



Zakład Wytwórczy Aparatów Elektrycznych Sp. z o.o.
Installation and Service Manual



MARK40

Vertical disconnector 123, 245 i 420 kV

Manual No. DTR.01.04.06.EN

We connect
with ENERGY

.....○ **WARNING!**

During the operation of electrical equipment, certain parts of these devices are normally under dangerous voltage, and mechanical parts, also remotely controlled, can move quickly.

Failure to follow the warning instructions can result in serious personal injuries or material damage.

Only suitably qualified personnel can work on or near the device. This personnel must know exactly all safety rules and rules for maintaining the device in accordance with this instruction.

The problem-free and safe operation of this device requires proper transport, proper storage, construction and assembly as well as careful service and maintenance.

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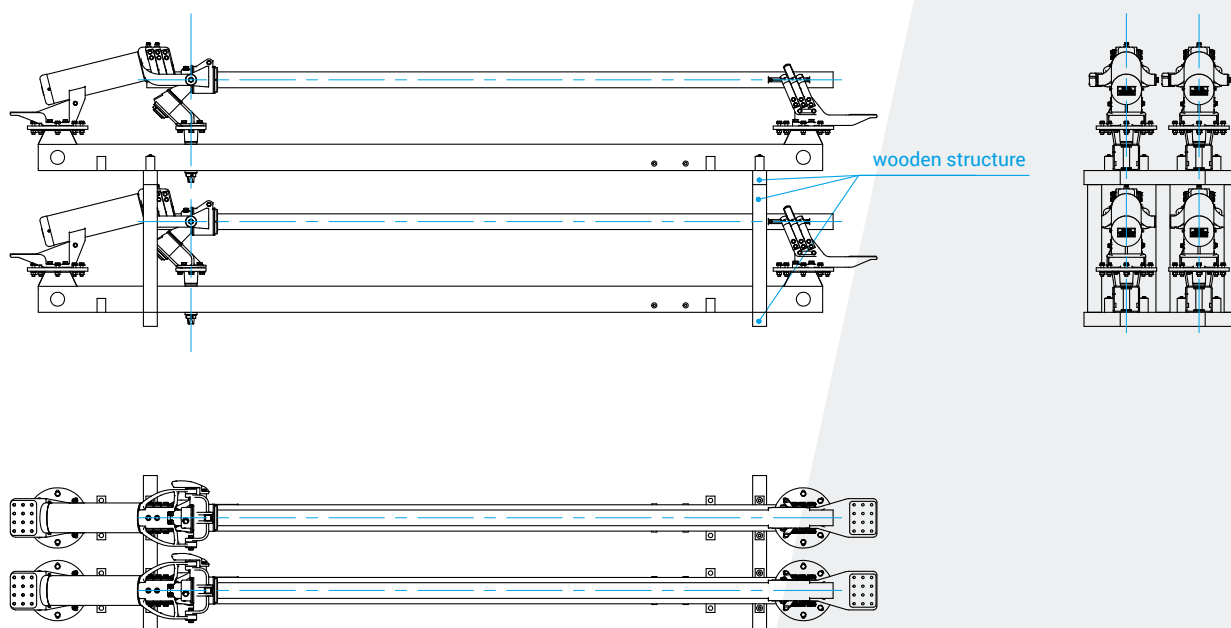
1. TRANSPORT

1.1. Unpacking and inspection

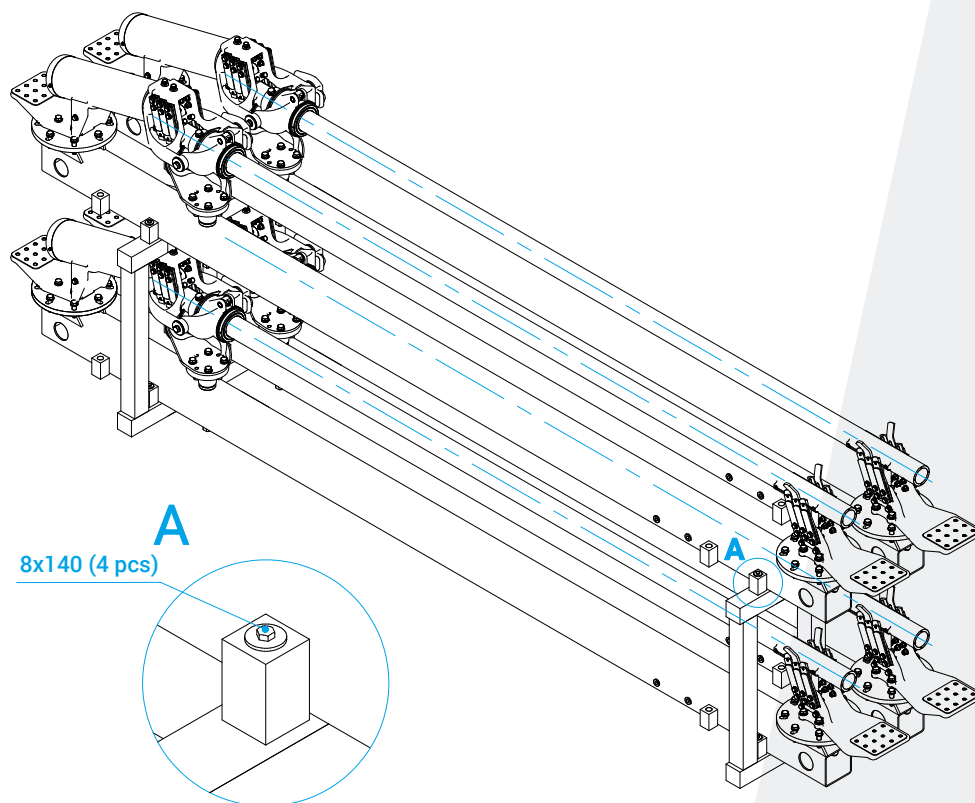
Immediately after receiving the disconnecter, the delivery's compliance with the packing list should be checked. Then one should check whether the disconnecter has not been mechanically damaged during transport and the data on the nameplate match the order.

1.2. Storage and transport

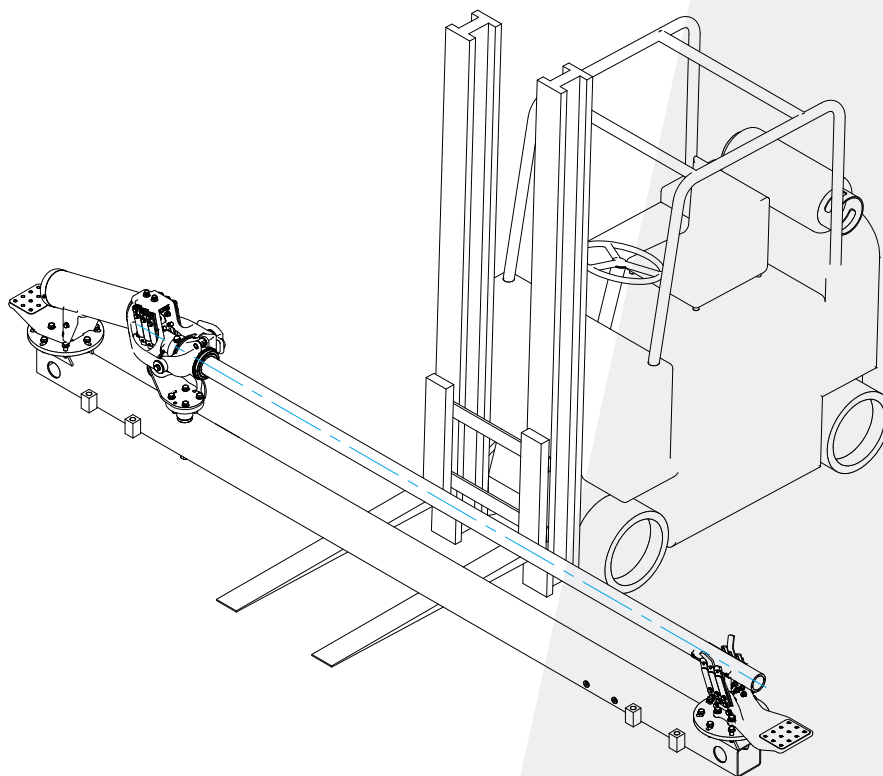
The disconnecters poles are transported in a partially assembled condition, ie the base frame together with the current path form the basic set, while the other elements (insulators, contact's corona rings, driving sockets, etc.) are delivered separately for installing during assembly. The basic sets are packed in several pieces on a wooden structure, as it is shown in the following drawing.



In the case of the purchase of a disconnecter's version with an earthing switch, all parts used for the earthing switch's construction (the knife of earthing switch, counterweight beams, counterweights, pins, spacers, coupling tie rods, earthing switch contact, knife's support and shaft of the earthing switch) are also delivered separately in packs. When preparing the pole for assembly, the wooden beams should be removed by unscrewing the four screws with the spanner 13.



During unloading, the disconnector's poles should be lifted with a forklift, as shown in the following graphics.

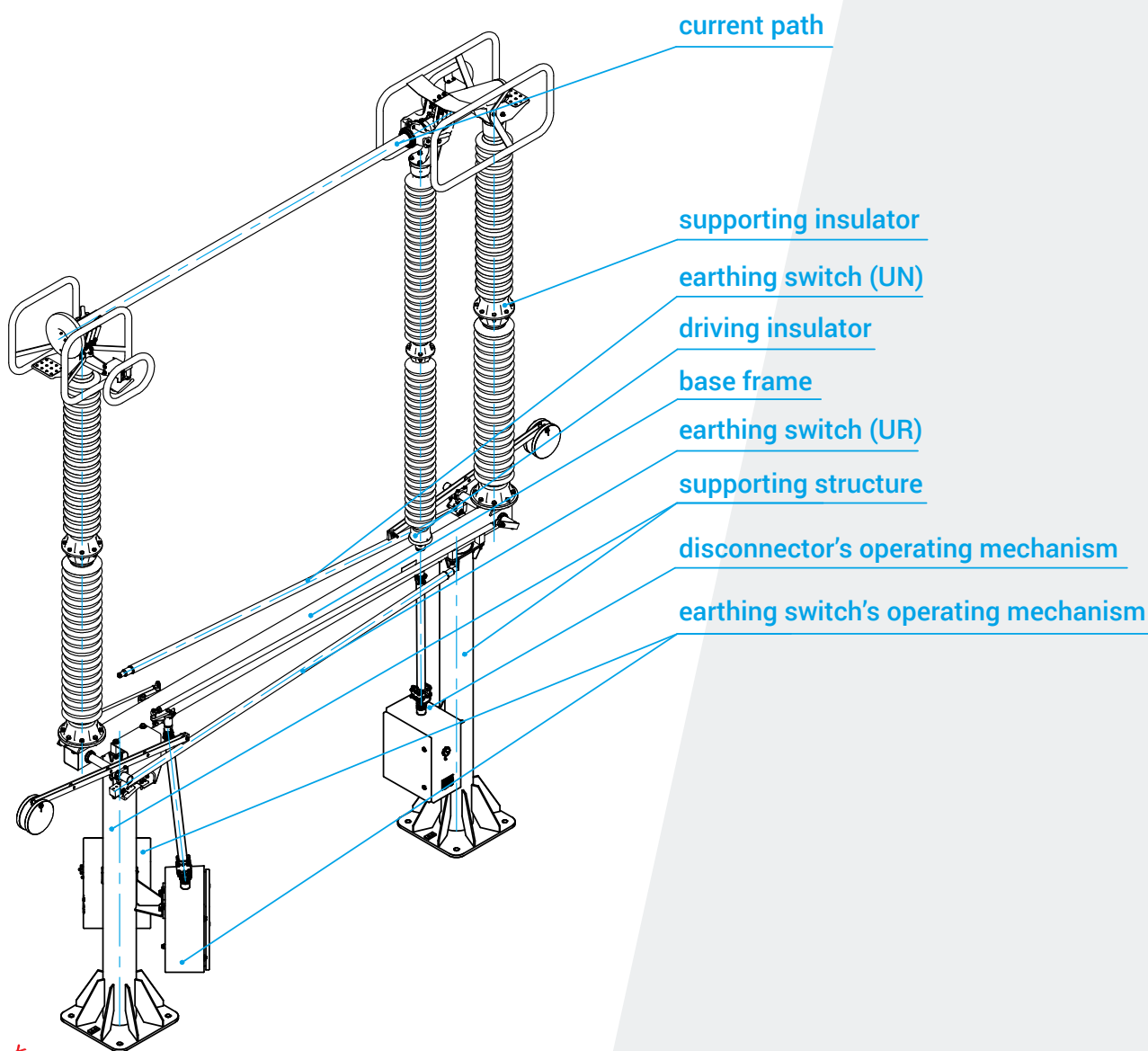


During transportation, the poles must be secured against tipping over and the disconnector knife should be closed. Disconnectors can be transported by means of transport with open cargo area. Disconnectors poles can be stored in an open space, but poles should be set so that the base frame does not stand directly on the ground.

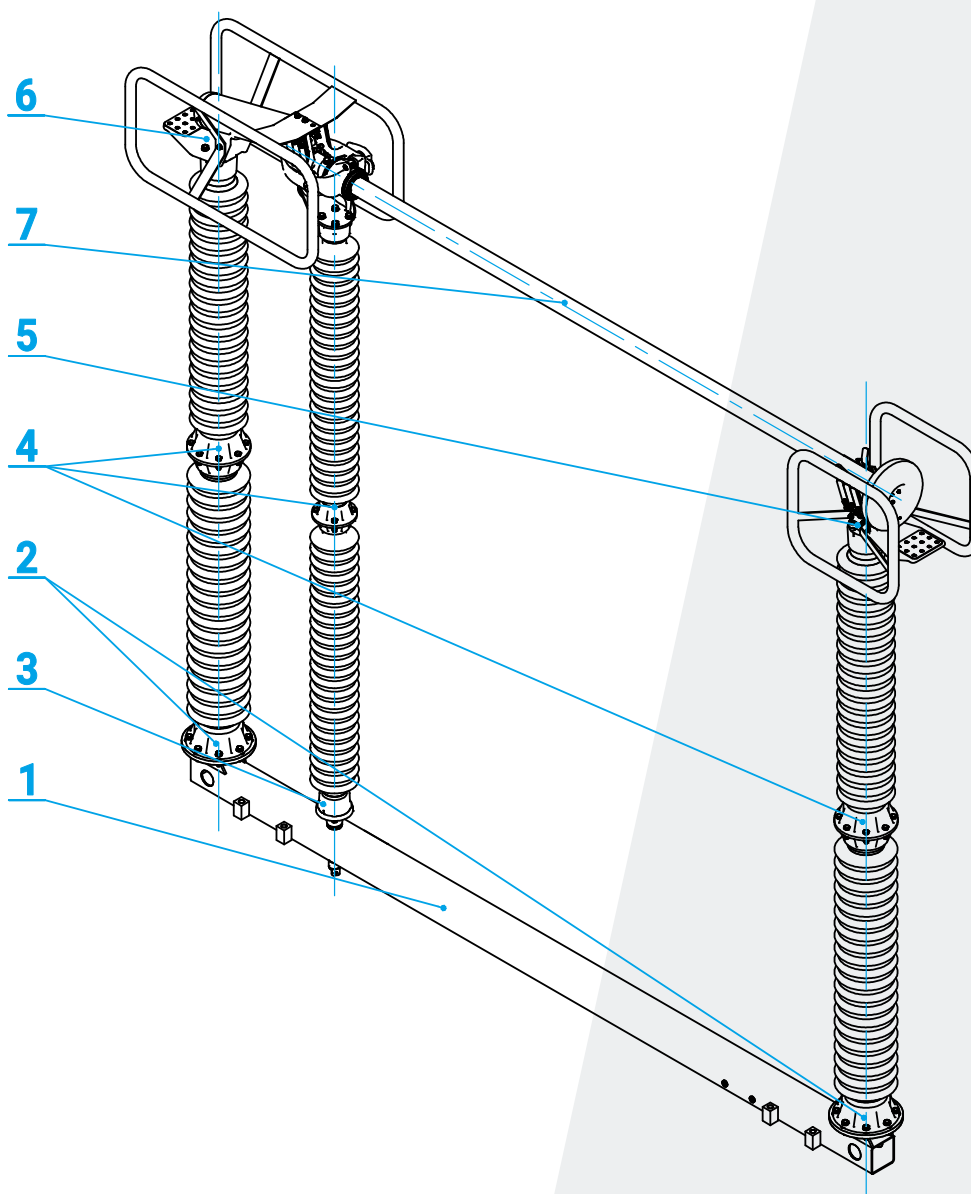
2. DESCRIPTION

2.1. Construction and principle of operation

The outdoor disconnector type Mark-40 is a three-column insulating switch with the secant movement of contacts in the vertical plane, intended for work in networks with voltage depending on the version (123-420 kV) at frequencies up to and including 50 Hz. The disconnector can be used as a single-pole switch with an individual operating mechanism. Disconnectors poles can be set in parallel or in series. A visual sketch of the Mark-40 disconnector pole with two earthing switches is presented below.



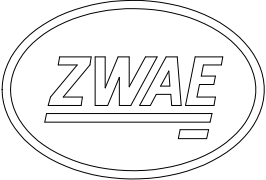
Details of the Mark-40 disconnector's pole construction are illustrated in the next drawing. Each pole possess an individual base frame [1] equipped with two fixed feet [2] and a rotating foot [3] on which porcelain insulators [4] are mounted. On top of the insulators are assembled the followings: movable contact head [5], fixed contact head [6] used to transfer the rotating movement of the driving insulator to the secant movement of current path [7].



2.2. Climatic conditions

The disconnecter is adapted for outdoor operation, at ambient temperature from -40 to +40 ° C and relative humidity up to 100%.

2.3. Nameplate

| | | | |
|---|---|------------|---|
|  | DISCONNECTING SWITCH | | |
| | Type MARK40-3/420/4000/UN/50/1/F50/08P25 | | |
| | no./year 1812345/2018 | | |
| ○ | Rated voltage | Ur 420 kV | ○ |
| | rated continuous current | Ir 4000 A | |
| | Lightning impulse withstand voltage | Up 1425 kV | |
| | rated short-circuit withstand current (1sec.) | Ik 50 kA | |
| | weight | m 1290 kg | |
| www.zwae.com.pl | | | |

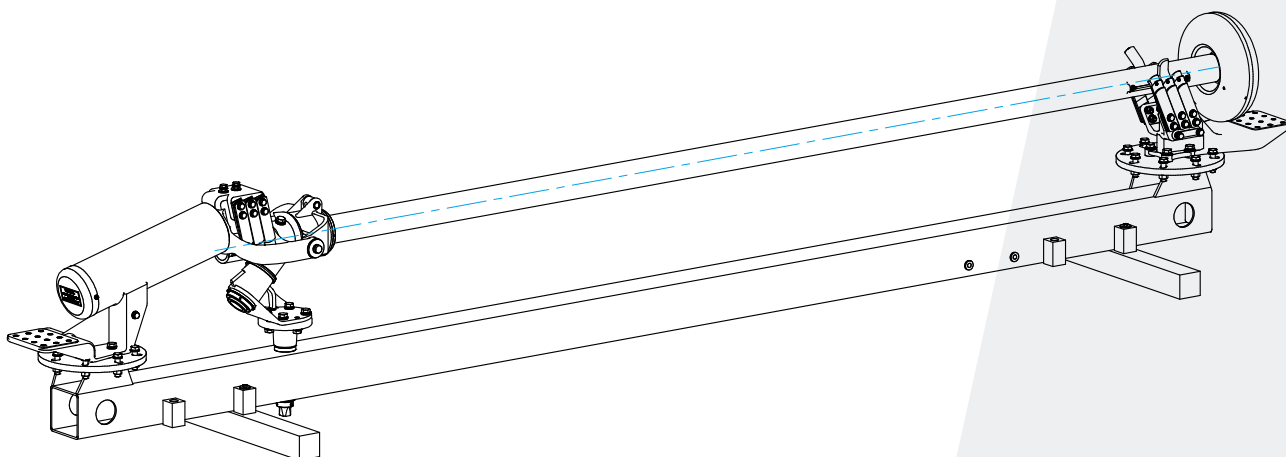
2.4. Basic technical parameters

| No | Parameter | Value | | |
|-----|---|----------------------------------|----------------------------------|----------------------------------|
| | | | | |
| 1. | Rated operating voltage | 123 [kV] | 245 [kV] | 420 [kV] |
| 2. | Rated continuous current | 2500 [A] 3150 [A] 4000 [A] | 2500 [A] 3150 [A] 4000 [A] | 2500 [A] 3150 [A] 4000 [A] |
| 3. | Peak current | 125 [kA] | 125 [kA] | 125 [kA] |
| 4. | Short-circuit current, 1 sec. | 50 [kA] | 50 [kA] | 50 [kA] |
| 5. | Test voltage (50 Hz): - earth and pole to pole insulation - contact to contact insulation | 230 [kV] 265 [kV] | 460 [kV] 530 [kV] | 520 [kV] 610 [kV] |
| 6. | Surge test voltage: - earth and pole to pole insulation - contact to contact insulation | 550 [kV] 630 [kV] | 1050 [kV] 1200 [kV] | 1425 [kV] 1425 (+240)* [kV] |
| 7. | Operational rated surge test voltage: - earth insulation - contact to contact insulation | - - | - - | 1050 [kV] 900 (+345)* [kV] |
| 8. | Radio interference voltage | <2500 [μV] | <2500 [μV] | <2500 [μV] |
| 9. | Mechanical strength | 2000 cycles | 2000 cycles | 2000 cycles |
| 10. | Motor operating mechanism | NSO80 | NSO80 | NSO80 |

* Peak values of alternating voltage supplied to the opposite terminal are shown in brackets

3. INSTALLATION AND ADJUSTMENT

The disconnecter is delivered partially assembled, as shown in the following figure.



The assembly is limited to:

- a) assembling and leveling the base frame on the supporting structure,
- b) assembling and setting of insulators,
- c) assembling of movable contact head and fixed contact head,
- d) assembling of corona rings,
- e) assembling and coupling of the operating mechanism with disconnecter,
- f) earthing of the base frames and the operating mechanism.

3.1. Preparation of contact surfaces

The contact resistance of the connected elements depends primarily on the quality and cleanliness of the contacting surfaces. Therefore, these surfaces should be prepared very precisely. The method of preparing of aluminum, silver-plated and galvanized contact surfaces is shown below:

• aluminum – aluminium connection

The oxide layer should be removed from the contact surface by using a wire brush. After this treatment, the surface should be matt gray, devoid of shiny areas. Any chips and aluminum dust should be thoroughly removed from the surface, eg by lubricating with acid-free petroleum jelly and then removing it. After this treatment, the surface should be lubricated with acid-free petroleum jelly to protect it from oxidation of aluminum. Such prepared surface should not be exposed to the interaction of the atmosphere longer than the time needed to prepare the cooperating surface.

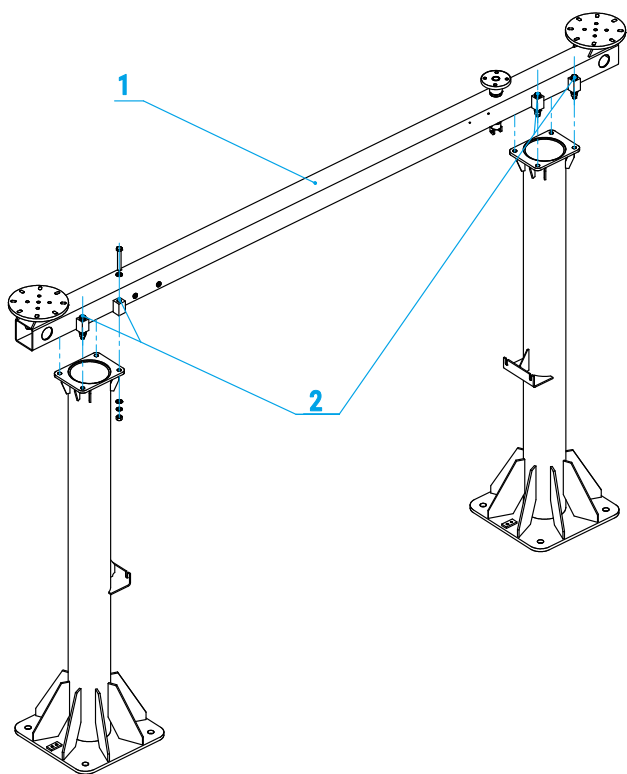
• **copper – silver connection**

The copper surfaces should be cleaned of oxides by using a brass wire brush and then should be proceeded as for the aluminum surface. Silver-plated surfaces do not need to be cleaned with a brush, but they can be cleaned with a delicate abrasive material, eg steel wool. After cleaning the surface should be covered with a thin layer of acid-free petroleum jelly.

• **zinc – zinc connection**

The surfaces should be cleaned by using of steel wire brush and then covered with a thin layer of grease.

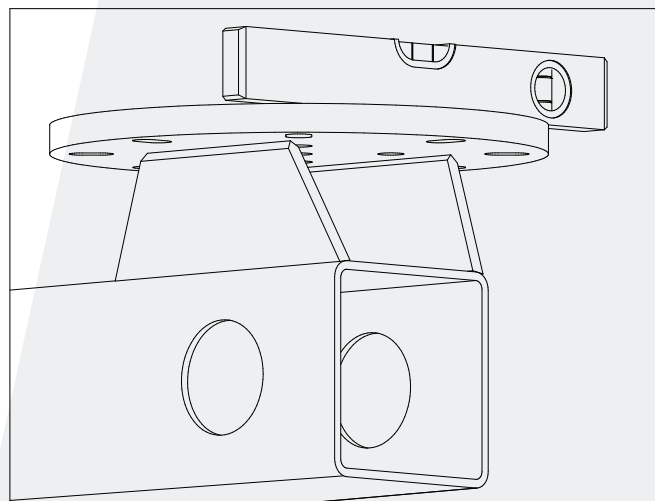
3.2. Assembling of the base frame



Used elements:

- 1.** Base frame of the disconnecter – 1pc.
- 2.** - screw M20x140 – 8 pcs.
- Spring washer 20 – 8 pcs.
- Nut M20 – 8 pcs.

After mounting the base frame, one should check the level of the surface in two planes.

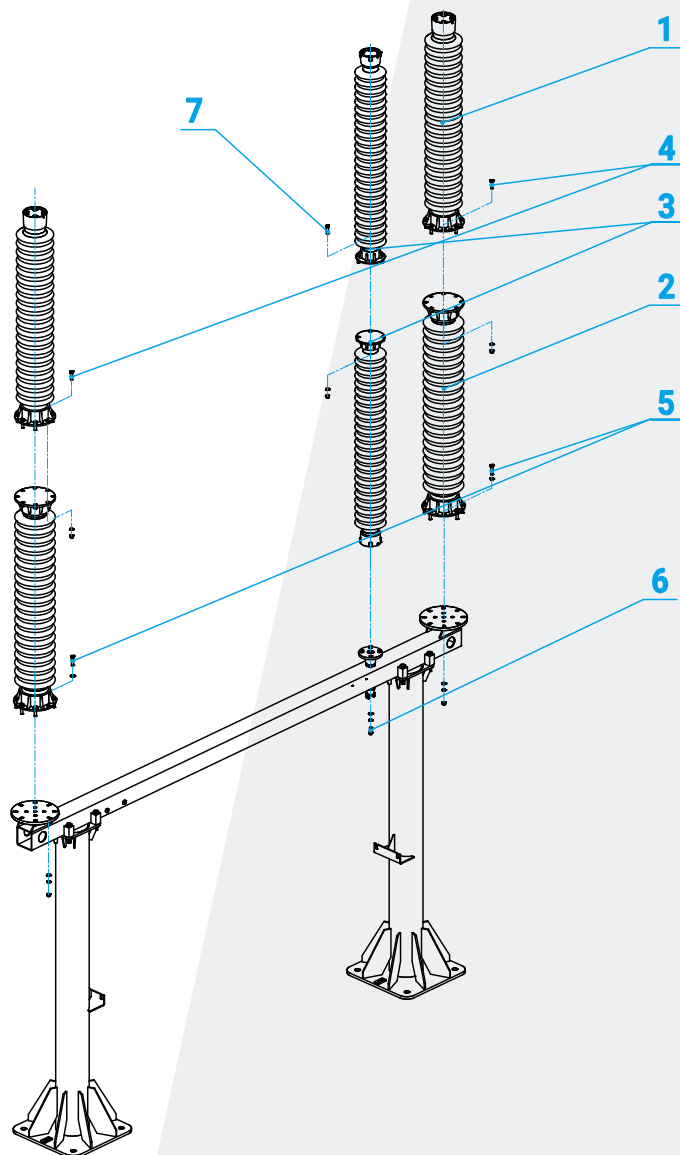


3.3. Assembling of the insulators

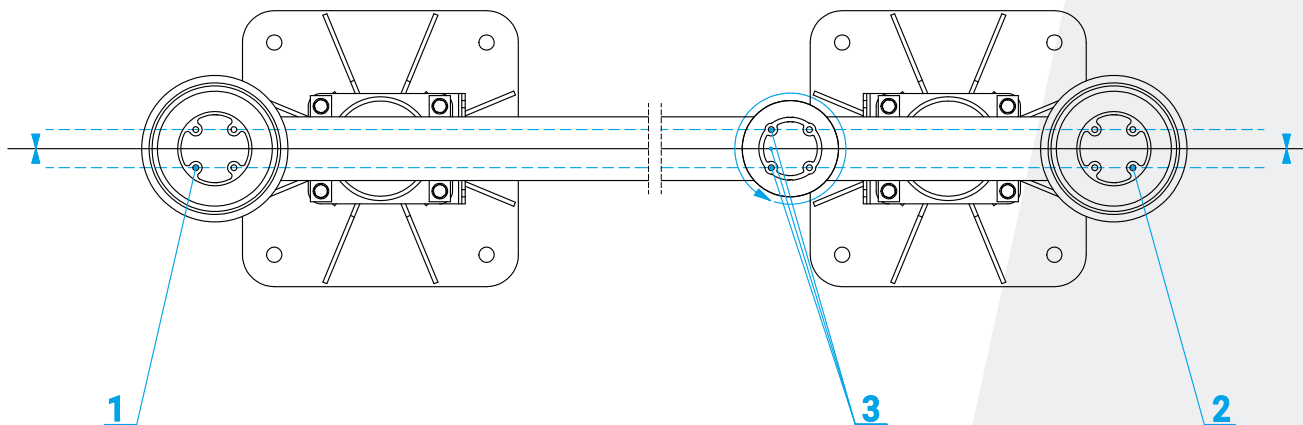
Insulators are recommended to be screwed when they are on the ground and then mounted on the disconnecter's base frame using a crane.

Used elements:

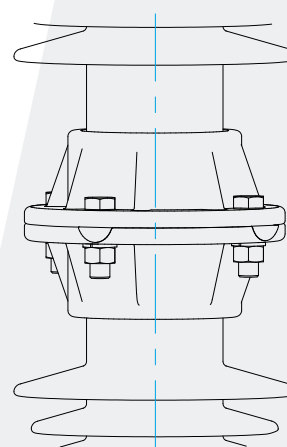
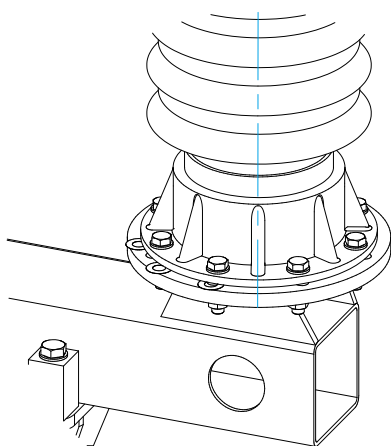
- 1. supporting insulator - 2 pcs.
- 2. supporting insulator - 2 pcs.
- 3. driving insulator - 1 pc.
- 4. - screw M16x65 - 16 pcs.
- spring washer 16 - 16 pcs.
- nut M16 - 16 pcs.
- 5. - screw M16x60 - 16 pcs.
- washer 17 - 32 pcs.
- spring washer 16 - 16 pcs.
- nut M16 - 16 pcs.
- 6. - screw M16x40 - 4 pcs.
- washer 17 - 4 pcs.
- spring washer 16 - 4 pcs.
- 7. - screw M16x50 - 4 pcs.
- spring washer 16 - 4 pcs.
- nut M16 - 4 pcs.



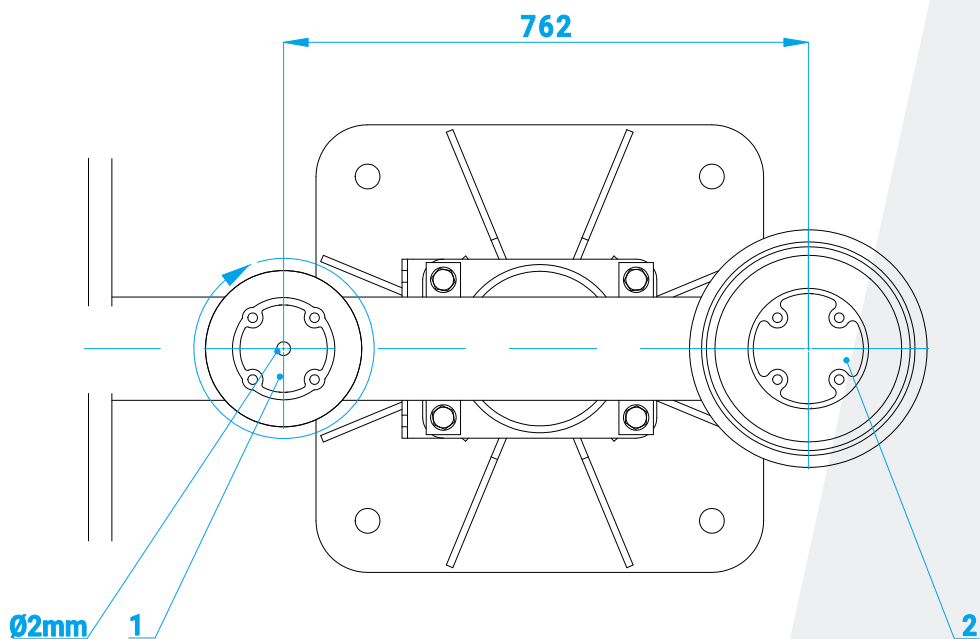
The insulators assembled on the base frame should be set in one plane. For that purpose is recommended usage of cord, which provided from hole [1] axis to hole [2] axis enables insulators to be set in one plane [3].



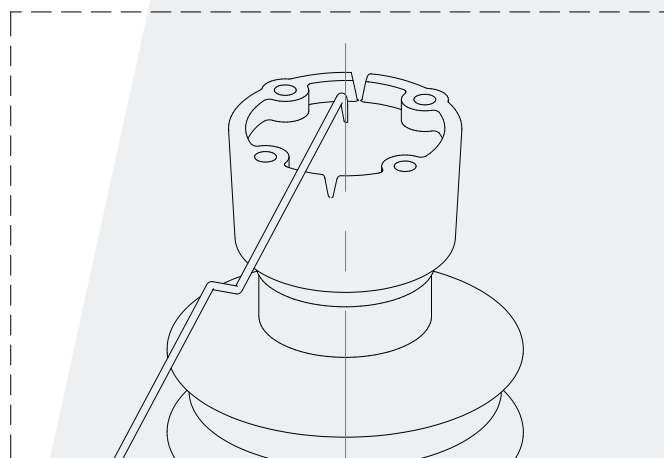
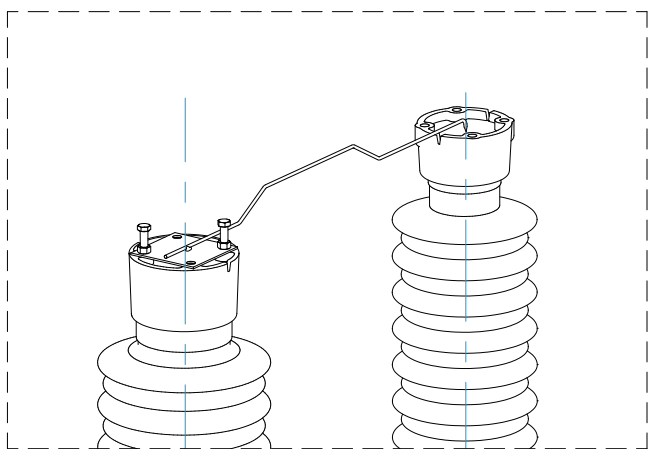
The adjustment is made with the use of adjustment washers allowing for proper adjustment of deviation of insulators. This method is presented on the next two drawings.



After setting the plane of insulators, one should set the distance of the driving insulator.



This adjustment is made using the tool shown in the following drawings. The tool should be mounted on the fixed insulator [2]. By rotating the driving insulator [1], one should determine potential deviations from the axis indicated by the tool. If necessary, the adjustments should be made in the manner discussed earlier. The permissible radial runout of the center of the driving insulator is 1 mm.

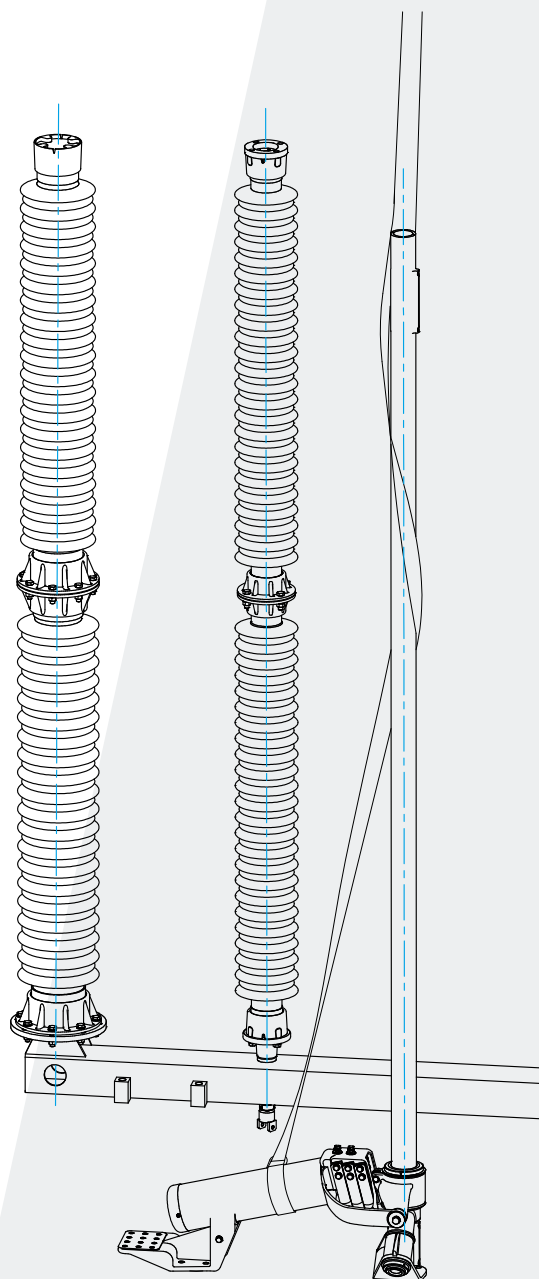
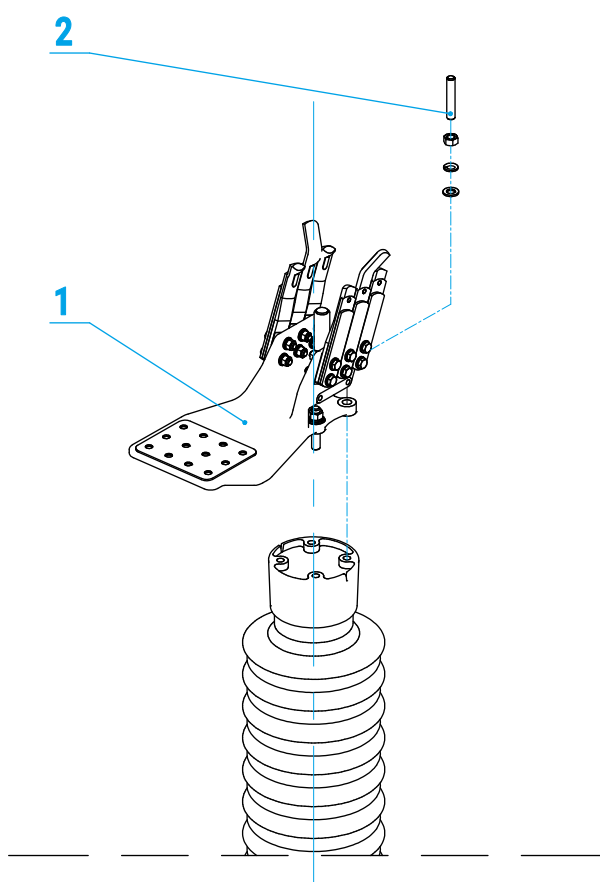


3.4. Assembling of the movable contact head

After the insulators are properly adjusted, the movable contact head is mounted [1].

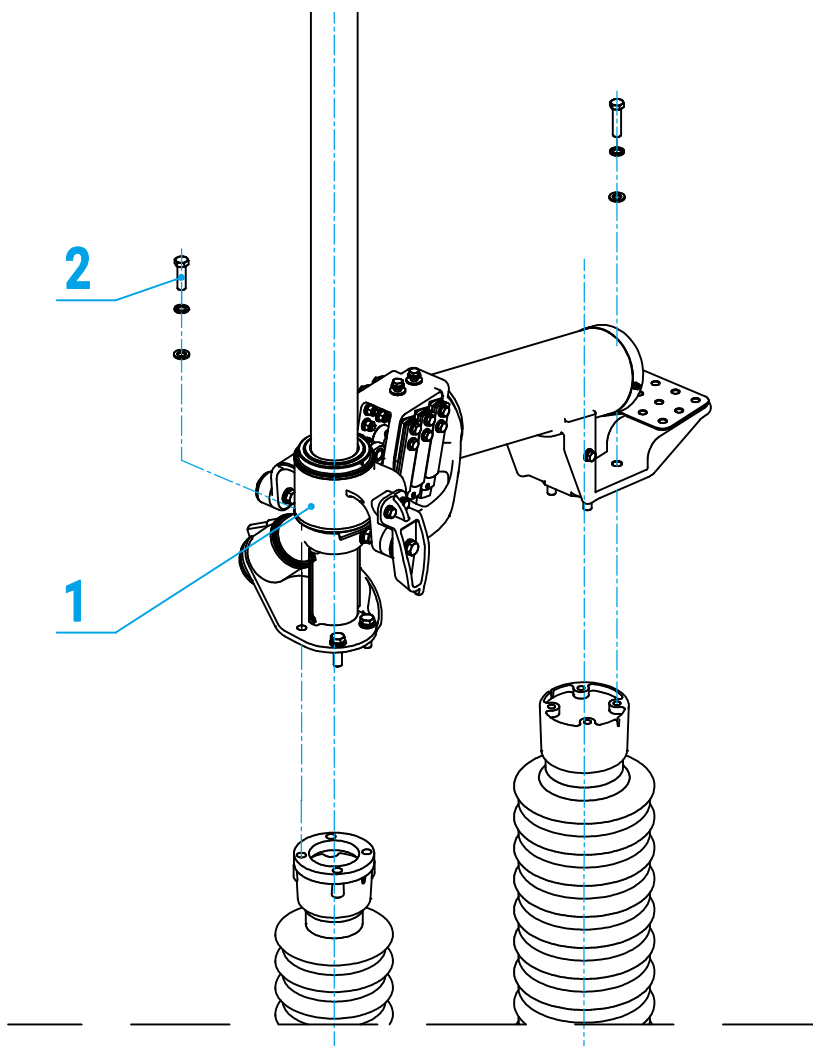
Used elements:

- screw M16x40 - 4 pcs.
- washer 17 - 4 pcs.
- spring washer 16 - 4 pcs.



3.5. Assembling of the fixed contact head with current path

The fixed contact head is assembled using a crane. The way of hanging the fixed contact head with the current path is shown in the drawing.



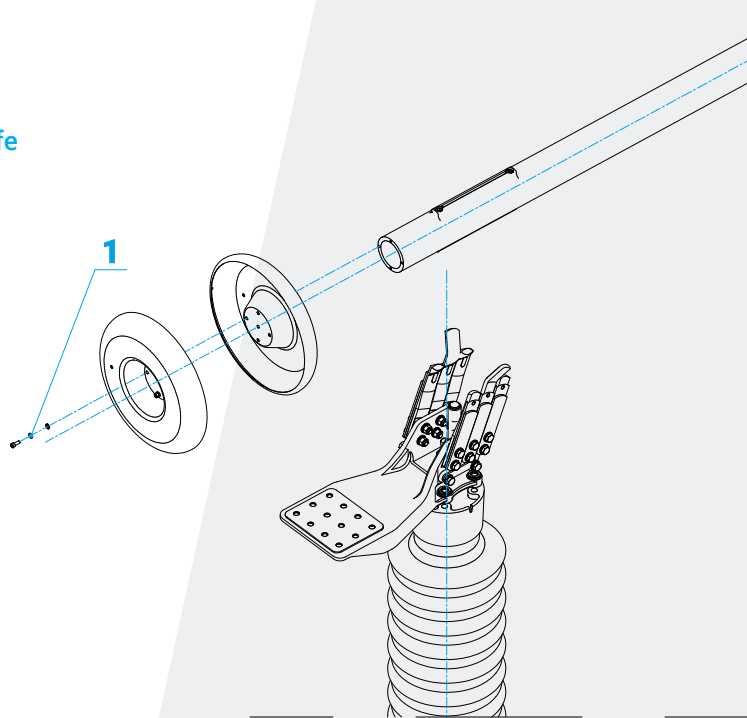
Used elements:

- 2. - screw M16x40 - 8 pcs.
- washer 17 - 8 pcs.
- spring washer 16 - 8 pcs.

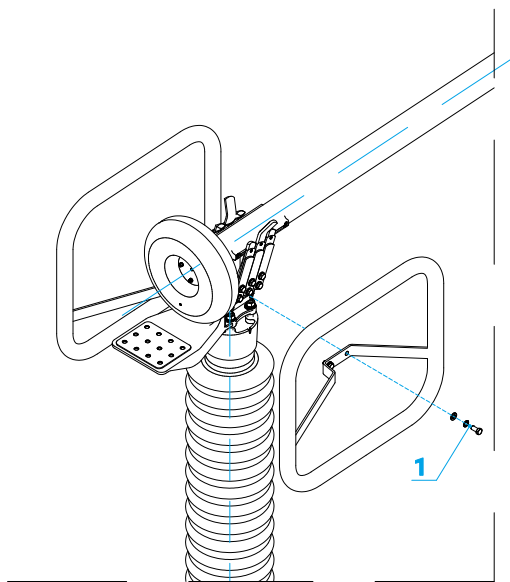
3.6. Assembling of the corona ring of the knife

Used elements:

- 1. - screw M6x20 - 4 pcs.
- washer 6,4 - 4 pcs.
- spring washer 6,4 - 4 pcs.



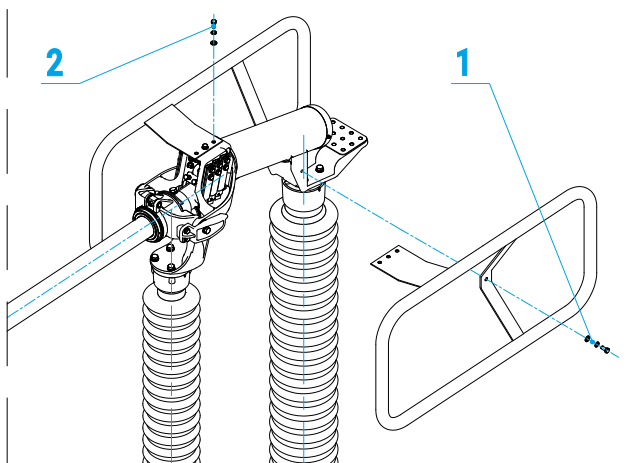
3.7. Assembling of the corona rings of the movable contact head of the knife



Used elements:

- 1. - screw M12x25 - 4 pcs.
- washer 13 - 4 pcs.
- spring washer 12 - 4 pcs.

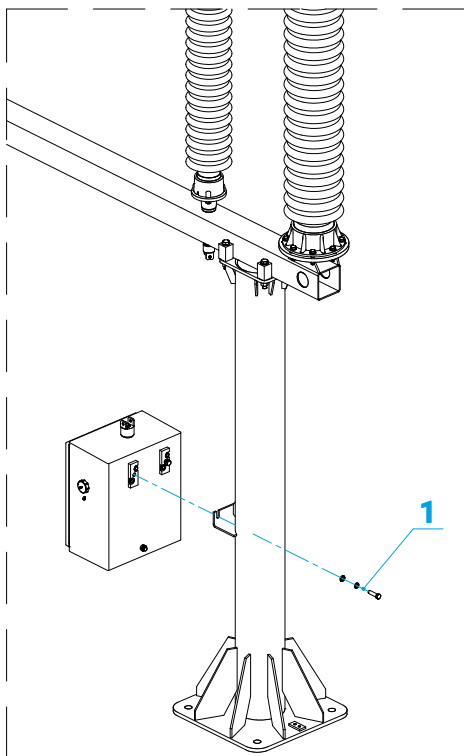
3.8. Assembling of the corona rings of the fixed contact head



Used elements:

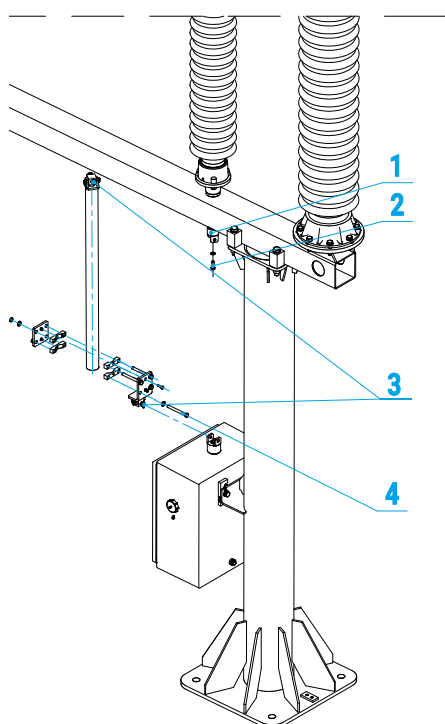
- 1. - screw M12x25 - 2 pcs.
- washer 13 - 2 pcs.
- spring washer 12 - 2 pcs.
- 2. - screw M12x25 - 2 pcs.
- washer 13 - 2 pcs.
- spring washer 12 - 2 pcs.

3.9. Assembling of the operating mechanism



Used elements: **1.** - screw M16x45 - 2 pcs.
 - washer 17 - 2 pcs.
 - spring washer 17- 2 pcs.

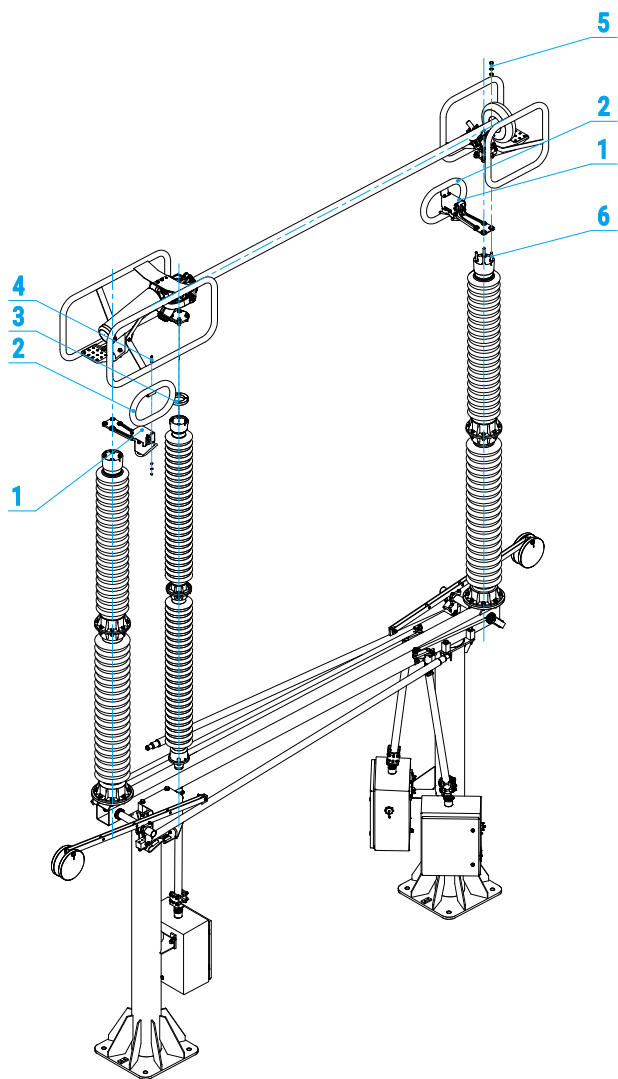
3.10. Assembling of the driving shaft



Used elements:
1. driving socket - 1 pc.
2. - screw M12x30 - 1 pc.
 - spring washer 12 - 1 pc.
3. - pin 80mm - 1 pc.
4. - screw M12x120 - 4 pcs.
 - washer 13 - 8 pcs.
 - spring washer 12 - 4 pcs.
 - nut M12 - 4 pcs.

3.11. Assembling of the fixed contact of the earthing switch

The earthing switch type UN-4 is assembled to the disconnecter type Mark-40. The assembly of it is taking place during the assembly of the disconnecter. Components and the method of assembling of the fixed contact of the earthing switch is presented in the next drawing.

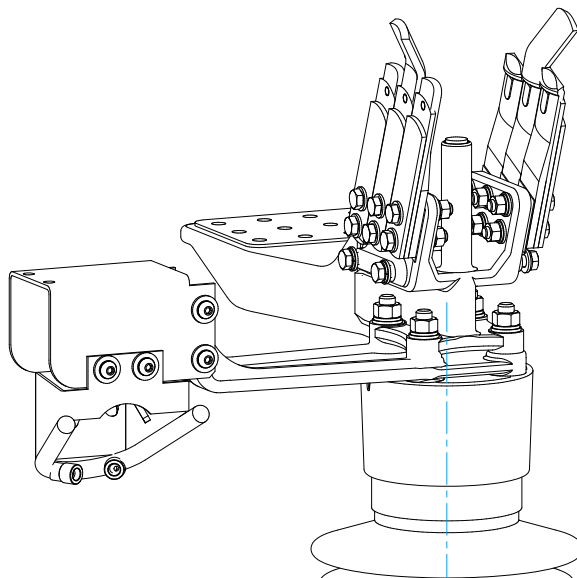


Used elements (the given quantities refer to a single earthing switch):

1. fixed contact of the earthing switch – 1 pc.
2. corona ring of the earthing switch – 1 pc.
3. spacer – 1 pc. *
4. - screw M10x25 – 2 pcs.
- washer 10 – 4 pcs.
- spring washer 10 – 2 pcs.
- nut M10 – 2 pcs.
5. - nut M16 – 4 pcs. (UN only)
- washer 17 – 4 pcs.
- spring washer 16 – 4 pcs.
6. Pin M16x95 – 4 pcs.

* If only the UN earthing switch is assembled, the spacer washer is also assembled under the movable contact head of the disconnecter. If only the UR earthing switch is assembled, the spacer washer is assembled on the driving insulator and supporting insulator of the fixed contact head of current path.

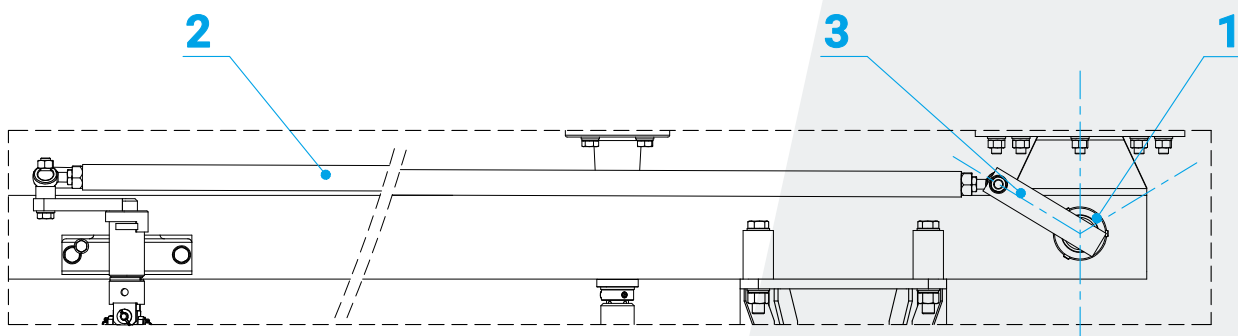
The properly mounted contact of the earthing switch is shown on the next drawing.



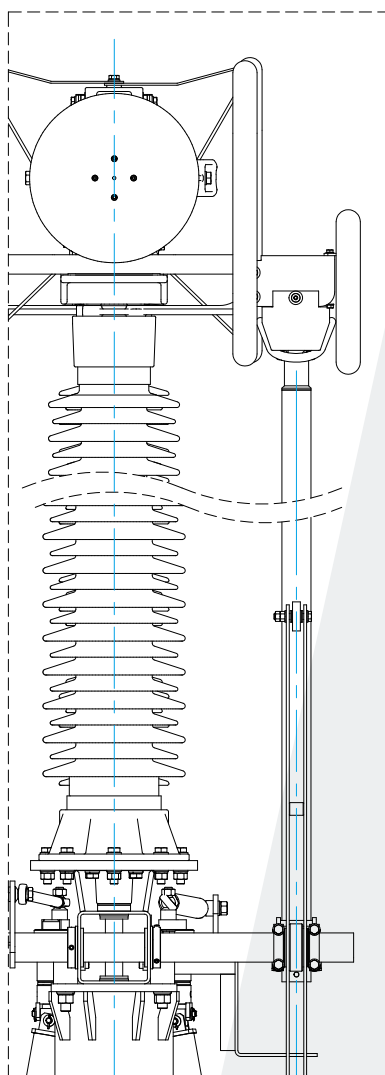
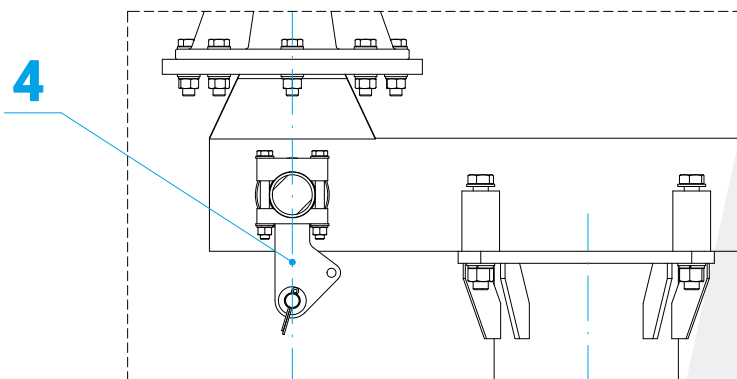
3.12. Assembling and adjustment of the knife of the earthing switch.

The adjustment is carried out as follows:

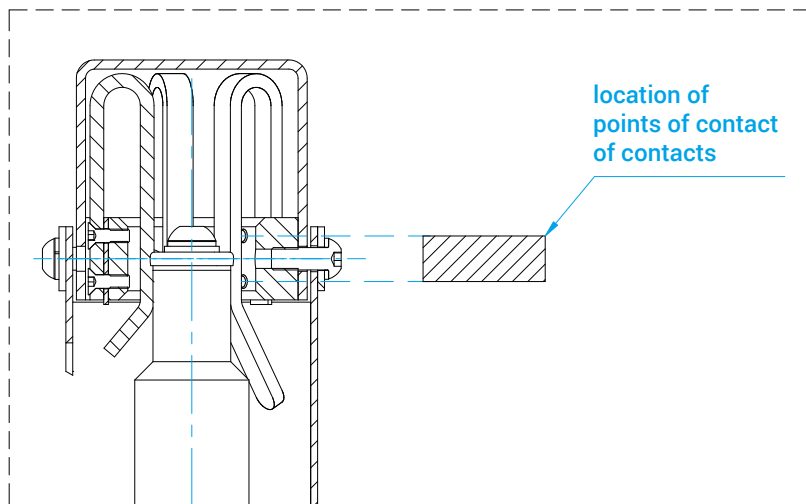
- a) one should assembly the bearing sleeves [1] in the disconnector's base frame, and then adapt the diameter of the holes to the diameter of the crank (it is allowed to increase the diameter using, for example, a flap wheel on the drill). The length of the coupling tie rod [2] should be adjusted in such a way that the crank [3] turns symmetrically in relation to the axis of the supporting insulator, according to the following graphics. Adjustments should be made visually.



b) one should assembly the body [4] so that it is in the perpendicular position to the base frame of the disconnecter. At the same time, one should set it in the axis with the fixed contact of the earthing switch.



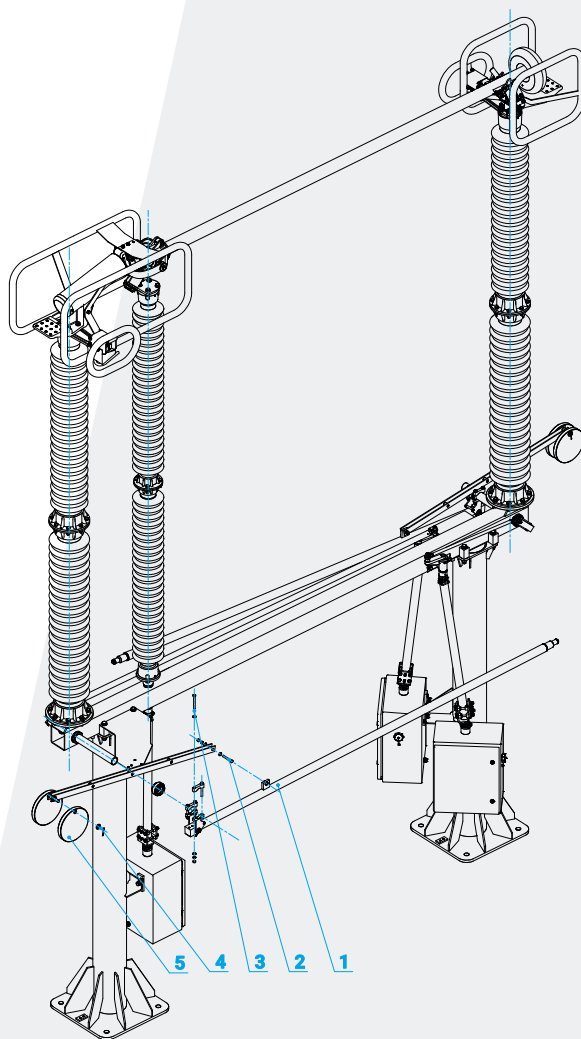
c) one should make final adjustment of the coupling tie rod [2] to set the position of tangency.

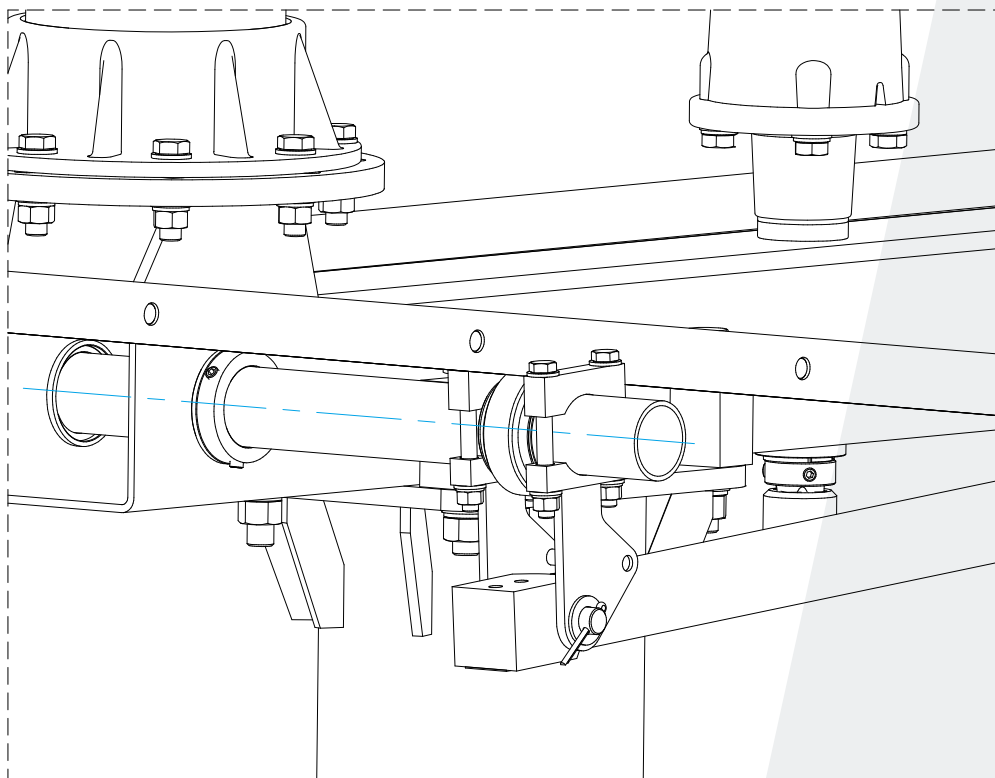


The next drawing shows how to assembly the knife of the earthing switch.

Elements used (the given quantities refer to a single earthing switch):

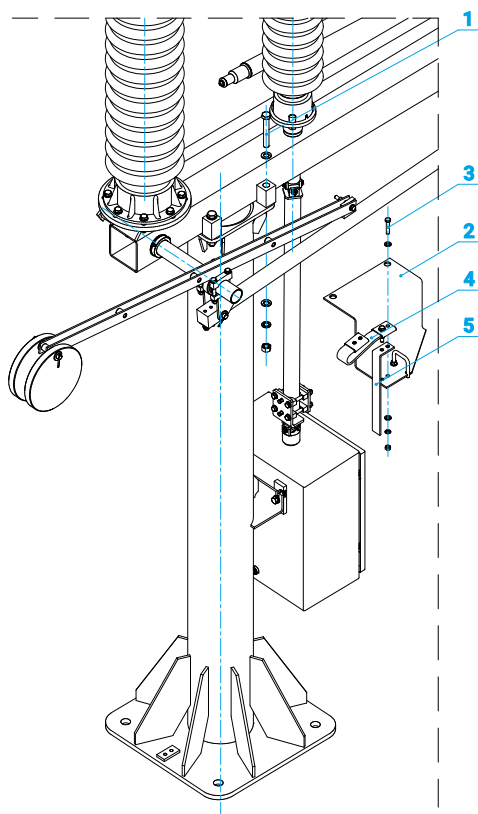
1. The knife of the earthing switch – 1 pc.
2. - screw M12x60 – 1 pc.
- washer 13 – 4 pcs.
- nut M12 – 2 pcs.
3. - screw M12x110 – 4 pcs.
- washer 10 – 8 pcs.
- spring washer 13 – 4 pcs.
- nut M10 – 4 pcs.
4. - washer 21 – 2 pcs.
- split pin – 2 pcs.
5. counterweight of the earthing switch – 1 pc.





3.13. Assembling of the earthing cable

After assembling of the earthing switch knife, the earthing cable should be connected according to the instruction below.

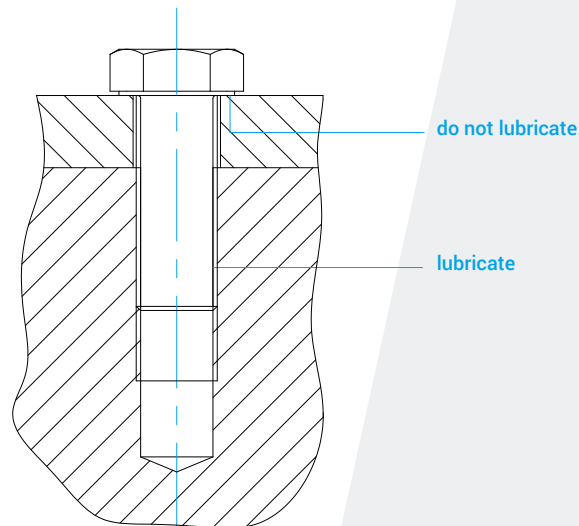


Elements used (the given quantities refer to a single earthing switch):

- 1. - screw M20x140 – 2 pcs.
- washer 21 – 4 pcs.
- spring washer 20 – 2 pcs.
- nut M20 – 2 pcs.
- 2. earthing switch bracket – 1 pc.
- 3. - screw M12x60 – 2 pcs.
- washer 13 – 4 pcs.
- spring washer 12 – 2 pcs.
- nut M12 – 2 pcs.
- 4. earthing cable – 1 pc.
- 5. stave

3.14. Table of tightening torque for screws [Nm]

| Material | Dimension | | | | | |
|---------------------------------------|-----------|----|-----|-----|-----|-----|
| | M6 | M8 | M10 | M12 | M16 | M20 |
| Steel 8.8 black steel | 10 | 25 | 50 | 85 | 207 | 405 |
| Steel 8.8 Electrogalvanizing steel | 8.6 | 21 | 42 | 72 | 174 | 340 |
| Steel 8.8 hot-dip galvanized steel | 9 | 22 | 45 | 76 | 186 | 364 |
| A2-70 Stainless steel | 6 | 14 | 29 | 50 | 124 | 240 |



4. OPERATING MANUAL

Disconnecter's switching is achieved through maneuvering an appropriate manual or motor operating mechanism.

4.1. Notes on switching operations

a) When switching the disconnecter or its earthing switch, the safety at work regulations in force at the place of their installation must be observed.

b) The disconnector connected to work under voltage can be switched only when there is certainty that the breaking or making current will have a negligible value, or that there will be no significant change in voltage between the terminal elements of any pole.

c) The disconnector must not be closed until its earthing switch is open.

d) The earthing switch of the disconnector connected to work under voltage can be switched from the open position to the closed position only when the disconnector is open and after making sure that the earthing switch will connect at most the discharging current of capacities of the bushings, busbars, incoming supplies, and short cables or overhead lines, with parameters of current and voltage given in the technical data.

5. INSPECTIONS AND MAINTENANCE

5.1. Visual inspections

It is recommended to carry out visual inspections in accordance with the regulations in force at the switchgear or after each failure or short circuit. In particular should be checked:

- a) condition of current path's contacts,
- b) condition of the earthing switch's contacts.

5.2. Periodic check-ups

In order to ensure continuous and failure-free operation of the disconnector, it is necessary to perform periodic check-ups. While the internal regulations in force in the distribution centre do not oblige to more frequent maintenance, inspections are required in accordance with the following schedule:

- Periodic inspection - after 5 years of operation or after 1000 operation cycles;
- General inspection - after 10 years of operation or after 2000 operation cycles.

During inspection and maintenance, the applicable regulations for the operation of energy devices and the requirements determining the safety of work of the inspectors must be obeyed.

The scope of activities to be performed during each maintenance is as follows:

- a) Periodic inspection:
 - check the condition of the current path contacts;
 - check the condition of the earthing switch contacts;
 - check the correctness of taking the end positions;
 - check the condition of mechanisms and bearings;
 - check tightness of screw connections and fasteners;
 - clean the outer surfaces of insulators;
 - check the condition of protective coatings and parts protecting against corrosion;
 - lubricate the current path contacts and the earthing switch contacts (not required for disconnectors)

equipped with graphite AgC contacts)¹⁾;

- perform thermal inspection of the disconnector at rated current²⁾.

b) General inspection:

- perform the complete set of activities described above for the periodic inspection;
- clean all moving parts;
- measure the voltage drop of the disconnector's main circuits at current $I = 100A$ DC³⁾;
- check dimensional compliance of the disconnector with the dimensional drawing, in particular insulation gaps and spaces between live parts;
- check the condition of anti-interference screens (if installed);
- check technical condition of insulators⁴⁾;
- check the operation and condition of arcing contacts (if installed)⁵⁾;
- check earthing of the disconnector bases.

When assessing condition of the disconnector's contacts, check if the silver coating on the contact surfaces has not been permanently damaged. If necessary, replace damaged contacts with new ones.

²⁾ In case of thermal imaging tests, the permissible temperature values given in Table 14 of the PN-EN 62271-1: 2018-02 standard should be adopted as a criterion for assessing the correct operation of the disconnector.

³⁾ In case of measuring the voltage drop of the main circuits of a disconnector not connected to the busbar system, the acceptable values indicated in the factory test report of the finished product should be taken as the criterion for assessing the correct operation of the disconnector. In the case of a disconnector connected to the busbar system, the voltage drop should not exceed $250 \mu\Omega$.

⁴⁾ When assessing the condition of insulators, it is necessary to check if there are no losses or damage to the insulators, with particular emphasis on the surface of the shade. If necessary, replace damaged insulators with new ones.

⁵⁾ When assessing the condition of the apparatus' arcing contacts, it is necessary to check whether there are no cavities or pits on the contact surfaces. If necessary, replace damaged contacts with new ones.

5.3. Spare parts and recommended service materials

The use of high quality components and operational experience indicate long live service of disconnectors (not less than 40 years). In case of damage to the disconnector due to improper assembly or operation, it is possible of for the manufacturer to repair it for a payment. The Mark-40 type disconnector has no parts that should be replaced during normal operation in service life of the disconnector.



The following materials should be used for maintenance of disconnectors:

- a) MOBILGREASE 28 used for lubrication of electric contacts (earthings, contacts of HV switches),
- b) LUBRICANT for bearings, e.g. LT4 or similar, used for lubricating of ball joints.

6. UTILIZATION

Mark-40 type disconnectors are made of recyclable materials.

The main materials from which the disconnectors are made are:

- steel (hot-dip galvanized);
- aluminum;
- copper.

Disconnectors do not contain any dangerous substances. In accordance with applicable regulations, it is possible to return a worn out, complete disconnector to the manufacturer.

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