Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Insulators of Transmission Lines

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Technical Specifications for Insulators of Transmission Lines

1- GENERAL REQUIREMENTS

This specification covers the minimum requirements for rating, material, design, construction, and testing of porcelain, glass or composite insulators used in transmission line in 63 to 400 kV power systems. Insulators shall be designed, manufactured and tested in accordance with the applicable requirements of the latest editions of following standards and specifications:

IEC 60591: Sampling rules and acceptance criteria

IEC 60060: High voltage test techniques

IEC 60071: Insulation co-ordination

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

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 part1,2: ceramic or glass insulator units for ac systems.

IEC 60433: Ceramic insulators for ac systems-characteristics of insulator units of the long rod type

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 60720: Characteristics of line post insulators

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.

CISPR publication 1 "Radio interference measuring apparatus"

ASTM A 47M "Specification for ferritic malleable iron casting"

ASTM A 220 "Specification for pearlitic malleable iron casting"

ASTM A 536 "Specification for ductile casting iron"

ASTM A 668 "Specification for forged steel"
ASTM A C151 "Test method for autoclave expansion of Portland cement"
ASTM A 153 "Zinc coating (hot-dip) on iron and steel hardware"

2- GLASS AND CERAMIC INSULATORS

2-1- Technical Specifications

The line post, string and long rod 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 electromechanical strength. All imprinted information shall be legible, clear and permanent.

The insulation parts of the insulator shall be made of wet process porcelain or toughened glass. The surface of porcelain or glass of the insulator shall be completely plain and smooth. The glaze of porcelain insulator shall have a smooth surface and the glaze missing shall be limited to the amount specified in IEC 60383-1 and it shall be free of any hole, crack, splitting and puncture. The glass insulation shall have a smooth surface without any impurity particles or bubble. Bubbles with diameter more than 2 mm in the grooves, is not acceptable.

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

The main characteristics of cap & pin, line post and long rod insulators shall comply with IEC 60305, 60720, 60433 respectively.

Dimensions and permitted tolerances of clevis and tongue couplings of string insulator units shall comply with IEC 60471.

Dimensions and permitted tolerances of ball and socket couplings of string insulator units shall comply with IEC 60120.

Specifications of locking devices for ball and socket couplings of string insulator units including dimensions and tolerances shall comply with IEC 60372.

Insulator sockets shall be made of malleable iron according to ASTM A49 grade 35018 and 32510 or ductile iron according to ASTM A536 grade 60-40-18 or 65-45-12 or forged steel.
Plugs of insulator shall be made of forged steel according to ASTM A668. These shall be free of any non preferable effects like holes or split that may influence their operation or strength.
Sockets and plugs shall have hot dip galvanized coating. The galvanized coating shall satisfy the requirements of the IEC 60383.
Locking split pin shall be made of bronze or stainless steel. The "w" type design is not acceptable.
The cement used for assembly shall be of Portland or alumina and shall resists against expansion and retraction. Expansion factor of Portland cement shall be less than 0.12% according to ASTM A151.
Insulation parts, top and bottom fittings shall be centrally mounted using Portland or alumina cement. The tolerances of axial, radial and angular displacements shall be according to IEC 60383.

2-2- Tests

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

- **Tests Applicable to Line Post Insulators**
- **Type tests including:**
- Verification of dimensions
- Dry lighting impulse withstand voltage test
- Wet power frequency withstand voltage test
- Mechanical failing load test

- **Sampling tests including:**
- Verification of dimensions
- Temperature cycle test
- Mechanical failing load test
- Thermal shock test
- Porosity test
- Galvanizing test
- **Routine tests including:**

- Routine visual inspection
- Routine mechanical test

Tests Applicable to String Insulators Units

- **Type tests including:**
  - Verification of dimensions
  - Dry lighting impulse withstand voltage test
  - Wet power frequency withstand voltage test
  - Electro- Mechanical failing load (for ceramic insulators)
  - Mechanical failing load (for glass insulators)
  - Thermal mechanical performance
  - Residual mechanical strength after insulation failure
  - Providing a certificate for expansion factor of cement

- **Sampling tests including:**
  - Verification of dimensions
  - Verification of the axial, radial and angular displacement
  - Verification of the locking system
  - Temperature cycle test
  - Electro- Mechanical failing load
  - Mechanical failing load
  - Thermal shock test
  - Puncture withstand test
  - Porosity test
  - Galvanizing test

- **Routine tests including**
  - Routine visual inspection
  - Routine mechanical test
  - Routine electrical test

3- COMPOSITE INSULATORS

3-1- Technical Specifications

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.

Due to the important role of insulator core in mechanical strength, the core shall be made of glass-fiber reinforced with high strength epoxy resin.

The insulator core shall be resistant to phenomenon like: hydrolyze / erosion and tensions faced with during the service.

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. They shall be made of malleable iron or forged steel.

The space between the fitting and case shall be covered with a suitable cover, in such a way that resists against water penetration. This 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.

Specifications of end fittings shall comply with the specifications indicated in the drawings and the mentioned tolerances.

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

Allowed tolerances in insulator dimensions shall comply with IEC 61109.

3-2- 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 including:**
  - Tests on connections and fittings
  - Force – time test on assembled core
  - Test on cover of insulator
  - Test on core material
  - Flammability test

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

4- 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.

5- TRANSPORTATION, STORAGE AND INSTALLATION

5-1- 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 a roofed 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 box or PVC tube and shall not be placed on the ground. For packing of composite insulators, thick carton pipes shall be used. Transportation, storage and installation of composite insulators shall be performed according to CIGRE-183.

5-2- 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.

5-3- Inspections before installation

It shall be noted that the number of unpacked insulators be limited to the necessary ones 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, these 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 chain of insulator or insulator 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 deburning tool.

Installation of damaged insulators shall be highly avoided.

5-4- 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.

5-5- Installation

After unpacking the insulators, they should not be placed on the ground. In order to do that a suitable size canvas should be spread on the plain surface and then the insulators will be placed 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 insulator 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.
The long insulators should not be bent more than the permissible limit during the movement and installation.
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 strings insulator, 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 actions.
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.
Composite insulators shall not be used as a ladder.
After energizing the transmission line, a night inspection shall be done. If there is any corona around the fitting, corona ring or arcing horns, some proper actions shall be taken for its correction.

6- INSPECTION AND SUPERVISION

During the construction and test of the insulators, with the request of buyer, all needed facilities shall be provided by the contractor in order to make buyer able to perform needed inspections. In case the test results are acceptable, buyer can reject the manufacturer's product if they do not comply with the technical specifications in either erection or operation phase.

7- SPARE PARTS AND SPECIAL TOOLS

The recommended spare parts for 5 years trouble free operation and 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 rules
- Certificate of performing type tests on the proposed insulator from a well known international laboratory in the last 10 years or by the approval of the representatives of the buyer in the last 5 years.
- Satisfaction letter from last customers who have used this type of insulators

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

Documents, electrical and mechanical drawings of design, construction, test, packing, labes, transportation, storage, installation, local and operation test of insulators listed below but not limited to them, shall be provided.

- Design calculation sheets to establish adequacy of insulators in any respect
- 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
- Mounting details
- Monthly progress report
- Work schedules
- List of drawings
- List of components

Schedule (I) , (II)

Insulators Used in Transmission Lines

in 63-400 kV Systems

Technical specifications for insulators of transmission lines 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	Max system voltage	kV_{rms}	420	245	145	72.5
1-3	Nominal system frequency	KHz	50	50	50	50
1-4	Lighting impulse withstand voltage	kV_{peak}	*	*	*	*
1-5	Switching impulse withstand voltage	kV_{peak}	*	*	*	*
1-6	Admissible rate of electric arc resulting from back flashover	Failures / 100 km-year	*	*	*	*
1-7	Admissible rate of electric arc resulting from switching over voltages	Failures /100 switching operations	*	*	*	*
1-8	Short circuit level in system for 0.5 second	MVA	*	*	*	*
1-9	Max RIV at 500 KHz measured at 15% over max voltage	dB/ μV	60	60	60	60

Technical specifications for insulators of transmission lines 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 Transmission Line**					
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	Max average ambient temperature	°C	*	*	*	*
2-4	Max solar radiation	W/m^2	*	*	*	*
2-5	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
2-6	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
2-7	Max wind speed	m/s	30/40/45	30/40/45	30/40/45	30/40/45
2-8	Max wind speed at ice condition	m/s	20	20	20	20
2-9	Ice thickness coating	mm	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25
2-10	Altitude above sea level	m	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500
2-11	Keraunic level along the transmission line	Days/year	*	*	*	*
2-12	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 insulators of transmission lines table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	66/63 kV
3	**Line Post Insulators**					
3-1	Insulation material		*	*	*	*
3-2	Min dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
3-3	Min wet lighting switching withstand voltage	kV_{peak}	*	*	*	*
3-4	Min 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	Min electro mechanical – mechanical failing load	kN	*	*	*	*
3-8	Nominal length	m	*	*	*	*
3-9	Dimensions and characteristics of top fitting	mm	*	*	*	*
3-10	Dimensions and characteristics of bottom fitting	mm	*	*	*	*

Technical specifications for insulators of transmission lines 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	Min dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
4-3	Min wet power frequency withstand voltage	kV_{rms}	*	*	*	*
4-4	Min creepage distance	mm	*	*	*	*
4-5	Min electro mechanical – mechanical failing load	kN	*	*	*	*
4-6	Nominal length	m	*	*	*	*
4-7	Top and bottom fitting dimensions and types according to IEC	mm	*	*	*	*

Technical specifications for insulators of transmission lines table (I)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	66/63 kV
5	**Long Rod or String Insulator Set**					
5-1	Min dry lighting impulse withstand voltage	kV_{peak}	*	*	*	*
5-2	Min wet switching withstand voltage	kV_{peak}	*	*	*	*
5-3	Min 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 units per string and arrangement		*	*	*	*
5-6	Length of each string	mm	*	*	*	*
5-7	Min creepage distance	mm	*	*	*	*

* These quantities will be specified by engineer

Technical specifications for insulators of transmission lines 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	Max average daily temperature	°C				
1-4	Max solar radiation	w/m^2				
1-5	Allowed pollution level					
1-6	Altitude above sea level	m				
1-7	Max allowed wind speed	m/s				
1-8	Max allowed wind speed at ice condition	m/s				
1-9	Max allowed ice thickness	mm				
1-10	Allowed relative humidity	%				
1-11	Seismic acceleration in design	g				
1-12	Necessary documents including test reports, outline drawings/ catalogues/ maintenance and installation/ instruction manuals/ references/ list of spare parts	Yes/No				

Technical specifications for insulators of transmission lines table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
2	**Line Post Insulator**					
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				
2-11	Min puncture voltage	kV_{peak}				

Technical specifications for insulators of transmission lines 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	Tensional 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	Color of insulator glaze					

Technical specifications for insulators of transmission lines table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
3	**Long Rod and String Insulator Unit**					
3-1	Manufacturer's name and country					
3-2	Manufacturer's type design					
3-3	Year of construction					
3-4	Applicable standard					
3-5	IEC standard designation					
3-6	Insulator material					
3-7	Dry lighting impulse withstand voltage (positive and negative polarity)	kV_{peak}				
3-8	Lighting impulse withstand voltage for a string containing 5 units	kV_{peak}				
3-9	Wet power frequency withstand voltage	kV_{rms}				
3-10	Wet power frequency withstand voltage for a string containing 5 units	kV_{rms}				
3-11	Min puncture voltage	kV_{peak}				
3-12	Residual mechanical strength after insulation failure					
3-13	Mechanical failing load	kN				
3-14	Electromechanical failing load	kN				
3-15	Max nominal diameter	mm				
3-16	Nominal creepage distance	mm				
3-17	Top and bottom fitting pitch circle diameter according to IEC	mm				
3-18	Weight of an insulator unit	kg				
3-19	Insulator color					

Technical specifications for insulators of transmission lines table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	**230 kV**	**132 kV**	**63/66 kV**
3-20	Material used in insulator					
3-20-1	Insulation					
3-20-2	Cap					
3-20-3	Pin					
3-20-4	Cement					
3-20-5	Locking split pins					
3-21	Min thickness of galvanized coating	mm				
3-22	Number of insulators in each package					
4	**Long Rod and 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	Max RIV at 1 MHz	μV				
4-5	Max allowed tensile strength					
4-5-1	Insulators	kN				
4-5-2	Accessories	kN				

Technical specifications for insulators of transmission lines table (II)

ITEM	Description		Technical Particulars For Systems With Following Nominal Voltages			
			400 kV	230 kV	132 kV	63/66 kV
4-6	Safety factor on max loading condition					
4-7	Washable in service	Yes / No				
4-8	Overall length	mm				
4-9	Arcing distance	mm				
4-10	Min creepage distance	mm				
4-11	Number of units in each string set					
4-12	Number of strings and configuration of string					