



INDEPENDENT POWER TRANSMISSION OPERATOR S.A.  
TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION

June 2017

## **SPECIFICATION No SS-133/12** **400 kV METAL OXIDE SURGE ARRESTERS WITHOUT GAPS**

### **I. SCOPE**

This specification covers IPTO's requirement with regard the rated characteristics, design features and testing of Surge Arresters for the 400KV system.

### **II. KEYWORDS**

Arresters, Surge arresters, Lightning arresters, metal oxide resistors, surge arrester sections, surge arrester units.

### **III. TYPE**

Metal oxide surge arresters without gaps.

### **IV. USE**

The metal oxide surge arresters without gaps are used for the protection of 400/150/30kV auto-transformers and 400kV underground cables against switching and lightning surges.

### **V. OPERATING CONDITIONS**

- |    |                     |   |   |
|----|---------------------|---|---|
| 1. | Installation        | : | Outdoors                                |
| 2. | Ambient Temperature | : | Minimum: -25°C<br>Maximum: +45°C        |
| 3. | Altitude            | : | Up to 1000m above sea level.            |
| 4. | Other Conditions    | : | Snow, ice and fog                       |
| 5. | Pollution level     | : | Heavy to moderate depending on location |
| 6. | Wind speed          | : | 150km/h maximum                         |
| 7. | Relative humidity   | : | ≤ 95%                                   |

## **VI. ELECTRICAL CHARACTERISTICS OF 400KV SYSTEM**

1.	Nominal Voltage	:	400 kV
2.	Maximum Operating Voltage (phase to phase)	:	420 kV
3.	Maximum temporary over-voltage (phase to ground)	:	360 kVrms
4.	Number of phases	:	3
5.	Rated frequency	:	50 Hz
6.	Short circuit level	:	40 kA
7.	Basic impulse Insulation level (crest)	:	1550 kV
8.	Method of grounding (earthing).	:	The 400kV system is solidly earthed

## **VII. HOW ARRESTER IS TO BE CONNECTED TO THE SYSTEM**

Phase - to - Earth.

## **VIII. STANDARDS**

The surge arresters shall conform to IEC 60099-4.

## **IX. ARRESTER REQUIRED CHARACTERISTICS**

1.	Continuous operating voltage $U_c$ (COV)	:	267 – 289 kVrms
2.	Rated Voltage as defined in IEC 60099-4, $U_r$	:	360 kVrms
3.	Rated frequency	:	50 Hz
4.	Class	:	Station
5.	Duty	:	High
6.	Designation	:	SH
7.	Nominal discharge current $I_n$ (8/20 $\mu$ s)	:	20 kA peak
8.	Residual voltage at 20 kA lighting current impulse (8/20 $\mu$ s), (lightning impulse protection level, LIPL)	:	$\leq 1020$ kV peak
9.	Residual voltage at 2 kA switching current impulse (>30/60 $\mu$ s), (switching impulse protection level, SIPL)	:	$\leq 772$ kV peak
10.	Thermal energy rating	:	$\geq 10$ kJ/kV

- |     |  |   |   |
|-----|--|---|---|
| 11. | Repetitive charge transfer rating $Q_{rs}$                     | : | $\geq 2.4$ C                                  |
| 12. | Rated short circuit current                                    | : | 40 kArms                                      |
| 13. | External housing characteristics                               |   |   |
|     | a. Insulation material of the external housing                 | : | Silicon rubber                                |
|     | b. Lightning impulse voltage withstand (1.2/50 $\mu$ s)        | : | 1550 kV peak                                  |
|     | c. Switching impulse voltage withstand, wet (250/2500 $\mu$ s) | : | 1175 kV peak                                  |
|     | d. Creepage distance   | : | $\geq 10500$ mm                               |
|     | e. Shed profile  | : | Normal or alternating                         |
| 14. | Method of mounting   | : | Upright, vertically on a steel structure.     |
| 15. | Number of units  | : | Two (2) or three (3)                          |
| 16. | Type of the surge arrester                                     | : | without or with enclosed gas volume           |
| 17. | Seal leak rate (only for arresters with enclosed gas volume)   | : | $\leq 1.0$ $\mu$ Pa $\cdot$ m <sup>3</sup> /s |
| 18. | Radio interference level                                       | : | $\leq 2500$ $\mu$ V at $1.05xU_c$             |
| 19. | Internal partial discharge level                               | : | $\leq 10$ pC at $1.05xU_c$                    |

## **X. ADDITIONAL REQUIREMENTS**

### **1. Surge counter with resistive leakage current meter**

Each surge arrester shall be equipped with a surge counter, which shall include a leakage current meter, with at least five digits for the surge counter. The leakage current meter will measure the total leakage current, as well as the resistive leakage current, using third harmonic analysis.

### **2. Support insulators**

Four (4) support insulators for the installation of the surge counter with the leakage current meter must be provided. The support insulators must be able to withstand the long-term as well as the short-term mechanical forces affecting the arrester. They must also have adequate electrical strength so that they do not flash-over under the stress of voltage drops across the surge counter/leakage current meter.

3. **External housing of the arrester**

The external housing of the arrester shall be of silicon rubber with a minimum leakage distance of 10500 mm.

The silicon rubber shall be hydrophobic and resistant to pollution and to UV radiation.

4. **Terminals**

Each arrester shall be equipped with a vertical flat line terminal of 100mm x 130mm in dimensions and thickness of 12mm minimum either of Aluminum or silver-plated Copper for connection to the high-voltage system.

Similarly each arrester shall be equipped with a terminal stud for connection to earth through the surge counter.

5. **Fittings**

All metal fitting of the surge arresters shall be hot dip galvanized steel, unless they are from aluminum alloy or stainless steel.

6. **Bolts, nuts and washers**

The bolts nuts and washers which are needed for the mounting of the arrester on a steel support structure must be part of the supply.

These bolts, nuts and washers must be of hot dip galvanized steel or stainless steel.

7. **Grading ring**

The arrester shall be equipped, on its top, with one (1) or two (2) grading rings in order to control the voltage distribution along the arrester, if this is deemed by the manufacturer.

8. **Arrangement of the arrester**

Multi-column arresters are not allowed.

9. **Pressure relief diaphragm**

The arrester shall be equipped with a pressure relief diaphragm, if it is required by the design of the surge arrester.

**XI. TESTS**

**A. Type tests (Design tests)**

The surge arresters shall be subjected to the following tests as described in IEC 60099-4 standard. Each test can be performed on the complete arrester or on a suitable arrester section, as described in the standard.

1. Insulation withstand tests on the arrester housing, including lightning impulse test and wet switching impulse test, or relevant calculations of arcing distance.
2. Residual voltage tests, including steep current impulse test, lightning impulse test and switching impulse test.

3. Test to verify long term stability under continuous operating voltage.
4. Test to verify the repetitive charge transfer rating.
5. Heat dissipation behaviour test
6. Operating duty test.
7. Power frequency voltage versus time tests, including tests with and without prior duty.
8. Short circuit tests, including high and low current tests.
9. Test to verify the bending moment of the arrester.
10. Test to verify the bending moment of the support insulators, if they are not included in previous test .
11. Seal leak rate test (only for arresters with enclosed gas volume).
12. Radio interference voltage (RIV) test or partial discharge (PD) test with measurement of internal and external discharges (without additional external shielding).
13. Test to verify the dielectric withstand of internal components, if this is not covered by the operating duty test.
14. Tests of internal grading components (if existing), including long term stability test and thermal cyclic test.
15. Weather ageing test, including salt fog test and UV light test.

**B. Routine Tests**

The following routine tests, in accordance with IEC 60099-4 shall be conducted on all arresters of the order.

1. Measurement of reference voltage.
2. Measurement of lightning impulse residual voltage on the complete arresters or on each arrester unit or on a sample of one or more resistor elements from each arrester unit.
3. Internal partial discharge test (PD) on each arrester unit.
4. Leakage test on each arrester unit (only for arresters with enclosed gas volume).

**C. Acceptance Tests**

The tests shall be performed on the nearest lower whole number to the cube root of the number of arresters of the order, in accordance with IEC 60099-4.

1. Measurement of reference voltage on the complete arrester or on each arrester unit.
2. Measurement of lightning impulse residual voltage on the complete arrester or on each arrester unit.
3. Internal partial discharge test (PD) on the complete arrester or on each arrester unit.

**D. Special Test**

The test shall be performed once for each order, in accordance with IEC 60099-4.

- Thermal stability test on three suitable arrester sections, by repeating the thermal recovery portion of the operating duty type test.

## **XII. INFORMATION WHICH MUST BE PROVIDED BY ALL BIDDERS**

The bidder shall provide the following:

1. Outline drawings of the arrester itself, the bottom plate and top plate. These drawings shall include a cross section view and a side view of the arrester and top view of the plates.
2. Technical data sheet describing the offered surge arrester and the surge counter/leakage current meter.
3. Bidder shall provide all the technical data requested in attachment "A", attached to this hereby specification.  
Incomplete submission of attachment "A" shall constitute sufficient reason for rejection of the offer.
4. Any type test certificates for the type test listed in this hereby specification. Type test certificates will be accepted only if they are fully explanatory. If the type test certificates concern resistors or units or sections and not the arrester as whole, then the following information shall be included along with the certificates:
  - a. A statement that the resistor or unit or section of the certificate is used in the offered arrester.
  - b. Total number of resistors or units or sections used in the offered arrester.

## **XIII. NAME - PLATE DATA**

The following minimum information shall appear on the nameplate of non-corrosive material, permanently attached to the arrester.

1. Manufacturer's name or trade mark, type and identification of the arrester.
2. Serial number and year of the manufacture.
3. Class, duty and designation of the arrester.
4. Continuous operating voltage ( $U_c$ ).
5. Rated voltage ( $U_r$ ).
6. Nominal discharge current ( $I_n$ ).
7. Rated short circuit current ( $I_s$ ).
8. Identification of the assembling position of the unit (for each unit of multi-unit arresters).

## **XIV. INFORMATION TO BE SUPPLIED BY THE SUCCESSFUL BIDDER**

1. Complete outline drawings (cross view, side view, top view) of the surge arrester and its metal fittings for approval (3 sets) prior to the construction of the surge arrester.
2. Drawing of the surge counter/leakage current meter.

3. Arrester characteristics of power frequency voltage versus time, with and without prior duty. The characteristics will show the temporary overvoltage (TOV) capability of the arrester.
4. Assembly instructions for the arrester itself and for the surge counter/leakage current meter.
5. Proposed maintenance instructions (if any).

#### **XV. PACKAGING**

The arresters shall be delivered in entirely closed and robust wooden boxes of at least 20mm thickness. The boxes will be of "pallet type", with strengthened base. Each box will contain one (1) arrester and all necessary assembling material.

**"ATTACHMENT A"**  
**400 kV METAL OXIDE SURGE ARRESTERS WITHOUT GAPS**

**INFORMATION BY BIDDERS**

1. Type of offered surge arrester : .....
2. External housing characteristics
  - a. Insulation material of the external housing : .....
  - b. Lightning impulse voltage withstand (1,2/50 $\mu$ s) : .....
  - c. Switching impulse voltage withstand, wet (250/2500 $\mu$ s) : .....
  - d. Creepage distance : .....
  - e. Dry arcing distance : .....
3. Number of units of which the surge arrester consists of : .....
4. Surge arrester required characteristics
  - a. Continuous operating voltage (COV)  $U_c$  : .....
  - b. Rated voltage,  $U_r$  : .....
  - c. Rated frequency : .....
  - d. Class and duty : .....
  - e. Designation : .....
  - f. Nominal discharge current  $I_n$  (8/20 $\mu$ s) : .....
  - g. Residual voltage at steep current impulse (1/<20 $\mu$ s) at 20 kA, excluding inductive voltage contribution : .....
  - h. Residual voltage at steep current impulse (1/<20 $\mu$ s) at 20 kA, including inductive voltage contribution (STIPL) : .....



- i. Residual voltage at lightning impulse (8/20 $\mu$ s)
    - at 10 kA : .....
    - at 20 kA (LIPL) : .....
    - at 40 kA : .....
  - j. Residual voltage at switching current impulse (>30/60 $\mu$ s) at 2 kA (SIPL) : .....
  - k. Thermal energy rating  $W_{th}$  : .....
  - l. Repetitive charge transfer rating  $Q_{rs}$  : .....
  - m. Rated short circuit current  $I_s$  : .....
  - n. Reference current at 20°C : .....
  - o. Range of acceptance of reference voltage at 20°C : .....
  - p. Maximum allowable resistive leakage current at 231 kV and 20°C : .....
- 5. Is the surge arrester equipped with a surge counter which also includes a leakage current meter? : .....
  - 6. Does the leakage current meter provide measurement of the resistive leakage current, using third harmonic analysis? : .....
  - 7. Are four (4) support insulators provided for the installation of the surge counter/leakage current meter? : .....
  - 8. Measuring range of the leakage current meter for the total leakage current : .....
  - 9. Measuring range of the leakage current meter for the resistive leakage current : .....
  - 10. Number of digits of the surge counter : .....

11. Maximum allowable length of cable between arrester and surge counter : .....
12. Maximum allowable length of conductor between surge counter and earthing grid : .....
13. Type of material, shape and dimensions of the line terminal : .....  
.....
14. Type of material and shape of the earth terminal : .....
15. Are all metal fittings of the arrester made of hot-dip galvanized steel or of aluminum alloy or of stainless steel? : .....
16. Are the bolts, nuts and washers which are needed for the mounting of the arrester part of the supply? : .....
17. Are the bolts, nuts and washers of hot dip galvanized steel or stainless steel? : .....
18. Is the surge arrester equipped with one or more grading rings? : .....
19. Type of material of the grading rings : .....
20. Diameter of the widest grading ring : .....
21. Required radial clearance of other metallic structures from the axis of the arrester, to ensure correct operation of the arrester : .....
22. Is the surge arrester without or with enclosed gas volume? : .....
23. Percentage of enclosed gas volume to total internal volume of arrester (if applicable) : .....
24. Is the arrester equipped with a pressure relief diaphragm?

- (if applicable) : .....
25. Seal leak rate (if applicable) : .....
26. Internal partial discharge level : .....
27. Radio interference voltage level : .....
28. Cantilever strength of the  
surge arrester : .....
29. List of all internal components of  
the surge arrester : .....  
.....  
.....  
.....
30. Technical data of any internal grading  
equipment, e.g. capacitors, resistors  
(if applicable) : .....  
.....  
.....  
.....  
.....  
.....
31. Weight of the arrester : .....
32. Indicate the size of the  
earthing lead and the type of material  
which shall consist of : .....
33. Type of silicon rubber used  
in the proposed arrester : .....
34. Is the offered silicon rubber  
hydrophobic and resistant to pollution  
and UV radiation? : .....
35. Is the surge arrester suitable for  
upright vertical mounting on steel structure? : .....
36. Lightning impulse voltage withstand  
level of the support insulators : .....
37. Does the packaging follow the  
requirements of par. XV ? : .....