

Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

**General Technical Specification and
Execution Procedures for Transmission
and Subtransmission Networks
Earthing System in High Voltage
Substations**

NO: 459-1

Office of Deputy for Strategic Supervision
Bureau of Technical Execution System
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Technical Specification of Earthing Systems



1- GENERAL REQUIREMENTS

This specification covers the minimum requirements for rating, materials, design, manufacturing, inspection, testing and packing of earthing system equipment. Earthing system means grid, earthing rods, conductors, risers, connectors & joint and exothermic materials, which shall be designed, manufactured, and tested in accordance with the applicable requirements of the following standards and this specification.

ANSI/IEEE std. 80-2000, "IEEE Guide for safety in alternating current substation grounding".

JIS C 3002, "Testing methods of copper & aluminum wires."

JIS H 3250, "Copper and copper alloy rods & bars.

All amendments, Supplements and reference publications listed within the above standards shall also apply. Basic necessary data for design of the earthing system equipment shall be as specified in table (I).

2- DESIGN AND CONSTRUCTION

The earthing system shall be designed to keep the step and touch voltage within acceptable limits, therefore ensuring the safety of personnel and equipment.

The measured ground resistance shall be such that the potential rise of the grid with respect to remote earth shall not exceed 5 kV for the single line to ground fault level specified.

2.1 Earthing Grid

The earthing grid shall be combination of buried conductors and earthing rods (if necessary). The conductors shall be laid in parallel lines and where practical shall be located along rows of structures or equipment to provide short earth connections. The grid shall be subdivided into a number of sections interconnected with test links, accessible from above ground. The grounding grid shall be effectively protected against corrosion. Cathodic protection, if conceded, shall be subject to approval by the engineer. The grounding system shall be designed so as to include all overhead line terminal towers. Terminal towers shall be earthed by extending the system outside the boundary fence so as to envelope all towers within the earth system. They shall be bonded directly to the earth system in at least two locations. The metal substation fence immediately below any overhead line entering or leaving the site should be earthed at that location.

2.2 Steel Structure and Equipment Grounding

Every steel structure that carries insulators or apparatus shall be connected to the ground grid. To ensure contact even if a connection fails or a cable is cut off, every structure must be connected via two different risers to two different parts of the grounding grid. Steel structures shall not be used as parts of the protective earth connection of apparatus.

Steel structures more than one leg shall be connected with the two risers from different legs. Apparatus frames shall not be used as connections between support legs. If there is not other connection between steel structure legs, all shall be connected via their own risers. Operating mechanisms and motor drives placed on separate stands shall be connected as above.

2.3 Fence Grounding

The grounding grid must extend approximately 1.5m outside the fence line. The fence shall be connected to the grounding grid at intervals less than 30m. All corner fence posts shall also be connected to the grounding grid. The fence immediately below any overhead line entering or leaving the site shall be earthed at that location.

2.4 Miscellaneous Grounding

Earth terminals of low voltage equipment shall be earthed by wires designed for the actual earth fault current. Risers or earth conductors are not allowed to come in touch with control cables.

When buried steel is inevitable (e.g. water pipes), the point where the connection to the grid is made, and its immediate vicinity, shall be insulated from contact with the soil, thus avoiding corrosion damages.

A stranded copper conductor (cable trench ground bus) is laid in cable trench and to be connected to all cable trays.

All control and relay panels shall have a Continuous earth bus run of sectional area not less than 35 mm² Cu along the bottom of the panels each end being connected to the main earthing system. Metal cases of instruments and metal bases of relays on the panels shall be connected to the bar by conductors of sectional area of not less than 2.5 mm².

Grounding for high frequency coupling equipment and lightning arresters shall be via a ground rod of approved dimensions. In the case of lightning arresters, the connection from arrester to ground shall be as short as possible. Shield wire of all the towers shall be connected to the grounding grid.

2.5 Earthing Grid Conductors

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.

2.6 Riser Conductors

These conductors shall be designed to carry the earth fault current for the appropriate designed maximum duration without causing an excessive temperature rise.

2.7 Earthing Rods

Size and type of the Grounding rods must be in accordance with mentioned specifications.

2.8 Joints and Connectors

All joints and connectors that connect various parts of earthing grid into an electrically continuous system should be evaluated in terms of conductivity, thermal and current capacity and mechanical strength and reliability.

Exothermic welds shall be used for under ground connections, joint the conductors with a material that has about the same fusing temperature, so that the entire connection can be viewed as being an integral part of one homogeneous conductor. Connection between steel parts and riser conductors should be made by pressed cable lugs with two holes in the contact pad.

3- INFORMATION LABEL

Information which are quoted below must be written on the label of conductor boxes and spool. Labels must have resistance in various ambient conditions and corrosion.

- Number of contract
- Box and spool dimension
- Total box and spool weight with material
- Net conductor or equipments weight in spool
- Technical number of material
- Total conductor length
- Cross section of conductor

4. TEMPORARY GROUNDING DEVICES

Earthing for working shall normally be achieved with the help of both fixed grounding switches and portable grounding equipment. Where portable grounding equipments is used, phase conductors and steel supports shall both be equipped with fixed contacts to which the portable equipment shall be connected.

All earthing units intended for connection to the conductor shall be as a rule be capable of carrying the specified fault current of the system for one second.

5. TESTS

Type (if required) and routine and special test shall be carried out in accordance to the latest edition of specified standards:

- Resistance and conductivity measurement
- Chemical analysis
- Visual inspection
- Dimensional test
- Tensile and elongation test
- Bending test
- Hardness test

6. DRAWINGS AND DOCUMENTS

6.1. Documents to be given by tendered.

- Filled schedule CB (II)
- Catalogs and technical pamphlets
- Outline drawings
- Detailed summary of exceptions to tender specifications
- Reference list
- List of special tools
- List of spare parts
- Summary of type test reports

6.2. Documents to be given by contractor/ supplier

The electrical and mechanical design, manufacture, factory tests, labeling, packing, installation, site tests and grounding system performance documents and manuals shall be submitted not limited to the following:

- Design calculation sheets to establish adequacy of grounding system in any respect
- Outline dimension
- Name plate drawing
- Transportation, warehousing, assembling, erection, commissioning, operating and maintenance manuals
- Site tests manuals
- Equipment list
- Packing details
- Test reports and certificate of test
- Monthly progress report
- Drawing lists
- Final as built Doc/Dwg
- Plan and details of grounding system

7. COMMISSIONING TESTS

- Global inspection of correct installation and settlement
- Global inspection of conductor's size and type
- Global inspection of connectors and joints consist of ground electrodes, steel structures, weld points, material compatibility in joint points, ect.
- Control of ground grid continuity
- Measurement of ground connector's electrical conductivity
- Measurement of total ground grid resistivity
- Measurement of touch and step voltage

SCHEDULE ES (I)
RATINGS AND CHARACTERISTICS OF EARTHING SYSTEM

ITEM	DESCRIPTION	TECHNICAL PARTICULARS
1	<u>General characteristics</u>	
1.1	Implementation standard	IEEE & JIS
1.2	Nominal system voltage	kV 400/230/132/63
1.3	Maximum fault current	kA *
1.4	Peak of fault current and X/R of the grid	
1.5	Maximum fault current duration	Sec *
1.6	Maximum shock duration	Sec *
1.7	Maximum ambient temperature	°C 40/45/50/55
1.8	Minimum ambient temperature	°C -40/-35/-30/-25
1.9	Depth of ground grid	m 0.5
1.10	Acceptable relative humidity	% 90/95/more than 95
1.11	soil corrosion	*
1.12	Soil resistant	Ω.m *
2	<u>Earthing grid conductors:</u>	*
2.1	Type	Stranded
2.2	Material	Copper
2.3	Area cross section	mm ² *
3	<u>Riser conductors</u>	
3.1	Type	Stranded
3.2	Material	Copper
3.3	Area cross section	mm ² *
4	<u>Earthing Road</u>	
4.1	Material	Copper clad steel
4.2	Diameter	mm *
4.3	Length of each rod	m *
4.4	Rods connection method	*
5	<u>Surface layer</u>	Yes/ No *
5.1	Resistivity	Ω.m *
5.2	Thickness	mm *

SCHEDULE ES (I)
RATINGS AND CHARACTERISTICS OF EARTHING SYSTEM

ITEM	DESCRIPTION	TECHNICAL PARTICULARS
6	Control building and cable trenches grounding conductors	
5.1	Type	Stranded
5.2	Material	copper
5.3	Area cross section	*
5.4	Length	*
7	Type of joints and connectors	
7.1	Under ground connectors joints	Exothermic weld
7.2	Over ground connectors joints	Bolted- pressure type

* These will be specified by engineer

SCHEDULE ES (II)
RATINGS AND CHARACTERISTICS OF EARTHING SYSTEM

ITEM	DESCRIPTION	TECHNICAL PARTICULARS
1	General Information	
1.1	Max ambient temperature	°C
1.2	Min ambient temperature	°C
1.3	Acceptable relative humidity	%
1.4	Documents: test reports, plans, Drawings, catalogs, operating and maintenance manuals, training booklets, references, spare parts list, etc...	Yes/No
2	Earthing grid conductor	
2.1	Manufacturer's name	
2.2	Type	
2.3	Material	
2.4	Grid conductor cross section	mm ²
2.5	Number of conductor strand	
2.6	Length of each conductor	m
2.7	Total length	m
2.8	Total weight of spool	kg
2.9	Current density	A/mm ²
3	Riser conductors	
3.1	Manufacturer's name	
3.2	Type	
3.3	Material	
3.4	Cross section	mm ²
3.5	No. of strand	
3.6	Length	m
3.7	Total weight of spool	kg

SCHEDULE ES (II)
RATINGS AND CHARACTERISTICS OF EARTHING SYSTEM

ITEM	DESCRIPTION	TECHNICAL PARTICULARS
4	Earthing Rods	
4.1	Manufacturer's name	
4.2	Material	
4.3	Diameter	mm
4.4	Length of each rod	m
4.5	Total length of rods	m
4.6	Total weight of box	kg
5	Control building & cable trench earthing	
5.1	Manufacture's name	
5.2	Material	
5.3	Cross section (size)	mm ²
5.4	Length	m
5.5	Total weight of spool	kg
6	Connectors & joints	
6.1	Manufacturer's name	
6.2	Type of underground connectors & joints	
6.3	Type of over ground connectors & joints	
6.4	No. of under ground connectors & joints	
6.4.1	Four sided connectors	
6.4.2	Three sided connectors	
6.4.3	Grid conductors to earthing rods connectors	
6.4.4	Grid conductors to risers connectors	
6.4.5	Risers to earthing rods connectors	
6.5	No. of over ground connectors & joints	
6.6	No. of joints related to grid conductors and cable trenches and panels	
6.7	Total weigh of box	kg

SCHEDULE ES (II)
RATINGS AND CHARACTERISTICS OF EARTHING SYSTEM

ITEM	DESCRIPTION	TECHNICAL PARTICULARS
7	Surface layer	
7.1	Material	
7.2	Thickness	mm
7.3	Resistivity	$\Omega.m$
8	Temporary earthing devices	
8.1	Type	
8.2	Material	
8.3	Size	
8.4	Permitted short circuit current (1 sec)	KA