Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Voltage Transformers at HV Substations

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Description **PAGE**

Technical Specification of Voltage Transformers

1- GENERAL REQUIREMENT

This specification covers the requirements for the design, manufacturing, checking, factory testing, marking, packing, transportation, storage, installation and commissioning tests for voltage transformers in 63 to 400 kV substations.

Voltage transformers shall be designed, manufactured and tested according to the applicable requirements of the latest edition of the following standards and to this specification:

IEC 60044-2: induced voltage transformers

IEC 60270: Measurement of partial discharge

IEC 60296: Specification for unused mineral oils for transformers and switchgears

IEC 6044-5: Capacitive voltage transformers

IEC 60358: Coupling capacitors and capacitor dividers

ISO 1461: Metallic coatings – hot dip galvanized coating on fabricated ferrous products requirements

All amendments, supplements and reference publications listed in the above standards shall also apply.

Voltage transformer shall be complete with spare parts and all necessary accessories for safe and proper operation. Basic equipment data and rating shall be as specified in table I.

2- DESIGN AND CONSTRUCTION

Voltage transformers shall be suitable for outdoor installation on supporting structures.

Voltage Transformers with the same ratings and characteristics shall be interchangeable.

Voltage transformer shall withstand without damage, when energized at rated voltage, the mechanical, electrical and thermal effect of an external short circuit at the secondary winding for the duration of 1 Sec.

All parts exposed to corrosion shall be constructed of non-corrosive material, or be hot dip galvanized to a thickness as specified in ISO 1461.

Voltage transformers shall have electrically completely separated secondary windings.

The design of voltage transformers shall be such that the accuracy shall not be affected by the presence of pollution on the external surface of the insulation.

The capacitor elements shall be enclosed in an oil filled porcelain chamber. The porcelain chamber shall be hermetically sealed with oil resistant and weather proof gaskets. The porcelain to metal joints shall be such as to ensure an oil tight seal is obtained under all loading conditions imposed at the high voltage terminal, particularly during transport to site.

Inner Insulation shall be Satisfactorily and permanently protected against moisture.

All steps shall be taken to ensure free expansion of the oil between the ambient temperatures specified.

In addition to all equipment necessary for voltage transformers, the following Supplements shall be provided:

- A filling plug
- A draining valve
- A draining cap
- Lifting facilities for lifting the completely assembled transformer filled with oil

where epoxy resin is used in the primary winding construction, this shall serve only to absorb mechanical shock and strain and not be subject to electrical stress. It shall not be directly exposed to atmosphere.
All measures shall be taken to protect the high frequency coupling terminal against rain and vermin when in use, so as to avoid the possibility of being shorted to earth. The capacitor voltage transformer shall fully comply with the applicable requirements of PLC coupling.

Inductive voltage transformer shall be equipped with a oil level indicator which shall be easily visible from ground level.

Capacitive voltage transformer must have a manometer which shall be easily visible and possible to read during operation.

The lower metallic part of voltage transformer shall be provided with two earthing clamps in opposite sides.
One potential shield in the primary winding to prevent undue over voltage appearing on the secondary terminals (terminal to terminal and terminal to ground) shall be provided.
Appropriate provisions shall be made to enable high frequency carrier signal to be coupled to the capacitor unit. The low voltage terminal, shall be suitable for connection either to earth terminal or HF equipment
Capacitive voltage transformers shall be so designed that by the use of an appropriate damping device, Ferro-resonance does not occur and its additional device burden shall be considered.
Magnetization curves of intermediate voltage transformer of EMU and Ferro- resonance damping device shall be given.
Each secondary winding shall satisfy both metering and protection accuracy according to mentioned technical requirements.
Measurement of accuracy class must perform in secondary terminals of voltage transformer. Therefore measurement must consider effect of any internal resistance and any fuse if voltage transformer has two or more secondary windings characteristics, accuracy class of windings must specify separately as every winding can keep own characteristics in rated output range when output of the other winding is changed from zero to 100% rated burden.
Error diagram of capacitive voltage transformer from zero to 100% of rated burden shall be given. For protection class voltage range shall be from 2% of rated voltage to rated voltage multiplied by the rated voltage factor and for metering class 80-120% of rated voltage.
The frequency dependence of voltage error and phase displacement at rated output and rated voltage shall be given in the error diagram of the voltage transformer (for protection $96\%<f<102\%$ and for metering $99\%<f<101\%$)

The accuracy class for metering purpose shall be valid at any voltage between 80% to 120% of rated voltage and burdens with a power factor of 0.8 lagging, whilst at the same time the other winding have an output of any value from zero up to 100% of the upper limit of the specified output range. accuracy class for protection purpose shall be valid at any voltage between 5% to rated voltage multiplied by rated voltage factor and burdens between 25% and 100% of rated burden at a power factor of 0.8 lagging, whilst at the same time the other winding has an output of any value from zero up to 100% of the upper limit of the specified output range.

If a short circuit applied to secondary winding of a CVT excited with voltage equal to rated voltage multiply by appropriate voltage factor, and instantaneously cleared ferro-resonance duration (T_f) and maximum instantaneous error (ε_f) must accord with IEC 60044-5 clause 7-4.

The short circuit impedance should not exceed 0.25 ohm measured on the secondary terminals at 1 V(rms) and 50 Hz.

Measured temperature coefficient of capacitor shall not exceed from value which certified by manufacturer

Secondary circuits shall be earthed at one point only. A separate earth link shall be provided for each secondary winding and shall be situated at the transformer terminal box.

Secondary terminal box of capacitive voltage transformer shall be equipped with gland plate of adequate size to allow connection of necessary cables to be carried out comfortably. The terminal box shall be accessible when the transformer is in operation and also be provided with rain-protected, net covered, breather holes and resist against light and weather conditions.Secondary terminal box must have protection degree of IP54 or IP55.All metal parts in this box shall be corrosion resistant. If required, heater equipped with thermostat could be considered for secondary terminal box.

All terminal boxes shall be equipped with:

- one set of terminal blocks.
- one set of HRC fuses or MCBS with remote indication facilities.
- Grounding terminals for earthing secondary windings.

Secondary terminal and earthing clamps shall be suitable for connection of up to the 10 mm stranded conductor.

Earth terminal of intermediate voltage transformer (IVT) of EMU must capable to withstand a power frequency test voltage with 3 kV rms and duration of one minute. Furthermore insulation level of secondary winding – alone and also with other secondary windings must capable to withstand a power frequency test voltage with 3 kV rms and duration of one minute.

3- PLC Coupling Requirements

Coupling capacitor shall be suitable for transmission within frequency range 35-450 kHz

Equivalent series resistance of coupling capacitor should be smaller than 40 ohm within 35-450 kHz.

Natural frequency of coupling capacitor shall be higher than 1 MHz.
Intermediate voltage transformer of EMU shall not cause more than 1 dB damping within 35-450 kHz and the actual value shall be given.
Stray capacitance and stray conductance of low voltage terminal in the high frequency range shall not exceed 200 pF and 20 micro siemens respectively.

4- Characteristics of capacitor divider of CVT

Allowable tolerance of actual capacitance related to rated capacitance shall be between -5% to +10%. capacitance of two capacitor unit (high voltage capacitor and medium voltage capacitor) shall not differ by more than 5% from the reciprocal ratio of the rated voltages of the units.
Design of coupling capacitor shall permit safe passage of a steady state and high frequency current with 1 A r.m.s. one ampere current equals with 400 watt power for terminal resistance of $400\,\Omega$.

5- Name Plate

A legible name plate shall be provided and fixed in a visible position on the tank.
In addition to characteristics required according to IEC 60044-2 and IEC 60044-5, year of manufacture, applicable standard, the total weight of the voltage transformer and the serial number shall be given in name plate.
A legible circuit diagram plate showing the transformer connection and terminal marking, shall be permanently fixed to the transformer in the neighborhood of the terminal box. The separated main data for the different connections shall be clearly shown on the plate.

Information created on name plate must be in such a way that resists on weather conditions such as sunlight, raining, winding and etc.

Size and arrangement of name plate and circuit diagram plate shall be approved by engineer.
Plates shall be constructed of stainless steel or anodized sheet of aluminum.

6- Spare Parts and Tools

The manufacturer's recommended spare parts for 5 years free operation and any special tools necessary for erection, commissioning and repair should be provided.

7- Tests

Voltage transformer according to it's type, should be tested with following type, routine and special tests.

7.1- Inductive voltage transformers (According to IEC 60044-2)

a) Type tests

- Temperature rise test
- Impulse test on primary winding
- Lighting impulse test
- Switching impulse test
- Wet test
- Short circuit withstand capability test
- Accuracy test

b) Routine tests

- Verification of terminal markings
- Power frequency withstand test on primary winding and measurement of partial discharge
- Power frequency withstand test between sections and a secondary windings
- Accuracy test

c) Special tests

- Chopped lightning impulse test on primary winding
- Capacitance and tan δ measurement
- Mechanical test

7.2- Capacitive voltage transformers (according to IEC 60044-5)

a) Typical tests

- Temperature rise test
- Chopped impulse test
- Ferro-resonance test
- Transient response test
- Accuracy test
- Lightning impulse test
- Tightness of electromagnetic unit
- Short circuit withstand test
- Wet test
- Capacitance and tan δ measurement

- Radio interference voltage test
- Accuracy check

b) Routine tests

- Power frequency withstand test on electromagnetic unit
- Accuracy Check
- Ferro-resonanse Check
- Power frequency withstand test on secondary winding
- Power frequency withstand test on low voltage terminal
- Verification of terminal markings
- Tightness of capacitor voltage divider
- Capacitance and tan δ test
- Partial discharge measurement
- c) Special tests
- Measurement of the transmission factor of high frequency over voltage
- Mechanical strength test
- Determination of the temperature coefficient (T_C)
- Tightness design test of capacitor unit

7.3- Capacitive voltage divider (according to IEC 60358)

a) Typical tests

- High frequency capacitance and equivalent series resistance measurement
- Stray capacitance and conductance of the low voltage terminal measurement
- AC, dry and wet voltage test
- Dry and wet switching voltage test
- Lightning impulse test
- Discharge test
- Partial discharge test
- Determination of temperature coefficient
- Cantilever test

b) Routine tests

- Capacitance measurement at power frequency

- Capacitor loss measurement
- Voltage test
- Voltage test between low voltage and earth terminal
- Partial discharge test
- Sealing test

8- DRAWING AND DOCUMENTS

8.1- Documents to be given by tenderer

- Filled schedule V.T (II)
- Catalogue and technical pamphlets
- Summery of type test reports
- Outline drawing with specify of center of gravity
- Detailed summary of exceptions to tender specifications
- Reference list
- List of special tools
- List of spare parts

8.2- Documents to be given by contractor / supplier

The electrical and mechanical design, fabrication, factory testing, marking, packing transportation, warehousing, erection, commissioning test, operation and maintenance drawings of voltage transformer which are as follow and not limited to the following shall be submitted.

- Calculation sheets to establish adequacy of CVT in any respect.
- Loading on terminals
- Nameplate drawings
- Complete terminal box drawings
- Detailed drawing and technical specification for porcelain insulator
- Routine test certificates
- Type test documents
- Shipping, warehousing, assembly, erection, commissioning, operating and maintenance instruction manuals
- List of components
- Packing details

- Ratings and current / time curve for secondary circuit's protective device
- Work schedules and mountly progress report
- Drawing list
- Final as built Doc/Dwg.
- Dismantling, reassembling and adjusting manuals

9- Transportation, Storage, Installation and commissioning

It is essential that the transport, storage, installation and commissioning of voltage transformer be performed in accordance with instructions given by the manufacturer.

The instructions for the transport and storage should by given before delivery.

The instructions for the installation and commissioning should be given by the time of delivery at the latest.

9.1- Storage

Voltage transformer can be stored in a covered or open air condition according to manufacturer instructions. If voltage transformers are stored in open air, at least they shall be covered with plastic tissues. These plastic tissues shall not be put directly on galvanized surfaces and an air channel shall be mounted to prevent any infiltration of water.

Storage is called to a place that:

- It has a ceiling
- Its floor is firm and uniform.
- Air humidity shall be less than 50%
- Air temperature 20 ± 10 C°

To prevent water from reaching the voltage transformer, it shall be stored in an elevation upper than floor level. To prevent any corrosion caused by the infiltration of water, the plastic cover shall be removed (not for spare parts).

After receiving of each voltage transformer the following items shall be checked:

- voltage transformer delivery is according to order documents.
- There is no damage or shortage in the delivered voltage transformer

If there is any damage, the box shall be opened and all damages shall be photographed. These shall be reported. Storage of a voltage transformer in moist and not well ventilated air may cause the change of color of galvanized surfaces. This change of color is generally named white corrosion and is not a reason for rejecting the goods. All parts shall be stored in away are always accessible. The surrounding ambient of voltage transformer shall be clean of any dust, smoke, flamable or corrosive gasses, steam or salt.

In this condition, the storage shall be cleaned before storing process.

For storing the voltage transformer, the original box shall be used but the plastic cover shall be removed. Spare parts shall be kept in their original boxes and stored in storage. This is specially important for plastic parts (for water proofing and etc). these parts shall be kept away from sunlight to prevent them drying. Spacer washers can be stored for just a short time in the storage.
The tank and the bottom section of the capacitor voltage divider are always delivered assembled and are not allowed to be opened or separated.
The top capacitor sections, if any are normally packed separately. Up to three sections can be packed in each case.

9.2- Checking and Erection

Voltage transformers must be check carefully after to be carried to destination. Insulators must be checked to external damages. Capacitor units must be checked for no oil visible outside the unit. If any oil is discovered outside the unit, amount of leakage must be estimated before removing it by clearing. If new oil appears, contact should be done with the manufacturer.
During lifting, bottom unit must be lifted from the pallet by using the lugs in the bottom of transformer. Suitable support for the upper part of the unit must be used in order to prevent the unit from turning over during the lifting procedure. Chains must not be used, preferably use ropes.

9.2.1. Erection stages

1. Bottom unit must be carefully placed on the structure (support) and must be tightened to the support with appropriate bolts. Avoid mechanical shocks.
2. Upper unit must be carefully placed on the top of the already erected unit and must be tightened to bottom unit with appropriate bolts. Avoid mechanical shocks. If the stack consists further units repeat this section.
3. Mount the primary teminal.
4. External connections, cables and grounding connection must be made. Earthing of low voltage terminal when not used together with carrier equipment must be considered.
5. High voltage terminal must be connected to line. Low voltage terminal is usually connected to earth terminal at delivery. If carrier equipment is to be used, an overvoltage protection shall be connected between the low voltage terminal and earth terminal and the link between this terminal and the earth terminal shall be removed. For this grounding of the EMU, a separate earth clamp is provided on one of the feet of the transformer as standard.

6. Terminals which belongs to the damping circuit must be checked for ensure of connecting together and not grounded.

9.3. Commissioning

After a voltage transformer 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 voltage transformer.

The manufacturer shall produce a program of site commissioning checks and tests. Repetition of the full program of routing tests, already performed in the factory, shall be avoided as the purpose of commissioning tests is for confirmation of

- Existence of no damage
- Compatibility of separate units

- Correct assembly
- Correct performance of the assembled voltage transformer.

For this purpose the commissioning tests shall include, but not limited to the following items. The results of the tests shall be recorded in a test report.

9.3.1. Commissioning tests

- Apparent inspection and ensuring of appropriate installation and electrical connections.
- Ensure of direct connection between metal case and earthing system.
- Oil leakage and oil level control.
- Insulation resistance of primary section with MEGGER.
- Insulation resistance of secondary section with MEGGER.
- Transformation ratio test.
- Measurement of ohmic resistance of primary winding.
- Measurement of ohmic resistance of secondary winding.
- Polarity test.

Voltage transformer table (I)
Ratings and characteristics of voltage transformer

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	**245 kV**	**145 kV**	**72.5 kV**
1	**Particulars of systems**					
1.1	Highest system voltage	kV	420	245	145	72.5
1.2	Nominal system frequency	Hz	50	50	50	50
1.3	Short circuit level insite	kA	*	*	*	*
1.4	Number of phases		3	3	3	3
1.5	System neutral earthing		Solidly earthed	Solidly earthed	Solidly earthed	Solidly earthed / non-Solidly earthed
1.6	Max. duration of short time current on secondary winding	Sec	1	1	1	1
2	**Service conditions**					
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	-40/-35/-30/-25	-40/-35/-30/-25	-40/-35/-30/-25	-40/-35/-30/-25
2.3	Altitude above sea level	m	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500	1000/1500/2000/2500
2.4	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
2.5	Max. wind velocity	m/s	30/40/45	30/40/45	30/40/45	30/40/45
2.6	Wind velocity at ice condition	m/s	20	20	20	20
2.7	Ice coating thickness	mm	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25

Voltage transformer table (I)
Ratings and characteristics of voltage transformer (continued)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	**245 kV**	**145 kV**	**72.5 kV**
2.8	Seismic acceleration	m/s^2	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
2.9	Relative humidity	%	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95
3	**Voltage transformer characteristics**					
3.1	Class (outdoor / indoor)		Outdoor	Outdoor	Outdoor	Outdoor
3.2	Connection in system		Phase to earth	Phase to earth	Phase to earth	Phase to earth
3.3	Type		Oil immersed, capacitor	Oil immersed, capacitor	Oil immersed, capacitor	Oil immersed, capacitor
3.4	Highest voltage for equipment	kV	420	245	145	72.5
3.5	1 minute PFWL	kV	460/510/570/630	275/325/360/395/460	185/230/275	140
3.6	LIWL	kV_{peak}	1150/1175/1300/1425	650/750/850/950/1050	450/550/650	325
3.7	SIWL	kV_{peak}	850/950/1050	-	-	-
3.8	Max. R.I.V at $\frac{1.1U_m}{\sqrt{3}}$ at 1 MHZ	μ volt	500	500	500	500
3.9	Rated primary voltage	kV	$\frac{400}{\sqrt{3}}$	$\frac{230}{\sqrt{3}}$	$\frac{132}{\sqrt{3}}$	$\frac{63(66)}{\sqrt{3}}$
3.10	Rated secondary voltage	V	$\frac{100}{\sqrt{3}}/\frac{110}{\sqrt{3}}$	$\frac{100}{\sqrt{3}}/\frac{110}{\sqrt{3}}$	$\frac{100}{\sqrt{3}}/\frac{110}{\sqrt{3}}$	$\frac{100}{\sqrt{3}}/\frac{110}{\sqrt{3}}$

Voltage transformer table (I)
Ratings and characteristics of voltage transformer (continued)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	**245 kV**	**145 kV**	**72.5 kV**
3.10.1	Rated voltage of residual voltage winding	V	$\frac{100}{3}/\frac{110}{3}/100/110$	$\frac{100}{3}/\frac{110}{3}/100/110$	$\frac{100}{3}/\frac{110}{3}/100/110$	$\frac{100}{3}/\frac{110}{3}/100/110$
3.11	Rated voltage factor:					
3.11.1	Continuous		1.2	1.2	1.2	1.2
3.11.2	30 sec.		1.5	1.5	1.5	1.5
3.12	Number of secondary windings		2	2	2	2
3.13	Accuracy class of each winding		0.5+3P	0.5+3P	0.5+3P	0.5+3P
3.14	Rated output of each winding	VA	*	*	*	*
3.15	Min. external creep age distance	mm/kV	*	*	*	*
3.16	Tensile force on HV terminal due to connected conductor:					
3.16.1	Horizontal	N	1000	1000	1000	1000
3.16.2	Vertical	N	1000	1000	1000	1000
3.17	Maximum temperature rise	°C	*	*	*	*
3.18**	Capacitive voltage divider:					
3.18.1**	Min. coupling capacitance	pF	4400	4400	4400	4400

Voltage transformer table (I)
Ratings and characteristics of voltage transformer (continued)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	**245 kV**	**145 kV**	**72.5 kV**
3.18.2**	Natural frequency	MHz	≥ 1	≥ 1	≥ 1	≥ 1
3.18.3**	Equivalent series resistance	Ω	≤ 40	≤ 40	≤ 40	≤ 40
3.19	Short circuit impedance of voltage transformer	Ω	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25
3.20	Insulator colour		Brown	Brown	Brown	Brown
3.21	Protection degree of secondary terminal box		IP54 / IP55	IP54 / IP55	IP54 / IP55	IP54 / IP55

* These will be specified by designer.
** These shall be mentioned only for capacitive voltage transformer

Voltage transformer table (II)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
1	**General**					
1.1	Manufacturer's name and country					
1.2	Manufacturer's type designation					
1.3	Class (outdoor / indoor)					
1.4	Type					
1.5	Applicable standard					
1.6	Applicable site and ambient condition:					
1.6.1	Max. design ambient temperature	°C				
1.6.2	Min. design ambient temperature	°C				
1.6.3	Design altitude above sea level	m				
1.6.4	Pollution level					
1.6.5	Max. permissible ice thickness	mm				
1.6.6	Design seismic acceleration					
1.6.7	Max. permissible wind velocity	m/s				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
1.7	Document (test reports/ outline/ drawings/ catalogues/ maintenance & installation manuals/ instruction manuals/ references/ list of spare parts)					
2	**Rated values & characteristics:**					
2.1	Method of sealing oil filled chamber					
2.2	Rated primany voltage	kV				
2.3	Rated secondary voltage	V				
2.4	Highest voltage for equipment	kV				
2.5	Rated voltage factor:					
2.5.1	Continuous					
2.5.2	30 sec.					
2.6	Insulation level in standard condition:					
2.6.1	LIWL	kV_{peak}				
2.6.2	SIWL	kV_{peak}				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.6.3	1 minute PFWL:					
2.6.3.1	Dry	kV				
2.6.3.2	Wet	kV				
2.7	Max. R.I.V. at 1.1 $U_m / \sqrt{3}$ and 1 MHz	μ volt				
2.8	Rated power frequency withstand Voltage for secondary windings	kV				
2.9	Rated transformation ratio					
2.10	Voltage ratio adjustment:					
2.10.1	Total range	%				
2.10.2	Each step	%				
2.11	Number of secondary winding					
2.12	Accuracy class for each winding					
2.13	Rated output for each winding	VA				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.14	Thermal limiting output of each secondary winding	VA				
2.15	Total thermal limiting output of each secondary winding	VA				
2.16	Permissible secondary S.C. time with rated Voltage maintained on primary terminal	Sec				
2.17	Short circuit impedance	Ω				
2.18	Temperature rise in rated output	°C				
2.19*	Capacitive voltage divider:					
2.19.1*	Class, thickness and grade of paper (or any other insulating material) used in capacitors					
2.19.2*	Design stress of paper (or any other insulating material used in capacitors)	kV/mm				
2.19.3*	Rated capacitance	pF				
2.19.4*	High voltage capacitor capacitance	pF				
2.19.5*	Intermediate voltage capacitor capacitance	pF				
2.19.6*	Tangent of loss angle in rated voltage					

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.19.7*	Suitable for PLC frequency	kHz				
2.19.8*	Equivalent series resistance for 35-450 kHz At site condition	Ω				
2.19.9*	Natural frequency	Hz				
2.19.10*	Method of controlling stress distribution in paper insulation (or any other insulating material used in capacitors)					
2.19.11*	Intermediate voltage	kV				
2.19.12*	Temperature coefficient	1/°K				
2.20	Attenuation of intermediate voltage Transformer within 35-450 kHz					
2.21*	Method of suppressing feroresonance phenomena					
2.22*	Transeient Response Class (According to IEC 60044-5)					
2.23	External insulator:					
2.23.1	Type					
2.23.2	Manufacturer's name and country					
2.23.3	Number of pieces					
2.23.4	Creepage distance	mm				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.23.5	Washable in service	Yes/No				
2.23.6	Permissible cantilever moment	N-m				
2.23.7	Ultimate tensional strength	N-m				
2.23.8	Insulator colour					
2.24	Max. allowed static forces applied at					
	Outermost point of the HV terminals:					
2.24.1	Horizontal	N				
2.24.2	Vertical	N				
2.25	Max. allowed dynamic forces applied at					
	Outermost point of the HV terminals:					
2.25.1	Horizontal	N				
2.25.2	Vertical	N				
2.26	Overall height	mm				
2.27	Overall width	mm				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.28	Max. shipping dimensions	m×m×m				
2.29	Weight of oil	kg				
2.30	Type and grade of oil used in					
2.30.1	Capacitor unit					
2.30.2	Intermediate voltage transformer					
2.31	Total weight of a single phase Capacitor voltage transformer	Kg				
2.32	Permitted inclination (refer to vertical axis):					
2.32.1	During storage	Degree				
2.32.2	During transport	Degree				
2.33	Material of Conducting parts					
2.34	Type and material of HV terminal					
2.35	Corona ring provided?	Yes/No				

Voltage transformer table (II) (continued)
Guaranteed Technical Information of Voltage Transformer (to be supplied with tender)

ITEM	DESCRIPTION		TECHNICAL PARTICULARS			
			420 kV	245 kV	145 kV	72.5 kV
2.36	VT designed for mounting of line trap on it?	Yes/No				
2.37	Intermediate tap is brought – out?	Yes/No				
2.38	VT equipped with accessories?	Yes/No				
	(If yes, state accessories)					
2.39	Natural frequency	Hz				
2.40	Damping factor	%				
2.41	Max. ground acceleration which can withstand					
2.42	Protection degree (IP code) of secondary terminal box					
2.43	Heater for secondary terminal box provided?	Yes/No				

* These shall be mentioned only for capacitive voltage transformer.