

Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

**General Technical Specification and
Execution Procedures for Transmission
and Subtransmission Networks
Lightning Arrester at
High Voltage Substations**

NO: 501- 1

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CONTENTS

<u>DESCRIPTION</u>	<u>PAGE</u>
1- General requirements	3
2- Design and construction	3
3- Surge counter	4
4- Name plate	5
5- Tests	5
5.1- Type tests	5
5.1.1- Type tests on porcelain hosed surge arrester	5
5.1.2- Type tests on polymer housed surge arrester	6
5.2- Routine tests	6
5.3- Acceptance tests	6
6- Drawing & documents	7
6.1- Documents to be given tenderer	7
6.2- Documents to be given by contractor/ supplier	7
7- Packaging, shipment and installation	8
8- Commissioning	8
8.1- Primitive inspection	8
8.2- Commissioning test	8

Technical Specification of Lightning Arrester



1- General requirements

This specification covers the requirements for the design, manufacturing and factory testing of ZnO lightning arresters.

Arrester shall be designed, manufactured and tested in accordance with the applicable requirements of this specification and latest revision of IEC 60099 and ISO 1461, included all amendments, supplements and references publications listed within the above standard unless different specified in this technical specification.

For proper operation, each arrester must be have any characteristics in Schedule LA(I) of this specification and be suitable for use at the specified site and environmental conditions.

2- Design and construction

The design of the arresters shall be such that a reasonably uniform potential drop exists across each section of the arrester regardless of any distortion of the electrostatic field or the presence of fog or water on the arrester porcelain.

The arrester units shall be interchangeable with like rated units of the same type.

The arresters shall be such designed to facilitate inspection and to ensure satisfactory operation under atmospheric conditions.

Arresters shall be such designed and manufactured prevailing at site and under such sudden variation of voltages as may be met with under working conditions on the system.

Metal oxide non-linear resistance blocks shall have uniform thermal and current density distribution. The material design of non-linear resistance blocks shall be such that under specified severe condition specially under temporary over voltages, thermal runaway shall not occur.

The resistance block units shall have an insulation covering at the edges with suitable mechanical and electrical strength to protect and eliminate flashovers at the edges.

The contact surface of the blocks shall have metallic or other treatment for improving the contact between blocks themselves and end connections.

Manufacturer shall submit power frequency voltage characteristic to time curve for determining of thermal stability time of surge arrester because of temporary over voltages.

The method of assembly of the arrester shall be such that adequate contact pressure at all time maintained between the faces of the series non-linear resistance blocks. The design of the lightning arrester shall be such that it cannot be affected by vibration, mechanical shock or change in temperature. The design shall be such that the protection level shall not be affected by pollution of the external insulation.

All joints shall be made in an approved manner such that the diverter is hermetically sealed with material which will not deteriorate under any service conditions.

Each arrester shall be fitted with pressure relief.

The sealing of arrester such that it shall not be affected by transportation and live washing of arrester shall be possible while in service.

Partial discharge value at $1.05 U_c$ shall not exceed from 50 pC.

The arresters shall be mechanically dimensioned for stresses from tensile force of terminals, wind and ice load as well as earthquake forces.

It shall be suitable for pedestal mounting on support steel structure or bracket mounting on power transformer.

Surge arrester shall be equipped with hot galvanizing terminals and clamps for connecting surge arrester to high voltage side and earth by aluminum or copper conductor.

Housing of arrester shall be made of appropriate insulator.

All components exposed to corrosion shall be made of non - corrosive material, or be hot galvanized according to ISO-1461.

3. Surge counter

Surge counters shall be of static components with the electromechanical type counter and suitable for continuous service without required any auxiliary source.

They shall be robust and capable of withstanding repeatedly without damage, the maximum discharge current of the arrester. Internal parts shall be unaffected by atmospheric conditions on site. Alternatively a weather-proof housing shall be provided and this shall be designed to allow the recording device to be read without exposing the internal parts to the atmosphere.

The counter shall be connected in the main earth-lead from the arrester in such a manner that its surge impedance not materially altered.

Bolted links shall be provided so that the surge counter may be short circuited and removed without taking the arrester out of service.

The arrester base shall be insulated from the ground and be connected to the counter by insulated cable.

The output terminal of counter shall be earthed directly by bare copper conductor. The insulated cable and bare connections shall have adequate thermal and mechanical strength for the duty they are employed for.

A leakage current detector should be provided as an integral part of surge counter and it should be so placed that leakage current can be read easily from ground level. The value of leakage current beyond which the operation is abnormal shall be clearly marked in red color.

4. Name plate

The arrester shall be equipped with stainless steel or anodized sheet of aluminum rating plates, fixed in a visible position showing the following information:

- Continuous operating voltage
- Rated voltage
- Rated frequency
- Nominal discharge current
- Pressure relief rated current in kA_{rms}
- Line discharge class
- Contamination withstand level of enclosure
- The manufacture name or trademark, type and identification of the complete arrester.
- The year of the manufacture
- Serial number

The inscription shall be made by etching, engraving, stamping or other approved methods.

5. Tests

Type test and routine and special tests shall be carried out in accordance to latest edition of IEC standard 60099-4 including:

5.1. Type tests

According to the types of surge arresters the following tests shall perform:

5.1.1. Type tests on porcelain hosed surge arrester

- Insulation withstand tests (on the housing) under dry and wet conditions
- Residual voltage tests for defining the protective levels of the arresters
- Long duration current impulse withstand test for showing the ability of the resistor elements to withstand possible dielectric and energy stresses without puncture or flashover
- Pressure relief test for showing the ability of the arrester housing to withstand short circuit currents without violent shattering of the housing under specified test conditions
- Artificial pollution tests

- Operating duty test for showing the thermal stability of the arrester under defined conditions
- Partial discharge test

5.1.2. Type tests on polymer housed surge arrester

- Insulation withstand tests on the arrester housing
- Long duration current impulse withstand test
- Operating duty tests
- Tests of arrester disconnectors/ fault indicators
- Artificial pollution tests
- Moisture ingress test demonstrates the ability of the arrester to resist ingress of moisture after being subjected to specified mechanical stresses
- Weather ageing test to demonstrates the ability of the arrester to withstand specified climatic conditions (this test does not apply to polymer housed arresters intended for indoor use only)

5.2. Routine tests

- Measurement of reference voltage (U_{ref})
- Residual voltage tests
- Partial discharge and contact noise test according to IEC 60270
- Leakage test for sealed housing arresters
- Performance test on surge counter
- Current distribution test for multicolumn arresters
- Residual voltage tests

5.3. Acceptance tests

The following tests shall be made on the nearest lower whole number to the cubic root of the number of arresters to be supplied:

- Measurement of power frequency voltage at the reference current
- Lightning impulse residual voltage test
- Partial discharge test at rated voltage for $t < 10$ sec and 1.05 time its continuous operating voltage.

6. Drawing & documents

6.1. Documents to be given by tenderer

- Filled schedule LA (II)
- Catalogue and technical pamphlets of arrester and counter
- Summary of type test reports
- Outline drawing
- Detailed summary of exceptions to tender specifications
- Reference list
- List of special tools
- List of spare parts

6.2. Documents to be given by contractor/ supplier

The electrical and mechanical design, fabrication, factory testing, working, packing, transportation, warehousing, erection, site test, operation and maintenance drawings, documents and manuals shall be submitted but not limited to the following:

- Design calculation sheets to establish adequacy of arresters in any respect
- Outline dimension and cut- away drawings of arresters including component arrangement and H.V terminals
- Loading on structure and foundation
- Nameplate drawings
- Internal circuit drawings
- Predictive maintenance manual
- Leakage current detector reading for different operation condition of surge arrester
- Predictive test sheets of counter and surge arrester
- Packing details
- Shipping, warehousing, assembly, erection, commissioning, operating and maintenance instruction manuals
- Documents related to specific absorbed energy capability curve
- Site tests instruction manuals
- List of components
- Routine test certificates

- Type test documents
- Work schedules and monthly progress report
- Final as built Doc/Dwg
- Dismantling, reassembling & adjusting manuals

7. Packaging, shipment and installation

To insure maximum safety during transport, the arresters shall be packed in specially designed crates which will provide protection against all normal transport and handling forces. It is essential that the crates are located at all times the correct way up, as indicated by the arrow marking on the outside of the crates.

The crates shall not be stood up vertically on end, due to the danger of falling over.

Before removing the arrester units, carefully inspect each packing crate for damage indicative of dropping or mishandling.

The crates are designed with apertures on all sides, so that any damage to the porcelain housing of the arrester will be visible.

Each arrester should be carefully re-inspected for damage of any kind after removal from the packing crate.

If any damage is found or suspected, the arrester shall not be installed.

The arrester shall install in accordance with manufacturer instruction.

8. Commissioning

After surge arrester has been installed and all connections have been completed, commissioning tests are recommended to be performed to confirm that transportation and storage have not damaged the surge arrester.

8.1. Primitive inspection

- Visual inspection of connections (structure and high voltage terminals)
- Visual inspection of earthing connection conductor
- Visual inspection of insulators and cleaning them

8.2. Commissioning test

- Insulating resistance measurement with MEGGER
- Leakage current measurement
- Correctness operation test of surge arrester counter

Schedule LA (I)
Rating and characteristics of lightning arrester

ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
2.5	Relative humidity %	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95
2.6	Pollution level	Low/medium/ high/very high	Low/medium/ high/very high	Low/medium/ high/very high	Low/medium/ high/very high	Low/medium/ high/very high	Low/medium/ high/very high
2.7	Solar radiation W/m ²	*	*	*	*	*	*
2.8	Seismic acceleration g	0.2/0.25/0.3/0.35	0.2/0.25/0.3/0.35	0.2/0.25/0.3/0.35	0.2/0.25/0.3/0.35	0.2/0.25/0.3/0.35	0.2/0.25/0.3/0.35
2.9	Max. wind velocity m/s	20/30/40/45	20/30/40/45	20/30/40/45	20/30/40/45	20/30/40/45	20/30/40/45
2.10	Wind velocity at ice condition m/s	20	20	20	20	20	20
2.11	Keraunic level Days/year	*	*	*	*	*	*
2.12	Ice coating thickness mm	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25
2.13	Unusual operation conditions	**	**	**	**	**	**
3	Arrester duty						
3.1	Class Outdoor/ indoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor
3.2	Connection in system	Phase to earth	Phase to earth	Phase to earth	Phase to earth	Phase to earth	Phase to earth
3.3	Distance between arrester and latest protected equipment.	Specified from layout and in conformity with engineer opinion	Specified from layout and in conformity with engineer opinion	Specified from layout and in conformity with engineer opinion	Specified from layout and in conformity with engineer opinion	Specified from layout and in conformity with engineer opinion	Specified from layout and in conformity with engineer opinion
4	Characteristics of arrester						
4.1	Continuous operating voltage kV	$\geq \frac{24}{\sqrt{3}}$	$\geq \frac{36}{\sqrt{3}}$	$\geq \frac{72.5}{\sqrt{3}}$	$\geq \frac{145}{\sqrt{3}}$	$\geq \frac{245}{\sqrt{3}}$	$\geq \frac{420}{\sqrt{3}}$
4.2	Rated voltage kV	18/21/24	30/33/36	54/60/66/72	108/120/132	180/192/204/216/228	342/360/378/396
4.3	Line discharge class according to IEC 60099-4	1/2	1/2	2/3	2/3	2/3/4	3/4/5
4.4	Nominal discharge current with 8/20 μsec wave shape kA _{peak}	10	10	10	10	10	10/20

Rating and characteristics of lightning arrester

ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
4.5	Residual voltage:						
4.5.1	Max. 8/20 μ sec lightning impulse current residual voltage	kV _{peak}	*	*	*	*	*
4.5.2	Max. 30/80 μ sec switching impulse current residual voltage	kV _{peak}	*	*	*	*	*
4.6	Min. insulation withstand level of surge arrester enclosure in standard condition:						
4.6.1	Against power frequency voltage	kV _{rms}	*	*	*	*	*
4.6.2	Against standard lightning impulse	kV _{peak}	*	*	*	*	*
4.6.3	Against standard switching impulse	kV _{peak}	*	*	*	*	*
4.7	Creepage distance of surge arrester insulator	mm	*	*	*	*	*
4.8	Washable in service	Yes/No	Yes	Yes	Yes	Yes	Yes
4.9	Color of insulator		Brown/ Gray	Brown/ Gray	Brown/ Gray	Brown/ Gray	Brown/ Gray
4.10	Type of insulator		porcelain/ polymer	porcelain/ polymer	porcelain/ polymer	porcelain/ polymer	porcelain/ polymer
5	Additional equipment:						
5.1	Surge counter (Yes/No)	One phase/ three phase	*	*	*	*	Yes Yes
5.2	Type of counter		Pionter	Pionter	Pionter	Pionter	Pionter
5.3	Leakage current detector provided?	Yes/ No	*	*	*	*	*
5.4	Number of impulse counter	One in each phase/ one in three phase	*	*	*	*	*

**Schedule LA (I)
Rating and characteristics of lightning arrester**

ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
5.5	Base of surge arrester insulated Yes/ No	Yes	Yes	Yes	Yes	Yes	Yes
5.6	Type of high voltage terminal Module/ pin	*	*	*	*	*	*
5.7	Corona ring Yes/ No	No	No	No	No	Yes	Yes
5.8	Portable leakage current detector provided? Yes/ No	***	***	***	***	***	***

*: These will be specified by engineer.

** : Unusual operation conditions are included the following:

- Smoke and vapor which may cause surface corruption of insulation and accessories.
- Existence of moisture, damp, rain and water vapor beyond the limits.
- Mixture with exploding possibility containing dust, gas and smoke.
- Unusual mechanical condition such as: earthquake, vibration, excessive wind velocity, high ice loading and large lever forces.
- Unusual conditions during transportation and ware housing.
- Heat producer sources adjacent to surge arrester.

***: It's better to select according to operator opinion.

Schedule LA (II)
Guaranteed technical information of lightning arrester
(To be supplied with tender)

ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
1	General						
1.1	Manufacture's name and country						
1.2	Manufacture's type designation						
1.3	Manufacture's name of ZnO discs						
1.4	Class and type						
	Outdoor/ indoor						
1.5	Applicable standard						
1.6	Applicable site and ambient conditions:						
1.6.1	Max. design ambient temperature						
	°C						
1.6.2	Min. design ambient temperature						
	°C						
1.6.3	Max. average value of daily temperature						
	°C						
1.6.4	Design altitude above sea level						
	m						
1.6.5	Pollution level						
1.6.6	Max. permissible ice thickness						
	mm						
1.6.7	Design seismic acceleration						
	g						
1.6.8	Max. permissible wind velocity						
	m/s						
1.7	Document (test reports/ outline drawings/ catalogues/ maintenance & installation manuals/ instruction manuals/ references/ list of spare parts)						
2	Rated values & characteristics						
2.1	Continuous operating voltage						
	kV _{rms}						
2.2	Rated voltage						
	kV _{rms}						

Schedule LA (II)
Guaranteed technical information of lightning arrester
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ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
2.3	Rated frequency	Hz					
2.4	Reference voltage (under defined ambient temperature)	kV _{rms}					
2.5	Reference current (under defined ambient temperature)	A					
2.6	Continuous current (under defined ambient temperature):						
2.6.1	Resistive component	mA					
2.6.2	Capacitive component	mA					
2.6.3	Total continuous current	mA					
2.7	Max. residual voltage for lightning impulse current with 8/20 µsec wave shape:						
2.7.1	With 5 kA peak value	kV _{peak}					
2.7.2	With 10 kA peak value	kV _{peak}					
2.7.3	With 20 kA peak value	kV _{peak}					
2.8	Max. residual voltage for switching impulse current with 30/80 µsec wave shape:						
2.8.1	With 500A peak value	kV _{peak}					
2.8.2	With 1kA peak value	kV _{peak}					
2.8.3	With 2kA peak value	kV _{peak}					
2.8.4	With 3kA peak value	kV _{peak}					
2.9	Max. residual voltage for steep current impulse with 1/20 µsec wave shape:						
2.9.1	With 10kA peak value						
2.9.2	With 20kA peak value						

Schedule LA (II)
Guaranteed technical information of lightning arrester
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ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
2.10	Nominal discharge current						
2.11	Line discharge class as per IEC 60099-4						
2.12	Specific absorbed energy capability						
2.13	Power frequency voltage versus time characteristics included?						
2.14	Max. internal partial discharge at 1.05U _c						
2.15	High current/ short duration impulse withstand						
2.16	Low current/ long duration impulse withstand (Rectangular wave):						
2.16.1	Peak current						
2.16.2	Virtual duration of peak						
2.17	Pressure relief capability						
2.18	Thermal capability to discharge a line with following characteristics:						
2.18.1	Thermal capability						
2.18.2	Length of line						
2.18.3	Surge impedance of line						
2.18.4	Subjected to a switching surge						
2.19	Max. RIV level measured at $\frac{1.1U_m}{\sqrt{3}}$ and 1MHz						
2.20	Will the voltage and currents (protected level) be affected by pollution on external insulation						
3	Constructional features						
3.1	Dimension of ZnO discs (diameter×height)						
3.2	Dimension of surge arrester						
3.3	Total weight of arrester						
3.4	Sealing method of complete arrester						
3.5	Method used to sealing test						

Schedule LA (II)
Guaranteed technical information of lightning arrester
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ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
4	External insulation						
4.1	Manufacturer's name and type of designation						
4.2	Manufacturers country						
4.3	Material						
4.4	Max. diameter of insulator						
4.5	Total external creepage distance						
4.6	Washable in service?						
4.7	Type of grease (if any) applied to insulator						
4.8	Rated power frequency short duration withstand voltage:						
4.8.1	Dry						
4.8.2	Wet						
4.9	Quantity of used section arrester in each phase						
4.10	Lightning impulse withstand voltage						
4.11	Switching impulse withstand voltage						
4.12	Static bending failing load:						
4.12.1	Horizontal						
4.12.2	Vertical						
4.13	Dynamic bending failing load						
4.14	Type of insulator						
5	Surge counter						
5.1	Manufacturer's type designation						
5.2	Manufacturer's country						
5.3	Sensitivity of surge counter (minimum for operation)						
5.4	Corresponding test wave shape for operation assurance						

Schedule LA (II)
Guaranteed technical information of lightning arrester
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ITEM	DESCRIPTION	TECHNICAL PARTICULARS					
		20 kV	33 kV	63/66 kV	132 kV	230 kV	400 kV
5.5	Peak voltage across counter when tested for operation						
5.6	Arrester continuous current monitoring unit included into surge counter?						
5.7	Alarm facilities for arrester deterioration?						
5.8	Magnitude of continuous current when starting deterioration						
5.9	Number of counter						
5.10	Max. range of indicator plate of leakage current						
5.11	Cable between arrester and counter						
5.11.1	Manufacturer and type						
5.11.2	Electrical withstand level						
5.11.3	Cross section						
6	Terminals						
6.1	Type						
6.2	Material						
6.3	Corona starting voltage						
6.4	Rated current						
6.5	Static bending failing load:						
6.5.1	Horizontal						
6.5.2	Vertical						
6.6	Dynamic bending failing load						
6.7	Corona ring						
6.7.1	Number						
6.7.2	Diameter						