Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Auxiliary-Grounding Transformers at HV Substations

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CONNTENTS

Description **PAGE**

Technical Specification of Auxiliary- Grounding Transformer

1- General Requirements

This specification covers the requirements of the design, manufacturing, factory testing, packing and marking of combined auxiliary and grounding transformer (AGTR) and accessories.

Transformer shall be designed, manufactured and tested according to the requirement of the latest edition of the following standards:

IEC 60076: Power transformers

IEC 60289: Reactors

IEC 60137: Bushings for alternating voltage above 1000 V

IEC 60156: Methods for determination of the electric strength of insulating oils.

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

IEC 60076-7: Loading guide for oil immersed power transformer

IEC 60076-8: Terminal and tapping marking for power transformers

IEEE 32: Requirements, terminology & test, procedure for neutral grounding devices.

All amendments, supplements and reference publications of the above mentioned standards shall also be applied.

Additional to the following specifications, other requirements and specifications for power transformers should be applied.

Transformer shall be core type, three phase, oil immersed, self cooled and shall have two separate windings as interconnected star (zig-zag) on the high voltage side and star with neutral on the low voltage side. HV side will be directly connected to the main power transformer. The neutral point of the interconnected zig-zag winding shall be grounded solidly or via resistor.

The transformer shall mechanically withstand solid line- to- ground fault on the low voltage terminals, with fault contributions from the high voltage only. The transformer and accessories should be designed and constructed to withstand sufficiently the forces due to shipping, erection and maintenance.

The transformer oil shall be of mineral type without PCB (poly chlorinated biphenyl), in accordance with IEC 60296 uninhibitent anti oxidant type and with napthenic base.

The transformer shall deliver its specified full rate capacity under the specified conditions of ambient air temperatures and elevation.

The transformer shall be designed and assembled in such a manner that the average sound level will not exceed from specified value.

The transformer bushings should be manufactured according to IEC 60137.

The combined auxiliary and earthing transformer should be capable for operating under overvoltage condition (from 105% to 110%) and deliver nominal current at 105% nominal voltage.

2- Design and Construction

2-1- Core

The core of the transformer shall be constructed from highest quality, non- aging, cold- rolled, grain oriented, silicon steel especially suitable for the purpose. The steel shall be in thin laminations, and rolled to insure smooth surfaces at the edges. Both sides of each sheet shall have an insulated surface treatment or coating providing the required interlamination resistance.

The cores shall be carefully assembled and rigidly clamped to insure adequate mechanical strength to support the windings and to prevent shifting of the laminations in fault condition and during shipment.

All steel sections used for supporting the core shall be shot or sand blasted.

Insulated pockets of the core are to be connected so that no potential difference will exist between them.

2-2- Windings

The windings of the transformer shall be made from copper and assembled in a manner best suited for the particular application. Proper consideration shall be given to all factors of service such as high dielectric and mechanical strength of insulation, minimum dielectric losses, uniform electrostatic flux distribution and minimum restrictions to free circulation of oil.

Coils shall be made up, shaped and braced to provide for expansion and contraction due to temperature changes in order to avoid abrasion of insulation and to provide rigidity to resist movement and distortion caused by abnormal operating conditions.

The entired design, construction and treatment of the windings and their assembly on the core shall embody the latest improvements in the art and conform to best modern practice.

Transformer shall be capable of withstanding for a period of 2 seconds application of normal three- phase line voltage to two line terminals of the zig-zag winding with the other line terminal and the neutral terminal connected solidly to earth.

The zig-zag winding of transformer, when at its maximum temperature due to continuous full load on the star low voltage winding, shall be designed to carry for thirty seconds without injurious heating the estimated ground fault current.

The low voltage (star- connected) winding shall have specified continuous rating.

2-3- Tank

The transformer tank shall be a steel case of substantial construction, which shall be oil tight and provided with an oil tight cover.

The gaskets shall be made of a resilient material which shall not deteriorate under the action of hot oil and shall remain oil tight.

The transformer shall be provided with suitable eyebolts and/ or lugs for lifting the completely assembled transformer. Lifting lugs and attachments shall have ample factor of safety to allow for possible unequalized lifting forces.

The transformer tank shall be capable of withstanding without leakage or distortion, an internal gas pressure of 1.0 kg/cm^2.

The transformer shall be provided with steel base suitable for wheels to support the transformer and prevent the tank from bearing on the support pad.

The 63 kV transformer tank shall be provided with a pressure relief device with alarm and trip contacts, to protect the tank against an explosion due to arcing blow the surface of the oil.

Valves for oil circulation should be provided on transformer tank.

The tank shall be equipped with:

- Gate valve for removal of oil.
- Oil sampling valve.
- Buchholtz relay.
- Indicating top oil thermometer with alarm and trip contacts.
- Rating plate.
- Two earth terminal on opposite sides.
- Attaching plate for jacks (for 63 kV transformer).
- Oil filling valve (for 63 kV transformer).
- Vacuum possibility (for 63 kV transformer).
- Gas injection possibility (for 63 kV transformer).

2-4- Tap changers

The transformer shall be equipped, if required, with a manually operated tap changer for changing connections to the taps in the high voltage windings. Taps will be changed only when the transformer is de- energized. The tap changer control shall be located above oil level and shall be accessible through the tank cover. An external operating handle, a position indicator and provision for locking in any operating position shall be provided.

2-5- Bushings

The transformer shall have leads brought porcelain bushings best suited for the voltage of the lead, with a high factor of safety. Bushings of same voltage shall be inter changeable between units. All bushings shall be so designed that there will be no stressing of any parts due to temperature changes and adequate means shall be provided to accommodate conductor expansion. Bolts or equivalent clamp type terminals shall be furnished on the bushings.

All porcelain used in the bushings shall be manufactured by the wet process and shall be homogeneous, free from laminations, cavities or other flaws affecting its mechanical strength or dielectric quality tough and impervious to moisture.

Bushing shall be located in the transformer so that minimum clearances applicable for the insulation level are available between live part and live part to earthed structure.

63 kV bushing should have arcing horn.

2-6- Conservator

A conservator tank shall be mounted in extension of the side of the cover, hurdle expansion of heated oil contained in the main transformer tank. The conservator shall be equipped with the followings:

- A filling valve.
- A drain valve.
- An oil level gauge.
- A handhole for inspection and cleaning (for 63 transformer).
- Valve for isolation of conservator from tank (for 63 kV transformer).
- Dehydrating breather.

In 230 and 400 kV substations, the conservator of transformer preferably should be of sealed type.

2-7- Control housing

A large enough control housing shall be provided for the terminals, internal circuit fuses, all control and auxiliary circuits and equipment. It shall be provided with vents, screened against dust, insects, thermostatically controlled heater, removable gland plate over cable entries and internal light with door switch shall also be provided. Terminal size and wire cross section in control circuit should be 2.5 mm^2 and 10% spare terminals should be provided.

2-8- Cable box

A cable box for voltage up to 33kV should be considered to connecting the power transformer tertiary to auxiliary- earthing transformer primary bushings via power cable. Also auxiliary- earthing transformer secondary cable box should have possibility for erection of secondary fuses or MCCB.

3- Rating Plate

The rating plate of the transformer shall be of aluminum and include information in accordance with IEC 60076:

- Type of the transformer
- Indoor/ outdoor
- Manufacturer name
- Serial number
- Year of production
- Number of phases
- Nominal frequency
- Nominal voltage and tap range
- Nominal continuous capacity
- Nominal neutral current and its duration
- Insulation levels
- Winding connections
- Zero sequence impedance
- Short circuit impedance
- Cooling system
- Total weight
- Type and weight of oil

4- Spare Parts and Tools

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

5- Tests

The following tests shall be carry out for transformer according to IEC 60076 and IEC 60289.

5-1- Type test

- Dielectric tests
- Temperature rise tests

5-2- Routine tests

- Measurement of winding resistance
- Measurement of zero sequence impedance
- Measurement of no load and current
- Dielectric tests
- Sampling and test of insulating oil
- Measurement of voltage ratio and check of voltage vector relationship
- Measurement of impedance voltage and load loss
- Tap changer tests

5-3- Special tests

- Short time current test
- Measurement of sound level

Engineer shall have access to the works for determination or assessment of compliance with the provision of this specification and witness the contractor's inspection or tests.

A certification of compliance of the equipment design, type and routine test stipulated in the applicable standards shall be produces by contractor. Owner reserves the right to have representative present during final shop and functional testing.

The contractor shall advise the date of test at least 60 days in advance.

6- Drawings & Documents

6-1- Documents to be given by tenderer

- Filled schedule AGTR (II)
- Catalogue & technical pamphlets
- Winding's type
- Summery of test reports
- Outline drawing
- Detailed summary of exceptions to tender specifications
- Packing, transportation, operation, installation and storage instruction manuals
- Spare parts list
- Reference list

6-2- Documents to be given by contractor/ supplier

The electrical and mechanical design, fabrication, factory testing, marking, packing, transportation, storage, erection, site test, operation and maintenance drawing/ documents and manuals shall be submitted not limited to the following:

- Calculation sheets to establish adequacy of transformer in any respect
- Outline dimension and cut away drawings
- Location and outlines of all bushings and terminal boxes
- Total weight and weight of oil
- Protection and electrical circuit diagrams
- Nameplate drawings
- Test report and certification of compliance
- Erection and site test manuals
- Operating and maintenance instruction manuals
- Guide for foundation design and transformer fixing method
- Shipping, warehousing, assembly, erection, commissioning, operating, repair and maintenance instruction manuals
- List of component
- Drawing list
- Other documents and drawings according to power transformer specification

7- Installation of Auxiliary- Grounding Transformer

Installation should be done according to the manufacturer instructions and guides. Upon reception, a through inspection should be made for detecting any failure or damage due to transportation. Vulnerable parts such as terminal box or bushings should be inspected with especial care. Before unloading the transformer from the vehicle, insulation tests should be applied with megger, and in case of any insulation damage, the transformer should be deported to the manufacturer.

If there is evidence of damage or rough handling in transit, an inspector representing the carder and the manufacturer should be notified.

For unloading the transformer from the vehicle, the preferable way is handling by crane.

If the foundation and the vehicle have same levels, then the transformer can be moved on rails with its wheels.

Where a transformer cannot be handled by a crane or moved on wheels, it may be skidded or moved on rollers or slip plates, depending upon compatibility of transformer base design.

The transformer should always be handled in normal upright position unless information from the manufacturer indicates it can be handled otherwise.

Lifting lugs and eyes are normally provided for lifting the complete transformer in vertical manner.

Transformer movement in all stages of loading, transportation, unloading and installation on foundation should be done without any shock on the transformer.

The auxiliary- grounding transformer is usually installed near the power transformer on the different foundation.

The primary terminals should be connected to the high voltage conductors and busbars while care should be done to not stressing these terminals above their mechanical withstand capabilities. The ground connection will be through the neutral terminal which usually located at the base of the transformer tank.

8- Commissioning Tests

- Check the installation situation on the foundation or rails
- Visual inspection and checking of accessories
- Check the tank earth connection
- Insulation resistance test
- Winding ratio test on each tap

- Vector group test on principal tap position
- No load current test
- Oil insulation test
- Winding resistance measurement on each tap
- Measurement of tg δ
- Tests on bushing CTs including ratio, polarity, insulation resistance and saturation curve
- Check manual and mechanical tap changer operation including interlocks and indicators
- Measurement of impedance voltage on each tap position
- Insulation resistance test on control and auxiliary circuits
- Check wiring, accessories and protection of auxiliary and control panels
- Check operation of instruments and their calibration
- Check operation of buchholtz relay
- Check operation of piping
- Check the position of the conservator and the silicagel breather
- Check the position of bushings
- Check secondary connection of CTs
- Check neutral connection to ground
- Check for oil leakage

SCHEDULE AGTR (I)

RATING AND CHARACTERISTICS OF AUXILIARY & GROUNDING TRANSFORMER

ITEM	DESCRIPTION		TECHNICAL Particular
1	**Particulars of system**		
1.1	Highest system voltage	kV	24/36/72.5
1.2	Nominal system frequency	Hz	50
1.3	Number of phases		3
1.4	System neutral earthing		Solidly earthed/ resistance earthed
1.5	Max. duration of short time current	Sec	1
2	**Service condition**		
2.1	Max. ambient temperature	°C	40/45/50/55
2.2	Min. ambient temperature	°C	-40/-35/-30/-25
2.3	Altitude above sea level	m	1000/1500/2000/2500
2.4	Pollution level		L/M/H/VH
2.5	Max. wind velocity	m/s	30/40/45
2.6	Wind velocity at ice condition	m/s	20
2.7	Ice coating thickness	mm	5/10/20/25
2.8	Seismic acceleration	m/s^2	0.2g/0.25g/0.3g/0.35g
2.9	Relative humidity	%	90/95/more than 95
2.10	Average value of daily temperature	°C	*
2.11	Solar radiation	°C	*
3	**AGTR characteristics**	w/m^2	
3.1	Class	outdoor/indoor	outdoor
3.2	Rated voltage:		
3.2.1	HV winding	kV	20/33/63
3.2.2	LV winding	V	400
3.3	Rated frequency	Hz	50
3.4	Rated continuous power at site	kVA	160/200/250/315/400/500/800
3.5	Rated time	S	30/60
3.6	Vector group		ZNyn5/ZNyn11/ZNyn1/ZNyn7
3.7	Method of cooling		ONAN
3.8	Impedance voltage	(%)	*

SCHEDULE AGTR (I)
RATING AND CHARACTERISTICS OF
AUXILIARY & GROUNDING TRANSFORMER

ITEM	DESCRIPTION		TECHNICAL Particular
3.9	Windings insulation levels:		
3.9.1	Rated lightning impulse withstand voltage:		
	HV terminal	kV_{peak}	*
	Neutral end	kV_{peak}	*
3.9.2	Rated one minute power frequency withstand voltage:		
	HV terminal	kV	*
	LV terminal	kV	*
	Neutral end	kV	*
3.10	Bushings insulation level:		
3.10.1	Rated lightning impulse withstand voltage:		
	HV	kV_{peak}	*
	LV	kV_{peak}	*
	Neutral	kV_{peak}	*
3.10.2	Rated one minute power frequency withstand voltage:		
	HV	kV	*
	LV	kV	*
	Neutral	kV	*
3.11	Max. temperature rise at rated power:		
3.11.1	Winding	°C	*
3.11.2	Top oil	°C	*
3.12	Short circuit strength:		
3.12.1	HV system fault level (one & three phase)	kA	*
3.12.2	LV system fault level (one & three phase)	kA	*
3.12.3	Short circuit duration	Sec	2
3.13	De energized tap changer:		
3.13.1	Is required?	Yes / No	Yes
3.13.2	Winding location		HV winding

SCHEDULE AGTR (I)
RATING AND CHARACTERISTICS OF
AUXILIARY & GROUNDING TRANSFORMER

ITEM	DESCRIPTION		TECHNICAL Particular
3.13.3	Rated current	A	*
3.13.4	Tapping range	±%	±2 x %2/5
3.13.5	Number of steps		5
3.14	Rated zero sequence impedance	Ω/phase	*
3.15	HV bushing creepage distance	mm	*
3.16	Method of line to terminal connection:		
3.16.1	HV side		*
3.16.2	LV side		*
3.16.3	Neutral end		*
3.17	Sound level (measured acc. To IEC 60076-10)	dB	*
3.18	Max. RIV at 1.05 Um (acc. To NEMA 107)	µV	*
3.19	Method of neutral earthing:		
3.19.1	HV side		*
3.19.2	LV side		*
3.20	Auxiliary power supply voltage:		
3.20.1	AC	V	400/230
3.20.2	DC	V	*
3.21	Wheels:		
3.21.1	Is required?	Yes / No	*
3.21.2	Unidirectional / bi- directional		*
3.22	Oil class (acc. To IEC 296)		*
3.23	Max. shipping height	(m)	*
3.24	Control cabinet protection degree		IP54
3.25	Type of conservator (air bag / conventional)		*

*: Will be specified by engineer.

SCHEDULE AGTR (II)
GUARANTEED TECHNICAL INFORMATION OF AUXILIARY & GROUNDING TRANSFORMER (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL Particular
1	**General**		
1.1	Manufacturer's name and country		
1.2	Manufacturer's type & designation		
1.3	Class	outdoor/indoor	
1.4	Applicable standard		
1.5	Applicable site & ambient condition:		
1.5.1	Max. design ambient temperature	°C	
1.5.2	Min. design ambient temperature	°C	
1.5.3	Design altitude above sea level	m	
1.5.4	Pollution level		
1.5.5	Max. permissible ice thickness	mm	
1.5.6	Design seismic acceleration	m/s^2	
1.5.7	Max. permissible wind velocity	m/s	
1.6	Documents (test reports/ outline drawings/ catalogues/ maintenance & installation manuals/ instruction manuals/ references/ list of spare parts)		
2	**Rated values and characteristics**		
2.1	Rated primary voltage	kV	
2.2	Rated secondary voltage	V	
2.3	Highest system voltage in primary	kV	
2.4	Highest system voltage in secondary	V	
2.5	Rated output power at site condition	kVA	
2.6	Rated frequency	Hz	
2.7	Type of cooling method		
2.8	Continuous output power at principal tap	kVA	
2.9	Short circuit current in neutral point	A	
2.10	Type connection (HV/LV)		
2.11	Time duration of ground fault	sec	

SCHEDULE AGTR (II)
GUARANTEED TECHNICAL INFORMATION OF AUXILIARY & GROUNDING TRANSFORMER (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL Particular
2.12	Max. temperature rise at rated power outputs corrected for altitude & ambient temp. of site:		
2.12.1	Top- oil	°C	
2.12.2	Winding	°C	
2.12.3	Hottest spot	°C	
2.13	Deenergized tap changer:		
2.13.1	Type		
2.13.2	Manufacturer		
2.13.3	Rated current	A	
2.13.4	Total range	%	
2.13.5	Total number of steps		
2.13.6	Variation per steps		
2.13.7	Position of tapping (winding)		
2.14	Vector group		
2.15	Impedances (base of rating power):		
2.15.1	Positive sequence impedance at 75 (°C), on principal tapping	%	
2.15.2	Positive sequence impedance at 75 (°C), max. raise voltage	%	
2.15.3	Positive sequence impedance at 75 (°C), max. lower voltage	%	
2.15.4	Zero sequence impedance at 75 (°C) and principal tap	Ω/ phase	
2.16	Rated short circuit strength (1 and 3 phase):		
2.16.1	HV winding	kA	
2.16.2	LV winding	kA	
2.16.3	Short circuit duration	Sec	
2.17	Insulation levels at IEC condition:		
2.17.1	Lightning impulse withstand voltages:		
	HV winding/ bushing	kV_{peak}	
	LV winding/ bushing	kV_{peak}	

SCHEDULE AGTR (II)
GUARANTEED TECHNICAL INFORMATION OF AUXILIARY & GROUNDING TRANSFORMER (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL Particular
2.17.2	One minute power frequency withstand voltage:		
	HV winding/ bushing	kV	
	LV winding/ bushing	kV	
	Neutral end/ bushing	kV	
2.18	Max. sound level (according to IEC 60076-10)	dB	
2.19	Max. RIV at 1 MHZ (according to NEMA 107)	µvolt	
2.20	Vibration at rated frequency and voltage at 75°C	µm	
2.21	Efficiency at full and at 3/4 full load	%	
3	**Bushing data:**		
3.1	Manufacturer		
3.2	Type		
3.3	Creepage distance:		
3.3.1	HV side	mm	
3.3.2	LV side	mm	
3.3.3	Neutral	mm	
3.4	Max. mechanical forces on HV & LV bushings:		
3.4.1	Static, horizontal	N	
3.4.2	Static, vertical	N	
3.4.3	Dynamic, horizontal	N	
3.4.4	Dynamic, vertical	N	
3.5	Loss angle at working voltage		
3.6	Electrostatic capacity of complete bushing	PF	
3.7	Test standard		
4	**Exciting current:**		
4.1	At rated voltage when excited from HV side	A	
4.2	As above at 110% rated voltage	A	

SCHEDULE AGTR (II)
GUARANTEED TECHNICAL INFORMATION OF AUXILIARY & GROUNDING TRANSFORMER (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL Particular
5	**Losses:**		
5.1	Load losses at rated frequency, 75°C & rated current on principal tapping	kW	
5.2	Load losses at 75°C & max. raise voltage tapping	kW	
5.3	Load losses at 75°C & max. lower voltage tapping	kW	
5.4	No load losses at rated frequency & rated voltage on principal tapping	kW	
6.1	Flux density of core at rated frequency and voltage on principal tap	Tesla	
6.2	As above at 110% rated voltage	Tesla	
6.3	Current density at rated power & rated voltage:		
6.3.1	HV winding	A/mm^2	
6.3.2	LV winding	A/mm^2	
7	**Tank:**		
7.1	Type of tank		
7.2	Thickness of tank	mm	
8	**Vacuum withstand capacity:**		
8.1	Tank	mm Hg	
8.2	Radiators	mm Hg	
8.3	Conservator	mm Hg	
8.4	Positive pressure withstand of transformer		
9	**Oil:**		
9.1	Class (as per IEC 60296)		
9.2	Type (inhibited/ non- inhibited)		
9.3	Details of inhibitor		
9.4	Dielectric strength & test standard:		
9.4.1	New	kV	
9.4.2	After treatment	kV	

SCHEDULE AGTR (II)
GUARANTEED TECHNICAL INFORMATION OF AUXILIARY & GROUNDING TRANSFORMER (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL Particular
9.5	Quantity of oil:		
9.5.1	Main tank	Litres	
9.5.2	Conservator	Litres	
9.6	Way of shipping		
9.7	Designation		
10	**Physical data:**		
10.1	Overall height, including bushings	mm	
10.2	Overall width, including mounted accessories	mm	
10.3	Overall length, including mounted accessories	mm	
10.4	Height for lifting core & coils from tank	mm	
10.5	Max. shipping dimensions (largest item) (L × W × H)	mm	
10.6	Weight of oil	kg	
10.7	Total weight of complete transformer	kg	
10.8	Max. shipping weight:		
10.8.1	Heaviest item	kg	
10.8.2	All items	kg	
10.9	Type of fixing on the foundation		
10.10	Type of colour (RAL)		