

**Islamic Republic of Iran**  
**Vice Presidency for Strategic Planning and Supervision**

**General Technical Specification and  
Execution Procedures for Transmission  
and Subtransmission Networks  
Lightning Protection at  
HV Substations**

**NO: 485**

**Office of Deputy for Strategic Supervision  
Bureau of Technical Execution System  
<http://tec.mporg.ir>**

**Energy Ministry - Tavanir Co.  
Power Industry Technical Criteria  
Project  
[www.tavanir.ir](http://www.tavanir.ir)**



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# **Lightning Protection**





## **1. General**

This specification covers the requirements for the rating, material, design, construction, testing and installation of lightning protection system equipment. It shall be designed, manufactured and tested in accordance with the latest edition of the IEEE 998, IEC 60888, IEC 61089, DIN 185, DIN 101 and reference publications listed within.

## **2. Shielding wire**

Shielding wire shall be stranded galvanized steel wire or aluminum clad steel wires (AS or AW). The cross section and the type of the guard wires shall be as specified.

## **3. Lightning mast**

Lightning mast shall be twisted galvanized steel wire or aluminum clad steel twisted. The cross section of the lightning mast shall be as specified.

## **4. Riser conductors**

Conductors use for connection guard wires and lightning masts to earthing system shall be copper conductors, chosen to directly earth the shield wires, through the dead end pressure clamps. Cross section of the riser conductor shall be as specified. Material and mechanical strength of the buried conductors have to be suitable to carry the earth fault current and maximum duration at restrict temperature rise under fault condition

## **5. Joints and connectors**

Shield wire shall be connected to the steel structures through suitable joints and connectors which are consisted of turn buckle, U bolts, dead end pressure clamps, yoke plates, shekels and parallel groove clamps. Dead end pressure clamps shall be as such to have a solid connection with riser conductors. Dead end clamp connects on one side shield wire with aluminum or galvanized steel material and on another side to riser conductor with copper material. There for the clamp should be protected against corrosion, eg. by bimetal ...

Lightning mast shall be connected to the steel structures and riser conductors through suitable joints and connectors such as base terminal and plate clamps. Base terminals which is used for connection of lightning mast to structure shall have hard connection with structure surface and can withstand mechanical forces from lightning mast. Clamps shall be non-corrosive and appropriate for electrical connection of lightning mast to earthing system. All joints and connectors have to be suitable to carry the earth fault current and maximum duration at restrict temperature rise under fault condition.

## **6. Name Plate**

The name plate shall be from weather proof and corrosion proof material.

### **6.1. Shield wire**

On each package or conductor drum, the name plate with following information shall be installed:

- No of contract.
- Dimension of drum or packing.
- Total weight and cross section of conductors of drum or packing.
- Net Wight of conductor or equipment on drum or packing.
- Item No. of material.
- Length of conductor in the drum.

### **6.2. Lightning mast**

On each package name plate following information shall mention:

- No of contract
- Total weigh and cross section of conductors of packing.
- Item No. of material.
- Total quantity of lightning mast in package.

## **7. Tests**

Testing the shield wires and riser conductors shall be performed to ensure that design and material conform to the specification.



## **7.1. Guard wires**

All the following type and sample tests shall be performed according to the latest edition of the IEC 61888, 61089 and 61889.

### **7.1.1 Type test**

- Stress- strain curves
- Breaking strength of conductor

### **7.1.2. Sample tests**

- Strain on wires
- Stress at 1 percent extension on steel wires
- Wrapping for steel wires
- Zinc coating in steel wires
- Cross section area of conductor
- Overall diameter of conductor
- Weight per unit length of conductor (linear density)
- Breaking strength after stranding
- Surface condition of conductor
- Lay ratio and direction of lay of conductor
- Electrical resistance
- Galvanizing test

## **7.2. Riser conductors test**

All the following sample tests shall be performed on riser conductor according to the lasted edition of the BS 125 and DIN 48201 standards.

- Strain on copper wires
- Wrapping
- Diameter measurement of wires
- Strain on conductor

- Weight per unit length of conductor
- Outer surface of conductor
- Lay ration and direction of lay of conductor
- Electrical resistance measurement
- Bending tests
- Stiffness tests

## **8. spare parts and special tools**

The manufacturer recommended spare parts for 5 years trouble free operation and any special tools deemed necessary for erection, maintenance operation and repair, shall be provided.

## **9. Drawing and documents**

### **9.1. Document to be given by tender**

- Filled schedule of direct lightning stroke protection system
- Cataloged and technical pamphlets
- Outline drawing
- Detailed summary of exceptions to tender specifications
- List of supplied direct lightning stroke protection systems
- Spare part list
- Especial tool list
- Summary of test reports
- Packing, shipping, warehousing, erection and operating instruction manuals

### **9.2. Documents to be given by contractor/supplier**

The design, fabrication, factory test, packing, marking, shipping, warehousing, erection, site tests, operation repairing and maintenance documents and electrical and mechanical drawing and manuals of direct lightning strode protection shall be submitted but not limited as follows:

- Calculation sheets to establish adequacy of direct lightning protection system in any respect.
- Outline drawings.
- Drawing that specify dimension and shape of drums, weight, type, size and other specifications.
- Complete descriptions of the cleaning of the conductor.
- Erection, operating and maintenance instruction manuals.
- Site tests instruction manuals.
- Equipment list.
- Packing, shipping and warehousing details.
- Tests reports and certification of compliance.
- Monthly work progress report.
- Time schedules.
- Drawings list.

**Schedule Direct Lightning's Stroke Protection (1)  
Rating And Characteristic**

ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
<b>1</b>	<b>Standard</b>	IEC, IEEE, BS, DIN	IEC, IEEE, BS, DIN	IEC, IEEE, BS, DIN	IEC, IEEE, BS, DIN
<b>2</b>	<b>Particulars of System:</b>				
2.1	Nominal system voltage	63/66	132	230	400
2.2	Highest system voltage	72.5	145	245	425
2.3	Nominal system frequency	50	50	50	50
2.4	Insulation level against lightning impulse	*	*	*	*
2.5	Critical current of substation equipment	Specify in accordance with system specification, layout and conductor characteristic	Specify in accordance with system specification, layout and conductor characteristic	Specify in accordance with system specification, layout and conductor characteristic	Specify in accordance with system specification, layout and conductor characteristic
2.6	Desired shielding failure flashover rate	*	*	*	*
<b>3</b>	<b>Service condition:</b>				
3.1	Max, ambient temperature	40/45/50/55	40/45/50/55	40/45/50/55	40/45/50/55
3.2	Min. ambient temperature	-40/-35/-30/-25	-40/-35/-30/-25	-40/-35/-30/-25	-40/-35/-30/-25
3.3	Relative humidity	90/95/more than	90/95/more than	90/95/more than	90/95/more than
3.4	Pollution level	Low/medium/high/very high/special	Low/medium/high/very high/special	Low/medium/high/very high/special	Low/medium/high/very high/special

**Schedule Direct Lightning's Stroke Protection (1)**  
**RATING AND CHARACTERISTIC**

ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:				
		63/66 kV	132 kV	230 kV	400 kV	
3.5	Seismic acceleration	m/s <sup>2</sup>	0.2g-0.25g-0.3g-0.35g	0.2g-0.25g-0.3g-0.35g	0.2g-0.25g-0.3g-0.35g	0.2g-0.25g-0.3g-0.35g
3.6	Wind velocity in:					
3.6.1	Ice condition	m/s	20	20	20	20
3.6.2	10 min. duration	m/s	*	*	*	*
3.6.3	5 sec duration	m/s	*	*	*	*
3.7	Ice coating thickness	mm	5/10/20/25/25	5/10/20/25/25	5/10/20/25/25	5/10/20/25/25
3.8	Keraunic level in substation place	Days/ year	*	*	*	*
3.9	Average value of daily temperature	°C	*	*	*	*
3.10	Solar radiation	W/m <sup>2</sup>	*	*	*	*
<b>4</b>	<b>Ground wire specification:</b>					
4.1	Type		GS/AS/AW	GS/AS/AW	GS/AS/AW	GS/AS/AW
4.2	Overall diameter	mm	*	*	*	*
4.3	Cross section	mm <sup>2</sup>	*	*	*	*
4.4	Modulus elasticity	kN/mm <sup>2</sup>	*	*	*	*
4.5	Rated tensile strength	kN	*	*	*	*
4.6	Length	m	*	*	*	*
<b>5</b>	<b>Lightning mast:</b>					
5.1	Type		GS/AS/AW/GS	GS/AS/AW/GS	GS/AS/AW/GS	GS/AS/AW/GS

**Schedule Direct Lightning's Stroke Protection (1)  
RATING AND CHARACTERISTIC**

ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
5.2	Diameter mm	*	*	*	*
5.3	Cross section mm <sup>2</sup>	*	*	*	*
5.4	Length m	*	*	*	*
<b>6</b>	<b>Riser conductors specification:</b>				
6.1	Type	Stranded	Stranded	Stranded	stranded
6.2	Material	Copper	Copper	Copper	copper
6.3	Cross section mm <sup>2</sup>	*	*	*	*
6.4	length m	*	*	*	*
<b>7</b>	<b>Number of joints and connectors used in direct lightning stroke protection:</b>				
7.1	Number of shackles	*	*	*	*
7.2	Number of U bolts	*	*	*	*
7.3	Number of yoke plates	*	*	*	*
7.4	Number of dead and pressure clamps	*	*	*	*
7.5	Turn buckle	*	*	*	*
7.6	Number of parallel groove clamps	*	*	*	*
7.7	Other joints and connectors (type/number)	*	*	*	*

\* This will be specified by engineer.

**Schedule Direct Lightning's Stroke Protection (II)**  
**Guaranteed Technical Information Of Direct Lightning Stroke Protection**  
**(To Be Supplied With Tender)**

ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
<b>1</b>	<b>General information:</b>				
1.1	Designed shielding failure flashover				
	Failure/100km-year				
1.2	Used method in direct lightning stroke protection design and applicable standard:				
1.2.1	Electrogeometric model method (used design current)				
1.2.2	Empirical curves (selected failure rate of design)				
1.2.3	Other methods (applicable standards)				
1.3	Site characteristic and environmental conditions:				
1.3.1	Max. ambient temperature				
	°C				
1.3.2	Min. ambient temperature				
	°C				
1.3.3	Pollution level				
1.3.4	Max. allowable ice coating thickness				
	mm				
1.3.5	Seismic acceleration in design				
	g				
1.3.6	Max. allowable wind velocity				
	m/sec				
1.3.7	Average value of daily temperature				
	°C				
1.3.8	Solar radiation				
	W/m <sup>2</sup>				
1.3.9	Surge impedance				
	Ω				

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ITEM	DESCRIPTION		Technical Specification for Systems With Following Nominal Voltages:			
			63/66 kV	132 kV	230 kV	400 kV
1.3.10	Insulation level against lighting impulse	kV <sub>peak</sub>				
1.4	Is there necessary documents including test reports/designs/drawings/catalogues/repairing and erection manuals/instruction manuals/references/ spare part list?	Yes/No				
<b>2</b>	<b>Ground wire specification:</b>					
2.1	Manufacturer's name and country					
2.2	Manufacture's type designation					
2.3	Type of conductor					
2.4	Total diameter	mm				
2.5	Cross section	mm <sup>2</sup>				
2.6	Cladding material					
2.7	Current rating at 20 °C	A				
2.8	Resistance at 20 °C	Ω/km				
2.9	Modules elasticity	kN/mm <sup>2</sup>				
2.10	Coefficient of linear expansion	/°C				
2.11	Weight per length unit	kg/m				
2.12	Rated tensile strength	kN				
2.13	Total length	m				
2.14	Number of wires					



**Schedule Direct Lightning's Stroke Protection (II)**  
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ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
<b>3</b>	<b>Lightning mast specifications:</b>				
3.1	Manufacturer's name and country				
3.2	Manufacturer's type designation				
3.3	Height				
	m				
3.4	Number				
3.5	Total diameter				
	mm				
3.6	Cross section				
	mm <sup>2</sup>				
3.7	Current rating at 20 °C				
	A				
3.8	Resistance at 20 °C				
	Ω/km				
3.9	Cladding material				
3.10	Weight				
	kg/m				
<b>4</b>	<b>Riser conductors:</b>				
4.1	Manufacturer's name and country				
4.2	Manufacturer's type designation				
4.3	Material				
4.4	Gross section				
	mm <sup>2</sup>				
4.5	Total length				
	m				
4.6	Weight per length unit				
	kg/m				

**Schedule Direct Lightning's Stroke Protection (II)**  
**Guaranteed Technical Information Of Direct Lightning Stroke Protection**  
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ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
<b>5</b>	<b>Joints and connectors used in direct lightning stroke protection:</b>				
5.1	Shackle:				
5.1.1	Manufacturer's name and country				
5.1.2	Manufacturer's type designation				
5.1.3	Type				
5.1.4	Size				
5.1.5	Modulus elasticity				
5.1.6	Quantity				
5.1.7	Min. tensile strength				
5.2	U, bolts:				
5.2.1	Manufacturer's name and country				
5.2.2	Manufacturer's type designation				
5.2.3	Type				
5.2.4	Size				
5.2.5	Modulus elasticity				
5.2.6	Quantity				
5.2.7	Min. tensile strength				

**Schedule Direct Lightning's Stroke Protection (1I)**  
**Guaranteed Technical Information of Direct Lightning Stroke Protection**  
**(To Be Supplied With Tender)**

ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
5.3	Yoke plates:				
5.3.1	Manufacturer's name and country				
5.3.2	Manufacturer's type designation				
5.3.3	Type				
5.3.4	Size				
5.3.5	Modulus elasticity	kN/mm <sup>2</sup>			
5.3.6	Quantity				
5.3.7	Min. tensile strength	kN			
5.4	Dead end pressured clamps				
5.4.1	Manufacturers name and country				
5.4.2	Manufacturers type designation				
5.4.3	Type				
5.4.4	Size				
5.4.5	Modulus elasticity	kN/mm <sup>2</sup>			
5.4.6	Quantity				
5.4.7	Min. tensile strength	kN			

**Schedule Direct Lightning's Stroke Protection (II)**  
**Guaranteed Technical Information Of Direct Lightning Stroke Protection**  
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ITEM	DESCRIPTION	Technical Specification for Systems With Following Nominal Voltages:			
		63/66 kV	132 kV	230 kV	400 kV
5.5	Turn buckle:				
5.5.1	Manufacturer's name and country				
5.5.2	Manufacturer's type designation				
5.5.3	Type				
5.5.4	Size				
5.5.5	Modulus elasticity	kN/mm <sup>2</sup>			
5.5.6	Quantity				
5.5.7	Min. tensile strength	kN			
5.6	Parallel groove clamps:				
5.6.1	Manufacturer's name and country				
5.6.2	Manufacturer's type designation				
5.6.3	Type				
5.6.4	Size				
5.6.5	Modulus elasticity	kN/mm <sup>2</sup>			
5.6.6	Quantity				
5.6.7	Min. tensile strength	kN			
5.7	Other used joints and connectors (manufacturer's name and country/ manufacturer's type designation/ type/ size/ modulus elasticity/ Min. tensile strength)				