

1ZSC000562-AAJ en, Rev. 1

Vacuum on-load tap-changers, type VUBB
Technical guide

Power and productivity
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Original instruction

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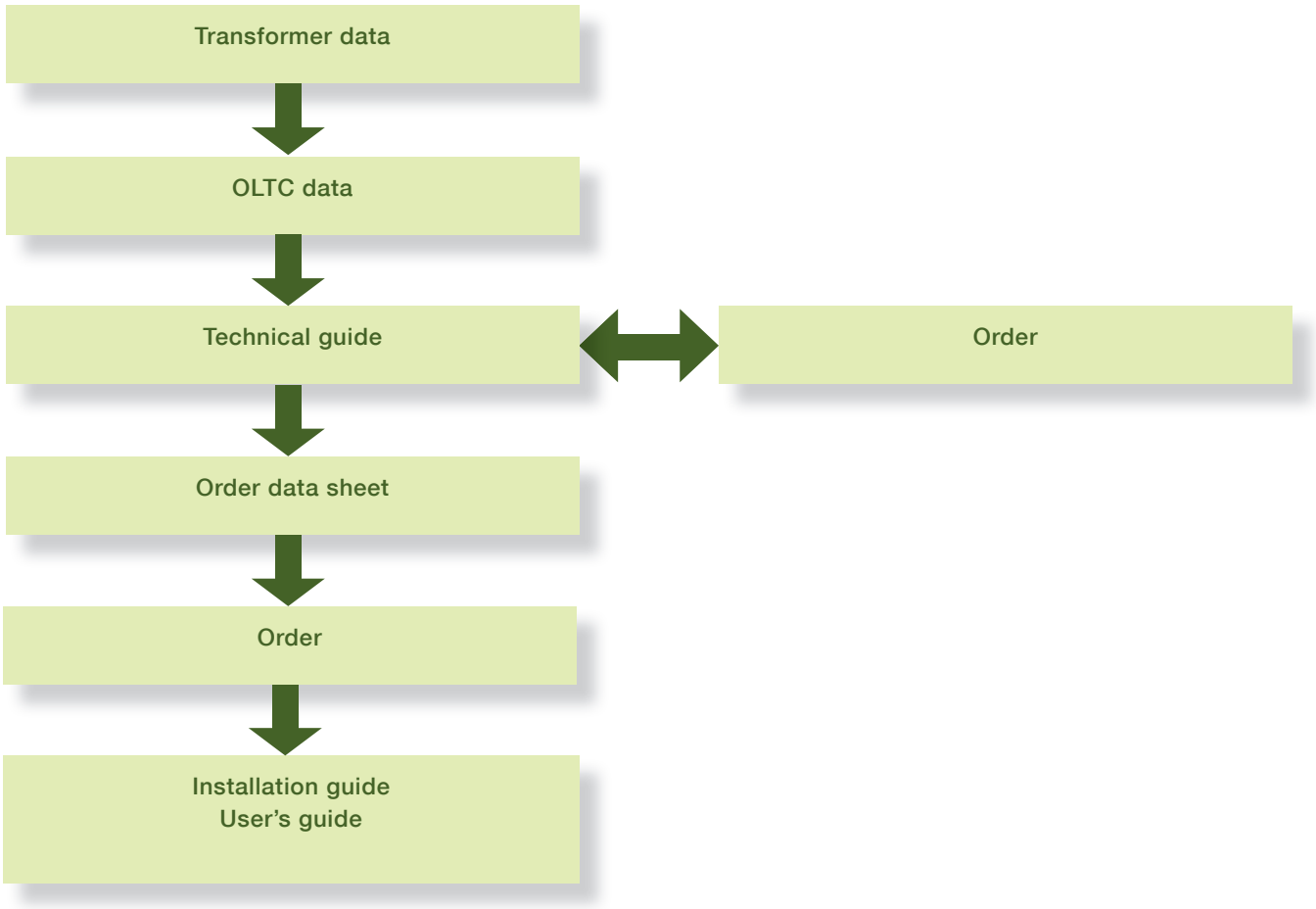
Selection process

Below is a schematic, showing the selection process. Before the selection can begin, certain input data has to be collected.

When the type of tap-changer is identified, the selection of the right size is made in this technical guide, where the special features are chosen. The order data form can then be completed and sent to ABB, either by using the traditional ordering data sheets or by using the electronic version, which is available at www.abb.com/electricalcomponents.

Information about mounting and service is given in the installation guide and the user's guide.

Further questions and detailed product information is available upon request. For any further assistance, please do not hesitate to contact ABB.



Introduction

This technical guide has been produced to allow transformer manufacturers, and their designers and engineers, access to all the technical information required to assist them in their selection of the appropriate on-load tap-changer.

The technical information pertaining to tap-changers and motor-drive mechanisms manufactured by ABB has been divided and is contained in separate documents, with one document for each type.

The information provided in this document is intended to be general and does not cover all possible applications. Any specific application not covered, for instance other applications than net applications, should be referred directly to the manufacturer.

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Manufacturer's declaration

The manufacturer **ABB AB**
Components
SE-771 80 LUDVIKA
Sweden

Hereby declares that the **VUBB on-load tap-changer** complies with the following requirements:

By design, the machine, considered as component on a mineral oil-filled power transformer, complies with the requirements of

- Machinery Directive 89/392/EEC (amended 91/368/EEC and 93/44/EEC) and 93/68/EEC (marking) provided that the installation and the electrical connection are correctly realized by the manufacturer of the transformer (e.g. in compliance with our installation instructions)
- EMC Directive 89/336/EEC regarding the intrinsic characteristics of emission and immunity levels
- Low Voltage Directive 73/23/EEC (modified by Directive 93/68/EEC) concerning the built-in motor and apparatus in the control circuits.

Certificate of Incorporation:

The VUBB on-load tap-changer must not be put into service until the machinery into which they have been incorporated has been declared in conformity with the Machinery Directive.

Date 2012-03-30

Signed by .....

Hans Linder

Title Manager of Division for Tap-Changers

Design

Functional description

The on-load tap-changer is a device for changing the tapping connection of a winding while the transformer is under load. The main purpose is to keep a constant voltage out from the transformer and to compensate for variations in the load situation. The tap-changer is connected to the transformer via the tap winding. The main function is tap selection, which is done by changing the number of turns on the regulating winding.

Although numerous different circuit solutions are available, the selected solution has been found to have the best combination of technical performance and potential for economic operation. By using auxiliary contacts in combination with vacuum interrupters, the contacts are used for carrying current and the vacuum interrupters are used for the energized switching. With this solution, only two vacuum interrupters are required per phase.

The electrical circuit principle for the VUBB is shown in Figs. 1-18. The purpose of the operation is to commute the load from one tap to the other, in order to change the voltage.

Depending on in which direction the center shaft is rotating, two different contact sequences are obtained – either the main contacts operate first, or in the other direction, the transition contacts operate first.

The figures on the following pages show the contact sequence together with the physical position of the interrupter.

Switching sequence, moving with resistor side first

1. Position for continuous load through fixed contact 1.

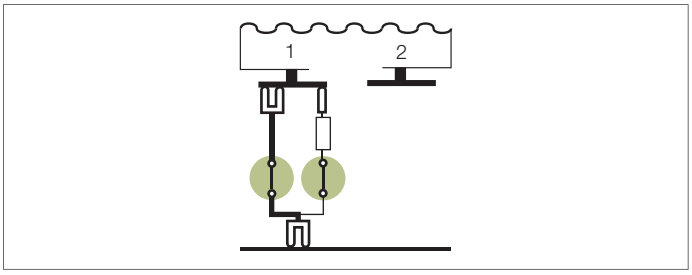


Fig. 1.

2. Resistor auxiliary contact leaves the fixed contact 1.

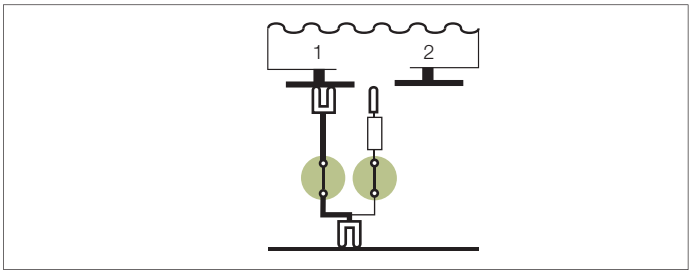


Fig. 2.

3. Resistor vacuum interrupter opens.

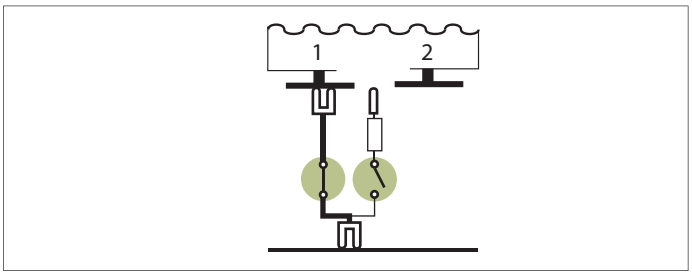


Fig. 3.

4. Resistor auxiliary contact enters fixed contact 2.

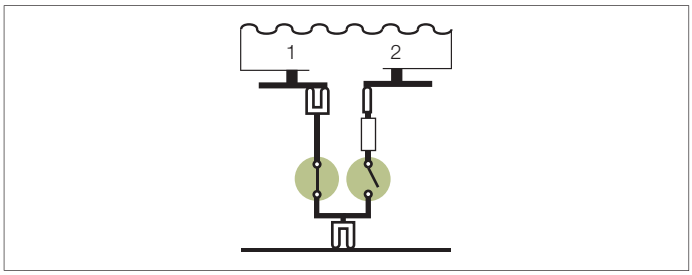


Fig. 4.

5. Resistor vacuum interrupter closes, causing a circulating current.

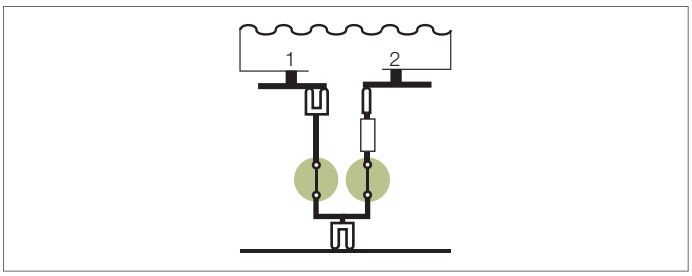


Fig. 5.

6. Main vacuum interrupter opens, breaking the circulating current and commuting the load current to the resistor branch.

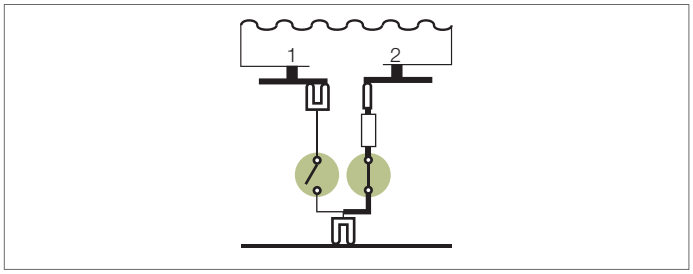


Fig. 6.

7. Main auxiliary contact leaves fixed contact 1.

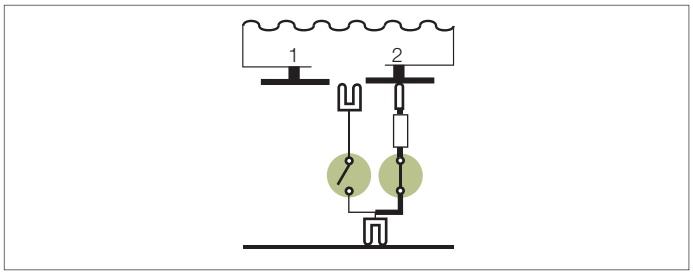


Fig. 7.

8. Main auxiliary contact enters fixed contact 2.

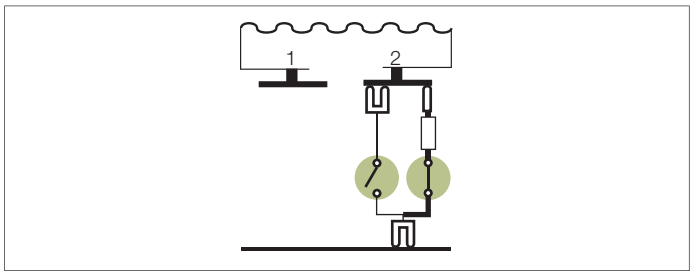


Fig. 8.

9. Main vacuum interrupter closes, commuting the load current to the main branch. Continuous load on fixed contact 2.

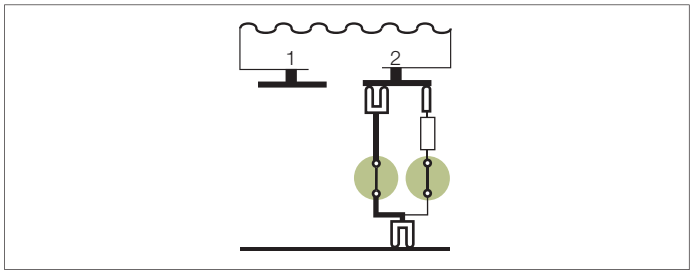


Fig. 9.

Switching sequence, moving with main contact first

1. Position for continuous load through fixed contact 2.

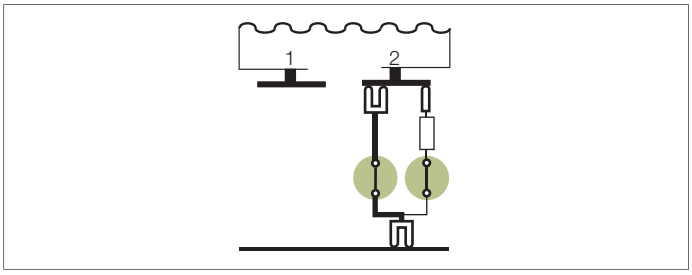


Fig. 10.

2. Main vacuum interrupter opens, breaking the load current, and by that commutes it to the resistor branch.

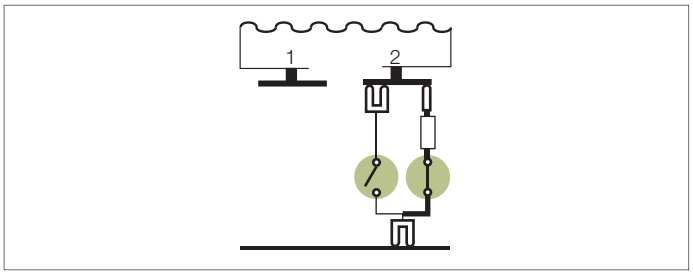


Fig. 11.

3. Main auxiliary contact leaves fixed contact 2.

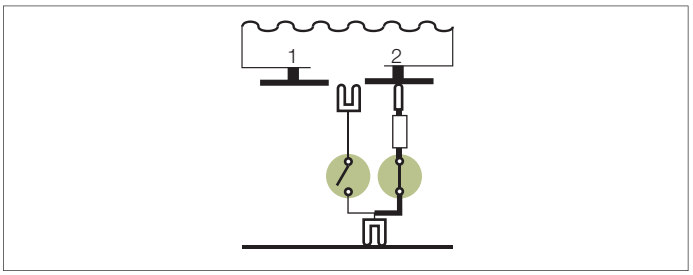


Fig. 12.

4. Main auxiliary contact enters fixed contact 1.

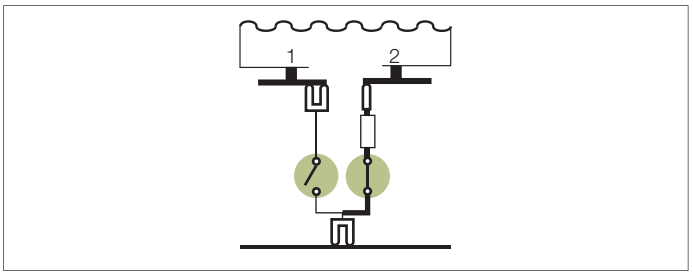


Fig. 13.

5. Main vacuum interrupter closes. The load current commutes to the main branch, and a circulating current starts.

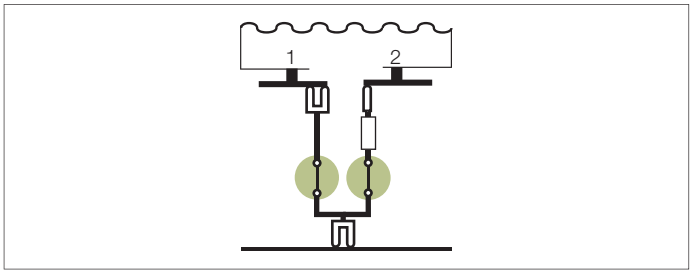


Fig. 14.

6. Resistor vacuum interrupter opens, breaking the circulating current

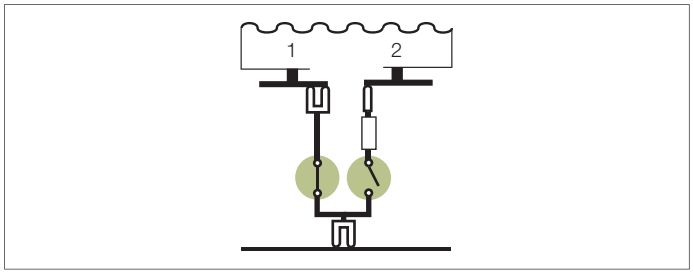


Fig. 15.

7. Resistor auxiliary contact leaves fixed contact 2.

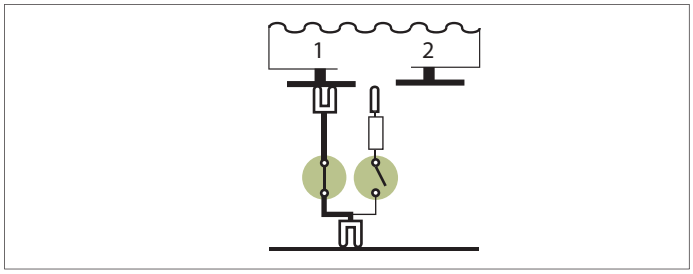


Fig. 16.

8. Resistor vacuum interrupter closes.

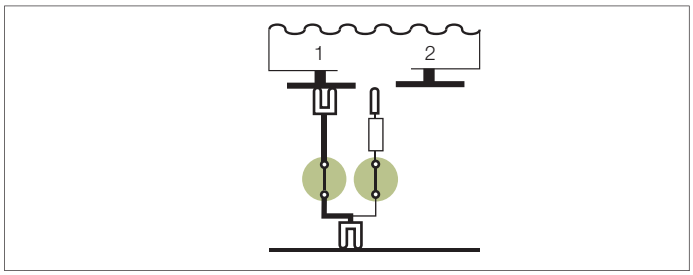


Fig. 17.

9. Resistor auxiliary contact enters fixed contact 1.

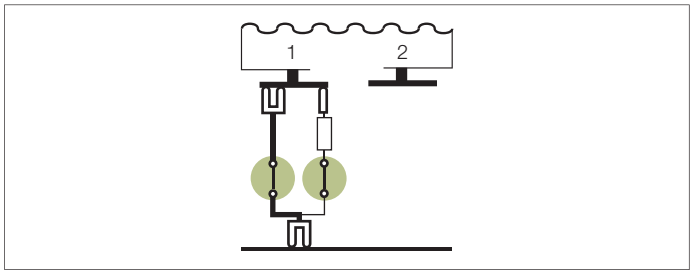


Fig. 18.

System overview

The ABB on-load tap-changers have been developed over many years to provide maximum reliability. The simple and robust design gives provides a service life equal to the service life of the transformer in most applications.

The implementation of vacuum technology improves breaking capacity, increases contact life and reduces maintenance.

The design allows easy access to function control of the switching sequence.

The VUBB on-load tap-changer is of the in-tank design. The motor-drive mechanism is attached to the transformer tank and connected to the tap-changer by means of drive shafts and a bevel gear. The motor-drive mechanism is not described in this manual.

The tap-changer is mainly comprised of a housing, a mechanical drive system, a change-over selector and a selector switch.

The tap-changer is designed so that it is suitable for both cover mounting and for yoke-mounting (pre-mounting on the transformer's active part).

Cover-mounting means that the tap-changer is lowered through a hole in the transformer cover and then bolted straight onto the transformer cover.

Yoke-mounting means that the tap-changer is temporarily put onto a fork located on the active part of the transformer. The transformer cover is then lowered onto the tank, and the tap-changer is lifted and bolted to the cover. Yoke-mounting allows the transformer manufacturer to connect the windings to the tap-changer before drying, without having the transformer cover-mounted.

The tap-changer type VUBB can be switched using:

- Linear switching; see Fig. 19.
- Plus/minus switching; see Fig. 20.
- Coarse/fine switching; see Fig. 21.

The general arrangement of a tap-changer system can be executed using:

- Three-phase star point connection; see Fig. 22.
- Three-phase delta fully insulated connection; see Fig. 23.

For single-phase connection, contact ABB.

Types of switching

Linear switching (type L)

Upon linear switching, the regulating range is equal to the voltage of the tapped winding. No change-over selector is used.

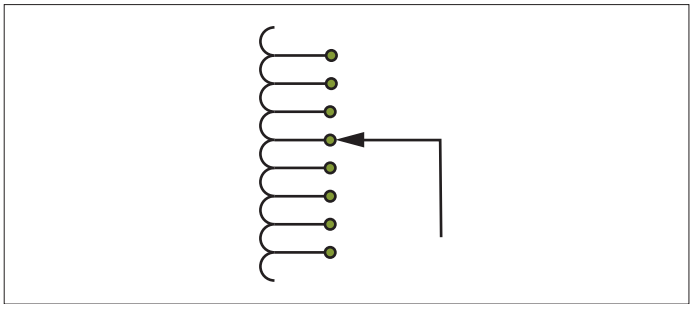


Fig. 19. Linear switching.

Plus/minus switching (type R)

Upon plus/minus switching, the change-over selector extends the regulating range to twice the voltage of the tapped winding, by connecting the main winding to different ends of the regulating winding.

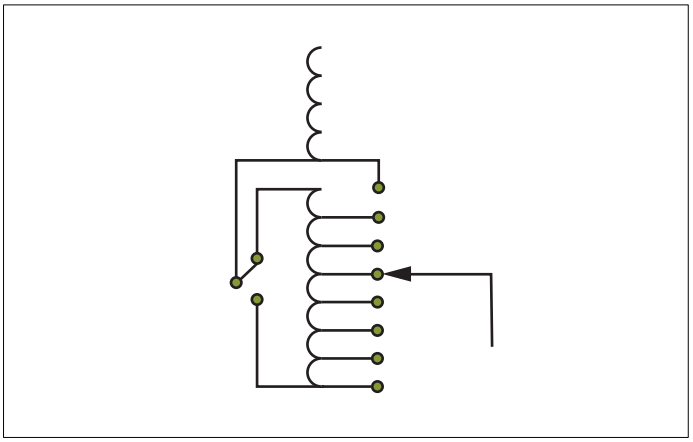


Fig. 20. Plus/minus switching.

Coarse/fine switching (type D)

Upon coarse/fine switching, the change-over selector extends the regulating range to twice the voltage of the tapped winding, by connecting or disconnecting the coarse regulating winding.

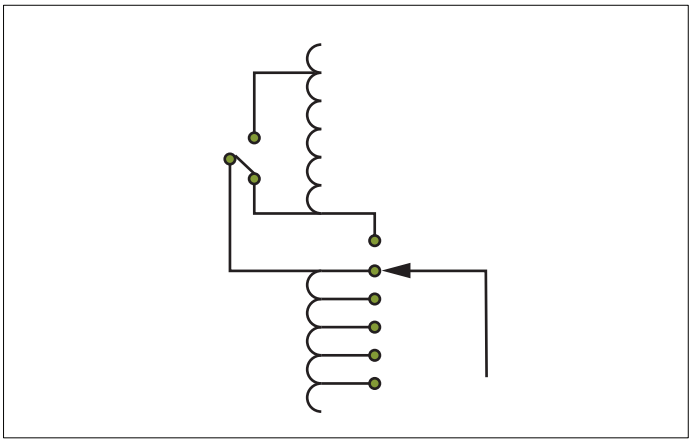


Fig. 21. Coarse/fine switching.

Types of connection

Three-phase star point (N)

Only one unit is required for all three phases. The transformer's neutral point is in the tap-changer.

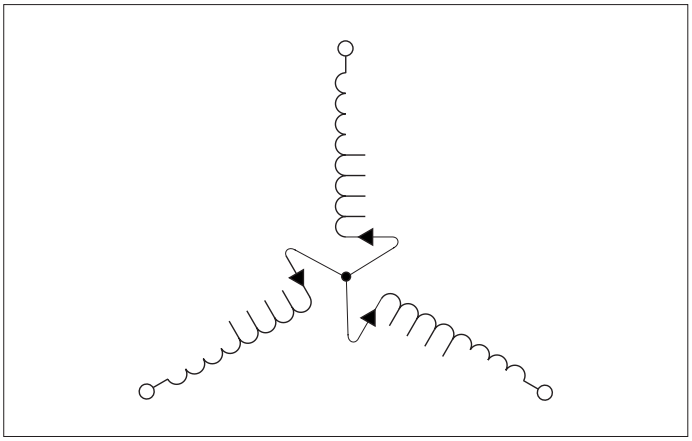


Fig. 22. Three-phase star point connection.

Three-phase delta fully insulated (T)

Only one unit is required for all three phases.

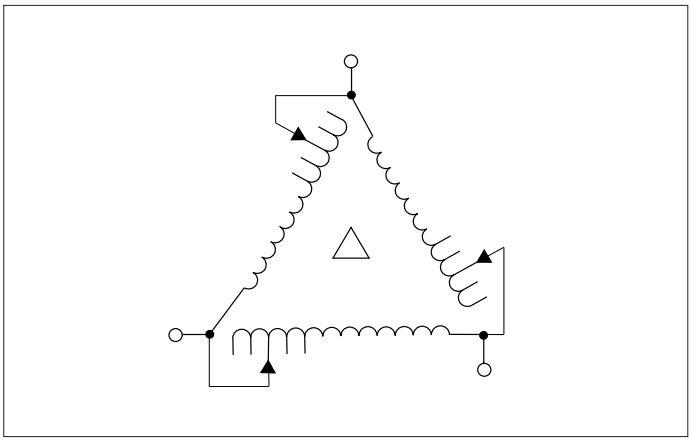


Fig. 23. Three-phase delta fully insulated connection.

Housing
The purpose of the housing is to seal and provide mechanical support.

The top section forms the flange that is used for mounting to the transformer cover, and for carrying the gear box for the operating shafts. The top section includes a connection for the conservator pipe and draining connections, a grounding terminal, the supervisory device and the cover with its gasket.

The housing has high quality seals that guarantee vacuum and overpressure-proof performance under all service conditions. During operation, some particles from mechanical wear will be produced. These pollutants must not enter the transformer and the housing is therefore designed to provide hermetically sealing between the vacuum selector switch and the transformer.

The top and bottom sections of the housing cylinder are made of cast aluminum. They are fixed to a cylinder of fiberglass-reinforced plastic. The bushings through the cylinder wall are sealed by O-ring gaskets. Each unit is tested under vacuum and the outside is exposed to helium and checked for leaks with a helium gas detector.

Selector switch
The selector switch is used to execute the electrical sequence described on pages 9-12.

The VUBB tap-changer contains three selector switches, one per phase.

The function of the selector switch is to select a tap in the tap winding and to carry and commutate the load current. The selector has multiple fix contacts, each connected to a different tap in the regulating winding.

Change-over selector
The tap-changer can also be equipped with a change-over selector for plus/minus or coarse/fine switching; see Figs. 20 and 21.

The selector switch has a maximum of 10 positions, but with the change-over selector, this number can be doubled.

Contacts
The contacts inside the selector switch are used for carrying the electrical load. The contacts are comprised of fixed and moving contacts. The fixed contacts are located on the housing. The moving contacts are located on the selector switch shaft.

Vacuum interrupters
During switching operations of vacuum tap-changers, the arcing takes place in the vacuum interrupters and not in oil.

Transition resistors
The purpose of the transition resistors is to allow a make-before-break operation by limiting the circulating current when bridging two taps.

Spring loaded mechanism
The spring loaded mechanism ensures a fast and complete switching sequence even if the power supply fails.

The mechanism is normally operated by the motor-drive unit, but can also be hand-cranked by an operator.

The motor-drive mechanism and bevel gear are fitted to the transformer tank and the drive shafts are fitted to complete the assembly of motor-drive mechanism, bevel gear and tap-changer before oil filling and testing.

Motor-drive mechanism
The bevel gear, mounted on the cover, transfers the motion from the motor-drive mechanism, via the drive shafts, to the tap-changer's spring-loaded mechanism.

The motor-drive mechanism provides the force to allow the tap-changer to operate. Energy is provided from a motor through a series of gears and out through a drive shaft. Several features are incorporated within the mechanism to promote long service intervals and reliability.

Accessories and protection devices
The tap-changer can be equipped with various protection devices. The standard protection device is the pressure relay. An oil flow relay is also available.

A pressure relief device with an alarm signal is also available, as well as certain other supervisory sensors.

For more information about accessories and protection devices, see the technical description. **1ZSC000562-AAD**.

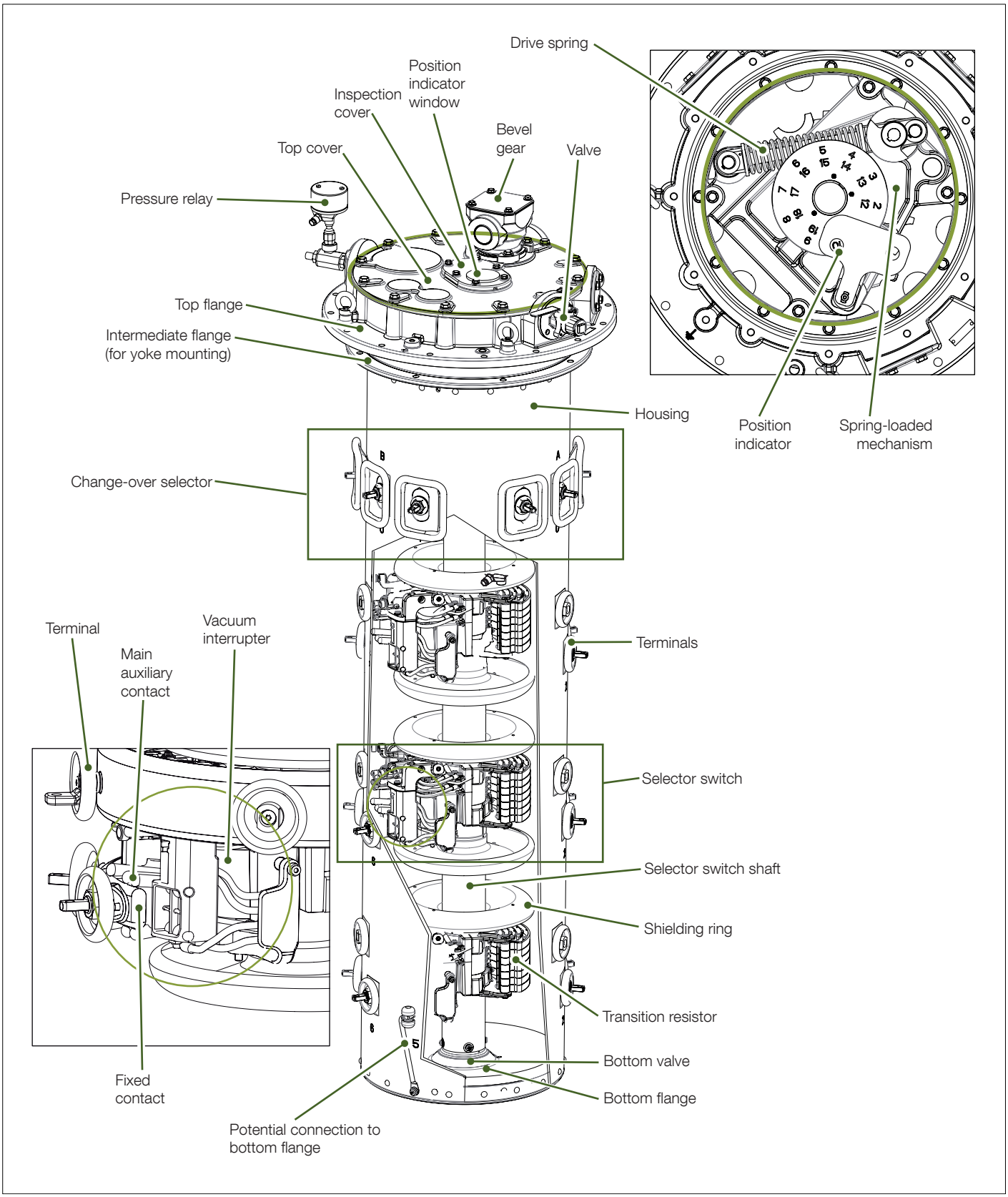


Fig. 24. VUBB overview.

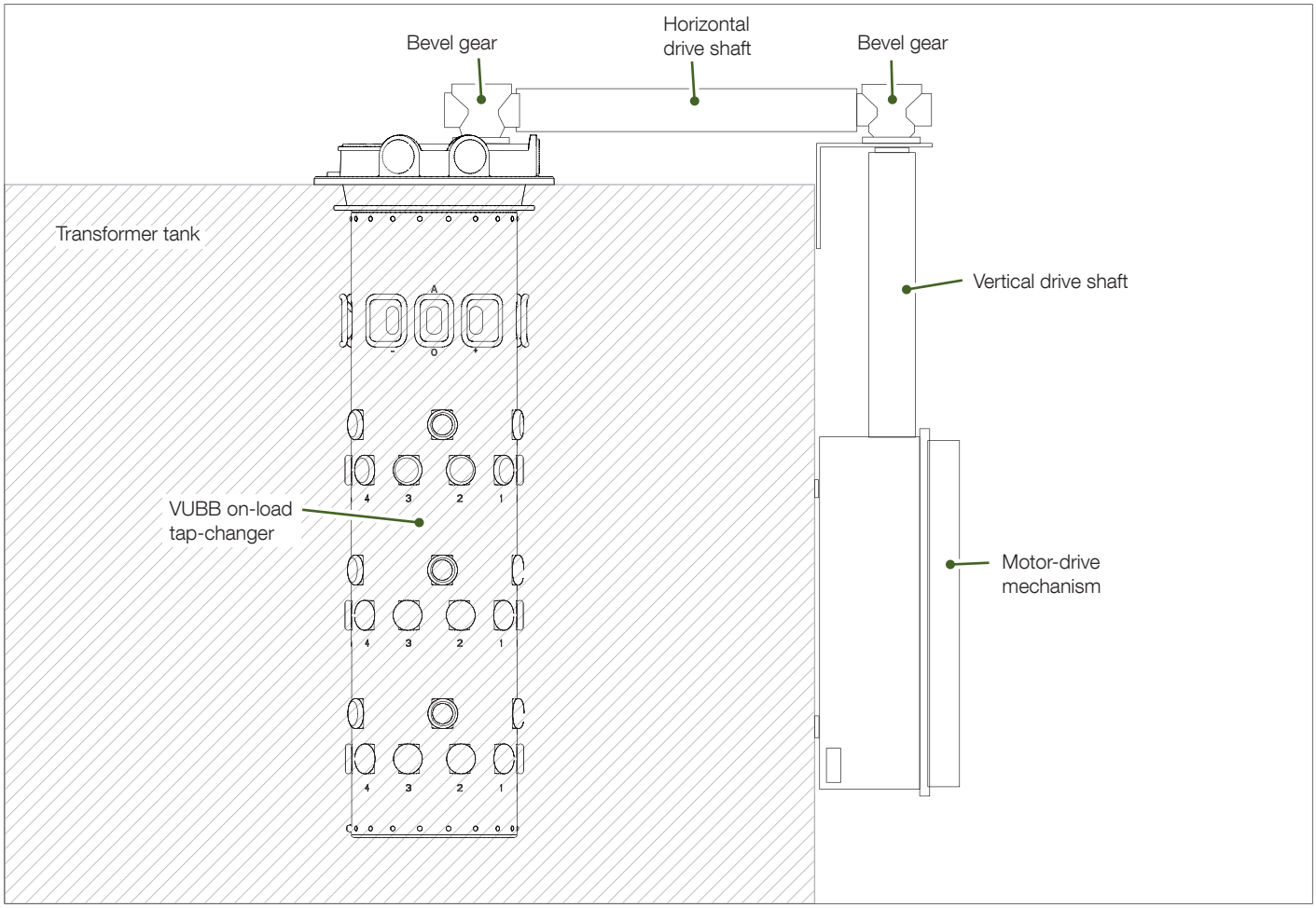


Fig. 25. System overview.

Rating plate

The rating plate is placed on the door of the motor-dive unit.

The unit's serial number is placed on the top flange of the tap-changer, and on the rating plate.

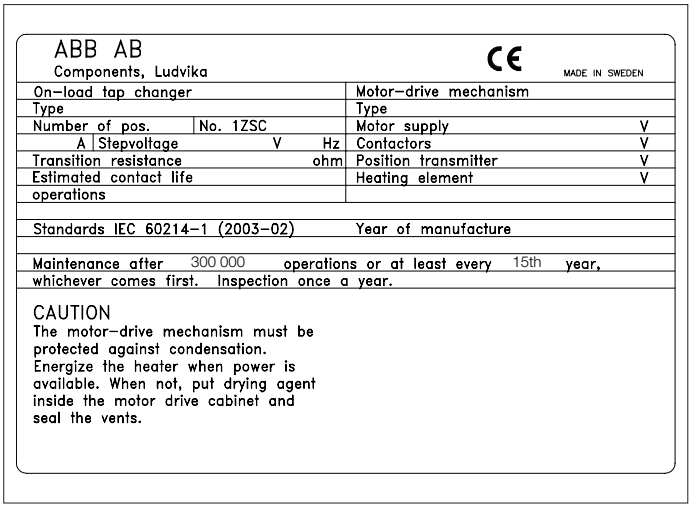


Fig. 26. Example of rating plate.

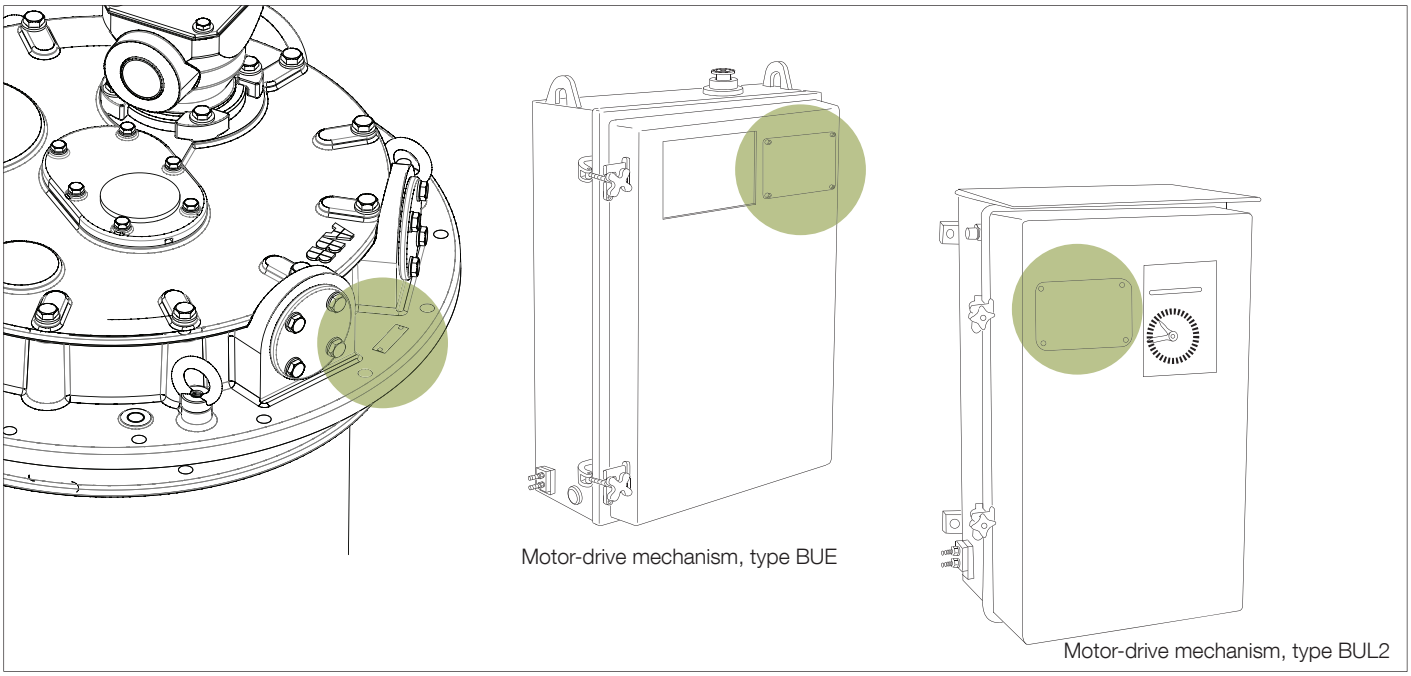


Fig. 27. Placement of serial number plate and rating plate.

Characteristics and technical data

Type designation

The tap-changer type name is designated as shown in Fig. 28.

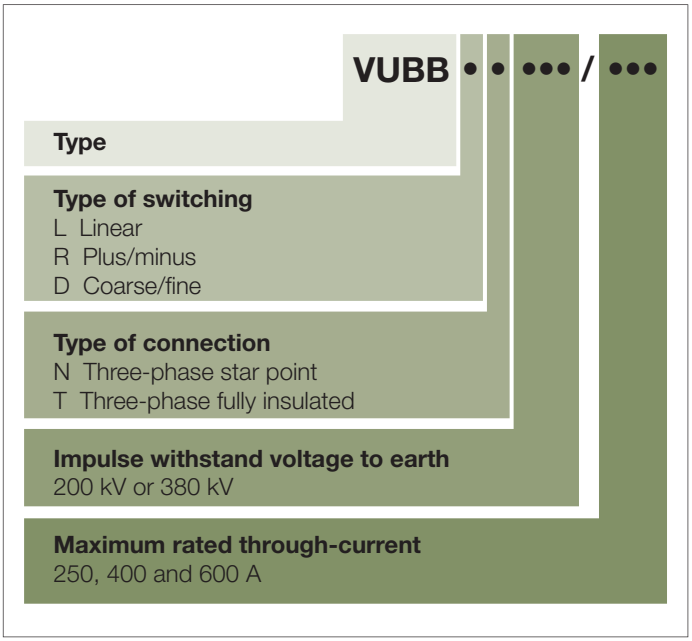


Fig. 28. VUBB type designation.

Standards and testing

The VUBB on-load tap-changers fulfill the requirements according to IEC 60214-1, 2003 and IEEE C57.131-2012.

The type tests include:
- Temperature rise test
- Switching tests
  - Breaking capacity
  - Service duty
- Short-circuit current test
- Transition impedance test
- Mechanical tests
- Dielectric tests

In addition to these tests, the VUBB has undergone a great number of tests to ensure the quality, reliability and high standards of the tap-changer.

The routine tests include:
- Check of assembly
- Mechanical test
- Sequence test
- Auxiliary circuits insulation test
- Tightness test
- Final inspection

Special applications, load conditions and environments

Please contact the supplier for advice in the following cases:

- For non-network applications.
- In case of unusual load conditions such as:
  - Overloads beyond IEC 60076-7, 2005
  - Overloads beyond IEEE C57.91-1995
  - Loads beyond the data specified in this document
  - Extreme environmental conditions
  - Insulating liquids other than mineral oil
  - Tap-changers working in parallel

Maximum number of positions

- Linear switching: 10 positions
- Plus/minus switching: 19 positions
- Coarse/fine switching: 19 positions

Rated through-current

Rated through-current is the current flowing through a tap-changer towards the external circuit that the apparatus is capable of transferring from one tap to the other at the relevant rated step voltage and which can be carried continuously while meeting the requirements of IEC 60214-1, 2003.

The rated through-current is stated on the rating plate.

Short circuit current strength

The short circuit current strength is verified with three applications of 3-second duration, without moving the contacts between the three applications. Each application has an initial value of 2.5 times the short circuit current value.

Maximum rated through-current [A, rms]	Short circuit current [A, rms]	[A, peak]
250, 400 and 600	6,000	15,000

Table 1. Short circuit current strength.

Rated phase step voltage

Rated step voltage for each value of rated through-current, highest permissible voltage between terminals that are intended to be connected to successive taps of the transformer. See Fig. 29.

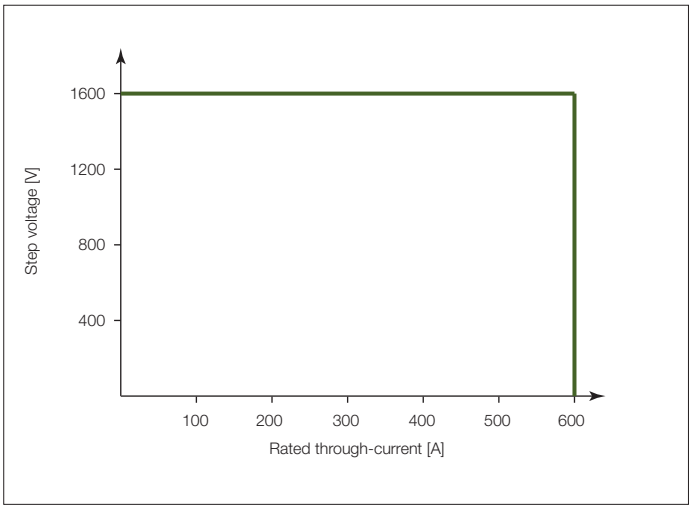


Fig. 29. Rated phase step voltage.

Highest phase service voltage across the tap winding

The highest permissible phase service voltage is the product of the maximum number of taps and the allowed step voltage according to the rated phase step voltage diagram above.

Contact life

The contact life of the vacuum interrupter is 600,000 operations, regardless of the rated through-current.

Power flow direction

Selector switch vacuum tap-changers operate according to the asymmetrical pennant cycle to minimize the complexity of the product. The VUBB nonetheless has full power flow capacity in both directions. That is possible thanks to the superior breaking performance and low contact erosion of the vacuum interrupters.

Mechanical endurance

The mechanical life of the tap-changer is based on an endurance test. The test showed that mechanical wear was negligible, and that the tap-changer was still mechanically sound after more than 1,200,000 operations.

Occasional overloading

If the rated through-current of the tap-changer is not less than the highest value of tapping current of the tapped winding of the transformer, the tap-changer will not restrict the occasional overloading of the transformer, according to IEC 60076-7, 2005-12, and IEEE C57.91-1995.

To meet these requirements, the VUBB have been designed so that the contact temperature rise over the surrounding oil never exceeds 20 K at a current of 1.2 times the maximum rated through-current of the tap-changer.

Oil temperature

The temperature of the oil surrounding the tap-changer shall be between -25 and +105 °C for normal operation, as illustrated in Fig. 30.

Temperature of the conductors

The temperature of the conductors connected to the terminals of the tap-changer must not exceed 30 K above the surrounding oil.

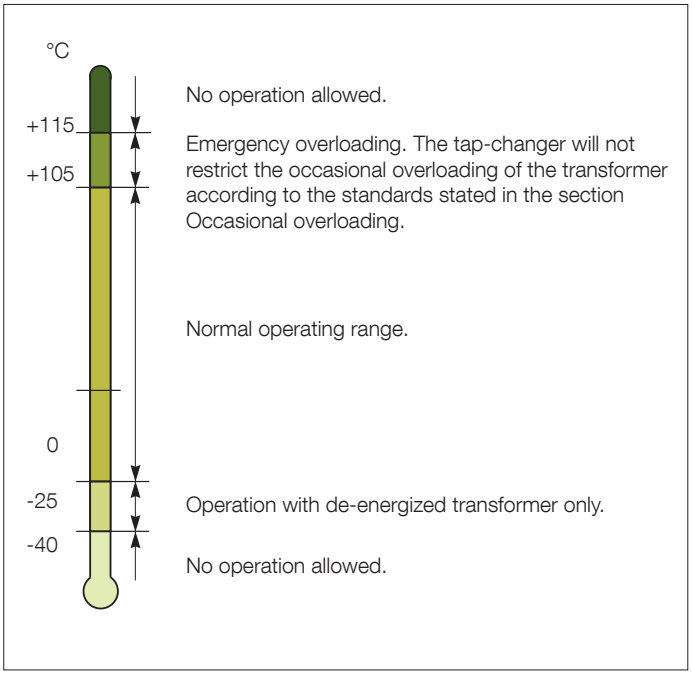


Fig. 30. Oil temperature.

Insulation levels

The insulation levels are indicated as 1.2/50 µs impulse withstand voltage – power frequency withstand voltage.

	UBB.N	UBB.T
a1	200-70	200-70
a2	200-70	200-70
b1	200-70	-
c1	200-70	200-70
d1	250-95	
f3	490-165	490-165
g1	380-140	380-140
g2	490-165	490-165
h1		380-140
h2		490-165
h3		490-165

Table 2. Insulation levels.

a1 Between electrically adjacent contacts in the fine selector, not connected.
a2 Between the first and last electrical contacts in the fine selector.
b1 Between non-connected taps of different phases in the fine selector for neutral point applications.
c1 Between ends of the coarse winding in coarse/fine switching.
d1 Between non-connected taps of different phases in the change-over selector in neutral applications.
f3 Between the + end of the coarse/fine winding and the moving fine selector contact.
g1 Between connected contacts and ground. Normally between the change-over selector contacts and the top flange or the shield below the mechanism.
g2 Between non-connected contacts and ground.
h1 Between connected contacts of different phases.
h2 Between a connected contact of one phase and a non-connected contact of another phase.
h3 Between non-connected contacts of different phases.

VUBB BIL [kV]	Insulation levels [kV] to ground	(between phases fully insulated)	Maximum service voltage between phases for fully insulated design[1] [kV]
200	200–70	200–70	36.5
380	380–140	380–140	76

Table 3.
1) Class II according to IEC 60214, clause 5.2.6.

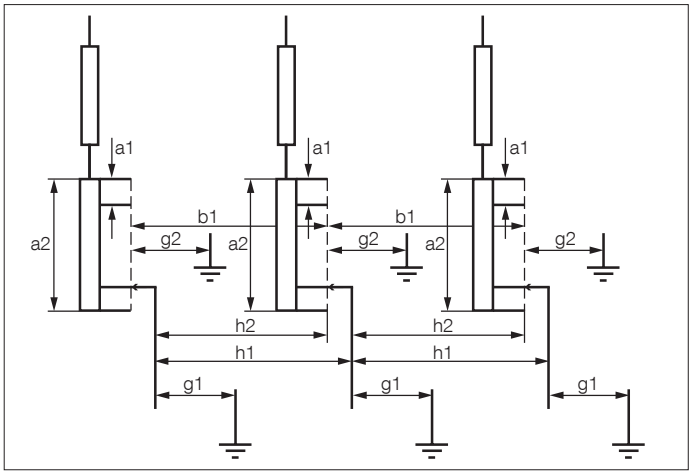


Fig. 31. Linear switching (type L).

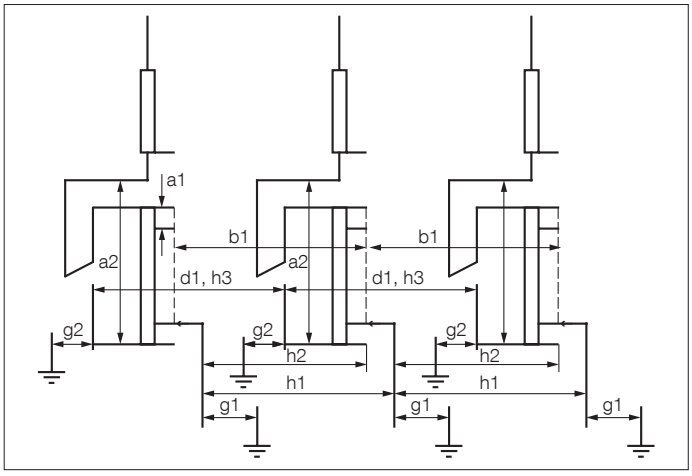


Fig. 32. Plus/minus switching (type R).

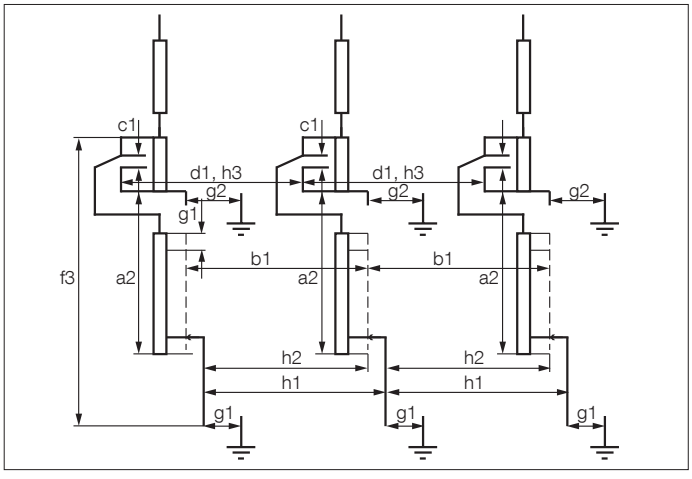


Fig. 33. Coarse/fine switching (type D).

Tie-in resistor

When the change-over selector operates, the tapped winding is disconnected for a short time. The voltage of that winding is then determined by the voltage of, and the capacitances to, the surrounding windings or tank wall/core. For certain winding layouts, voltages and capacitances, the capacitive controlled voltage will reach magnitudes that are too high for the change-over selector. In these cases, potential controlling resistors, tie-in resistors, should be connected according to Fig. 34.

The tie-in resistor is connected between the middle of the tapped winding and the output terminal; see single-phase diagrams in this document. This means that power is continuously dissipated in the resistors that add to the no-load losses of the transformers. The resistors must also be dimensioned for the power dissipation.

The VUBB has a change-over selector with two breaking distances in series as well as a high opening and closing speed. This provides a very high breaking capacity and low gas generation. The small amount of gases generated in spite of this, stays in the tap-changer housing since the change-over selector is located inside the selector switch housing.

The following limits apply to the change-over selector:

Selector switch	Max. recovery voltage (kV rms)	Max. capacitive current (mA rms)
VUBB	40	250

Table 4.

The capacitive current is the current passing through the change-over selector before it opens. Because of these high values, tie-in resistors are seldom needed on the VUBB.

When ordering, provide the winding layout and information according to the example in Fig. 35 and Table 5, and the supplier will calculate whether tie-in resistors are needed or not. If needed, the supplier will choose the correct tie-in resistors. If anything is unclear, contact the manufacturer.

Winding	Phase voltage	Connection
High voltage (HV)	66 kV (H1)	Delta
Regulating winding (RW) (voltage across)	6.6 kV (U)	Plus/Minus

Table 5. Example of winding layout and information.

C1 = Capacitance between HV and RW
C2 = Capacitance between tank and RW
Frequency 50 Hz

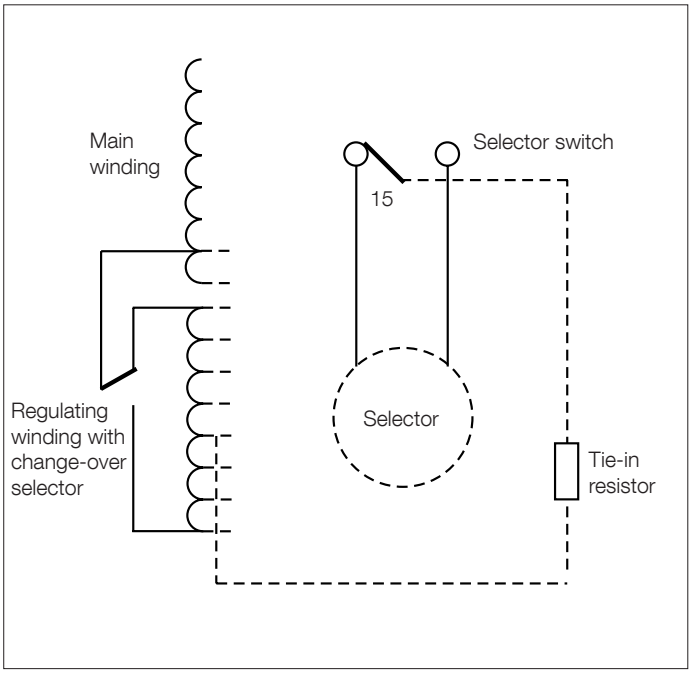


Fig. 34. Tie-in resistor example.

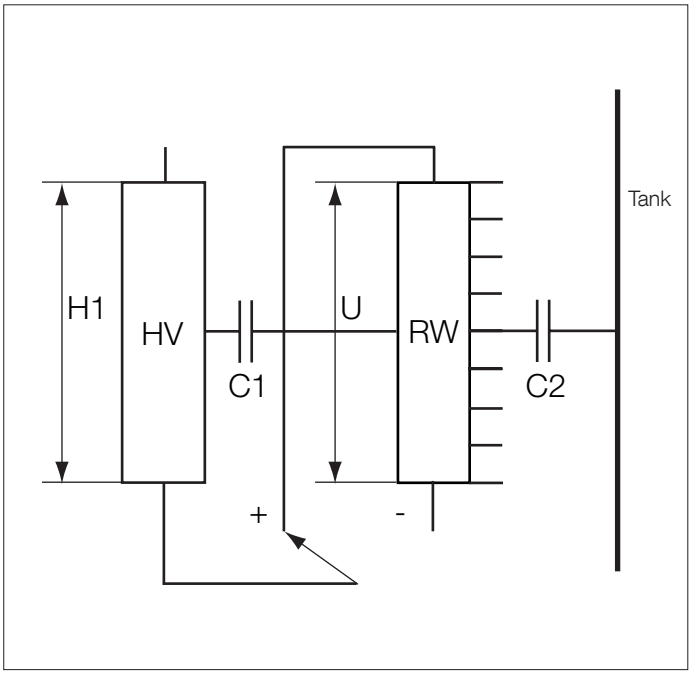


Fig. 35. Example of winding layout and information.

Installation

For a complete installation instruction; see the installation guide.

Drying

The tap-changer should be stored indoors and left in its plastic shipping cover until it is time for assembly. A drying agent is placed inside the packing cage to keep the tap-changer dry during transport.

The tap-changer can be dried together with the transformer according to one of the following processes:

– Vapor phase
– Alternating hot air and vacuum

The temperature must not exceed 135 °C. The maximum pressure difference between the tap-changer and transformer must not exceed 100 kPa for alternating hot air and vacuum. For the vapor phase, no pressure difference is allowed; see the installation guide.

Oil

The tap-changer contains about 300 liters of oil. The oil quality should be Oil LC set -30° according to IEC 60296:2012. Inhibited oil is preferred.

Oil conservator

The transformer manufacturer must provide a conservator for the tap-changer. Consider the following as a guideline for the design.

1. The breathing device should prevent moisture from getting into the tap-changer compartment and allow for temperature variation.
2. The oil volume should be such that the oil level is always within the range of the oil level indicator at all predictable temperatures.
3. X corresponds to a height for a maximum recommended pressure difference between the tap-changer tank and the transformer tank of 50 kPa.
4. H corresponds to a height for a maximum pressure difference between the tap-changer and the atmosphere of 70 kPa.
5. The oil level for the tap-changer should be equal to or below the oil level of the transformer. During service, the value is temporarily allowed to be negative.
6. Vacuum-proof conservator if the tap-changer should be oil-filled under vacuum with the conservator mounted.

Oil filter unit

No oil filter unit is required for the VUBB since arcing takes place inside the vacuum interrupters and not in the oil.

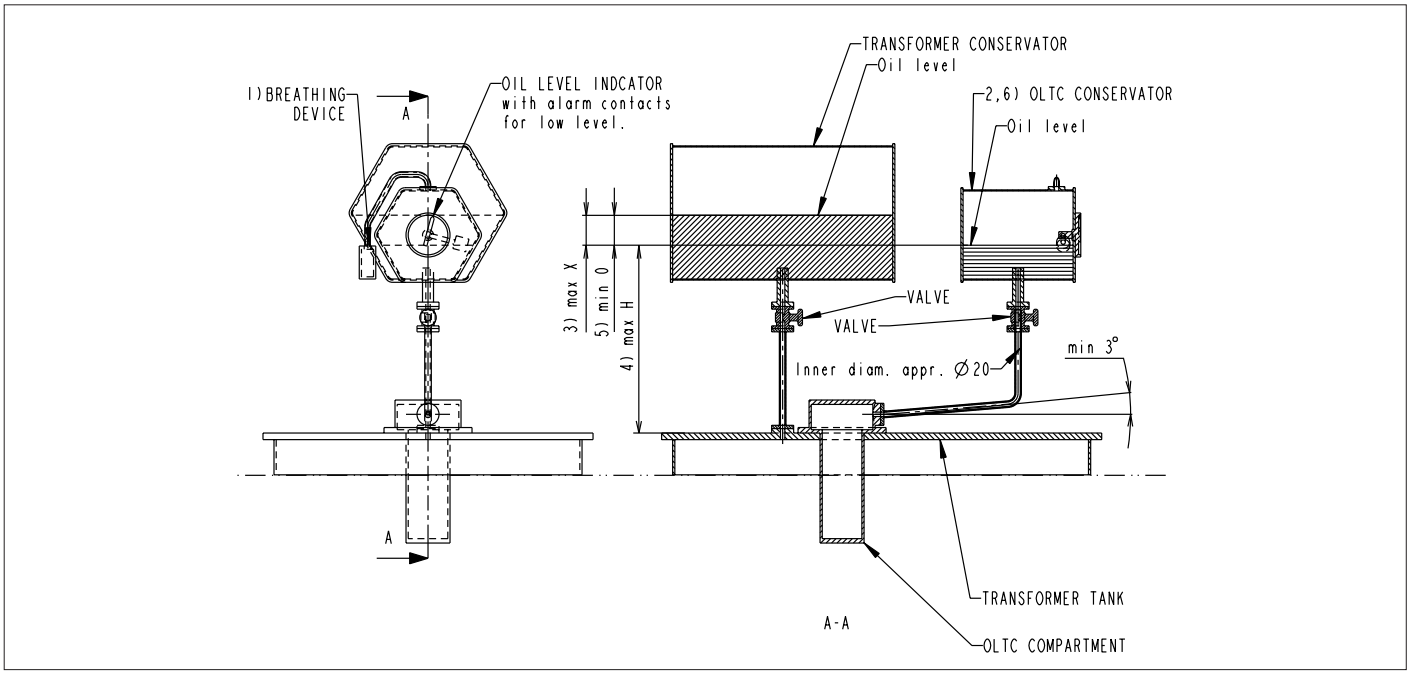
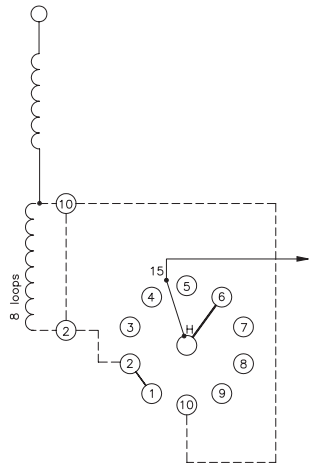
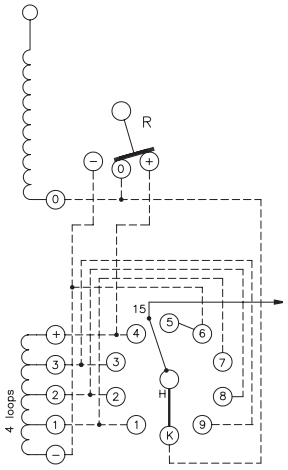
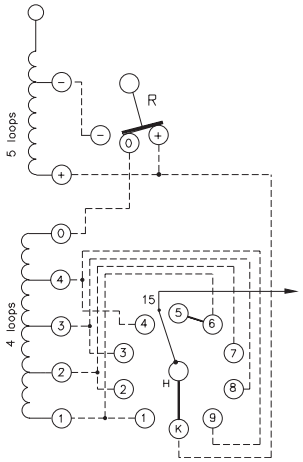
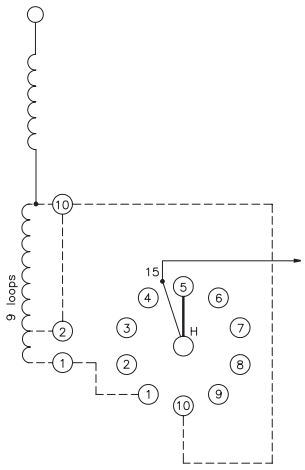


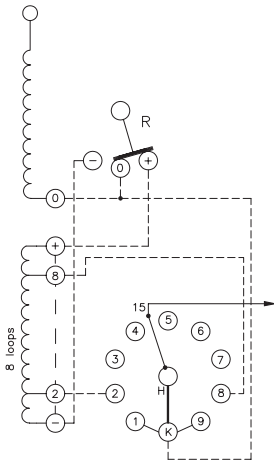
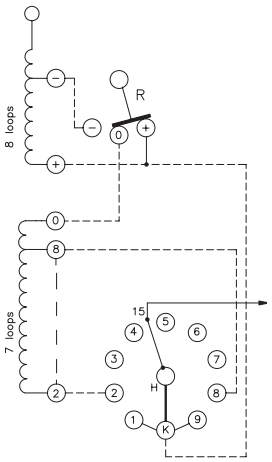
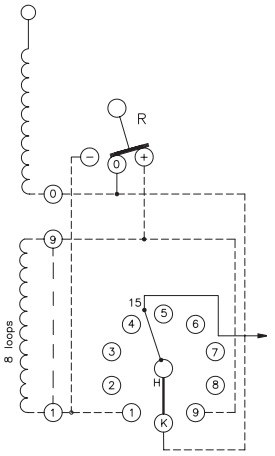
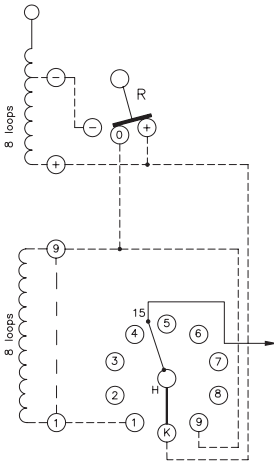
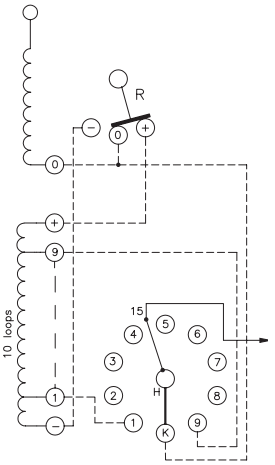
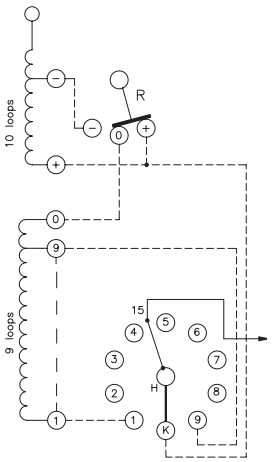
Fig. 36.

Single-phase diagrams

The basic connection diagrams illustrate the different types of switching and the appropriate connections to the transformer windings. The diagrams illustrate the connections with the maximum number of turns in the transformer winding, with the tap-changer in position 1.

The tap-changer can also be connected in such a way that position 1 gives a minimum effective number of turns in the transformer winding with the tap-changer in position.

	Linear	Plus/Minus	Coarse/Fine
8 steps			
Number of loops:	8	4	4
Number of tap positions:	9	9	9
9 steps			
Number of loops:	9		
Number of tap positions:	10		

	Linear	Plus/Minus	Coarse/Fine
14 steps			
Number of loops:		8	7
Number of tap positions:		15	15
16 steps			
Number of loops:		8	8
Number of tap positions:		17	17
18 steps			
Number of loops:		10	9
Number of tap positions:		19	19

Maintenance

The VUBB tap-changer has been developed to provide maximum reliability. The simple and robust design provides a service life that equals the service life of the transformer. A minimum of maintenance is required for trouble-free operation.

Inspection

Inspection of the tap-changer at the same time as other activities are carried out on the transformer is recommended. The inspection should be carried out at least every 6th year, and it can be carried out while the transformer is in service. This inspection is to be carried out by site personnel.

The inspection consists of a visual check of the motor-drive mechanism and the conservator. The quality of the insulating oil is also checked. At this inspection, the counter is read to determine when maintenance is due.

Table 6. Maintenance schedule.

Time or number of operations	Inspection yearly	Oil sampling, after 6, 11, 15 years
Type of action		
Check oil level at conservator	x	
Check the breather	x	
Visual check of motor-drive mechanism	x	
Test of oil quality (IEC 60422)		x
Dissolved gas analysis (DGA)		x

The tap-changer should be maintained regularly at intervals of 300,000 operations, or 15 years. The relevant information is stated on the rating plate. In this way, the mechanical integrity can be confirmed and the contact wear monitored, and the necessary preparations can be made for replacing the vacuum interrupters.

Dimensions and weights

Dimensions
The complete dimension drawings are in Figs. 37-39.

Weights
The approximate weight of the VUBB tap-changer is stated below. The stated weights do not include the weights of the motor-drive mechanism and the drive shaft system.

Tap-changer without oil 280 kg

Weight of required oil 270 kg

Total weight 550 kg

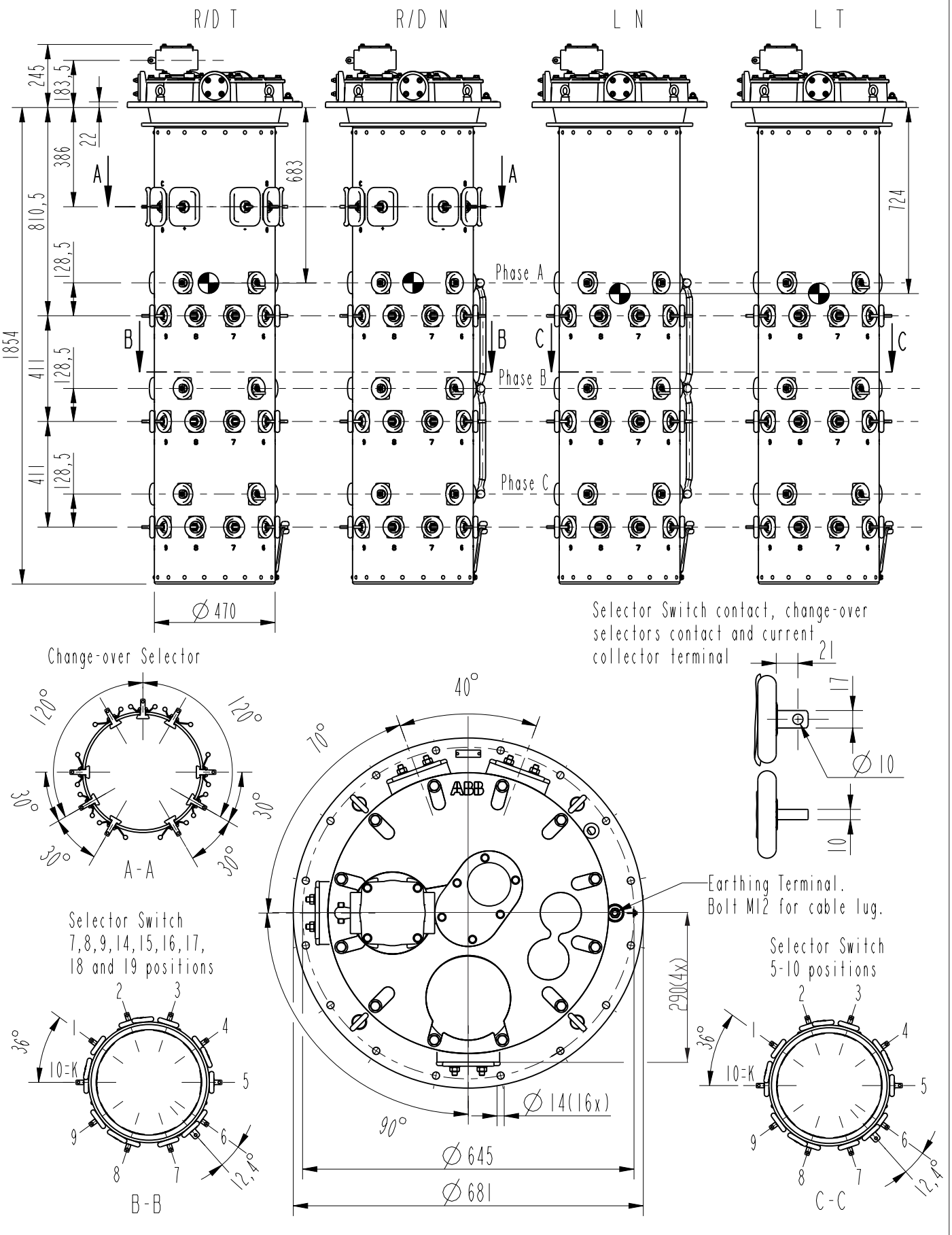
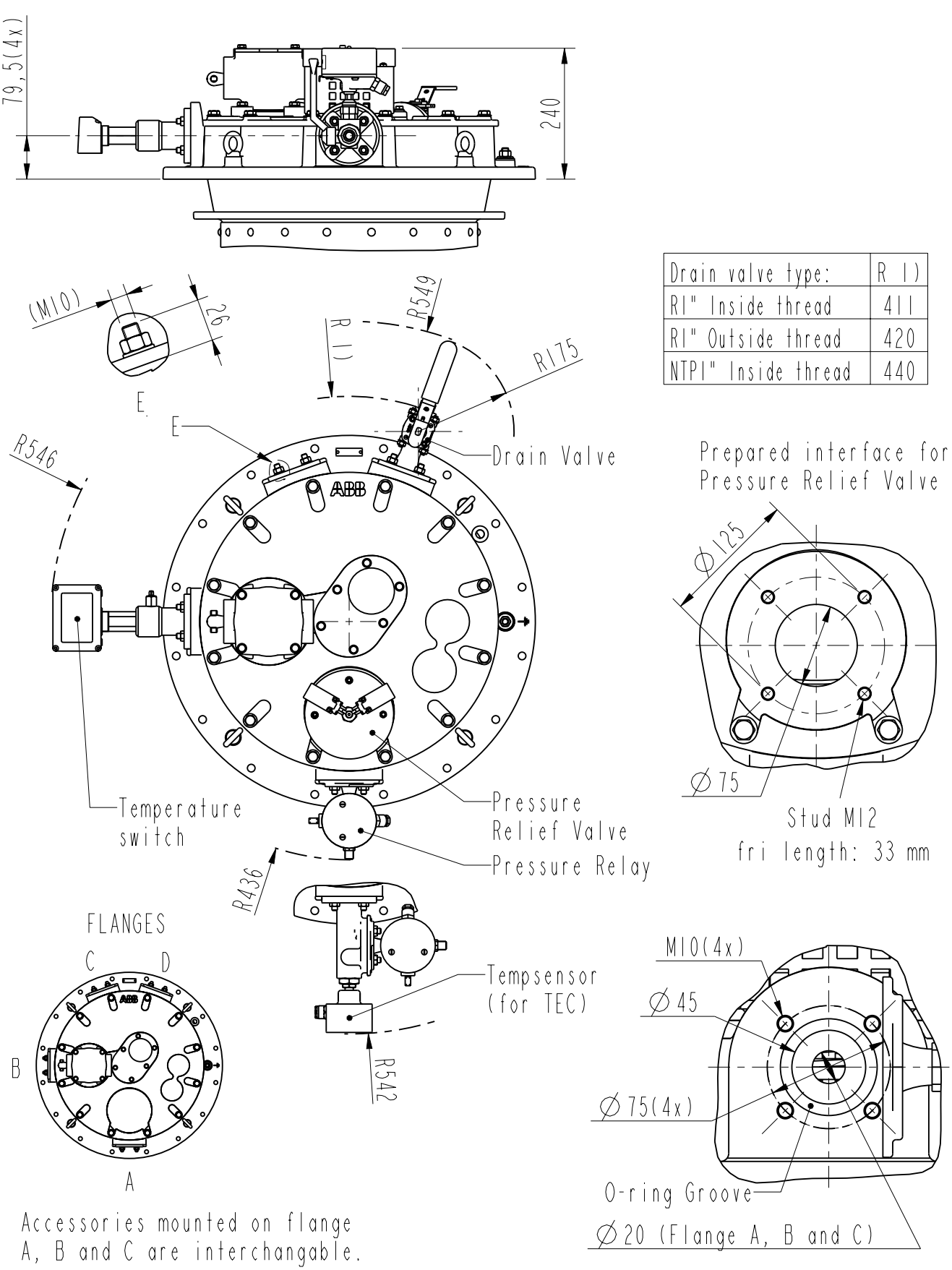


Fig. 37. Dimension drawing.



Drain valve type:	R 1)
R1" Inside thread	411
R1" Outside thread	420
NTPI" Inside thread	440

Fig. 38. Dimension drawing.

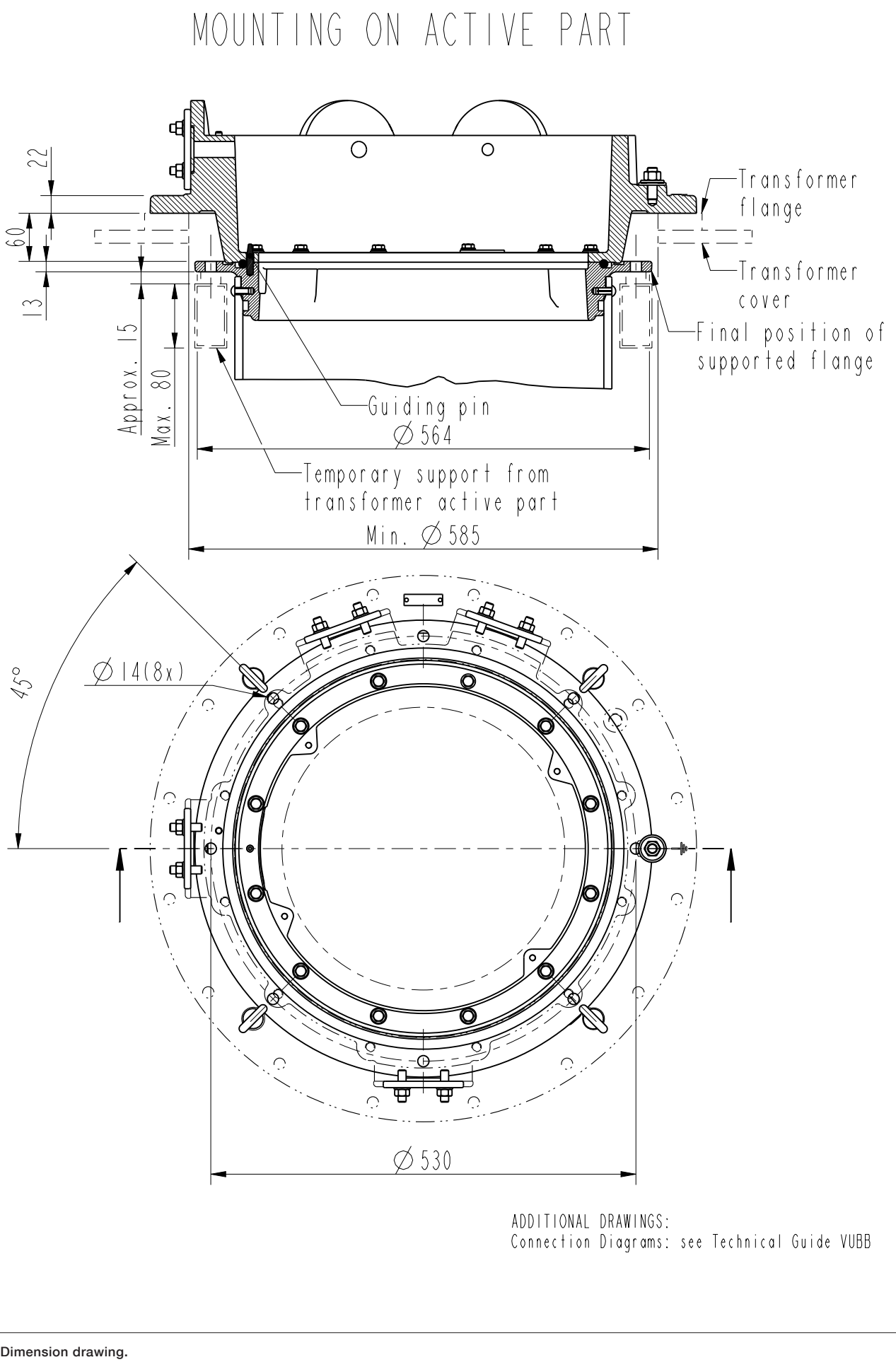


Fig. 39. Dimension drawing.

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