- 2 capacitors
- 1 phase of disconnector
- 1 phase of earthing switch on generator side – optional
- 1 phase of earthing switch on transformer side – optional
- 1 phase of starting switch – optional
- optional components

4 Underneath the pole frame:
- Gas equipment of circuit-breaker
- Operating linkages
- Short-circuiting connection of earthing switch on generator side – optional

5 Mounted to the pole frame:
- SDM drive for disconnector
- SDM drives for earthing switches – optional
- SDM drive for starting switch – optional

6 Control cubicle
7 Hydraulic spring operating mechanism for circuit-breaker

4.2.1 Pole frame

The pole frame is a firm steel construction mounted on four pole frame supports.

Assemblies mounted to the pole frame:

- above the pole frame:
  - three enclosures
- at the side of the pole frame:
  - hydraulic spring operating mechanism
  - SDM drives
- underneath the pole frame:
  - gas equipment of circuit-breaker
  - operating linkages
  - short-circuiting connection of earthing switch on generator side – optional

4.2.2 Enclosure

Assemblies on top of the enclosures:

- cover of enclosure

Assemblies inside of the enclosure:

- 1 interrupting chamber of the circuit-breaker
- 2 capacitors
- 1 phase of the disconnector
- 1 phase of earthing switch on generator side – optional
- 1 phase of earthing switch on transformer side – optional
- 1 phase of starting switch – optional
- optional components

Insulating medium: air

The 3 enclosures are mounted onto the pole frame. All live parts of the product are located inside of the enclosure. The enclosure of the product is welded to the enclosures of the isolated-phase bus of the plant.

Inspection windows allow visual inspection of the switching positions of the disconnector and the earthing switches.

The enclosure is electrically insulated from the pole frame. Earthing of the enclosure has to be executed according to the plant‘s internal earthing concept.

4.2.3 Circuit-breaker

The circuit-breaker comprises:

- 3 interrupting chambers
- gas equipment
- hydraulic spring operating mechanism with operating linkage
- 6 capacitors

The circuit-breaker consists of three interrupting chambers –one per phase– and an operating linkage which connects the interrupting chambers to their common operating mechanism. The gas equipment interconnects the gas compartments of the interrupting chambers.

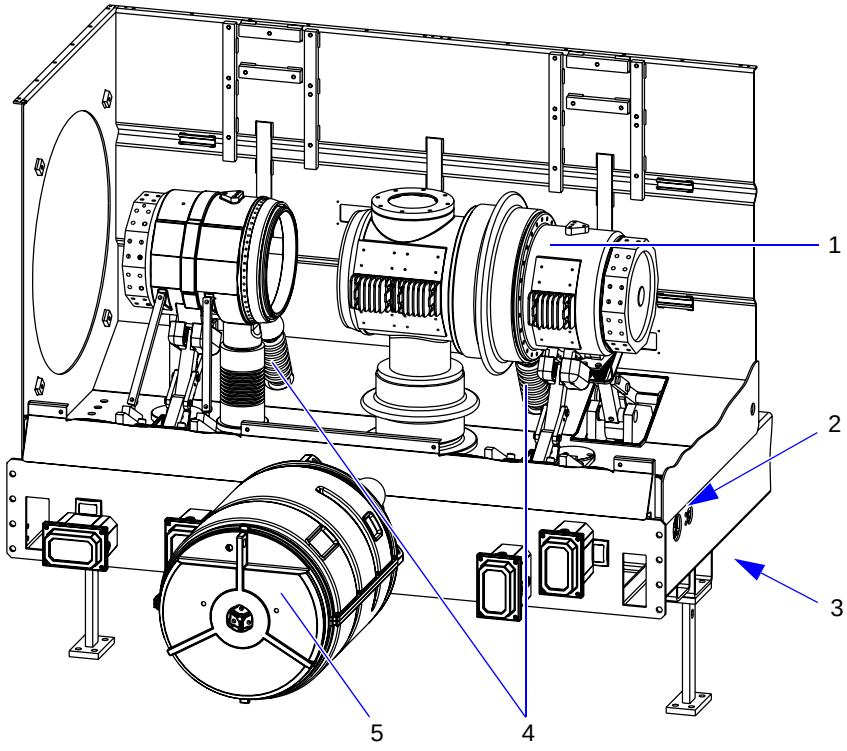


Fig. 4-3 Circuit-breaker, standard equipment

1 Interrupting chamber of circuit-breaker
2 Density indicator SF6 and filling terminal
3 Density monitoring switch, below pole frame
4 2 capacitors per phase
5 Hydraulic spring operating mechanism

4.2.3.1 Interrupting chamber

The interrupting chamber comprises:

- 2 housings, base, insulators
- nominal and arcing contact system
- gear connected to operating linkage
- insulating and quenching medium: SF6 gas

The three interrupting chambers are the live parts of the circuit-breaker, containing the contact systems for making, breaking, and carrying current. The interrupting chambers are filled with SF6 gas.

4.2.3.2 Gas equipment

The gas equipment comprises:

- copper pipework
- density monitoring switch
- density indicator
- filling terminal

The copper pipework connects the 3 interrupting chambers, the density monitoring switch, the density indicator, and the filling terminal. Self-closing gas couplings are mounted at each end of the pipework.

4.2.3.3 Operating linkage

The operating linkage consists of a long linear rod which interconnects pivotable levers on the shafts of the 3 interrupting chambers with the linearly moving operating piston of the hydraulic spring operating mechanism. The operating linkage is positioned within the framework of the pole frame and the linear shaft operates at right angles with the main current path of the product.

4.2.3.4 Hydraulic spring operating mechanism

The hydraulic spring operating mechanism is mounted to the exterior side of the pole frame. The hydraulic spring operating mechanism comprises:

- disc springs
- high-pressure oil cylinders
- hydraulic system
- quickly switching changeover valves
- operating piston, attached to the operating linkage

For further information see Section 1.3.6 Additional documents, page 21.

4.2.3.5 Capacitor

1 capacitor per phase is connected to the generator side and 1 to the transformer side of the product.

4.2.4 Disconnector

The disconnector comprises:

- 1 SDM drive with operating linkage and gear
- 3 switching units, 1 per phase
  The 3 switching units are located inside the 3 enclosures. An operating linkage underneath the pole frame interconnects the 3 switching units with the common drive of the disconnector.

Each switching unit is a horizontally arranged, air insulated switch of tubular design. In the closed position the moving contact tube engages with finger contacts at both ends. The finger contacts are arranged circularly around the housings. The contact tube is driven by the SDM drive via the operating linkage underneath the pole frame and the gear inside the enclosure.

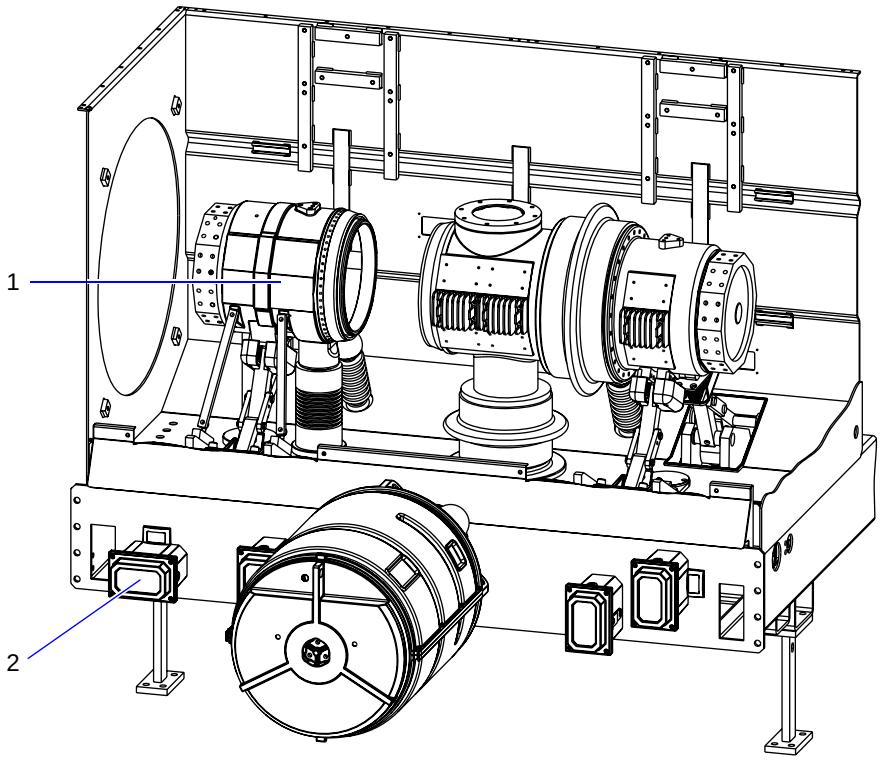


Fig. 4-4 Disconnector, standard equipment

1 Switching unit
2 SDM drive with operating linkage

4.2.5 SDM drives

One drive comprises:

- 3 phase asynchronous motor
- gearbox

A 3 phase asynchronous motor drives a gearbox which is connected to the operating linkage of either the disconnector, an earthing switch or the starting switch.

One drive is respectively connected to each of the following:

- the disconnector
- the optional earthing switch on generator side

  – or –

  the optional earthing switch with short-circuiting connection
- the optional earthing switch on transformer side
- the optional starting switch

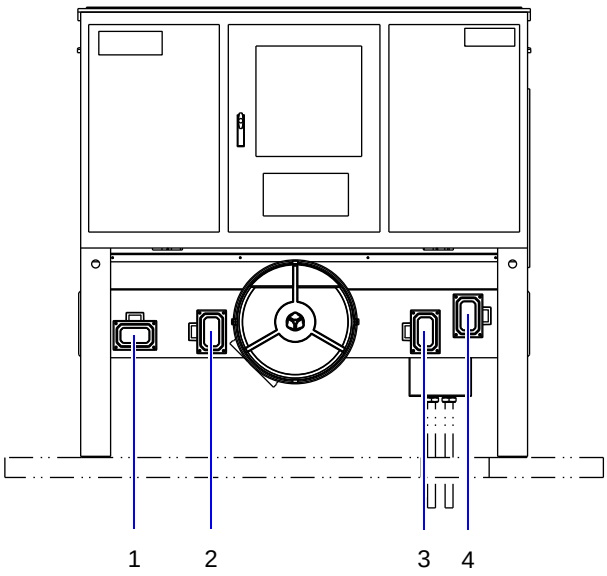


Fig. 4-5 Locations of SDM drives

1 Disconnector
2 Earthing switch on transformer side – optional
3 Earthing switch on generator side – optional
– or
Earthing switch with short-circuiting connection – optional
4 Starting switch – optional

4.2.6 Control cubicle

NOTE

Plant specific variants

The control cubicle is equipped by the manufacturer according to the plant specific product configuration. For detailled equipment see Section 1.3.6.1 Plant specific documents, page 21.

The control cubicle is a metal enclosed cabinet with three lockable front doors. It houses devices and wiring connections required for the operation and control of the generator circuit-breaker system.

The front doors are connected to the cubicle by flexible earthing connections. Inside the left side door a document tray is provided.

Light inside the control cubicle is switched by contact switches attached to the front doors. A heating system can be installed to ensure a constant temperature and to reduce humidity. Heating operation is controlled by a thermostat mounted inside the control cubicle.

The control cubicle is provided with eyelets for transport.

Central door

A frame behind the inspection window of the central front door holds the control panel. Elements of the control panel:

- mimic diagram with illuminated pushbuttons
- operation counters
- signal lamps for events and alarms
- interlocking key switch S2

Left/right door

The two doors give access to the inner compartments. Elements of the inner compartments:

- mounted panels for control devices, for example:
  - protection switches
  - miniature circuit breakers
  - relays
  - fuses
- terminal blocks as interfaces for direct wiring

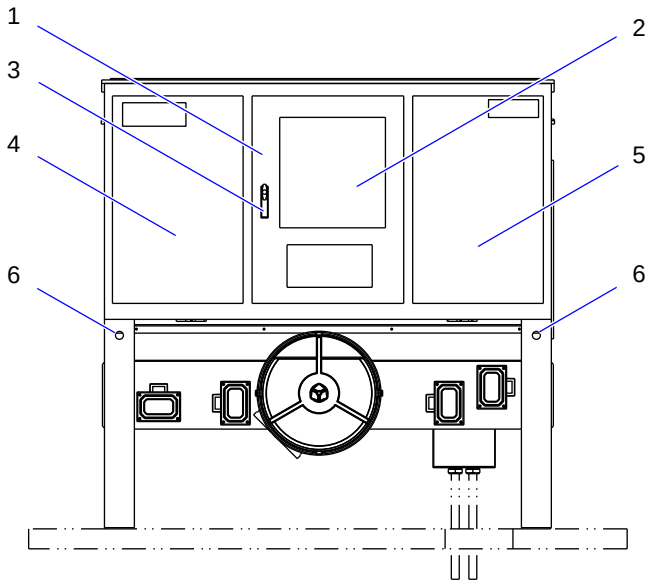


Fig. 4-6 Control cubicle, front view

1 Central front door to control panel
2 Inspection window for control panel
3 Lockable doorknob for front doors
4 Left door to inner compartment
5 Right door to inner compartment
6 Eyelet for transport

4.2.7 Optional equipment

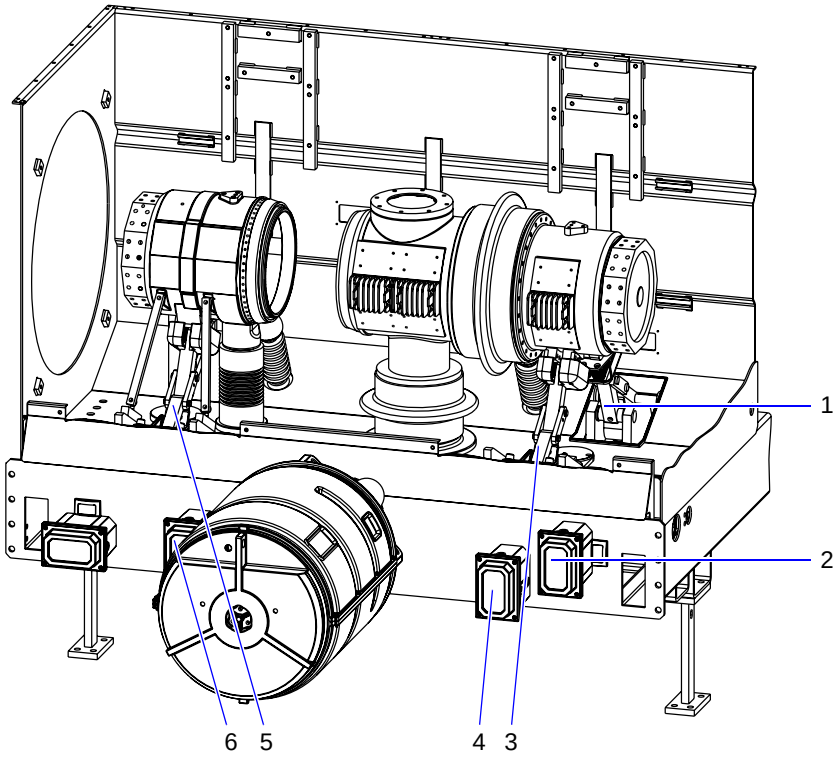


Fig. 4-7 Overview interior, optional equipment

Starting switch
1 Switching unit
2 SDM drive with operating linkage
Earthing switch on generator side on the generator side
3 Switching unit
4 SDM drive with operating linkage
and – optionally:
with short-circuiting connection
Earthing switch on transformer side on the transformer side
5 Switching unit
6 SDM drive with operating linkage

4.2.7.1 Earthing switch on transformer side

The earthing switch on transformer side comprises:

- SDM drive with operating linkage;
  see Section 4.2.5 SDM drives, page 78
- 3 switching units, 1 per phase
  The 3 switching units are located inside the 3 enclosures. An operating linkage underneath the pole frame interconnects the 3 switching units with the common drive of the earthing switch. Each switching unit comprises two contacts:
  - a pivoting contact with its pivot point fixed to the enclosure
  - a stationary contact fixed to the housing of the disconnector

4.2.7.2 Earthing switch on generator side

The earthing switch on generator side comprises:

- SDM drive with operating linkage;
  see Section 4.2.5 SDM drives, page 78
- 3 switching units, 1 per phase
  The 3 switching units are located inside the 3 enclosures. An operating linkage underneath the pole frame interconnects the 3 switching units with the common drive of the earthing switch. Each switching unit comprises two contacts:
  - a pivoting contact with its pivot point fixed to the enclosure
  - a stationary contact fixed to the interrupting chamber of the circuit-breaker
- optionally:
  short-circuiting connection interconnecting the 3 phases

4.2.7.3 Starting switch

The starting switch comprises:

- SDM drive with operating linkage;
  see Section 4.2.5 SDM drives, page 78
- 3 switching units, 1 per phase
  The 3 switching units are located inside the 3 enclosures. An operating linkage underneath the pole frame interconnects the 3 switching units with the common drive of the starting switch. Each switching unit comprises two contacts:
  - a pivoting contact with its pivot point fixed to the enclosure
  - a stationary contact fixed to the housing of the disconnector

4.2.8 Optional components

NOTE

A combination of different components may reduce the maximum permissible number of each of the selected components. For details on standard and optional equipment:

– Section 1.3.6.1 Plant specific documents, page 21.
– Section 2.7 Scope of delivery, page 48 with Tab. 2-3 Combinations of surge arresters and voltage transformers, page 50

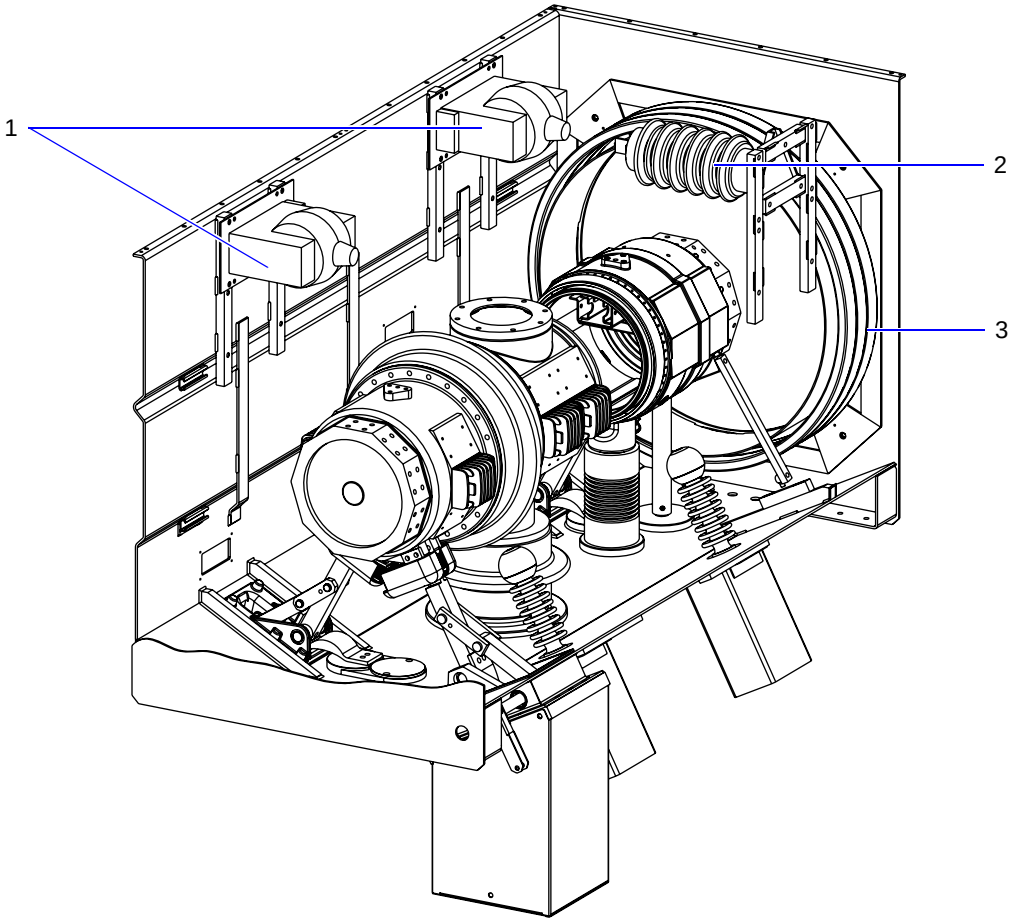


Fig. 4-8 Components, example configuration

1 Voltage transformer
2 Surge arrester
3 Current transformer

4.2.8.1 Current transformer

The current transformers are of ring-core type. Permissible number of components per phase:

- 1 current transformer on the generator side and the transformer side of the product, respectively

Each current transformer can be equipped with up to 3 cores, depending on output power and class required. The secondary windings are permanently wired to terminal blocks in the control cubicle.

4.2.8.2 Voltage transformer

The single-phase voltage transformers are of cast resin type. Voltage transformers may be installed on the generator side and/or the transformer side of the product.

Each voltage transformer can be equipped with 1 or 2 secondary windings, depending on output power and class required. The secondary windings are permanently wired to terminal blocks in the control cubicle.

Permissible number of components per phase:

– Section 2.7 Scope of delivery, page 48 with Tab. 2-2 Possible equipment options, page 49

4.2.8.3 Surge arrester

On each side of the circuit-breaker one surge arrester can be provided.

Permissible number of components per phase:

– Section 2.7 Scope of delivery, page 48 with Tab. 2-2 Possible equipment options, page 49

4.3 Function

4.3.1 Pole frame

The pole frame bears the weight of the product. Along with the enclosures it holds the components and assemblies in their required mounting positions.

4.3.2 Enclosure

The enclosure:

- provides protection:
  - against approach to or contact with live parts
  - against contact with moving parts
  - for the equipment against external influences
- carries the reverse current
- holds – along with the pole frame – the components and assemblies in their required mounting positions

4.3.3 Circuit-breaker

The circuit-breaker:

- carries the full load current of the generator and ensures the required insulation level at all times
- connects the synchronised generator with the step-up transformer
- separates the electrical connection between the generator and the step-up transformer
- interrupts load currents up to the full load current of the generator
- performs closing and opening operations under no-load conditions
- interrupts transformer-fed short-circuit currents and generator-fed short-circuit currents
- interrupts currents under out-of-phase conditions
- carries transformer-fed short-circuit currents and generator-fed short-circuit currents for a short time

4.3.3.1 Interrupting chamber

For the interruption of current the self-blast principle is used.

Separate contact systems for breaking and for continuous current carrying are used.

4.3.3.2 Gas and gas equipment

SF6 Gas

SF6 gas serves the following functions:

- insulation and quenching
- absorption of mechanical forces

An adequate gas density is necessary for both functions.

Density monitoring switch

Gas density is controlled by the density monitoring switch which provides status information to generate blocking and alarm signals. The signals are available on the interfaces of the circuit-breaker, see Section 2.3.1.2 Gas and gas equipment, page 31.

Density indicator

The density indicator facilitates to check the density of SF6 gas visually, see Section 5.2 Gas equipment, page 108.

4.3.3.3 Operating linkage

The operating linkage transmits switching forces from the hydraulic spring operating mechanism to the interrupting chambers thus operating the three interrupting chambers simultaneously.

4.3.3.4 Hydraulic spring operating mechanism

The hydraulic spring operating mechanism operates the interrupting chambers by means of stored energy.

The technical concept of the hydraulic spring operating mechanism combines the mechanical energy storage in disc springs and the hydraulic operating and control principles. The force created by the disk springs acts on high-pressure oil cylinders converting the mechanical energy into hydraulic energy. For the closing operation as well as for the opening operation a set of quickly switching changeover valves serves to transfer the hydraulic energy into a movement of the operating piston. The operating piston then actuates the operating linkage of the circuit-breaker.

NOTE

At any time the spring mechanism is mechanically pre-charged with high tension, independent of the operating condition of the hydraulic spring operating mechanism.

Status information of the hydraulic spring operating mechanism

The hydraulic spring operating mechanism provides status information to generate blocking and alarm signals. The signals are available on the interfaces of the circuit-breaker, see Section 2.3.1.3 Hydraulic spring operating mechanism, page 32.

4.3.3.5 Capacitor

Capacitors reduce the rate of rise of the transient recovery voltage appearing during switching.

4.3.4 Disconnector

The disconnector:

- carries the full load current of the generator
- ensures the required insulation levels in the closed and in the open position at all times
- performs close and open operations under no-load conditions
- carries transformer-fed short-circuit currents and generator-fed short-circuit currents for a short time

4.3.5 SDM drive

SDM drives actuate the switching movements of the disconnector, the earthing switches and/or the starting switch. The rotatory movement of the drive is converted to the active switching movement by means of gearboxes and operating linkages.

The operating panel of the SDM drive is equipped with a key locking system which comprises safety functions:

- A micro switch prevents motorised operation, if the hand crank is inserted into the corresponding opening of the operating panel and the connected switching element is manually operated.
- Other micro switches prevent motorised operation if the SDM drive is locked in the CLOSE or OPEN switching position.

An indicator next to the operating panel is mechanically coupled to the SDM drive and signals the switching position of the connected switching element.

Status information about the CLOSE or OPEN switching position is provided for switchgear interlocking.

4.3.6 Control cubicle

The control cubicle comprises the following functions:

- Function of the cubicle
  - electromagnetic shielding
- Functions of the control panel
  - selection of REMOTE or LOCAL operating mode
  - local operation
  - deactivation of switching operations from the main control desk except for TRIP II opening operation of the circuit-breaker
  - local indication of event and alarm signals
  - local indication of operation counters
- Functions of the inner compartments:
  - control power supply
  - switchgear interlocking
  - relay of control signals from the main control desk to the connected switching elements in REMOTE operating mode
  - relay of TRIP II signals to the circuit-breaker independent of the selected operating mode
  - relay of control signals from REMOTE and LOCAL operating modes to the connected switching elements
  - relay of event and alarm signals from the connected switching elements to control panel and main control desk
  - relay of customer-specific signals from components to the main control desk
  - control of heating system

Details of plant specific configuration:

– Section 1.3.6.1 Plant specific documents, page 21.

4.3.7 Optional equipment

4.3.7.1 Earthing switch on transformer side

The earthing switch on transformer side is used as a safety and protection element.

By closing the earthing switch, all or a section of the live parts inside the enclosure are solidly earthed.

The earthing switch performs the following functions.

- The earthing switch ensures the required insulation level in the open switching position at all times.
- The earthing switch performs closing and opening operations under no-load conditions.
- The earthing switch carries transformer-fed short-circuit currents for a short time.

For specifications:

– Section 2.3.1.8 Earthing switch – optional, page 36

4.3.7.2 Earthing switch on generator side

The earthing switch on generator side is used as a safety and protection element.

By closing the earthing switch, all or a section of the live parts inside the enclosure are solidly earthed.

The earthing switch performs the following functions.

- The earthing switch ensures the required insulation level in the open switching position at all times.
- The earthing switch performs closing and opening operations under no-load conditions.
- The earthing switch carries generator-fed short-circuit currents for a short time.

For specifications:

– Section 2.3.1.8 Earthing switch – optional, page 36

For calibration purposes, in the variant with short-circuiting connection:

- The earthing switch interrupts generator-fed short-circuit currents up to the values specified.
- The earthing switch makes generator-fed short-circuit currents up to the values specified.

For specifications:

– Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

4.3.7.3 Starting switch

The starting switch is used to connect a turbine-generator set to an acceleration device during start-up of the power generating unit.

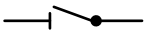
The starting switch performs the following functions.

- The starting switch ensures the required insulation levels in the closed and open switching positions at all times.
- The starting switch performs closing and opening operations under no-load conditions.
- The starting switch performs closing and opening operations under capacitive load conditions.
- The starting switch carries generator-fed short-circuit currents for a short time.

For specifications:

– Section 2.3.1.10 Starting switch – optional, page 38

Start-up principle diagrams: presentation conventions

Symbol	Meaning
	Motor/Generator
	Turbine
	Step-up transformer
	Energy flow direction
	Energy flow
SFC 	Static frequency converter
	Circuit-breaker closed
	Circuit-breaker open
	Disconnector closed
	Disconnector open

Tab. 4-2 Symbols

Abbreviation	Meaning
Q0	Circuit-breaker
Q9	Disconnector
Q91	Starting switch
SFC	Static frequency converter
HVCB	High voltage circuit-breaker

Tab. 4-3 Abbreviations

Start-up principle with static frequency converter

Example configuration

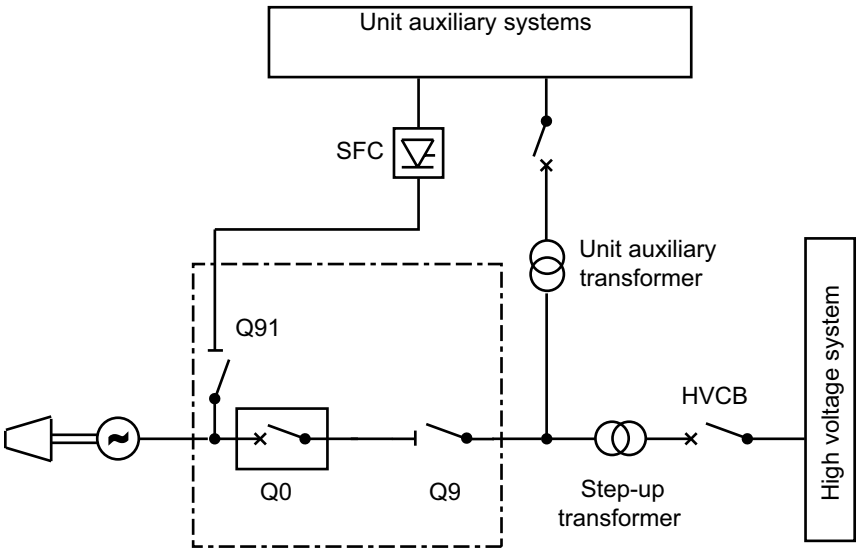


Fig. 4-9 Start-up principle with static frequency converter, overview

The following sequence of single line diagrams illustrates the stages of starting a gas turbine-generator set by means of a static frequency converter:

- acceleration by static frequency converter
- opening starting switch
- completion

Acceleration by SFC

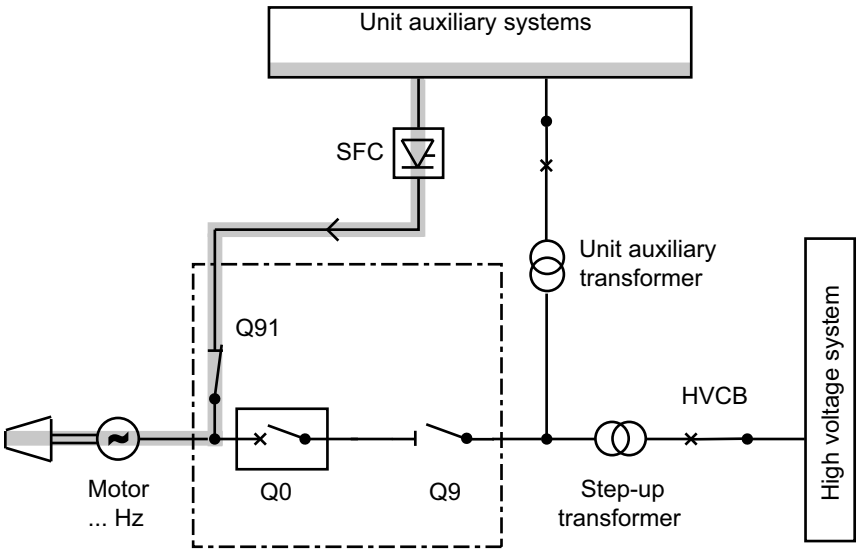


Fig. 4-10 Start-up principle with static frequency converter, acceleration by static frequency converter

Initial conditions

- Circuit-breaker Q0 is open.
- Disconnector Q9 is open.
- Starting switch Q91 is closed.

Acceleration by static frequency converter

Initially, the gas turbine-generator set is spinning at turning gear speed.

With activation of the static frequency converter, the energy for the acceleration of the gas turbine-generator set is supplied by the static frequency converter. The generator acts as a motor driving the turbine.

The frequency of the static frequency converter increases according to the demands of the start-up sequence of the turbine.

Acceleration of the turbine by the static frequency converter is finished when the turbine has reached its self-sustaining speed. The static frequency converter is deactivated.

Opening starting switch

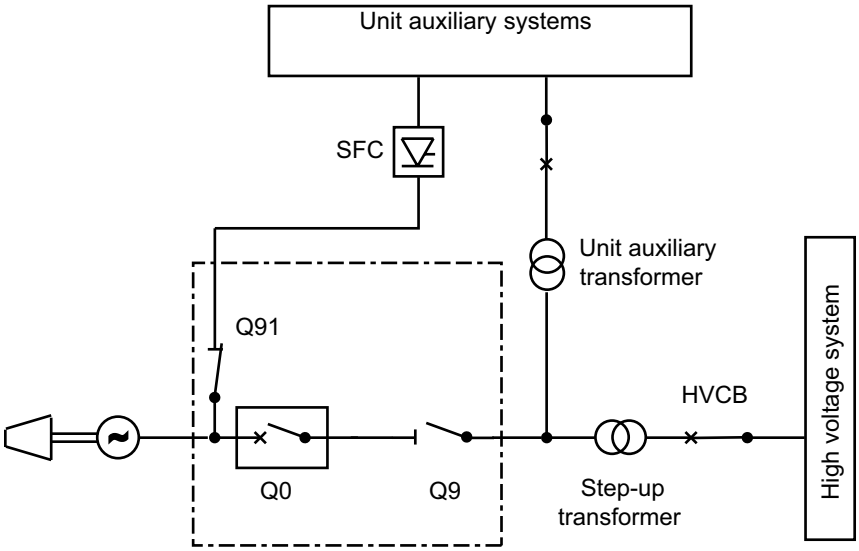


Fig. 4-11 Start-up principle with static frequency converter, opening starting switch under capacitive load conditions

Initial conditions

- Circuit-breaker Q0 is open.
- Disconnector Q9 is open.
- The turbine has reached its self-sustaining speed.
- Static frequency converter SFC is deactivated.
- Switching position of starting switch Q91 is closed.

Opening starting switch under capacitive load conditions

There is no energy flow, starting switch Q91 can be opened.

In continuation, the gas turbine-generator set accelerates to its nominal frequency, 50/60 Hz.

- The generator is ready to be connected to the high voltage system if the generator is in phase with the high voltage system.

Completion

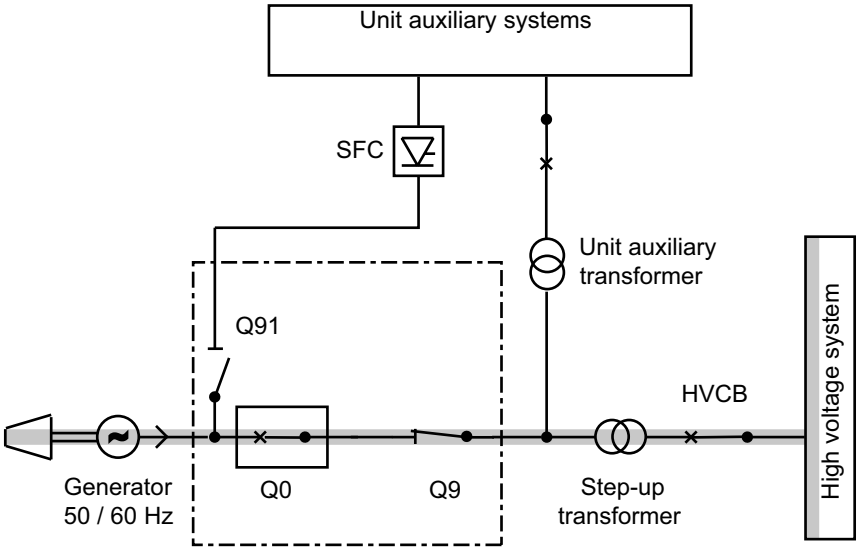


Fig. 4-12 Start-up principle with static frequency converter, completion

Preconditions

- Starting switch Q91 is open.
- The generator is in phase with the high voltage system.

Final state

- Disconnector Q9 is closed.
- Circuit-breaker Q0 is closed.

Start-up is completed and the generator is connected to the high voltage system.

4.3.8 Optional components

4.3.8.1 Current transformer

Current transformers convert primary currents into secondary currents for control and/or statistical purposes.

4.3.8.2 Voltage transformer

Voltage transformers convert primary voltages into secondary voltages for control and/or statistical purposes.

4.3.8.3 Surge arrester

Surge arresters provide protection against overvoltages.

4.4 Safety and control equipment

4.4.1 Safety concept

The safety concept considers two operating modes:

- REMOTE from the plant main control desk
- LOCAL from the control cubicle

Note that the overall safety concept and the REMOTE and LOCAL control schematic are plant specific and in the direct responsibility of the plant officer/ operating company.

4.4.2 Key locking

NOTE

Opening operations TRIP II ignore mode selection

If LOCAL mode is selected, this selection will be ignored by TRIP II signals. Thus the circuit-breaker is capable to perform opening operations TRIP II independent from mode selection.

Safekeeping of the keys and administration of access authorisation are the responsibility of the plant officer/operating company.

4.4.2.1 Interlock key

The interlock key operates the interlocking key switch S2 of the control cubicle. The interlock key enables to switch between REMOTE and LOCAL operating modes. When the interlocking key switch S2 is in LOCAL position, the key cannot be removed.

4.4.2.2 Access key of SDM drive

The access key is required to perform any operating action on the operating panel of the SDM drive. If the access key is inserted, the SDM drive cannot be operated REMOTE from the plant main control desk or LOCAL from the control cubicle.

4.4.3 Switchgear interlocking

The sections below describe the typical design of switchgear interlocking. Preconditions for switching operations are stated in each section. These preconditions include interlocking conditions of optional equipment. For details on plant specific interlocking refer to Section 1.3.6.1 Plant specific documents, page 21.

NOTE

Interlocking with control cubicles of third party manufacturers

It is the responsibility of the plant officer/operating company to install an interlocking system which effectively eliminates inappropriate switching operations.

Switchgear interlocking prevents hazardous operating conditions caused by inappropriate switching operations of the following elements:

- circuit-breaker
- disconnector
- earthing switches
- starting switch

If the product is operated in combination with the control cubicle of the manufacturer:

- The interlocking circuits are part of the circuitries which control the switching elements.
- Options for customer control and external interlocking are provided.
- The status of interlocking alarms is indicated on the signal board.

Details on signals:

– Tab. 4-1 Definitions of switching elements, page 72
– Section 2.3.1.2 Gas and gas equipment, page 31
– Section 2.3.1.3 Hydraulic spring operating mechanism, page 32
– Section 2.3.1.6 SDM drive, page 35

4.4.3.1 Circuit-breaker protection

In order to ensure safe and reliable operation of the circuit-breaker Q0 the following preconditions must always be fulfilled:

- density of SF6 gas above minimum functional density
- spring travel of the disc springs of the hydraulic spring operating mechanism above the thresholds for closing and opening operations

Fig. 4-13, page 99 and Fig. 4-14, page 99:
Closing operations CLOSE and opening operations TRIP I can be actuated either from LOCAL or from REMOTE.

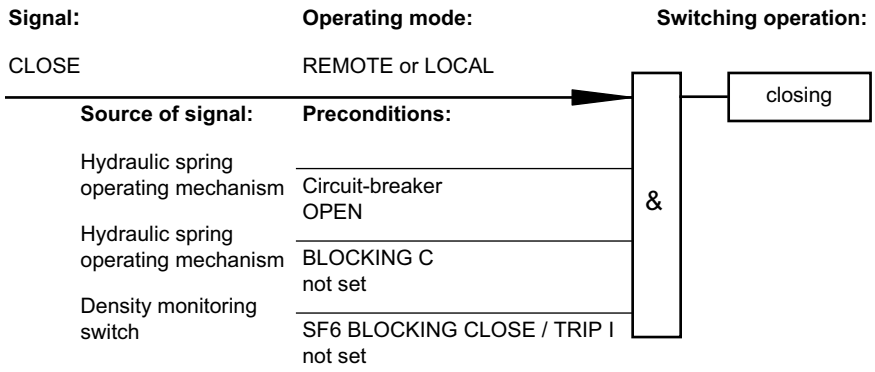


Fig. 4-13 Closing operation Q0-CLOSE

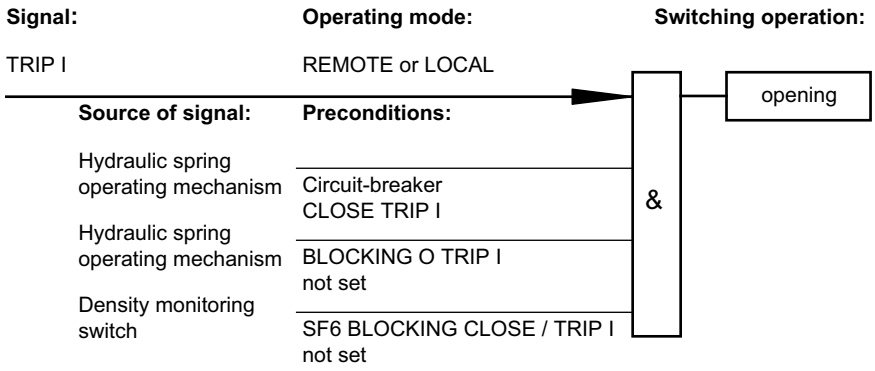


Fig. 4-14 Opening operation TRIP I

Fig. 4-15, page 100:
Opening operations TRIP II are always released from REMOTE. If the LOCAL mode is selected, this selection will be ignored by the TRIP II signal. Thus the circuit-breaker is capable to perform opening operations TRIP II independent from mode selection.

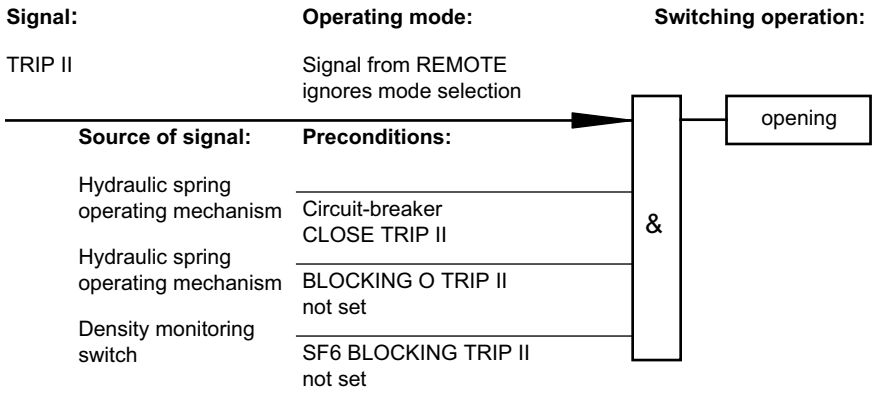


Fig. 4-15 Opening operation TRIP II

4.4.3.2 Operation of the circuit-breaker

Closing operation

REMOTE Q0-CLOSE

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: disconnector Q9 closed
- status of SDM drive: earthing switch Q81 open
- status of SDM drive: starting switch Q91 open
- conditions for circuit-breaker protection: fulfilled,
  see Fig. 4-13 Closing operation Q0-CLOSE, page 99

LOCAL Q0-CLOSE

Signal from LOCAL, interlocking key switch S2 in position LOCAL, external interlocking must ensure that the circuit-breaker is not energised

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: disconnector Q9 open
- EXTERNAL INTERLOCKING: FREE
- conditions for circuit-breaker protection: fulfilled,
  see Fig. 4-13 Closing operation Q0-CLOSE, page 99

Opening operation

`TRIP I` Signal from `REMOTE`, interlocking key switch `S2` in position `REMOTE`, under responsibility of the main control desk

– or –

Signal from `LOCAL`, interlocking key switch `S2` in position `LOCAL`

Internal interlocking:

The following precondition must be fulfilled:

- conditions for circuit-breaker protection: fulfilled,
  see Fig. 4-14 Opening operation `TRIP I`, page 99

`TRIP II` Signal from `REMOTE`, under responsibility of the main control desk

Internal interlocking:

The following precondition must be fulfilled:

- conditions for circuit-breaker protection: fulfilled,
  see Fig. 4-15 Opening operation `TRIP II`, page 100

NOTE

Unpredictable switching operations of circuit-breaker

Opening operations `TRIP II` are always released from `REMOTE`. If the `LOCAL` mode is selected, this selection will be ignored by the `TRIP II` signal. Thus the circuit-breaker is capable of performing opening operations `TRIP II` independent from mode selection.

4.4.3.3 Operation of the disconnector

NOTE

Disconnector has no switching capability

External interlocking must ensure that the disconnector is not energised during opening and closing operations.

Closing operation
Q9-CLOSE

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: disconnector Q9 open
- status of SDM drive: Q9 NOT OPERATED BY KEY
- status of hydraulic spring operating mechanism: circuit-breaker Q0 open
- status of SDM drive: earthing switch Q81 open
- status of SDM drive: earthing switch Q82 open
- EXTERNAL INTERLOCKING: FREE

Opening operation
Q9-OPEN

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: disconnector Q9 closed
- status of SDM drive: Q9 NOT OPERATED BY KEY
- status of hydraulic spring operating mechanism: circuit-breaker Q0 open
- EXTERNAL INTERLOCKING: FREE

4.4.3.4 Operation of earthing switches

NOTE

External interlocking of earthing switches:

External interlocking must ensure that earthing switches are not closed towards live conductors.

Operation of an earthing switch with short-circuiting connection:

It must be ensured that the earthing switch does not switch currents exceeding the values specified:

– Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

Earthing switch on generator side

Closing operation
Q81-CLOSE

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: earthing switch Q81 open
- status of SDM drive: Q81 NOT OPERATED BY KEY
- status of hydraulic spring operating mechanism: circuit-breaker Q0 open
- status of SDM drive: disconnector Q9 open
- status of SDM drive: starting switch Q91 open
- EXTERNAL INTERLOCKING: FREE

Opening operation
Q81-OPEN

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following precondition must be fulfilled:

- status of SDM drive: earthing switch Q81 closed
- status of SDM drive: Q81 NOT OPERATED BY KEY
- EXTERNAL INTERLOCKING: FREE

Earthing switch on transformer side

Closing operation
Q82-CLOSE

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: earthing switch Q82 open
- status of SDM drive: Q82 NOT OPERATED BY KEY
- status of SDM drive: disconnector Q9 open
- EXTERNAL INTERLOCKING: FREE

Opening operation
Q82-OPEN

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

– or –

Signal from LOCAL, interlocking key switch S2 in position LOCAL

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: earthing switch Q82 closed
- status of SDM drive: Q82 NOT OPERATED BY KEY
- EXTERNAL INTERLOCKING: FREE

4.4.3.5 Operation of starting switch

NOTE

External interlocking of starting switch:

It must be ensured that the starting switch does not switch currents exceeding the values specified. Starting switches are designed to switch capacitive loads only. Performance characteristics:

– Section 2.3.1.10 Starting switch – optional, page 38

Closing operation
Q91-CLOSE

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: starting switch Q91 open
- status of SDM drive: Q91 NOT OPERATED BY KEY
- status of hydraulic spring operating mechanism: circuit-breaker Q0 open
- status of SDM drive: earthing switch Q81 open
- EXTERNAL INTERLOCKING: FREE

Opening operation
Q91-OPEN

Signal from REMOTE, interlocking key switch S2 in position REMOTE, under responsibility of the main control desk

Internal interlocking:

All of the following preconditions must be fulfilled:

- status of SDM drive: starting switch Q91 closed
- status of SDM drive: Q91 NOT OPERATED BY KEY
- EXTERNAL INTERLOCKING: FREE

5 Operating and indicating elements

This section is addressed to the plant officer/operating company and certified technicians and gives an overview of the operating and indicating elements.

5.1 Introduction

The following assemblies of the product comprise indicating elements:

- gas equipment
- hydraulic spring operating mechanism

The following assemblies of the product comprise operating and indicating elements:

- SDM drives
- control cubicle

NOTE

Do not attempt to operate the product unless the information about the operation itself has been read, understood and trained.

The operation itself is described in Section 7 Operation, page 157.

5.2 Gas equipment

5.2.1 Density indicator SF6

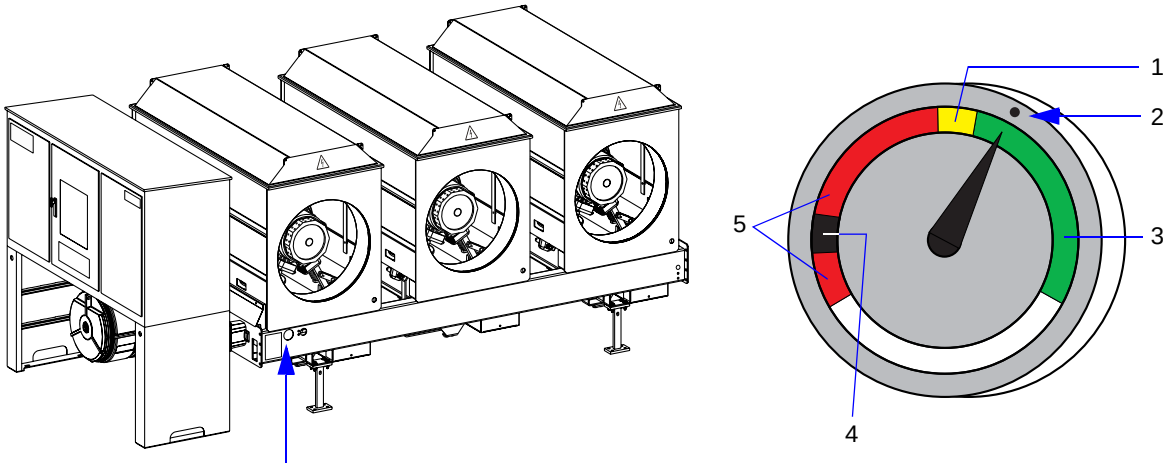


Fig. 5-1 Density indicator

1 Indication range YELLOW
2 Marking point BLACK
3 Indication range GREEN
4 Indication range BLACK
5 Indication range RED

5.2.1.1 Indication ranges

`GREEN` The green indication range is also referred to as operating range. The gas density is all right.

`YELLOW` The yellow indication range is also referred to as critical range. The gas density is critical.

`RED` The red indication range is also referred to as blocking range. The gas density is too low. The circuit-breaker must not be operated.

`BLACK` The black indication range is also referred to as transport range. During transportation the gas density must be within the transport range. The circuit-breaker must not be operated.

Values of density, refer to:

– Section 2.3.1.2 Gas and gas equipment, page 31

5.2.1.2 Marking point

`BLACK` The black marking point is referred to as rated filling density.

NOTE

Density of the SF6 gas above marking point `BLACK`

Density of the SF6 gas is correctly displayed if there are no temperature differences between interrupting chamber and density indicator. These conditions may not be fulfilled when the conductors of the product are energised.

Correct reading of the gas density is only possible with stable temperatures during down time.

Technical data of density indicator:

– Section 2.3.1.2 Gas and gas equipment, page 31

5.3 Hydraulic spring operating mechanism

Further information on the hydraulic spring operating mechanism and its signals:

– Section 1.3.6 Additional documents, page 21
– Section 2.3.1.3 Hydraulic spring operating mechanism, page 32

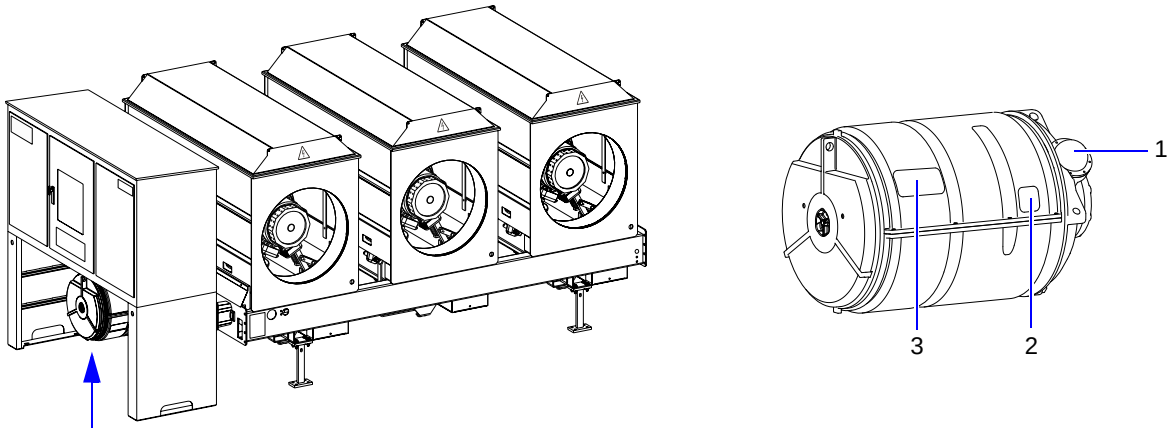


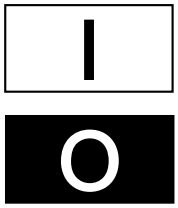
Fig. 5-2 Indicating elements of the hydraulic spring operating mechanism

1 Position indicator of the circuit-breaker
2 Inspection window for the filling level of hydraulic oil
3 Inspection window for the spring travel

5.3.1 Indicating elements

5.3.1.1 Position indicator for the circuit-breaker

The hydraulic spring operating mechanism has an indicator which shows the switching position of the circuit-breaker. The circuit-breaker can be either in the CLOSE or OPEN position.



The switching position of the circuit-breaker is displayed as follows, if not otherwise specified:

- I = ON — black on white background, circuit-breaker CLOSE
- O = OFF — white on black background, circuit-breaker OPEN

5.3.1.2 Indicator for filling level of hydraulic oil

The filling level can be observed in a gauge-glass, visible through the inspection window in the housing of the hydraulic spring operating mechanism.

The filling level is only correctly displayed if the spring mechanism is in a completely tensioned position.

5.3.1.3 Indicator for spring travel

NOTE

At any time the spring mechanism is mechanically pre-charged with high tension, independent of the operating condition of the hydraulic spring operating mechanism.

The indicator for the spring travel is visible through an inspection window in the housing of the hydraulic spring operating mechanism. The position of a white adhesive strip attached to one of the springs shows to what extent the hydraulic spring operating mechanism is charged.

5.4 SDM drive

The SDM drives are mounted to the pole frame of the product. Several drives can be provided depending on the plant specific product configuration, see Section 1.3.6.1 Plant specific documents, page 21.

Regardless of the function of the installed drives, the operating and indicating elements are identical, but differ in their mounting position.

The operating and indicating elements are arranged on the operating panel of the corresponding SDM drive and in an associated window.

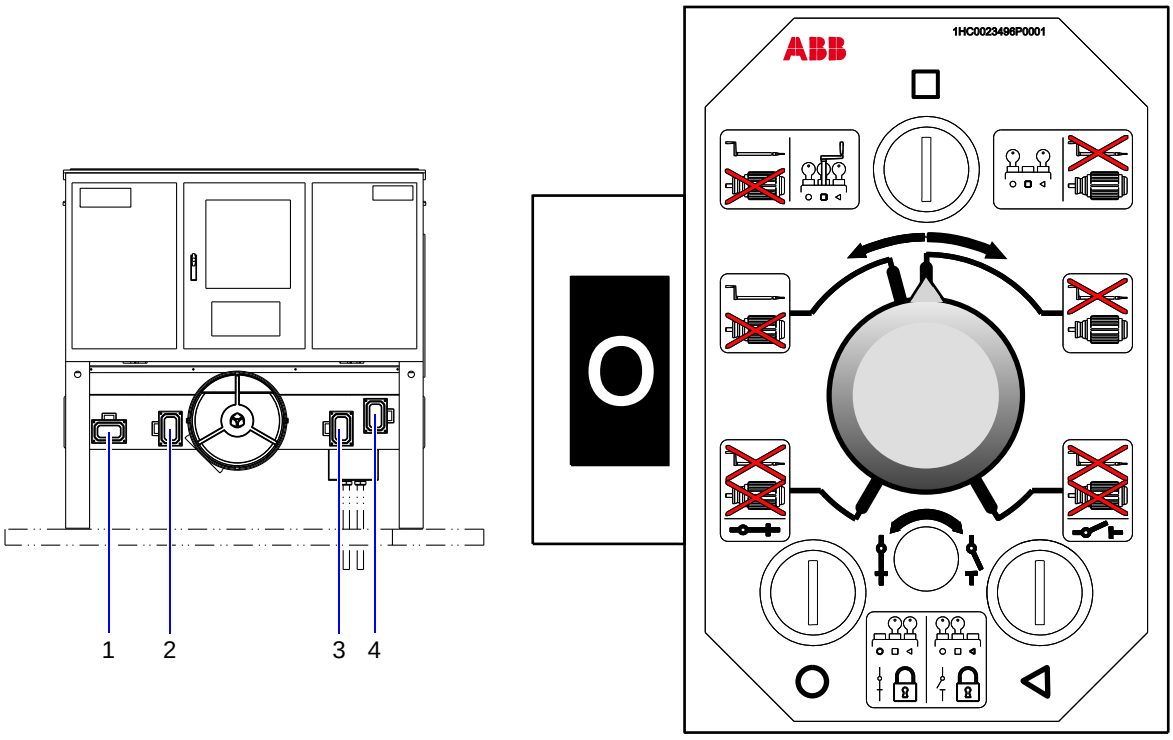


Fig. 5-3 Operating and indicating elements of SDM drives, locations

1 SDM drive for disconnector
2 SDM drive for earthing switch on transformer side – optional
3 SDM drive for earthing switch on generator side – optional
4 SDM drive for starting switch – optional

5.4.1 Operating elements

NOTE

Permission for access to the product and safe-keeping of the keys for the product is the responsibility of the plant officer/operating company.

Access and locking keys:

- only fit into the drive which they were supplied with
- are individually coded and can only be used for the allocated key switch

Hand crank:

- should be secured to the holding device below the pole frame

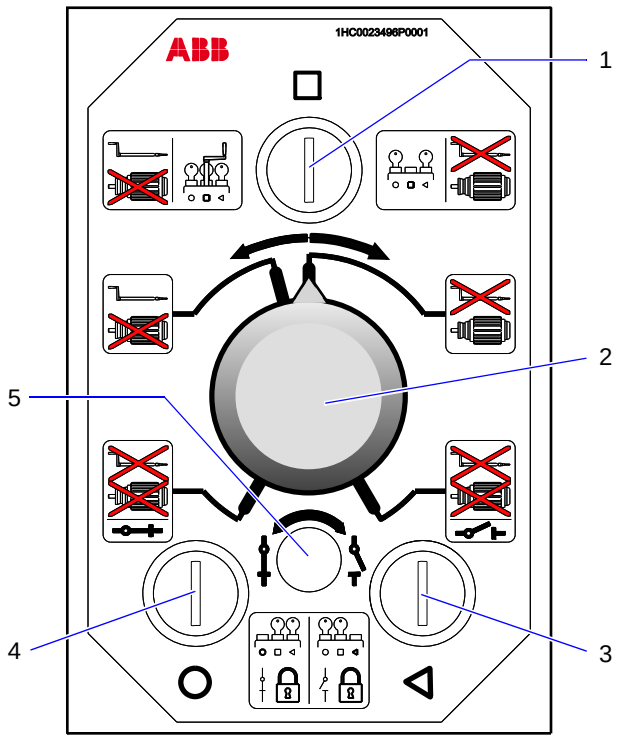


Fig. 5-4 Operating elements on the operating panel of the SDM drive

1 Key switch for access key
2 Knob for selecting the drive mode
3 Key switch for locking key OFF
4 Key switch for locking key ON
5 Opening for insertion of hand crank

Access key

The access key is required to perform any operating action on the operating panel of the SDM drive.

Knob for selection of drive mode

The knob for selection of the drive mode enables the settings:

- hand crank operation
- motorised operation
- locking the drive in the OFF position
- locking the drive in the ON position

The possible settings depend on:

- locking or unlocking by the access key and the locking keys
- the switching position of the connected switching element

Locking key for OFF position

Hand crank and motorised operation of the SDM drive can be blocked by removing the locking key for the OFF position.
Preconditions:

- The connected switching element is in the switching position OFF.
- The corresponding locking mode is selected by the knob for selection of drive mode.

Locking key for ON position

Hand crank and motorised operation of the SDM drive can be blocked by removing the locking key for the ON position.
Preconditions:

- the connected switching element is in the switching position ON.
- the corresponding locking mode is selected by the knob on the operating panel.

Hand crank

The hand crank can be used to manually move the connected switching element to the switching positions ON or OFF. For this purpose the hand crank can be inserted into the corresponding opening of the operating panel.
Precondition:

- Hand crank operation is selected by the knob for selection of drive mode.

5.4.2 Indicating elements

The SDM drive has the following indicating elements:

- in the window next to the operating panel:
  position indicator for the connected switching element
- on the operating panel:
  locking tab in the opening for insertion of the hand crank

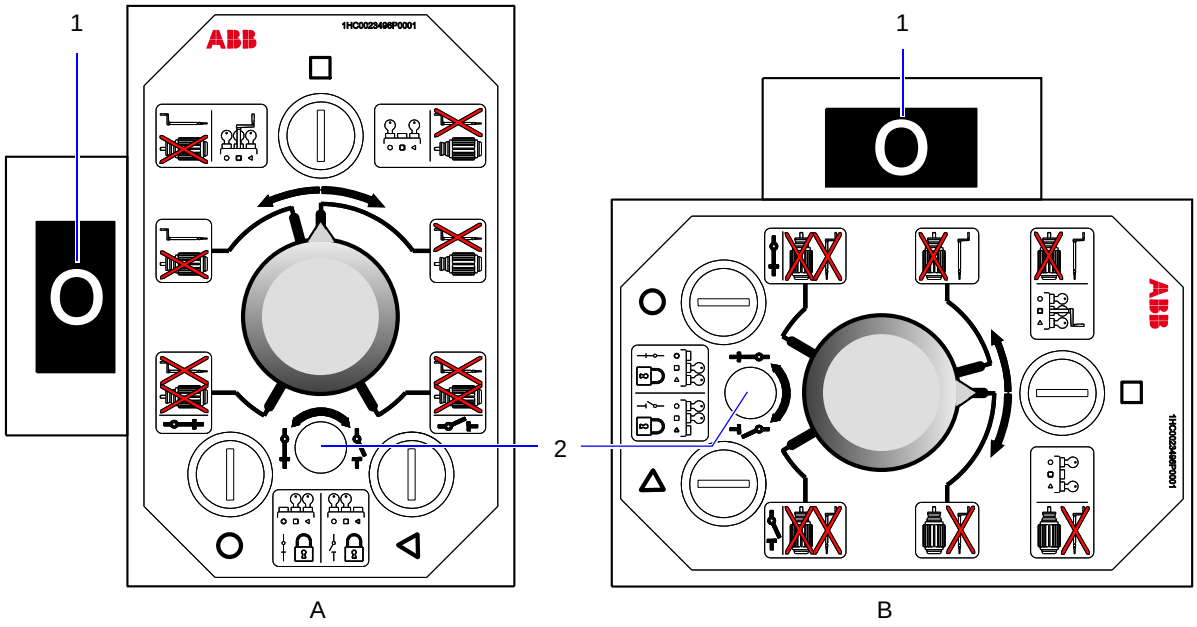
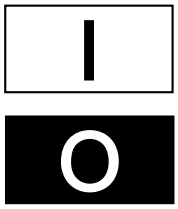


Fig. 5-5 Indicating elements of the SDM drive

A	Vertical mounting position
B	Horizontal mounting position
1	Position indicator
2	Locking tab for hand crank

5.4.2.1 Position indicator

The position indicator in the window next to the operating panel of the SDM drive shows the switching position of the connected switching element. The connected switching element can be either in the CLOSE or OPEN position.



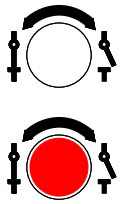
The switching position of the connected switching element is displayed as follows, if not otherwise specified:

- I = ON black on white background, status CLOSE
- O = OFF white on black background, status OPEN

If the operating panel is installed horizontally, the window with the position indicator is located directly above the horizontally mounted operating panel.

5.4.2.2 Locking tab for hand crank

The locking tab ensures that the hand crank can only be inserted if hand crank operation is selected by the knob for the selection of the drive mode. The locking tab for hand crank use can be either OPEN or LOCKED.



The status of the locking tab for the hand crank is displayed as follows, if not otherwise specified:

- no tab locking tab for hand crank OPEN
- red tab locking tab for hand crank LOCKED

Knob for the selection of the drive mode:

– Section 5.4.1 Operating elements, page 113

5.5 Control cubicle

5.5.1 Control panel

The control panel is located behind the central door of the control cubicle.

Mimic diagram

The upper left part of the control panel displays a mimic diagram with illuminated pushbuttons, which serve as operating and indicating elements simultaneously. Operation with pushbuttons is only possible in LOCAL operating mode.

Signal board

The following elements of the control panel are located below the mimic diagram:

- key operated interlocking switch S2
- event counters
- indicators for event and alarm signals

NOTE

Event signals for all switching operations of the switching elements connected to the control cubicle are monitored. These signals are provided by the manufacturer and may be displayed on the control panel of the control cubicle. For detailled information refer to Section 1.3.6.1 Plant specific documents, page 21.

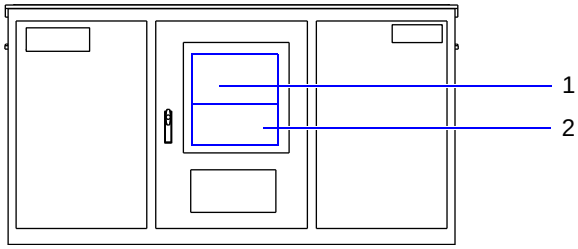


Fig. 5-6 Control cubicle with control panel

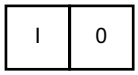
1 Mimic diagram
2 Signal board

5.5.2 Operating elements

NOTE

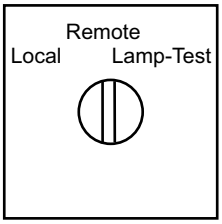
Permission for access to the product and safe-keeping of the keys for the product is the responsibility of the plant officer/operating company.

5.5.2.1 Illuminated pushbuttons of mimic diagram



In LOCAL operating mode the pushbuttons serve as operating elements. In REMOTE operating mode this function is disabled.

5.5.2.2 Interlocking key switch S2



Interlocking key switch S2 with key positions LOCAL–REMOTE–LAMP TEST. This key switch is operated by the interlock key:

– Section 4.4.2 Key locking, page 97

In REMOTE position all switching operations are controlled from the main control desk. Event and alarm signals are relayed to the main control desk via the control cubicle.

In LOCAL position the control from the main control desk is disabled. The only possible switching operation from REMOTE is a TRIP II opening operation of the circuit-breaker. In LOCAL position the connected switching elements can be switched via the illuminated pushbuttons of the mimic diagram.

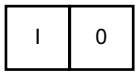
A lamp test is performed if the interlocking key is turned to the LAMP TEST position.

NOTE

The interlock key can only be removed from the interlocking key switch S2 when the interlocking key switch is in position REMOTE.

5.5.3 Indicating elements

5.5.3.1 Illuminated pushbuttons of mimic diagram



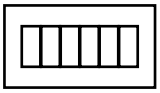
In REMOTE and LOCAL operating modes the illuminated pushbuttons serve as indicating elements.

The actual position of a switching element is indicated by illumination of the corresponding pushbutton.

If not specified otherwise:
Closed position of a switching element is indicated by the pushbutton marked I; open position of a switching element is indicated by the pushbutton marked 0. Illuminated pushbuttons are in the colours green and red:

- I=ON red, position of switching element CLOSE
- 0=OFF green, position of switching element OPEN

5.5.3.2 Counters

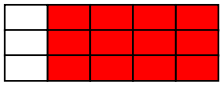


The counters show the accumulated close-open operations. Regular counter readings are a vital part of maintenance.

Standard equipment on the signal board:

- Operation counter for circuit-breaker
  Number of close-open operations of circuit-breaker
- Pumping operation counter for circuit-breaker
  Number of starting operations of pumping motor for hydraulic spring operating mechanism

5.5.3.3 Alarm signals



Alarm signals are displayed in blocks. The indicating colour of alarm signals is red, if not otherwise specified.

During normal operation the indicating elements should not be illuminated. There is a fault if one of the alarm signals is set.

The selection of signals displayed on the signal board is described in the plant specific documents. Signal names, and location of the single indicators are given in the plant specific layout:

– Section 1.3.6.1 Plant specific documents, page 21.

The following alarm signals are provided by the manufacturer

TRIP II CIRCUIT FAULT	One or more of the preconditions for opening operations TRIP II are not fulfilled.
TRIP I CIRCUIT FAULT	One or more of the preconditions for opening operations TRIP I are not fulfilled.
CLOSE CIRCUIT FAULT	One or more of the preconditions for closing operations CLOSE are not fulfilled.
DC VOLTAGE FAULT TRIP II	The pump motor of the hydraulic spring operating mechanism or one or more elements of the controlling circuitries for opening operations TRIP II are not supplied with the correct supply voltage.
DC VOLTAGE FAULT CLOSE / TRIP I	The pump motor of the hydraulic spring operating mechanism or one or more elements of the controlling circuitries for opening operations TRIP I and closing operations CLOSE are not supplied with the correct supply voltage.
DC VOLTAGE FAULT PUMP MOTOR	The pump motor of the hydraulic spring operating mechanism is not supplied with the correct supply voltage.
BLOCKING C	Insufficient pressure for the drive mechanism of the hydraulic spring operating mechanism. The circuit-breaker can only perform one more opening operation.
BLOCKING O	Insufficient pressure for the drive mechanism of the hydraulic spring operating mechanism. The circuit-breaker cannot perform another closing or opening operation.
LONG TIME PUMP RUNNING	The threshold for switching off the pump motor of the hydraulic spring operating mechanism is not reached within a defined interval.

SF6 LOW DENSITY	Density of SF6 gas has fallen below alarm density.
SF6 BLOCKING	Density of SF6 gas has fallen below minimum functional density. For safety reasons minimum functional density is monitored by two independent micro switches, generating the signals SF6 BLOCKING CLOSE / TRIP I and SF6 BLOCKING TRIP II.
AC VOLTAGE I FAULT	One of the 3 phase AC voltage supplies is not available. AC VOLTAGE I and AC VOLTAGE II are two independent power supplies for SDM drives.
AC VOLTAGE II FAULT	One of the 3 phase AC voltage supplies is not available. AC VOLTAGE I and AC VOLTAGE II are two independent power supplies for SDM drives.
PHASE-SEQUENCE FAILURE	Incorrect phase-sequence of the 3 phase AC voltage supply, either AC VOLTAGE I or AC VOLTAGE II.
MOTOR PROT. SWITCH TRIPPED	A motor protection switch for SDM drives has been activated. Optionally there may be different motor protection switches for disconnector and earthing switches on generator side and on transformer side. If more than one SDM drive is protected by one protection switch, the affected SDM drive must be identified.
AC VOLTAGE FAULT HEATING	The heating system of the control cubicle is not supplied with the correct supply voltage.

6 Erection

This section is addressed to the plant officer/operating company.

6.1 Introduction

This section describes the erection of the product.

Packing and unpacking are only described to the extent relevant to erection work. For further information see:

– Section 9 Packaging, page 209.
– Section 11 Transport, page 223.

6.1.1 Safety instructions

The general safety instructions must be observed as stated in Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

6.1.1.1 Safety at work

DANGER

Falling loads

If suspended or elevated loads fall down, fatal injury and damage to equipment may occur.

1. Use the personal protective equipment.
2. Cordon off hazardous areas.
3. Keep the working area free.
4. No persons should stand below suspended or elevated loads.
5. Ensure that loads are correctly secured.
6. Only use faultless hoisting gear and auxiliary material which have sufficient bearing capacities and which are approved for the loads.
7. Only lift the product by the attachment points provided.
8. Ensure that the hoisting gear and cranes are used correctly.
9. Transport the product horizontally.

DANGER

Accidents during transport on rollers or wheels

If loads get out of control, fatal injury and damage to equipment may occur.

1. Use the personal protective equipment.
2. Only use faultless hoisting gear and auxiliary material which have sufficient bearing capacities and which are approved for the loads.
3. Move loads slowly and carefully.
4. Avoid slipping or shifting of the loads.

DANGER

Falling hazard

Work at height may involve the risk to fall down.

1. Secure yourself against falling.
2. Use only secure scaffolding, ladders and other devices approved by the site safety officer.

6.1.1.2 Means of transport

WARNING

Transport accidents by use of wrong lifting equipment

Each product of the manufacturer is delivered with a lifting equipment which is unique to the corresponding product.

Observe following preventive measures:

1. Only use the lifting equipment which was specifically delivered for this product type.
2. Observe the centre of gravity.
3. Do not use the lifting equipment for other purposes.

For further information:

– Section 6.3 Unpacking and transport, page 128
– Section 11 Transport, page 223

Lifting beam

The maximum load-bearing capacity is punched into a front face of the lifting beam:

- product type
- load-bearing capacity
- pole centre spacing

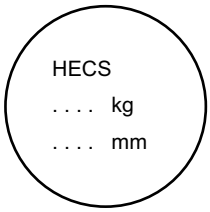


Fig. 6-1 Front face of lifting beam, example

6.1.2 Target group

The plant officer/operating company and work officers are responsible that work must only be performed by trained personnel:

- Hoisting gear and transport equipment has to be used only by trained personnel.
- Welding work has to be performed only by techicians with suitable training and in compliance with valid regulations.

6.2 Prerequisites

NOTE

The plant specific layout and the plant specific documents are decisive for the product. See Section 1.3.6.1 Plant specific documents, page 21.

6.2.1 Supplied documents

On the outside of the transport crate in a document pocket:

- packing list
- transport instructions

Inside the transport crate:

- copy of the packing list
- copy of the transport instructions

Inside the enclosures, attached to the capacitors:

- installation instructions for performing high voltage tests of the IPB, see Section 6.11.1 High voltage test, page 155.

6.2.2 Infrastructure

The following equipment must be provided by the plant officer/operating company at the site:

- crane
- material for protection against sparks and spillings, caused during welding, cutting, and grinding work
- welding equipment
- standard tools
- torque wrench 80 and 130 Nm

6.2.2.1 Standard accessories

The following accessories are included in the scope of delivery.

Per order and product type

If several shipments of identical products are supplied, the following items are only supplied with the first shipment.

- 1 maintenance lever, packed separately
- lifting equipment for transportation, packed separately:
  - 1 lifting beam
  - 2 seats for lifting beam
  - 2 round slings
  - 2 belt slings
  - 4 shackles

Per product and shipment

The following items are included per product and shipment.

- 1 hand crank for SDM drives, attached to the pole frame
- 2 transport brackets, attached to the pole frame
- 4 transport supports, attached to the pole frame
- 4 pole frame supports, attached to the transport supports
- 8 shims, attached to a pole frame support
- 2 belt slings for the control cubicle, attached to the side walls of the control cubicle
- 2 shims for the control cubicle, attached to a support of the control cubicle

6.2.2.2 Optional accessories

Optional accessories are included according to plant specific documents and packing list:

– Section 1.3.6.1 Plant specific documents, page 21.

6.3 Unpacking and transport

CAUTION

Protect the product against pollutants and moisture

Pollutants and moisture might damage the product.

1. Do not expose the product to environmental conditions incompatible with those specified in Section 2.5 Ambient conditions, page 43.
2. Keep the product in storage if adequate environmental conditions cannot permanently be provided, see Section 10 Storage, page 219.
3. Pack the product if it is already unpacked and adequate environmental conditions cannot permanently be provided,
   see Section 9 Packaging, page 209.

6.3.1 Receipt of goods

The product is assembled, packed and transported as a complete unit. See Section 9 Packaging, page 209.

1. After receipt of the goods check the packaging for transport damage.
2. Record any transport damage immediately after receipt of the goods.
3. Notify the manufacturer immediately about any damage, including a detailed report and photographs.

6.3.2 Transport with packaging

See Section 11 Transport, page 223.

6.3.3 Unpacking

1. Remove packing list and transport instructions from the document pocket on the outside of the transport crate.
2. Remove the lid of the transport crate.
3. Remove the side walls of the transport crate one at a time.
4. Remove the struts.
5. Remove the adhesive tape and packing material.
   Leave the plastic film on the enclosure opening for protection.
6. Slacken the screw connections at the base of the crate.

6.3.4 Checking received goods

1. Check the received goods to ensure that all parts listed on the packing list are supplied.
2. Record any deviations in writing.
3. Check the gas density,
   for details see Section 5.2.1 Density indicator SF6, page 108.

   Fig. 6-2 SF6 gas density during transport, page 129:

   – The pointer of the density indicator must be in the BLACK indication range.
   – A lower level in the RED range means, the density is too low. This must be regarded as transport damage and reported.
4. Notify the manufacturer immediately about any damage, including a detailed report and photographs.

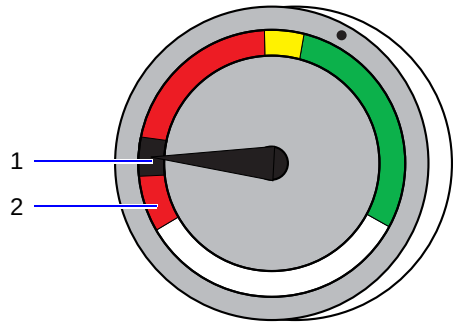


Fig. 6-2 SF6 gas density during transport

1 Indication range BLACK, density for transport
2 Indication range RED, density too low

6.3.5 Lifting the product

NOTE

Manufacturer's lifting equipment is individually designed for lifting the corresponding product of the manufacturer.

1. Always use the lifting equipment supplied with the product.
2. Do not use this lifting equipment for other purposes.

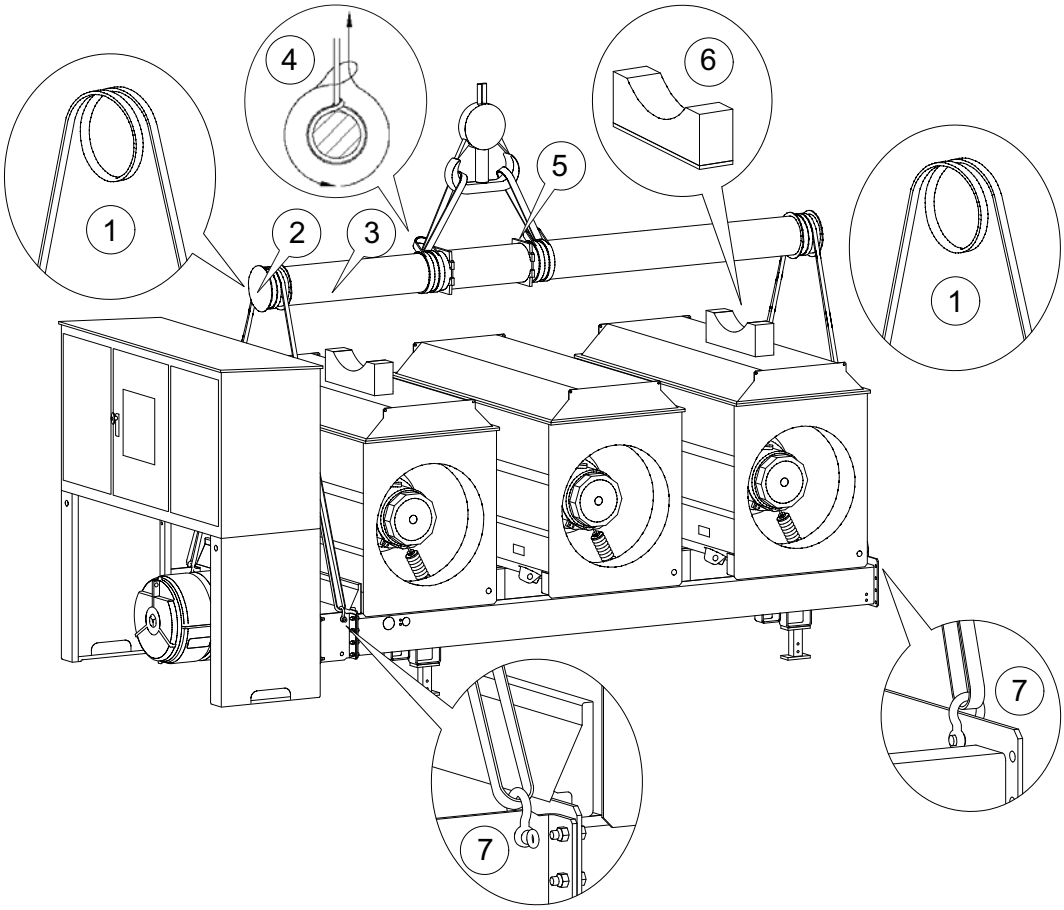


Fig. 6-3 Lifting equipment

1 Belt slings
2 Labelling “CUBICLE”
3 Lifting beam
4 Round slings
5 Centring clamps
6 Seats for lifting beam
7 Shackles on the pole frame

6.3.5.1 Attaching the crane hook to the lifting beam

Fig. 6-3, page 130:

The positions of the centring clamps (5) on the lifting beam (3) balance the centre of gravity of the product. The lifting beam is correctly positioned if the labelling (2) faces towards the control cubicle/hydraulic spring operating mechanism.

1. Attach a round sling (4) by looping it once around the lifting beam (3) on the outer side of a centring clamp (5).
2. Repeat on the other centring clamp (5).
3. Attach the free nooses of the round slings (4) to the crane hook.

6.3.5.2 Placing the lifting beam onto the enclosures

Fig. 6-3, page 130:

1. Place the 2 seats (6) for lifting beam onto the enclosure covers.
2. Place the lifting beam (3) onto the seats (6).

6.3.5.3 Attaching the lifting beam to the product

Fig. 6-4, page 132:

1. Loop belt slings once around the ends of the lifting beam, between the outer clamps (2 1), (4 3).
2. Make sure that the belt slings do not overlap and do not hang over the outer clamps.
3. Hook shackles onto the nooses of the belt slings (1), (2) and attach the shackles to the transport brackets on the pole frame.
4. Hook shackles onto the nooses of the belt slings (3), (4) and attach the shackles to the pole frame.
5. Carefully lift the lifting beam until the belt slings are slightly tensioned.

While the belt slings are being tensioned:

6. Make sure that the round slings are positioned correctly on the lifting beam so that the product is lifted horizontally.
7. Make sure that the belt slings and shackles do not damage the product.

When the belt slings are tensioned:

8. Remove the seats from the covers of the enclosures.

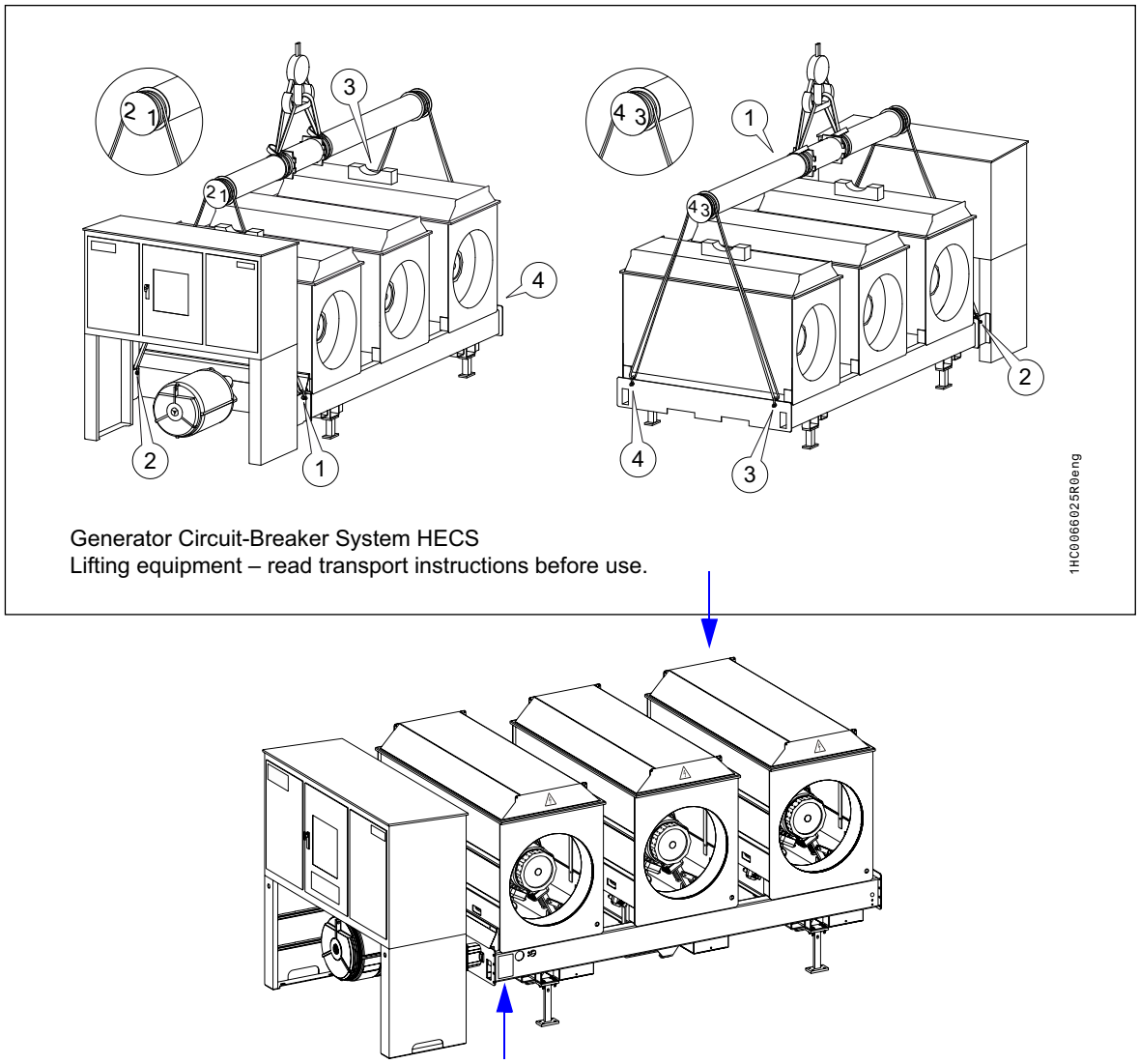


Fig. 6-4 Labels on pole frame

6.3.5.4 Transport by crane

1. Slowly lift the product with a crane.
   While lifting the product:
   a) Make sure that the product is suspended on the crane as horizontally as possible.
   b) Make sure that the product does not swing or sway.
2. Carefully transport the product to the erection site.
3. Keep the product attached and secured to the lifting equipment and the crane until the product is bolted/welded in place.

NOTE

Before setting down the product at the erection site, transport supports must be replaced by pole frame supports.

The product may temporarily be placed on the transport supports. It does not matter if the screw-mounted pole frame supports are attached or not.

6.3.5.5 Replacing transport supports by pole frame supports

The supports are replaced while the product is suspended from the crane.

1. Maintain a short distance to the ground.
2. The product must be suspended as horizontally as possible from the crane and should not swing or sway.
3. Keep the product steady with the assistance of additional personnel while keeping a safe distance.
4. Slacken the bolts and remove the transport supports.
5. Remove the shims and keep them for aligning the product.
6. Secure the pole frame support.
   The bolts for the transport supports can be reused to this purpose.
7. Tighten the bolts to 130 Nm only after the final aligning of the product.
8. Carefully set down the product.

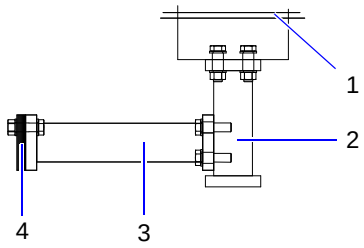


Fig. 6-5 Transport support with pole frame support and shims

1 Pole frame
2 Transport support, steel
3 Pole frame support, galvanised
4 8 shims mounted on pole frame support

6.4 Installation preparation

Additional details of installation preparation, particularly space requirements and floor layout, depend on the plant specific product configuration:

– Section 1.3.6.1 Plant specific documents, page 21.

6.4.1 Space requirements

1. Add required space to the overall dimensions of the product.
   – Make sure there is sufficient height to lift assemblies with a crane out of the enclosure during overhaul.
   – Provide space to work on disassembled parts and store them temporarily.

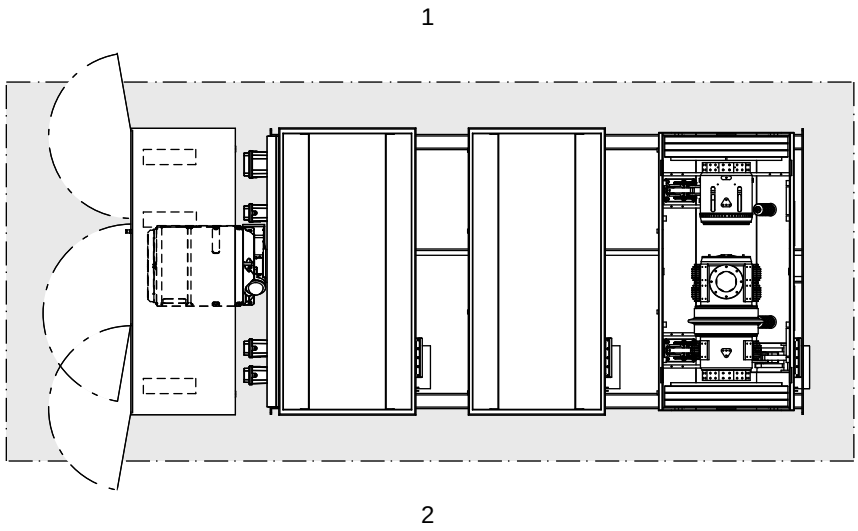


Fig. 6-6 Space requirements

1 Transformer side
2 Generator side

6.4.2 Floor layout

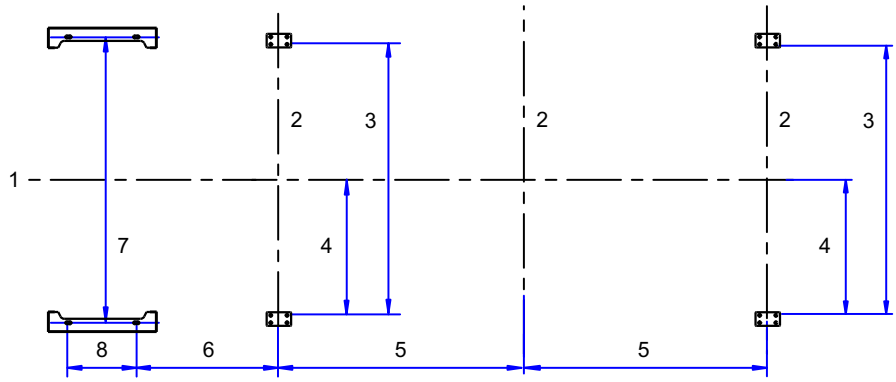


Fig. 6-7 Floor layout

1 Centre line of product
2 Phase centre lines

Distances, equidistant between:

3 nearest fixing holes of pole frame supports across centre line of product
4 centre line of product and nearest fixing holes of pole frame supports
5 phase centre lines

Control cubicle, distances between:

6 fixing holes of control cubicle and phase centre line
7 fixing holes across centre line of product
8 fixing holes at the side walls

6.4.3 Pole frame supports

All pole frame supports must be secured with at least 2 diagonally opposed securing elements at the erection site.

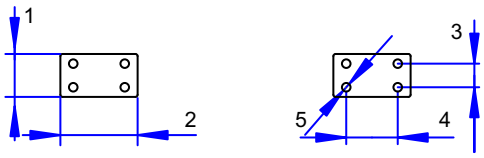


Fig. 6-8 Pole frame support dimensions

1 Width
2 Length
3 Distance between fixing holes
4 Distance between fixing holes
5 Hole diameter

6.4.3.1 Dynamic forces

For switching operations, dynamic forces for each pole frame support have to be observed:

- in vertical direction
- in horizontal direction, in parallel to the isolated-phase bus
- in horizontal direction, at right angle to the isolated-phase bus

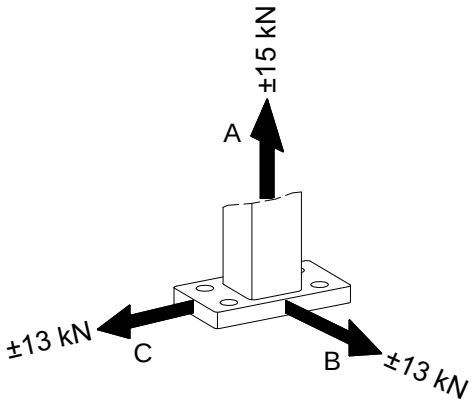


Fig. 6-9 Dynamic forces on pole frame support

A vertical dynamic forces
B horizontal dynamic forces parallel to isolated-phase bus
C horizontal dynamic forces at right angle to isolated-phase bus

6.5 Erection site preparation

Prerequisites:

- Sufficient space available, see Section 6.4.1 Space requirements, page 135.
- The erection site must be horizontal and even. Differences in height should not exceed 2 mm at the support points of the pole frame supports. Greater differences result in subsequent extra work.
- The floor must be clean.

NOTE

Alignment of the product must be coordinated with the supplier of the isolated-phase bus. Connecting dimensions:

– Section 6.7.1 Connecting the IPB, page 147

6.5.1 Erection on concrete floor

The dynamic forces and quality of the concrete must be taken into account for calculating the securing elements and torques.

1. Determine the securing elements and the torques.
2. Measure the erection site and mark the hole positions.
3. Drill the holes for the securing elements.
4. Clean the erection site.

6.5.2 Erection on steel structure

If the product is installed on a steel structure it can be bolted or welded in place.

6.5.2.1 Securing by bolting

The dynamic forces and the quality of the steel must be taken into account for calculating the securing elements and torques.

1. Determine the securing elements and the torques.
2. Measure the erection site and mark the hole positions.
3. Drill the holes for the securing elements.
4. Clean the erection site.

6.5.2.2 Securing by welding

The dynamic forces and the quality of the steel must be taken into account for calculating the welding seams.

1. Determine the welding method.
2. Measure the erection site and prepare the welds.
3. Clean the erection site.

6.6 Product erection

6.6.1 Aligning the product

NOTE

Alignment of the product must be coordinated with the supplier of the isolated-phase bus. Connecting dimensions:

– Section 6.7.1 Connecting the IPB, page 147

The product is still attached to the crane hook.

1. Make sure that the transport supports are replaced by the pole frame supports.
   – Section 6.3.5.5 Replacing transport supports by pole frame supports, page 134
2. Carefully lift the product and transport it to the erection site.
3. Position the product correctly on the erection site.
4. Align the pole frame horizontally with the aid of the shims.
   – Permissible tolerance: 2 mm
5. Slightly fix the product to the floor with the securing elements.

6.6.2 Securing the product

6.6.2.1 Concrete floor

1. Make sure that preparatory work has been performed, see:
   Section 6.5.1 Erection on concrete floor, page 138
2. Bolt the product to the concrete floor with the securing elements.
3. Tighten the securing elements to the corresponding torque.

6.6.2.2 Steel structure

1. Make sure that preparatory work has been performed, see:
   Section 6.5.2 Erection on steel structure, page 138
2. Securing by bolting
   a) Bolt the product to the steel structure with the securing elements.
   b) Tighten the securing elements to the corresponding torque.

   – or –
3. Securing by welding
   a) Weld the product in place.

6.6.3 Removing the lifting equipment

1. Place the lifting beam onto the enclosures, see
   Section 6.3.5.3 Attaching the lifting beam to the product, page 131.
2. At both ends of the lifting beam:
   Remove the belt slings from the lifting beam.
3. Remove the lifting beam from the enclosure.
4. Release the lifting equipment from the crane hook.
5. Keep the lifting equipment in a safe place for later use.

The control cubicle remains attached to the pole frame of the product at this stage.

6.6.4 Control cubicle

NOTE

For transportation, the control cubicle is attached to the pole frame. After placing the product in its final position, the control cubicle must be separated from the pole frame in order to minimize vibrations originating from switching operations of the generator circuit-breaker system.

If the control cubicle is attached to the pole frame, there is a clearance between the surface of the erection site and the supports of the control cubicle. Thus the weight of the control cubicle applies shearing forces onto the transport brackets between control cubicle and pole frame.

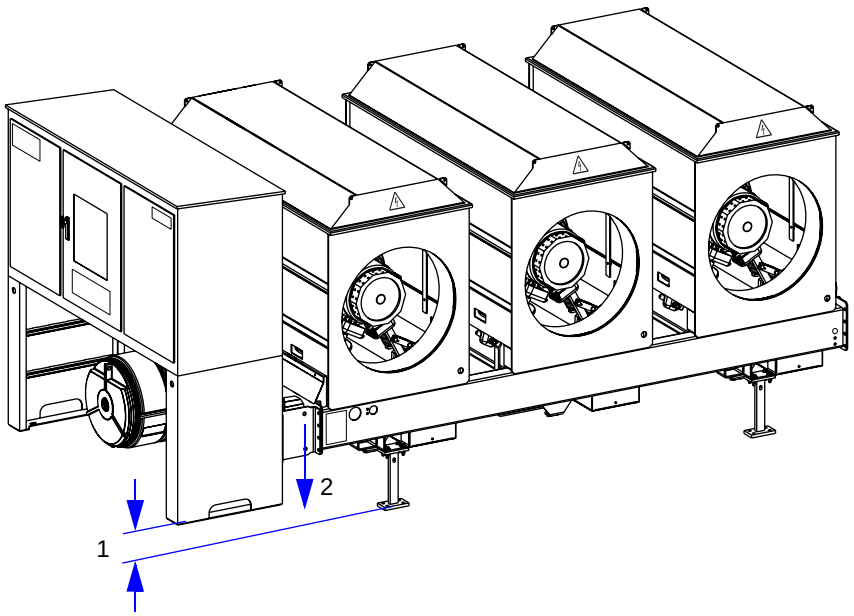


Fig. 6-10 Control cubicle clearance

1 Clearance
2 Shearing forces

6.6.4.1 Attaching the control cubicle to the crane hook

The belt slings for lifting the control cubicle are attached to the two side walls inside the supports of the control cubicle.

Two shims for aligning the control cubicle are attached to a rear support of the control cubicle

1. Attach the belt slings to the eyelets of the control cubicle.
2. Attach the belt slings to the crane hook.

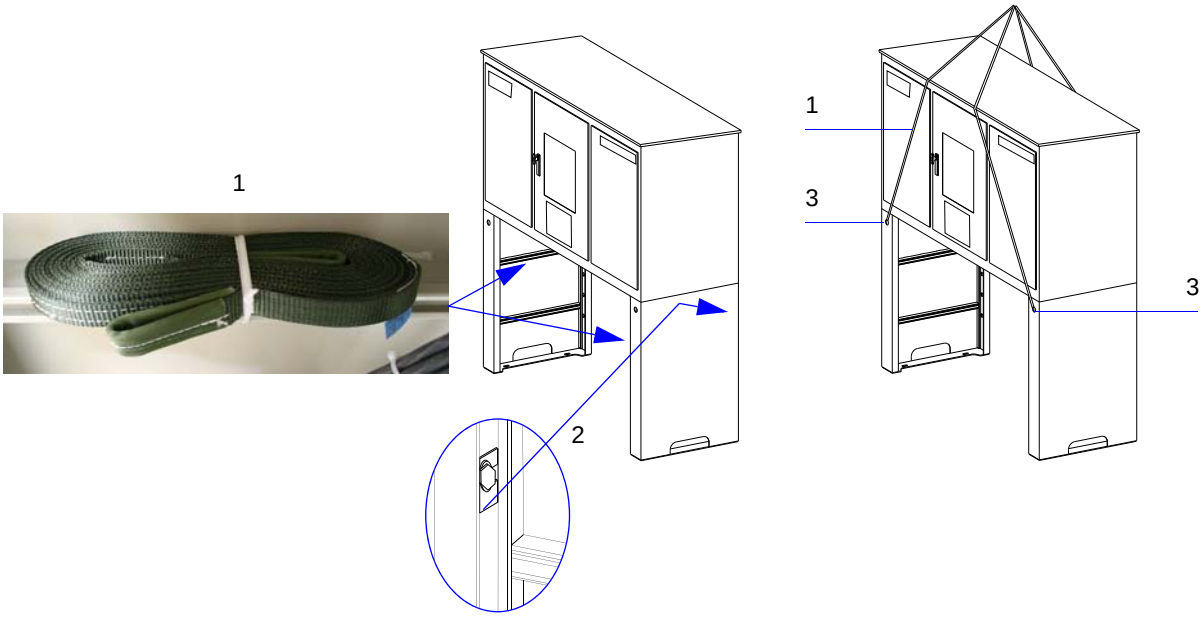


Fig. 6-11 Lifting equipment and shims of control cubicle

1 Belt sling
2 Shims
3 Eyelet for transport

6.6.4.2 Separating the control cubicle from the pole frame

NOTE

This action sequence only applies if the control cubicle is mounted to the product.

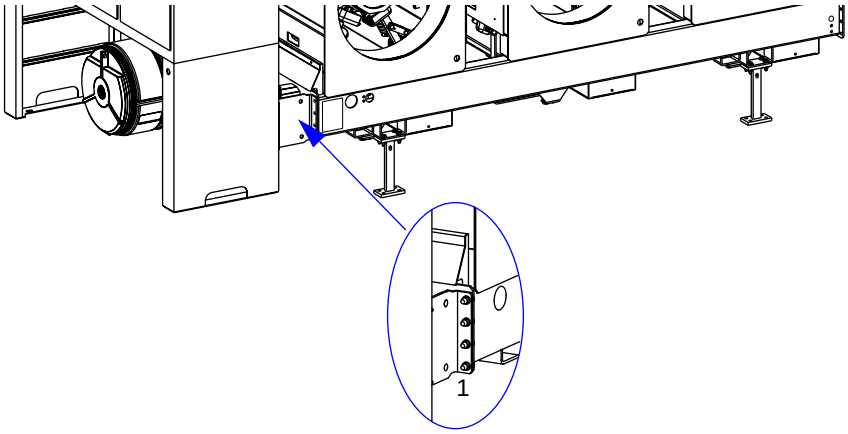


Fig. 6-12 Separating the control cubicle from the generator circuit-breaker system

1 Transport bracket

1. Make sure that the control cubicle is secured to the lifting equipment.
2. Because of the clearance between surface of erection site and supports of control cubicle:
   Carefully lift up the product in order to release any forces on the transport brackets between control cubicle and pole frame.
3. On each side of the control cubicle:
   Remove the the transport bracket between the control cubicle and the pole frame.

The control cubicle can now be lifted independent from the pole frame.

NOTE

Damage of cable connections

In its standard version the control cubicle is already connected to the drives and control equipment of the generator circuit-breaker system.

1. Do not apply any forces onto the cables between control cubicle and pole frame.

6.6.5 Aligning the control cubicle

The control cubicle is still attached to the crane hook.

1. Carefully lift the control cubicle and transport it to the erection site.
2. Position the control cubicle correctly on the erection site.
3. Align the control cubicle with the aid of the shims.
   – Permissible tolerance: 2 mm
4. Slightly fix the product to the floor with the securing elements.
5. Keep the control cubicle attached to the lifting equipment and the crane until the product is secured in its final position.

6.6.6 Securing the control cubicle

6.6.6.1 Concrete floor

1. Ensure that preparatory work has been performed, see:
   Section 6.5.1 Erection on concrete floor, page 138.
2. Bolt the product to the concrete floor with the securing elements.
3. Tighten the securing elements to the corresponding torque.

6.6.6.2 Steel structure

NOTE

Control cubicle not suitable for welding

The control cubicle must be secured by other methods than welding.

1. Ensure that preparatory work has been performed, see:
   Section 6.5.2.1 Securing by bolting, page 138.
2. Bolt the product to the steel structure with the securing elements.
3. Tighten the securing elements to the corresponding torque.

6.6.7 Releasing the control cubicle from the crane hook

1. Remove the belt slings from the crane hook.
2. Remove the belt slings from the control cubicle.
3. Store the lifting equipment in a safe place for later use.

6.7 Connection zone

CAUTION

It is the responsibility of the supplier of the isolated-phase bus to ensure that the requirements as defined in the plant specific documents are met, see Section 1.3.6.1 Plant specific documents, page 21.

Strictly follow the installation instructions of the supplier of the isolated-phase bus.

1. Dimensioning of sub-assemblies and execution of installation must comply with valid regulations.
2. The supplier of the isolated-phase bus bears responsibility for dimensioning of the IPB according to the technical data of the product, see Section 2.3 Performance characteristics and technical data, page 29.
3. The specifications of the tested connection zones must be observed, see Section 1.3.6.1 Plant specific documents, page 21.
4. Wear the personal protective equipment.
5. Protect the product and installed components so that they cannot be damaged by sparks, spillings, and water.

   Sparks and spillings are caused by welding, cutting, and grinding work. The resulting damages reduce the lifetime of components and the function of the product.
6. The welding seams must be executed in compliance with valid regulations.

IPB **I**solated-**P**hase **B**us

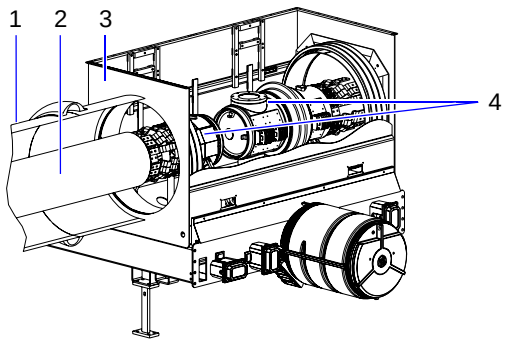


Fig. 6-13 Connection zone, definitions

1 Enclosure of IPB
2 Conductor of IPB
3 Enclosure of product
4 Conductor of product

CAUTION

Thermal and mechanical forces

The conductors and enclosures of the product must not absorb thermal and/or mechanical forces.

1. Ensure that connections to the conductors of the IPB are built flexibly.
2. If other equipment than the optional manufacturer's supply is used:
   a) Ensure that the given specifications are met, see Fig. 6-15, page 148 Fig. 6-16, page 149 and Fig. 6-17, page 150.
   b) Ensure that the conductor area of the flexible connections is capable to carry the currents specified, see Section 2.3.1 Generator circuit-breaker system, page 29.
3. Ensure that contact areas are greased, see Section 6.7.1.3 Mounting the flexible connections, page 150.
4. Ensure that the enclosures of the IPB do not transmit mechanical forces exceeding 2000 N onto the enclosures of the product. The use of compensators reduces the impact of thermal strain.
5. Ensure that the connections between the enclosures of IPB and product are capable to carry the reverse currents.

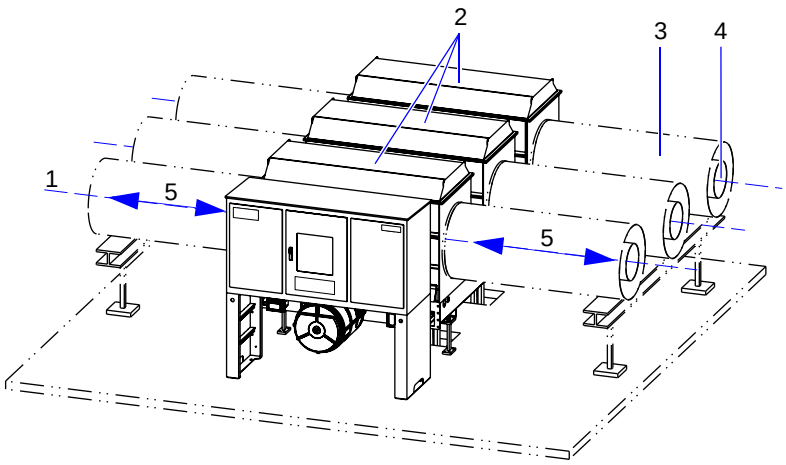


Fig. 6-14 Mechanical forces on the product enclosure

1 Phase centre line
2 Cover of the product enclosure
3 Enclosure of IPB
4 Conductor of IPB
5 Maximum permissible mechanical forces on product enclosure

6.7.1 Connecting the IPB

Access: Through the covers of the product enclosures

Tolerances: Fig. 6-15, page 148, Fig. 6-16, page 149 and Fig. 6-17, page 150.

1. Ensure that the product is correctly aligned, see Section 6.6.1 Aligning the product, page 139.
   a) The conductors of the IPBs must be aligned to the conductors of the product.
   b) The enclosures of the IPBs must be aligned to the enclosures of the product.
2. Remove the protective plastic film from the enclosure opening.
3. Protect the product and installed components so that they cannot be damaged by sparks and spillings.
4. For each individual conductor of the IPB:
   Align the conductor terminal to the conductor of the product and weld the conductor terminal to the respective conductor of the IPB.
   – Conductor terminals are part of optional manufacturer's supply.
5. During welding work on the product:
   The enclosures of the product must be closed to prevent deformation caused by heat.
   Ensure that:
   a) the covers of the product enclosures are closed
   b) the fixing bolts of covers are tightened.
6. Weld the enclosures of the IPBs to the enclosures of the product. Section 6.7.1.1 Enclosure, page 148:
   a) Ensure that the welding seams are made air tight and that they carry the reverse currents.
   b) It is recommended to use connecting rings to comply with the given specifications.
7. Open the covers of the product enclosures.
8. Mount the flexible connections:
   – Section 6.7.1.2 Flexible connections, page 149
   – Section 6.7.1.3 Mounting the flexible connections, page 150
9. Remove the protection against sparks and spillings.
10. Close the covers of the product enclosures.
    – Torque of the fixing bolts for covers: 15 Nm

6.7.1.1 Enclosure

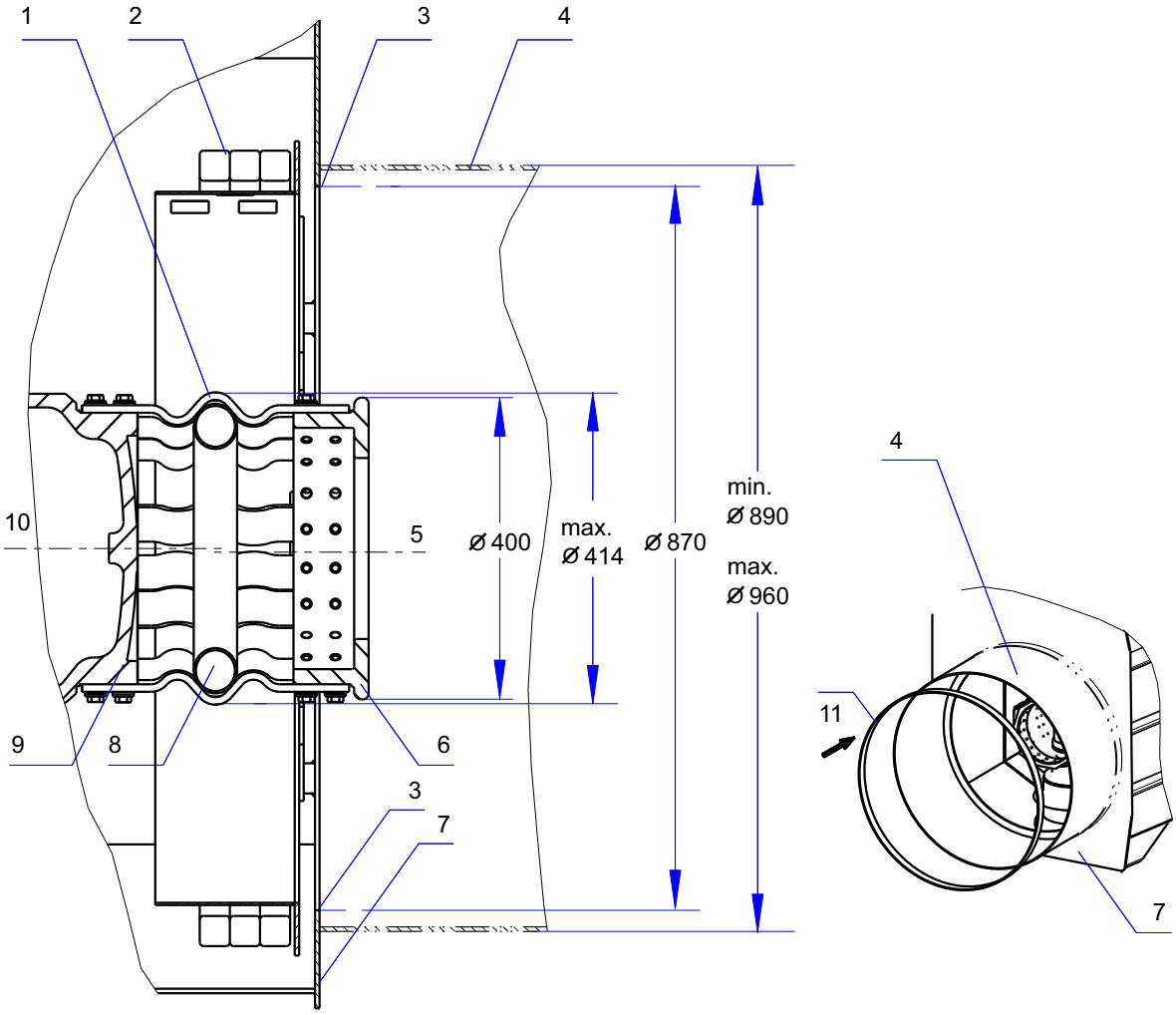


Fig. 6-15 Connecting the enclosure, dimensions in mm

1 Flexible connections, 15 copper elements, conductor area 480 mm² each
2 Current transformer – optional
3 Opening in product enclosure
4 Enclosure of the IPB
5 Phase centre line of conductor terminal
6 Conductor terminal for IPB
7 Enclosure of the product
8 Support ring
9 Conductor of the product
10 Phase centre line of the product
11 Connecting ring – recommendation

6.7.1.2 Flexible connections

NOTE

The contents of this section refer to optional manufacturer's supply:

- flexible connections
- support ring
- conductor terminal for IPB

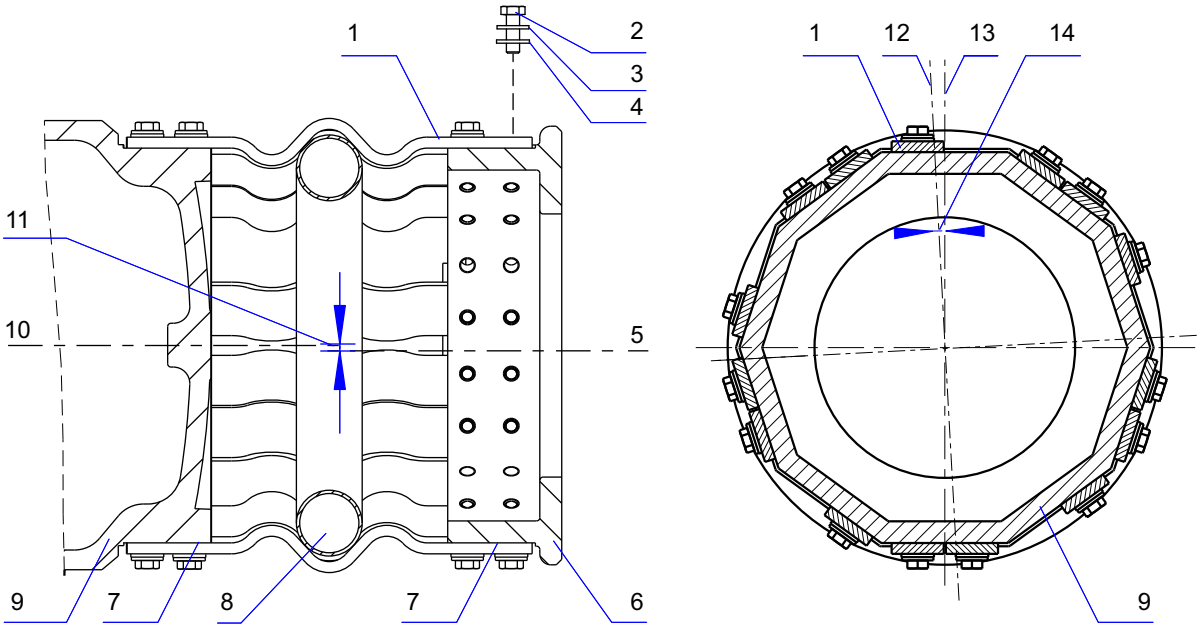


Fig. 6-16 Flexible connection of IPB, elements

left: longitudinal section right: cross section

1 Flexible connections, 15 copper elements,
conductor area 480 mm² each, with mounting elements:
– 2 Hexagonal bolt M12×35, property class 8.8, 80 Nm
– 3 Conical spring washer
– 4 Washer

5 Phase centre line of conductor terminal
6 Conductor terminal for IPB
7 Surfaces silver plated
8 Support ring
9 Conductor of the product
10 Phase centre line of the product
11 Maximum distance between phase centre lines of product phase and conductor terminal, in each direction
12 Central axis of conductor terminal
13 Central axis of product phase
14 Maximum rotation between central axes of product phase and conductor terminal

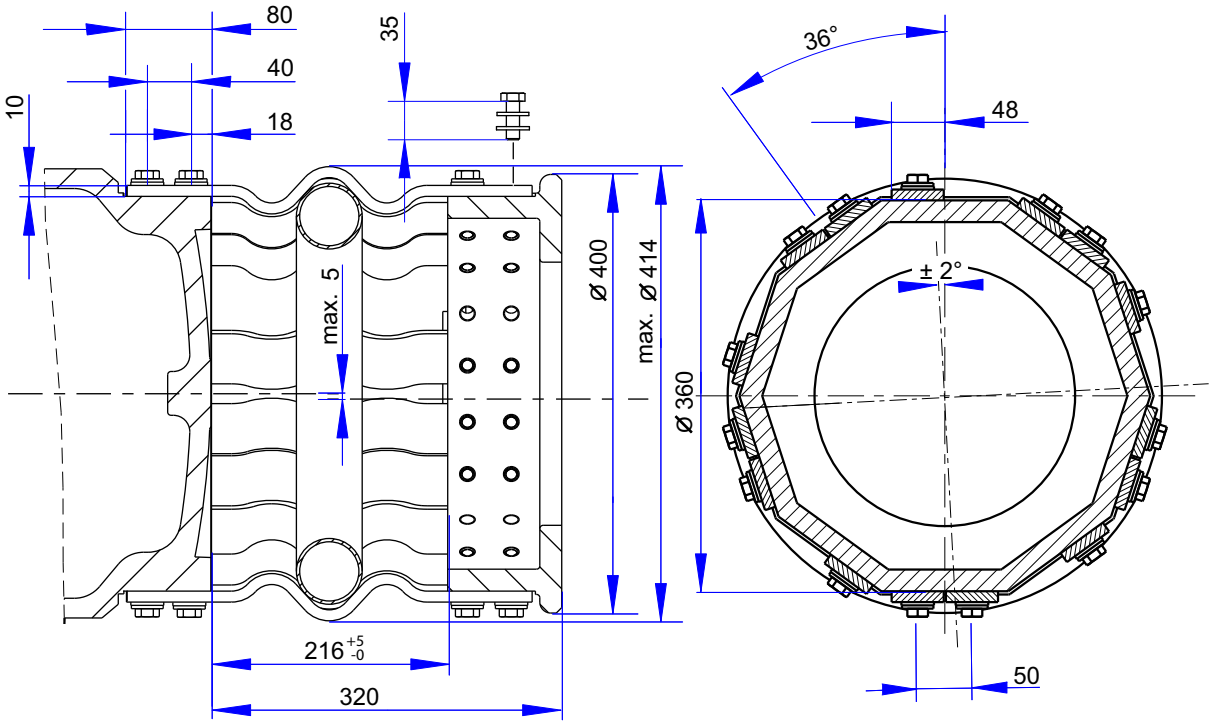


Fig. 6-17 Flexible connection of IPB, dimensions in mm

6.7.1.3 Mounting the flexible connections

The flexible connections should be mounted in coordination with the commissioner, see Section 6.11 Request for commissioning, page 154.

The following action sequence must be carried out for each individual phase:

– Fig. 6-16, page 149
– Fig. 6-17, page 150

1. Thoroughly clean all silver-plated contact areas with a cleaning agent.
   – Leave time for drying.
2. Apply grease `OKS VP 980` to all silver-plated contact areas.
   – Thickness of coating: 8 µm.
   – Check: Fingerprint easily visible, string formation not permissible.
3. Mount the bottom half of flexible connections with hexagonal bolts M12×35, conical spring washers, and washers, and tighten to a torque of 80 Nm.
4. Fit the support ring on the assembled flexible connections.
5. Mount the top half of flexible connections with hexagonal bolts M12×35, conical spring washers, and washers, and tighten to a torque of 80 Nm.

6.8 Protective earthing

NOTE

Earthing of the enclosures must be executed according to the plant specific documents.

The enclosures are electrically insulated from the pole frame.

Earthing of pole frame and control cubicle:

- Minimum cable cross-section of the protective conductor:
  16 mm^2 copper

The following earthing points are marked:

- two earthing points on the pole frame
- two earthing points on the control cubicle

Correct earthing of pole frame and control cubicle:

1. Connect 1 earthing point of the control cubicle to protective earthing of the plant.
2. Connect 1 earthing point of the pole frame to protective earthing of the plant.

Both, the control cubicle and the pole frame must be earthed separately.

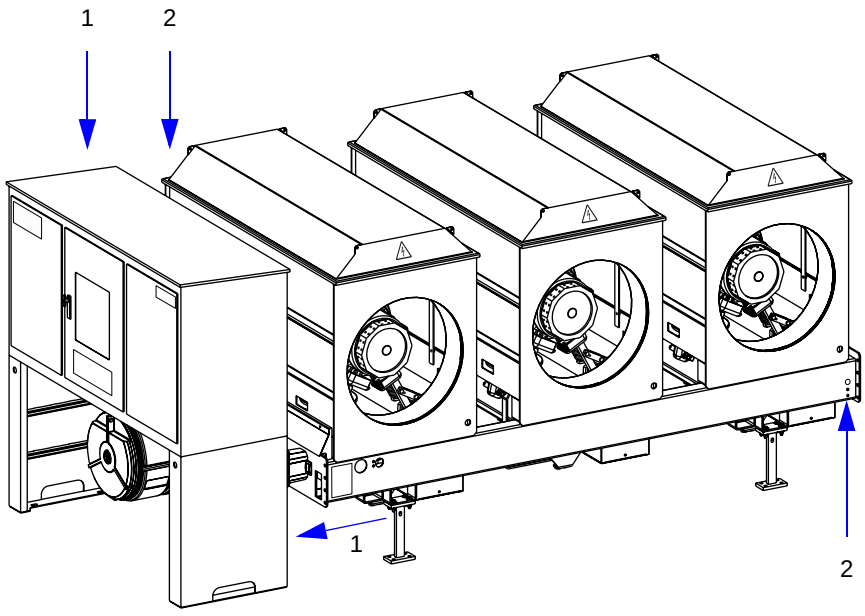


Fig. 6-18 Possible protective earth connections

1 Protective earth signs on the control cubicle
2 Protective earth signs on the pole frame

6.9 Cabling

In its standard version the control cubicle is already connected to the drives and control equipment of the generator circuit-breaker system.

If the control cubicle is not connected, the cabling must be carried out after the following products are in their final installation positions:

- Generator Circuit-Breaker System HECS-100M
- Control cubicle

The following items must be wired to the control cubicle:

- density monitoring switch
- hydraulic spring operating mechanism
- SDM drives
- current transformers
- voltage transformers

Details on wiring and cabling:

– Section 1.3.6.1 Plant specific documents, page 21.

CAUTION

Damage to the product

Operations with insufficient SF6 gas filling density damage the mechanics of the circuit-breaker even if no currents are switched.

1. Do not operate the circuit-breaker with insufficient gas filling density, see Section 5.2.1 Density indicator SF6, page 108.
2. Do not operate the circuit-breaker before commissioning is completed.

1. Ensure that concepts of switchgear interlocking are followed:
   – Section 4.4.3 Switchgear interlocking, page 98
2. Prepare installations of AC and DC power supplies:
   – Section 2.4 Power supply, interfaces, connections, page 41

6.10 Completion of erection work

Checklist

1. On welds:
   Ensure that corrosion protection is intact.
2. Ensure that the transport brackets are removed.
3. Ensure that the hand crank for SDM drives is stored in the holding device below the pole frame.
   If the hand crank is not in place:
   a) Insert the shaft of the handcrank into the tube.
   b) Secure the hand crank against misuse and loss by means of securing pin and padlock.
4. Store the maintenance lever for later use.
5. Pack, label and store manufacturer's lifting equipment for later use.
   – Section 9 Packaging, page 209
6. Recycle the packaging material.
   – See Section 12 Disposal, page 227.

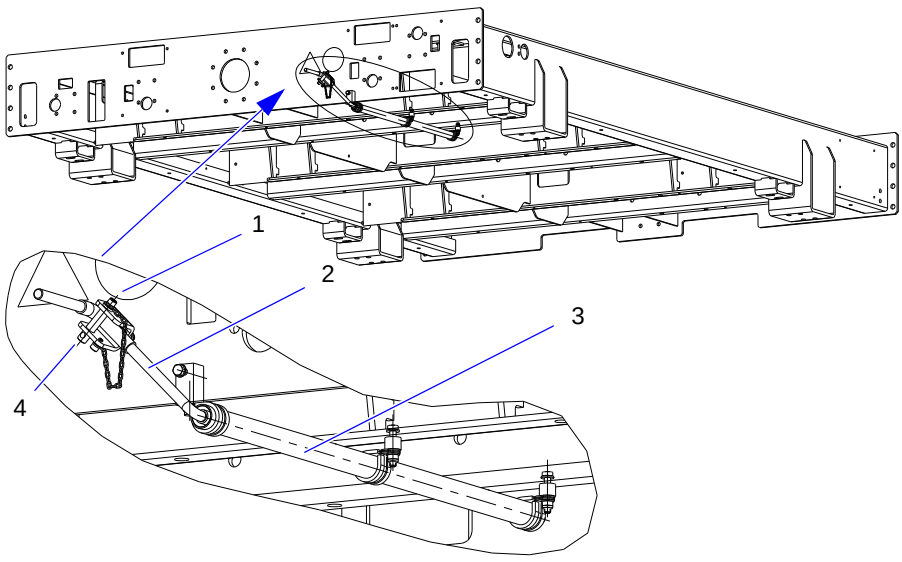


Fig. 6-19 Holding device for hand crank, overview and detail

1 Securing pin with chain
2 Hand crank
3 Tube
4 Hole for padlock

6.11 Request for commissioning

In order to organise effective commissioning procedures the plant officer/ operating company is requested to report the general condition on site.

Checklist

- The product is:
  - positioned at final location
  - fixed to the ground
  - freely accessible for the commissioner
- For products which must be accessed through the cover of the enclosure:
  - Lifting device for the covers is available.
  - Space to temporarily store the covers is available.
- Temporary or final installations of AC and DC power supplies are:
  - completed
  - checked
  - available
- Already installed electrical connections of the customer control can temporarily be removed by the commissioner.
- A filled SF6 gas container and filling devices are available, preferably next to the product.
  - Provide fitting adapters, if necessary.
- Assistance by a skilled technician is available.
- Consumables are available, such as:
  - protective covers
  - rags
  - cleaning additives, recommended: ethanol (ethyl alcohol)
- Sufficient lighting and a table to do the paperwork is available.
- Health and safety obligations (workplace safety, emergency contacts, scaffolding) are fulfilled.
- A responsible and authorized person on site is available to sign the “taking over certificate” for the customer.

The following items influence the duration and thus the costs of commissioning.

- The enclosures of the product are welded to the enclosures of the IPB,
- The flexible connections are ready to be connected to the conductors of the IPB.
- Protective earthing is completed.
- Cabling and wiring of signals, alarm indications and interlocking are:
  - completed
  - checked
- Maintenance lever for hydraulic spring operating mechanism and hand crank for SDM drives are available next to the product.
- A work bench with bench vice is available next to the product.

Upon receipt of the report on the general condition on site the manufacturer will arrange for the commissioning on site.

6.11.1 High voltage test

If a high voltage test is required, the testing procedures should be performed under supervision of a certified commissioner or overhauler. It is thus recommended to perform a high voltage test during commissioning.

If, for any reason, a high voltage test is to be performed after commissioning has been completed:

- Contact the manufacturer,
  see Section 1.1 Manufacturer and customer support, page 13.

NOTE

The test voltages are given in the factory acceptance test report. The maximum permissible test voltage during high voltage tests must be below 75 % of the power-frequency withstand voltage for system tests,
see Section 1.3.6.1 Plant specific documents, page 21.

Erection

Request for commissioning

7 Operation

This section is addressed to the plant officer/operating company and certified technicians.

7.1 Introduction

7.1.1 Safety instructions

The general safety instructions must be observed as stated in Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

DANGER

Electrocution – power installation

Hazardous voltages are present inside of the product enclosure. Electric flashover to personnel and objects may lead to death.

1. Do not open or remove any parts of the enclosure:
   - if the generator side is energised
   - if the transformer side is energised
   - with optional starting switch:
     if the static frequency converter is energised
   - if the product is in operation
2. Prerequisites to open the enclosure:
   - generator disconnected or shut down
   - transformer disconnected or earthed
   - with optional starting switch:
     static frequency converter disconnected or earthed
   - conductors of isolated-phase bus earthed
   - power supply and control voltage of product disconnected

DANGER

Explosion during operation

Any switching operation with insufficient gas filling density may cause explosion of an interrupting chamber.

1. Only operate the circuit-breaker if the filling density of SF6 gas is in the range GREEN, see Section 5.2.1 Density indicator SF6, page 108.

If the number and/or nature of switching operations exceed the limits given within this document any further operation may cause explosion of an interrupting chamber.

1. Be aware of the consequences resulting from switching operations.
2. Observe the maintenance schedule to keep the product in its functional condition. See Section 8 Maintenance, page 175.

DANGER

Explosion hazard

Operation of the drive for the disconnector:

1. Ensure that the circuit-breaker is open if the drive for the disconnector is operated.
   - Section 4.4.3.3 Operation of the disconnector, page 102

Operation of the drives for earthing switches:

1. Ensure that earthing switches are not closed towards live conductors.

Operation of the drive for an earthing switch with short-circuiting connection:

1. Ensure that the earthing switch does not switch currents exceeding the values specified:
   - Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

Hand crank may only be used for maintenance purposes!

WARNING

Bruises

Unexpected switching operations may cause injuries by movements of operating linkages.

1. Never stay underneath the pole frame:
   - during operation
   - during commissioning, maintenance and overhaul, if the hydraulic spring operating mechanism is charged and/or if a SDM drive is in the motorised operation mode

7.1.2 Target group

Correct execution of work is the responsibility of the plant officer/operating company.

Minimum qualification for assigned personnel: operator

- according to Section 1.2 Target groups, page 14.

7.2 Operating modes

The following operating modes must be considered:

- `REMOTE` from the plant main control desk:
  Description of operation in the `REMOTE` operating mode is not part of this document. The information is provided by the plant officer/operating company.
- `LOCAL` operating mode:
  - `LOCAL` from the control cubicle
    If the product is operated in combination with the control cubicle of the manufacturer:
    see Section 7.4 Control cubicle, page 167
  - `LOCAL` on product:
    see Section 7.3 SDM drive, page 160

Safety concepts for operation:

- Section 4.4 Safety and control equipment, page 97

7.3 SDM drive

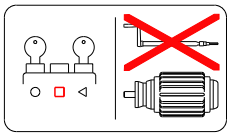
Depending on the plant specific product configuration the following SDM drives may be present:

- SDM drive for disconnector
- SDM drive for earthing switch on generator side
- SDM drive for earthing switch on transformer side
- SDM drive for starting switch

The operating and indicating elements of SDM drives are accessible on the pole frame, see Section 5.4 SDM drive, page 112.

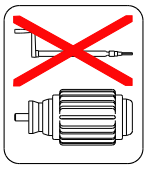
7.3.1 Normal operation

During normal operation the operating panel is secured with a cover and the SDM drive is in the motorised operation mode. The connected switching element can be switched REMOTE from the plant main control desk or LOCAL from the control cubicle. It is not possible to change settings on the operating panel of the SDM drive.



Settings for normal operation:

- □ access key: removed
- ▷ locking key for OFF position: inserted
- ○ locking key for ON position: inserted
- switching position of the connected switching element: ON or OFF
- locking tab for hand crank: LOCKED



Knob for selection of drive mode:

- in motorised operation

7.3.2 Using control panel of SDM drive

Prerequisites

Before starting any manipulations:

- Generator: disconnected or shut down
- Transformer: disconnected or earthed
- With optional starting switch:
  Static frequency converter: disconnected or earthed
- Access key: required
- Permit to work: required
  - Section 3.6 Safety recommendations and standard procedures, page 64

If the control cubicle of the manufacturer is in use:

- Operating mode of the control cubicle: LOCAL

NOTE

The procedures for obtaining a permit to work and any reports for documentation of the permit to work are the responsibility of the plant officer/operating company.

Access and locking keys are provided by the plant officer/operating company when the permit to work is granted. When the work has been completed the keys must be returned to the plant officer/operating company. Deviations must be noted in the permit to work.

Access and locking keys:

- only fit into the drive which they were supplied with
- are individually coded and can only be used for the allocated key switch

Hand crank:

- should be secured to the holding device below the pole frame

Operating elements necessary:

Access key

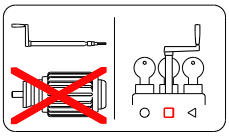
Locking key for OFF position

Locking key for ON position

Hand crank

Knob for selection of drive mode

7.3.2.1 Enabling the operating panel for operation



The drive modes can only be set when the operating panel has been enabled with the access key ☐:

1. Release and remove the cover of the operating panel with a screwdriver.
2. Insert the access key ☐ into key switch for the access key.
3. Turn the access key clockwise by 90°.

   The operating panel is enabled for operation and motorised operation of the SDM drive is no longer possible.

7.3.2.2 Setting the drive modes

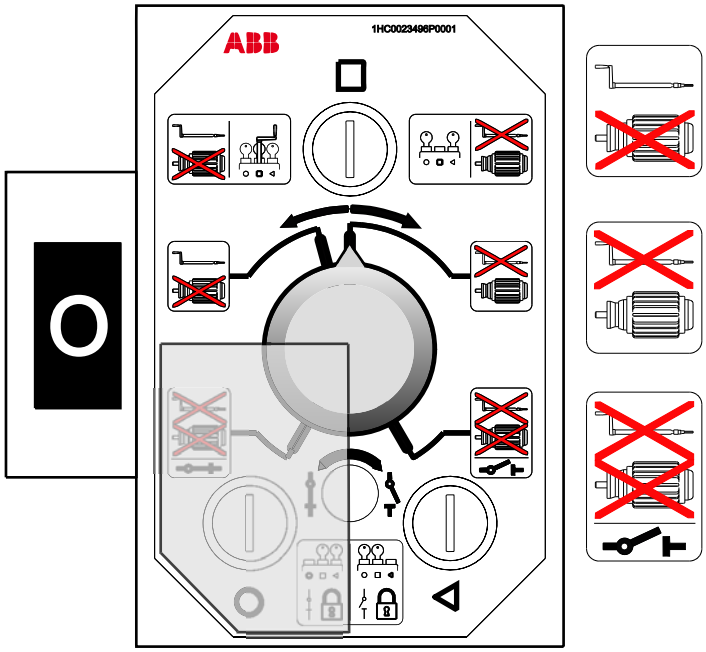
With the access key ☐ inserted, the drive modes can be changed by turning the knob for selection of drive mode.

The availability of drive modes depends on the switching position of the switching element connected. This can be in position ON or OFF. The switching position is shown by the position indicator in the window next to the operating panel of the drive.

Possible settings of drive mode:

– Fig. 7-1 Switching element in switching position OFF, page 163
– Fig. 7-2 Switching element in switching position ON, page 163

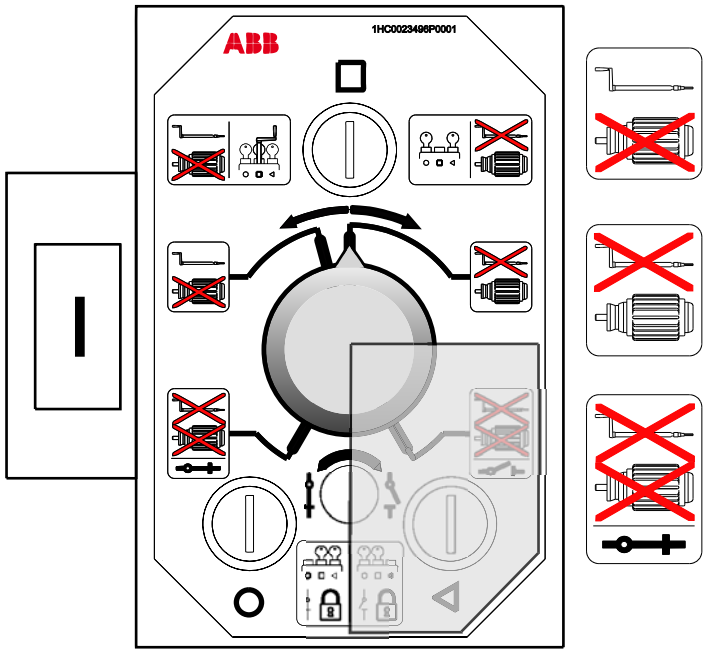
The operating elements which are unavailable with the respective switching position are greyed-out in these figures.



Possible drive modes:

- hand crank operation
- motorised operation, for example from the control cubicle of the manufacturer
- locking the drive in the OFF position

Fig. 7-1 Switching element in switching position OFF

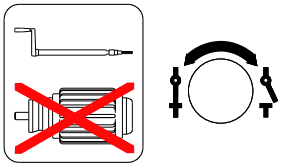


Possible drive modes:

- hand crank operation
- motorised operation, for example from the control cubicle of the manufacturer
- locking the drive in the ON position

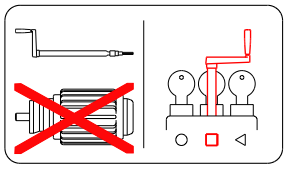
Fig. 7-2 Switching element in switching position ON

7.3.2.3 Hand crank operation



1. Ensure that the access and locking keys are inserted.
2. Knob for selection of drive mode:
   select hand crank operation

   The locking tab for the hand crank is OPEN.



3. Insert the hand crank into the opening for insertion of the hand crank.
4. By turning the hand crank: Move the connected switching element into the required switching position.

   The turning direction to the switching positions ON and OFF is marked by arrows and symbols above the opening for insertion of hand crank.

NOTE

To select another drive mode first remove the hand crank.

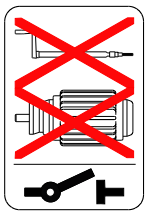
7.3.2.4 Locking a switching element

NOTE

The SDM drive can only be locked if the connected switching element is in the required switching position, to change switching position:

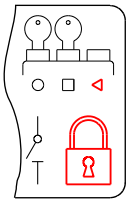
– Section 7.3.2.3 Hand crank operation, page 164

Locking the drive in the OFF position



1. Ensure that the access and locking keys are inserted.
2. Knob for selection of drive mode:
   select locking the drive in the OFF position

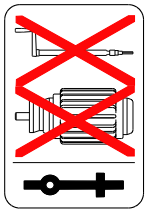
   The locking tab for the hand crank is LOCKED.



3. Turn the locking key for OFF position ▷ by 90° in a clockwise direction and pull out the key.

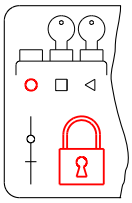
   Motorised operation and hand crank operation of the connected switching element are blocked.

Locking the drive in the ON position



1. Ensure that the access and locking keys are inserted.
2. Knob for selection of drive mode:
   select locking the drive in the ON position

   The locking tab for the hand crank is LOCKED.



3. Turn the locking key for ON position ○ by 90° in a clockwise direction and pull out the key.

   Motorised operation and hand crank operation of the connected switching element are blocked.

7.3.2.5 Unlocking a switching element

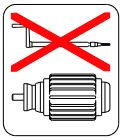
Unlocking the OFF position:

1. Insert the locking key for OFF position ▷ and turn it by 90° in an anticlockwise direction.

Unlocking the ON position:

1. Insert the locking key for ON position ○ and turn it by 90° in an anticlockwise direction.

7.3.2.6 Returning to normal operation



1. Ensure that the locking keys are inserted.
2. Knob for selection of drive mode:
   select motorised operation
3. Turn the access key □ by 90° in an anticlockwise direction and pull out the key.
4. Mount the cover of the operating panel with a screwdriver.
5. Return the access key □ to the plant officer/operating company.
6. Clear the permit to work:
   – Section 3.6 Safety recommendations and standard procedures, page 64

7.4 Control cubicle

NOTE

Permission for access to the product and safe-keeping of the keys for the product is the responsibility of the plant officer/operating company.

7.4.1 REMOTE operating mode

During normal operation of the plant the generator circuit-breaker system should be in REMOTE operating mode:

- interlocking key switch S2 in position REMOTE
- interlocking key removed
- control cubicle locked

The connected switching elements can be switched REMOTE from the plant main control desk. Safekeeping of the 2 keys and administration of access authorisation are the responsibility of the plant officer/operating company.

7.4.2 Using control panel of control cubicle

Prerequisites

Before starting any manipulations:

- Access key: required
- Interlocking key for switch S2: required
- Permit to work: required
  - Section 3.6 Safety recommendations and standard procedures, page 64

NOTE

The procedures for obtaining a permit to work and any reports for documentation of the permit to work are the responsibility of the plant officer/operating company.

The access key and the interlocking key for switch S2 are provided by the plant officer/operating company when the permit to work is granted. When the work has been completed the key must be returned to the plant officer/operating company. Deviations must be noted in the permit to work.

Access and interlocking keys are individually coded and can only be used for the allocated control cubicle.

7.4.2.1 Access to the control panel

To have access to the control panel, the control cubicle has to be unlocked.

1. Insert the access key into the lock of the door in front of the control panel and unlock.
2. Open the door for access to the control panel.

7.4.2.2 Switching operating mode on the control cubicle

1. Insert the interlock key into the interlocking key switch S2 on the signal board.
2. Turn the key into the LOCAL or REMOTE position.

7.4.2.3 Performing a LAMP TEST

1. Insert the interlock key into the interlocking key switch S2 on the signal board.
2. Turn the key into the LAMP TEST position.
   As a result:
   – all indicating elements should be illuminated

7.4.2.4 Operation in LOCAL operating mode

NOTE

Opening operations TRIP II ignore mode selection

If LOCAL mode is selected, this selection will be ignored by TRIP II signals. Thus the circuit-breaker is capable to perform opening operations TRIP II independent from mode selection.
See Section 4.4 Safety and control equipment, page 97.

NOTE

In REMOTE operating mode operation of the switching elements on the control cubicle is inhibited. The pushbuttons for the switching elements are illuminated, but inactive.

NOTE

Due to the electrical interlocking principles some switching elements cannot always be operated.
See Section 4.4 Safety and control equipment, page 97.

The actual position of a switching element is indicated by illumination of the pushbutton on the mimic diagram. To initialise a switching operation of a switching element press the pushbutton which is not illuminated at that time.

1. Insert the interlock key into the interlocking key switch S2 on the signal board.
2. Turn the key into the LOCAL position.
3. Press the desired pushbutton.
   As a result:
   – the switching element changes status
   – illumination of the pushbuttons changes

7.4.2.5 Returning to REMOTE operating mode

1. Turn the interlock key for interlocking key switch S2 into the REMOTE position.
2. Pull out the key for interlocking key switch S2.
3. Close the door of the control cubicle.
4. Lock the door of the control cubicle.
5. Pull out the access key for the control cubicle door.
6. Return both keys to the plant officer/operating company.
7. Clear the permit to work:

7.5 Fault recognition

The following instructions apply if switchgear interlocking is installed according to Section 4.4.3 Switchgear interlocking, page 98.

7.5.1 Gas equipment

NOTE

Contact the manufacturer if there are discrepancies between indication on the density indicator SF6 and the signals from the density monitoring switch:

– Section 1.1 Manufacturer and customer support, page 13

Density monitoring switch: Signal	**Density indicator SF6: Indication range**	**Meaning**	**Action required**
No signal set	GREEN	Gas density is all right.	No action required
SF6 LOW DENSITY	YELLOW	There may be a gas leakage.	Contact manufacturer
SF6 LOW DENSITY and SF6 BLOCKING[a]	RED	There may be a gas leakage. The circuit-breaker must not be operated any longer.	Contact manufacturer

Tab. 7-1 Signal description and meaning

a: For safety reasons minimum functional density is monitored by two independent micro switches, SF6 BLOCKING CLOSE / TRIP I and SF6 BLOCKING TRIP II.

Description of signals:

– Section 2.3.1.2 Gas and gas equipment, page 31

7.5.2 Hydraulic spring operating mechanism

Signal	Meaning	Action required
LONG TIME PUMP RUNNING[a]	The threshold for switching off the pump is not reached within a defined interval. The pump will not restart unless the signal is manually reset.	Pump is defective: – Contact manufacturer
BLOCKING C	Insufficient pressure for the drive mechanism of the hydraulic spring operating mechanism. The circuit-breaker can only perform one more opening operation.	Check supply voltages. If fault persists: – Contact manufacturer
BLOCKING C and BLOCKING O[b]	Insufficient pressure for the drive mechanism of the hydraulic spring operating mechanism. The circuit-breaker cannot perform another closing or opening operation.	Check supply voltages. If fault persists: – Contact manufacturer
DC VOLTAGE FAULT TRIP II[a]	The pump motor of the hydraulic spring operating mechanism or one or more elements of the controlling circuitries for opening operations TRIP II are not supplied with the correct supply voltage.	If power supply cannot be established: – Contact manufacturer
DC VOLTAGE FAULT CLOSE / TRIP I[a]	The pump motor of the hydraulic spring operating mechanism or one or more elements of the controlling circuitries for opening operations TRIP I and closing operations CLOSE are not supplied with the correct supply voltage.	If power supply cannot be established: – Contact manufacturer
DC VOLTAGE FAULT PUMP MOTOR[a]	The pump motor of the hydraulic spring operating mechanism is not supplied with the correct supply voltage.	If power supply cannot be established: – Contact manufacturer

Tab. 7-2 Signal description and meaning

a: Signal is only available in combination with a control cubicle of the manufacturer.
b: For safety reasons the blocking range of spring travel is monitored by independent micro switches for TRIP I and TRIP II.

Description of signals from hydraulic spring operating mechanism:

– Section 2.3.1.3 Hydraulic spring operating mechanism, page 32

7.5.3 SDM drives

Signals are only available in combination with a control cubicle of the manufacturer.

Signal	Meaning	Action required
`MOTOR PROTECTION SWITCH TRIPPED` Sources of signal: – disconnector `Q9` – earthing switch `Q81` – earthing switch `Q82` – starting switch `Q91` Optionally there may be different motor protection switches for disconnector `Q9` and earthing switches `Q81` and `Q82`. If more than one SDM drive is protected by one protection switch, the affected SDM drive must be identified.	The motor of an SDM drive has been overloaded. Possible reasons: – failure of power supply – mechanical defect of operating linkage – motor defective The drive will not restart unless the motor protection switch is manually reset.	Check supply voltages and phase-sequence. Operate the affected drive with hand crank, see Section 7.3 SDM drive, page 160: – Attend to noise and smooth running Operate the affected drive from the control cubicle, see Section 7.4 Control cubicle, page 167: – Attend to noise and smooth running If fault persists: – Contact manufacturer
`AC VOLTAGE I FAULT` `AC VOLTAGE II FAULT`	One of the 3 phase AC voltage supplies is not available.	Also check phase-sequence. If power supply cannot be established: – Contact manufacturer
`PHASE-SEQUENCE FAILURE`	Incorrect phase-sequence of the 3 phase AC voltage supply, either `AC VOLTAGE I` or `AC VOLTAGE II`	If power supply cannot be correctly connected: – Contact manufacturer

Tab. 7-3 Signal description and meaning

7.5.4 Control cubicle

Signal	Meaning	Action required
AC VOLTAGE FAULT HEATING	The heating system of the control cubicle is not supplied with the correct supply voltage.	If power supply cannot be established: – Contact manufacturer

Tab. 7-4 Signal description and meaning

7.5.5 Switchgear interlocking

Signals are only available in combination with a control cubicle of the manufacturer.

Signal	Meaning	Action required
TRIP II CIRCUIT FAULT	One or more of the preconditions for opening operations TRIP II are not fulfilled.	Check: – Tab. 7-1, page 170 – Tab. 7-2, page 171
TRIP I CIRCUIT FAULT	One or more of the preconditions for opening operations TRIP I are not fulfilled.	Check: – Tab. 7-1, page 170 – Tab. 7-2, page 171
CLOSE CIRCUIT FAULT	One or more of the preconditions for closing operations CLOSE are not fulfilled.	Check: – Tab. 7-1, page 170 – Tab. 7-2, page 171
No fault signal set but the desired switching operation cannot be carried out.	One or more of the preconditions for switchgear interlocking are not fulfilled.	See Section 4.4.3 Switchgear interlocking, page 98

Tab. 7-5 Signal description and meaning

8 Maintenance

This section is addressed to the plant officer/operating company and certified technicians.

8.1 Introduction

The section gives an overview of the maintenance concept and the maintenance work required. A maintenance plan is provided which enables the planning of tasks to be carried out to retain the product in its functional state.

8.1.1 Safety instructions

The general safety instructions must be observed:

– Section 3 Safety instructions, page 51

Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

The maintenance plan must be strictly followed to prevent a wearout failure which may lead to a critical fault. Non-observance is considered to be mishandling.

8.1.2 Target group

The appropriate planning of maintenance is the responsibility of the plant officer/operating company. The minimum qualification for assigned personnel must be in accordance with:

– Section 1.2 Target groups, page 14

In case of uncertainties with regard to interpretation do not hesitate to contact the manufacturer:

– Section 1.1 Manufacturer and customer support, page 13

8.2 Maintenance concept

Manufacturer’s maintenance concept is intended to:

- ensure a qualified service for the product against predictable and unpredictable events for product lifetime or at least 20 years after termination of production
- ensure the knowledge to service the product for product lifetime or at least 20 years after termination of production
- ensure the availability of wear and tear parts for product lifetime or at least 20 years after termination of production
- maximise the time the product is in operation
- keep the costs for maintenance predictable

8.2.1 Targets of maintenance

Maintenance is intended to:

- retain the product in its safe and functional condition
- reduce the risk of unexpected down times of the respective unit

8.3 Maintenance chart

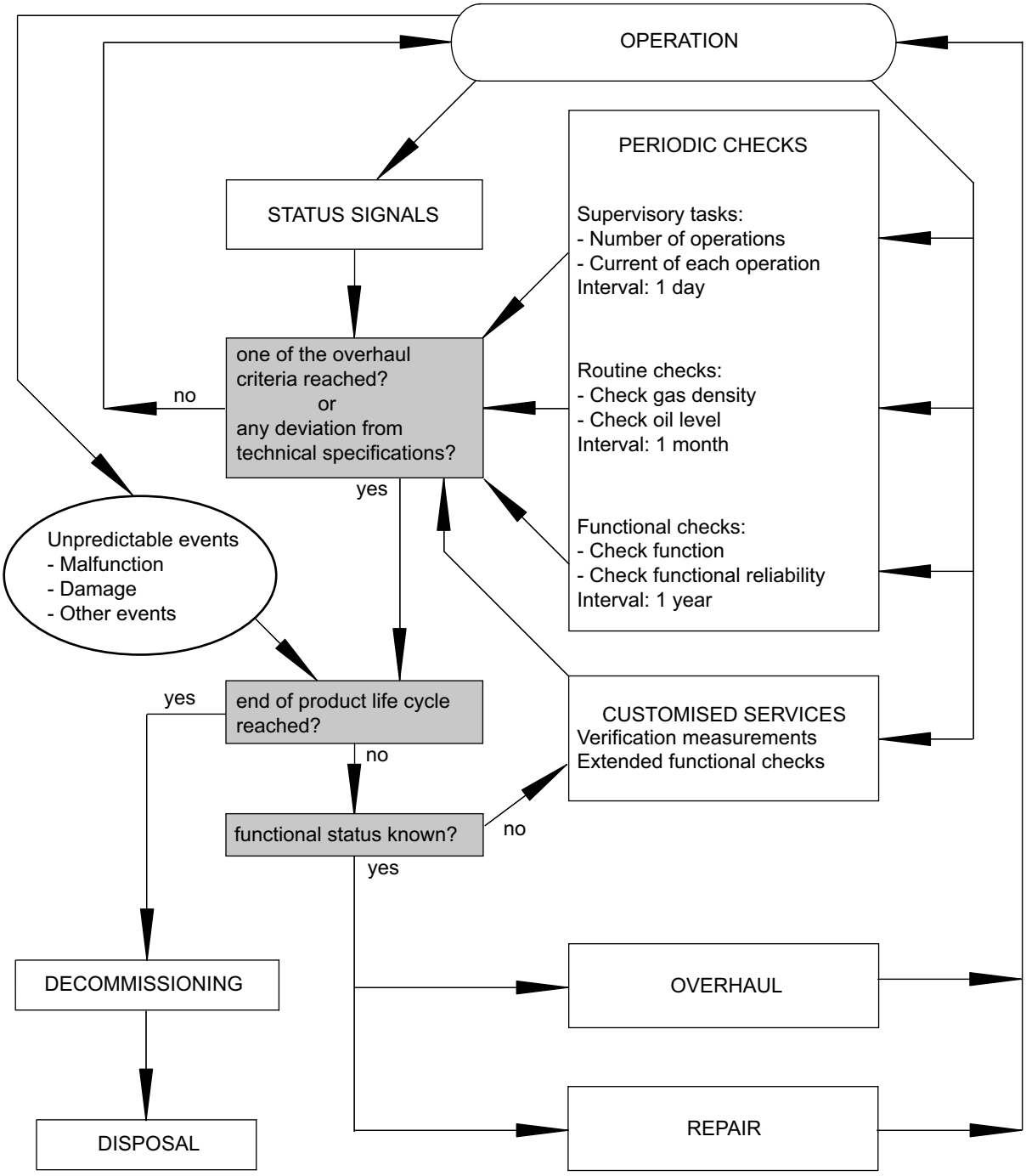


Fig. 8-1 Maintenance chart

8.3.1 Status signals

DANGER

Hazardous operating conditions

The following hazardous operating conditions must definitely be avoided:

SF6 gas density below the minimum functional density:

- An interrupting chamber may explode if currents are switched off beyond.
- Operations with insufficient gas filling density damage the mechanics of the circuit-breaker even if no currents are switched.

Spring travel of the disc springs of the hydraulic spring operating mechanism below the thresholds for closing and opening operations:

- The circuit-breaker will not reliably switch.

If the product is operated in combination with the control cubicle of the manufacturer:

- Switching is blocked at hazardous operating conditions. The corresponding failure is indicated on a signal board.

If the control cubicle is not in use:

- It is the responsibility of the plant officer/operating company to install a control system which effectively eliminates operation at hazardous operating conditions.

Safety relevant status signals:

– Section 4.4 Safety and control equipment, page 97

Auxiliary means to detect overhaul criteria and failures

NOTE

Evaluating systems for status signals are not part of the product.The availability of such systems depends on plant specific configuration.

The full set of status signals is available only in combination with a control cubicle of the manufacturer.

Status signals which may be evaluated to substitute periodic checks:

For signal description see:

– Section 7.5 Fault recognition, page 170

NOTE

Switching operations of disconnector, earthing switches, and starting switch

It is the responsibility of the plant officer/operating company to count close-open operations of these switches. Automated recording is possible by connecting the status signals of SDM drives to counters.

Counters in the control cubicle:

- Operation counter
  displays the number of close-open operations of the circuit-breaker.
  – Usage: The total number of close-open operations is essential to determine if an overhaul criterion is reached.
- Pumping operation counter
  displays the number of starting operations of the pump of the hydraulic spring operating mechanism.
  – Usage: The number of pumping operations per day may be taken as a measure to monitor internal tightness of the hydraulic spring operating mechanism, see documentation of the hydraulic spring operating mechanism.

Refer to:

– Fig. 8-1 Maintenance chart, page 177 for overview
– Section 8.5 Periodic checks, page 186 for task descriptions
– Section 8.3.2.2 Overhaul criteria, page 180 for a listing of overhaul criteria
– Section 8.4.1 Adapting time intervals, page 184 for assistance to configure an optimised maintenance plan

8.3.2 Scheduled maintenance

Scheduled maintenance serves to analyse and, if necessary, to re-establish the functional state of the product. If evaluating systems are used to monitor status signals these optional systems must also be checked.

Scheduled maintenance involves periodic checks which must be performed regularly, based upon fixed intervals specified in a maintenance plan.

Refer to:

– Fig. 8-1 Maintenance chart, page 177 for overview
– Section 8.4 Maintenance plan, page 183
– Section 8.5 Periodic checks, page 186 for task descriptions

8.3.2.1 Analysing tasks

The following items of the maintenance plan are aimed to analyse the functional state of the product and associated optional systems:

- Periodic checks under the responsibility of the plant officer/operating company, see Section 8.5 Periodic checks, page 186.
- Customised services, by arrangement with and under the responsibility of the manufacturer, see Section 8.6 Customised services, page 194.

Normal operation of the product can be resumed if the analysing tasks do not reveal that an overhaul criterion is reached. Otherwise overhaul is required.

8.3.2.2 Overhaul criteria

Overhaul is required if one of the following criteria is reached.

Circuit-breaker

- Mechanical overhaul:
  20000 close-open operations
- Electrical overhaul:
  Accumulated ablation coefficient reaches 20000.

Disconnector

- Mechanical overhaul:
  20000 close-open operations

Earthing switch – optional

- Mechanical overhaul:
  5000 close-open operations

Earthing switch with motor operated short-circuiting connection – optional

- Mechanical overhaul:
  5000 close-open operations
- Electrical overhaul:
  Number of switching operations under residual voltage conditions reaches 20 close-open operations.
  Any individual switching operation must not exceed the values specified:
  – Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

Starting switch – optional

- Mechanical overhaul:
  10000 close-open operations
- Electrical overhaul:
  Number of switching operations with small capacitive currents ≤0.5 A reaches 5000 close-open operations.
  Any individual switching operation must not exceed the values specified:
  – Section 2.3.1.10 Starting switch – optional, page 38

Generator circuit-breaker system

- Time based overhaul:
  20 years:

Any of the listed items leads to an overhaul; the first occurrence must be considered seriously.

For calculating overhaul criteria:

– Section 8.7.1 Mechanical lifetime, page 199
– Section 8.7.2 Electrical lifetime, page 200

8.3.2.3 Overhaul tasks

If an overhaul criterion has been reached the manufacturer offers overhaul packages which re-establish the functional state of the product.

Refer to:

– Section 8.7.3.1 Mechanical overhaul, page 207
– Section 8.7.3.2 Electrical overhaul, page 208
– Section 8.7.3.3 Time based overhaul, page 208

8.3.2.4 End of product life cycle

End of product life cycle is defined as follows:

- mechanical:
  - 40000 close-open operations,
    see Section 8.7.1 Mechanical lifetime, page 199.
- time based:
  - 40 years

8.3.3 Administrative tasks

It is the responsibility of the plant officer/operating company:

- to organise maintenance work
- to be always competent about the functional state of the product
- to keep in contact with the manufacturer

To meet the above tasks the maintenance plan must be adapted to the plant specific conditions:

– Section 8.4 Maintenance plan, page 183

8.3.3.1 Organising overhaul

Overhaul requires a shutdown of the product and the respective unit within the plant.

To reduce down times of the plant:

- Overhaul should be synchronised with the annual shutdown of the respective unit within the plant.
- The expected date of overhaul can be estimated from the number of close-open operations per year.
- Contact the manufacturer early enough to schedule overhaul as desired.

NOTE

Electrical overhaul

The plant officer/operating company is advised to plan overhauls of contact material in due time, before $\sum k(I)$ has reached a value of 15000. In case of $\sum k(I) > 15000$, an additional switching of an over-current would immediately lead to a value of $\sum k(I) > 20000$ at which the circuit-breaker must not be operated any longer:

– Section 8.7.2 Electrical lifetime, page 200

8.4 Maintenance plan

Periodic checks				**Target group[a]**
•	supervisory tasks	time interval	1 day	operator
•	routine checks	time interval	1 month	operator
•	functional checks	time interval	1 year	operator
Customised services				
•	verification measurements	as required / by arrangement		certified commissioner, DRM[b]: certified overhauler
•	extended functional checks	as required / by arrangement		certified overhauler
Overhaul				
•	mechanical overhaul			
	– circuit-breaker	counter readings	20000 CO[c]	certified overhauler
	– disconnector	number of operations	20000 CO[c]	
	– earthing switch – optional	number of operations	5000 CO[c]	certified overhauler
	– earthing switch with motor operated short-circuiting connection – optional	number of operations	5000 CO[c]	certified overhauler
	– starting switch – optional	number of operations	10000 CO[c]	certified overhauler
•	electrical overhaul			
	– circuit-breaker	accumulated ablation coefficient	20000	certified overhauler
	– earthing switch with motor operated short-circuiting connection – optional	number of operations under residual voltage conditions[d]	20 CO[c]	certified overhauler
	– starting switch – optional	number of operations with small capacitive currents ≤0.5 A[d]	5000 CO[c]	certified overhauler
•	time based overhaul			
	– generator circuit-breaker system	time interval	20 years	certified overhauler
End of product life cycle				
•	mechanical		40000 CO[c]	
•	time based		40 years	

Tab. 8-1 Maintenance plan

a: Minimum certificate
b: DRM = dynamic resistance measurement
c: CO = close-open operations
d: Any individual switching operation must not exceed the values specified. See Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37 and Section 2.3.1.10 Starting switch – optional, page 38

The maintenance plan states the maintenance tasks necessary. The intervals refer to a frequently switching circuit-breaker, e.g. in a pumped storage power plant.

An evaluation of status signals is not considered by this maintenance plan:

– Section 8.3.1 Status signals, page 178

For information on lifetime:

– Section 8.7.1 Mechanical lifetime, page 199
– Section 8.7.2 Electrical lifetime, page 200

8.4.1 Adapting time intervals

It is the responsibility of the plant officer/operating company to adapt the maintenance plan to the local conditions.

Supervisory tasks, 1 day interval

Logging all switching operations is considered a vital and integral part of the maintenance. Mechanical and electrical lifetime are based upon the total number of close-open operations and the effective value of switched current (rms-value) for each operation.

NOTE

It must be ensured that all close-open operations are counted and that no fault is indicated. Suitable counters and status signals are available if the product is operated in combination with the control cubicle of the manufacturer:

– Section 8.3.1 Status signals, page 178

It is the responsibility of the plant officer/operating company:

– to verify the function of counters
– to log all close-open operations if suitable counters are not available
– to verify status signals

Adapting the interval of supervisory tasks:

- An interval of 1 day assumes that there are frequent switching operations, e.g. in a pumped storage power plant.
- If the product switches rarely the interval may be prolonged.
- If an automated evaluating system is involved, supervisory tasks should focus on checking the reliability of the evaluating system; the interval may be prolonged.

Routine checks, 1 month interval

The routine checks are aimed to verify the tightness of the gas equipment and the hydraulic spring operating mechanism. Sudden failures of both systems are detected by alarming and blocking signals:

– Section 8.3.1 Status signals, page 178

Adapting the interval of routine checks:

- The interval should only be modified if the status signals are permanently monitored by an evaluating system.
  Under these conditions routine checks should focus on checking the reliability of the evaluating system; the interval may be prolonged to one year.

Functional checks, 1 year interval

Functional checks are aimed to verify the functional state of the product. A shutdown of the product and the respective unit within the plant is required.

- The interval must not be modified.
- Functional checks of rarely switching products ensure the reliability of the product in emergency situations.

The timing of the functional checks should be synchronised with the annual shutdown of the respective unit within the plant.

Customised services

Customised services are performed by arrangement with and under the responsibility of the manufacturer and should be carried out to complete scheduled maintenance. A shutdown of the product and the respective unit within the plant is required.

- The interval depends on plant specific operating cycles.

NOTE

The manufacturer recommends dynamic resistance measurements at $\sum k(I)=5000$ and again at $\sum k(I)=10000$ and $\sum k(I)=15000$.

8.5 Periodic checks

DANGER

Electrocution – power installation

Hazardous voltages are present inside of the product enclosure. Electric flashover to personnel and objects may lead to death.

1. Do not open or remove any parts of the enclosure:
   - if the generator side is energised
   - if the transformer side is energised
   - with optional starting switch:
     if the static frequency converter is energised
   - if the product is in operation
2. Prerequisites to open the enclosure:
   - generator disconnected or shut down
   - transformer disconnected or earthed
   - with optional starting switch:
     static frequency converter disconnected or earthed
   - conductors of isolated-phase bus earthed
   - power supply and control voltage of product disconnected

The following periodic checks may be carried out while the product, the transformer, and the generator are in operation:

- supervisory tasks
- routine checks

The following periodic checks must only be carried out during shutdown of the product and the respective unit within the plant:

- functional checks

8.5.1 Supervisory tasks

Interval: 1 day, see Section 8.4.1 Adapting time intervals, page 184.

Target group: Operator

Prerequisites:

- Generator: in operation
- Product: in operation
- Enclosures of the product remain closed
- Access to control cubicle: not necessary

Tasks: Collect the following data for logbook entries:

- Date and time
- Alarm signals on the signal board of the control cubicle
- Counter readings of operation counter and pumping operation counter
- Total number of close-open operations
- Effective value of switched current (rms-value) for each switching operation, switched current = 0 A for no load switching operations
- Calculation of corresponding ablation coefficient
- Accumulated sum of ablation coefficients since last overhaul

Results:

- Record findings in logbook or report form.
- Compare results with criteria for overhaul.
- Depending on results or, if queries arise:
  - Contact manufacturer for advice and/or further actions.
  - Report deviations with report and photos to manufacturer.

For detailed descriptions:

- Tab. 8-1 Maintenance plan, page 183
- Section 8.7.1 Mechanical lifetime, page 199
- Section 8.7.2 Electrical lifetime, page 200

8.5.2 Routine checks

Interval: 1 month to 1 year, see Section 8.4.1 Adapting time intervals, page 184.

Target group: Operator

Prerequisites:
- Generator: in operation
- Product: in operation
- Enclosures of the product: remain closed
- Access to control cubicle: necessary

Tasks:
- Repeat supervisory tasks:
  - Section 8.5.1 Supervisory tasks, page 187
- Check gas density:
  - Section 8.5.2.1 Check gas density, page 189
- Check oil level on hydraulic spring operating mechanism:
  - Section 8.5.2.2 Check oil level, page 190
- On the control cubicle: perform lamp test
  - Section 7.4.2 Using control panel of control cubicle, page 167

Results:
- Record findings in logbook or report form.
- Compare results with criteria for overhaul.
- Depending on results or, if queries arise:
  - Contact manufacturer for advice and/or further actions.
  - Report deviations with report and photos to manufacturer.

8.5.2.1 Check gas density

1. Check the density of the SF6 gas and note down the position of the pointer.
2. Interpretation of the reading:
   – Section 5.2.1.1 Indication ranges, page 109

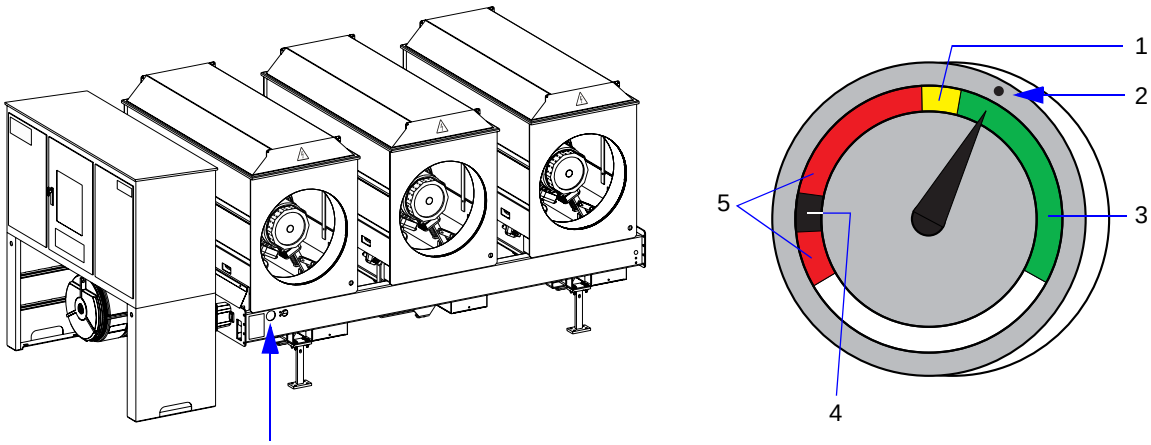


Fig. 8-2 Density indicator

1 Indication range YELLOW
2 Marking point BLACK
3 Indication range GREEN
4 Indication range BLACK
5 Indication range RED

8.5.2.2 Check oil level

1. Visually check the oil level.
   – Follow the instructions in the document of the hydraulic spring operating mechanism,
   see Section 1.3.6 Additional documents, page 21.

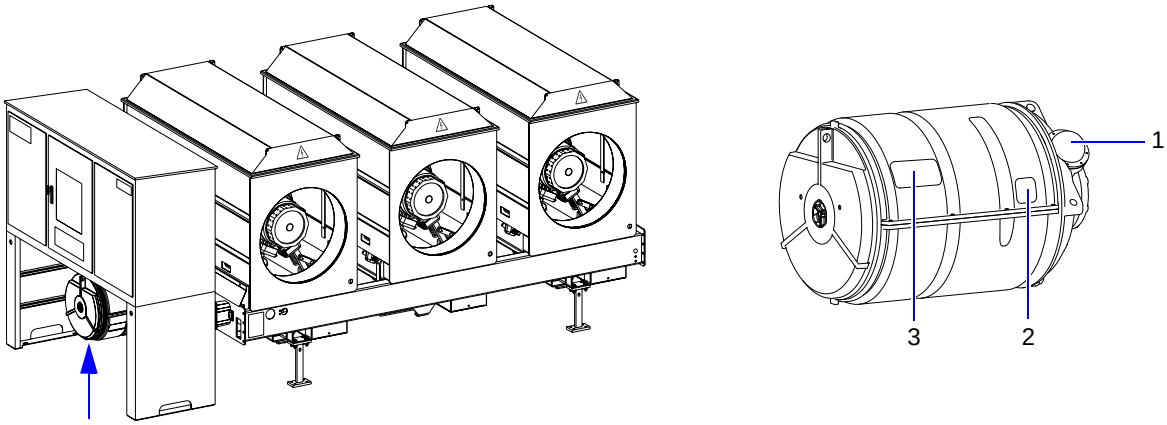


Fig. 8-3 Indicating elements of the hydraulic spring operating mechanism

1 Position indicator of the circuit-breaker
2 Inspection window for the filling level of hydraulic oil
3 Inspection window for the spring travel

8.5.3 Functional checks

Interval: 1 year

Target group: Operator, certified commissioner, overhauler and/or supervisor

8.5.3.1 Check function

Prerequisites

- Generator: disconnected or shut down
- Transformer: disconnected or earthed
- With optional starting switch:
  Static frequency converter: disconnected or earthed
- Conductors of isolated-phase bus: earthed
- Power supply and control voltage of product: required
  - Section 2.4 Power supply, interfaces, connections, page 41
- Enclosures of the product: remain closed
- Access to control cubicle: necessary

Tasks

- Operate the circuit-breaker from the control cubicle by using electric control.

  During the switching operations attend to any abnormalities, particularly with regard to noise, status signals, runtime of the pump of the hydraulic spring operating mechanism. Observe the documentation of the hydraulic spring operating mechanism.
  - Section 1.3.6 Additional documents, page 21.
- Operate the SDM drives:
  - from the control cubicle by using electric control, see Section 7.4.2 Using control panel of control cubicle, page 167
  - from the control panel by using the hand crank, see Section 7.3.2 Using control panel of SDM drive, page 161

  During the switching operations attend to any abnormalities, particularly with regard to noise and status signals.
- Check heating system of the control cubicle.
  - Section Checking heating system, page 192
- Check illumination inside the control cubicle
  - Section Checking illumination, page 192

Results

- Record findings in logbook or report form.
- Compare results with criteria for overhaul.
- Depending on results or, if queries arise:
  - Contact manufacturer for advice and/or further actions.
  - Report deviations with report and photos to manufacturer.

Checking heating system

1. Set thermostat to value above actual temperature.
2. Check if heating system starts up.
3. Set hygrostat to value below actual humidity.
4. Check if heating system starts up.
5. If a check failed:
   Replace thermostat/hygrostat.
6. Set thermostat/hygrostat back to original value.

Checking illumination

1. Check illumination of inner compartments.

   If there is no illumination:

   a) Check supply voltage

   If one lamp is not illuminated:

   a) Check contact switch: replace switch if necessary.
   b) Check bulb: replace bulb if necessary.

8.5.3.2 Check functional reliability

Prerequisites

- Generator: disconnected or shut down
- Transformer: disconnected or earthed
- With optional starting switch:
  Static frequency converter: disconnected or earthed
- Conductors of isolated-phase bus: earthed
- Power supply and control voltage of product: disconnected
- Enclosures of the product: must be opened
- Access to control cubicle: necessary

Tasks

- Repeat supervisory tasks and routine checks:
  - Section 8.5.1 Supervisory tasks, page 187.
  - Section 8.5.2 Routine checks, page 188.
- Check for external, visually recognisable damages on the product.
- Check mechanical connections for intactness and stability.
- Check electrical connections for intactness and stability.

Results

- Record findings in logbook or report form.
- Compare results with criteria for overhaul.
- Depending on results or, if queries arise:
  - Contact manufacturer for advice and/or further actions.
  - Report deviations with report and photos to manufacturer.

8.6 Customised services

Customised services support the safe and reliable operation of the product and reduce the risk of an instantaneous unavailability.

Customised services may be carried out:

- as a part of scheduled maintenance
- after the occurrence of an unpredictable event to verify the physical condition of the product

The manufacturer offers service packages comprising the following items:

- verification measurements:
  - travel measurement vs. time
  - dynamic resistance measurement
- extended functional checks:
  - gas equipment
  - hydraulic spring operating mechanism

Interval

Customised services are performed by arrangement with and under the responsibility of the manufacturer. Contact the manufacturer early enough to schedule the services as desired.

Prerequisites

- Generator: disconnected or shut down
- Transformer: disconnected or earthed
- With optional starting switch:
  Static frequency converter: disconnected or earthed
- Conductors of isolated-phase bus: earthed
- Power supply and control voltage of product: available
- Enclosures of the product: must be opened

Equipment

Customised services require special measurement equipment depending on the tasks to be performed.

Time required

The time indicated in the description of the individual tasks is approximate and refers to net time duration required for the tasks to be performed, including the necessary measurement equipment set-up and completion of the tasks.

The time required does not include possible time delays for administrative, organisational and infrastructural reasons.

8.6.1 Verification measurements

Results — Measurement graphs and records. The results are checked against previous test protocols based on test measurement, factory acceptance tests, etc.

Recommendations — The results enable the plant officer/operating company to decide either

- for an immediate overhaul

  – or –

- to continue operation.
  If operation is continued the results enable the plant officer/operating company to synchronise further maintenance activities with other maintenance activities in the respective unit within the plant,
  see Section 8.3.3 Administrative tasks, page 182.
  Further maintenance activities:
  – deferred overhaul
  – further verification measurements

8.6.1.1 Travel measurement vs. time

The result of a travel measurement vs. time is to verify the mechanical performance of the product. The travel measurement vs. time is recommended for rarely switching products and after storage periods of more than 12 months.

Target group — Certified commissioner, overhauler, and/or supervisor

Time required — Approx. 10 net working hours

8.6.1.2 Dynamic resistance measurement

NOTE

The manufacturer recommends dynamic resistance measurements at $\sum k(I)=5000$ and again at $\sum k(I)=10000$ and $\sum k(I)=15000$.

The dynamic resistance measurement determines the ablation of the arcing contact material. It can thus be used to verify the degree of ablation calculated by the ablation coefficient k:

– Section 8.7.2 Electrical lifetime, page 200.

Dynamic resistance measurements must individually be performed for each interrupting chamber.

Target group: Certified overhauler and/or supervisor

Time required: Approx. 10 net working hours

Expressions used

rms-value: Root-mean-square value

Time difference: Time difference between the separation of the nominal contacts and the separation of the arcing contacts.

Background

During each opening operation, depending on the rms-value of the switched current, a fraction of the arcing contact material is ablated. This leads to a shorter time difference – between the separation of the nominal contacts and the separation of the arcing contacts – during the next switching operation.

Measuring principle

During an opening operation abrupt resistance changes coincide with the separation of the nominal contacts and the separation of the arcing contacts. According to Ohm's law, at a constant DC test current these resistance changes result in sudden changes of the voltage drop measured over the interrupting chamber. The corresponding time difference is determined as the relevant measurement.

The circuit-breaker requires overhaul if the time difference has fallen below a defined minimal value.

8.6.2 Extended functional checks

Target group: Certified overhauler, and/or supervisor

8.6.2.1 Gas equipment

The service for gas equipment includes:

- A general mechanical inspection of:
  - the piping and connections
  - the density monitoring switch and the density indicator
- A calibration of the density monitoring switch and the density indicator with a calibrated density gauge.
- Optional:
  Checking the quality of the SF6 gas inside the product.
- Refilling gas, if necessary.

Time required: Approx. 10 net working hours

8.6.2.2 Hydraulic spring operating mechanism

The service for the hydraulic spring operating mechanism includes:

- Visual inspection.
- The inspection of:
  - the external and internal tightness
  - the carbon brushes
  - the trip coils
- The measurement of the runtime of the pump.

Time required: Approx. 10 net working hours

8.7 Overhaul information

Overhaul is corrective maintenance to restore the required functional state of the product.

The manufacturer offers special overhaul packages which match the specific maintenance requirements.

Overhaul comprises a partial dismantling of the product, the replacement of line replaceable units and mechanical and/or electrical parts due to wear and tear as well as re-assembling and re-commissioning.

Appropriate to the respective scope the manufacturer offers special overhaul packages:

- mechanical overhaul
- electrical overhaul
- time based overhaul

Target group

Certified overhauler or supervisor

Assistants

2 skilled technicians are requested for assistance.

Time required

See Section 8.7.3 Overhaul packages, page 207.

The respective time indicated is approximate and refers to net time duration required for the tasks to be performed, including the necessary equipment set-up and completion of the tasks.

The time required does not include possible time delays for administrative, organisational and infrastructural reasons.

The given value of time required assumes an easy access to the product.

Planning

Contact the manufacturer early enough to synchronise overhaul of the product with other maintenance activities in the respective unit of the plant.

Prerequisites

All overhaul packages require:

- Generator: disconnected or shut down
- Transformer: disconnected or earthed
- With optional starting switch:
  Static frequency converter: disconnected or earthed
- Conductors of isolated-phase bus: earthed
- Power supply and control voltage of product: available but disconnected
- Enclosures of the product: must be opened

8.7.1 Mechanical lifetime

Mechanical lifetime is based on the number of close-open operations. The counter for close-open operations of the circuit-breaker is located on the signal board of the control cubicle.

Mechanical lifetime must be considered for:

- circuit breaker
- disconnector
- earthing switches
- starting switch

The plant officer/operating company must ensure that all close-open operations are counted:

- if there is no control cubicle
- if there is no counter

Mechanical overhaul is required if the corresponding overhaul criterion is reached:

– Section 8.3.2.2 Overhaul criteria, page 180

8.7.2 Electrical lifetime

Electrical lifetime is based upon the accumulated ablation of contact material during all switching operations.

Electrical lifetime must be considered for:

- circuit-breaker:
  opening and closing operations must be considered differently
- earthing switch with motor operated short-circuiting connection
- starting switch

Electrical overhaul is required if the corresponding overhaul criterion is reached:

– Section 8.3.2.2 Overhaul criteria, page 180

Expressions used

rms-value	Root-mean-square value
Time difference	Time difference between the separation of the nominal contacts and the separation of the arcing contacts.
150 % I_C	150 % of rated normal current

8.7.2.1 Opening operations of circuit-breaker

During each opening operation, depending on the rms-value of the switched current, a fraction of the arcing contact material is ablated. To calculate this loss of contact material, an ablation coefficient k is assigned to each opening operation. The ablation coefficient is proportional to a reduced time difference, see Section 8.6.1.2 Dynamic resistance measurement, page 196.

It is important to measure the rms-value of the switched current correctly. Shortly before contact separation, the current may rise or decrease. Therefore, the current must be measured just before contact separation takes place, typically during the last two cycles before contact separation.

Fig. 8-4, page 201 exemplarily shows the course of the current during an opening operation. If a calculation was based upon the continuous current, the assigned ablation coefficient k would be undervalued because, in the given example, the current rises just before contact separation takes place.

NOTE

Fig. 8-4, page 201 shows that current changes may occur in advance of an opening operation. Magnitude and direction of these current changes depend on the plant specific conditions under which the circuit-breaker is operated.

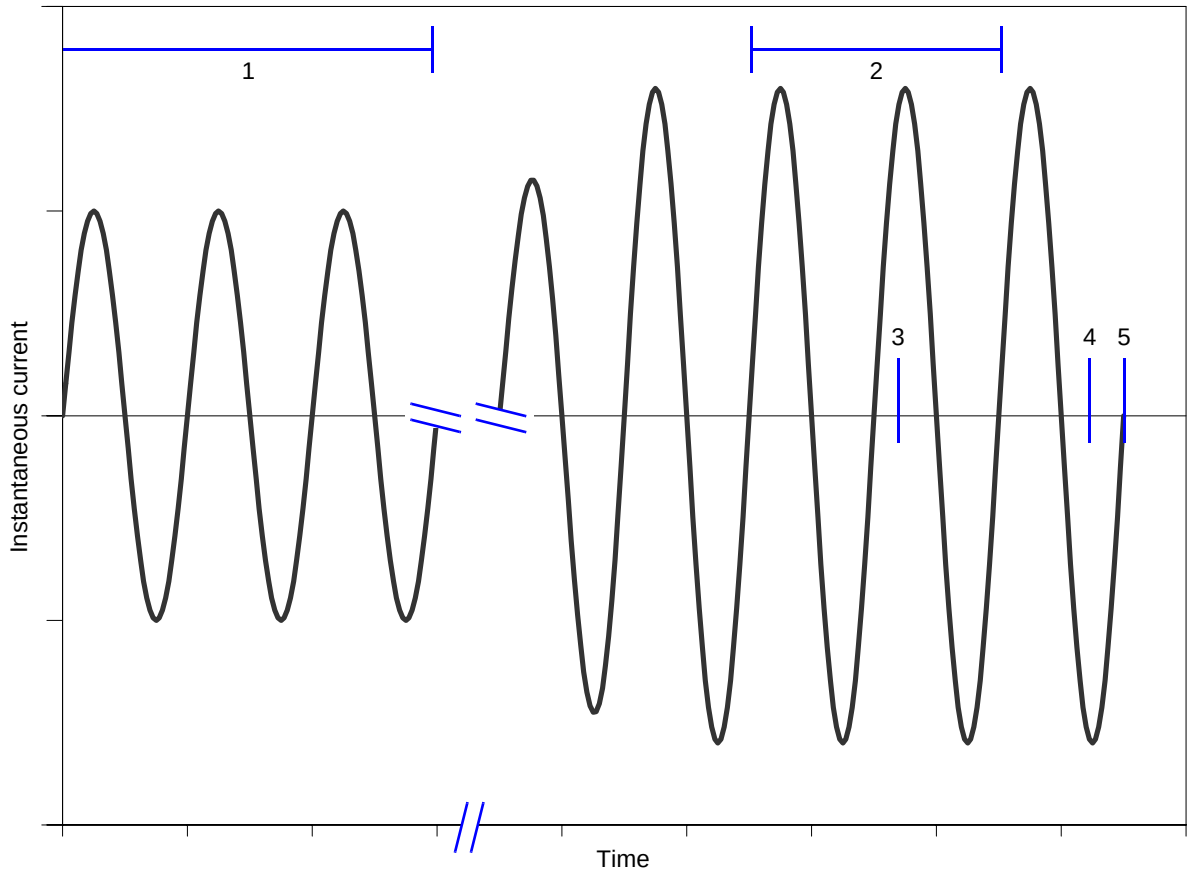


Fig. 8-4 Course of current during an opening operation

1 Continuous current
2 Interval for measuring the current
3 Trip signal
4 Contact separation
5 Current interruption

Calculating individual ablation coefficients k

The ablation coefficients k for all currents I between 0 kA and rated short-circuit current are displayed in:

– Fig. 8-5 Ablation coefficient k, page 204

Small currents

For small currents electrical wear due to the ablation of contact material is negligible and mechanical wear limits lifetime. This fact is accommodated by fixing the ablation coefficient k to 1. If a circuit-breaker only switched these small currents, the criteria for mechanical overhaul and electrical overhaul would be reached simultaneously.

For small currents:

$k = 1$

Load currents

For load currents up to 150 % I_C the ablation coefficient rises continuously. Within this range the ablation coefficient is proportional to the ablation of the arcing contacts.

For load currents $\leq$150 % I_C:

$k = f(I)$

Over-currents

Currents above 150 % I_C are assumed to be over-currents. Due to the higher voltage stress, the breaking of such currents creates longer arcing times than the breaking of currents below rated normal current I_C. At these conditions the ablation of contact material increases disproportionately.

In addition, high electrodynamic forces arise which reduce the mechanical lifetime of the circuit-breaker.

Furthermore, currents above 150 % I_C may be undervalued because the monitoring current transformer is operated at its saturation level. By default the operating ranges of current transformers are dimensioned for the rated normal current I_C.

As a consequence, any current above 150 % I_C is assumed to be an over-current to which a ablation coefficient k of 5000 is assigned.

For over-currents >150 % I_C:

$k = 5000$

Total sum of ablation coefficients k

The criterion for electrical overhaul is defined by the formula:

- total sum of ablation coefficients k: $\sum k(I) > 20000$

During the entire operational time of the circuit-breaker, the ablation coefficients k of all individual opening operations must be added up as exemplarily shown in Tab. 8-2, page 205.

As long as the sum $\sum k(I)$ is smaller or equal to 20000, at least one additional over-current switching operation is possible. As soon as $\sum k(I)$ reaches a value greater than 20000 the circuit-breaker must not be operated any longer and an overhaul must be performed.

For organising overhaul:

– Section 8.3.3 Administrative tasks, page 182

The plant officer/operating company is advised to plan overhauls in due time, before $\sum k(I)$ has reached a value of 15000. If $\sum k(I)$ is greater than 15000 one additional over-current switching operation will increase $\sum k(I)$ to a value above 20000 at which the circuit-breaker must not be operated any longer.

Summation of ablation coefficients k restarts after completion of the electrical overhaul.

Validation by dynamic resistance measurement

The calculation of the total sum of the ablation coefficients k can be validated by dynamic resistance measurements, see Section 8.6.1.2 Dynamic resistance measurement, page 196.

NOTE

The manufacturer recommends dynamic resistance measurements at $\sum k(I)=5000$ and again at $\sum k(I)=10000$ and $\sum k(I)=15000$.

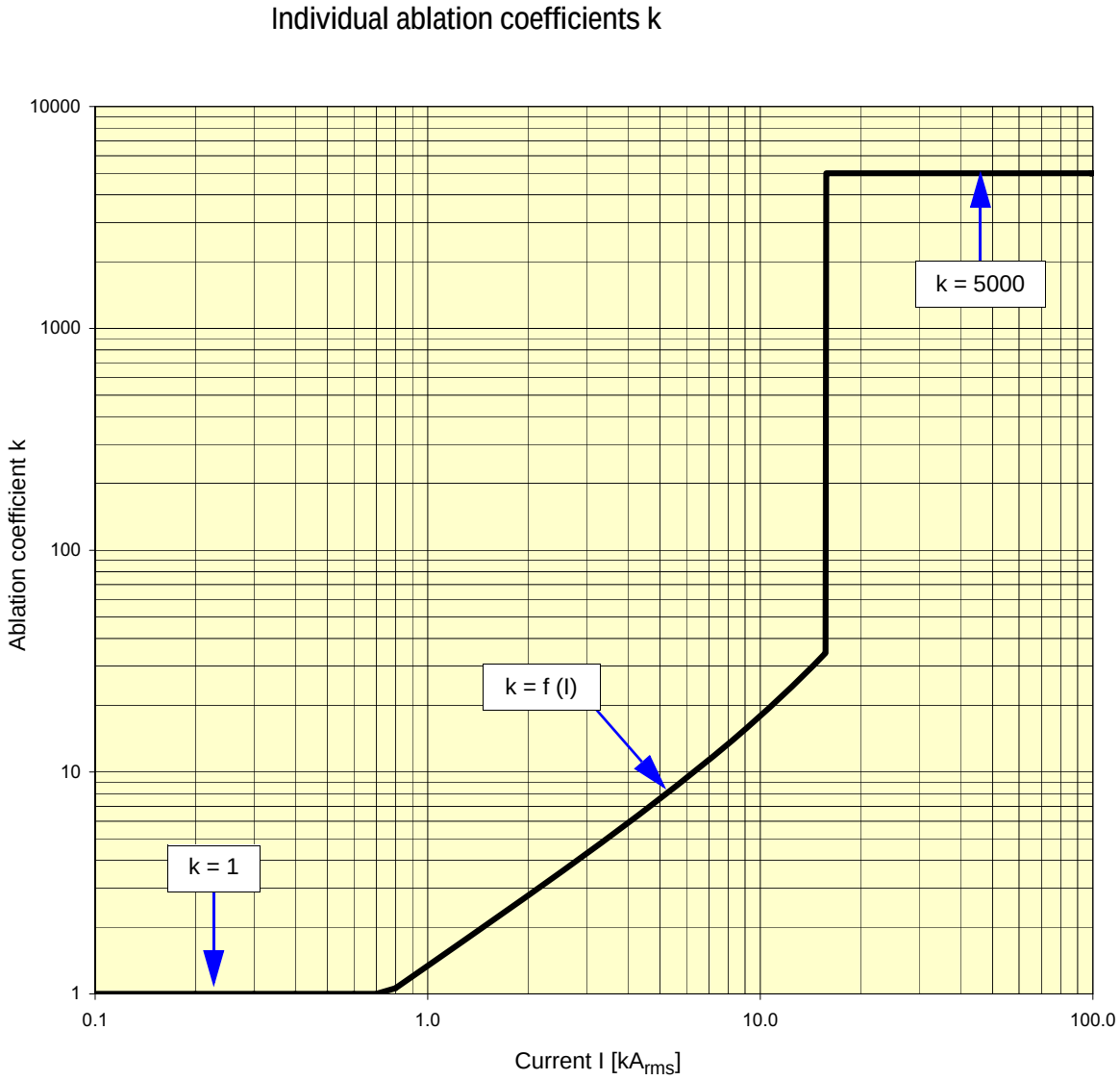


Fig. 8-5 Ablation coefficient k

with k =	1	if	0 kA $_{rms}$	≤ I <	0.755 kA $_{rms}$	small currents
	f (I)	if	0.755 kA $_{rms}$	≤ I ≤	150 % I_C	load currents
	5000	if	150 % I_C	< I		over-currents

f (I) $k = 0.001459 \cdot I^3 + 0.03209 \cdot I^2 + 1.326 \cdot I - 0.02062$

Example of calculation for the total sum of ablation coefficients k

Assuming exemplary operations the values k(I) are calculated according to the formula in Fig. 8-5, page 204.

Number and specification of operations:		**Individual k(I)**	**∑ k(I)**
93	mechanical operations without load	1.00	93
523	opening operations at 0.3 kA_{rms}	1.00	523
2700	opening operations at 1.2 kA_{rms}	1.62	4372
412	opening operations at 7.5 kA_{rms}	12.34	5086
2	opening operation at 10.2 kA_{rms}	18.39	37
1	opening operation at 45.9 kA_{rms}	5000.00	5000
	Sum of all operations:		**15111**

Tab. 8-2 Calculation example

Rated normal current I_C = 13.0 kA_{rms}

The circuit-breaker has reached ∑ k(I) = 15111 of 20000 = 76 % of its electrical lifetime.

The overhaul criterion would be reached with one additional over-current switching operation.

8.7.2.2 Closing operations of circuit-breaker

During closing operations with currents up to 150 % I_C the arcing time is much shorter than during opening operations, and the loss of material is negligible. Therefore, the ablation coefficient k is set to 0 for all closing operations below 150 % I_C. The mechanical wear is already accommodated by the subsequent opening operation, having $k \geq 1$.

However, closing operations with currents above 150 % I_C and up to the rated short-circuit current may strongly influence the mechanical lifetime because of the high electrodynamic forces during closing. In such cases, the manufacturer has to be contacted:

– Section 1.1 Manufacturer and customer support, page 13

8.7.2.3 Earthing switch with motor operated short-circuiting connection

The electrical lifetime is based on the number of switching operations under residual voltage conditions. Any individual switching operation must not exceed the values specified:

– Section 2.3.1.9 Earthing switch with motor operated short-circuiting connection – optional, page 37

The plant officer/operating company must ensure that all switching operations under residual voltage conditions are counted.

Refer also to:

– Section 8.5.1 Supervisory tasks, page 187
– Tab. 8-1 Maintenance plan, page 183

8.7.2.4 Starting switch

The electrical lifetime is based on the number of switching operations with small capacitive currents ≤0.5 A. Any individual switching operation must not exceed the values specified:

– Section 2.3.1.10 Starting switch – optional, page 38

The plant officer/operating company must ensure that all switching operations under residual voltage conditions are counted.

Refer also to:

– Section 8.5.1 Supervisory tasks, page 187
– Tab. 8-1 Maintenance plan, page 183

8.7.3 Overhaul packages

Depending on the action needed, a combination of the overhaul tasks may be appropriate.

8.7.3.1 Mechanical overhaul

Mechanical overhaul is required if the associated overhaul criterion is reached.

During mechanical overhaul, movable parts need replacement due to wear and tear. Mechanical overhaul includes partial dismantling, replacement of the hydraulic spring operating mechanism, sealings, guide rings, screws, bolts, etc. as applicable.

Time required

Circuit-breaker:

- 60 net working hours
- 30 net working hours if interchangeable interrupting chambers are available from stock

Disconnector:

- 45 net working hours

Earthing switch:

It is unlikely that the criterion for mechanical overhaul will be reached before time based overhaul becomes necessary.
If mechanical overhaul becomes necessary:

- 10 net working hours per switch

Starting switch:

- 10 net working hours

8.7.3.2 Electrical overhaul

Electrical overhaul is required if the associated overhaul criterion is reached.

During electrical overhaul, the electric contacts and movable parts need replacement due to ablation, wear and tear. Electrical overhaul includes partial dismantling, replacement of contacts, operating linkage, sealings, guide rings, screws, bolts, etc. as applicable.

Time required

Circuit-breaker:

- 60 net working hours

Earthing switch with motor operated short-circuiting connection:

- 10 net working hours

Starting switch:

- 10 net working hours

8.7.3.3 Time based overhaul

Time based overhaul is required if the product reaches the age defined for overhaul.

The overhaul includes partial dismantling, replacement of insulators, drives, sealings, guide rings, screws, bolts, etc. as applicable.

Time required

Circuit-breaker:

- 60 net working hours

Disconnector:

- 30 net working hours

Earthing switch:

- 10 net working hours per switch

Starting switch:

- 10 net working hours

9 Packaging

This section is addressed to the plant officer/operating company.

9.1 Introduction

This section describes the manufacturer's packaging of the product, its assemblies, spare parts, and/or operating materials.

This section provides information on:

- maintaining the proper condition of the product in a packed condition
- professional packing procedures

9.1.1 Safety instructions

The general safety instructions must be observed, see Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

9.2 Preconditions

The following preconditions must be complied with:

1. If the product already was in operation:
   Ensure that decommissioning was professionally performed.
   Decommissioning should be performed by the manufacturer:
   – Section 1.1 Manufacturer and customer support, page 13
2. Ensure that the pointer of the density indicator SF6 is in the BLACK indication range:
   – Section 6.3.4 Checking received goods, page 129

9.3 Basic information

NOTE

Original packaging of the product is in the responsibility of the manufacturer.

Re-packaging for storage or transport is in the responsibility of the plant officer/operating company.

9.3.1 Purpose and selection of the packaging

The expected mechanical stress and environmental demands during storage and transport require packaging which provides sufficient protection to maintain the usability of the product.

The packaging must provide sufficient protection against:

- mechanical stress and damage caused by:
  - stacking pressure
  - acceleration
  - impact
  - vibration
- corrosion resulting from the effects of the weather such as:
  - air humidity
  - extreme temperatures
  - high salinity of the air
  - sand storms
- environmental impacts such as:
  - industrial gases
  - precipitation containing pollutants
- soiling

The manufacturer’s packaging meets modern cargo handling standards.

For further information:

– Section 2.5 Ambient conditions, page 43.
– Section 10 Storage, page 219
– Section 11 Transport, page 223

9.3.2 Markings of the packaging

NOTE

The identification marks must comply with internationally valid regulations, lettering written in upper case characters.

The manufacturer’s packaging provides the following information:

- packing list and transport instructions, attached to the outside of the crate
- cautionary and handling instructions, highlighted with suitable symbols
- attachment points on the crate
- heavy crates and crates with an off-centre centre of gravity or top heaviness are marked in the following manner:
  - correctly positioned centre of gravity symbol
  - the additional labelling “CENTRE OF GRAVITY”
- as a minimum the crate comprises the following shipping marks:
  - crate number
  - order number
  - complete address of the recipient
  - complete address of the sender
  - gross weight
  - dimensions

Further information about documentation and unpacking:

– Section 6.2.1 Supplied documents, page 126
– Section 6.3 Unpacking and transport, page 128.

9.3.3 Temporary corrosion protection

Corrosion protection is applied according to valid standards. The type of corrosion protection depends on the mode of transport and the required protection period.

Overland transport

The packing method VCI (volatile corrosion inhibitor) is used as a standard for protection periods up to 6 months.

For longer protection periods and depending on project or plant specific agreements the desiccant method may be used:

- Protection periods up to 6 months:
  Polyethylene foils are used.
- Protection periods exceeding 6 months:
  Polyethylene foils with aluminium-vapour-barrier are used.
- protection periods exceeding 24 months:
  Polyethylene foils with aluminium-vapour-barrier are used and an additional moisture indicator is installed.

Overseas transport

The desiccant method is used as a standard:

- Protection periods up to 6 months:
  Polyethylene foils are used.
- Protection periods exceeding 6 months:
  Polyethylene foils with aluminium-vapour-barrier are used.
- Protection periods exceeding 24 months:
  Polyethylene foils with aluminium-vapour-barrier are used and an additional moisture indicator is installed.

Monitoring relative air humidity

If the storage period exceeds 24 months a moisture indicator with a window is fitted to monitor the relative air humidity inside the packaging. The measuring scale should range from 30 to 50 % relative air humidity.

An inspection window, covered by a hinged cover, is provided at the position of the indicator.

9.3.4 Securing and padding

The packed good is padded with foam rubber or rubber buffers. Only non-hygroscopic materials such as plastic scraps, polyurethane chips or polystyrene beads are used as filling and stuffing materials; wood shavings or similar are not suitable.

NOTE

The contact surfaces between wood and bright metal is isolated with chemically neutral films to prevent the corrosive effect of wood acids on the metal.

9.3.5 Boxes and crates

The boxes and crates are suitable for the intended purpose and are sufficiently stable. They comply with the required load capacities.

On crates made of planks:

- The floors are constructed to permit any water entering the crates to drain away.
- The openings are dimensioned in a way that they do not close over when the wood swells up.
- A water barrier is fitted to the lids to prevent the formation of water pockets.
- The moisture content of the planks and wood does not exceed 18 %.

9.3.6 Hazardous goods

Any goods classed as hazardous are packed in accordance with the international hazardous goods regulations and loaded separately if necessary.

The following applies for packaging of such goods:

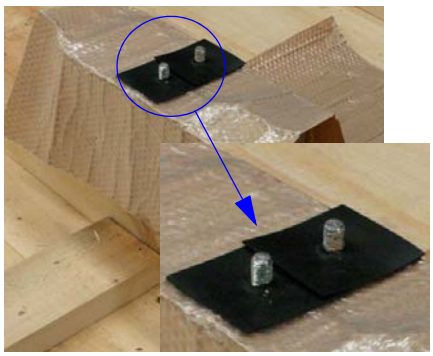
- Prescribed packaging and containers are used.
- The crates are marked with the necessary labels for identification of hazardous goods.
- Hazardous goods certificates are enclosed with the consignments.

9.4 Packing the product

The manufacturer’s packaging procedure is exemplarily described for the desiccant method.

9.4.1 Preparation

The floor of the crate is provided.



The carrier beams of the crate floor are covered with padding material.

Holes for the fixing bolts are drilled into the carrier beams and the fixing bolts are mounted.

Gaskets are fitted onto the fixing bolts.

Polyethylene foil with aluminium-vapour-barrier is placed onto the floor of the crate.

Instructions of the packaging manufacturer are observed.

The fixing bolts are punctured through the polyethylene foil.

Gaskets are fitted onto the fixing bolts, serving to tighten the holes in the polyethylene foil.

The floor of the crate is covered with padding material.

If the product is packed for long term storage:
A hole is drilled in the side wall as an inspection window for the moisture indicator.

9.4.2 Packing

A desiccant is placed within each enclosure.

The openings of the enclosures are sealed with plastic film.

The product is lifted onto the carrier beams with a crane.

The product is secured with nuts on the fixing bolts of the carrier beams.

The entire product is covered with padding material.

The padding material is secured with adhesive tape.

Polyethylene foil with aluminium-vapour-barrier is placed on top of the product.

Packaging
Packing the product

Additional desiccant is attached between padding material and polyethylene foil.

If the product is packed for long term storage:
The moisture indicator is fitted into the polyethylene foil.

The polyethylene foil on top of the product is welded with the polyethylene foil on the floor of the crate.

Air is evacuated from the packaging.

The product is hermetically sealed.

Supports are fixed to the crate floor to increase the stability of the carrier beams.

Side walls and struts are mounted.

The lid of the transport crate is mounted and closed.

If the product is packed for long term storage:
A marking at the position of the moisture indicator is added and a cover for the inspection window is mounted.

Metal brackets are mounted to the attachment points of the crate. These brackets protect crate and hoisting gear during lifting.

The centre of gravity is determined and marked on the crate. Marking of the crate is completed.

9.4.3 Packing the lifting equipment

After being used the lifting equipment must be packed as follows:

1. Line a crate with packing material.

2. Pack into the crate:
   - seats for lifting beam
   - lifting beam,
   - round slings
   - shackles

3. Enclose a desiccant.
4. Enclose the packing list
5. Seal the packing material with adhesive tape.

6. Place the lid onto the crate; nail the lid into position.
7. Label the crate.
   As a minimum, the labelling must include:
   - corresponding product and product type
   - packing date

10 Storage

This section is addressed to plant officer/operating company.

10.1 Introduction

This section describes the necessary steps for storing the product, its assemblies, spare parts, and operating materials over a specific period of time.

Inspection of received goods, warehouse organisation and warehouse management are the responsibility of the plant officer/operating company and therefore not dealt with in this document.

In order to maintain the stored goods in a proper condition:

- The ambient conditions during storage must be taken into account, see Section 2.5 Ambient conditions, page 43.
- The stored goods should be adequately packed, see Section 9 Packaging, page 209.

10.1.1 Safety instructions

The general safety instructions must be observed, see Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

10.1.2 Target group

Correct execution of work is the responsibility of the plant officer/operating company.

10.2 Storage conditions

10.2.1 Storage method

Storage is the responsibility of the plant officer/operating company. Choice of the storage method should be based on the purpose of storage. The product, its elements and/or spare parts should be packed for their protection, refer to Section 9 Packaging, page 209.

10.2.2 Storage period

The storage period is limited according to the type of corrosion protection, see Section 9.3.3 Temporary corrosion protection, page 212. The instructions of the supplier of hazardous goods must be observed.

NOTE

If the storage period is expected to exceed 24 months, a moisture indicator with window must be provided in the packaging for monitoring purposes.

The packaging condition must be checked in accordance with:

– Section 10.3 Maintenance during storage, page 221

10.2.3 Space requirements

The storage space must be arranged to accommodate the size of the packed product, its elements and/or spare parts. Each individual stored element must be freely accessible for inspection purposes.

The following factors must be taken into account for storage:

- size
- weight
- required ground bearing capacity
- distance to neighbouring devices

10.2.4 Physical conditions

Physical conditions for storage:

– Section 2.5 Ambient conditions, page 43

10.2.5 Danger information

The safety and handling information attached to the packaging must be observed:

– Section 9.3.2 Markings of the packaging, page 211

10.2.6 Identification

The stored goods are marked during packaging:

– Section 9.3.2 Markings of the packaging, page 211

10.3 Maintenance during storage

Interval Annually

Packaging and corrosion protection

Checking the condition of the packaging:

1. Inspect the condition of the packaging of the stored goods for damages.
2. If necessary replace the damaged packaging elements.

During storage periods of more than 24 months:

3. Check the moisture indicator,
   see Section 9.4.2 Packing, page 215.
4. If the air humidity exceeds 50 % the desiccant must be replaced.

10.4 Re-commissioning after storage

For re-commissioning after periods of storage:

– See Section 6 Erection, page 123
– especially Section 6.11 Request for commissioning, page 154

Storage

Re-commissioning after storage

11 Transport

This section is addressed to plant officer/operating company.

11.1 Introduction

This section describes the necessary steps for transporting the product.

Depending on the destination the shipping mode is selected either by road, rail, sea or air.

In order to protect the product during transportation:

- The goods to be transported must be adequately packed, see Section 9 Packaging, page 209.
- The transport conditions must be taken into account.

11.1.1 Safety instructions

The general safety instructions must be observed, see Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

During the transport of heavy loads situations can occur which endanger personnel, goods and equipment.

DANGER

Falling loads

If suspended or elevated loads fall down, fatal injury and damage to equipment may occur.

1. Use the personal protective equipment
2. Cordon off hazardous areas.
3. Keep the working area free.
4. No persons should stand below suspended or elevated loads.
5. Ensure that loads are correctly secured.
6. Only use faultless hoisting gear and auxiliary material which have sufficient bearing capacities and which are approved for the loads.
7. Only lift the product by the attachment points provided.
8. Ensure that the hoisting gear and cranes are used correctly.
9. Transport the product horizontally.

DANGER

Accidents during transport on rollers or wheels

If loads get out of control, fatal injury and damage to equipment may occur.

1. Use the personal protective equipment
2. Only use faultless hoisting gear and auxiliary material which have sufficient bearing capacities and which are approved for the loads.
3. Move loads slowly and carefully.
4. Avoid slipping or shifting of the loads.

11.1.1.1 Manufacturer's lifting equipment

Manufacturer's lifting equipment is individually designed for lifting the corresponding product of the manufacturer, see:

– Section 6.3.5 Lifting the product, page 130

Lifting beam

The maximum load-bearing capacity is punched into a front face of the lifting beam:

- product type
- load-bearing capacity
- pole centre spacing

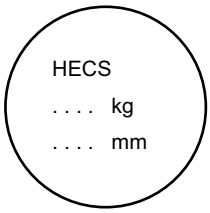


Fig. 11-1 Front face of lifting beam, example

11.1.2 Target group

Correct execution of work is the responsibility of the plant officer/operating company.

Personnel executing the work must be trained in using the following tools:

- hoisting gear and transport equipment such as:
  – crane
  – forklift truck
  – transport rollers

11.2 Transport with packaging

1. Only use hoisting gear with a sufficient bearing capacity.
2. Observe the transport instructions.
   – The transport instructions are contained in a document pocket on the transport crate.
3. Observe the permissible weight of the load and the safety instructions for the means of transport.
4. Observe the transport marks.

   The transport crate is marked with internationally valid symbols such as lifting points, centre of gravity, weight etc.,
   see Section 9.3.2 Markings of the packaging, page 211.
5. Loading with a crane:

   a) Attach the transport crate at the points provided.

   b) Lift the transport crate horizontally.

   – or –

   Loading with a forklift truck:

   a) Lift the transport crate from below.
6. Secure the transport crate on the means of transport on all sides with a tensioning force which is suitable for the overall weight of the product.

11.3 Transport without packaging

WARNING

Transport supports/pole frame supports may break into the loading surface of the transport vehicle.

Observe the localised weights!

If the product is loaded without a transport crate, the loading area must be suitable for carrying the corresponding localised weight at the contact points of the transport supports/pole frame supports.

- To determine the localised weights:
  – see net weight indication on product's rating plate
  – see packing list, Section 6.2.1 Supplied documents, page 126

1. If the product already was in operation:
   Ensure that decommissioning was professionally performed.
   Decommissioning should be performed by the manufacturer:
   – Section 1.1 Manufacturer and customer support, page 13
2. Ensure that gas density is within the indicating range BLACK of the density indicator SF6:
   – Section 6.3.4 Checking received goods, page 129
3. For the means of transport observe:
   – the bearing capacity of the hoisting gear
   – the cargo weight
   – the localised weights at the contact points of the transport supports/ pole frame supports
4. Lift the product and deposit it onto the loading area:
   – Section 6.3.5 Lifting the product, page 130
   Ensure that the product remains secured to the lifting equipment and the crane until the product is secured on the loading area.
5. Secure the product on the means of transport on all sides with a tensioning force which is suitable for the overall weight of the product.
6. Slacken the weight on the crane and remove the lifting equipment.
7. Pack the manufacturer's lifting equipment:
   – Section 9.4.3 Packing the lifting equipment, page 218
8. Load the manufacturer's lifting equipment together with the transported goods.
9. Protect the transported goods against effects of weather and pollution with a tarpaulin.

Unload the goods in reverse sequence.

12 Disposal

This section is addressed to the plant officer/operating company.

12.1 Introduction

ENVIRONMENT

Pollution of water, air and soil

1. Observe all environmental protection legislation.
2. Comply with all laws and directives for correct handling of the respective equipment and material groups.
3. Comply with the instructions of the supplier.

12.1.1 Safety instructions

The general safety instructions must be observed, see Section 3 Safety instructions, page 51. Legislatory regulations, international standards, and the guidelines of the plant officer/operating company regarding work safety and accident prevention also apply.

12.1.2 Target group

Correct execution of work is the responsibility of the plant officer/operating company.

12.2 Preconditions

The following precondition must be complied with:

1. Ensure that decommissioning of the product was professionally performed. Decommissioning must be performed by the manufacturer:
   – Section 1.1 Manufacturer and customer support, page 13

Dismantling of hydraulic spring operating mechanism

DANGER

Devices may explosively break apart

At any time the spring mechanism is mechanically pre-charged with high tension, independent of the operating condition of the hydraulic spring operating mechanism.

1. The hydraulic spring operating mechanism must be dismantled by the manufacturer.

12.3 Recycling and disposal

The equipment should always be collected separately or in material groups in accordance with the classification of the equipment.

12.3.1 Oil

Several oil types can be recycled. The following criteria must be taken into account for differentiation purposes:

- manufacturer's information
- duration of use
- conditions under which the oil was used

Recyclable oils — Collect and return to the supplier or a qualified dealer for **processing**.

Used oil — Collect and return to the supplier or a qualified dealer for **disposal**.

12.3.2 SF6 gas

DANGER

Handling SF6 gas

Observe the safety instructions when handling SF6 gas:

– Section 3.5.2 Working with SF6 gas, page 61

Used SF6 gas — Return to the supplier or a qualified dealer for processing.

12.3.3 Acids

Electric arcs in SF6 atmosphere produce decomposition products. The decomposition products form corrosive acids when they come into contact with water or air humidity.

DANGER

Handling the decomposition products of the SF6 gas

Observe the safety instructions when handling SF6 gas:

– Section 3.5.2 Working with SF6 gas, page 61

Return the decomposition products and acids immediately to a qualified dealer for disposal.

12.3.4 Paper

Clean — Return non-coated paper, printed or plain, in bundles to an appropriate recycling plant.

Soiled — Paper soiled with oil or other contaminants and coated paper must be disposed of in a furnace equipped with a filter.

12.3.5 Cardboard

Clean — Return non-coated cardboard, also corrugated cardboard, printed or plain, to an appropriate recycling plant.

Soiled — Cardboard soiled with oil or other contaminants and coated cardboard must be disposed of in a furnace equipped with a filter.

12.3.6 Wood

Clean — Untreated wood can be disposed of at a shredding plant.

Soiled — Treated wood must be disposed of in a furnace equipped with a filter.

12.3.7 Plastic

Plastic should be returned to an appropriate recycling plant. Adhesive tape can be disposed of with normal waste.

12.3.8 Polystyrene

Packaging sections and polystyrene chips with the designation:

– polystyrene, the code PS or 076

Additional feature:

– polystyrene breaks with a dry cracking sound when bent

Polystyrene should be returned to an appropriate recycling plant.

12.3.9 Metals

Metals should be sorted and recycled by grade.

12.4 Standardised disposal assemblies

12.4.1 Dismantling

The assemblies are dismantled by the manufacturer when the product is taken out of operation.

12.4.2 Intermediate storage

For intermediate storage of assemblies destined for further use:

– Section 9 Packaging, page 209
– Section 10 Storage, page 219

12.5 Disposal depots, authorities

12.5.1 Return to manufacturer

Materials can only be returned to the manufacturer in special cases when this has been agreed:

– Section 1.1 Manufacturer and customer support, page 13

12.5.2 Notification of authorities

The respective legislation and directives of the plant officer/operating company apply.

12.5.3 Notification of manufacturer

Notification for statistical purposes is required:

– Section 1.1 Manufacturer and customer support, page 13

ABB Switzerland Ltd
High Voltage Products, High Current Systems
Brown-Boveri-Strasse 5
CH-8050 Zurich
Switzerland

www.abb.ch