

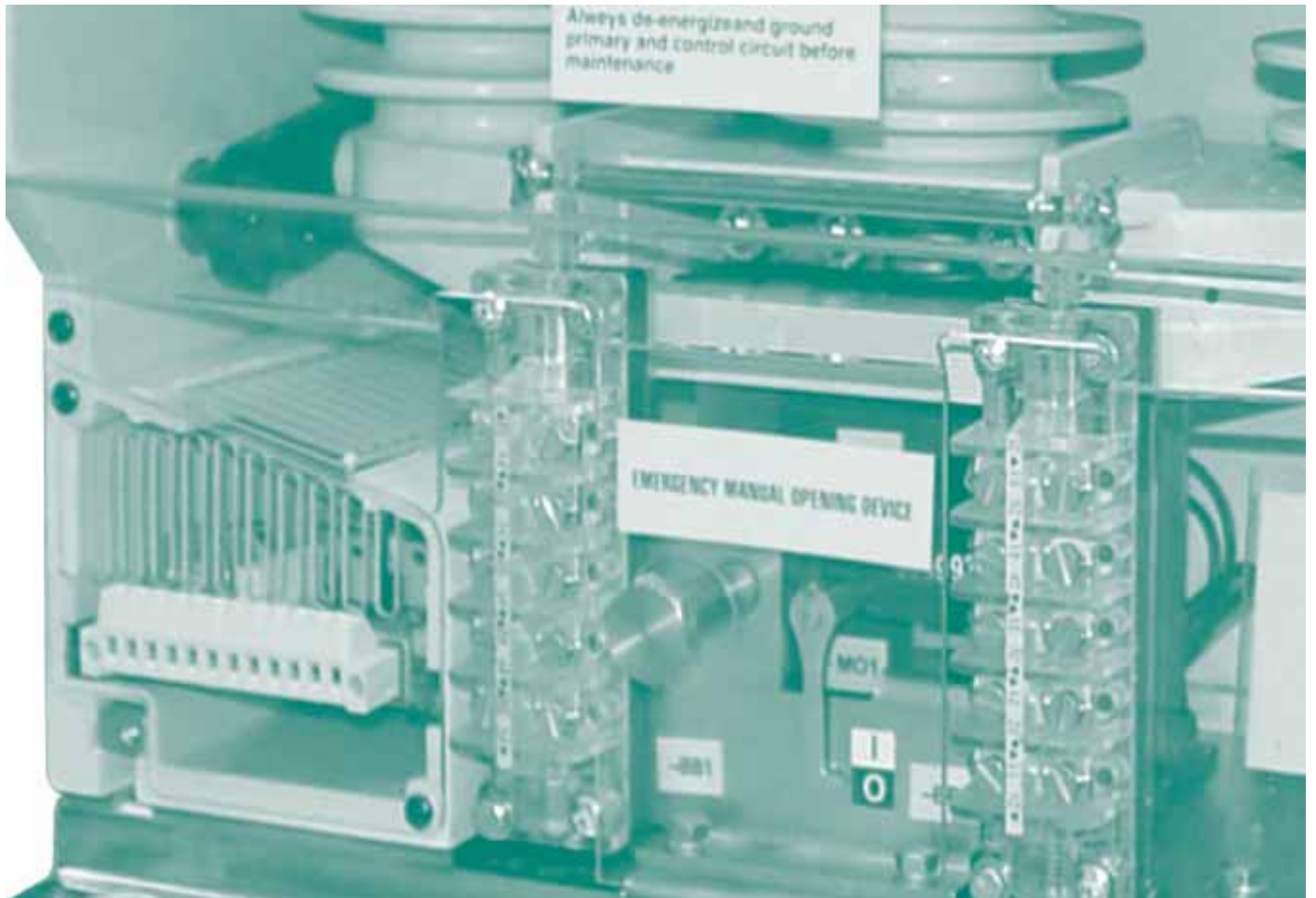


Product Instruction

# V-Contact VSC Medium Voltage Vacuum Contactors



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# Description



## General

The medium voltage V-Contact VSC contactors are apparatus suitable for operating in alternating current and are normally used to control users requiring a high number of hourly operations.

The V-Contact VSC contactor introduces the drive with permanent magnets, already widely used, experimented and appreciated in medium voltage circuit-breakers, into the worldwide panorama of medium voltage contactors.

The experience acquired by ABB in the field of medium voltage circuit-breakers fitted with drives with "MABS" permanent magnets, has made it possible to develop an optimised version of the actuator (bistable MAC drive) for medium voltage contactors.

The drive with permanent magnets is activated by means of an electronic multi-voltage feeder. The feeders differ according to the integrated functions and to the auxiliary power supply voltage.

Three bands of power supply are available with which all the voltage values required by the major international Standards can be covered.

Each feeder is able to take any voltage value within its own operating band.

## Versions available

The V-Contact VSC contactors are available in the following versions:

Version	Rated voltage	Type
Fixed	3.6 kV	VSC 7
	7.2 kV	VSC 7
	12 kV	VSC 12
Withdrawable	7.2 kV	VSC/P 7
	12 kV	VSC/P 12

All the contactors mentioned above are available, on request, in one of the two following versions.

- **SCO** (Single Command Operated): closing takes place by supplying auxiliary power to the special input of the multi-voltage feeder. On the other hand, opening takes place when the auxiliary power is either voluntarily cut off (by means of a command) or involuntarily (for lack of auxiliary power in the installation).
- **DCO** (Double Command Operated): closing takes place by supplying the input of the closing command of the apparatus in an impulsive way. On the other hand, opening takes place when the input of the opening command of the contactor is supplied in an impulsive way.

## Fields of application

The V-Contact VSC contactors are suitable for controlling electrical apparatus in industry, in the service sector, in the marine sector, etc. Thanks to the breaking technique with vacuum interrupters, they can operate in particularly difficult environments.

They are suitable for control and protection of motors, transformers, power factor correction banks, switching systems, etc. Fitted with suitable fuses, they can be used in circuits with fault levels up to 1000 MVA (VSC7 - VSC12).

### Compliance with Standards

V-Contact VSC contactors comply with the Standards of the major industrialised countries and in particular with the IEC 60470 (2000) and GB/T 14808 Standards.

### Operating characteristics

- Ambient temperature: - 5°C... + 40°C
- Relative humidity: < 95 % (without condensation)
- Altitude: < 1000 m s.l.m.

For other conditions, please contact us.

### Main technical characteristics

- Chopping current value  $\leq 0.5$  A
- Maintenance-free
- Suitable for installation in prefabricated substations and switchgear both of the card (slim line) and traditional type
- High number of operations
- Direct checking of contact wear
- Long electrical and mechanical life
- Remote control
- Multi-voltage feeder
- Bistable drive of the type with permanent magnets

### Electrical life

The electrical life of V-Contact VSC contactors is defined in category AC3.



### Interruption principle

The main contacts operate inside the vacuum interrupters (the level of vacuum is extremely high:  $13 \times 10^{-5}$  Pa).

On opening, there is rapid separation of the fixed and moving contacts in each contactor interrupter.

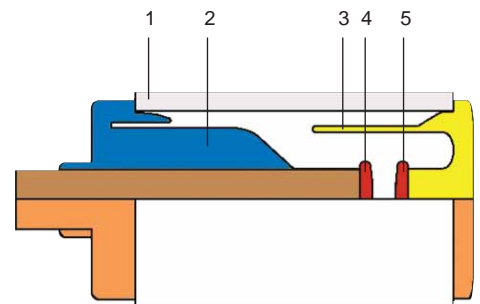
Overheating of the contacts, generated at the moment they separate, causes formation of metallic vapours which allow the electric arc to be sustained up to the first passage through zero current.

On passage of zero current, cooling of the metallic vapours allows recovery of high dielectric resistance able to withstand high values of the return voltage.

For motor switching, the value of the chopped current is less than 0.5 A with extremely limited overvoltages.



Schematic cross-section of the vacuum interrupter.



- 1 Ceramic housing
- 2 Seal diaphragm
- 3 Metal screen
- 4 Moving contact
- 5 Fixed contact



### "MAC" magnetic drive

ABB has implemented this technology in the field of contactors on the basis of experience gained in the field of circuit-breakers with magnetic drive.

The magnetic drive adapts perfectly to this type of apparatus thanks to its precise and linear travel.

The drive, which is of bistable type, is fitted with an opening and a closing coil.

The two coils - individually energised - allow the drive mobile armature to be moved from one of the two stable positions to the other.

The drive shaft is solid with the mobile armature and held in position in a field generated by two permanent magnets (fig. A).

Energising the coil opposite to the magnetic latching position (fig. A) of the core, the magnetic field is generated (fig. B), which attracts and moves the mobile armature into the opposite position (fig. C).

Every opening and closing operation creates a magnetic field concordant with the one generated by the permanent magnets, with the advantage of keeping the intensity of the field itself constant during service, regardless of the number of operations carried out.

The energy needed for operation is not supplied directly by the auxiliary power supply, but is always "stored" in the capacitor which acts as an energy accumulator, and therefore operation always takes place with constant speeds and times, independently of the divergence of the power supply voltage from the rated value.

The auxiliary power supply has the only aim of keeping the capacitor charged.

Consumption is therefore minimal. The power required is less than 5 W. In order to re-instate the rated power value in the capacitor after an operation, there is an inrush of 15 W for a duration of a few tens of milliseconds. For the reasons indicated above, both for the DCO and for the SCO version it is necessary to supply the auxiliary circuits which recharge the capacitor with a continuous auxiliary power supply of 5W (this value can reach 15W for a few milliseconds immediately following each operation). Careful selection of the components and a precise design make the electronic multi-voltage feeder extremely reliable, unaffected by electromagnetic interference generated by the surrounding environment and free of any emissions which may affect other apparatus placed in the vicinity.

These characteristics have made it possible for the V-Contact VSC contactors to pass the electromagnetic compatibility tests (EMC) and obtain the CE mark.

Fig. A

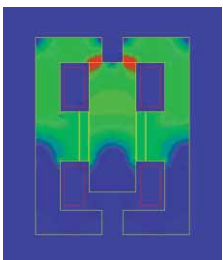


Fig. B

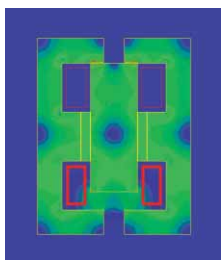


Fig. C

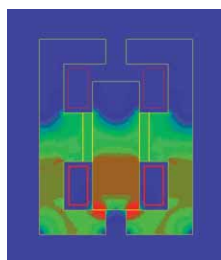
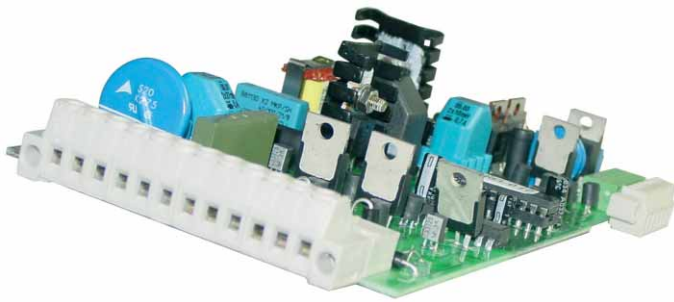


Fig. A - Magnetic circuit in the closed position.

Fig. B - Magnetic circuit with the opening coil supplied.

Fig. C - Magnetic circuit in the open position.



### Control Module / Feeder

As standard, the electronic control module is fitted with a connector with screw terminal board for connection of the auxiliary circuits.

### Technical Documentation

For more in-depth technical and application aspects of the VSC contactors, also consult the publication on UniGear ZS1 code 1YHA000015.

### Quality System

Conforms to the ISO 9001 Standards, certified by an external independent organization.

### Environmental Management System

Conforms to the ISO 14001 Standards, certified by an external independent organization.

### Health and Safety Management System

Conforms to the OHSAS 18001 Standards, certified by an external independent organization.



# Contactor Selection and Ordering

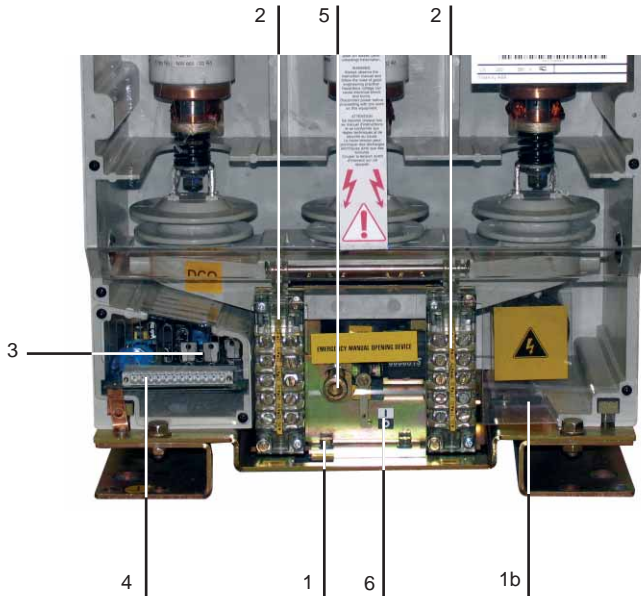
General characteristics		IEC 60470 GB/T 14808	VSC 7 400A - VSC/P 7 400A	
			Contactor 3.4.105	Starter 3.4.110
Rated voltage	Ur [kV]	4.1	7.2	7.2
Withstand voltage at 50 Hz	Ud (1 min) [kV]	4.2	32	32
Impulse withstand voltage	Up [kVp]	4.2	60	60
Rated frequency	fr [Hz]	4.3	50–60	50–60
Rated current	Ie [A]	4.101	400	400
Short-time withstand current for 1 s	Ik [A]	4.5	6,000	6,000
Rated peak current	Ip [kA peak]	4.6	15	15
Rated short-circuit time	tk [s]	4.7	1	1
Breaking capacity up to	Isc [kA]	4.107	–	–
Short-circuit making capacity up to	I <sub>ma</sub> [kA]	4.107	–	–
Number of operations (rated values)				
Contactor SCO	time / h	4.102	900	900
Contactor DCO	time / h	4.102	900	900
Maximum rated admissible overcurrent for 1/2 period (peak value)	[kA]	–	55	–
Rated load and overload characteristics in category of use:				
(Category AC4) 100 closing operations	[A]	4.103, 4.104	4,000	4,000
(Category AC4) 25 opening operations	[A]	4.103, 4.104	4,000	4,000
Rated voltage of the switching devices and auxiliary circuits		4.8, 4.9		
Feeder type 1 (24 ... 60 DC)		■	■	■
Feeder type 2 (110 ... 130 AC–DC)		■	■	■
Feeder type 3 (220 ... 250 AC–DC)		■	■	■
Mechanical life		4.105	1,000,000	1,000,000
Electrical life (category AC3) <sup>(3)</sup>		4.106	100,000	100,000
Electrical life at rated current		4.106	1,000,000	1,000,000
Apparatus wear classification (type)		4.107.3	C	C
Short-circuit breaking capacity	[A]	4.107, 6.104	6,000	6,000
Short-circuit making capacity	[peak A]	4.107, 6.104	15,000	15,000
Limit above which the fuse blows <sup>(4)</sup>	[A]	4.107.3	–	–
Switching times				
Opening time	[ms]	–	20...30	20...30
Closing time	[ms]	–	35...45	35...45
Weight				
Fixed	[kg]	–	20	20
Withdrawable (excluding the fuses)	[kg]	–	49	49
Overall dimensions				
Fixed contactor				
Height	(H) [mm]	–	371	371
Width	(W) [mm]	–	350	350
Depth	(D) [mm]	–	215	215
Withdrawable contactor				
Height	(H) [mm]	–	636	636
Width	(W) [mm]	–	531	531
Depth	(D) [mm]	–	657	657
Tropicalisation (IEC 721–2–1)		–	■	■
			<b>VSC 7 - 400A</b>	
Ultimate performances for Rated voltage	[kV]	–	2.2/2.5	3.3
–Motors	[kV]	–	1,000	1,500
–Transformers	[kVA]	–	1,100	1,600
–Capacitors	[kVAr]	–	1,000	1,500
Ultimate performances for back-to-back capacitor banks Rated voltage				
–Rated current	[A]	–	250	250
–Maximum transient current of the capacitor	[kA]	–	8	8
–Maximum transient frequency of capacitor connection	[kHz]	–	2.5	2.5



VSC 12 400 A - VSC/P 12 400A			
Combined with fuses 3.4.110.5	Contactor 3.4.105	Starter 3.4.110	Combined with fuses 3.4.110.5
7.2	12	12	12
32	42	42	42
60	75	75	75
50-60	50-60	50-60	50-60
(i)	400	400	(1)
6,000	6,000	6,000	6,000
15	15	15	15
1	1	1	1
50 (2)	-	-	50 (2)
50 (2)	-	-	50 (2)
900	900	900	900
900	900	900	900
-	55	-	-
4,000	4,000	4,000	4,000
4,000	4,000	4,000	4,000
■	■	■	■
■	■	■	■
■	■	■	■
1,000,000	1,000,000	1,000,000	1,000,000
100,000	100,000	100,000	100,000
1,000,000	1,000,000	1,000,000	1,000,000
C	C	C	-
-	4,000	4,000	-
-	8,000	8,000	-
5,000	-	-	5,000
20...30	20...30	20...30	20...30
35...45	35...45	35...45	35...45
-	20	20	-
49	49	49	49
371	425	425	425
350	350	350	350
215	215	215	215
636	636	636	636
531	531	531	531
657	657	657	657
■	■	■	■
VSC 12-400A			
3.6/5	6.2/7.2	12	
1,500	3,000	5,000	
2,000	4,000	5,000	
1,500	3,000	4,800 (5)	
250	250	(6)	
8	8	(6)	
2.5	2.5	(6)	

- (1) Depending on the capacity of the coordinated fuse
- (2) Value linked to the breaking capacity of the fuse: refer to the fuse manufacturer's documentation.
- (3) Electrical life obtainable by following the maintenance programme given in the installation manual.
- (4) This is the current value determined by intersection of the time-current trip curves of two protection devices in this case the fuse and any thermal protection relay.
- (5) Overvoltage dischargers or RC filters must be fitted.
- (6) For availability ask ABB

## Strd fittings



VSC 7-VSC 12

1 MAC Drive with permanent magnets with capacitor for storing energy (1b)

### 2 Auxiliary contacts

Contactor	Choices available	Normally open	Normally Closed
VSC 7 400A	1	5	5
VSC 12 400A	1	5	5
VSC /P 7 400A	1	4	5
VSC/P 12 400A	1	4	5

3 Multi-voltage feeder. Different power supply ranges are available:

- Feeder type 1: 24-60V DC
- Feeder type 2: 110-130V DC/AC
- Feeder type 3: 220-250V DC/AC

4 Socket/plug with terminal at terminal box

5 Manual emergency opening operation

6 Mechanical Open/Closed indicator

7 Fuseholders (only for withdrawable contactor)

The withdrawable contactor is fitted with fuseholders able to hold DIN or BS type fuses according to what the customer requests.

The fuses must have the dimensions and striker of average type according to DIN 43625 standards with maximum cartridge size  $e=442\text{mm}$  and BS 2692 with maximum cartridge size  $L=553\text{mm}$ .

The electrical characteristics must conform to the IEC 60282-1 standards.

The fuseholder is fitted with a special kinematics mechanism which automatically opens the contactor when even a single fuse blows and prevents contactor closing when even a single fuse is missing.

8 Isolation interlock with the truck (only withdrawable contactor).

This prevents isolation or racking-in the contactor into the switchgear if the apparatus is in the closed position, and also prevents contactor closing during the isolation run.

### Characteristics of the auxiliary contacts of the contactor

Rated voltage	24...250V AC-DC
Rated current $I_{th}$	10A
Insulation voltage	2500V 50Hz (1min)
Electric resistance	3m $\Omega$

The rated current and breaking capacity values in category AC11 and DC11 are indicated below.

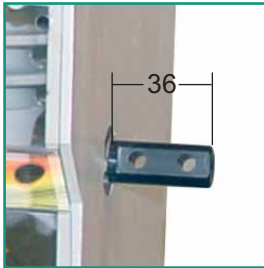
$U_n$	$\text{Cos}\varphi$	T	$I_n$	$I_{cu}$
220V~	0.7	-	2.5A	25A
24V-	-	15ms	10A	12A
60V-	-	15ms	6A	8A
110V-	-	15ms	4A	5A
220V-	-	15ms	1A	2A

## Optional accessories

The table below indicates availability of the accessories in relation to the various types of contactor.

Table of accessory availability	VSC 7 400A	VSC/P 7 400A	VSC 12 400A	VSC/P 12 400A
1a Interfacing shaft on feeder side	■			
1b Interfacing shaft on capacitor side	■		■	
2a Mechanical operation counter	■		■	
2b Electric operation counter		■		■
3 Undervoltage function	■	■	■	■
4 Adapter for fuses		■		■
5 Connection alternative to the fuses		■		■
6 Isolation lock		■		■
7 Locking magnet in the truck		■		■
8 Lock for different rated currents <sup>(1)</sup>		■		■

(1) Compulsory for UniGear switchgear.



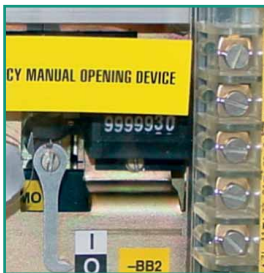
### 1 Interfacing shafts

These can be used to interface the apparatus with the kinematics of the switchgear to make interlocks and/or signals.

The length of interfacing shafts is 36mm, the mounting as indicated in the following table:

Position	Feeder side(left)	Capacitor(right, see picture)
VSC 7 400A	■	■
VSC 12 400A	-	■

Note: for the utilization parameters (angles and forces applicable), please refer to the manual.



### 2 Operation counter

Mechanical operation counter for fixed versions, electric operation counter for withdrawable versions. This is a device which counts the contactor closing cycles.

### 3 Undervoltage function

First of its type, the V-Contact VSC contactor is fitted with an undervoltage function with selectable delays of 0; 0.5; 1; 2; 3; 4; 5 s.

This accessory must be specified at the time of order because it cannot be mounted at a later stage.



#### 4 Adapter for application of fuses

The kit includes all the accessories needed to adapt and mount three fuses (according to DIN Standards with dimension e less than 442 mm; according to BS Standards with dimension L less than 553 mm).

The kit can be installed directly onto the fuseholder supports. The fuses must have dimensions and striker of average type according to DIN 43625 and BS 2692 (1975) Standards. The electrical characteristics must conform to the IEC 282-1 (1974) Standards.

To select the fuses, see "Conditions of use according to the load" - chapter 3. The adaptation kits are available in the following types:

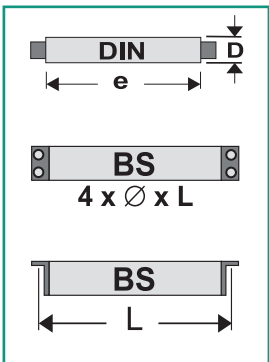
3A For fuses according to DIN Standards with distance e = 192 mm

3B For fuses according to DIN Standards with distance e = 292 mm

3D For fuses according to BS Standards (4 x 10 x L = 305 mm)

3E For fuses according to BS Standards (4 x 10 x L = 410 mm)

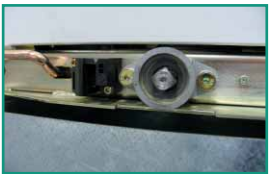
3F For fuses according to BS Standards with distance L = 454 mm.



#### 5 Connections alternative to the fuses

The kit includes three flat copper busbars and fixing screws to be installed when the fuses are not needed.

The kit can be installed directly onto the fuseholder supports.



#### 6 Isolation lock

Isolation lock for UniGear type ZS1 switchgear and PowerCube modules.

It prevents the apparatus from being racked-in if the unit door is open.

This lock only works if the door of the switchgear/enclosure is also fitted with the corresponding lock.



### 7 Locking magnet in the truck

This only allows the withdrawable contactor to be racked into/out of the enclosure with the electromagnet energised and the contactor open.

The table below shows the power supply voltages available.

Un		Un	F
24V-		120V~	50Hz
30V-		127V~	50Hz
48V-		220V~	50Hz
60V-		230V~	50Hz
110V-		240V~	50Hz
125V-		Un	F
220V-		110V~	60Hz
Un	F	120V~	60Hz
24V~	50Hz	127V~	60Hz
48V~	50Hz	220V~	60Hz
60V~	50Hz	230V~	60Hz
110V~	50Hz	240V~	60Hz

### 8 Lock for different rated currents (only withdrawable versions)

This prevents insertion of the plug-socket and therefore apparatus closing, in a panel provided for a circuit-breaker.

This lock, which is compulsory for UniGear switchgear, requires the same lock provided on the enclosure / switchgear.

# Specific Product Characteristics

## Electromagnetic compatibility

The V-Contact VSC vacuum contactors ensure operation without unwarranted trips when there are interferences caused by electronic apparatus, by atmospheric disturbances or by discharges of electrical type. Moreover they do not produce any interference with electronic apparatus in the vicinity of the apparatus.

The above is in compliance with IEC 60694, 60470, 61000-6-2, 61000-6-4 Standards, as well as with the EEC 89/336 European Directive regarding electromagnetic compatibility (EMC), and the feeders are CE marked to indicate their compliance.

## Resistance to vibrations

V-Contact VSC contactors are unaffected by mechanically or electromagnetically generated vibrations.

## Tropicalisation

V-Contact vacuum contactors are manufactured in compliance with the prescriptions regarding use in hot-humid-saline climates. All the most important metal parts are treated against corrosive factors corresponding to ambient conditions C in compliance with the UNI 3564-65 Standards.

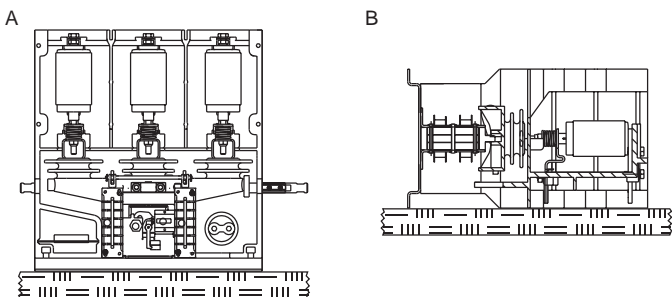
Galvanization is carried out in compliance with the UNI ISO 2081 Standard, classification code Fe/Zn 12, with thickness of  $12 \times 10^{-6}$  m, protected by a layer of conversion mainly consisting of chromates in compliance with the UNI ISO 4520 Standard. These construction characteristics mean that all the V-Contact VSC series apparatus and their accessories comply with climate graph no. 8 of the IEC 7212-1 and IEC 68-2-2 (Test B: Dry Heat) / IEC 68-2-30 (Test Bd: Damp Heat, cyclic) Standards.

## Installation of fixed contactors

The performance of the contactor remains unaltered in the installation positions indicated:

- A) Wall-mounted with moving contacts at the bottom.
- B) Wall-mounted with moving contacts at the top.

VSC 7-VSC 12



## Altitude

It is well-known that the insulating properties of air decrease as the altitude increases.

This phenomenon must always be taken into account during the design stage of insulating parts of equipment which is to be installed over 1000m about sea level. In this case a correction coefficient must be applied, which can be taken from the graph drawn up according to the indications given in the IEC 62271-1 or GB 11022 standards.

For altitudes above 1000m, ask ABB.

## Environmental protection programme

The V-Contact VSC contactors are constructed in compliance with the ISO 14000 Standards (Guidelines for environmental management).

The production processes are carried out in compliance with the Standards for environmental protection both in terms of reduction of energy consumption and raw materials and of production of waste. All this is thanks to the environmental management system in the production facility conforming to what is certified by the certifying Organisation.

The minimal environmental impact during the life cycle of the product (LCA - Life Cycle Assessment), is obtained by targeted selection of materials, processes and packing made during the design stage. The production techniques prepare the products for easy dismantling and easy separation of the components to allow maximum recycling at the end of the useful life cycle of the apparatus.

For this purpose, all the plastic components are marked according to ISO 11469 (2nd ed. 15.05.2000).

When compared with a contactor fitted with a traditional operating mechanism, V-Contact VSC contactors allow an energy saving which prevents emission into the atmosphere of about 7000 kg of carbon dioxide (CO<sub>2</sub>).

## Use of fuses according to the load

### Motor control and protection

The motors are supplied in low voltage, normally up to a power of 630 kW. Over the latter power, medium voltage power supply is preferable (from 3 to 12 kV) with the aim of reducing costs and dimensions of all the apparatus which are part of the circuit. The V-Contact can be used for voltages from 2.2 kV up to 12 kV and for motors up to a power of 5000 kW, thanks to the simplicity and sturdiness of the control mechanisms and the long life of the main contacts.

To ensure protection against short-circuit, it is necessary to combine the contactors with appropriate current-limiting fuses. This solution allows the costs of the load-side apparatus (cables, current transformers, busbar and cable anchoring devices, etc.) to be further reduced and to make the user practically independent of any subsequent enlargements of the plant and of the consequent increased in network power.

### Procedure for selecting the fuses for motor protection (1)

Selection of the fuses suitable for motor protection must be made by verifying the service conditions.

The data to be taken into consideration are:

- power supply voltage
- start-up current
- duration of start-up
- number of start-ups/hour
- current at full motor load
- short-circuit current of the installation

Searching for trip coordination with the other protection releases in order to adequately protect the contactor, current transformers, cables, the motor itself and all the other apparatus present in the circuit, which could be damaged by prolonged overloads or by a specific let-through energy ( $I^2t$ ) higher than the one which can be withstood, also figures among the selection criteria.

Protection against short-circuit is carried out by the fuses, always selected with a rated current higher than that of the motor to prevent their intervention on start-up. This method of selection does not,

however, allow their use as protection against repeated overloads - a function already not guaranteed by them, especially with current values included up to the end of the initial asymptotic stretch of the characteristic curve.

A release with inverse or independent time is therefore always needed for protection against overloads. This protection must be coordinated with the one carried out by the fuse, working so that the release and fuse curves intersect at a point to allow the following:

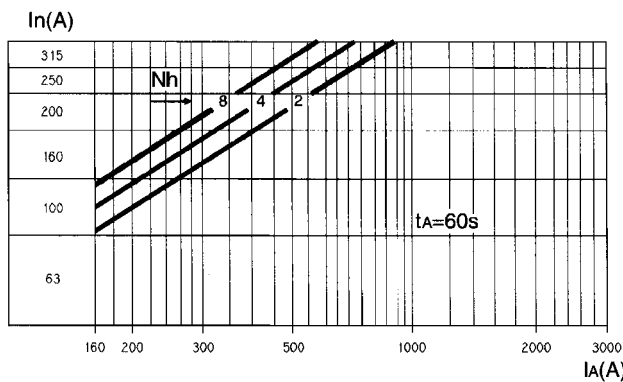
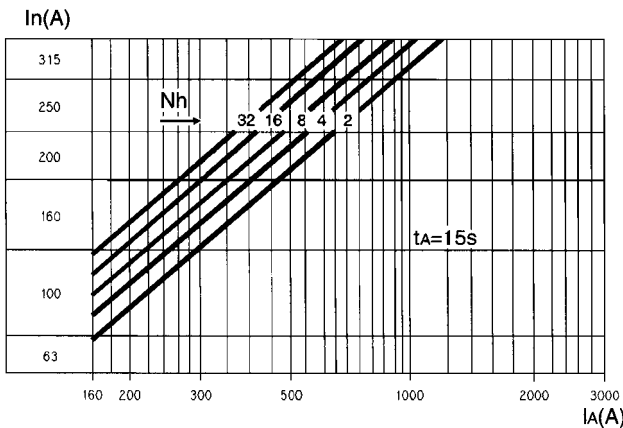
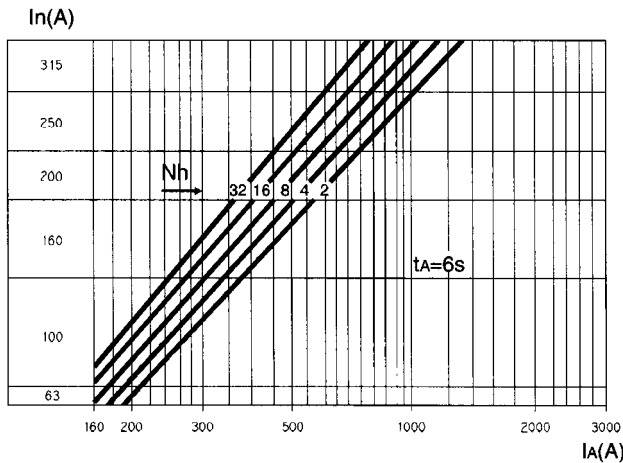
- 1) Motor protection against overcurrents due to overloads, single-phase running, blocked rotor and repeated start-ups. Protection entrusted to an indirect relay with inverse or definite time delay trip which acts on the contactor.
- 2) Protection of the circuit against fault currents, between phases and towards earth, of low value, entrusted to a release with inverse or definite time delay trip, which must only intervene for the short-circuit values which can be interrupted by the contactor.
- 3) Protection of the circuit against fault currents higher than the breaking capacity of the contactor up to the maximum fault withstand current. Protection entrusted to the fuse.

To verify the service conditions, proceed as follows:

- **Rated voltage  $U_n$ .** This must be equal to or higher than the service voltage of the installation.

Check that the level of insulation of the network is higher than the switching overvoltage value generated by the fuses, which for the fuses used by ABB is widely below the limit fixed by the IEC 282-1 Standards.

Fig. A - Fuse selection curves for motor start-up.  
ABB CMF type fuses.



$I_n$  = rated current of the fuse  
 $I_A$  = motor start-up current  
 $N_h$  = number of motor start-ups in one hour  
 $t_A$  = maximum motor start-up time

- **Rated current  $I_n$ .** This must be selected by consulting the diagrams indicated in fig. A which refer to the case of starting at fairly even time intervals, except for the first two start-ups of each hourly cycle which can take place in immediate succession.

Each diagram refers to a different starting time: 6 s - 15 s - 60 s, respectively.

In the case of start-ups close together, it must be checked that the starting current does not exceed the value of  $I_f \times K$ , where  $I_f$  is the fuse blowing current in correspondence with the starting time of the motor, and  $K$  is a minor factor of the unit, a function of the  $I_n$  of the fuse and which can be taken from the table given in figure B.

- **Full load motor current.** The rated current of the fuse must be of a value equal to or higher than 1.33 times the rated current value of full motor load.

This condition is, in any case, always obtained for motors started at full voltage for which the procedure described for selection of the rated fuse current necessarily imposes values which are always higher than 1.33  $I_n$ .

- **Short-circuit current.** The short-circuit current limiting curves in fig. C allow the short-circuit current limitation on the load side of the fuses involved in the fault to be appreciated. And this implies smaller sizing of the load side apparatus.

### Example of coordination for overload of a fuserelay with inverse time delay trip

Motor characteristics:

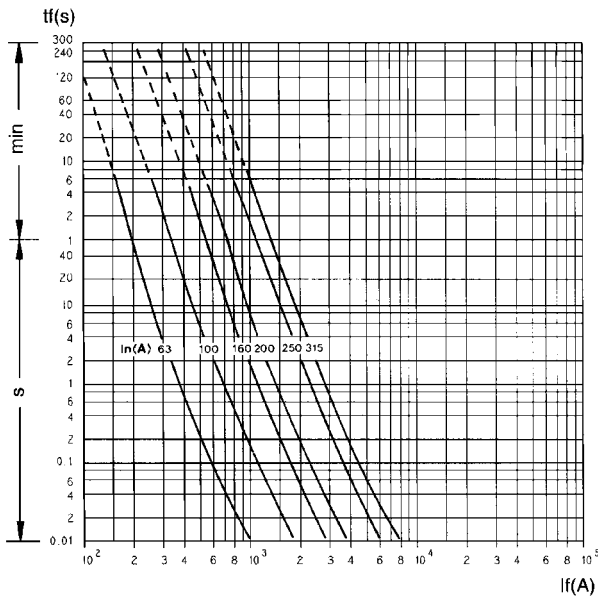
$P_n$  = 1000 kW  
 $U_n$  = 6 kV  
 $I_{start}$   $\approx 5 I_n = 650$  A  
 $T_{start}$  = 6 s  
 No. hourly operations = 16.

In the curve with starting time of 6 s in fig. A, in correspondence with the 650 A starting current value, the straight line, traced for 16 hourly start-ups, intersects in the range of the 250 A fuse.

In the fuse blowing time curve, it can be noted that the 250 A fuse blows in 6 s (starting time) when it is passed through by a current of 1800 A.



Fig. B - Curve of fuse blowing times and table for selection of factor K. ABB CMF type fuses.



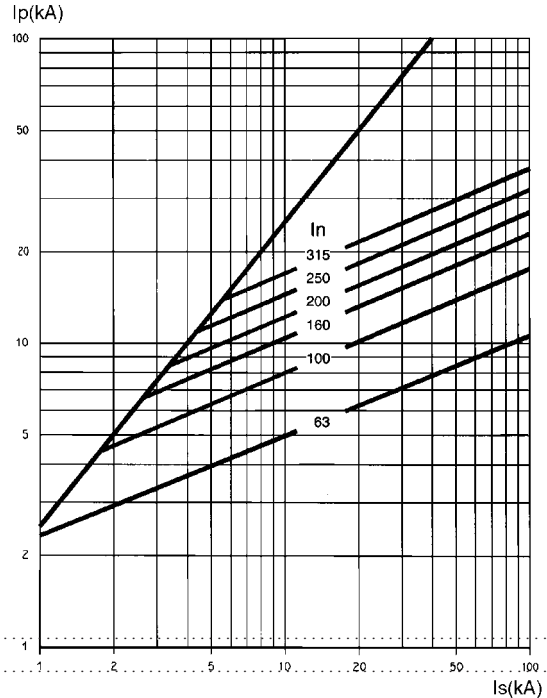
In the table in fig. B, the K coefficient for the 250 A size is 0.6, from which the value  $I_f \times K = 1080$  A is taken, which is higher than the start-up current (650 A), so use of the 250 A fuse is also legitimate in respect of this condition, which regards the possibility of start-ups close together.

By observing the blowing curve of the 250 A fuse, the need to use a relay with inverse time delay trip, or a relay with definite time delay trip for protection against overloads can be noted.

It must be remembered that prolonged overheating, above the temperature foreseen for the class of insulating materials, is harmful and strongly prejudices the life of electric machines.

Fig. D shows the graph relative to the motor considered in the example.

Fig. C - Short-circuit current limitation curves. ABB CMF type fuses.



$I_s$  = prospective short-circuit symmetrical current  
 $I_p$  = current limited by the fuse (peak value)

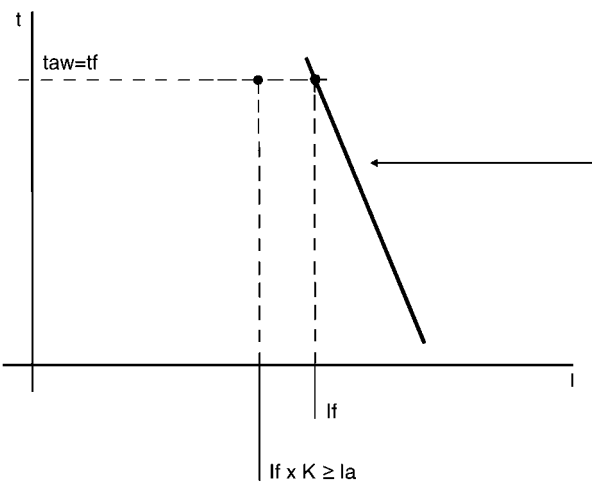


Table for selection of factor K

Un(kV)	In(A)	63	100	160	200	250	315
3.6	63	100	160	200	250	315	
7.2	63	100	160	200	250	315	
12	63	100	160	200	-	-	
K		0.75	0.75	0.7	0.7	0.6	0.6

### Motor starting

Motor starting poses the problem of the high current consumption on inrush.

In most cases, since these are asynchronous motors, the start-up current can take on the following values:

- asynchronous with simple squirrel cage 4.5 ... 5.5  $I_n$
- asynchronous with double squirrel cage 5 ... 7  $I_n$
- asynchronous with wound motor: low values, dependent on selection of the starting resistances.

This current cannot be available if the short-circuit power of the network is not sufficiently high and, in any case, can give rise to a drop in voltage for the whole duration of starting, which cannot be tolerated, from the loads derived from the network itself. Normally a voltage drop between 15 and 20% is considered acceptable except for verification needed in the case of special users.

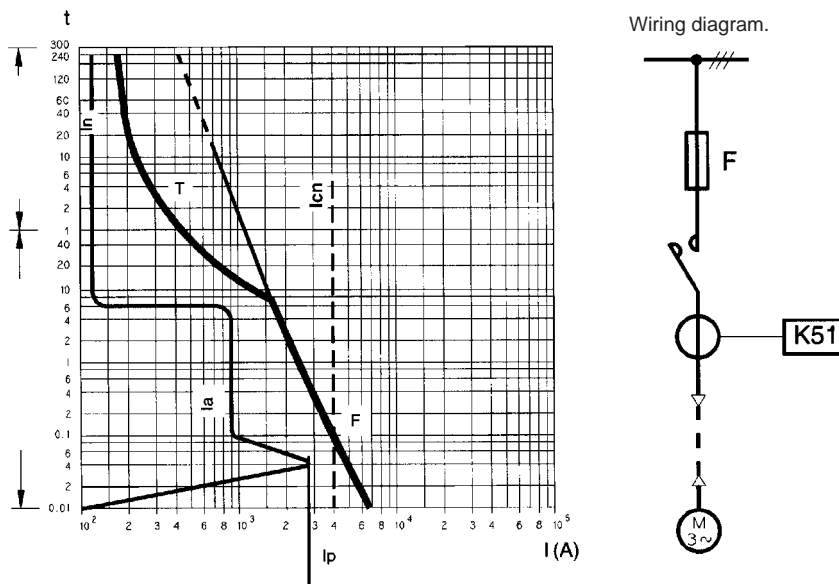
The full voltage start-up condition can be checked analytically and turns out to be possible in most cases.

If the calculations show that the start-up power causes a voltage drop higher than the admissible one, starting with reduced voltage must be used, with consequent reduction in the start-up current.

For this purpose, starting with a step-down autotransformer is generally used.

For large motors it may be more convenient to use a transformer, whose sizing can be a little higher than the power required by the motor, dedicated exclusively to the machine: start-up therefore takes place with reduced voltage (strong voltage drop on the secondary winding of the transformer) without the rest of the plant being affected.

Fig. D - Graph showing the coordination between 250 A fuse and relay with inverse time delay trip.



- $I_{cn}$  = maximum short-circuit current in amperes that the contactor can interrupt
- $I_a$  = motor start-up current in amperes
- $I_n$  = motor rated current in amperes
- $t$  = time in seconds
- $I$  = current in amperes
- $F$  = time-current characteristic of the 250 A fuse
- $T$  = inverse time characteristics of the indirect relay for protection against overloads (K51)
- $I_p$  = peak value of the motor connection current

By suitably combining different enclosures, with withdrawable contactors appropriately fitted with accessories, any motor starting, control, protection and measurement diagram can be made.

Fig. E shows some typical electric diagrams which can be made with withdrawable contactors.

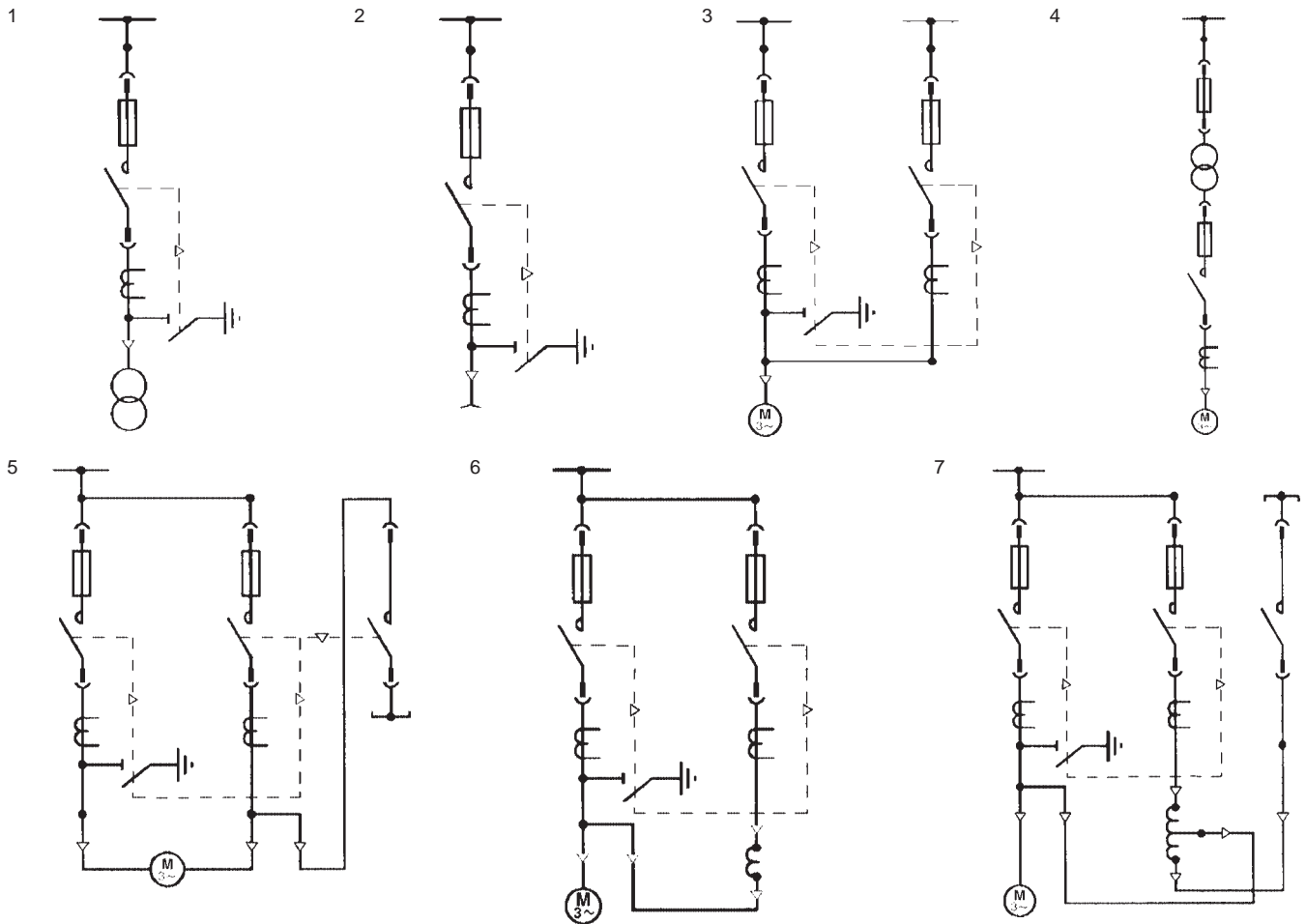
### Transformer protection and fuse selection <sup>(1)</sup>

When contactors are used for transformer control and protection, they are fitted with special types of current-limiting fuses which guarantee selectivity with other protection devices and which can take the high transformer connection currents without deterioration.

Unlike what has been seen for motors, in this case protection against overcurrents on the medium.

Fig. E - Typical diagrams of transformer power supply and motor starting

1 Transformer power supply | 2 Motor starting with full voltage | 3 Reversal of motor running | 4 Motor starting with dedicated transformer  
5 Star-delta motor starting | 6 Motor starting with reactor | 7 Motor starting with autotransformer



<sup>(1)</sup> Selection criteria relative to ABB CEF type fuses.

voltage side of the transformer is not indispensable since this task is carried out by the protection provided on the low voltage side. The protection on the medium voltage side can be entrusted to the fuse alone, which must be selected taking into account the no-load connection current, which can reach values up to 10 times the rated current for smaller transformers built with orientated crystal core laminations.

The maximum connection current is reached when circuit-breaker closing takes place in correspondence with passage through zero of the voltage.

Another result to be guaranteed is protection against faults in the low voltage winding and in the connection stretch from this to the circuit-breaker located on the secondary winding, avoiding the use of fuses with rated current which is too high, to be able to ensure tripping within a short time even under these fault conditions.

A rapid check of the short-circuit current at the secondary terminals of the transformer and on the supply side of the circuit-breaker on the secondary, if placed at a significant distance, allows the trip time to be verified on the fuse blowing curve.

The table of use given below takes both the required conditions into account, i.e. rated current sufficiently high to prevent unwarranted blowing during the no-load connection phase and, in any case, of a value which guarantees protection of the machine against faults on the low voltage side.

### Connection of capacitors

The presence of current transients, which occur during switching-in of a capacitor bank, requires attention during the calculation procedures. In fact, assessment of the size of the phenomenon provides the elements for selecting the switching apparatus suitable for connecting/disconnecting the bank and for guaranteeing its protection in the case of overload.

To make this calculation, the power factor correction installations must be divided into two types:

- 1) installations with a single three-phase capacitor bank (single bank installations)
- 2) installations with several three-phase capacitor banks, which can be connected separately (multiple bank installations).

In the first type of installations there is only one type of switching-in transient, called switching-in transient of a single capacitor bank to the network. An example of a typical current transient is shown in fig. A.

In the second type of installations there are two types of switching-in transients:

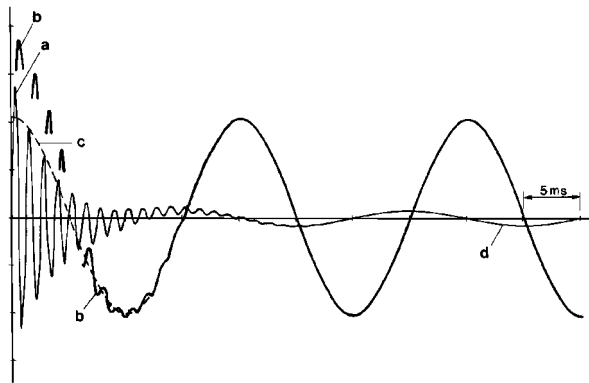
- on connection of the first capacitor bank there is the switching-in transient of a capacitor bank to the network
- on connection of the other banks there is a switching-in transient of a capacitor bank to the network with other banks already supplied in parallel. In this case, the current transient is the type shown in fig. B.

### Selection table for fuses for transformers

Rated voltage [kV]	Rated transformer power [kVA]														
	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
	Rated fuse current [A]														
3.6	40	40	63	63	63	63	100	100	160	160	200	250	315	--	--
5	25	25	40	40	63	63	63	100	100	160	160	200	250	250	315
6.6	25	25	26	40	40	63	63	63	100	100	100	160	200	200	250
7.2	25	25	26	40	40	63	63	63	63	100	100	160	160	160	200
10	16	16	25	25	25	40	40	63	63	63	100	100	160	160	160
12	16	16	16	25	25	25	40	40	63	63	63	100	100	160	160

Fig. A - Example of a current transient during connection of a single capacitor bank.  
 a = Transient switching-in current: first peak at 600 A peak and 920 Hz frequency.  
 b = Transient voltage at the 400 kVAR bank terminals.  
 c = Power supply phase voltage  $10 / \sqrt{3} = 5.8$  kV.  
 d = Rated bank current at 50 Hz: 23.1 A.

Trend of the current and voltage during and after the switching-in transient.



Trend of the current and voltage during the first 10ms of the switching-in transient.

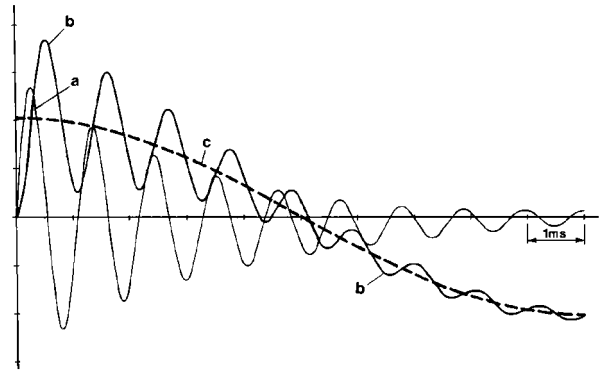
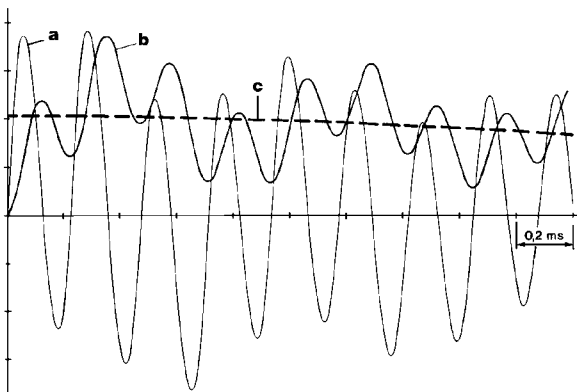
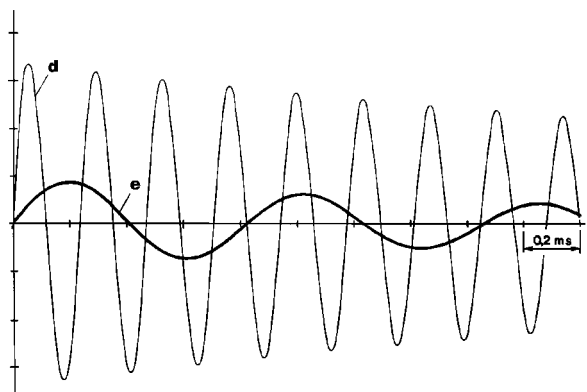


Fig. B - Example of a current transient during connection of a capacitor bank with another one already supplied with voltage.  
 a = Transient switching-in current: 1800 A peak and 4280 Hz frequency.  
 b = Transient voltage at the 400 kVAR bank terminals  
 c = Power supply phase voltage:  $10 / \sqrt{3} = 5.8$  kV.  
 d = Component at 4280 Hz frequency of the transient switching-in current.  
 e = Component at 1260 Hz frequency of the transient switching-in current.

Trend of the current and voltage during the first 2 ms of the switching-in transient.



Trend of the two components of the total current (see graph above).



### Selection of contactors suitable for connection of capacitor banks

The CEI 33-7 and IEC 871-1/2 Standards specify that the capacitor banks "... must be able to operate correctly under overload with an effective line current value up to 1.3 I<sub>n</sub>, not taking into account the transients".

The switching, protection and connection devices must therefore be designed to withstand continuously a current 1.3 times the current there would be at the rated sinusoidal voltage and at the rated frequency. According to the effective value of the capacity, which may also be 1.10 times the rated value, this current can have a maximum value of 1.3 x 1.10 = 1.43 times the rated current.

It is therefore advisable to select the rated normal current of the contactor for operating the capacitor bank at least equal to 1.43 times the rated current of the bank.

The V-Contact VSC contactors completely fulfil the requirements of the Standards, particularly those regarding connection and disconnection operations of banks and the overvoltages which, in any case, do not exceed three times the peak value of the rated phase voltage of the installation.

It is necessary to apply overvoltage surge arresters for the VSC 12 contactors.

### Single bank

The parameters of the current transient, peak values and own frequency, which are present in the case of connection of the bank to the network, are usually of notably smaller size than those in the case of multiple banks. It is, however, necessary to check the values with the calculation and make sure that the peak current is equal to or less than:

Contactor	Peak current
VSC 7 400 A	8 kAp
VSC 12 400 A	Ask ABB

### Two or more banks (back-to-back)

In the case of several capacitor banks, it is necessary to make the calculations regarding the installation, considering operation of a single bank with the other capacitor banks already connected. Under these conditions, it is necessary to check that:

- the maximum switching-in current does not exceed the value given below (see table);
- the switching-in current frequency does not exceed the value given below (see table).

Contactor	Peak current	Maximum switching-in frequency	I <sub>p</sub> (kA) x f (Hz)
VSC 7 400	8 kAp	2,500 Hz	20,000
VSC 12 400	Ask ABB	Ask ABB	Ask ABB

For switching-in current values under the values indicated, the switching-in frequency can be increased so that the product-I<sub>p</sub> (kA) x f (Hz) - is as indicated in the table.

For example, in the case of the VSC 7 400A contactor, the I<sub>p</sub> (kA) x f (Hz) value must not exceed 8 x 2,500 = 20,000.

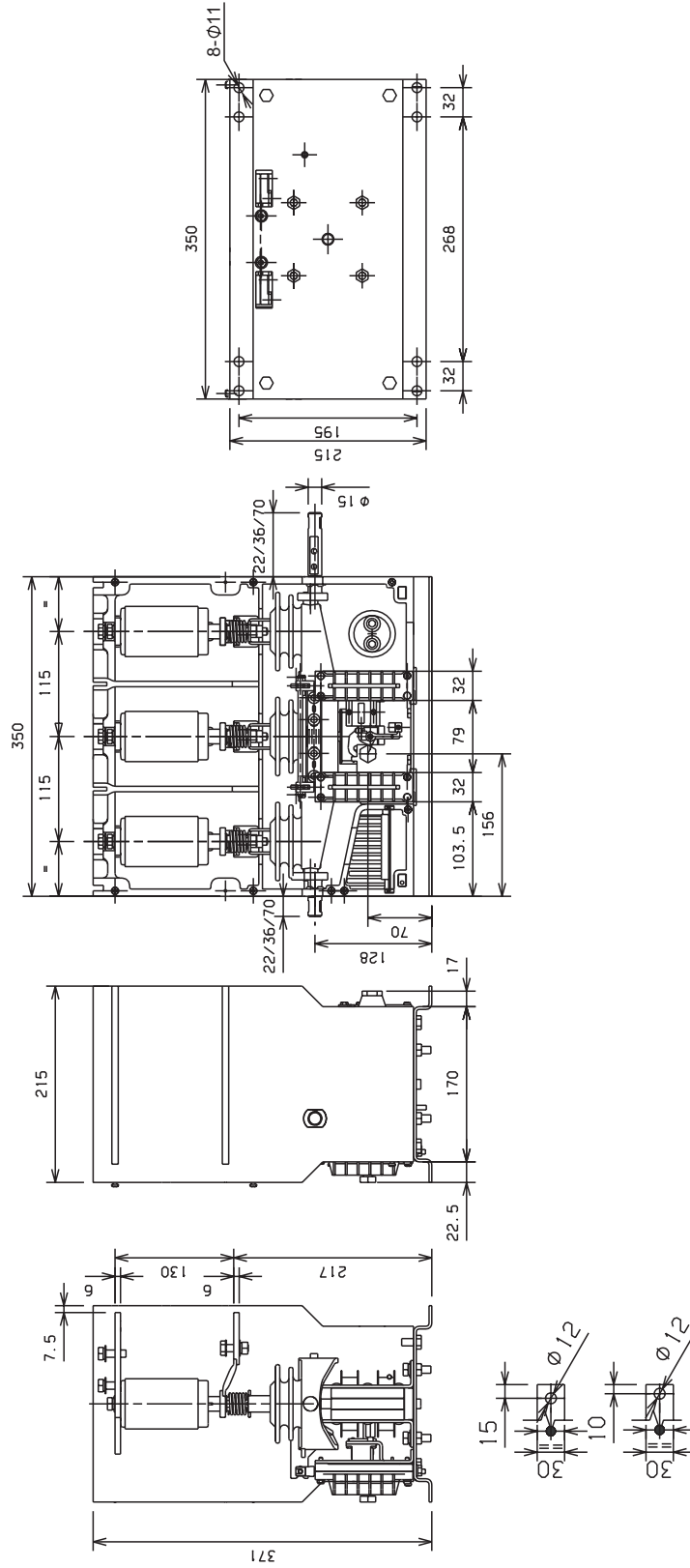
To calculate the switching-in current and frequency, refer to the ANSI C37.012 Standards or to the IEC 62271-100 Annex H Standards.

Should higher values than those indicated be obtained in the calculations, it is necessary to connect air reactors of suitable value in the circuit.

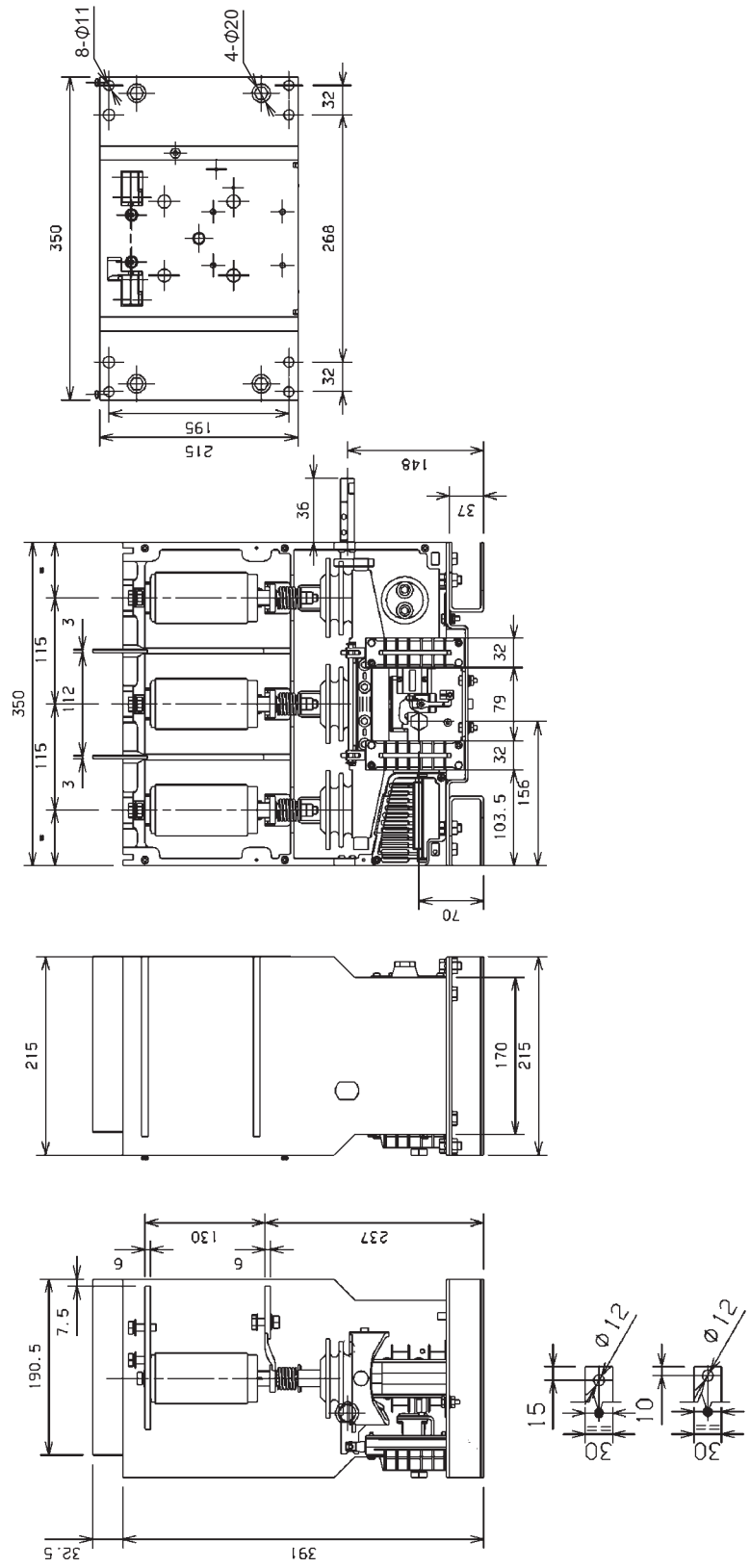
The use of reactors is, however, recommended in the case of frequent operations with high switching-in frequencies.

# Overall Dimensions

VSC 7 fixed contactor

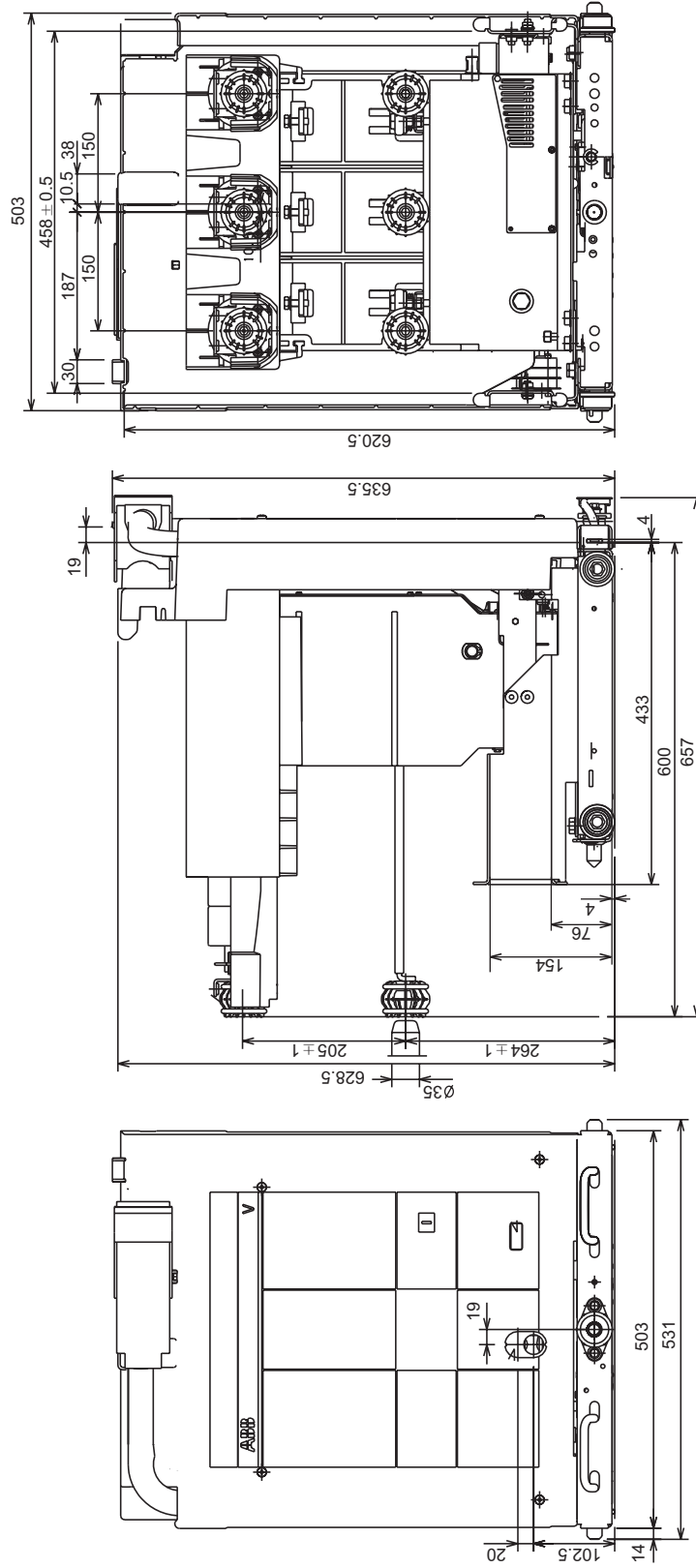


VSC 12 fixed contactor



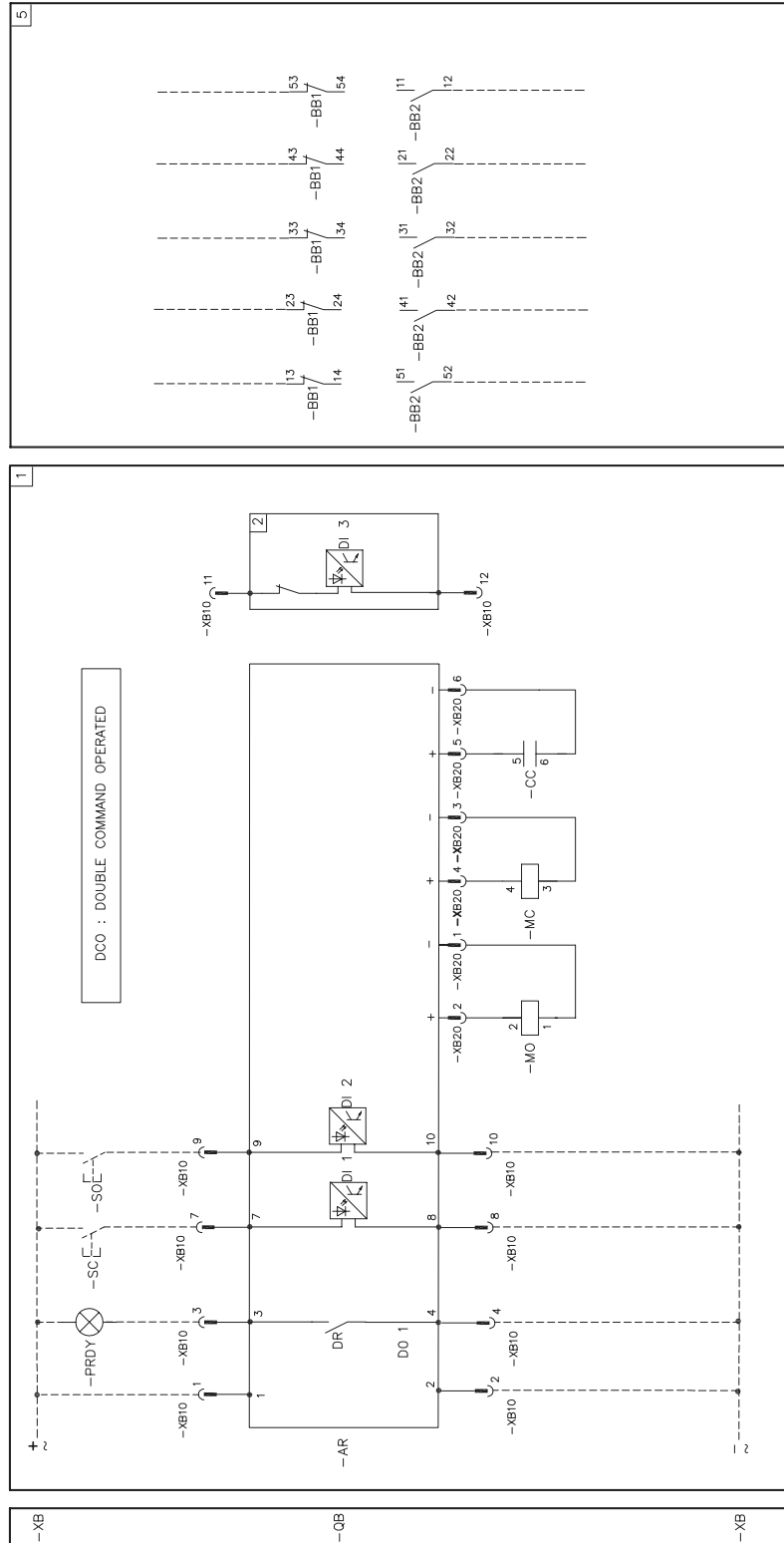


VSC/P 7 - VSC/P 12 withdrawable contactor

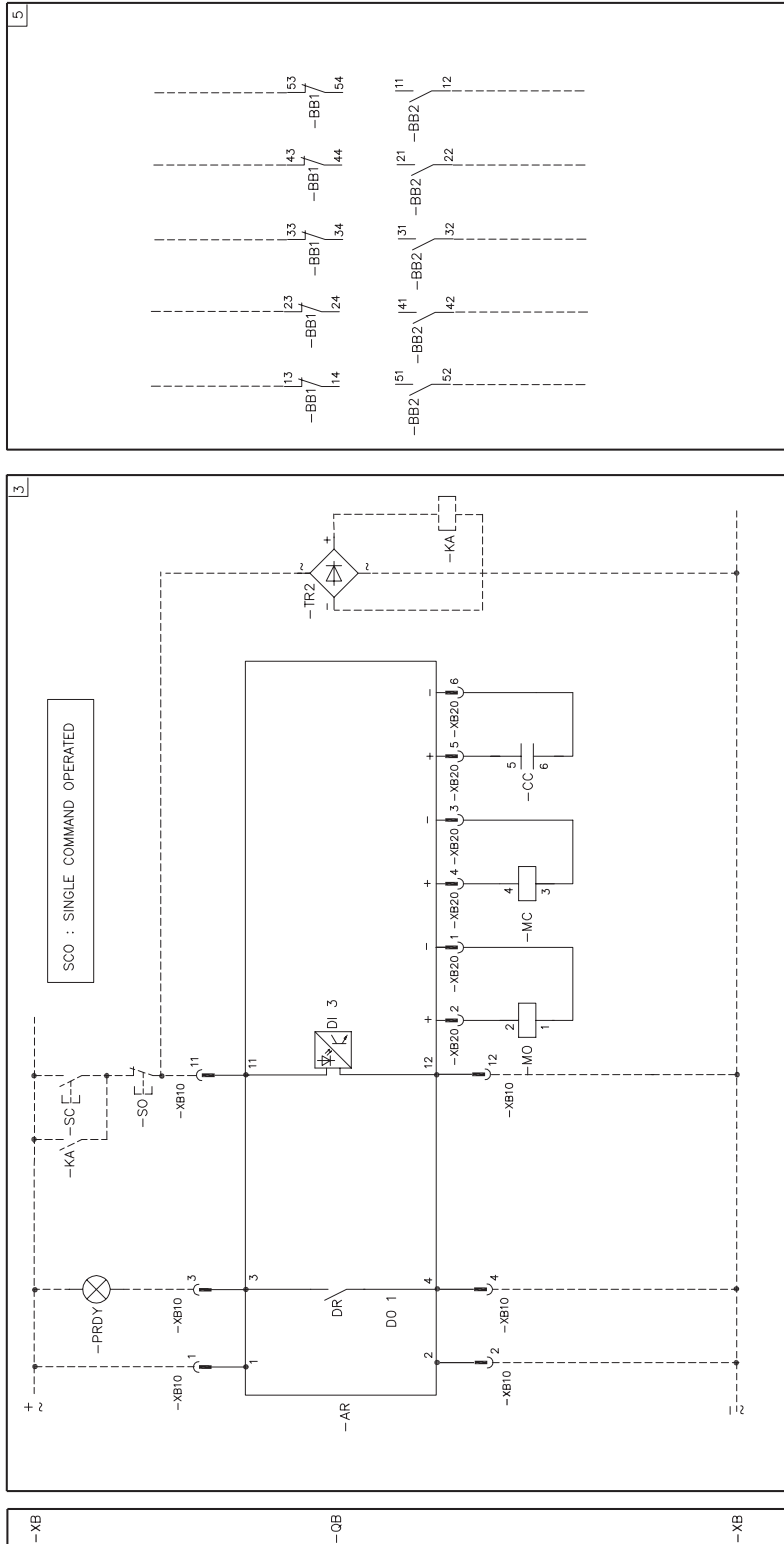


# Electric Circuit Diagram

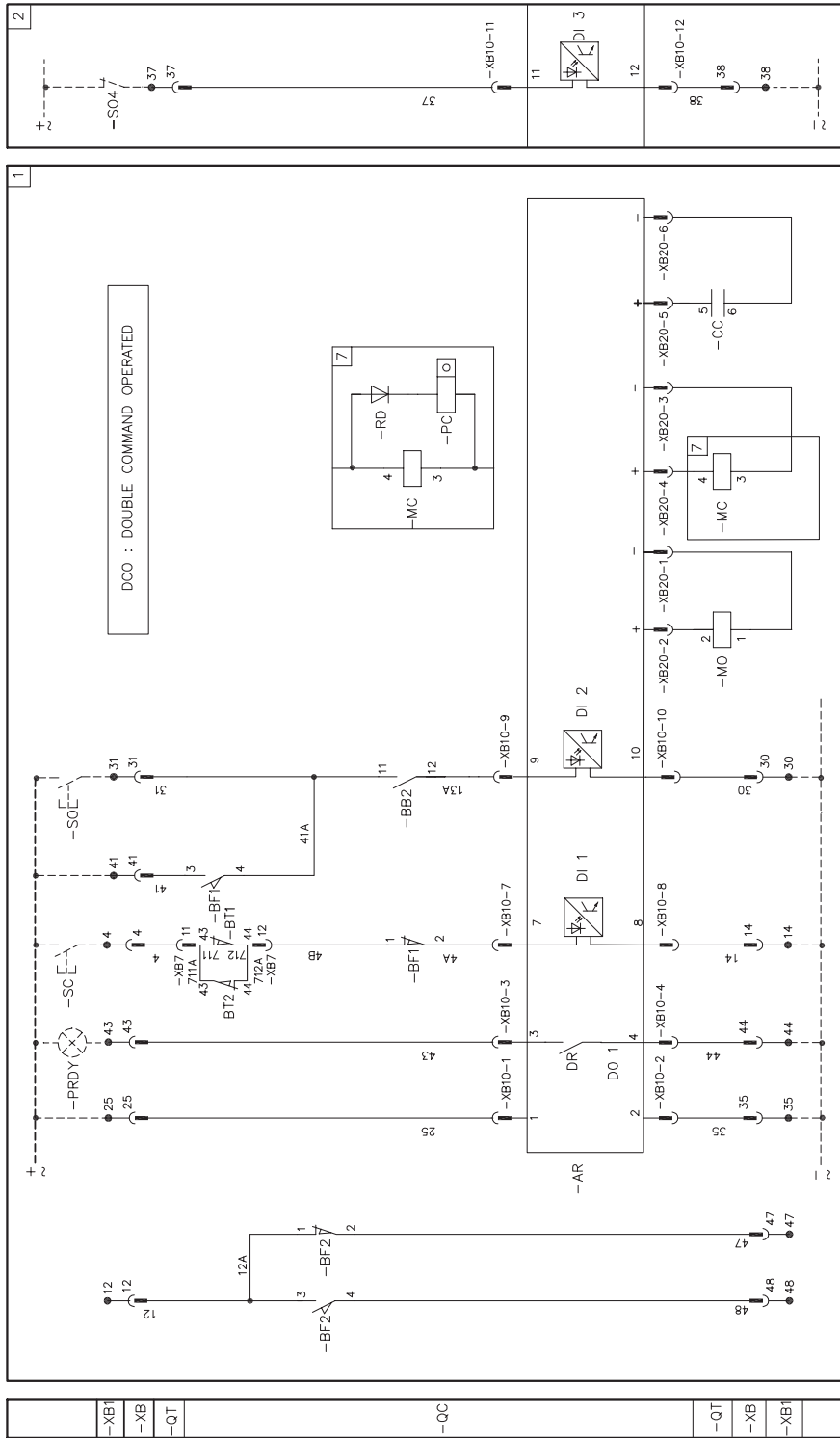
As an example, the diagram given below shows the contactor circuits. In any case, to take product evolution into account, it is always useful to refer to the circuit diagram provided with each piece of apparatus.  
**VSC fixed contactor - DCO version (Double Command Operated)**



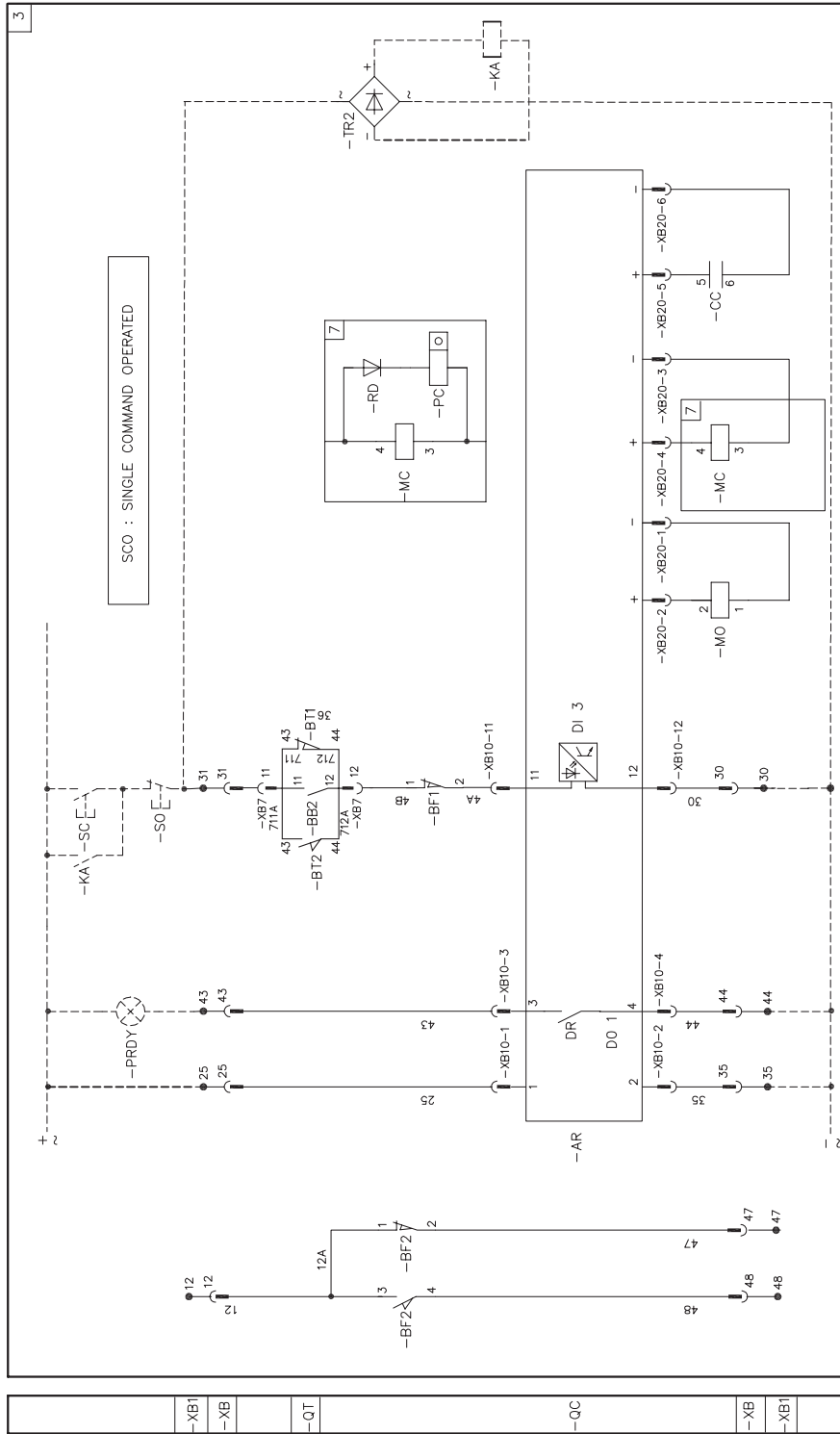
VSC fixed contactor - SCO version (Single Command Operated)



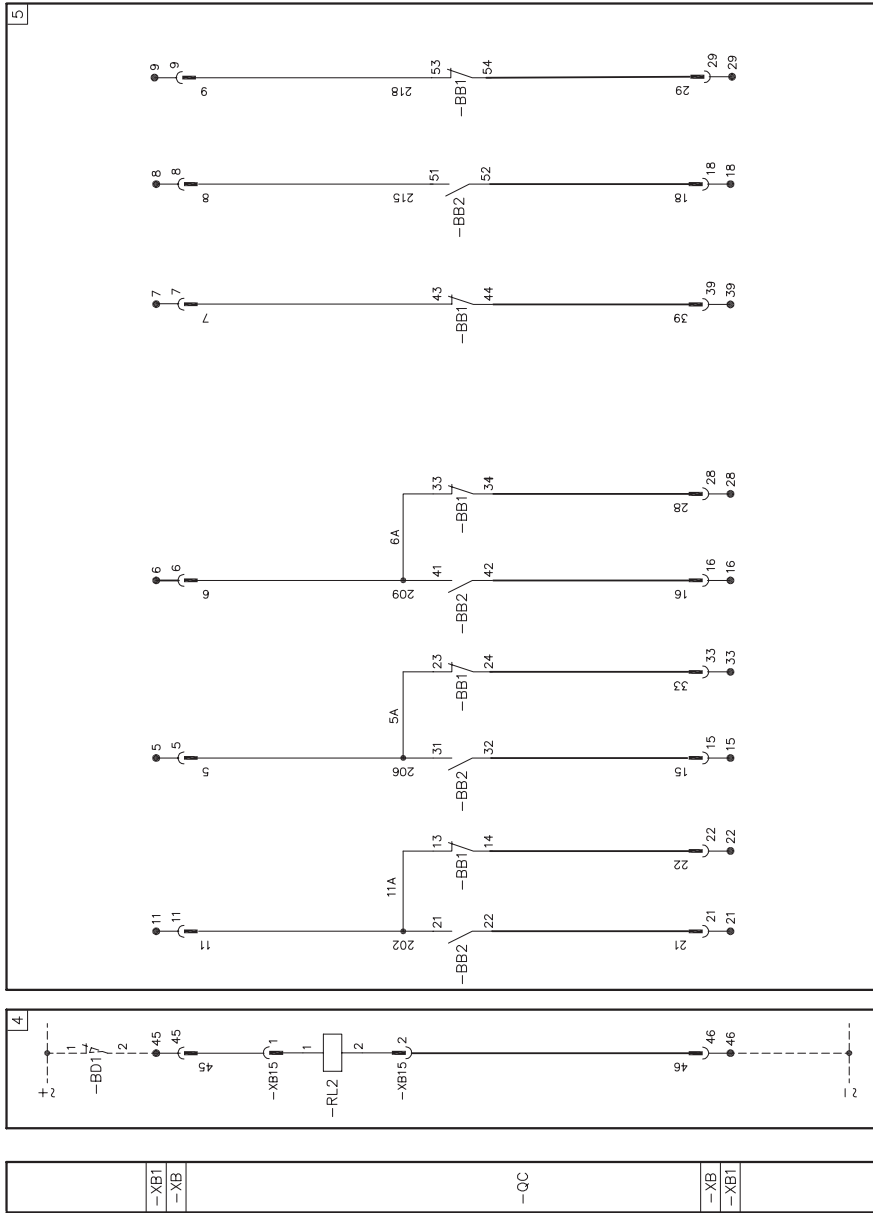
VSC/P withdrawable contactor - DCO version (Double Command Operated)



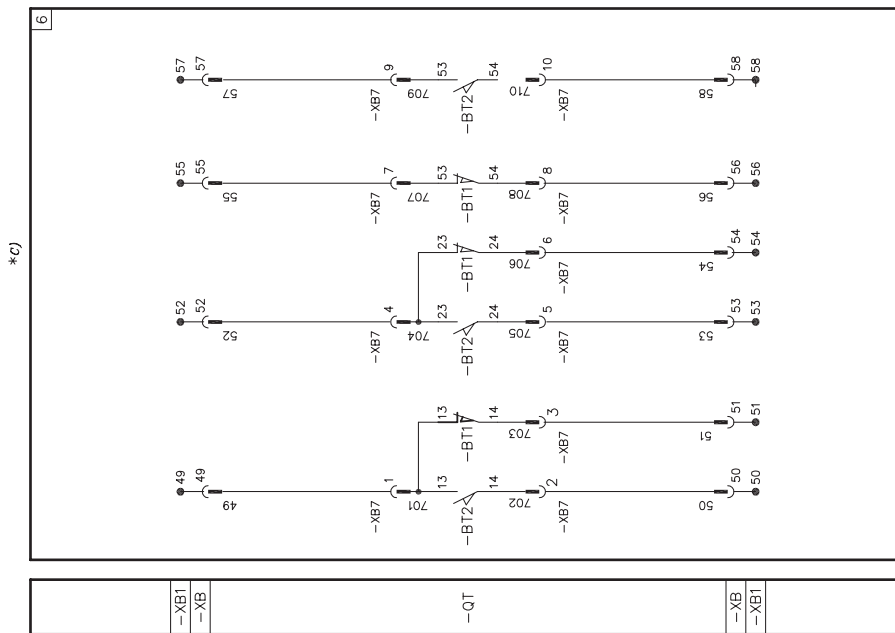
VSC/P withdrawable contactor - SCO version (Single Command Operated)



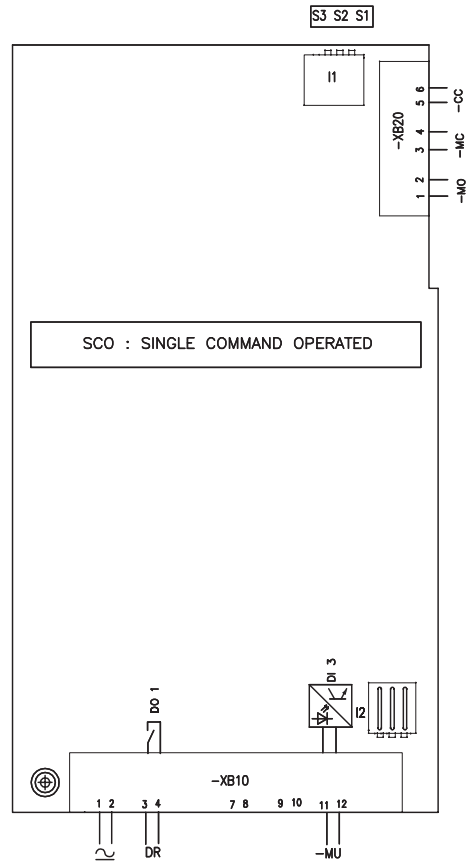
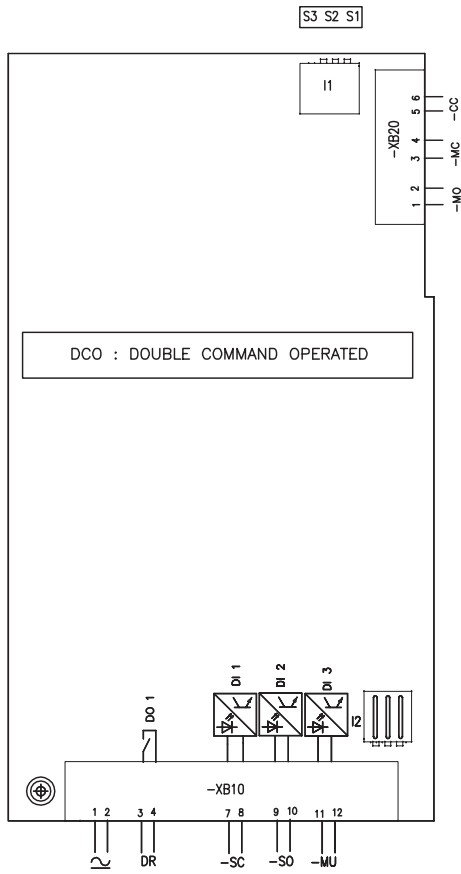
VSC/P withdrawable contactor



VSC/P withdrawable contactor



VSC/P contactors - electronic cards



Output contact  
DO 1 Unit ready

Input signals

DI 1 Command closed (SCO)

DI 2 Command open (SCO)

DI 3 Undervoltage (DCO). Command closed (SCO)



### State of operation represented

The diagram indicates the following conditions:

- Contactor open
- Control circuits de-energized.

### Caption

XB	= Customer's delivery terminal box of contact circuits
XB1	= Switchgear terminal box (outside the contactor)
QC	= Contactor
QB	= Customer's circuit-breaker or changeover device
MO	= Shunt opening release
MC	= Shunt closing release
SC	= Closing push-button
SO	= Opening push-button
CC	= Capacitor
AR	= Control and protection unit
BB1-BB2	= Auxiliary contacts(N_2 packs of 5 contacts)
BT1	= Contacts for electrically signaling contactor in the connected position
BT2	= Contacts for electrically signaling contactor in the isolated position
BT3	= Contactor position contact-open during truck isolating travel
DR	= Contact for electrically signaling control and actuating circuits ready.

The following two conditions are fulfilled:

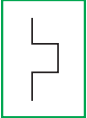


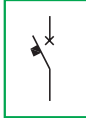
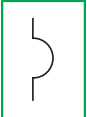

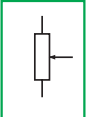
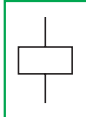
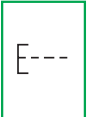
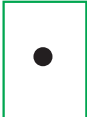

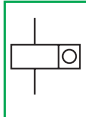

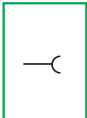
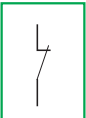
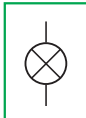

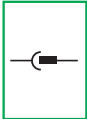
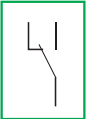
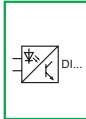
- capacitive energy available
- electronic system working

PRDY	= Signalling for control and actuating circuits ready. The following two conditions are fulfilled: <ul style="list-style-type: none"><li>- capacitive energy available</li><li>- electronic system working</li></ul>
SO4	= Pushbutton or contact for opening undervoltage contactor (contact closed with voltage present)
BF1,BF2	= Position contacts of medium voltage fuses
RL2	= Locking magnet, if de-energized, it prevents contactor to be racked in/out of the enclosure.
KA	= Auxiliary relay or contactor
RD	= Diode
PC	=Electric operation counter
TR2	=Rectifier

### Description of figures

Fig.1	= Control circuits of the contactor DCO version.
Fig.2	= Undervoltage only on request for DCO version.
Fig.3	= Control circuits of contactor SCO version.
Fig.4	= Locking magnet on the truck.
Fig.5	= Auxiliary contacts of contactor.
Fig.6	= Contacts for electrically signaling contactor in the connected and isolated positions, located on the truck.
Fig.7	= Electric operation counter circuit.

## Graphic symbols for electric diagrams

	Thermal effect		Conductor in shielded cable (e.g. three conductors)		Capacitor (general symbol)		Power circuit-breaker with automatic opening
	Electromagnetic effect		Connections of conductors		Potentiometer with moving contact		Control coil (general symbol)
	Pushbutton control		Terminal or clamp		Make contact		Electronic impulse counter
	Earth (general symbol)		Socket		Break contact		Lamp (general symbol)
	Conductive electric part, frame		Socket and plug (female and male)		Changeover contact with momentary interruption		Digital isolated binary inputs

# Product quality and environmental protection

The V-Contact VSC medium voltage vacuum contactors are produced in compliance with the requirements of international standards for the quality management system and environmental management system. In these fields, the excellent level is proved by quality certificates according to ISO 9001 and by the EMS according to ISO 14001.

End of life of product:

The ABB Company is committed to complying with the relevant legal

and other requirements for environment protection according to the ISO 14001 standard.

The duty of company is to facilitate subsequent recycling or disposal at the end of product life. During disposal of the product, it is always necessary to act in accordance with local legal requirements in force.

We use the following methods of disposal:

Disposal can either be carried out thermally in an incineration plant or by storing on a waste site.

Raw material	Recommended method of disposal
Metal material (Fe, Cu, Al, Ag, Zn, W, others)	Separation and recycling
Thermoplasts	Recycling or disposal
Epoxy resin	Separation of metal material and the disposal of rest
Rubber	Disposal
Oil as dielectric (transformer oil)	Draining from equipment and further recycling or disposal
SF <sub>6</sub> gas	Discharging from equipment and further recycling or disposal
Packing material-wood	Recycling or disposal
Packing material-foil	Recycling or disposal

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We reserve the right to make changes in the course of technical development.