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1 General

This document constitutes the Requirement Specification for the AC Arresters for the ±800 kV, 6000 MW, HVDC Raigarh to Pugalur Terminal Project. The arresters are installed to protect vital equipment against the detrimental impact from over-voltages.

The equipment shall comply with the requirements of this specification and of General technical requirements- Section 3 [1]. In case of conflicting information, this specification shall prevail.

2 Scope

This technical specification covers the requirements of design, manufacture, testing at works, packing, loading at works and transport to respective site of metal oxide gapless type arresters complete with all accessories such as insulating base, surge monitor, HV power connector, 8m of insulated interconnecting copper rod/strip between arrester and surge monitor, nuts, bolts and washers (as per section 11) for bolting the arrester units, fixing the surge monitor to structure, connecting the earthing, etc.

The equipment is required for the following project:

Name of customer : Power Grid Corporation of India Ltd (POWERGRID)

Name of the project : ±800kV, 6000MW HVDC Raigarh – Pugalur Terminals

Site : Raigarh & Pugalur

Refer section-3 of this document for project details and general specification.

3 Quantities

3.1 Raigarh and Pugalur Stations

Sl. No.	Description	Raigarh		Pugalur	
		Quantity#	Item Designation*	Quantity#	Item Designation*
1	9 kV Surge arrester complete with all accessories such as insulating base, surge counter, HV power connector, 8m length insulated interconnecting copper rod/strip of 75 sq.mm etc. Including fixing hardware as per Clause 11	8 No	=P(1,2,3,4). WT.F(3,4)	8 No	=P(1,2,3,4). WT.F(3,4)
2	Spare for Sl. No.1	3 No	Spare	3 No	Spare

*Item designation is for the purpose of name plates

Note:- Copper rod/strip shall be supplied in complete length required for all arresters on each site separately.

Final quantity may change upto ±30%

4 Deviations

The bidder shall list all the deviation from the specification separately. Offers without specific deviation will be deemed to be totally in compliance with the specification and NO DEVIATION on any account will be entertained at a later date.

5 Standards

The test procedures and test parameters of this Specification are based on IEC 60099-4, Metal oxide surge arresters without gaps for a.c. systems [3]. Where relevant, reference has also been made to Guidelines for the application of metal oxide arresters without gaps for HVDC converter stations, prepared by CIGRE Working group 33/14.05 (referred to in the following as TC33 Guidelines [4]).

6 Technical data

Minimum requirements of the electrical data and test parameters are provided in the Technical Data (TD) below.

6.1 Technical data

	Site		Raigarh & Pugalur
	Item Designation		=P(1,2,3,4).WT .F(3,4)
	Location		Converter transformer primary neutral arrester
1	Maximum continuous operating voltage, U_c, rms value	kV rms	~0
1.1	Rated voltage	kV rms	9
2	Maximum discharge voltage for 8/20 μs current wave for 10kA crest:	kV crest	25
3	Arrester housing insulation withstand		
3.1	• Lightning impulse	kV crest	50
4	Minimum discharge capability		
4.1	Line discharge class as per IEC		2
5	Partial discharges		< 10 pC
6	Maximum System voltage	kV	NA

7 Design

7.1 General

All arresters shall be of the gapless metal oxide type. An arrester may be composed of parallel arrester housings.

The design of the arresters shall take into account and shall optimize the spread in current sharing between parallel columns of the same arrester.

The features and constructional details of arresters shall be in accordance with requirement stipulated hereunder.

- a) Arresters shall be of hermetically sealed units, self-supporting construction and generally suitable for mounting on tubular support structures.
- b) The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.
- c) The arresters shall be designed to withstand a certain degree of contamination. Site pollution shall be considered as Heavy as per IEC 60815 (1986).
- d) Seals shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.
- e) The outer insulator shall be of polymer housing. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for the arrester.
- f) The end fittings shall be made of non-magnetic and corrosion proof material.
- g) Internal components shall be designed to minimize internal corona and also to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the polymer housing. Organic materials are not permitted as this may influence the reliability of the arrester.
- h) The heat treatment cycle details along with necessary quality checks used for individual blocks along with insulation layer formed across each block shall be furnished by the Bidder. Metalizing coating thickness for reduced resistance between adjacent discs shall be furnished along with procedure for checking the same. Details of thermal stability test for uniform distribution of current on individual disc shall also be furnished.
- i) The sealing arrangement of the surge arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.
- j) The cantilever strength of the surge arrester with polymer housing shall not be less than 150 kg.
- k) The surge arresters shall be fitted with pressure relief devices suitable for preventing violent failure of insulator housing and providing path for flow of rated fault currents in the event of arrester failure. Details shall be furnished in the bids along with quality checks.

Pressure relief class shall be as per Table VII of IS-3070 or equivalent

7.2 RIV Design

The arresters shall be free of external corona at the maximum continuous operating voltage to earth.

7.3 Terminals

HV-terminal to be provided with a clamp suitable for single ACSR lapwing conductor.

Terminal for earthing connections shall have a rectangular shape with two holes. Hole diameter shall be 14 mm. Distance between holes shall be 40 mm. Bolt size shall be M12. Minimum required mechanical strength of a terminal is to withstand a force of 750N in any direction. Terminals for *surge arresters* may also be manufactured of galvanized steel. The earth terminal shall be designed for the connection of a copper rod/strip of 75 sq.mm. The terminals shall be designed to meet the requirements in IEC TR62271-301.

7.4 Insulators

The insulators shall be of polymer type.

1 Polymer insulators

Color of polymer insulators shall comply with requirements as per IEC61462. The color shall preferably be grey, RAL 7035 or similar. Other colors may be used after approval from BHEL

The minimum nominal specific creepage distance is 43 mm/kV; base for creepage distance is U_c . Polymer housings shall be provided with pressure relief devices.

7.5 Seismic requirements

The arrester shall conform to the seismic requirements as specified in General technical requirements- Section 3.

7.6 Surface treatment

The equipment shall have sufficient corrosion resistance by the use of corrosion resistant materials or by using coatings. The choice of protection shall be based on the environmental classification given in ISO 12944-2 (1998). The environmental class shall be C3.

Hot dip galvanized coating on fabricated iron and steel articles shall be according to ISO 1461(1999). A special moisture and fungus resistant varnish shall be applied to parts, which may be subject or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface or part where the treatment shall interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

7.7 EMC Design

N. A.

7.8 Accessories

7.8.1 Surge counters

Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole/ phase unit along with necessary connection. Suitable leakage current meters for the arresters with no key interlocking system during operation should also be supplied within the same enclosure. The reading of the ammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends.

Surge monitor consisting of discharge counters and milliammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard mounting pad.

Discharge counters shall be mounted on support structure of the arrester and surge counters and leakage current meter shall be located in such a way that the readings can be taken during energised condition of the equipment. Connection between the Surge Arrester base and Surge Monitor shall be through a 8.0 m (minimum) long insulated copper rod/strip of at least 75 sq.mm area. The rod/strip shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material. Total length (instead of pieces) of the insulated copper rod/strip for all arresters shall be supplied to each site separately.

7.8.2 Base

All installed arresters with surge counters shall be equipped with an insulating base.

7.9 Section of an arrester

As per IEC 60099-4, section 3.61.

Several tests are performed on a section of an arrester (prorated section according to TC33). A section of an arrester is a complete, suitably assembled part of an arrester, comprising all necessary components in such proportion to accurately represent, for a particular test, the characteristics of a complete arrester. A section of an arrester is not necessarily a unit of an arrester. A section of an arrester may, for a certain test, be a single block.

7.10 Reference voltage

The reference voltage of an arrester is defined in IEC 60099-4, section 6.2. The reference current should be defined by the manufacturer in the Routine Test Report.

The reference voltage of a multi-unit arrester is the sum of the reference voltages of the individual units.

7.11 Current sharing requirements

The background for the requirements on current sharing is given in TC33 Guidelines, section 6.4.

7.12 Thermal stability

The thermal stability of a ZnO arrester is its ability to discharge a specified energy without thermal runaway under subsequent transient and steady state voltage conditions.

The operating conditions, for which the thermal stability is defined, generally consist of an initial energy discharge followed by an over-voltage sequence followed by the maximum continuous operating voltage.

Reference is also made to this matter in the IEC 60099-4, section 9.2.2.

8 Nameplates

General requirements on nameplates may be specified in General technical requirements- Section 3. The material of nameplate shall be stainless steel. The information on the nameplates shall be in accordance with IEC 60099-4, section 4.1

9 Environment

The arresters will be placed outdoors in the switchyard.

The converter stations environment is defined as sub-tropical with a preponderance of high temperature and high humidity.

10 Quality program

The quality program level to be applied by the Supplier is ISO 9001 or equivalent. An Inspection and Test Plan (ITP) covering, as a minimum but not limited to, all routine tests, type tests and verifications, etc. as specified in this Requirement Specification shall be issued for approval. The ITP shall also cover Customer Witness Points, based on current market praxis, and the basic in-process inspections normally performed during production by the Supplier.

11 Fixing Hardware

Hot dip galvanized (M10 and above) or electro-galvanized (below M10) hardware shall be provided for the following, as applicable.

- Bolting of individual arrester units and unit to insulating base.
- Bolting of insulating base to steel structure / concrete pedestal.
- Bolting the surge monitor to structure / concrete pedestal.
- Bolting the HV and LV terminals to the arrester.
- Bolting the interconnecting copper lead from arrester earth terminal to surge monitor.

12 Routine tests

12.1 Tests on blocks

12.1.1 Energy withstand test

The purpose of this test is to ensure that no block with a reduced energy capability is accepted for assembly.

The test shall be performed by subjecting all blocks to high-energy impulses with cooling to room temperature allowed between each.

Blocks with insufficient energy capability shall be rejected.

12.1.2 Routine residual voltage test

The test shall be as per IEC 60099-4, section 9.1 b.

The residual voltage for a suitable impulse current in the range 0.5 to 10 kA impulse shall be measured and recorded for each block (e.g. by printing on the block).

Acceptance criteria for the test shall be stated in the Routine Test Report.

12.2 Tests on sections of the arrester

A section of the arrester is a complete, suitably assembled part of an arrester necessary to represent the behavior of a complete arrester with respect to a particular test. See IEC 60099-4, section 3.61.

12.2.1 Current sharing test

N.A.

12.2.1.1 Simultaneous testing of parallel columns

N.A.

12.2.1.2 Matching of groups

N.A.

12.3 Tests on arrester units

An arrester unit is defined as an assembled unit with end fittings, as per IEC 60099-4

12.3.1 Current sharing test between parallel arrester units

N.A.

12.3.1.1 Matching of arrester units

N.A.

12.3.2 Arrester residual voltage

The residual voltage of the arrester unit may be determined by adding the residual voltage measured in section 12.1.2 for all series connected blocks.

The total residual voltage of each complete arrester is determined by adding the residual voltages of each arrester unit. The residual voltage limits for the arrester shall be specified in the Routine Test Report for the complete arrester.

12.3.3 Reference voltage test

The reference voltage of an arrester is defined in IEC 60099-4, section 9.1 a. The reference current should be defined by the manufacturer in the Routine Test Report.

A reference voltage test shall be performed on each arrester unit at the reference current.

Necessary information defining the minimum reference voltage of a complete arrester design shall be presented in the Routine Test Report. The test shall verify that the sum of the reference voltages measured on the arrester units is higher than or equal to the pre-defined value for the complete arrester.

12.3.4 Internal partial discharge test

The test is performed at an equivalent power frequency voltage for the arrester unit corresponding to the value of the complete arrester as defined in section 6. The internal partial discharge levels shall be measured in accordance with the provisions of IEC 60270. The acceptance level for the partial discharges shall be a steady state level less than 10 pC.

Additional corona shielding of external parts is permitted for the internal partial discharge tests, provided that internal voltage grading is not affected by the shielding.

12.3.5 Leak test

As per IEC 60099-4, section 9.1 e, valid only for units with enclosed gas volumes.

12.4 Tests on block batches

The purpose of these tests is to ensure that all batches of blocks meet the requirements on energy absorption and ageing proven by the type tests. The manufacturer shall propose suitable tests for this purpose for the approval of ABB AB, HVDC. The tests shall be included in the Inspection and Test Plan (ITP).

12.5 Test on surge counters

The surge counters shall be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficiency of the same. Additional routine/functional tests with one 100A (switching surge) and 10kA current impulse, (8/20μs) shall be performed on the surge counter.

Surge monitors shall be routinely tested for water dip test at 1.5m for 30 minutes. No water vapors shall be visible on the monitor glass.

13 Type tests

The bidder shall offer type tested equipment for the project and the Employer shall accept the equipment type test reports under the following conditions:

- (i) Type test in accordance with the IEC 60099-4
- (ii) Type tests performed within ten (10) years from the date of 28th July 2015
- (iii) The type tested equipment shall be of the same design, insulation class and rating as per the equipment offered under this contract

In the event that equipment furnished includes important modifications of, or significant departure from, the designs of equipment on which type test report has been furnished or if there is evidence that the equipment does not comply with the requirements of the Specifications, type test procedure was not properly followed as laid down in standards, the bidder shall conduct the type tests without any cost implication to the Purchaser.

13.1 Residual voltage test

As per IEC 60099-4, section 8.3.

Residual voltage tests shall be carried out on three samples of section of an arrester, consisting of single blocks. The following tests shall be performed on each section of an arrester in open air.

- Steep current impulse residual voltage test
- Lightning impulse residual voltage test
- Switching impulse residual voltage test

The highest measured voltage versus the current per column shall be presented as a curve. The voltage shall be presented in relation (p.u.) to the maximum measured voltage at a certain current. The current amplitude defining this base voltage, guaranteed residual voltage, shall be the same as used in the routine test in section 12.1.2.

The residual voltage of the complete arrester is defined by this curve and the sum of the residual voltages measured on individual blocks in the routine test in section 12.1.2.

The residual voltage at the specified current for an arrester with more than one column is obtained from the curve defined above, for a current equal to the specified current divided by the number of parallel columns.

13.1.1 Steep current impulse residual voltage tests

This test shall be applicable if steep current ratings are defined in section 6.

The test shall be as per IEC 60099-4, section 8.3.2. The voltage crest values shall not exceed the protection characteristics defined in 6. The current range shall be 2-20 kA unless a higher current per column is specified in 6.

13.1.2 Lightning impulse residual voltage test

As per IEC 60099-4, section 8.3.3.

The voltage crest values shall not exceed the maximum protection characteristics defined in section 6. The current range shall be 0.1-20 kA unless a higher current per column is specified in section 6.

13.1.3 Switching impulse residual voltage test

As per IEC 60099-4, section 8.3.4.

The voltage crest values shall not exceed the maximum protection characteristics defined in section 6, nor be less than the minimum value, when such is defined. The current range shall be 0.1 to 3 kA unless a higher current per column is specified in section 6.

13.2 Operating duty test

A description of the operating duty test is provided in IEC 60099-4, section 8.7. The full test sequence is illustrated in Figures 3 in IEC 60099-4.

The discharge energy of the section of an arrester shall be increased with the differential ratio between the maximum tolerated current deviation (β in accordance with section 12.2.1) and the current deviation actually measured in section 13.2.1. See also TC33 Guidelines, section 7.1.7.

If matching of parallel arrester units is performed in the routine testing of the arresters, the discharge energy shall be further increased as defined in section 12.3.1.1.

13.2.1 Current sharing test

N.A.

13.3 Test to verify long term stability under continuous operating voltage

As per IEC 60099-4, section 8.4.

13.4 Verification of thermal prorated section

As per IEC 60099-4, Appendix B.

13.5 Accelerated ageing procedure

As per IEC 60099-4, section 8.4.

13.6 Short-circuit test

A short circuit test shall be carried out in accordance with IEC 60099-4, Section 8.10.

If nothing else is defined in section 6 the arrester shall be tested with a symmetrical fault current of 40 kA .

13.7 Insulation withstand test of the arrester housing

Insulation withstand tests shall be carried out in accordance with IEC 60099-4, section 8.2.

Test voltages shall be as stated in IEC 60099-4.

14 Acceptance tests

The acceptance tests shall be carried out by the supplier on arresters of each type and rating as per IEC 60099-4, clause 9.2.

1.	Reference Voltage Measurement	9.2.1a)
2.	Lightning Impulse Residual Voltage Test	9.2.1b)
3.	Partial Discharge Test	9.2.1c)

14.1 Special acceptance tests

1. Thermal stability test on three sections
2. Aging test for Zinc oxide blocks as an acceptance test is to be carried out on 3 samples for 72 hours at maximum continuous over voltage (MCOV) and at a temperature of 115°C. Acceptance norm being I_r (resistive current)/watt loss shall remain or decrease at the end of 72 hrs from the value taken after 1 hour of start of test.
3. Wattloss test

15 Tests on insulator

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

16 Verifications

The below design verifications are to be performed by means of verifying reports in lieu of performing corresponding tests. The reports shall be sufficiently detailed in its justification to facilitate and support the approval of each clause to be verified. Additionally mounted equipment shall be duly considered when influence is applicable.

The verification reports and its supporting documents, e.g. reports on previous tests etc., shall be referred to in, and submitted with, the ITP. If verifications are still “to be done” at the submittal of the ITP, the text “To be verified” shall be written in the ITP.

16.1 Seismic requirements

Fulfillment of the seismic requirements shall be verified.

16.2 EMC Requirements

N.A

16.3 Declaration of conformity

A Declaration of Conformity (DoC), including references to applicable EU Directives and, when applicable, referenced equipment standards, shall be issued. The Technical Construction File (TCF), supporting the DoC, shall be stored by the supplier and ready to be submitted at the latest two weeks after request. The operation and maintenance manuals, including assembly and installation instructions, must include safety precautions and adequate warnings for

equipment related hazards to personal safety when handling the equipment. In case of no applicable EU Directive for the equipment, a written statement confirming this fact shall be issued. Such a statement must explain why this is the case and before issuing, at least the following EU Directives shall be considered:

- Machinery Directives
- Low Voltage Directive

16.4 External corona

N.A.

17 Enclosures

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18 References

- [1] *TB-391-316-000*, General technical requirements- Section 3
Generally applicable clauses are 3.1 to 3.11; 3.13, 3.14, 3.16.2, 3.16.4, 3.17, 3.18, 3.22, 3.25.
- [2] Not used
- [3] IEC 60099-4, Metal oxide surge arresters without gaps for a.c. systems.
- [4] CIGRE 33-14.05 Publication 34, (TC33) Guidelines for the application of metal oxide arresters without gaps for HVDC converter stations
- [5] IEC 60270, Partial discharge measurements