Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Substation Insulators (63 kv- 400 kv)

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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

CONNTENTS

Technical Specification for Insulators of Transmission lines

Technical specifications for insulators

1- SCOPE

The aim of this volume is to cover the technical specifications of glass, porcelain and composite insulators used in 63 kV to 400 kV substations.

2- GENERAL REQUIREMENTS

This specification covers the minimum requirements for rating, material, design, construction, testing and installation of insulators used in HV substations. Insulators shall be designed, manufactured and tested in accordance with the applicable requirements of the latest editions of following standards and specifications:

IEC 60060: High voltage test techniques

IEC 60071: Insulation co-ordination

IEC 60120: Dimensions of ball and socket couplings of string insulator units

IEC 60168: Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V

IEC 60273: Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V

IEC 60305: Ceramic or glass insulator units for ac systems-characteristics of insulator units of the cap and pin type

IEC 60372: Locking devices for ball and socket couplings of string insulator units

IEC 60383: Insulators for overhead lines with a nominal voltage above 1000 V: Ceramic or glass insulator units for ac systems.

IEC 60437: Radio interference test on high-voltage insulators

IEC 60471: Dimensions of clevis and tongue couplings of string insulator units

IEC 60507: Artificial pollution tests on high-voltage insulators to be used on ac systems

IEC 60672: Ceramic and glass-insulating materials

IEC 60707: Flammability of solid non-metallic materials when exposed to flame sources - list of test methods

IEC 60797: Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric

IEC 60815: Guide for the selection of insulators in respect of polluted conditions

IEC 61109: Composite insulators for ac overhead lines with a nominal voltage greater than 1000 V

IEC 61466: Composite string insulator insulator units for overhead lines with a nominal voltage greater than 1000 V.

3- GLASS AND CERAMIC INSULATORS

3-1- TechnicalSpecifications

The post and string insulators shall be complete with all necessary accessories for proper operation. Basic necessary data and ratings shall be as indicated in schedule INS (I). The insulators shall be suitable for use at the specified elevation and under the ambient air temperatures and loading conditions. Under the glaze of each insulator shall be marked with the initials or trademark of the manufacturer, year and location of manufacturer and the guaranteed mechanical or electromechanical strength (In post insulators, lightning withstand voltage shall be imprinted in addition to what specified above). All imprinted information shall be legible, clear and permanent.

The insulation parts of the insulator shall be made of wet process porcelain. The surface of porcelain of the insulator shall be completely plain and smooth. The glaze of porcelain insulator shall be free of any hole, crack, split and puncture.

The insulators shall be designed in such a way that reduces radio interference to the lowest possible and be corona free. There shall be no hole regeneration in insulator unit.

The main characteristics of post insulators shall comply with IEC 60273, post insulators shall comprise of fully interchangeable units of solid core cylindrical type.

The selected post insulators shall be capable of bearing different loads, additionally these shall satisfy the electrical requirements.

End fittings of post insulators shall be capable of bearing of specified torsional forces.

The wind load and short circuit current electromagnetic force cause bending moment on the end of the bus which can impose torsion on the insulator (to calculate the torsion load value, the end of the bus shall be taken as completely fixed).

The metal fittings of post insulators shall be of out-flange type which require no cement inside the porcelain.

For a force applied at a distance c above the cap, the specified rating is multiplied by a factor of $\frac{h}{h+c}$ (where h is the height of insulator).

Sockets of insulator shall be made of malleable iron with high quality machined casting grade.

Plugs of insulator shall be made of forged steel with high quality machined casting grade. These shall be free of any non preferred effects like holes or split that may influence their operation or strength.
Sockets and plugs shall have hot dip galvanized coating which satisfies the requirements of IEC 60383.
The cement used for assembling shall be of Portland or alumina and shall resists against expansion and retraction.
Insulation parts, top and bottom fittings shall be centrally mounted using Portland or alumina cement.
The normal maximum values for the tolerances of parallelism, eccentricity and angular deviation shall comply to BS 3297 part 2.

3-2- Tests

All type, sampling and routine tests on glass and ceramic insulators (used in HV substations) shall be performed in comply with the latest edition of IEC 60383 and 60168 standard and the references mentioned in it.

3-2-1-Tests Applicable to Station Post Insulators

- **Type tests:**

- Dry lighting impulse withstand voltage test
- Wet switching impulse withstand voltage test
- Wet power frequency withstand voltage test
- Mechanical failing load test

- **Special type tests (Agreed between manufacturer and purchaser)**

- Test for deflection under load
- Radio interference test
- Artificial pollution test

- **Sampling tests:**

- Verification of dimensions
- Temperature cycle test
- Mechanical failing load test
- Porosity test (for ceramic insulators only)
- Galvanizing test

- **Routine tests:**

- Routine thermal shock test for toughened glass parts only
- Routine visual inspection
- Routine mechanical test

3-2-2- Tests Applicable to String Insulators Units

- **Type tests:**

- Verification of dimensions
- Wet power frequency withstand voltage test
- Dry lighting impulse withstand voltage test
- Electro- Mechanical failing load (for ceramic insulators)
- Mechanical failing load (for glass insulators)
- Thermal mechanical performance

- **Sampling tests:**

- Verification of dimensions
- Verification of the axial and angular displacement
- Verification of the locking system
- Temperature cycle test
- Electro- Mechanical failing load (for ceramic insulators)
- Mechanical failing load (for glass insulators)
- Thermal shock test (for glass insulators)
- Puncture withstand test (type of applied voltage is determined with agreement of manufacturer and purchaser)
- Porosity test
- Galvanizing test

- **Routine tests:**

- Routine visual inspection
- Routine mechanical test
- Routine electrical test

4- COMPOSITE INSULATORS

4-1- TechnicalSpecifications

The insulator manufacturer shall provide a valid certificate to show at least 10 years experiences in producing composite insulators.

Data of sold insulators including: year of production, location of installation, operating voltage, pollution condition and specification of user shall be provided by the manufacturer.

For similar manufacturers, the higher priority will be given to those who have more experiences in design and production of composite insulators.

The metal surface of each insulator shall be marked with the initials or trade mark of the manufacturer, year and location of manufacturer and the guaranteed electromechanical strength. All imprinted information shall be legible, clear and permanent.

The specifications of research units, laboratory facilities and quality control services of manufacturers shall be available.

The composite insulators shall be made of two parts; core and housing. The insulators shall be equipped with necessary end couplings as indicated by design.

The core shall be made of glass-fiber reinforced with high strength epoxyresin and shall be resistant to phenomenon like: hydrolyze / erosion and tensions during the service.

The insulator core shall be coated by a sealed layer of silicon rubber with specific thickness.

The insulator housing shall protect the core against environmental condition, pollution and humidity. The housing can have umbrella if it is indicated in design. These umbrellas shall be mounted in a suitable way on the core of insulator to provide the necessary creepage distance.

Core shall be equipped with suitable end fittings to transfer the mechanical force. These shall be made of malleable iron (for post insulators) or forged steel (for string insulators). The space between the fitting and case shall be covered with a suitable cover, in such a way that resists against water penetration. The cover shall cover the surface of iron fittings and insulator housing. End fittings shall be connected to insulator core in such a way that does not harm the insulator core.

Tightness of insulators against water shall be confirmed with the proper test procedures.

4-2- Tests

All design, type, routine, sampling tests on composite insulators (which are used in transmission lines) shall be performed in comply with the latest edition of IEC 61109 standard and the references mentioned in it.

- **Design tests:**
  - Tests on connections and fittings
  - Force – time test on assembled core
  - Test on cover of insulator
  - Test on core material
  - Flammability test

- **Type tests:**
  - Dry lighting impulse with stand voltage test
  - Wet power frequency with stand voltage test
  - Wet switching impulse with stand voltage test
  - Mechanical force – time test and strength test for connections between and fitting and housing of the insulator

- **Sampling tests:**
  - Verification of dimensions
  - Verification of locking system
  - Strength test for connections between and fitting and housing of the insulator and mechanical force test specified by SML.
  - Galvanizing test

- **Routine tests:**
  - Routine visual inspection
  - Routine mechanical test

5- PACKING

The packing of insulators shall be performed in such a way that avoids any harmful tension to insulators during the housing or transportation process.

The split pines shall be placed in locked position.

Each package shall contain only similar type of insulators.

Each package shall have the manufacturer designation or trade mark, main specifications and the number of insulators.

6- TRANSPORTATION, STORAGE AND INSTALLATION

6-1- Storage

It is necessary to store the insulators in a place with the conditions recommended by the manufacturer. For composite insulators it is necessary to store them in an enclosed place and it must be noted that storage place shall be free of any kind of pollution and oil or gas material. The insulators shall be kept in a box or PVC tube and shall not be placed on the ground.

6-2- Transportation

Precautionary measures shall be considered to avoid any harm to insulators during the transportation process. For long composite insulators, it is necessary that transportation is done in such a way that they do not bend.

For insulators with more than 2 meters long, the maximum bending (the mid point of composite insulator relative to its both heads) shall be less than 30 degrees against horizontal line.

Lifting the long insulators should be done by the ladder shaped devices which are made for this purpose. If these devices are not available, transportation shall be done with more crews.

6-3- Inspections before installation

It shall be noted that the number of unpacked insulators be limited to the necessary numbers during the installation process. If there is a delay in installation, the unpacked insulators shall be replaced in their box and cover and use them whenever needed.

All insulators shall be checked when unpacked. If there is any crack, failure, torn and missed glazed of ceramic insulators, scratch on the cover of umbrellas and the core of composite insulators or any thing like this, the insulators shall not be used unless the engineer inspects and decides about them.

If any damage is occurred to the insulators during the installation process, they shall be rejected and replaced with an intact one.

Corona rings, fittings, clamps and bolts of accessories of string or post insulators shall be concisely inspected and checked in order to avoid using them in case of any crack or break existence. If there is any bur, it shall be removed by using a proper deburring tool.

Installation of damaged insulators shall be highly avoided.

6-4- Cleaning

It is no need to clean the insulators in normal condition. If few of them need cleaning (due to bad condition of storage) they shall be cleaned with a clean wet cloth and then dried.

6-5- Installation

After unpacking the insulators, they should not be placed on the ground. In order to do that a suitable size canvas should be spreaded on the plain surface and the insulators places on it.

The plastic or PVC cover of the insulator shall not be cut (specially for composite insulators). The insulators should be brought out according to the manufacturer's instructions.

The insulators should not be dragged on the ground (specially for composite insulators).

The insulators can be washed just by using clean cloth and water. Using oil or petroleum material shall be highly avoided in composite insulators.

Placing tools and accessories on the insulators shall be avoided during the transportation. A proper container or cover shall be used during the transportation.

During the installation of the string or post insulators, it shall be noted that the corona rings and its accessories shall be placed in their location as specified in drawings. Some inspections shall be performed to get sure that they are free of any deficiencies. Non – preferred effects like sharp edges and burrs shall be removed with proper action.

In lifting, the rope/cable shall be connected to the iron parts of the insulator. Connection of rope to insulation parts of the insulator shall be highly avoided.

In installation no excessive force shall be exerted on the insulators. Turning one end of the insulator when the other end is fixed to some place, exerting force like lever, exerting abnormal pressure or bending forces shall be avoided.

In post insulators which are composed of more than two parts, the bolts shall be mounted in beneath. Composite insulators shall not be used as a ladder.

After energizing the substation, a night inspection shall be done. If there is any corona around the fitting, corona ring or arcing horns, proper actions shall be taken for its correction.

7- SPARE PARTS AND SPECIAL TOOLS

The manufacturer shall provide spare parts for 5 years trouble free operation. Any special tools deemed necessary for erection, operation and repair shall be provided by the manufacturer.

8- DRAWINGS AND DOCUMENTS

8-1- Documents to be Given by the Tenderers

- Filled schedule INS (II)
- Catalogue and technical pamphlets
- Summary of exceptions to technical specification
- Manufacturer references and qualifications
- List of spare parts
- List of special tools
- Summary of test reports
- Packing / transportation / storage / installation and maintenance manuals

8-2- Documents to be Given by Contractor / Supplier

Documents, electrical and mechanical drawings of design, test, packing, lables, transportation, storage, installation, local and operation test of insulators listed below, shall be provided.

- Design calculation (if necessary)
- Details of packing, transportation and housing
- Test reports and certificates of passed tests
- Erection, operation and maintenance manuals
- Drawings showing the outline dimensions, transportation, weight, type and other specifications of them
- Monthly progress report
- Work schedules
- List of drawings
- List of components

Schedule (I) , (II) Insulators Used in

Substations of 63-400 kV Systems

Technical specifications for insulators table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	66/63 kV
1	**System Specification**					
1-1	Nominal system voltage	kV_{rms}	400	230	132	63/66
1-2	Maximum system voltage	kV_{rms}	420	245	145	72.5
1-3	Nominal system frequency	Hz	50	50	50	50
1-4	Substation insulation level against lighting impulse in IEC condition	kV_{peak}	*	*	*	*
1-5	Substation insulation level against switching impulse in IEC condition	kV_{peak}	*	*	*	*
1-6	Substation insulation level against power frequency voltage in IEC condition	kV_{rms}	*	*	*	*

Technical specifications for substation insulators table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	**230 kV**	**132 kV**	**66/63 kV**
2	**Operating Conditions of Substation**					
2-1	Max. ambient temperature	°C	40/45/50/55	40/45/50/55	40/45/50/55	40/45/50/55
2-2	Min. ambient temperature	°C	-25/-30/-35/-40	-25/-30/-35/-40	-25/-30/-35/-40	-25/-30/-35/-40
2-3	Pollution level		Light/Medium/Heavy/ Very Heavy/Special	Light/Medium/Heavy/ Very Heavy/Special	Light/Medium/Heavy/ Very Heavy/Special	Light/Medium/Heavy/ Very Heavy/Special
2-4	Design 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
2-5	Max. wind speed	m/s	30/40/45	30/40/45	30/40/45	30/40/45
2-6	Max. wind speed at ice condition	m/s	20	20	20	20
2-7	Ice thickness coating	mm	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25
2-8	Altitude above sea level	m	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500
2-9	Keraunic level at station site	Days/year	*	*	*	*
2-10	Relative humidity	%	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95

Technical specifications for substation insulators table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	66/63 kV
3	**Station Post Insulators**					
3-1	Insulation material		*	*	*	*
3-2	Dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
3-3	Wet lighting switching withstand voltage	kV_{peak}	*	*	*	*
3-4	Wet power frequency withstand voltage	kV_{rms}	*	*	*	*
3-5	Min. creepage distance	mm	*	*	*	*
3-6	Max. RIV at 1 MHz measured at 10% over nominal max. voltage	μV	*	*	*	*
3-7	Mechanical – class of insulator according to IEC		*	*	*	*
3-8	Dimensions characteristics of insulator	mm	According to IEC60273	According to IEC60273	According to IEC60273	According to IEC60273
3-9	Dimensions and characteristics of insulator connections	mm	According to IEC60273	According to IEC60273	According to IEC60273	According to IEC60273

Technical specifications for substation insulators table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	66/63 kV
4	**String Insulator Unit**					
4-1	Type and insulation material		*	*	*	*
4-2	Dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
4-3	Wet switching impulse withstand voltage	kV_{peak}	*	*	*	*
4-4	Wet power frequency withstand voltage	kV_{rms}	*	*	*	*
4-5	Min. creepage distance	mm	*	*	*	*
4-6	Mechanical class of insulator according to IEC		*	*	*	*
4-7	Top and bottom fitting dimensions and types according to IEC	mm	*	*	*	*
4-8	Standard type or antifog?					
4-9	Overall height	mm	*	*	*	*

Technical specifications for substation insulators table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	**230 kV**	**132 kV**	**66/63 kV**
5	**String Insulator Set**					
5-1	Dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
5-2	Wet switching withstand voltage	kV_{peak}	*	----	----	----
5-3	Wet power frequency withstand voltage	kV_{rms}	*	*	*	*
5-4	Max. RIV at 1 MHz measured at 10% over nominal max. voltage	μV	*	*	*	*
5-5	Number of conductors and string arrangement		*	*	*	*
5-6	Number of units per string		*	*	*	*
5-7	Min. total creepage distance	mm	*	*	*	*
* These quantities will be specified by engineer						

Technical specifications for substation insulators table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
1	**General**					
1-1	Max. allowed ambient temperature	°C				
1-2	Min. allowed ambient temperature	°C				
1-3	Allowed pollution level					
1-4	Altitude above the sea level	m				
1-5	Max. allowed wind speed	m/s				
1-6	Max. allowed wind speed at ice condition	m/s				
1-7	Max. allowed ice thickness	mm				
1-8	Allowed relative humidity	%				
1-9	Seismic acceleration in design	g				
1-10	Necessary documents including test reports, outline drawings/ catalogues/ maintenance and installation/ instruction manuals/ references/ list of spare parts	Yes/No				

Technical specifications for substation insulators table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
2	**Post Insulators**					
2-1	Manufacturer's name and country					
2-2	Manufacturer's type design					
2-3	Year of construction					
2-4	Applicable standard					
2-5	IEC standard designation					
2-6	Insulator material					
2-7	Dry lighting impulse withstand voltage	kV_{peak}				
2-8	Wet switching withstand voltage	kV_{peak}				
2-9	Wet power frequency withstand voltage	kV_{rms}				
2-10	Radio interference					
2-10-1	Test voltage to ground	kV_{rms}				
2-10-2	Max. RIV at 1 MHz	μV				

Technical specifications for substation insulators table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
2-12	Bending failing load	kN				
2-13	Tension failing load	kN				
2-14	Torsional failing load	kN				
2-15	Compressive failing load	kN				
2-16	Safety factor on Max loading condition					
2-17	Washable in service	Yes / No				
2-18	Overall height	mm				
2-19	Min. creepage distance	mm				
2-20	Max. nominal diameter and its tolerances	mm				
2-21	Top metal fitting pitch circle diameter	mm				
2-22	Bottom metal fitting pitch circle diameter	mm				
2-23	Total weight of complete stack	kg				
2-24	Insulator color					

Technical specifications for substation insulators table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
3	**String Insulator Unit**					
3-1	Manufacturer's name and the country					
3-2	Manufacturer's type designation					
3-3	Year of construction					
3-4	Applicable standard					
3-5	IEC standard designation					
3-6	Insulation material					
3-7	Dry lighting impulse withstand voltage	kV_{peak}				
3-8	Wet switching impulse withstand voltage	kV_{peak}				
3-9	Wet power frequency withstand voltage	kV_{rms}				
3-10	Mechanical class according to IEC					
3-12	Nominal creepage distance	mm				
3-13	Top and bottom fitting pitch circle diameter according to IEC	mm				
3-14	Weight of an insulator unit	kg				
3-15	Color of the insulator					
3-16	Number of insulators in each box					
3-17	Type of insulator (standard / anti fog)					

Technical specifications for substation insulators table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
4	**Insulator String Set**					
4-1	Dry lighting impulse withstand voltage	kV_{peak}				
4-2	Wet switching withstand voltage	kV_{peak}				
4-3	Wet power frequency withstand voltage	kV_{rms}				
4-4	Radio interference					
4-4-1	Test voltage to ground	kV_{rms}				
4-4-2	Maximum RIV at 1 MHz	μV				
4-5	Maximum allowed tensile strength					
4-5-1	Insulators	kN				
4-5-2	Accessories	kN				
4-6	Safely factor on maximum loadingcondition					
4-7	Washable in service?	Yes / No				
4-8	Overall length	mm				
4-9	Arcing distance	mm				
4-10	Min. total creepage distance	mm				
4-11	Number of units in each string set					
4-12	Number of strings and configuration of string					