IEC 60099-4

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# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

AMENDMENT 2
AMENDEMENT 2

## Surge arresters –
## Part 4: Metal-oxide surge arresters without gaps for a.c. systems

## Parafoudres –
## Partie 4: Parafoudres à oxyde métallique sans éclateurs pour réseaux à courant alternatif



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# FOREWORD

This amendment has been prepared by IEC technical committee 37: Surge arresters.

The text of this amendment is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 37/354/FDIS | 37/357/RVD |

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.



*Replace definitions 3.66, 3.67 and 3.68 with the following new definitions:*

**3.66**
**specified long-term load**
**SLL**
force perpendicular to the longitudinal axis of an arrester, allowed to be continuously applied during service without causing any mechanical damage to the arrester

**3.67**
**specified short-term load**
**SSL**
greatest force perpendicular to the longitudinal axis of an arrester, allowed to be applied during service for short periods and for relatively rare events (for example, short-circuit current loads and extreme wind gusts) without causing any mechanical damage to the arrester

NOTE SSL does not relate to mechanical strength requirements for seismic loads. See M.2.

**3.68**
**mean breaking load**
**MBL**
the average breaking load for porcelain or cast resin-housed arresters determined from tests

### 6.14.1 Bending moment

*Change NOTE 1 of Subclause 6.14.1 as follows:*

NOTE 1 When determining the mechanical load applied to a surge arrester, the user should consider, for example, wind, ice and electromagnetic forces likely to affect the installation.

*Add the following subclause to 6.14:*

### 6.14.4 Mean value of breaking load (MBL)

The MBL shall be ≥ 1,2 times the specified short-term load (SSL) (see 8.9.4).

*Replace the existing Subclause 8.9 by the following new Subclause 8.9:*

### 8.9 Test of the bending moment

This test applies to porcelain and cast-resin housed arresters for $U_m$ > 52 kV. It also applies to porcelain and cast-resin housed arresters for $U_m$ ≤ 52 kV for which the manufacturer claims cantilever strength.

The complete test procedure is shown by the flow chart in Annex M.

### 8.9.1 General

This test demonstrates the ability of the arrester to withstand the manufacturer's declared values for bending loads. Normally, an arrester is not designed for torsional loading. If an arrester is subjected to torsional loads, a specific test may be necessary by agreement between manufacturer and user.

The test shall be performed on complete arrester units without internal overpressure. For single-unit arrester designs, the test shall be performed on the longest unit of the design. Where an arrester contains more than one unit or where the arrester has different specified bending moments in both ends, the test shall be performed on the longest unit of each different specified bending moment, with loads determined according to M.1.

The test shall be performed in two parts that may be done in any order:

– a bending moment test to determine the mean value of breaking load (MBL);
– a static bending moment test with the test load equal to the specified short-term load (SSL), i.e. the 100 % value of M.3.

### 8.9.2 Sample preparation

One end of the sample shall be firmly fixed to a rigid mounting surface of the test equipment, and a load shall be applied to the other (free) end of the sample to produce the required bending moment at the fixed end. The direction of the load shall pass through and be perpendicular to the longitudinal axis of the arrester. If the arrester is not axi-symmetrical with respect to its bending strength, the manufacturer shall provide information regarding this non-symmetric strength, and the load shall be applied in an angular direction that subjects the weakest part of the arrester to the maximum bending moment.

### 8.9.3 Test procedure

#### 8.9.3.1 Test procedure to determine mean value of breaking load (MBL)

Three samples shall be tested. If the test to verify the SSL (see 8.9.3.2) is performed first, then samples from that test may be used for determination of MBL. The test samples need not contain the internal parts. On each sample, the bending load shall be increased smoothly until breaking occurs within 30 s to 90 s. “Breaking” includes fracture of the housing and damages that may occur to fixing device or end fittings.

The mean breaking load, MBL, is calculated as the mean value of the breaking loads for the test samples.

NOTE Care should be taken because the housing of an arrester can splinter while under load.

#### 8.9.3.2 Test procedure to verify the specified short-term load (SSL)

Three samples shall be tested. The test samples shall contain the internal parts. Prior to the tests, each test sample shall be subjected to a leakage check (see 9.1 d)) and an internal partial discharge test (see 9.1 c)). If these tests have been performed as routine tests, they need not be repeated at this time.

On each sample, the bending load shall be increased smoothly to SSL, tolerance $^{+5}_{-0}$%, within 30 s to 90 s. When the test load is reached, it shall be maintained for 60 s to 90 s. During this time the deflection shall be measured. Then the load shall be released smoothly and the residual deflection shall be recorded. The residual deflection shall be measured in the interval 1 min to 10 min after the release of the load.

NOTE 1 Care should be taken because the housing of an arrester may break and splinter while under load.

NOTE 2 Agreement must be made with the manufacturer if it is necessary for any reason to apply a load that is more than 5 % above SSL.

### 8.9.4 Test evaluation

The arrester shall have passed the test if

– the mean value of breaking load, MBL, is ≥ 1,2 x SSL;
– for the SSL test
  – there is no visible mechanical damage;
  – the remaining permanent deflection is ≤ 3 mm or ≤ 10 % (whichever is greater) of maximum deflection during the test;
  – the test samples pass the leakage test in accordance with 9.1 d);
  – the internal partial discharge level of the test samples does not exceed the value specified in 9.1 c);

*Replace the existing Subclause 8.10 by the following new Subclause 8.10:*

### 8.10 Environmental tests

These tests apply to porcelain and cast resin-housed arresters.

#### 8.10.1 General

The environmental tests demonstrate by accelerated test procedures that the sealing mechanism and the exposed metal combinations of the arrester are not impaired by environmental conditions.

The test shall be performed on complete arrester units of any length.

For arresters with an enclosed gas volume and a separate sealing system, the internal parts may be omitted.

Arresters whose units differ only in terms of their lengths, and which are otherwise based on the same design and material, and have the same sealing system in each unit, are considered to be the same type of arrester.

#### 8.10.2 Sample preparation

Prior to the tests, the test sample shall be subjected to the leakage check of 9.1 d).

#### 8.10.3 Test procedure

The tests specified below shall be performed on one sample in the sequence given.

##### 8.10.3.1 Temperature cycling test

The test shall be performed according to test Nb of IEC 60068-2-14.

The hot period shall be at a temperature of at least +40 °C, but not higher than +70 °C. The cold period shall be at least 85 K below the value actually applied in the hot period; however, the lowest temperature in the cold period shall not be lower than –50 °C:

– temperature change gradient: 1 K/min;
– duration of each temperature level: 3 h;
– number of cycles: 10.

##### 8.10.3.2 Salt mist test

The test shall be performed according to Clauses 4 and Subclause 7.6, as applicable, of IEC 60068-2-11:

– salt solution concentration: 5 % ± 1 % by weight;
– test duration: 96 h.

#### 8.10.4 Test evaluation

The arrester shall have passed the tests if the sample passes the leakage check in accordance with 9.1 d).

### 10.6 Requirements

*Add the following items to 10.6:*

6.14.1 Bending moment – reference to 10.8.9

6.14.3 Insulating base – reference to 10.8.9. Environmental tests do not apply

6.14.4 does not apply

### 10.8.1 General

*Add the following items to 10.8.1:*

9) Test of the bending moment – see 10.8.9

10) Environmental tests do not apply

*Delete the following item from 10.8.1:*

13) Moisture ingress test

### 10.8.9 Test of the bending moment

*Replace the existing Subclause 10.8.9 by the following new Subclause 10.8.9:*

### 10.8.9 Test of the bending moment

This test applies to polymer (except cast-resin) housed arresters (with and without enclosed gas volume) for $U_m$ > 52 kV. It also applies to polymer (except cast-resin) housed arresters for $U_m \leq$ 52 kV for which the manufacturer claims cantilever strength.

Cast-resin housed arresters shall be tested according to 8.9. Arresters that have no declared cantilever strength shall be submitted to the terminal torque preconditioning according to 10.8.9.3.1.1, the thermal preconditioning according to 10.8.9.3.1.3 and the water immersion test according to 10.8.9.3.2.

The complete test procedure is shown by the flow chart in Annex M.

#### 10.8.9.1 General

This test demonstrates the ability of the arrester to withstand the manufacturer's declared values for bending loads. Normally, an arrester is not designed for torsional loading. If an arrester is subjected to torsional loads, a specific test may be necessary by agreement between manufacturer and user.

The test shall be performed on complete arrester units with the highest rated voltage of the unit. For single-unit arrester designs, the test shall be performed on the longest unit with the highest rated voltage of that unit of the design. Where an arrester contains more than one unit or where the arrester has different specified bending moments in both ends, the test shall be performed on the longest unit of each different specified bending moment, with loads determined according to M.1. However, if the length of the longest unit is greater than 800 mm, a shorter length unit may be used, provided the following requirements are met:

– the length is at least as long as the greater of
  – 800 mm
  – three times the outside diameter of the housing (excluding the sheds) at the point it enters the end fittings;

– the unit is one of the normal assortment of units used in the design, and is not specially made for the test;
– the unit has the highest rated voltage of that unit of the design.

A test in three steps (two steps for arresters for $U_m \leq 52$ kV) shall be performed one after the other on three samples as follows:

– on all three test samples a cyclic test comprising 1000 cycles with the test load equal to the specified long-term load (SLL);
– on two of the samples a static bending moment test with the test load equal to the specified short-term load (SSL), i.e. the 100 % value of M.3 and on the 3rd sample a mechanical preconditioning test as per 10.8.9.3.1;
– on all three samples a water immersion test as per 10.8.9.3.2.

Tolerance on specified loads shall be $^{+5}_{-0}$%.

NOTE 1 The cyclic test is not required for arresters for $U_m \leq 52$ kV.

NOTE 2 If +5 % is exceeded this should be agreed upon with the manufacturer.

### 10.8.9.2 Sample preparation

The test samples shall contain the internal parts.

Prior to the test, each test sample shall be subjected to the following tests:

– electrical tests made in the following sequence:
  – watt losses measured at $U_c$ and at an ambient temperature of 20 °C ± 15 K;
  – internal partial discharge test according to 9.1 c);
  – residual voltage test at (0,01 to 1) times the nominal discharge current; the current wave shape shall be in the range of $T_1/T_2$ = (4 to 10)/(10 to 25) µs;
– leakage tests in accordance with 9.1 d) for arresters with enclosed gas volume and separate sealing system.

If the partial discharge test according to 9.1 c) and the leakage test according to 9.1 d) have been performed as routine tests they need not be repeated at this time.

One end of the sample shall be firmly fixed to a rigid mounting surface of the test equipment, and a load shall be applied to the other (free) end of the sample to produce the required bending moment at the fixed end. The direction of the load shall pass through and be perpendicular to the longitudinal axis of the arrester. If the arrester is not axi-symmetrical with respect to its bending strength, the manufacturer shall provide information regarding this non-symmetric strength, and the load shall be applied in an angular direction that subjects the weakest part of the arrester to the maximum bending moment.

### 10.8.9.3 Test procedure

The test shall be performed on three samples. For arresters for $U_m > 52$ kV, the test is performed in three steps. For arresters for $U_m \leq 52$ kV, the test is performed in two steps.

**a) Arresters for $U_m$ > 52 kV**

Step 1:

– Subject all three samples to 1000 cycles of bending moment, each cycle comprising loading from zero to specified long-term load (SLL) in one direction, followed by loading to SLL in the opposite direction, then returning to zero load. The cyclic motion shall be approximately sinusoidal in form, with a frequency in the range 0,01 Hz – 0,5 Hz.

NOTE Due to the control of the testing machine it may take some cycles to obtain the SLL. The maximum number of these cycles should be agreed upon with the manufacturer. These cycles should not be included in the prescribed 1000 cycles.

The maximum deflection during the test and any residual deflection shall be recorded. The residual deflection shall be measured in the interval 1 min to 10 min after the release of the load.

Step 2.1:

Subject two of the samples from step 1 to a bending moment test. The bending load shall be increased smoothly to specified short-term load (SSL) within 30 s to 90 s. When the test load is reached, it shall be maintained for 60 s to 90 s. During this time the deflection shall be measured. Then the load shall be released smoothly.

The maximum deflection during the test and residual deflection shall be recorded. The residual deflection shall be measured within 1 min to 10 min after the release of the load.

Step 2.2:

Subject the third sample from Step 1 to mechanical/thermal preconditioning according to 10.8.9.3.1.

Step 3:

Subject all three samples to the water immersion test according to 10.8.9.3.2.

**b) Arresters for $U_m \leq 52$ kV**

Step 1.1:

Subject two samples to a bending moment test. The bending load shall be increased smoothly to specified short-term load (SSL) within 30 s to 90 s. When the test load is reached, it shall be maintained for 60 s to 90 s. During this time the deflection shall be measured. Then the load shall be released smoothly.

The maximum deflection during the test and any residual deflection shall be recorded. The residual deflection shall be measured in the interval 1 min to 10 min after the release of the load.

Step 1.2:

Subject a third sample to mechanical/thermal preconditioning according to 10.8.9.3.1.

Step 2:

Subject all three samples to the water immersion test according to 10.8.9.3.2.

#### 10.8.9.3.1 Mechanical/thermal preconditioning

This preconditioning constitutes part of the test procedure of 10.8.9.3 and shall be performed on one of the test samples as defined in 10.8.9.3.

#### 10.8.9.3.1.1 Terminal torque preconditioning

The arrester terminal torque specified by the manufacturer shall be applied to the test sample for a duration of 30 s.

#### 10.8.9.3.1.2 Thermo-mechanical preconditioning

This portion of the test applies only to arresters for which a cantilever strength is declared.

The sample is submitted to the specified long-term load (SLL) in four directions and in thermal variations as described in Figures 6 and 7.

NOTE If, in particular applications, other loads are dominant, the relevant loads should be applied instead. The total test time and temperature cycle should remain unchanged.

The thermal variations consist of two 48 h cycles of heating and cooling as described in Figure 6. The temperature of the hot and cold periods shall be maintained for at least 16 h. The test shall be conducted in air.

The applied static mechanical load shall be equal to SLL defined by the manufacturer. Its direction changes every 24 h at any temperature in the transition from hot to cold, or from cold to hot, as defined in Figure 7.

The test may be interrupted for maintenance for a total duration of 4 h and restarted after interruption. The cycle then remains valid.

Any residual deflection measured from the initial no-load position shall be reported. The residual deflection shall be measured within 1 min to 10 min after the release of the load.

#### 10.8.9.3.1.3 Thermal preconditioning

This portion of the test applies only to arresters for which no cantilever strength is declared.

The sample is submitted to the thermal variations as described in Figure 6 without any load applied.

The thermal variations consist of two 48 h cycles of heating and cooling as described in Figure 6. The temperature of the hot and cold periods shall be maintained for at least 16 h. The test shall be conducted in air.

#### 10.8.9.3.2 Water immersion test

The test samples shall be kept immersed in a vessel, in boiling deionised water with 1 kg/m$^3$ of NaCl, for 42 h.

NOTE 1 The characteristics of the water described above are those measured at the beginning of the test.

NOTE 2 This temperature (boiling water) can be reduced to 80 °C (with a minimum duration of 52 h) by agreement between the user and the manufacturer, if the manufacturer claims that its sealing material is not able to withstand the boiling temperature for a duration of 42 h. This value of 52 h can be expanded up to 168 h (i.e. one week) after agreement between the manufacturer and the user.

At the end of the boiling, the arrester shall remain in the vessel until the water cools to approximately 50 °C and shall be maintained in the water at this temperature until verification tests can be performed. The arrester shall be removed from the water and cooled to ambient temperature for not longer than three thermal time constants of the sample (as derived from the cooling curves of Annex B). The 50 °C holding temperature is necessary only if it is necessary to delay the verification tests after the end of the water immersion test as shown in Figure 8. Evaluation tests shall be made within the time specified in 10.8.9.4. After removing the sample from the water it may be washed with tap water.

#### 10.8.9.4 Test evaluation

Tests according to 10.8.9.2 shall be repeated on each test sample.

The arrester shall have passed the test if the following is demonstrated:

**a) Arresters for $U_m$ > 52 kV**

After step 2:

– there is no visible damage;

– the slope of the force-deflection curve remains positive up to the SSL value except for dips not exceeding 5 % of SSL magnitude. The sampling rate of digital measuring equipment shall be at least 10 $s^{-1}$. The cut-off frequency of the measuring equipment shall be not less than 5 Hz.

Maximum deflection during step 1 and 2 and any remaining permanent deflection after the test shall be reported.

After step 3:

within 8 h after cooling as defined in Figure 8:

– the increase in watt losses, measured at $U_c$ and at an ambient temperature that does not deviate by more than 3 K from the initial measurements, is not more than the greater of 20 mW/kV of $U_c$ (measured at $U_c$) or 20 %;

– the internal partial discharge measured at 1,05 times $U_c$ does not exceed 10 pC;

at any time after the above watt losses and partial discharge measurements:

– for arresters with enclosed gas volume and separate sealing system, the samples pass the leakage test in accordance with 9.1 d);

– the residual voltage measured on the complete sample at the same current value and wave shape as the initial measurement is not more than 5 % different from the initial measurement;

– the difference in voltage between two successive impulses at nominal discharge current does not exceed 2 %, and the oscillograms of voltage and current do not reveal any partial or full breakdown of the test sample. The current wave shape shall be in the range of $T_1/T_2$ = (4 to 10)/(10 to 25) µs, and the impulses shall be administered 50-60 s apart.

NOTE In case of extra long arresters where the blocks can be dismantled this part of the evaluation test can be performed on individual blocks or stacks of blocks. If the blocks cannot be dismantled a possible procedure would be to drill a hole in the arrester insulation to make contact with the internal stack at a metal spacer and in this way be able to test shorter arrester sections.

– the change in reference voltage measured before and after the two residual voltage tests does not exceed 2 %.

**b) Arresters for $U_m \leq 52$ kV**

After step 1:

– there is no visible damage;

– for step 1.1, the slope of the force-deflection curve remains positive up to the SSL value except for dips not exceeding 5 % of SSL magnitude. The sampling rate of digital measuring equipment shall be at least 10 $s^{-1}$. The cut-off frequency of the measuring equipment shall be not less than 5 Hz.

Maximum deflection during step 1 and any remaining permanent deflection after the test shall be reported.