

Disconnectors and earthing switches to be connected in the substation to flexible or rigid conductors, according to their documentation, shall be tested using flexible conductors with their rated static mechanical terminal load (e.g. longitudinal direction F_{a1} or F_{a2} in Figure 8 and F_{a1} , and F_{a2} in Figure 9) in a test setup with the dimensions given in Figure 3 or Figure 4 respectively. Disconnectors and earthing switches, according to their documentation, to be connected only to rigid conductors shall be tested with rigid conductors in a test arrangement with the same dimensions and without intentional static mechanical terminal load except the one given by the weight of rigid conductors. The dimensions and material of the conductors used shall be stated in the test report.

After applying 50 % of the longitudinal rated static terminal load, the disconnector or earthing switch may be adjusted, before the 100 % load is applied

All details referring to the test arrangement are mandatory, the details of the disconnector and earthing switch shown are given as an example.

For standardization of tests when they are performed with flexible conductors, where the rated currents of the equipment are larger than 1 250 A continuous current or 31,5 kA short-time withstand current for a duration of 1 s, two flexible conductors shall be used having a centre line distance of (70 ± 30) mm without spacers. Disconnectors and earthing switches of $U_r \geq 300$ kV shall also be tested with these two flexible conductors.

Unless the tested disconnector or earthing switch is solidly fixed to the foundation, the spring constant of the support structure has to be taken into consideration (IEC 60865-1).

The test report shall provide clear details of the mounting arrangements used for the tests or record that the disconnector was solidly fixed to the foundations.

Avoid introduction of forces not representative of service conditions by the connections to the supply, and static terminal loads larger than the rated static mechanical terminal loads of the test object.

If, in the test setup, the short side of the low-level conductor cannot be supported, it may be supported by the disconnector. This may result in a higher dynamic mechanical terminal load.

NOTE 1 In principle, Figure 3 can be used for testing earthing switches with an appropriate arrangement of the earth conductor.

NOTE 2 In principle, Figure 4 can be used for testing integrated earthing switches with an appropriate arrangement of the earth conductor.

7.6.3 Test current and duration

Subclause 7.6.3 of IEC 62271-1:2017 is applicable.

7.6.4 Conditions of disconnectors and earthing switches after test

Subclause 7.6.4 of IEC 62271-1:2017 is applicable with the following addition.

The rated peak withstand current and the rated short-time withstand current, carried by a disconnector or earthing switch in the closed position during the rated duration of short-circuit, shall not cause:

- mechanical damage to any part of the disconnector or earthing switch;
- separation of the contacts.

After the test, a no-load operation shall be made with the rated value of power supply for independent power-operated devices, with minimum value of power supply for dependent power-operated devices, and for manually (dependent or independent) operated devices with

a force no higher than the values given for manually operated devices in 6.105. The disconnector or earthing switch shall open at the first attempt.

In the case of performing the short-circuit withstand test with a single-phase test on one pole of a three-pole disconnector or earthing switch operated by a common driving mechanism or shaft, exact details of the test procedure and the measured torque/force at the exit of the driving mechanism during the no-load operation shall be reported in order to evaluate the test result with reference to the capability of the mechanism to operate the three-pole apparatus after a three phase short circuit occur. This test method may require the insertion of a torque/force measurement device in the power kinematic chain for testing. The measured torque/force in the power kinematic chain to open the pole under test of the disconnector or earthing switch tested shall be not more than the value given by the driving mechanism when blocking the exit of the driving mechanism divided by the number of poles of the switching device under test.

After the no-load operation, for earthing switches, sound earth connection and sound insulation shall be verified by the following:

- visual inspection shall be made (if possible). Significant contact erosion or significant contact welding should not be observed. Light welding of contacts is permitted;
- when significant contact erosion is suspected or if visual inspection is not possible without dismantling the contacts, sound earth connection shall be verified by checking the electrical continuity according to 7.4.3 of IEC 62271-1:2017;
- in case of doubt of insulating properties or if visual inspection is not possible without dismantling, 7.2.12 is applicable to verify the dielectric conditions across the isolating gap and to earth.

After the no-load operation(s), for disconnectors:

- to verify the current carrying capacity main circuit resistance measurement shall be made as close as possible to the contacts. The increase of resistance after the test shall not exceed 20 % of the value measured before the test;
- when the contact resistance exceeds this value a test under rated continuous current (7.5) shall demonstrate that the temperature rise in the contacts does not exceed the limits given in Table 14 of IEC 62271-1:2017, by monitoring the temperature at the points as close as possible to the contacts;
- visual inspection shall be made (if possible). In case of doubt of insulating properties or if visual inspection is not possible without dismantling, 7.2.12 is applicable to verify the dielectric conditions across the isolating gap and to earth.

7.7 Verification of the protection

Subclause 7.7 of IEC 62271-1:2017 is applicable.

7.8 Tightness tests

Subclause 7.8 of IEC 62271-1:2017 is applicable.

7.9 Electromagnetic compatibility tests (EMC)

Subclause 7.9 of IEC 62271-1:2017 is applicable.

7.10 Additional tests on auxiliary and control circuits

Subclause 7.10 of IEC 62271-1:2017 is applicable.

7.11 X-ray radiation test for vacuum interrupters

Subclause 7.11 of IEC 62271-1:2017 is applicable.

7.101 Test to prove the short-circuit making performance of earthing switches

7.101.1 General test conditions

Earthing switches, having a short-circuit making current capability, shall be subjected to two (class E1) or five (class E2) making operations respectively, in a making test series in accordance with the procedures of 7.101.7.

The following test methods are applicable for combined function earthing switches that have short-circuit making capability in the other function:

- the short-circuit making tests shall first be performed on the other functions, in accordance with the relevant standards, followed by the short-circuit making tests on the earthing function, without intermediate maintenance;
- alternatively, the short-circuit making tests on the combined function earthing switch may be performed on a new combined function earthing switch preceded by at least one short-circuit making test on the other function followed by the short-circuit making tests on the earthing function without intermediate maintenance. This test method verifies only the short-circuit making capability of the earthing switch.

7.101.2 Arrangement of the earthing switch for tests

The earthing switch shall be tested under the representative conditions of installation and use, concerning the connections, support, enclosure and dimensions, in accordance with 7.6.2.

Its operating device shall be operated in the manner prescribed and in particular, if it is electrically, hydraulically or pneumatically operated, it shall be operated at the minimum supply voltage or pressure.

For gas-filled earthing switches, the tests shall be performed at the minimum functional pressure for insulation and/or switching.

For convenience of testing:

- the supply voltage to the coil for the closing operation may be increased to obtain a consistent closing time, provided it does not increase the closing speed of the contacts;
- in order to obtain accurate closing times an electrically or pneumatically released latch may be introduced at the toggle point.

Earthing switches with independent manual operation may be operated by an arrangement provided for the purpose of making remote control possible.

NOTE For testing purposes, it can be necessary to measure the travel characteristics, for example by using a travel recorder.

7.101.3 Test frequency

Earthing switches shall be tested at rated frequency, with a tolerance of $\pm 10\%$.

However, tests with a peak factor of 2,6 or above, at a supply frequency of 50 Hz or 60 Hz cover the requirements of both frequencies.

7.101.4 Test voltage

The test voltage shall be as follows:

- a) for three-phase tests, the average value of the applied voltage phase-to-phase shall not be less than the rated voltage U_r and shall not exceed this value by more than 10 % without the consent of the manufacturer. The differences between the average value and the applied voltages of each pole shall not exceed 5 %;

- b) for single-phase tests, the applied voltage shall not be less than the phase-to-earth value $U_r/\sqrt{3}$, and shall not exceed this value by more than 10 % without the consent of the manufacturer, with the exceptions given below:

for single-phase tests on three-pole operated earthing switches which have a spread between the first and second contact touch during closing exceeding half a cycle of the rated frequency, the applied voltage phase-to-earth shall not be less than U_r .

7.101.5 Test short-circuit making current

The short-circuit current during making test shall be expressed in terms of the peak current and the symmetrical RMS current. The symmetrical RMS value of current in each phase at 0,2 s shall be at least 80 % of the rated short-time withstand current. The prospective peak current shall be equal to the rated short-circuit making current (I_{ma}) with the tolerance of 0 % and +5 %.

The duration of the short-circuit current shall be at least 0,2 s.

The earthing switch shall be tested under the two extreme cases specified as follows:

- a) making at the peak of the voltage wave, (with a tolerance of –30 electrical degrees to +15 electrical degrees) leading to a symmetrical short-circuit current and the longest pre-arcing time. For convenience of testing, alternative test methods may be followed. The alternative test methods are given in Annex D;
- b) making at the zero of the voltage wave, without pre-arcing, leading to a fully asymmetrical short-circuit current. For convenience of testing, the test may be carried out at reduced applied voltage to obtain the rated short-circuit making current (I_{ma}). It may happen that the making operation does not occur exactly at the zero of the voltage wave. However, the extreme case b) is considered met if the rated short-circuit making current has been obtained.

7.101.6 Test circuits

Making tests shall be performed using the three-phase test circuit or the single-phase test circuit.

Three-phase tests cover:

- the interaction between the different phases;
- the stresses on the operating mechanism (in the case of a common operating mechanism).

Three-pole earthing switches shall be tested in a three-phase circuit in order to cover applications in both effectively and non-effectively earthed neutral systems. For testing purposes, the severity of making tests in circuits with unearthed neutral or solidly earthed neutral are considered to be equivalent. However, single-phase testing of earthing switches of $U_r > 52$ kV is allowed in the following cases:

- a) multi-enclosure type or open-air type earthing switches with separately stored closing energy for each pole;
- b) earthing switches operated pole-after-pole.

7.101.7 Test procedures

For class E1, the tests shall be performed with a sequence of two C operations with one single no-load O in between, i.e. C – O (no-load) – C, unless the test laboratory needs more no-load operations between the closing operations.

For class E2 earthing switches, the test sequence is $2C - x - 2C - y - 1C$, where x and y represent arbitrary number of no-load operations. The 2C operations consists of

C – O (no-load) – C, unless the test laboratory needs more no-load operations between the closing operations. There is no requirement on the time interval between the two closing operations.

No maintenance is allowed during a test sequence.

For combined function earthing switches, the arbitrary number of no-load operations represented by x and y in the test sequence for class E2 may be replaced by switching operations.

Due to non-simultaneity of poles or different instants of initiation of pre-arcs in the different poles, a peak making current, which is higher than the rated value, may occur in one pole. This is particularly the case if, in one pole, the current begins to flow a few milliseconds later than in the other two poles. If the earthing switch fails during such an event, this is considered to be a failure of the earthing switch.

The requirements with regard to the instant of making as specified in Table 15 shall be achieved during the tests.

Table 15 – Requirements on the instant of making

Class E1	Class E2
2 tests	5 tests
At least 1 test fulfilling the requirements of 7.101.5 a)	At least 2 tests fulfilling the requirements of 7.101.5 a)
At least 1 test fulfilling the requirements of 7.101.5 b)	At least 2 tests fulfilling the requirements of 7.101.5 b)
NOTE Normally the speed of closing of the contacts of the earthing switches with short-circuit making capability is high enough that both maximum pre-arcing and maximum peak current can be reached within a same test, however at different phases.	

7.101.8 Behaviour of earthing switches when making short-circuit currents

The following applies during the making tests:

- a) enclosed earthing switches having a rated short-circuit making current shall, when making the short-circuit, not project flames, liquids, gases nor particles outside the enclosure;
- b) from open type earthing switches, flame or metallic particles shall not be projected beyond the boundaries specified by the manufacturer in the operating instructions.

7.101.9 Condition of earthing switch after short-circuit making tests

After performing the specified operations, mechanical parts, parts related to the electrical field control (for example field electrodes of a GIS earthing switch) and insulators of the earthing switch shall be practically in the same condition as before. The insulating properties shall not be degraded. The short-circuit making performance and short-time current withstand performance may be impaired.

NOTE The useful life of the earthing switch with regard to short-circuit making and short-time current withstand capability is normally considered to be at the end, after the specified number of making operations necessitating maintenance or replacement.

To verify this requirement, the earthing switch shall meet the following inspection conditions:

- a) mechanical conditions: After each operation only light welding of contacts is permitted. However, the earthing switch shall be able to open and close under the conditions given in 6.5 and 6.6, with the rated values for power operated devices or with 120 % of the values given for manually operated devices in 6.105 using the normal operating handle;

- b) electrical continuity: Visual inspection after the no-load operation is usually sufficient for checking the electrical continuity of the earthing switch. In case of doubt the electrical continuity shall be measured according to 7.4.3 of IEC 62271-1:2017;
- c) dielectric requirements: Visual inspection is usually sufficient for checking the above requirement. In case of doubt, a voltage test as a condition check according to 7.2.12 is to be performed. As an alternative, 6.2.11 of IEC 62271-100:2008 + AMD1:2012 + AMD2:2017 may be used for $U_r > 72,5$ kV. The minimum functional pressure of the gas for insulation shall be used, if applicable. For earthing switches that are sealed for life, the voltage test as a condition check is mandatory.

7.101.10 Invalid tests

In the case of an invalid test, it may become necessary to perform a greater number of short-circuit making tests than required by this document. An invalid test is one where one or more test parameters demanded by the document are not met. This includes, for example, current, voltage and time factors as well as point-on-wave requirements (if specified) and the additional features in synthetic testing.

The deviation from the document could make the test less or more severe. Four different cases are considered in Table 16.

Table 16 – Invalid tests

Test conditions related to standard	Earthing switch passed	Earthing switch failed
More severe	Test valid, result accepted	Test to be repeated with correct parameters Modification of the design of the earthing switch not required
Less severe	Test to be repeated with correct parameters Modification of the design of the earthing switch not required	Modification of the design of the earthing switch required, aiming for improvement of the making capability All tests to be repeated on the modified earthing switch
NOTE "More severe" is considered to be a test performed with voltage and/or current above the tolerances and additionally for the alternative test methods a test with longer prearcing time.		

In the case of less severe test conditions, the invalid part of the test-duty may be repeated without reconditioning of the earthing switch. In those cases, the test report shall include reference to the invalid test. However, in the case of a failure of the earthing switch during such additional tests, or at the discretion of the manufacturer, the earthing switch may be reconditioned and the complete test-duty repeated. If any record of an individual operation cannot be produced for technical reasons, individual operations are not considered invalid, provided that evidence can be given in another manner that the earthing switch did not fail and the required testing values were fulfilled.

In the case of three-phase direct testing (single power source), even if the requirements in 7.101.5 a) and/or 7.101.5 b) are still not met during the repetition of the complete test duty, the earthing switch is considered to have passed the test if the requirements specified in 7.101.8 and 7.101.9 are fulfilled.

7.101.11 Type test reports

The results of the type test shall be recorded in type-test reports containing sufficient data to prove compliance with the rated short-circuit making current performance requirements. Sufficient information should be included so that the essential parts of the earthing switch tested can be identified. Refer to 7.1.2 of IEC 62271-1:2017.

The test report shall contain the information about the test arrangements, test circuits and test procedures.

General information concerning the supporting structure of the earthing switch should be included. Information regarding the operating devices employed during the tests should, where applicable, be recorded.

Typical oscillographic or similar records shall be provided so that the following can be determined:

- the making current expressed as a peak value and the RMS value at 0,2 s;
- the applied voltages;
- instantaneous value of voltages at the moment of the making;
- pre-arcing time.

7.102 Operating and mechanical endurance tests

7.102.1 General test conditions

The test shall be made at the ambient air temperature of the test location. During the test, the ambient temperatures shall be recorded and maximum and minimum values included in the test report.

The supply voltage shall be measured at the terminals of the operating devices with full current flowing. Auxiliary equipment forming part of the operating device shall be included.

For three-phase disconnectors and earthing switches operated by one mechanism, where the application of terminal load is required, it shall be applied to all terminals simultaneously.

7.102.2 Contact zone test

This test shall be made in order to prove satisfactory operation of divided support disconnectors or divided support earthing switches, in the various positions of the fixed contact within the limits of the rated contact zone defined according to 5.103 and Figures 6 and/or 7. With the device in the open position, the fixed contact shall be placed in the following positions:

- a) at a height of h on the vertical axis of the assembly;
- b) at a height of $h - z_r$ on the same axis;
- c) at a height equal to h and displaced from the vertical axis horizontally by $+y_r/2$;
- d) at a height equal to h and displaced from the vertical axis horizontally by $-y_r/2$;
- e) positions a) to d) at a distance equal to $+x_r/2$;
- f) positions a) to d) at a distance equal to $-x_r/2$,

where

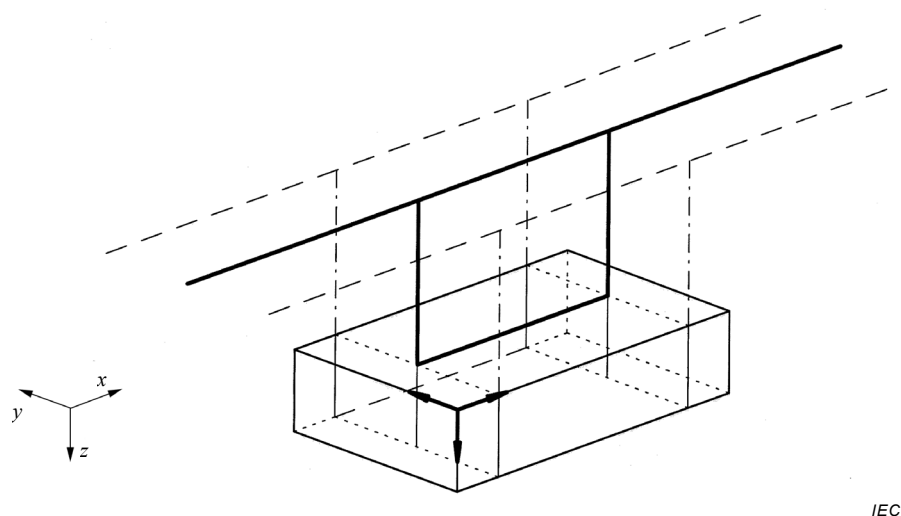
h is the highest position (stated by the manufacturer) of the fixed contact above the mounting plane;

x_r is the total amplitude of movement of the fixed contact in the x -direction;

y_r is the total amplitude of movement of the fixed contact in the y -direction;

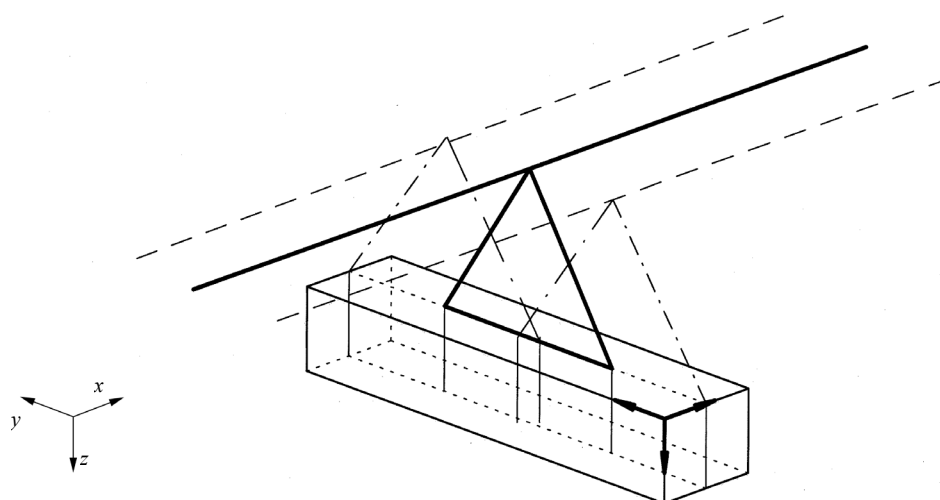
the subscript, r , indicates the rated value assigned to the disconnector or earthing switch by the manufacturer.

In each position, the device shall close and open correctly.

**Key**

- x Longitudinal to support (influence of temperature)
- y Perpendicular to support (influence of wind)
- z Vertical deflection (temperature and ice)

Figure 6 – Fixed contact parallel to support

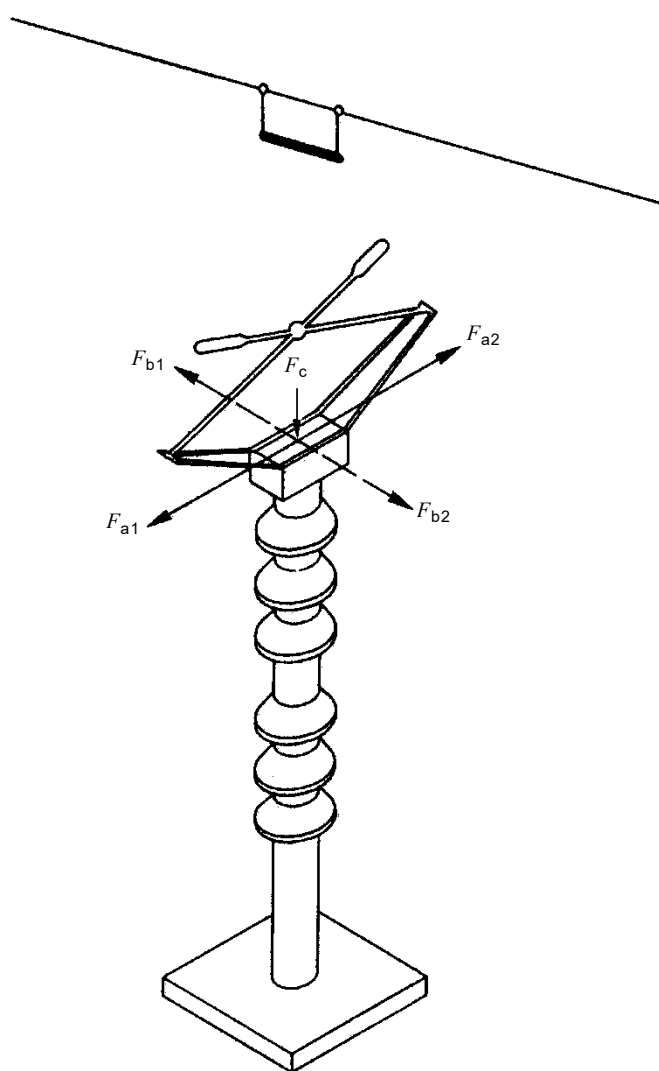


IEC

Key

- x* Longitudinal to support (influence of temperature)
- y* Perpendicular to support (influence of wind)
- z* Vertical deflection (temperature and ice)

Figure 7 – Fixed contact perpendicular to support



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NOTE Above the pantograph, the fixed contact is shown.

Figure 8 – Example of the application of rated static mechanical terminal loads to a (divided support) pantograph disconnector (or earthing switch)

7.102.3 Mechanical endurance test

7.102.3.1 Test procedure

The tests defined in 7.102.3.1 and in 7.102.3.2 shall be performed on disconnectors and earthing switches of class M0.

The mechanical endurance test shall consist of 1 000 operating cycles. For disconnectors or earthing switches having a rated terminal load, 50 % of the rated static terminal load shall be applied during the test in direction F_{a1} or F_{a2} (Figure 8 and Figure 9), without voltage on, or current through, the main circuit. For disconnectors having two or three insulators and a normally horizontal isolating gap, the 50 % rated static terminal load shall be applied at both sides of the disconnector, but in opposite directions. For disconnectors and earthing switches with one insulator (operating insulators not being taken into consideration), the terminal load shall be applied to only one side of the disconnector or earthing switch. After applying 50 % of the rated static terminal load, the disconnector or earthing switch may be adjusted before performing the tests.

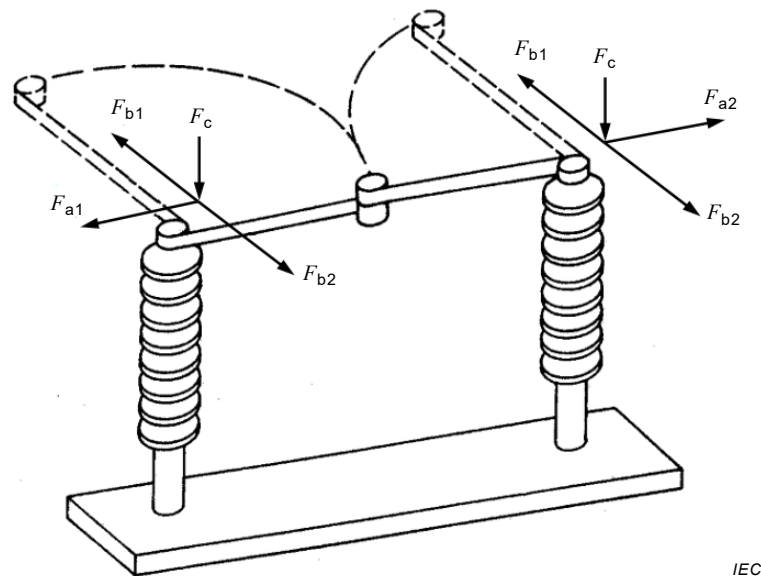


Figure 9 – Example of the application of rated static mechanical terminal loads to a two-column disconnect

The closed and open positions shall be attained during each operating cycle.

During the test, the operation of the control and auxiliary contacts and position-signalling devices (if any) shall meet the requirements expressed in 6.104 and 6.4 of IEC 62271-1:2017. The test is considered failed if any of the control and auxiliary contacts and position-signalling devices do not operate at one of the close-open operating cycles.

The test shall be made on disconnectors and earthing switches equipped with their own operating mechanisms. During the test, lubrication in accordance with the manufacturer's instructions is permitted, but no mechanical adjustment or other maintenance is allowed.

On a disconnector or earthing switch having a power-operated mechanism:

- 900 close-open operating cycles shall be made at the rated supply voltage and/or rated pressure of compressed gas supply;
- 50 close-open operating cycles at the specified minimum supply voltage and/or minimum pressure of compressed gas supply;
- 50 close-open operating cycles at the specified maximum supply voltage and/or maximum pressure of compressed gas supply.

No specific time intervals between operating cycles or between closing and opening operations are required. These tests shall be made, however, at a rate such that the temperature rises of the energised electrical control components do not exceed the specified values. For the same purpose, external cooling may be applied during the test.

For manually operated disconnectors and earthing switches, the handle may, for convenience of testing, be replaced by an external power-operated device. In this case, it is not necessary to vary the power parameters.

7.102.3.2 Verification of successful operation

For the evaluation of the operating characteristics, before and after the mechanical endurance test programme, the following operations shall be performed without the static terminal load applied: