E L E C T R I C I T Y G E N E R A T I N G A U T H O R I T Y O F T H A I L A N D

Supplemental Notice No. 1

Invitation to Bid No. TIPN-TX-04

Supply of 333.33 MVA 500 kV Power Transformer

Transmission System Improvement Project in Upper Northern Region to Enhance System Security

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The attached Supplemental Notice shall be considered as part of the bidding documents No. TIPN-TX-04.

As acknowledgement of receipt that all additions, deletions and revisions contained in this Supplemental Notice are incorporated into the above bidding documents, Bidder is requested to sign and return this acknowledgement via email address : burapat.dan@egat.co.th within three (3) days from the date of the announcement of this Supplemental Notice on http://www4.egat.co.th/fprocurement/biddingeng/.

The original acknowledgement which is manually signed in ink by a person or persons duly authorized shall be included in the proposal to be submitted on the bid opening date.

ELECTRICITY GENERATING AUTHORITY OF THAILAND

February 9, 2026

ACKNOWLEDGEMENT

This undersigned Bidder hereby certifies that the additions, deletions and revisions set forth in this Supplemental Notice to Invitation to Bid No. TIPN-TX-04 are incorporated as part of the above bidding documents and will be fully included in any bids which he may submit.

Signed _____

Title _____

Company _____

Date _____

E L E C T R I C I T Y G E N E R A T I N G A U T H O R I T Y O F T H A I L A N D

SUPPLEMENTAL NOTICE NO. 1

INVITATION TO BID NO. TIPN-TX-04

SUPPLY OF 333.33 MVA 500 kV POWER TRANSFORMER

TRANSMISSION SYSTEM IMPROVEMENT PROJECT
IN UPPER NORTHERN REGION TO ENHANCE SYSTEM SECURITY

The following supplemental information is hereby given for the above described Invitation:

1. Section C : Proposal

   Revise Proposal Data of the Power Transformer and Surge Arrester with the revised excel file of Proposal Data (Rev.1) attached.

2. Section I : Specifications

   Replace Specification No. 711 Rev. (Sept. 2025) with the revised one with Rev. (Jan. 2026) attached.

Bid submitted must be in accordance with this Notice. Receipt of this Notice shall be acknowledged by the Bidder on the proposal included in the Bidding Documents in the space provided on page C3, Article C-7. Supplemental Notices.

ELECTRICITY GENERATING
AUTHORITY OF THAILAND

February 9, 2026

Specification No 711

Oil filled Power Transformer

711-1 General. This specification covers the general requirements for design, manufactures, test and supply of the outdoor, oil-filled power transformer.

The specific ratings, characteristics and the special requirements and features of the transformer not cover herein are given in the accompanying Ratings and Features sheet.

711-2 Materials and Workmanship. All materials shall be new and shall be the best available for the purpose used, considering strength, ductility, durability and suitability for the intended service and best engineering practice. Workmanship shall be of the highest grade and in accordance with the best modern standard practice.

711-3 Service Conditions. All materials shall be suitable for installation and use at an altitude of 1000 m or less in a tropical climate with a maximum ambient temperature of 45°C, maximum 24 hour average temperature of 40°C, yearly average temperature of 30°C and 100% relative humidity without corrosion, deterioration or degradation of performance characteristics.

711-4 Codes and Standards. All equipment, materials, devices, fabrication and testing shall conform to the codes, specifications and standards listed below and all applicable codes, specifications and standard referenced therein.

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
IEC	The International Electrotechnical Commission
IEEE	The Institute of Electrical and Electronics Engineers
NEMA	National Electric Manufacturers Association
TIS	Thai Industrial Standards

All threaded parts requiring external connection shall have metric screw and pipe threads. All internal parts may have threads in accordance with the established specification in the country of manufacturer.

It is the intent that all equipment, materials, devices, fabrication and testing shall conform to the application codes, specifications and standards even though there

are not specifically noted herein. Equivalent codes, specifications and standards established and approved in the country of equipment or material manufacturer may be used subject to EGAT's approval. If this election is made, the Bidder shall so state and include in his bid the governing codes, specifications, and standards proposed together with an itemized list of specific deviations from the requirements of codes, specifications and standards referenced herein.

The latest issue of all codes, specifications and standards shall govern.

The most stringent requirement, in the event of code, specification or standard conflict, shall govern. This specification shall govern in the event of discrepancies between it and applicable codes, specifications and standards.

711-5 Working Stresses - The design of all components, particularly those subject to shock or stress reversal, shall incorporate reasonable factors of safety in all cases**.**

711-6 Design and Construction

711-6.1 Tank. Each transformer shall be provided with a steel case of substantial construction and a welded main cover. The tank shall be capable of withstanding, without leakage or permanent distortion of an internal gas pressure of 1 kg/cm^2 (14.22 lb/in^2) and a vacuum of 760 mm of mercury and shall be designed and constructed for full vacuum filling in the field. The maximum design positive and negative operating pressures shall be indicated on the nameplate. All valves, fittings and piping shall be designed and constructed for such vacuum filling. The tank cover shall not be designed to retain water.

The piping shall be arranged to have a slope of not less than 0.05 radians (2.86 degrees) from the horizontal and shall be upward toward the conservator. The highest point of every pocket in the tank and attachments in which gas may accumulate shall be connected together by piping and shall be connected through the Buchholz relay.

The tank shall also have suitable jacking pads, pulling eyes and lifting lugs. All the jacking pads, pulling eyes and skid base shall be designed and constructed for possibly moving the complete assembly transformer on roller in either direction. The jacking pads shall be located at the tank side wall of at least 40 cm above transformer base and shall be suitable for EGAT’s jack having base dimension of 30 cm x 25 cm in rectangular. The jacking pads and lifting lugs shall be welded on longer tank sides. The tank shall be provided with a fabricated structural steel skid base to allow skidding or moving on roller in either direction. The tank shall have four (4) jacking pads for applying force at the same time. The base and skids shall be fabricated as one piece with the distance between skids shall be in the range of 95 to 150 cm (center to center) for 115 kV and below Transformer and 120 to 150 cm (center to center) for 230 kV and above Transformer. A flat base plate is not acceptable.

The position of center of gravity for transformer under transportation condition and complete assembly condition shall be clearly marked on the transformer tank, the axes of center of gravity for both conditions shall be marked at skid base of all four sides of transformer. The distance between center of gravity under transportation condition and the center line of transformer shall not be more than 150 mm.

711-6.2 Core. Cores shall be constructed of high quality, non-aging, annealed, high permeability silicon steel. The steel shall be in thin laminations. Both sides of each sheet shall be insulated with a durable, high temperature inorganic coating. The cores shall be rigidly clamped with positive locking devices to insure adequate annealed, high permeability silicon steel. The steel shall be in thin mechanical strength to support the windings and prevent shifting of laminations during shipment, and also to reduce vibration to a minimum during operation. Cores shall be grounded at one point and two (2) bushings shall be provided for possible measuring the core insulation of 2.5 kV from top of the tank cover without lower the oil. One bushing for core and another bushing for core clamp.

711-6.3 Windings. The design, construction, and treatment of windings shall give proper consideration for all service factors, such as high dielectric and mechanical strength of insulation, coil characteristics, uniform electrostatic flux distribution, prevention of corona formation, and minimum restriction to free oil circulation.

Winding conductor shall be free from burrs, scale and splinters and shall be uniformly insulated. In every case, each conductor strand shall be insulated by varnish to avoid the risk of sulfur attack in contact with insulating oil. Bare conductor (without insulating paper and/or enamel) is not acceptable.

The hoop compressive stress of the winding which can be buckled due to the pressure during the short circuit condition shall be limited to the following:

a) In case of no cooling duct between turns in the disk coil, the average hoop compressive stress shall not be more than 35% of proof stress with permanent elongation of 0.2% ($\sigma_{0.2}$) of used copper.

b) In case of cooling duct being inserted between turns, the stress shall be controlled at the outermost turn with the same limitation as above item (a).

c) In case of epoxy resin being used for bonding conductor, the same condition as above item (a) and (b) shall be considered except that the stress shall be limited to not more than 50% of proof stress with permanent elongation of 0.2% ($\sigma_{0.2}$) of used copper.

Nevertheless, other factors concerning the transformer strength such as conductor size, bonding quality for continuous transposed conductor (CTC), etc. shall be considered by the manufacturer as well. Moreover, the manufacturer shall be fully responsible for the proposed transformer design.

All insulation shall be of uniform quality and void free. Current carrying joints or splices shall be welded or braced, properly formed and finished and insulated for the basic insulation level.

The insulating pressboard offered shall be the products of the manufacturers as shown on the list attached.

The completed winding assembly shall be securely held in place so that there will be no derangement or deformation due to stresses during shipment. Applied pressure for winding clamping shall be controlled by applied torque or pressure on clamping bolts. Torque value or pressure on clamping bolts and the coil height shall be recorded and submitted for our reference.

711-6.4 Core and Coil Assembly. The completed assembly of core and coils shall be dried in a vacuum sufficient to insure elimination of air and moisture within the solid insulation to less than 0.5% water by weight. After the drying process, the assembly shall be immediately impregnated with dry oil. Vacuum may be applied either in a special tank or in the transformer tank.

The core and coil assembly shall be adequately blocked and braced in the transformer tank to prevent any movement of the assembly during handling and shipment. Shipping clearance limitations may necessitate shipment of the transformer on its side. Any internal blocking or bracing which is to be removed from the transformer at its destination shall be colored a bright color such as red or yellow.

711-6.5 Oil Preservation. The conservator shall be provided with a rubber bag type oil preservation system with dehydrating breather to prevent the outside air from coming into contact with the transformer oil. This shall be accomplished by the use of a flexible nitrile air cell vented to the outside air through a desiccant, such as silica gel, in a weather tight breather. The breather desiccant container shall be fabricated with metallic container equipped with clearly visible side glasses and located for safe replacement, refill and maintenance can be made while the transformer is energized. The silica gel shall be nontoxic type.

The conservator shall be equipped with a combination of oil drain and oil filling valve, a combination of vacuum valve and upper filter-press connection. The conservator shall be capable of withstand without leakage or permanent distortion an internal pressure of 1 kg/cm^2 (14.22 lb/in^2) and a vacuum of 760 mm of mercury and shall be designed and constructed for vacuum filling in the field.

Lifting eyes shall be provided on the conservator tank.

711-6.6 Cooling Equipment. Each transformer shall be designed with a sufficient number of radiators or cooling units to operate as a self-cooled unit and with or without forced cooled ratings as specified in Ratings and Features sheets. The forced cooled ratings will be obtained by the use of single stage fans (Class ONAN/ONAF) two stages fans (Class ONAN/ONAF /ONAF) or two stages, fans and oil pumps (Class ONAN/ONAF/OFAF). In case of OFAF cooling class, the transformer shall be designed that the Static Electrification problem shall not occur.

Fans and oil pumps shall be automatically controlled by a transformer winding temperature relay. Cooling control equipment shall be installed in the transformer control cabinet.

Each radiator, unless it is made of stainless steel, shall be of galvanized with painted and shall be connected to the transformer tank through radiator valves, so that any individual radiator may be removed without taking the transformer out of service. Gasket joints shall be provided between the valves and machined steel flanges welded to the tank and to the radiator. An oil-tight blank flange shall be provided for each connection, for use when radiators are detached. Each radiator shall be designed and constructed for vacuum filling independently in the field and shall have a lifting eye, oil drain valve with flange, and a combination of vacuum flange and a vent. If cooler units furnished are of the finned-tube type, tubes, fins, and tube sheets shall be of corrosion-resistant material and shall be designed to permit replacement of individual cooler tube groups.

The loss of any fan or any oil pump shall not reduce the output of the transformer by more than 10%, with temperature rises maintained within specified limits. The verification of this condition shall be submitted for approval.

The oil pumps and motors shall be mounted on the transformer and shall have ample capacity to circulate the oil through the complete transformer and radiators and to maintain the temperature rise within the limit specified. The oil pumps shall be of the centrifugal type and shall be direct connected to the motors. The oil pumps and motors shall be completely oil-immersed and shall operate without the use of packing glands. Oil pump shall be located so that any pump may be removed or maintained with complete safety while the transformer is energized. Valves shall be located between the transformer tank and the pump and between the pump and radiator or cooler to permit pump removal without draining the oil from the transformer and radiator or cooler. The valves used shall be a type which offers minimum restriction of oil flow and shall be provided with an adjustable stuffing gland. Simultaneous operation of oil pumps, either starting or stopping, shall not cause any misoperation of the fault pressure relay and/or Buchholz relay. An oil flow indicator, with alarm contacts,

shall be furnished with each pump assembly to indicate normal pump operation and direction of oil flow.

Fan motors shall be of the totally-enclosed design. All motor shall be suitable for operation on a 3-phase, 4-wire, 400/230 Vac, 50 Hz power supply. Fan motor leads shall be totally enclosed in flexible liquid-tight and/or cable tray.

711-6.7 **Bushings**. All bushings shall be resin-impregnated paper-insulated bushing for capacitance graded bushing and shall be solid type for non-capacitance graded bushing. For resin-impregnated paper-insulated bushing, the inner space between insulator and condenser body, if any, must not be filled with oil or gas. The material, electrical and mechanical characteristics shall comply with the applicable requirements of the latest IEC 60137.

All porcelain used in bushing shall be wet process, homogeneous, and free from cavities or other flaws. The glazing shall be uniform in color and free from blisters, burns and other defects. The color of all porcelain insulators shall be chocolate brown. All porcelain parts of 230 kV and below bushing shall be one piece. The porcelain housing for 69 kV and above bushing shall be cemented to the flange.

All bushings shall be mounted so that their installation and removal may be accomplished without draining the oil below the top of the windings. The phase spacing between any bushings shall not be less than 800 mm.

<u>For Single Phase Transformer</u>;
The arrangement of the bushings on the transformer shall be located as shown on the drawing of "Layout for installation of 500 kV Single Phase Transformer" attached**.** The low voltage bushing shall be arranged for vertical take-off. The tertiary bushings shall be arranged side-by-side, on a line parallel to the centerline of the transformer separating the high side and low side. Both the low voltage and tertiary voltage bushings shall be top cover mounted.

<u>For Three Phase Transformer</u>;
The bushings shall be located in such a way that when facing against the high voltage side of the transformer, H_1 bushing shall be on the right-hand side, followed by H_2 and H_3 toward the left-hand side respectively. X_1, X_2, X_3 bushings of the low voltage side shall be directly opposite H_1, H_2, H_3 bushings respectively. Neutral bushing and tertiary bushing, if required, shall be located as shown on the drawing of "Bushings Location for Three Phase Transformer" attached**.**

<u>Package for Long Term Storage Bushing</u>; (For Resin Impregnated Paper (RIP) Condenser bushing)

Spare bushing(s) shall be packed in the long-term storage tank. The storage tank shall be filled with dry transformer oil and equipped with oil sight glass.

Other bushings shall be packed in the long-term storage bushing (at least 24 months) by the instruction manual. The manual shall be submitted together with the tender document during the bidding.

711-6.8 Control Cabinets

a) General

Each transformer shall be furnished complete with a tank mounted control cabinet in which shall be housed all cooling control devices; LTC control devices and accessories, control power air circuit breakers and annunciator, all as described herein; auxiliary alarm relays; and bushing current transformer short-circuiting type terminal blocks.

Each cabinet shall be of the dead-front type with gasket, vertically hinged and adequately braced front door(s). The doors shall have a latching handle complete with a key lock and key cover and 180 degree opening, complete with latching device to secure the door(s) in the full open position. Center-opening double doors shall be provided where the door width exceeds 760 mm. Double door cabinets shall not have latching or bracing devices between the doors that would prevent easy access to the enclosure interior.

The interior of the front door of the transformer control cabinet for a three-phase transformer, and of the common control cabinet for a single-phase transformer, shall be provided with a holder suitable for storing one complete set of transformer drawings and instruction books. The cabinets shall have baffled louvers complete with insect screens.

Each control cabinet shall be installed at an elevation such that control and selector switches and pushbuttons are located approximately 1.0 m above the operator's standing level. All cabinet installed control and selector switches and push buttons shall be dead-front mounted.

All control cabinets shall be weatherproof, rigidly framed and fabricated for 3 mm minimum thickness steel sheet.

Each control cabinet shall be provided with a gasket removable plate at the bottom for field conduit, armoured cable or cable tray drilling. The bottom of the control terminal cabinet shall be equipped with removable blank cover plate suitable for equipment above. If it is conduit, four (4) 88.9 mm diameter knock out type holes suitable for 3 inches rigid steel conduit shall be provided.

<u>For Single Phase Transformer</u>

A separate mounted transformer bank common control cabinet complete with supporting frame or members for installation on the transformer bank center phase foundation shall be furnished. This cabinet shall house all transformer bank common control and

indication devices and accessories including, but not limited to, LTC control devices and accessories, air circuit breakers, relays, and the common transformer annunciator, all as described herein; and auxiliary tripping and alarm relays.

All galvanized bolts, nuts and washers, including foundation anchor bolts, required for complete assembly and erection of the common control cabinet shall be furnished.

For Common control cabinet, terminal blocks shall be arranged by transformer phase (i.e., phase A-B-C) from left to right or from top to bottom when viewing the terminal blocks.

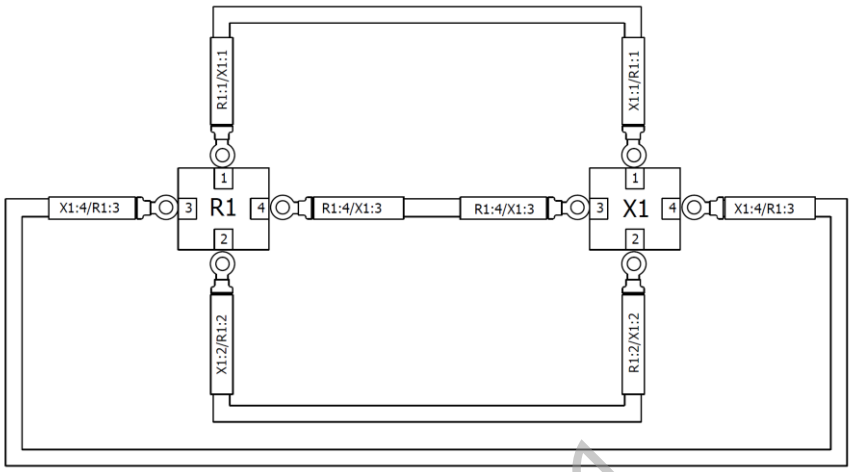
b) Wiring

All wiring for control power supply and for remote control, indication, alarm and tripping shall be connected to terminal blocks provided in this cabinet. All wiring shall be tin coated copper conductor, stranded, minimum voltage classification of 600 V with high temperature PVC insulation. Hinge wire shall be extra flexible Class K stranding.

All wiring shall be not less than 2.5 mm^2, except that all current transformer secondary winding wiring shall be not less than 6 mm^2 for secondary current 5 A and 4 mm^2 for secondary current 1 A. The cross-sectional area of internal wiring in the LTC motor drive mechanism shall be in accordance with the manufacturer's standard. All alarms, contacts and control and indication devices shall be completely wired.

Every point of terminal block and wire shall be assigned a designation, with identical designation on each corresponding terminal block and wire as following format:

The designation on each wiring end shall consist of both origin and destination designations which separated by '/' symbol. The origin designation shall always be indicated on the side adjacent to where the wiring is terminated while the far side shall always indicate the destination designation of the wiring. Depending on the arrangement of terminal block, device and wiring, wire designation on both ends of the same wiring may be different.



- The letter direction of wire mark shall be read from left to right (for horizontal wiring) and bottom to top (for vertical wiring).
- The terminal number of terminal block shall be arranged from top to bottom and left to right.

This same designation shall also be indicated in the schematic and wiring diagrams. As a rule, a designation will not change until the wire is terminated or connected to other equipment. All wiring shall be designated at both ends by printing on wire designation sleeves. Wire designation shall be by permanent method unaffected by heat, solvents, or steam, and not easily dislodge. Approximately 20% of spare wire designation sleeve shall be furnished. Adhesive labels shall not be acceptable.

Insulated ring tongue crimp type terminal shall be used for current transformer. Insulated ring tongue, ferrule, or cord-end crimp type terminals shall be used for other device and terminal block wire connections.

Within the control cabinet shall be mounted a terminal board to facilitate completing the wiring to external circuits. A barrier shall be provided in the terminal cabinet to separate the 400V circuits and their control from lower voltage circuits. Splices or tee connection shall not be permitted for wiring connection in control cabinet.

The terminal board shall consist of terminal blocks of 600 V molded block type with insulating barrier between terminals. Both ends of the low voltage wires shall be terminated by compression type terminal lugs. The interior wiring shall be terminated to the terminal block. Each terminal block shall have marking strip, and shall be equipped with the compression type terminal lugs for 4 mm^2 or larger cable to make connection with outgoing cables. The terminal blocks shall be provided with ten (10) percent but not less than ten (10) additional terminals as spares besides the necessary number. Two (2) or more external wires shall not be connected in one (1) terminal.

Terminal block connections shall be arranged for a maximum of one external wire connection per point. Terminal blocks for external wiring shall have the size suitable for termination of the following cables:

For AC supply	: 2x35 mm^2
For DC supply and	: 2x6 mm^2
For CT leads	
- Secondary current 5 A	: 2x6 mm^2
- Secondary current 1 A	: 2x4 mm^2
For others and spares	: 2x4 mm^2

The terminal blocks for AC circuit and the terminal blocks for DC circuit shall be separately grouped as well as the AC terminal blocks shall be covered with transparent plastic box.

All EGAT external alarm, control, indication and control power connections, except as indicated herein, will terminate in this control cabinet. The turn-key Contractor shall be responsible for all interconnections between the individual transformer control cabinets and the common control cabinet. For a supply Contract, EGAT shall be responsible for these external connections. In all cases, the sufficient quantity of cable completed with metallic cable tray for interconnections between individual transformer control cabinet and common control cabinet, drawings showing all cabinet interconnections shall be provided by transformer manufacturer. Each external wire shall be identified at each end with a metallic cable tag placed over the armoured cable or cable tray.

The Contractor shall furnish, and install where practicable armoured cable or cable tray for wiring all control, protective accessories and bushing current transformers. Short sections of flexible, waterproof conduit may be used for shock mounting. The armoured cable or cable tray shall be suitable connected to the transformer accessories and bushing current transformers and shall be connected to a control cabinet upon each transformer tank.

A minimum clearance of 125 mm shall be provided between terminal blocks to facilitate wiring.

c) Copper ground bus

A 25 mm wide x 6 mm thick or 30 mm wide x 5 mm thick copper ground bus with 4 mm drilled and tapped holes shall be provided with insulation support bushing and properly installed to the enclosure near the bottom of each control cabinet for current transformer secondary and control cable shield grounding. The holes shall be spaced on 20 mm center lines minimum. A 10 mm long binding head screw or screw with bronze spring washer shall be provided in each hole. The ground bus shall have a minimum of ten (10) holes and screws for control cable shields and shall be solidly connected to ground terminal.

connector located outside of the cabinet. EGAT shall have the option of specifying additional ground bus holes and screws at the time of drawing approval without additional cost to EGAT. The ground terminal connector shall be clamp type suitable for No 4/0 AWG copper stranded conductor which is directly connected to grounding system and provided at one end of each cabinet ground bus.

d) Space heater, Lighting and Outlet

Sufficient space heater and lighting with door control switch shall be provided in the control cabinet. The space heater circuit shall be as follows:

a) A set of space heater is operated continuously to maintain the temperature rise inside the cabinet within 5°C above the ambient temperature.
b) A set of space heater is operated with temperature supervised humidity control.

A space heater with temperature supervised humidity control shall be provided in each control cabinet and connected to the 230 V, 50 Hz single-phase power supply. The heaters shall be located to promote warm air circulation to prevent cabinet interior condensation while avoiding insulating material and other component accelerated deterioration.

Lighting, completed with control switch and two sets of 20 A, 250 V, two-pole three wire grounding device universal outlets for connection to the EGAT furnished single phase alternating current supply, shall be furnished and installed in each control cabinet.

711-6.9 Terminal Pad. Each equipment terminal for connecting to the line or other equipment shall be equipped with a suitable terminal pad unless otherwise specified. The terminal pad shall be provided with 14.3 mm (9/16 in) diameter holes with 45 mm (1-3/4 in) spacing between the centers of each hole in accordance with the NEMA Standards CC1, 4 holes arrangement shall be used for systems rated 230 kV and below and 6 holes (2×3 bolt pattern) arrangement shall be used for 500 kV systems.

The terminal pad shall be of high conductivity copper or aluminum alloy and, unless it is made of aluminum alloy, shall be plated with hot flowed electro-tin to a thickness of not less than 0.0127 mm (0.0005 in).

711-6.10 De-energized Tap Changer (DETC). An externally-operated tap changer, operated only when the transformer is de-energized, shall be furnished with each transformer if specified in Ratings and Features sheet. To prevent misoperation of the de-energized tap changer while the transformer is still energized, one set of interlocking contact for tripping off the circuit breaker with the provision that the circuit breaker shall be tripped before the possible operation of the de-energized tap changer shall be provided.

The tap changers shall be designed so that they can be operated conveniently, and shall include an operating hand wheel or handle, indicating pointer and dial, and means for locking the tap changer in any desire position. The operating hand wheel or handle shall be provided with steel enclosure and padlock to protect against the unauthorized operation. The locking device shall be arranged to prevent locking the tap changer in an intermediate position. The mark to indicate the position of the tap changer shall also be provided at the transformer tank where the tap changer mechanism shaft enters the transformer tank, so that if the shaft linkage is broken or loosen the tap position in evident.

For Single Phase Transformer

The circuit breaker trip contact shall be wired to the auxiliary tripping and lockout relay via transformer control cabinet and common control cabinet terminal block points.

711-6.11 On Load Tap Changer (LTC). The on load tap changer, if specified in Ratings and Features sheet, shall be the original design and shall have the contact life of not less than 500,000 numbers of tap change operation and shall have the changeable number of operations at maximum rated through-current of LTC provided without hot oil filter unit unless otherwise specified elsewhere of not less than 50,000 times or 5 years, whichever is earlier, without any inspection.

The LTC shall be of high speed resistor type provided either at the high voltage or low voltage side as specified in Ratings and Features sheet.

The LTC shall regulate the output at full capacity at all taps. Regulation through any auxiliary transformer is not acceptable

The LTC shall consist of separated diverter switch and tap selector, however for 50 MVA power transformer and below, selector switch type (combining the duties of diverter switch and tap selector) is acceptable. The diverter switch or selector switch shall have independent compartment and oil conservator from transformer main tank.

In case the in-tank selector switch (non-vacuum type) is provided, the hot oil filter unit shall be furnished and connected to the selector switch. The pumping operation shall be fully automatically via contacts from the motor drive unit during each tap change operation. The operating time for the pump shall be set relative to the oil volume of the tap changer oil compartment to ensure that during each pumping operation, the volume of

tap changer oil shall be passed several times through the filter. The pressure gauge with alarm contact shall be provided to indicate the excessive pressure in the filter tank for filter insert replacement.

The transition resistor shall be designed to withstand at least a number equivalent to one cycle (the movement of the tap changer from one end of its range to the other and return to its original position) of uninterrupted operation, therefore manual continuous consecutive tap-change of one cycle shall be possible without overheating or damaging the transition resistor. The mark to indicate the position of tap changer shall be provided for each pole of LTC.

The LTC equipment shall provide a range of regulation and percentage of each step as specified in the Ratings and Features sheet. The tap positions of LTC shall have no idle tap, meaning each operation of the LTC shall result in a voltage change to the next step, either higher or lower. Local and remote control and indication for the LTC equipment shall be furnished. The local control equipment shall be installed in a transformer control cabinet. The control devices furnished shall have accuracy class as defined in the IEC60076-21. In any case, if shipment of the LTC chamber is separated from the main tank, connection of these parts shall be made by welding to form into one unit.

The pressure relay or oil flow relay shall be provided to prevent excessive pressure in the diverter switch enclosure in case a fault should occur, causing vaporization of the oil and a normally open contact shall also be provided to trip the main circuit breaker at a pre-set pressure or flow rate. The design of the tap changing equipment shall be such that the mechanism will not stop in any intermediate position, however, if the mechanism through faulty operation does stop in an intermediate position, full load must be carried by the transformer without injury to the equipment. The mechanical position indicator shall be equipped in the motor drive cabinet. The LTC motor shall be designed to be of step control, which in any case the operation shall be of step by step.

The manufacturer of motor drive mechanism shall be the same as load tap changer.

The on load tap changer shall be equipped with but not limited to the following accessories:

a) LTC pressure relay or oil flow relay with a normally open trip contact for each diverter switch compartment.

b) Pressure relief device with a normally open alarm contact for each diverter switch compartment.

c) Oil-level gauge with a low-level normally open alarm contact.

d) Silica-gel breather for LTC conservator. Sizing is depended on manufacturer design, but shall not be less than 3.0 kg.

e) Valve with flange connection complete with blank cover plate of at least for the following items;

- Connecting valve for LTC conservator to LTC compartment
- Oil drain valve for LTC conservator and each LTC compartment
- Oil filling valve for LTC conservator and each LTC compartment

The drain and filling valves shall be extended down and located for ease in operating from ground level.

f) Fully detachable lifting device for LTC in-tank type, such as chain hoist and support etc., fixed on the transformer tank for lifting off the diverter switch or selector switch of the LTC from transformer tank to the ground level. The lifting device shall be properly kept in the separated cabinet mounted at the transformer tank.

711-6.12 Cable End Box. The cable end box, if required, shall be rigid weatherproof type complete with cable entry at the bottom and cover fixed by bolt at the front of the box for easy access of power cable installation and inspection. The cable end box shall be made of steel sheet, the thickness of such steel sheet shall be at least 2.5 mm and shall be fixed rigidly to the transformer tank. Color of the box shall be the same as the transformer tank.

Transformer bushing with clamp type connectors shall be provided. Cable terminators suitable for power cable size as specified in Ratings and Features sheet and installed rigidly inside the cable end box and the ground terminal completed with connector suitable for ground lead (provided by Contractor) for grounding of copper tape shielding from cable terminators to ground terminal shall be provided.

711-6.13 Sound Enclosure. Each sound enclosure, if required, shall be outdoor and waterproof. Outside shall be of steel plate and frame with anti-corrosion painted. Sound absorbing materials can be used inside of the sound enclosure for additional attenuation. Necessary ventilation (intake and outlet ducts, cooling fans, etc.) can be provided to prevent heat dissipation of the sound enclosure.

Specific layout, accessories, test details and other requirements not cover herein are given in the accompanying Ratings and Features sheet.

711-7 Short Circuit Capability The transformer shall be designed and constructed to withstand the mechanical and thermal stress produced by external short circuit limited by the impedance of the transformer and system impedance. The transformer shall also withstand the fault condition occurring while the maximum system voltage maintained at the unfaulted terminals during the fault condition.

The duration of the short circuit current is limited to 2 s.

The system impedance at all tap voltage shall be obtained from the system fault capacity as specified below.

Nominal System Voltage (kVrms)	System Fault Capacity (MVA)
525	60,000
230	30,000
115	8,000
69	5,000
33	750
22	500
11	500

The transformer manufacturer shall at least take the following into consideration when calculating the short circuit current:

a) All types of external short circuit such as three-phase fault, single line to ground fault, etc. shall be taken into consideration.

b) The fault current produced by the short circuit shall be considered to be resulted from power feed from both HV and LV sides. (Exception for SVC, STATCOM and Floating Solar Project Transformer, the fault current shall be considered to be resulted only power feed from HV side.)

c) The network ratio of zero and positive sequence component (X0/X1) for HV and LV sides of the transformer, which will be used in calculation, shall be $0.5 \leq X0/X1 \leq 3.0$. (The severe case that have difference network ratio between HV and LV sides shall be considered.)

d) The system voltage maintaining on transformer terminal shall not be less than the following:

Maximum tap	100% of tap voltage
Rated tap	105% of tap voltage
Minimum tap	105% of tap voltage

e) The first-cycle asymmetrical peak current factor ($K\times\sqrt{2}$) shall be calculated by using of x/r of the transformer in accordance with IEC Std. 60076-5.

Despite the fact that the designed calculation of transformer is definitely depended on the knowledge and technical know-how of the manufacturer, who shall also have full responsibility for the result of his design, EGAT will examine the transformer withstand by the enclosed formula as shown on “Requirement for Hoop Stress in Transformer” attached.

If EGAT found that the proposed transformer failed to comply with the specified criteria, the proposed transformer will be treated as a non-conformity EGAT's specification.

Detailed calculation showing all parameters of electro-mechanical stress and force results shall be submitted to demonstrate that the transformer as designed can withstand the effects of through faults both in magnitude and frequency. These data shall be compared to critical failure stress for each major failure mode such as inward radial hoop buckling, outward radial hoop stretching, conductor tilting, stress on spacer and coil end support force capability. The results shall include the magnetic leakage field plot.

Definition of similar transformer

A transformer is considered similar to another transformer taken as a reference if it has the following characteristics in common with the latter:

1) Same type of main winding, for example layer, helical, disc or pancake coil;
2) For Core Type, the considered transformer shall meet the requirement as follow;
   a) The relative stress (the ratio of actual stresses to proof stress with permanent Elongation of 0.2% ($\sigma_{0.2}$) of copper) for Hoop Compressive / Tensile Stress shall not exceed the reference transformer.
   b) The relative stress / forces other than specify in article (a) shall not exceed 110% of those relating to the reference transformer.
3) For Shell Type, the considered transformer shall meet the requirement as follow;
   a) The relative stress (the ratio of actual stresses to proof stress with permanent Elongation of 0.2% ($\sigma_{0.2}$) of copper) for Tensile / Compressive stress imposed on the conductor shall not exceed the reference transformer.
   b) The compressive stress on spacer shall not exceed the reference transformer.
   c) The relative stress / forces other than specify in article (a) shall not exceed 110% of those relating to the reference transformer.

The comparison forces and stresses in transformers accordance with Table A.1 or A.2, IEC 60076-5 shall be submitted together with tender document during the bidding.

Requirement for Hoop Stress in Transformer

1. Hoop Compressive Stress Calculation (for Core Type Transformer)

Basically, the average hoop compressive stress in core type transformer with concentric winding is derived from:

Where

$$\sigma_H = \frac{F_{r(avg)}}{2\pi \cdot (Na_c)}$$

$F_{r(avg)}$ = The average radial force generated by short circuit current and leakage flux

$$= \frac{1}{2}\frac{\mu_0 NI}{H_w} \cdot NI \cdot \pi D_m \qquad (\text{from } F = B \times IL)$$

μ_0 = The permeability of air

H_w = Height of winding

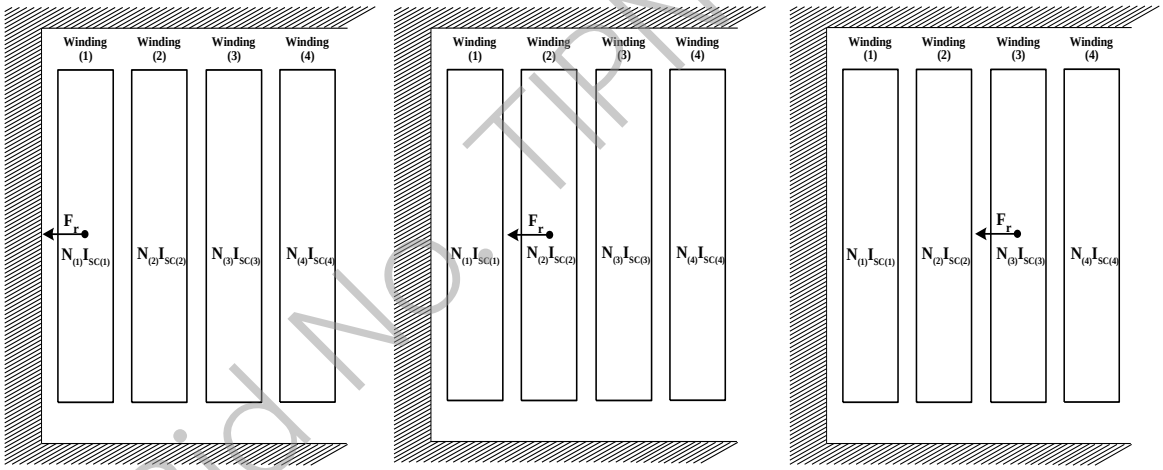
D_m = Mean diameter of winding

I = Current Magnitude

N = The number of turn of winding

a_c = The cross section area per turn of conductor

a) In case of no cooling duct between turns (or layers)



Apply with the density (ρ) of copper = 8900 kg/m^3

For the winding (1) which is the innermost winding

$$\sigma_{H(1)} = \frac{1}{8.9} \cdot \left(\frac{I_{sc(1)}}{a_{c(1)}}\right)^2 \cdot \frac{G_{w(1)}}{H_{w(1)}}$$

Where

$\sigma_{H(1)}$ = Hoop compressive stress in winding (1) ……kg/cm^2

$I_{sc(1)}$ = Short circuit through current in winding (1) ……...A$_{peak}$

$a_{c(1)}$ = Cross section area per turn of conductor in winding (1) …….mm^2

$G_{w(1)}$ = Gross weight of conductor in winding (1) ……kg

$H_{w(1)}$ = Height of winding (1) ……..mm

For the winding (2)

$$\sigma_{H(2)} = \frac{1}{8.9} \cdot \left(\frac{I_{sc(2)}}{a_{c(2)}} \right)^2 \cdot \frac{G_{w(2)}}{H_{w(2)}} \cdot \left[1 \oplus \frac{2 \cdot N_{(1)} I_{sc(1)}}{N_{(2)} I_{sc(2)}} \right]$$

Where

$\sigma_{H(2)}$ = Hoop compressive stress in winding (2) ……....kg/cm^2

$I_{sc(1)}$, $I_{sc(2)}$ = Short circuit through current in winding (1), (2) ……..A_{peak}

$a_{c(2)}$ = Cross section area per turn of conductor in winding (2) ……mm^2

$N_{(1)}$, $N_{(2)}$ = Number of turns in winding (1), (2) ……turns

$G_{w(2)}$ = Gross weight of conductor in winding (2) ……kg

$H_{w(2)}$ = Height of winding (2) ……..mm

Consider the operator "⊕" as the direction of $I_{sc(1)}$

The operator "⊕" = "–" if direction of the current is opposite to winding (2).

Or "⊕" = "+" if direction of the current is the same as winding (2).

For the winding (3)

$$\sigma_{H(3)} = \frac{1}{8.9} \cdot \left(\frac{I_{sc(3)}}{a_{c(3)}} \right)^2 \cdot \frac{G_{w(3)}}{H_{w(3)}} \cdot \left[1 \oplus \frac{2 \cdot N_{(1)} I_{sc(1)}}{N_{(3)} I_{sc(3)}} \oplus \frac{2 \cdot N_{(2)} I_{sc(2)}}{N_{(3)} I_{sc(3)}} \right]$$

Where

$\sigma_{H(3)}$ = Hoop compressive stress in winding (3) ……..……..kg/cm^2

$I_{sc(1)}$, $I_{sc(2)}$, $I_{sc(3)}$ = Short circuit through current in winding (1), (2), (3) ...……A_{peak}

$a_{c(3)}$ = Cross section area per turn of conductor in winding (3) ...…mm^2

$N_{(1)}$, $N_{(2)}$, $N_{(3)}$ = Number of turns in winding (1), (2), (3) ....……..…turns

$G_{w(3)}$ = Gross weight of conductor in winding (3) …...……kg

$H_{w(3)}$ = Height of winding (3) ……mm

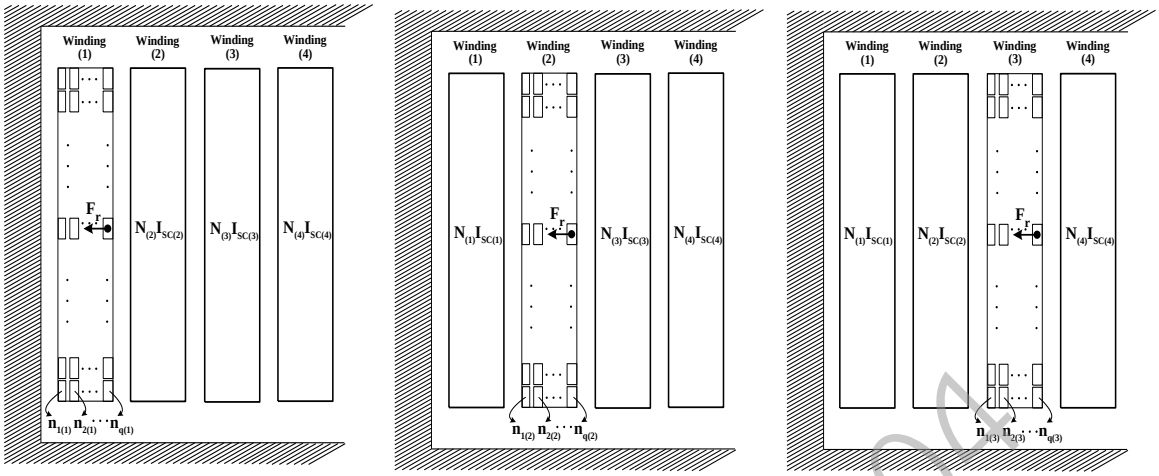
Consider the operator "⊕" on each term as the direction of $I_{sc(1)}$ and $I_{sc(2)}$ individually.

The operator "⊕" = "–" if direction of the current is opposite to winding (3).

Or "⊕" = "+" if direction of the current is the same as winding (3).

Note : To determine hoop stress in tap winding, The gross weight (G_w) and number of turn (N) in the active conductor at different tap position shall be taken into account.

b) In case of cooling duct being inserted between turns (or layers)



Apply with the density (ρ) of copper = 8900 kg/m^3

For the winding (1) which is the innermost winding

$$\sigma_{Hq(1)} = \frac{1}{8.9}\cdot\left(\frac{I_{sc(1)}}{a_{c(1)}}\right)^2\cdot\frac{G_{w(1)}}{H_{w(1)}}\cdot\left[\frac{2\cdot\left(\sum_{i=1}^{q-1} n_{i(1)}\right)+n_{q(1)}}{\sum_{i=1}^{q} n_{i(1)}}\right]\cdot\left[\frac{D_{mq(1)}}{D_{m(1)}}\right]$$

Where

$\sigma_{H\,q\,(1)}$ = The σ_H in outermost segment of winding (1) …….. kg/cm^2

$I_{sc(1)}$ = Short circuit through current in winding (1) ……...A_{peak}

$a_{c(1)}$ = Cross section area per turn of conductor in winding (1) ..….mm^2

$G_{w(1)}$ = Gross weight of conductor in winding (1) …..……kg

$H_{w(1)}$ = Height of winding (1) ……..mm

$n_{i(1)}$ = number of turn in the ith segment of winding (1) …… turn
(The sequence is started from core to outward)
qth is the outermost segment

$D_{mq(1)}$ = mean diameter of the outermost segment of winding (1) …….mm

$D_{m(1)}$ = mean diameter of winding (1) ……mm

For the winding (2)

$$\sigma_{Hq(2)} = \frac{1}{8.9}\cdot\left(\frac{I_{sc(2)}}{a_{c(2)}}\right)^2\cdot\frac{G_{w(2)}}{H_{w(2)}}\cdot\left[\frac{2\cdot\left(\sum_{i=1}^{q-1} n_{i(2)}\right)+n_{q(2)}}{\sum_{i=1}^{q} n_{i(2)}}\oplus\frac{2\cdot N_{(1)}I_{sc(1)}}{N_{(2)}I_{sc(2)}}\right]\cdot\left[\frac{D_{mq(2)}}{D_{m(2)}}\right]$$

Where

$\sigma_{H\,q\,(2)}$ = The σ_H in outermost segment of winding (2) ……. kg/cm^2

$I_{sc(1)}$, $I_{sc(2)}$ = Short circuit through current in winding (1), (2) ……...A_{peak}

$a_{c(2)}$ = Cross section area per turn of conductor in winding (2) ……mm^2

$N_{(1)}$, $N_{(2)}$ = Number of turns in winding (1), (2) ……turns

$G_{w(2)}$ = Gross weight of conductor in winding (2) ……kg

$H_{w(2)}$ = Height of winding (2) ……..mm

$n_{i(2)}$ = number of turn in the ith segment of winding (2) ……turn
(The sequence is started from core to outward)
qth is the outmost segment

$D_{mq(2)}$ = mean diameter of the outermost segment of winding (2) ……mm

$D_{m(2)}$ = mean diameter of winding (2) ……mm

Consider the operator "⊕" as the direction of $I_{sc(1)}$

The operator "⊕" = "–" if direction of the current is opposite to winding (2).

Or "⊕" = "+" if direction of the current is the same as winding (2).

For the winding (3)

$$\sigma_{Hq\,(3)} = \frac{1}{8.9}\cdot\left(\frac{I_{sc\,(3)}}{a_{c\,(3)}}\right)^2\cdot\frac{G_{w(3)}}{H_{w(3)}}\cdot\left[\frac{2\cdot\left(\sum_{i=1}^{q-1}n_{i(3)}\right)+n_{q(3)}}{\sum_{i=1}^{q}n_{i(3)}}\oplus\frac{2\cdot N_{(1)}I_{sc\,(1)}}{N_{(3)}I_{sc\,(3)}}\oplus\frac{2\cdot N_{(2)}I_{sc\,(2)}}{N_{(3)}I_{sc\,(3)}}\right]\cdot\left[\frac{D_{mq(3)}}{D_{m(3)}}\right]$$

Where

$\sigma_{H\,q\,(3)}$ = The σ_H in outermost segment of winding (3) ……. kg/cm^2

$I_{sc(1)}$, $I_{sc(2)}$, $I_{sc(3)}$ = Short circuit through current in winding (1), (2), (3) …….A_{peak}

$a_{c(3)}$ = Cross section area per turn of conductor in winding (3) ……mm^2

$N_{(1)}$, $N_{(2)}$, $N_{(3)}$ = Number of turns in winding (1), (2), (3) ……..……turns

$G_{w(3)}$ = Gross weight of conductor in winding (3) ……kg

$H_{w(3)}$ = Height of winding (3) ……..mm

$n_{i(3)}$ = number of turn in the ith segment of winding (3) ……turn
(The sequence is started from core to outward)
qth is the outmost segment

$D_{mq(3)}$ = mean diameter of the outermost segment of winding (3) ……mm

$D_{m(3)}$ = mean diameter of winding (3) ……mm

Consider the operator "⊕" on each term as the direction of $I_{sc(1)}$ and $I_{sc(2)}$ individually.

The operator "⊕" = "–" if direction of the current is opposite to winding (3).

Or "⊕" = "+" if direction of the current is the same as winding (3).

Note : To determine hoop stress in tap winding, The gross weight (G_w) and number of turn (N) in the active conductor at different tap position shall be taken into account.

2. Criteria for Hoop Compressive Stress

The calculated hoop compressive stress as above shall be satisfied the following criteria.

σ_H and/or $\sigma_{H\,q} \leq 0.35 \cdot \sigma_{0.2}$ of copper for the normal copper conductor or CTC being used,

or $\leq 0.5 \cdot \sigma_{0.2}$ of copper for bonded CTC being used

3. Criteria for Hoop Tensile Stress

The hoop tensile stress can be calculated by the same method as hoop compressive stress in winding (1).

The calculated hoop tensile stress shall not exceed 80% of the $\cdot\sigma_{0.2}$ of copper conductor being used.

In case of cooling duct being insert in between turn (or layer), the calculated hoop tensile stress of the innermost section should be applied.

In case of cooling ducts being inserted between turns (or layers) affects the resulting stresses and position of the maximum hoop compressive and hoop tensile stresses, calculations for separate windings by the cooling ducts can be conducted using the formula from item a), which is for cases of no cooling duct.

711-8 **Temperature Rise.** Average winding temperature rise as measured by resistance method when carrying maximum continuous rated capacity at each of the stages of cooling shall not exceed 60°C. Hottest spot winding temperature rise when carrying maximum continuous rated capacity at each of the stages of cooling shall not exceed 75°C.

The temperature rise of the insulating oil shall not exceed 60°C when measured near the top of the main tank.

Average winding temperature shall be determined by the resistance method. During the heat run tests, the tank wall surface hot spot temperature rise shall not exceed 70°C.

The temperature rise test shall be made at the tap connections that produce the highest temperature rise, which in turn cause maximum losses in the windings, of both the de-energized tap changer and the on-load tap changer.

For three winding transformer, the simulating current for temperature rise test shall be calculated from any of the following load losses, which is a part of total loss, that give the highest simulating current.

a) The combination of HV and LV load losses while HV and LV windings are delivering maximum output and TV winding is delivering no load.

b) The combination of HV, LV and TV load losses while HV winding is delivering maximum output and the combination of the LV and TV windings are delivering maximum output (while TV winding is delivering maximum output of its own capacity).

711-9 **Audible Sound Levels.** The average sound pressure level (A weighted) of the transformers shall not exceed the value as specified in the Rating and Features sheet when measured in accordance with the conditions outlined in the latest IEC Std 60076-10.

711-10 **Linearity of Excitation Current (For 500 kV)** - The excitation curve of the transformer shall be linear up to 105% of rated voltage applied.

711-11 **Insulating Oil.** The property of the insulating oil shall be accordance with EGAT's SPECIFICATION OF MINERAL INSULATING OIL. The insulating oil furnished for filling at site shall be compatible with the oil remaining on the core and coils after factory testing of the power transformer and the amount furnished shall be sufficient for actual filling all power transformer. The contractor shall furnish EGAT at least 1% of oil quantity for field application as required. The oil shall be shipped in non-returnable steel drums which shall become the property of EGAT.

Specification of the insulating oil used shall be furnished with the power transformer. The certified test report shall also be submitted and attached to the transformer test report.

711-12 Use of Inert Gas or Dry Air for Transportation. Each core and coil unit shall be shipped in an atmosphere of inert gas or dry air to prevent moisture absorption. The core and coils shall be shipped as a unit in their tank. Transportation drawing including with detail of internal pressure of either tank or storage device shall be submitted for approval.

711-13 Control and Protection Schematic Diagram

711-13.1 AC-DC Circuit Arrangement. EGAT shall provide 400/230 Vac, 50 Hz and 125 Vdc for auxiliary power supply. The Contractor shall furnish and install, where feasible, armoured cable or cable tray for all wiring as required. Short sections of flexible, waterproof conduit may be used for shock mounting. The Contractor shall arrange the schematic of AC and DC circuits as follows:

a) Disconnecting means shall be provided for possible connection or disconnection of AC and DC circuits to or from EGAT's AC and DC supply.

b) Circuit breakers of suitable interrupting rating but not less than 5 kA shall be provided for each branch of any AC or DC circuit. The LTC motor drive circuit breaker shall be operated by both thermal and magnetic trip. Contacts of all circuit breakers shall be operated by both manual and automatic trip.

Circuit breakers shall be furnished at least as follows:

a) Common control cabinet (For Single phase transformer)

1. Annunciator loss of DC supply indication AC supply circuit
2. Annunciator DC supply circuit
3. Auxiliary tripping and lockout relay DC supply circuit
4. Transformer bank common AC main control circuit
5. Transformer bank common AC branch control circuits as required
6. Other transformer bank common DC branch control circuits as required.

b) Each transformer control cabinet

1. Group 1 AC cooling circuit
2. Group 2 AC cooling circuit
3. LTC drive motor AC circuit
4. Annunciator loss of DC supply indication AC supply circuit
5. Annunciator DC supply circuit
6. Auxiliary tripping and lockout relay DC supply circuit (For Three phase transformer)
7. Other AC branch control circuits as required
8. Other DC branch control circuits as required.

c) Three phase AC undervoltage relay and DC undervoltage relay shall be provided and located as shown on drawing of "AC-DC Circuit Arrangement" attached.

711-13.2 LTC Control. The LTC, if required, shall be provided with overcurrent protection in order to prevent the tap-change operation during a short circuit, which would too greatly stress the contacts of the diverter switch. Three instantaneous and self-reset overcurrent relays shall be equipped and the function of protection shall be arranged as follows:

a. Whenever overcurrent is occurred, the control circuit for commanding LTC motor operation shall be blocked by the normally close contacts of the overcurrent relays. After overcurrent is cleared, the command control circuit shall be designed to recover immediately without any time delay.

b. If during tap-change and overcurrent is occurred, the LTC motor circuit shall be blocked through the mechanical cam switch, which close from the very beginning to the very end of every tap-change operation, and the normally open contacts of the overcurrent relays. The stop motion of the motor shall be made through the motor brake contactor. The total operating time from energization of overcurrent relay until motor circuit is blocked shall not be more than 35 ms. After overcurrent is cleared, the motor circuit shall be designed to recover with the possible adjustable time delay of 0-60 s.

c. For single phase transformer, three mounted, instantaneous, self-reset, phase overcurrent relays for diverter switch contact overstress protection and alarm indication on the common annunciator shall be provided in common control cabinet.

The schematic diagram for LTC overcurrent protection shall be as shown on typical drawing No TX-TSD-01 attached.

The LTC motor circuit shall be blocked when the tap change delay is occurred.

The control switches associated with the LTC equipment shall be of the rotary type and shall be designed for switchboard mounting with all contact mechanisms behind the panels. All contacts shall be enclosed in a cover or covers which can be easily removed. Each contact shall be of the readily renewable, self-cleaning type. Each control switch shall be insulated for 600 V, shall meet the requirements for dielectric tests and other applicable provisions of the latest version standards for power switching assemblies and shall have a continuous rating of at least 10 A. Each switch contact shall have an interrupting capacity on an inductive circuit of at least 2 A at 125 Vdc, and 20 A at 115 Vdc. A rectangular front of panel escutcheon plate shall be furnished and engraved showing the switch position of control switches. The switch identification shall be engraved on the escutcheon plate, or if necessary, on a separate adjacent nameplate furnished by the Contractor.

For Single Phase Transformer

Control equipment shall permit automatic and manual LTC control in the manner shown in the attached drawing. The equipment shall include the necessary devices for control and indication as follows:

a) Local single phase manual control and tap position indication at transformer control cabinet.

b) Local three phase automatic and manual control and phase tap position indication at transformer common control cabinet.

c) Remote three phase automatic and manual control and phase tap position indication and tap changer operation indication at remote control board.

d) Remote three phase automatic and manual control and phase tap position indication and tap changer operation indication at station control system.

When specified in the accompanying Ratings and Features Sheet, the LTC equipment shall include all necessary devices for master-follower scheme parallel operation with an existing transformer bank or another transformer bank furnished on the same purchase order. Drawings shall show by the use of solid lines all connections between transformer banks required for parallel operation. If parallel operation is not specified as being required, the LTC equipment shall include all necessary devices and provisions for future parallel operation, and dashed lines shall be used on the drawings to show all parallel operation connections required between transformers banks.
Alarm circuits for the following functions in addition to, but not limited to, those specified herein shall be furnished :

a) Tap position discrepancy between phases

b) Tap position discrepancy between transformer banks when operating in parallel (present or future)

c) Tap change sequence incomplete within time recommended by the manufacturer.

The overcurrent protection equipment shall include the necessary relay and bushing current transformers.

The following LTC equipment accessories in addition to those specified herein shall be furnished:

a) Mounted and wired in the common control cabinet (CCC)

1. LOCAL-TEST-REMOTE selector switch (43LTR)
2. 3PH-PHA-PHB-PHC selector switch (43BP)
3. LOWER-RAISE manual control switch, spring return to intermediate neutral position (384CS)
4. Three tap position receiver indicators. The tap position shall be indicated by .....IL, N, IR.....

5. LTC overcurrent relay of instantaneous and self-reset type with adjustable range around 150% of transformer rated current
6. 43SP selector switch

b) Mounted and wired in each transformer control cabinet (TCC)
1. Tap position receiver indicator. The tap position shall be indicated by ..... I L, N, IR.....
2. LOWER-RAISE manual control switch, spring return to intermediate neutral position (l84CS)

c) Mounted and wired on each transformer LTC drive mechanism cabinet (DMC)
1. LOWER-RAISE test push buttons or control switch.
2. 6-digit operation counter to register accumulated tap change operations
3. 6-digit operation counter with reset knob to register accumulated tap change operations
4. Mean for manual operation when power supply is lost
5. Step by step operation control devices
6. Tap position transmitting device for use with local and control board tap position receiver indicators
7. Multi-tap resistance device for station control and national control center tap position indication via a transducer. Each tap position shall have an equal resistance value of at least 500 ohms. The device shall have a common control arm that rotates in relation to, but independent from, the tap changer by gear drive from the tap changer drive shaft. An alternate method for tap position indication transmission may be considered if it is complied to EGAT's requirement and shall be subject to EGAT's approval.
8. Parallel operation checking device. Four (4) leads system shall be used for parallel operating checking.
9. Phase tap position discrepancy checking devices.
10. Mechanical tap position indicator. The tap position shall be indicated by...1L, N, 1R….
11. Hand lamp with on-off switch.
12. Space heater with thermostat and humidity control.

d) Delivered the following devices for installation by EGAT on remote control board (RCB) for each three-phase transformer bank control and indication
1. Three receiver tap position indicators for semi- flush mounting, approximately 10x10 $cm^{2,}$ dull black finish. The tap position shall be indicated by ...l L, N, l R.....
2. White indicating lamp for indicating the LTC during operation, the pilot lamp assemblies shall be of low power, cool operating, 24 Vdc, switchboard type and integrally mounted resistor for operation with 125 Vdc.

For Three Phase Transformer;

The LTC control circuit of the transformer shall be completely designed and provision shall be made for parallel operation as specified in the Ratings and Features sheet. The schematic diagram for future parallel operation part shall be shown by dotted line.

The mode for LTC control and switch positions on the escutcheon plate of selector switch and control switch shall be arranged as shown in relevant typical schematic diagram attached.

The following accessories and accessories for LTC control equipment shall be equipped for each transformer:

a) The Contractor shall deliver the following devices for installation by EGAT.

1. 43SP selector switch (installed at marshalling control cubicle).
2. Tap position receiver indicator for the tap changer, which shall be a flush mounting type switchboard instrument approximately 10 cm square. The tap position shall be indicated by … 1L, N, 1R (installed at remote control board).
3. White indicating lamp for showing the LTC during operation. The pilot lamp assemblies shall be of low power, cool operating, 24 Vdc, switchboard type and integrally mounted resistor for operation with 125 Vdc (installed at remote control board).

b) The Contractor shall furnish and mount the following control devices in the transformer control cabinet (TCC):

1. 43LTR (LOCAL - TEST - REMOTE) selector switch
2. 184CS (LOWER - RAISE) control switch of automatic or spring returned type to an intermediate "OFF" position for manual control of the motor-operated tap changer
3. Tap position receiver indicator. The tap position shall be indicated by ..... 1L, N, 1R .....
4. LTC overcurrent relay of instantaneous and self-reset type. (Having adjust range around 150% of transformer rated current.)
5. Three phase undervoltage relay for AC supply
6. Control and auxiliary relays

c) The Contractor shall furnish and mount the following control devices on the LTC driving mechanism cabinet (DMC):

1. " LOWER - RAISE " push buttons or control switch.
2. Means for manual operation when power supply is lost.
3. Tap change operation counter with two sets of 6 digits registering number, one set for registering the accumulated number of tap change performed and another set with resetting knob for possible recount of tap change performed.

4. Step by step operation control devices

5. LTC parallel operation checking device provided for possible future installation of other identical LTC power transformer. Four (4) leads system shall be used for parallel operation checking. The schematic diagram for four (4) transformers parallel tap check shall be as shown on typical drawing attached.

6. Mechanical tap position indicator. The tap position shall be indicated by...1L, N, 1R ...

7. Device for transmitting the tap changer position to the tap position receiver indicators located at the transformer control cabinet and remote control board.

8. Multi-tap resistor device with number of taps equal to number of required tap positions for possible remote tap position indication by telemetering through the tap position transducer. Each tap position shall have an equal resistance value of at least 500 ohms. The multi-tap resistor device shall have common rotating arm which rotates in relevant with, but independently from the LTC tap changer, for example, by gearing from tap change driving shaft.

   Any alternative provision for possible remote tap position indication by telemetering may be considered if it is complied with EGAT's requirement and shall be subjected to EGAT's approval.

9. Hand lamp with on-off switch

10. Space heater with thermostat and humidity control

711-13.3 Cooling Control. Fans and/or oil pumps shall be automatically controlled by a transformer winding temperature relay and shall be furnished with all necessary control and protective device. The control circuit for each group of fans and/or pumps shall include a circuit breaker with thermal and magnetic trip, contacts with overload protection. The fan group shall be designed so that the control may be interchanged by a manual selector switch for winding temperature and starting relay control to facilitate maintenance and equalize wear between stages.

<u>For Single Phase Transformer</u>;

Control equipment for each group of fans shall include a circuit breaker with thermal and magnetic trip and an alarm contact, a magnetic contactor, START-STOP push buttons for manual control and other necessary devices. The magnetic contactor shall have two electrically separate convertible contacts, or the equivalent, adjusted one normally open, one normally closed for cooling fan operation remote indication. The contacts shall be wired to common control cabinet terminal block points via transformer control cabinet terminal block points.

The Contractor shall furnish the following devices in the common control cabinet for cooling equipment control.

a) IND-MAN-AUTO selector switch for phase manual, bank manual and automatic cooling fan control.

b) FAN GRP.l 1st START-FAN GRP.2 1st START for fan group selection of first cooling stage

c) START-STOP push buttons for bank manual control of each group of cooling fan.

The Contractor shall furnish the following devices in the transformer control cabinet for cooling equipment control.

a) Automatic control of cooling equipment from winding temperature relay.

b) "START-STOP" push buttons for manual control for each group of fans and oil pump motors.

Each group of cooling equipment shall operate from the same power source.

For Three Phase Transformer;

The Contractor shall furnish motor controls for the following requirements:

a) Automatic control of cooling equipment from winding temperature relay.

b) "START-STOP" push buttons for manual control for each group of fans and oil pump motors.

c) MANUAL-AUTOMATIC selector switch for manual and automatic cooling fan control.

d) FAN GRP.l 1st START-FAN GRP.2 1st START for fan group selection of first cooling stage.

The Contractor shall furnish all equipment mounted and wired on the transformer. In addition, the Contractor shall provide ON-OFF operation signal contacts for each group of fans and oil pump motors, wired to the control cabinet.

711-13.4 Auxiliary Tripping and Lockout Relay. The auxiliary tripping and lockout relay, high speed, with the total operating time, including bouncing time of each relay, when the trouble is occurred until the lock out relay is operated, shall not be more than 20 ms, manual reset shall be performed, 125 Vdc with 10 electrically separate normally close contacts and 20 electrically separate normally open contacts in only one lockout relay. The lockout relay shall be provided and located in transformer control cabinet (for three phase transformer) and in common control cabinet (for single phase transformer). These contacts shall be used for tripping and lockout open circuit breakers for transformer faults. The 86ACO "NORMAL-OFF" cut-off selector switch with 10 electrically separate contacts of 10 A continuous current rating shall also be provided and located in transformer control cabinet (for three phase transformer) and in common control cabinet (for single phase transformer).

For any trouble which requires tripping order, the contact of the corresponding transformer protective relays shall be connection to

a) Directly initiate the auxiliary tripping and lockout relay through the series auxiliary current operating relay with holding coil for annunciator.

Or

b) Initiate high speed auxiliary voltage relay (operating time not more than 5 ms), self reset, DC voltage continuously operated type. Each high speed auxiliary voltage relay shall have at least 3 electrically separate normally open contacts, one contact for annunciator, one contact for Remote Terminal Unit (RTU), one contact for Fault Recording System (FRS) (only in case of single phase transformer) and one contact for initiation of auxiliary tripping and lockout relay. Each contact shall withstand at least 5 A, 125 Vdc at continuously duty.

The schematic diagram for tripping circuit shall be as shown on typical drawing No TX-TSD-04 attached.

711-13.5 Annunciator. A lamp type annunciator shall be furnished and installed within the control cabinet of the transformer. The annunciator shall indicate the transformer trouble described below.

Annunciator window shall be red in case of trip and winding temperature alarm stage 2, white in case of alarm. Transparent window shall be arranged in order that all individual trouble indicated on the annunciator panel can be visualized without opening the control cabinet cover.

Four (4) spare points of annunciator completed with annunciator circuit shall be provided in addition to the annunciators required. Each indication on nameplate shall be made of white translucent material, with black indicated letters. When any trouble contact is closed, the corresponding auxiliary relay of at least two independent contacts, one for signal lamp on annunciator panel and the other for remote indication, shall be energized and self-held which shall be reset, only if fault has already cleared, by the reset push button provided by the Contractor. Separate terminals shall be provided for each contact for remote indication. Each remote contact shall be wired to separate annunciator terminals. One remote indication contact shall be paralleled with other alarm points to provide a common remote alarm and one remote contact shall be provided for wiring to the substation sequence of events recorder.

The lamp test push button shall also be provided. Both reset and lamp test push button shall be mounted on the same panel of annunciator panel. If there are more than one fault occurs simultaneously, annunciators shall be annunciated correctly and only a fault that has cleared can be reset with the reset push button.

The schematic diagram for annunciator circuit shall be as shown on typical drawing No TX-TSD-03 attached.

The tripping circuit part shall be independent from the annunciator circuit part in order that tripping is still possible while annunciator circuit is off. Diodes and integrated circuit components are not allowed for tripping and annunciating circuits.

The contacts of all relay, gauges, and thermometers shall be insulated from ground and shall be of a positive, snap action or mercury type. All alarm and trip contacts shall be suitable for operation on 125 Vdc.

The annunciator control voltage shall be 125 Vdc. The control voltage for LOSS OF DC SUPPLY indication shall be 230V, 50 Hz single-phase.

For Single Phase Transformer;

When a transformer or bank trouble condition occurs, the corresponding annunciator window shall be illuminated and two electrically separate contacts for remote indication shall close. The window shall remain illuminated and the remote indication contacts shall remain close until the reset push button is operated and the trouble is cleared. Each remote indication contact shall be wired to separate annunciator terminals.

One remote indication contacts of each transformer annunciator point shall be paralleled and wired to an associated common alarm point on the common control cabinet annunciator via terminal block points in the transformer control cabinet and in the common control cabinet. The other remote indication contacts, each shall be wired to separated terminal block points in the common control cabinet via terminal block points in the transformer control cabinet for connection by EGAT to the marshalling panel for RTU.

For remote indication contacts of the common control cabinet annunciator, each contact shall be wired to separated terminal block point in the common control cabinet for connection by EGAT to the marshalling panel for RTU.

For those trouble conditions requiring both circuit breaker tripping and annunciation, the trouble contact shall trip the circuit breaker via the transformer auxiliary tripping and lockout relay. Therefore, a high speed auxiliary relay with electric latch connected in series with the trouble contact shall be furnished. One contact of the latter relay shall be connected to actuate the annunciator. Two contacts of the latter relay shall be wired to common control cabinet separated terminal block points via transformer control cabinet terminal block points for connection to the marshalling panel for RTU and marshalling panel for FRS respectively. The high speed auxiliary relay shall be unlatched and reset, after the trouble is cleared, by operation of the annunciator reset push button. The annunciator and the transformer auxiliary tripping and lockout relay circuits shall be electrically separated.

Each annunciator equipment shall include a reset push button and a lamp test push button mounted on the annunciator or immediately adjacent to the annunciator.

Annunciator panel, locate inside of the common control cabinet and transformer control cabinet, to indicate all Individual trouble of the transformer as listed in the "Common Transformer Annunciator Trouble & Tripping Schedule" and "Phase Transformer Annunciator Trouble & Tripping Schedule" attached.

For Three Phase Transformer;

When any trouble contact is closed, the corresponding auxiliary relay of at least two independent contacts, one for signal lamp on annunciator panel and the other for remote indication, shall be energized and self-held which shall be reset, only if fault has already cleared, by the reset push button provided by the Contractor. Separated terminals shall be provided for each contact for remote indication.

Annunciator panel, locate inside of the control cabinet, to indicate all Individual trouble of the transformer as listed in the "Transformer Control Cabinet Annunciator Trouble & Tripping Schedule (For Three phase transformer)" attached shall be provided.

711-13.6 Winding temperature relay

For Single Phase Transformer;

A total of three ambient temperature compensated winding temperature relays (one per winding) each with four sets of fully independent and adjustable switches with ungrounded contacts, factory adjusted close at temperatures no higher than the following values.

- Contact set No.1-95°C to initiate 1st stage cooling
- Contact set No.2-105°C to initiate 2nd stage cooling
- Contact set No.3- 115°C for alarm stage 1
- Contact set No.4-120°C for alarm stage 2

On decreasing temperature, contact sets No. 3 and No. 4 shall open at not more than 5°C below the closing temperature values. Similar contact sets of all relays shall be connected in parallel.

Each relay shall be responsive to the temperature of the hottest oil near the top of the transformer plus winding rise above hot oil temperature. The winding hot spot rise response shall be provided by a heating coil connected to the secondary of a current transformer located to sense winding current. The bellows heater system, rather than the pocket system (heating coil in relay thermometer bulb well), of establishing winding temperature is preferred.

Leads and means for calibration of each relay shall be provided and terminated in a weatherproof housing located on the transformer tank in a location convenient for inspection or testing.

All devices and accessories, including current transformers, required for operation of the relays shall be furnished.

The Contractor shall furnish all wiring and armoured cable or cable tray from the winding temperature relay equipment to the transformer control cabinet.

For Three Phase Transformer;

Any transformer with capacity smaller than 50 MVA shall be provided with one set of winding temperature relay, while another with capacity of 50 MVA or larger, provision of two sets of winding temperature relay, one for high voltage or series winding, the other for low voltage or common winding. Contacts for the two relays shall be connected in parallel.

Each set of winding temperature relay comprising of only one relay with ambient temperature compensation and four electrically separate sequence switches or at the Contractor's option, comprising of two relays with two or three switches each, may be furnished. The "make" and "break" temperatures of each switch shall be fully and independently adjusted. The first and second sequence switches will be used for controlling the cooling equipment. The third sequence switch will be used for alarm stage 1, and the fourth sequence switch will be used for alarm stage 2. The third and fourth sequence switches shall be suitable for operation on 125 Vdc. The heater of the winding temperature relay shall be connected to the secondary of a current transformer which has as its primary the lead to the power transformer winding. The bellow heater system, rather than the pocket system (heating coil in relay thermometer bulb well), of establishing winding temperature shall be furnished. The temperature sensing device shall be located in the oil near the top of the transformer.

The relay or relays shall be designed to be responsive to the current in the windings and to top oil temperature and shall be calibrated to operate on the duration and magnitude of the temperatures of the transformer winding and oil. The relays shall be factory adjusted to close at temperatures no higher than the following values.

- Contact set No.1-95°C to initiate 1st stage cooling
- Contact set No.2-105°C to initiate 2nd stage cooling
- Contact set No.3- 115°C for alarm stage 1
- Contact set No.4-120°C for alarm stage 2

With temperature decreasing the third and fourth sequence switches shall open contacts within 5°C below the closing values.

711-14 **Accessories.** Each transformer shall be furnished complete with, but not limited to, the following accessories in addition to those otherwise specified in this specification:

711-14.1 **Oil Level Indicator.** A dial type liquid level gauge with high and low-level alarm contact shall be furnished to monitor the transformer conservator oil level. The gauge shall be located for ease in reading from ground level. An output switch with output contacts shall be provided for annunciation. The relay shall include normally open contacts which shall be factory set to close when the oil level drops to an undesirable level. Dial range shall be matched with oil temp - oil level curve.

711-14.2 **Oil Temperature Indicator.** A dial type thermometer with the dial range of 0-150°C, display window shall be glass and alarm contact to close on high oil temperature shall be furnished to monitor the transformer oil temperature. The gauge shall be located for ease in reading from ground level at the transformer tank. Degree of Protection shall be IP65. 4-20 mA shall be provided for online monitoring system and the signal of Platinum resistance type 100 ohms (PT-100) at 0˚C shall be provided for remote indication.

711-14.3 **Winding Temperature Relay**. A dial type meter with the range of 0-160°C shall be furnished for winding temperature indication at the transformer tank. The display window shall be glass. The gauge shall be located for ease in reading from ground level at the transformer tank. Two separately adjustable output switches shall be furnished, one for annunciation and the other for energizing a lockout relay. Degree of Protection shall be IP65. 4-20 mA signal shall be provided.

711-14.4 **Winding hot-spot temperature detector.** A winding hot-spot temperature detector of the Platinum resistance type 100 ohms (PT-100) at 0˚C in high voltage winding and low voltage winding, shall be furnished together with necessary accessories, arranged for remote indication for use with a temperature recorder which will be provided and mounted on a switchboard by the others. The heater for the detector shall be connected to the secondary of a current transformer winding, and shall be located in the oil near the top of the transformer.

711-14.5 **Pressure relief device.** A self-reset type pressure relief device shall be provided to prevent excessive pressures from building up inside the tank which could cause equipment damage. The pressure relief device shall automatically reset following an operation and shall be furnished with a semaphore or other visible indicator of an operation of the device, visible from ground level. It shall have trip contacts to provide indication of an operation of the device. Degree of Protection shall be IP65.

711-14.6 **Buchholz relay.** A Buchholz relay shall be furnished which will provide fault pressure and gas detecting features. The Buchholz relay shall be furnished with two contact outputs, one for alarm and the other for trip which shall be free from operation due to vibration and pump surges. The relay shall be mounted in the connecting pipe between the main tank and the conservator and shall be complete with gas accumulation alarm feature. Valves with flange shall be provided for both sides of relay.

711-14.7 **Sudden pressure relay.** Sudden pressure relay with alarm contact mounted on the transformer tank below minimum oil level, for transformer with the capacity of 100 MVA or larger. Degree of Protection shall be IP65.

711-14.8 **Air detector relay.** Air detector relay to alarm the annunciator in the event that air enters the conservator as a result of rupture of the rubber bag.

711-14.9 **Valves.** Valves with flange connection completed with blank cover plate of at least for the followings:

- Two units for combination of oil drain valve and lower oil filter-press connection for main tank.
- A combination of oil filling valve, vacuum valve and upper oil filter-press connection for main tank
- Oil drain valve for main conservator
- A combination of oil filling valve, vacuum valve and upper oil filter-press connection for main conservator
- Connecting valve for main conservator to main tank (Excluding blank cover plate)
- Connecting valve between air part and oil part of main conservator for evacuation
- The drain and filter valves shall be extended down and located for ease in operating from ground level.

711-14.10 **Oil sampling device.**

711-14.11 **Diagrammatic nameplate,** including indication of EGAT's Contract No, Item No and EGAT's Serial No. The indication of impedance voltage shall also be included max. and min. tap voltage of on load tap changer and de-energized tap changer (if any).

711-14.12 **Oil temp-oil level curve plate.**

711-14.13 **Separate Stainless Steel Ground Terminal Connectors** of clamp type located at transformer base provided for the followings:

- HV surge arresters (if any)
- LV surge arresters
- TV surge arresters (if any)
- Neutral bushing
- Tertiary bushing for grounding purpose (if any)
- Transformer tank
- Transformer control cabinet

The ground terminal connectors shall be suitable for No 4/0 AWG copper cable. All the ground leads shall be of No 4/0 AWG insulated ground wire fixed by porcelain insulators on the transformer tank. All ground leads shall be

provided and connected from the above mentioned equipment to ground terminal connectors.

711-14.14 Cover, Handholes and Manholes. A welded main cover, handholes and manholes for servicing shall be provided with following minimum dimension:

Handholes : 22.9 cm in diameter,
or 11.4 cm x 36.8 cm if rectangular

Manholes : 38.1 cm in diameter,
or 25.4 cm x 40.6 cm if rectangular

711-14.15 Pressure gauge for transportation.

711-14.16 Three-dimensional shock recorder with time period recording chart of at least 3 months for transportation on the basis of returning back after the transformer arrive at the substation site.

711-14.17 Silica-gel breather for main conservator.

711-14.18 Ladder. Ladder fixed on transformer tank and extended to top part of conservator for servicing the transformer. The caution plate to prevent an unauthorized person shall be provided.

711-14.19 Suitable jacking pads, pulling eyes and lifting lugs.

711-14.20 Lighting and outlet.

711-14.21 Gas sampling valve. A gas sampling valve shall be furnished and located such that gas sampling for the detection of gas formation can be obtained safely while the transformer is energized.

711-15 Bushing Current Transformer. All bushing current transformers shall be in accordance with the latest IEC Std 61869 and shall have subtractive polarity. The bushing current transformers shall be in addition to those which may be required for operation of the temperature relays and load tap changing equipment. The secondary leads from all bushing current transformers shall be brought to short-circuiting-type terminal blocks located in the transformer control cabinet. A separate 6 point terminal block shall be provided for each current transformer secondary winding. The terminal blocks shall be of short circuiting, molded type with insulating barriers, ring tongue crimp type terminals and marker strips, and shall be rated 600 V. Each terminal block shall be capable of accommodating two 6 mm^2 stranded conductors minimum for secondary current 5 A and two 4 mm^2 stranded conductors minimum for secondary current 1 A. Terminal blocks shall be arranged in a vertical row or rows. In case of slide-type terminal blocks are provided, fixed side shall be from secondary leads of bushing current transformers and slide side shall be for external connections to control room.

A minimum clear space of 125 mm shall be provided between terminal blocks and between terminal blocks and the cabinet sides for training connections to the terminal blocks. All terminal block connections shall be made using ring tongue, crimp type terminals. Each terminal block current transformer tap connection shall be marked to identify the associated tap. All current transformer secondary

winding connections shall be 6 mm^2 minimum for secondary current 5 A and 4 mm^2 minimum for secondary current 1 A.

For Single Phase Transformer; All taps of each bushing current transformer shall be wired to the short circuiting terminal block in the transformer control cabinet and two wires from each CT short circuiting terminal block to the common control cabinet. Current transformers in the same core location on each transformer shall be three phase grouped (A-B-C) top to bottom. The Contractor shall furnish all necessary wiring conduit, cable tray and accessories for making the required current transformer to control cabinet and control cabinet to common control cabinet interconnections.

711-16 **Surge Arrester.** All surge arresters to be furnished shall meet all applicable requirements of the Specification of Metal Oxide Surge Arrester attached. When possible, the height of the arrester terminals shall match approximately the height of associated bushing terminals. Discharge counters with continuous AC leakage/internal current indicators shall be mounted approximately 1.5 m above ground level. Surge arrester to discharge counter to ground pad connections in accordance with the requirements stated herein shall be installed.

711-17 **Device Contacts.** All relay, gauge, thermometer and other device alarm and trip contacts shall be ungrounded, shall be positive, snap-action or mercury type and shall be rated at 125 Vdc. If necessary, interposing auxiliary relays may be furnished to satisfy these requirements.

711-18 **Gaskets.** Gaskets shall be unaffected by hot insulating oil, retain their resiliency during the life of the associated equipment, and be unaffected by weather while maintaining oil and gas tightness. Nitrile gaskets shall be used except where the gaskets may be affected by heat, such as during welding. In such case, cork-neoprene or cork-Nitrile gaskets shall be provided. Gaskets of cork or neoprene only will not be allowed. Gasket flanges shall have grooves or stops to prevent gasket over compression.

711-19 **External Clearances.** The transformer and all equipment attached to it shall have the external clearances between live parts specified in IEC Std 60076-3.

711-20 **Wind Load.** Each completely assembled transformer shall be designed to withstand wind with a velocity up to 125 km/h without damage to or impairment of operation of the transformer or any part thereof.

711-21 **Cleaning & Painting.** All interior and exterior surfaces of ferrous metalwork (including the sound enclosure, if required) shall be either galvanized in accordance with ASTM Designation A123 and A153 or painted. Surfaces to be painted shall be thoroughly cleaned to base metal by sand blasting or shot blasting and shall be thoroughly dry before application of any paint. After cleaning, the surfaces shall be given a priming or sealing coat of paint followed by two finishing coats. The paint used for the exterior finish coats shall have special heat, oil, and weather-resisting properties. The exterior surfaces of the transformer control cabinet and any other parts which expose to the outside looking (including the sound enclosure, if required) shall be painted in ANSI 70 light grey or MUNSELL NOTATION NO 7.5 BG 6/1.5. The total exterior paint thickness shall be a minimum of 105.

711-22 Markings & Nameplates. Each transformer shall be provided with an attached identification nameplate or nameplates satisfying, but not limited to, the requirements of IEC Std 60076. The nameplate(s) shall include the EGAT contract number, item number and EGAT's serial number and be located to be readily legible from ground level. The nameplate and/or an adjacent nameplate shall include for each current transformer the accuracy class and primary and all secondary ampere ratings and identification of the terminal to which each applies. A connection diagram of all windings, current transformer and associated devices shall be included in the nameplate. The nameplates shall be black letters engraved on a background.

Individual nameplates shall also be furnished with each valve, oil sampling device, level device, temperature device, Buchholz relay and all control cabinet devices which identify the device and pertinent characteristics.

Each transformer control, indicating and protective component, not otherwise clearly identified, shall be provided. All nameplate identification engraving shall be in English. Nameplate engraving shall be subject to EGAT approval.

All nameplates shall be anodized aluminum, stainless steel or other corrosion-resistant material and shall be attached with non-corroding screws.

711-23 Test. Test for power transformer, on load tap changer, de-energized tap changer, bushing and bushing current transformer shall be performed according to the requirement specified in each referred test item. The costs of all tests and reports shall be borne by the Contractor.

711-23.1 Type Test. The transformers shall be subject to the actual type tests, unless otherwise specify in each test item.

711-23.2 Routine Test. Each equipment shall be completely assembled at the factory and subject to the tests specified in each equipment test item.

711-23.3 Special Test. The test report shall be submitted together with tender document during the bidding if specified in Eligibility of Bidders.

711-23.4 Test Report. The report of all tests, curves and standard application data shall be furnished to EGAT immediately after completion of the tests.

711-23.5 Test Procedure. The Contractor shall submit the test procedure of routine tests and actual type tests to EGAT for approval. The test procedure shall consist of procedures, applied voltage, current and criteria to justify the result of the tests.

711-23.6 Test Items for Type Test.

a. Transformer. The tests shall be performed in accordance with the latest IEC Std 60076**.** One unit of transformer being supplied for each capacity and voltage rating shall be subject to the following test.

1. Temperature-rise type test

   The test shall be performed on each winding for each cooling stage. DGA result shall be shown before and after temperature rise test. The test report shall be shown the calculated values of the hottest spot winding temperature rise over top oil for each cooling stage.

   These calculation values shall include the effects of local loss generation and local cooling conditions which could affect the winding temperature rise. A standard allowance for extra temperature rise beyond that of the average winding temperature shall not be acceptable.

2. Switching impulse test.

   The transformer for 115 kV shall be performed the switching impulse test, which shall precede the low frequency tests. Oscillographic records of voltage and current with time scale of the tests performed shall be submitted.

3. Determination of sound level for each method of cooling for which a guaranteed sound level is specified (including no-load and load condition).

4. Vacuum deflection test on liquid immersed transformers.

   The transformer tank shall be subject to a vacuum of less than 10 mmHg for 30 min. After the test, the deformation shall be checked.

5. Pressure deflection test on liquid immersed transformers.

   The transformer tank shall be subject to an internal gas pressure of 1 kg/cm^2 for 30 min (or equivalent pressure giving 1 kg/cm^2 at every tank surface) and under the pressure test the leakage shall be checked.

6. Jacking pad capability test.

   The test shall be performed on complete assembled transformer with oil for 30 min.

b. On Load Tap Changer. The tests shall be performed in accordance with the latest IEC Std 60214. On load tap changer shall already have the type test record for same type or same family and similar ratings as proposed. The type test record shall be required and submitted together with tender document during the bidding.

c. De-energized Tap Changer. The tests shall be performed in accordance with the latest IEC Std 60214. De-energized tap changer shall already have the type test record for same type or same family and similar ratings as proposed. The type test record shall be required and submitted together with tender document during the bidding.

d. Bushing. The tests shall be performed in accordance with the latest IEC Std 60137. The tests shall be performed on one bushing of an identical unit. These tests may be omitted if a type test record of an identical unit can be submitted.

711-23.7 Test Items for Routine Test.

a. Transformer. The tests shall be performed in accordance with the latest IEC Std 60076**.** The following tests shall be performed.

1. Measurement of winding resistance
2. Measurement of voltage ratio and check of phase displacement
3. Measurement of short-circuit impedance and load loss

   The measurement shall be performed for all winding of each cooling stage by using the three wattmeters (for three phase transformer) method conformed to the following:

   – Maximum rated capacity at all tap connection.

   – Other stage of cooling at rated and extreme tap connections.

   The measurement shall be performed at rated tap current of each capacity, reduced current are not allow.

4. Measurement of no-load loss and current

   The measurement shall be carried out by using the three wattmeters (for three phase transformer) and the average-voltage voltmeter method from 10% up to 100% rated voltage with 10% interval, 105% and 110% rated voltage. (To be performed before and after the impulse test). Excitation curve shall be submitted.

5. Dielectric routine tests

   The tests shall include chopped wave lightning impulse test, full wave lightning impulse test and switching impulse test (for 230 kV and above) for every winding and neutral terminal.

   Impulses shall be applied in the sequence high voltage winding, low voltage winding, tertiary winding, neutral terminal. Oscillographic records with voltage, current and time scale of the tests performed shall be submitted.

   After all of Impulse tests, the operating test for On Load Tap Changer, if required, shall be performed. Transformer shall be energized at rated voltage and rated frequency at no-load condition, one complete cycle of operation shall be performed without failure.

6. Tests on on-load tap-changers, where appropriate.

7. Leak testing with pressure for liquid-immersed transformers (tightness test).

   The assembled transformer shall be subject to a pressure of 1 kg/cm^2 at the bottom of the tank for 12 h and then the leakage shall be checked.

8. Check of the ratio and polarity of built-in current transformers.

9. Check of core and frame insulation for liquid immersed transformers with core or frame insulation

   - Insulation between core and clamp.

   - Insulation between core and ground.

   - Insulation between clamp and ground.

10. Determination of capacitances windings-to-earth and between windings.

11. Measurement of d.c. insulation resistance between each winding to earth and between windings.

12. Measurement of dissipation factor (tan δ) of the insulation system capacitances.

13. Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment before and after completion of the test.

14. Cooling fan loss measurement.

15. Measurement of zero-sequence impedance(s) on three-phase transformers.

16. Measurement of frequency response (Frequency Response Analysis or FRA).

    The test shall be performed on complete assembled transformer. Test tap positions to be selected shall include maximum, rated, minimum tap of on load tap changer and the tap position giving only the main winding (without or the least tap winding). For transformer provided with de-energized tap changer, the full winding tap of the de-energized tap changer shall be selected.

    The measuring frequency range shall be from 20 Hz to 2 MHz. The result shall be plotted by “Amplitude or Magnitude (dB) vs frequency and Phase angle vs frequency in log scale”.

    Software file and XML file of FRA data shall be provided by contractor.

17. Dynamic resistance measurement (If LTC is required).

    The test shall be performed by the application of DC current or DC voltage to the winding with tap changer while the other winding short-circuited. The transient test current fluctuations shall be recorded during the tap changer switching process. The response shall be recorded with an oscilloscope, transient recorder or a specialized instrument. The oscillograms of maximum to minimum

tap and minimum to maximum tap with each tap transition shall be reported.

For the winding with tap changer connected in star connection. Simultaneous three phase test shall be performed and the test current flowed through each phase shall be 1 A or more while the other winding short-circuited.

For the winding with tap changer connected in delta connection. Single phase test shall be performed and the test current flowed through phase under test shall be 1 A or more. For this case the applied current shall be 1.5 A or more.

18. Single phase leakage impedance measurement (for reference).

    The test shall be performed by the application of the low-voltage single-phase voltage with rated frequency to each pair of phase terminal of one winding while the other winding on the same core leg short-circuited (using a low impedance conductor). The energized winding shall be the winding with higher voltage and the short-circuited winding shall be the winding with lower voltage. Each pair of windings shall be tested. The current shall be kept constant for each pair of tested winding at the full value such as 2, 3 or 5A. The test voltage shall be as close as 400 V.

    For items (1.), (2.), (3.) and (18.) the test shall be performed at all tap connections of on load tap changer for all windings. If there is de-energized tap changer, additional measurement shall be performed at max., rated and min. tap of on load tap changer for all tap connections of de-energized tap changer.

b. On Load Tap Changer. The tests shall be performed in accordance with the latest IEC Std 60214.

c. De-energized Tap Changer. The tests shall be performed in accordance with the latest IEC Std 60214.

d. Bushing. The tests shall be performed in accordance with the latest IEC Std 60137.

e. Bushing Current Transformer. The tests shall be performed in accordance with IEC Std 61869-1 & 61869-2.

f. Material Tests Report. Test report of the following material and accessories used in each supply shall be submitted

1. Insulating oil.
2. Silicon steel.
3. Copper conductor.
4. Insulation paper and pressboard.
5. Radiator.
6. Transformer supervisory equipment.

(a) Oil level indicator
(b) Oil temperature indicator
(c) Winding temperature relay / Winding hot spot detector
(d) Buchholz relay
(e) Pressure relief device
(f) Rubber bag rupture detector

g. Information for Reference. The following information for each transformer shall be submitted and attached in routine test report for maintenance purpose.

- Coil height for each winding before assembly and after complete assembly.

- Torque value on clamping bolts or pressure for each winding before assembly and after complete assembly.

- Photograph of each coil for each phase and photograph of core and coils assembly. The photograph of each coil shall be taken from the final production process before placing to the core, top view and front view shall be provided. The photograph of core and coils assembly shall be taken just prior to place the completed core and coils assembly into the tank, top view, front view, right view, left view and rear view shall be provided for complete set of photographs

711-23.8 Test Items for Special Test.

1. Short circuit test.

   The short circuit test record, in accordance with the following item 3. below, of the transformer similar design, which is subject to EGAT's approval, is required and shall be submitted together with tender document during the bidding.

   For transformer having the capacity of 50 MVA or less, the short circuit test record of the actual transformer instead of model unit of the transformer is required.

   If actual short circuit test is specified to be performed, the transformer required for short circuit tests shall be subject to the sequence of tests listed below in accordance with the latest IEC Std 60076-5 or IEEE Std C57.12.90.

   1. Internal inspection before tanking including measurement of coil height and torque value or pressure on clamping bolts for winding clamping.
   2. Routine tests according to the requirement of this specification before short circuit test.
   3. Short circuit test having the number and duration of tests conformed to IEC Std 60076-5 or IEEE Std C57.12.90.
   4. Detection of faults and evaluation of test results shall be conformed to IEC Std 60076-5 or IEEE Std C57.12.90.

5. The transformer is untanked for internal inspection including measurement of coil height and torque value or pressure on clamping bolts for winding clamping.

6. The transformer shall be retanked and the routine tests according to the requirement of this specification shall be performed after the short circuit test.

711-24 **Spare Parts**. Spare parts as specified in Price Schedule and one complete set of spare gasket for each transformer to be used during erection at site shall be supplied. All spare parts including spare gasket subject to damage or deterioration by moisture shall be packed in moisture-proof material. All spare parts shall be of the same materials and workmanship as the corresponding original parts and shall be interchangeable therewith.

711-25 **Appliances and Tools.** The Contractor shall furnish all special appliances and tools that the equipment manufacturer deems necessary for satisfactory installation, operation, testing and maintenance of the equipment, including assembly and disassembly. Special tools and appliances shall be constructed as those that are not readily available from appliance and tool suppliers in Thailand and those that the equipment manufacturer has procured or fabricated for use with the equipment or similar equipment. The Contractor shall submit to EGAT for approval a list of all appliances and tools required for above stated purposes and shall indicate thereon all furnished appliances and tools.

711-26 **Final Design Data.** The Contractor shall furnish the following final design data for each transformer based on final design calculations :

a) Losses in kilowatts at rated voltage and frequency:

   1. No load loss
   2. Load loses at maximum rated capacity

b) Percent regulation:

   1. At unity power factor
   2. At 0.90 power factor lagging
   3. At 0.80 power factor lagging

c) Excitation curve from 10% to 110% normal rated voltage. The following exciting current shall be clearly specified.

   1. At 110% of normal rated voltage
   2. At 105% of normal rated voltage
   3. At normal rated voltage
   4. At 95% of normal rated voltage
   5. At 90% of normal rated voltage
   6. At 80% of normal rated voltage

d) Temperature rise of all windings and top oil at each cooling capacity. Hot-spot factor and formula of this value shall be provided for calculation of Hottest spot winding temperature rise.

e) Overall dimensions and weight of all principal parts.

f) Identification by name and total weight and dimensions of heaviest part that must be lifted by the crane during assembly and disassembly.

g) Percent positive, negative and zero phase sequence impedance based on maximum rated capacity at max., rated and min. tap voltage of on load tap changer and de-energized tap changer for all winding.

h) Detailed calculation showing all parameters of electro-mechanical stress and force results shall be submitted to demonstrate that the transformer as designed can withstand the effects of through faults both in magnitude and frequency. These data shall be compared to critical failure stress for each major failure mode such as inward radial hoop buckling, outward radial hoop stretching, conductor tilting, stress on spacer and coil end support force capability. The results shall include the magnetic leakage field plot.

i) Data and information requirement as shown on "Winding Arrangement Data" and "Coil Conductor Data for Each Winding" attached sheets.

j) Permissible limit of partial discharge value.

k) The setting temperature value for the first and the second stage of cooling fan including calculation method.

In case of the sound enclosure is required, all of final design data shall be calculated and considered the transformer completed with the sound enclosure.

Increases in values of items (e) and (f) over those given in the Proposal Data shall be limited to 10% but not more than EGAT's specified values elsewhere.

Increases in values of Electro-Mechanical Stress/Force under short circuit condition or increases the relative stresses over those given in the Proposal Data shall be not acceptable.

EGAT reserves the right to review the detailed design of transformer without changing the guaranteed losses values.

711-27 Transportation. The transformer shall be designed to suit the trailer for transportation as shown on the Dwg. No EGAT-24A/L (1+1/2)-TH62 attached as well as the dimension and weight limitation specified elsewhere. The transformer shall be designed for transporting with the maximum trailer speed on highway at 45km/h. The permissible impact value of transformer during transportation shall be designed not less than ±3G in three dimensions (x, y, z axis). Shipping weight and dimensions of every transformer shall be measured and reported before transportation.

711-28 Drawings and Documents for Power Transformer. Drawings and documents for approval shall at least comprise of the following;

Final Design Data is the first document required to submit for approval after confirmation of Letter of Award of Contract.

A. Drawings for Approval

Item	Drawings Title	Approval and Final Dwgs	AutoCAD files	CD-ROM or USB flash drive
1	Drawing list of all drawings submitted for approval	x	-	x
2	Transformer outline including legend of all transformer accessories tabulated in table as shown in Table-1	x	x	x
3	Transformer bottom view showing the skidding base	x	x	x
4	Transformer foundation including location of control cabinet and grounding terminals.	x	x	x
5	Shipping and transportation sketch. (Main tank, LTC tank) including the value of pressure, moisture content and allowable impact figures	x	x	x
6	Transformer nameplate including transformer top and front view with dimension	x	-	x
7	CT connecting plate complete with current ratio	x	-	x
8	Oil temp oil level curve plate	x	-	x
9	Control schematic diagram with terminals indication of each relay, contact, switch, etc. (including list of associated apparatus tabulated in table as shown in Table-2) - AC & DC control - LTC control - LTC motor drive control - Cooling control - Annunciator, alarm & trip circuits with indication of the setting value of all protective devices - LTC oil filter unit control	x	x	x
10	De-energized tap changer	x	-	x
11	Selector switch and control switch position tabulation	x	-	x
12	Drilling plan of parts to be installed at the remote control board combined in one drawing	x	-	x
13	Common control cabinet outline (including indication of accessories location, nameplate of each accessory and annunciator windows with abbreviation of faults)	x	x	x
14	Transformer control cabinet outline (including indication of accessories location, nameplate of each accessory and annunciator windows with abbreviation of faults)	x	x	x

Item	Drawings Title	Approval and Final Dwgs	AutoCAD files	CD-ROM or USB flash drive
15	LTC driving mechanism cabinet and LTC oil filter unit control cabinet outline (including indication of accessories location and nameplate of each accessory)	x	-	x
16	Manual operated voltage setting device outline	x	-	x
17	Lifting device for diverter switch or selector switch	x	-	x
18	Bushing outline (HV, LV, TV, Neutral)	x	-	x
19	Terminal pad of - Bushing (HV, LV, TV, Neutral) - Surge Arrester	x	-	x
20	Grounding terminal connector	x	-	x
21	Terminal blocks layout of real physical arrangement including terminals indication and indication for external connection in : - Common control cabinet - Transformer control cabinet - LTC driving mechanism cabinet - LTC oil filter unit control cabinet	x	x	x
22	Wiring diagram (including internal wiring diagram) - In the common control cabinet - In the transformer control cabinet - In LTC driving mechanism cabinet - Of parts to be installed at the remote control board - In LTC oil filter unit control cabinet	x	x	x
23	Wiring connection of supervisory equipment including indication or wire sizes tabulated in table as shown in Table-3	x	-	x
24	Oil piping and valve connection diagram	x	-	x
25	Grounding connection arrangement with ground wire size indication	x	-	x
26	List of gasket and position with dimension	x	-	x
27	List of spare parts and spare gaskets with shape, quantity and dimension	x	-	x
28	Secondary terminal arrangement of bushing current transformer	x	-	x
29	Test tap outline for all bushings.	x	-	x

Item	Drawings Title	Approval and Final Dwgs	AutoCAD files	CD-ROM or USB flash drive
30	Conservator and Rubber bag with sizing calculation	x	-	x
31	Detailed connection of surge arrester, discharge counter and ground terminal connector	x	-	x
32	Bushing Turret with its dimension and details of BCT	x	-	x
33	Un-tanking sketch (detail for lifting core and coil for maintenance purpose)	x	-	x
34	Sound enclosure (if required)	x	x	x

B. Document for Approval

1. Description of contact capacity of all relays supplied tabulated in table as shown in Table-4.
2. List of tools and appliances.
3. Load list of transformer control cabinet and common control cabinet.
4. Container list.
5. Package for long term storage of bushing.
6. Verification to confirm that the loss of any fan or any oil pump shall not reduce the output of the transformer by more than 10%, with temperature rises maintained within specified limits.
7. Operating overload curve (such as Time (hr) vs Load (%)) with ambient temperature at 30 and 45 degree Celsius and with starting load from 60%, 80% and 100%
8. Magnetic field plot of transformer

Transformer Control Cabinet					
Power Consumption (AC)					
Equipment	Manufacturer	Power Consumption (W)	Qty	Total Power Consumption (W)	Continuous Load (Operate over 3 hrs continuously) Yes / No
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
Total					

Transformer Control Cabinet					
Power Consumption (DC)					
Equipment	Manufacturer	Power Consumption (W)	Qty	Total Power Consumption (W)	Continuous Load (Operate over 3 hrs continuously) Yes / No
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
Total					

Common Control Cabinet (for Single Phase)					
Power Consumption (AC)					
Equipment	Manufacturer	Power Consumption (W)	Qty	Total Power Consumption (W)	Continuous Load (Operate over 3 hrs continuously) Yes / No
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
Total					

Transformer Control Cabinet (for Single Phase)					
Power Consumption (DC)					
Equipment	Manufacturer	Power Consumption (W)	Qty	Total Power Consumption (W)	Continuous Load (Operate over 3 hrs continuously) Yes / No
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
Total					

C. Data and Descriptive Material

a) Bushing current transformer secondary excitation and ratio correction factor curves for each ratio (Published Characteristic Curve).

b) Operating description for

- LTC control
- LTC motor drive control
- Parallel Operation
- Cooling control
- Annunciating and tripping circuit

c) Descriptive or catalog data and drawings for

- On load tap changer
- Motor drive mechanism
- Oil filter unit for on load tap changer
- De-energized tap changer
- Conservator of transformer tank and LTC compartment
- Pressure gauge for transportation of transformer tank
- Three dimensional shock recorder for transportation
- Pressure relief device
- Buchholz relay
- Air detector relay for main conservator
- Transformer pressure relay
- LTC pressure relay or LTC oil flow relay
- Winding temperature relay
- Winding hot spot temperature detector
- LTC overcurrent relay
- Dial type oil level gauge
- Dial type oil temperature indicator
- Tap position indicator
- Multi-tap resistor device
- Auxiliary tripping and lockout relay
- Time delay relay for tap changer delay
- All kinds of auxiliary relay
- AC & DC undervoltage relay
- All kinds of selector switch, control switch and push button
- Manual setting device for setting the desired voltage level
- Silica gel breather

- All kind of valves
- Oil sampling device
- Cooling fan
- Radiator
- Transformer gaskets characteristic
- Insulating oil characteristics
- Transformer insulation material and pressboard
- Outlet of 20 A, 250 Vac

d) **Component Part Data** - One drawing shall be furnished showing the following information, as applicable, for each component part (contactors, relays, auxiliary relays, control devices, switches, etc.)

– Manufacturer
– Manufacturer's type and/or catalog number
– Rating
– Type and number of contacts
– Contact AC and DC continuous, make and resistive and inductive interrupting ratings
– Coil impedance and power factor
– Inrush or starting and continuous or running currents
– Pickup and dropout times and currents or voltages
– Operating time delay range if adjustable
– Expected service life Location

e) **Curve & Calibration Data Power Frequency** - Where applicable, all curves and calibration data shall be based on a power frequency of 50 Hz. Curves and calibration data based on a power frequency of 60 Hz with an applied correction factor for 50 Hz are not acceptable.

711-29 Instruction Manual for Power Transformer

Instruction manual shall consist of all necessary information and shall comprise of at least the following parts.

Part A Transformer instruction including installation, operation and maintenance manuals.

a. Transformer general technical information

b. Installation instruction including but not limited to

- Moving method for the transformer tank by skidding on the rollers
- Moving method for complete assembly transformer by skidding on the rollers
- Inspection including interpretation of shock recorder level
- Flow chart for installation
- Installation instruction
- Allowable exposed time for core and winding
- Criterion of water content of core and winding
- Vacuum oil filling
- Method of drying out at site
- Characteristic of insulating oil
- The acceptable value of deviation from factory test value of insulation resistance and insulation power factor after installation at site
- Tank assembly
- External assembly for complete transformer
- Detailed assembly of the sound enclosure at site (if any)

c. Maintenance and Operation instruction

- Routine inspection
- Maintenance
- Operation guide for current loading
- Guide for maintenance of long storage transformer
- Interpretation of gas analysis for transformer in service
- Assembly and disassembly instructions for on load tap changer complete with component parts list including ordering part numbers, designation of part No and part identification drawing
- Internal assembly of the transformer
- Guide for maintenance and inspection of the sound enclosure (if any)

Part B Instructions and manual catalogs including installation and maintenance manual of all accessories.

Part C Complete set of all final drawings including description of :

a. LTC control
b. LTC motor drive control
c. Cooling control
d. Annunciating and tripping circuit

Part D Final design data

The insulating pressboard offered shall be the products of the manufacturers as follows;

a. Weidmann of Switzerland

b. Weidmann Malyn of Ukraine (Moldable pressboard)

c. Weidmann Jiaxing of China (Moldable pressboard)

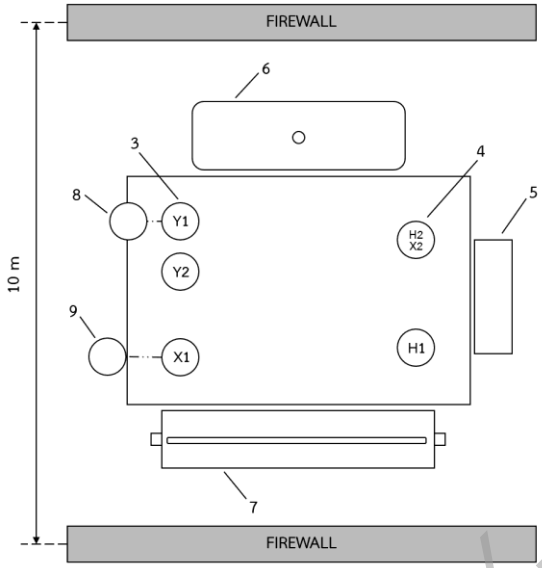
d. Figeholm of Sweden

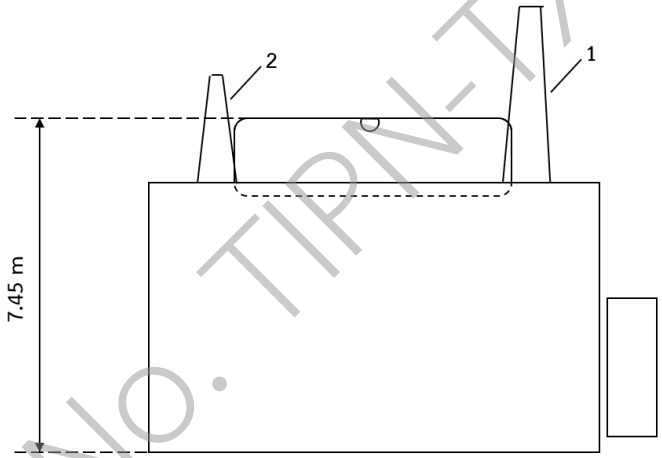
e. Oji Specialty Paper of Japan (only type T4 and T37)

f. Changzhou Yingzhong Electrical Co., Ltd. of China (only Pressboard type B.3.1 A, Laminated pressboard type LB3.1 A.2 and Moldable pressboard)

Nevertheless, the other insulating pressboard manufacturers can additionally be listed in this specification after having been approved by the EGAT Transformer Pressboard Manufacturer Qualification Committee. The procedures for approval can be requested from the Transmission System Engineering Division.

Layout for installation of 500 kV Single Phase Transformer



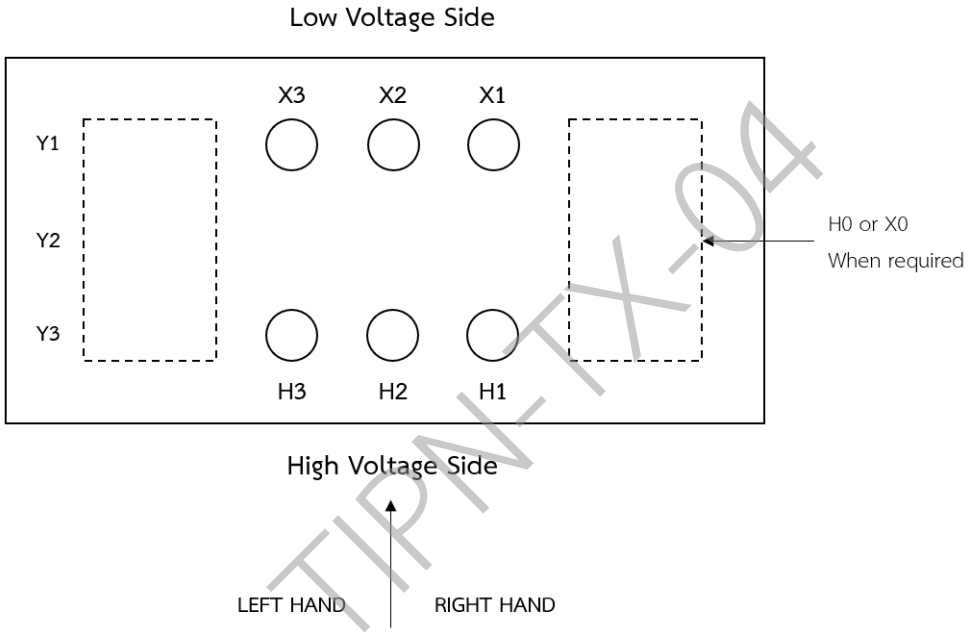


No.	*Description*
1.	HV Bushing
2.	LV Bushing
3.	TV Bushing
4.	Neutral Bushing
5.	Transformer Control Cabinet
6.	Conservator
7.	Radiator
8.	TV Surge Arrester
9.	LV Surge Arrester

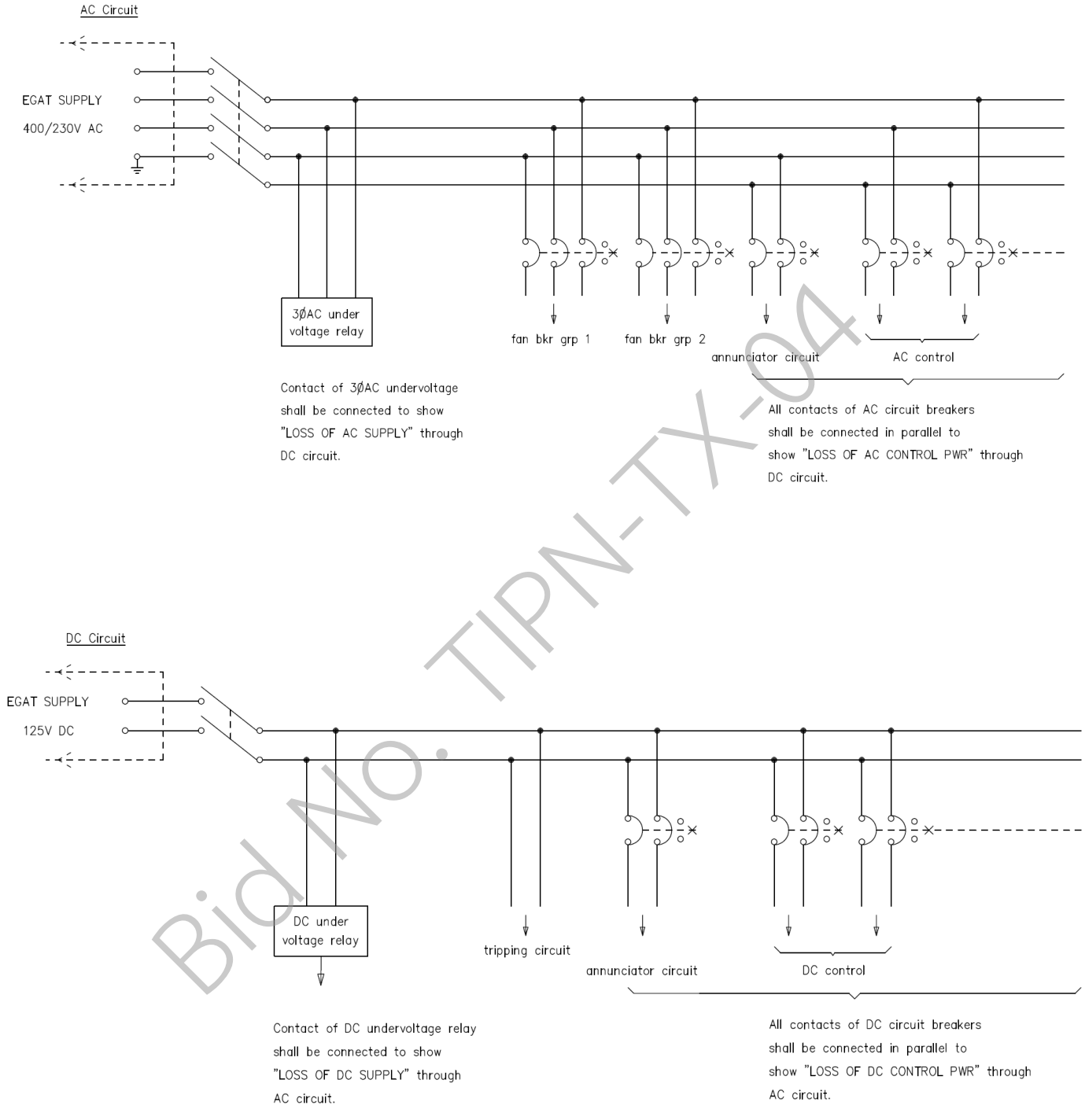
* Location of Radiators and Conservator are depended on manufacturer's design

** Surge arrester shall be located on tank wide side (the alignment of all high voltage terminal are parallel to firewall) to provide the electrical clearance with firewall

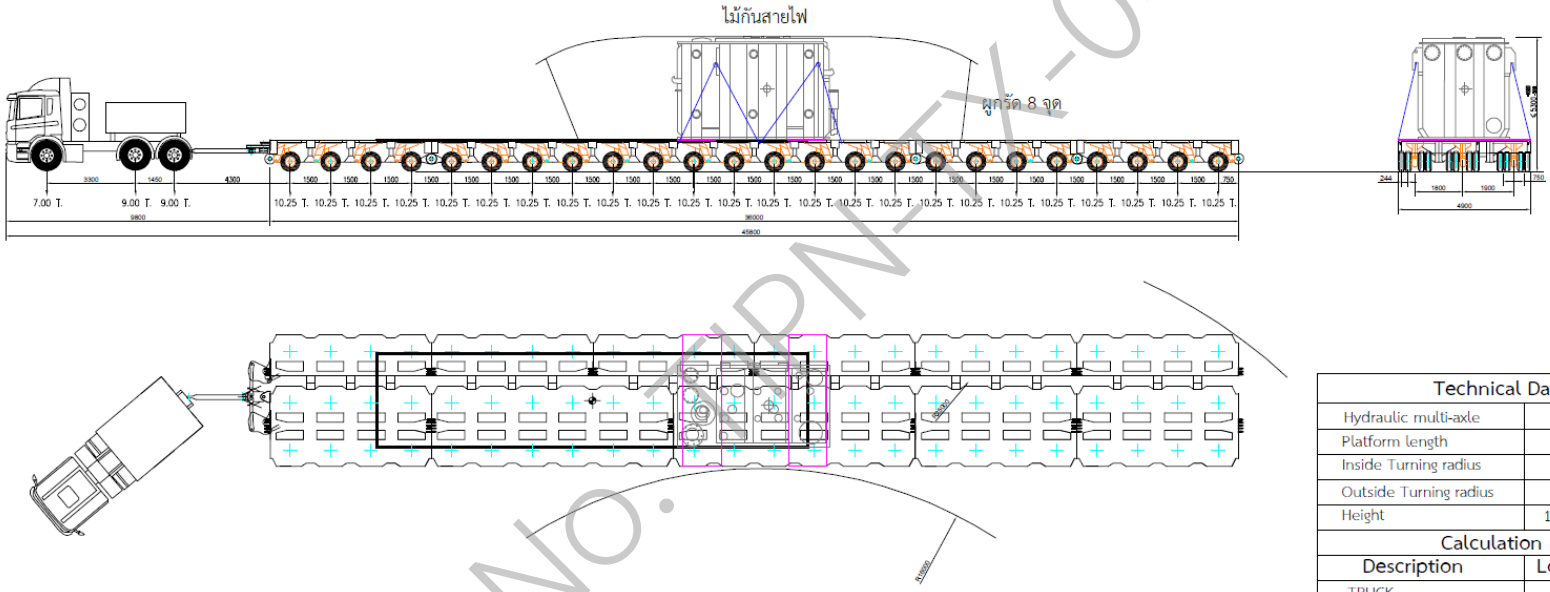
Bushings Location for Three Phase Transformer



AC-DC Circuit Arrangement



รูปแบบ Trailer ขนส่งเครื่องจักรและอุปกรณ์หนัก น้ำหนักรวมสินค้าไม่เกิน 271 T.



Technical Data	
Hydraulic multi-axle	24A/L (1+1/2)
Platform length	24000 mm.
Inside Turning radius	18000 mm.
Outside Turning radius	25000 mm.
Height	1180±300 mm.

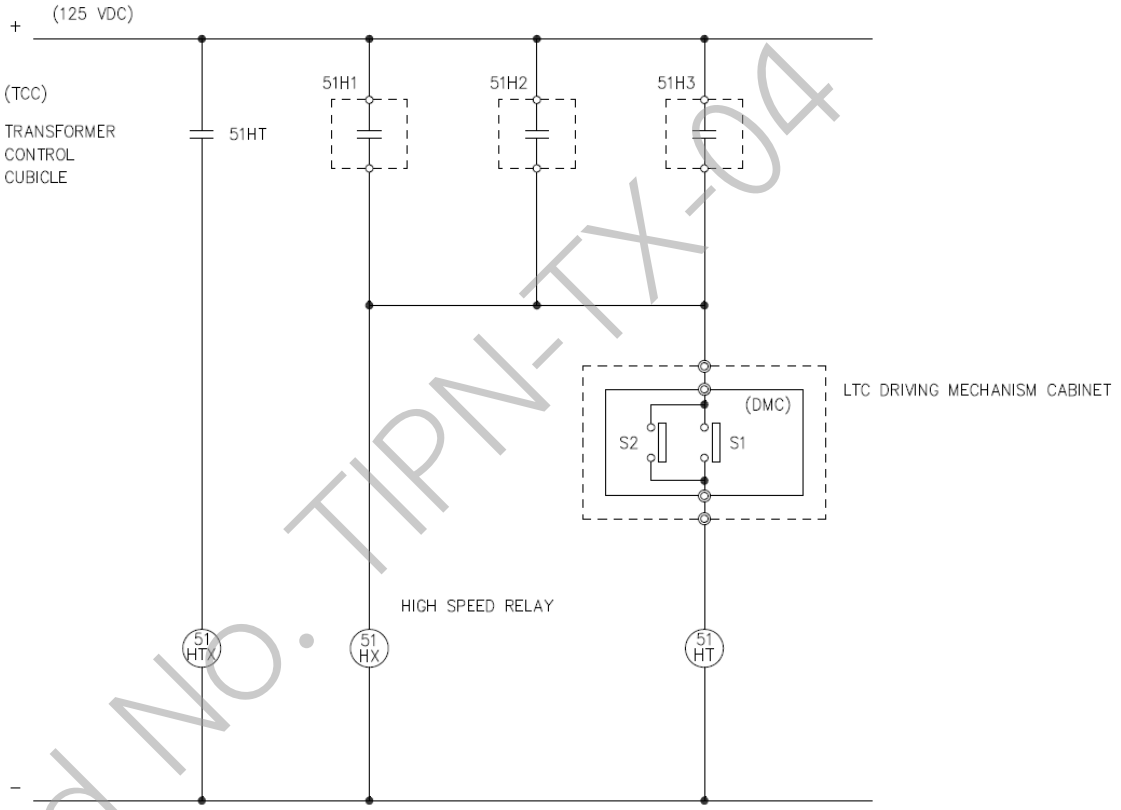
Calculation	
Description	**Load (Tons)**
TRUCK	13.00
COUNTER WEIGHT	12.00
TRAILER	96.00
CARGO (Limit)	150.00
TRAILER WITH CARGO	246.00
TOTAL	271.00
LOAD/LINE	10.25
LOAD/AXLE	3.41
LOAD/TYRE	1.10
AVG.GROUND PRESSURE	1.39Tons/m2

EGAT Transportation

EGAT TRANSPORTATION

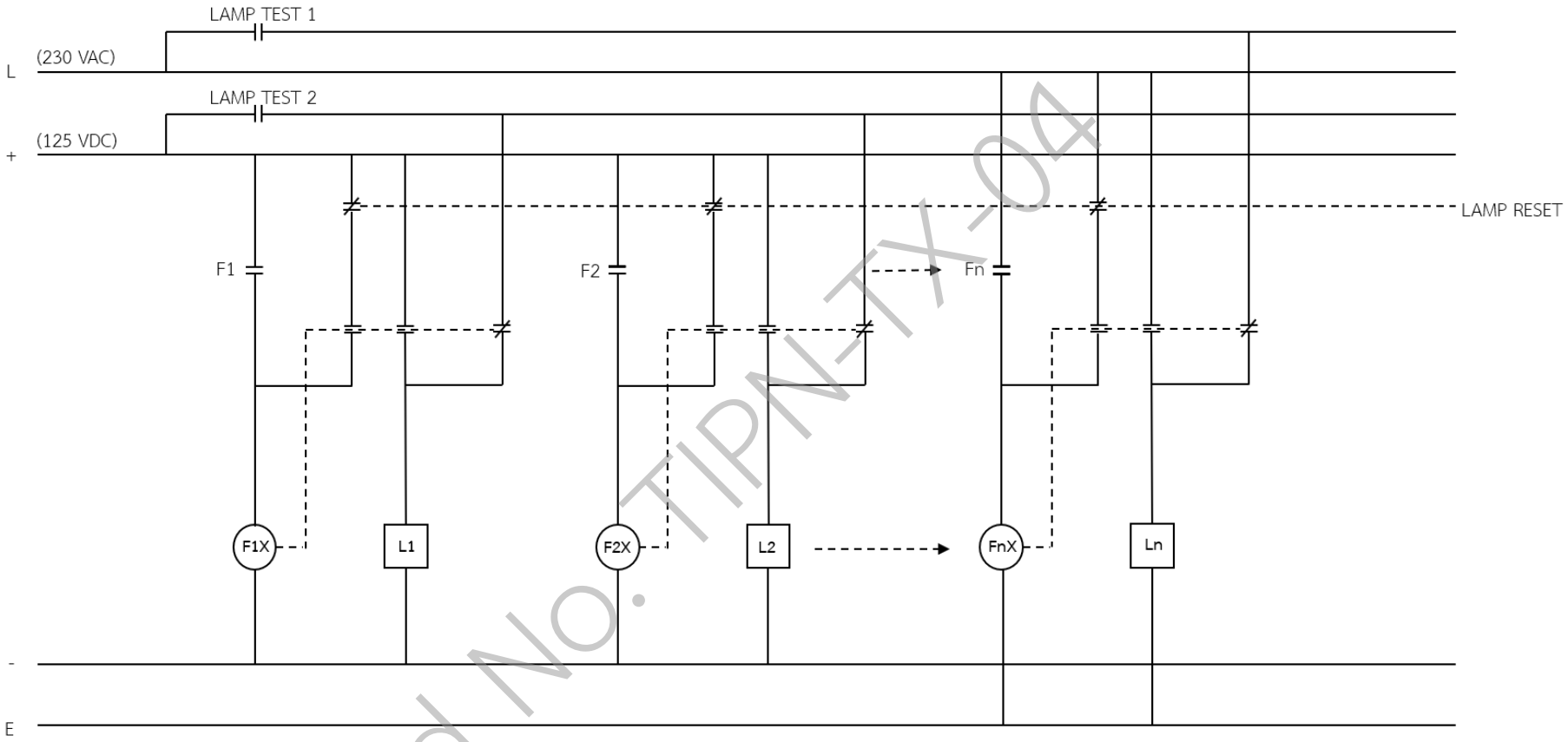
แผนกวิศวกรรมขนส่ง กองวิชาการขนส่ง ฝ่ายบริหารงานขนส่ง
การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย

PROJ.	งานขออนุญาตขนส่งหม้อแปลงฯ 150 ตัน	DRAWING NO.	EGAT-24A/L (1+1/2) -TH62	MRE	mm
		LAYOUT	01	DATE	2/07/62
DWG TITLE	แบบเทรลเลอร์ 24A/L (1+1/2). บรรทุกอุปกรณ์ไฟฟ้า	SCALE	N/A	REV.	00
DRAWN	นายภาณุทัตญ์ คงยิ่ง	APPR			



LEGEND	DESCRIPTION	LOCATION
51H1, 51H2, 51H3	INSTANTANEOUS AND SELF RESET OVERCURRENT RELAY	TCC
51HX	HIGH SPEED RELAY	TCC
51HT	TIME DELAY DROP OUT RELAY (ADJUSTABLE TIME 0–60 S.)	TCC
51HTX	AUXILIARY RELAY	TCC
S1, S2	CAM–OPERATED CONTACT FOR CONTROL DIRECTION	DMC

SUBSTATION ELECTRICAL EQUIPMENT ENGINEERING DIVISION		
LTC OVERCURRENT PROTECTION TYPICAL SCHEMATIC DIAGRAM		
Date : 12/1995	DWG. NO. TX–TSD–01	REV.

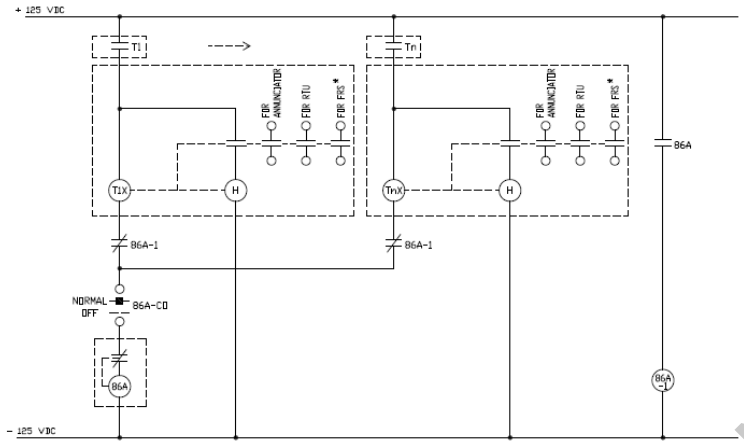


LEGEND	DESCRIPTION
F1, F2, ... , Fn	FAULT CONTACT FROM TRANSFORMER
F1X, F2X, ... , FnX	AUXIARY RELAYS
L1, L2, ... , Ln	FAULT INDICATIONS ON ANNUNCIATOR

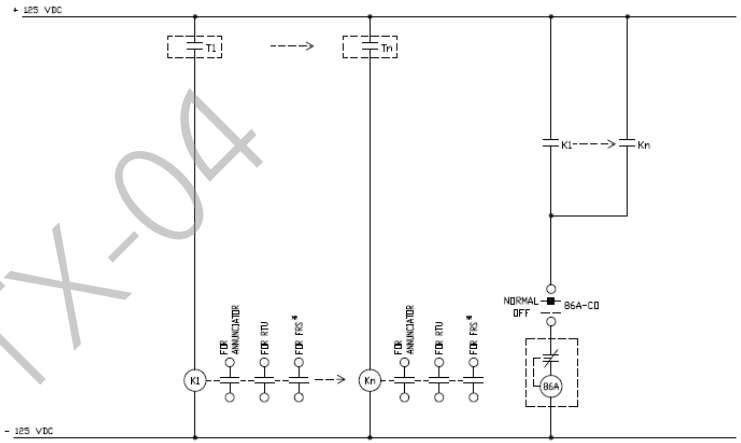
SUBSTATION ELECTRICAL EQUIPMENT ENGINEERING DEPARTMENT		
ANNUNCIATOR TYPICAL SCHEMATIC DIAGRAM		
DATE 03/2020	DWG NO. TX-TSD-03	REV. 0

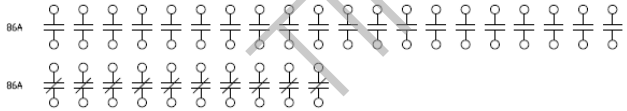
DWG.NO. TX – TSD – 04 REV. –

TYPICAL SCHEMATIC DIAGRAM NO.1



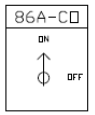
TYPICAL SCHEMATIC DIAGRAM NO.2





LEGEND	DESCRIPTION
T1....Tn	TROUBLE CONTACTS FROM TRANSFORMER
T1X....TnX	CURRENT RELAY WITH HOLDING COIL
K1....Kn	HIGH SPEED RELAY
86A	TRIPPING AND LOCKOUT RELAY
86A-1	AUXILIARY RELAY
86A-CO	CUT-OFF SWITCH

NOTE
* THE ADDITIONAL CONTACTS (FOR FRS) ARE REQUIRED ONLY IN CASE OF THE SINGLE PHASE AUTO-TRANSFORMER.



86A-CO CUT-OFF SWITCH POSITION

CONTACT	POSITION	
	ON	OFF
1 – 2	X	
3 – 4	X	
5 – 6	X	
7 – 8	X	
9 – 10	X	
11 – 12	X	
13 – 14	X	
15 – 16		X
17 – 18		X
19 – 20		X

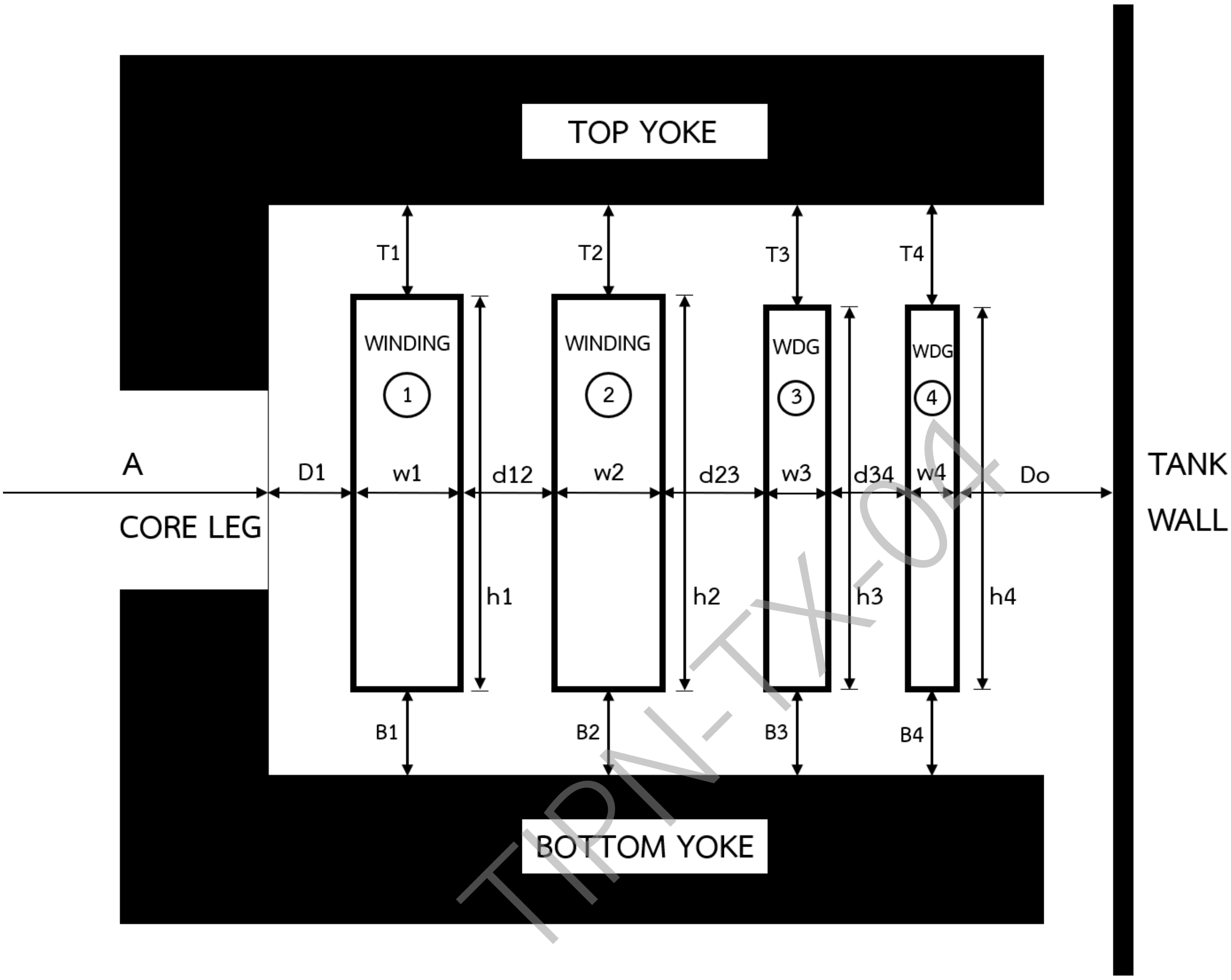
ISO 9001 TISI1999
CAD CENTER
DO NOT AMEND MANUALLY

REV.NO.	JOB NO.	JOB DESCRIPTION	DRAWN	DESIGNED	VERIFIED	VALIDATED	RECOMMENDED	CONCURRED	APPROVED	DATE
–	–	–	–	–	–	–	–	–	–	–

ELECTRICITY GENERATING AUTHORITY OF THAILAND

DRAWN –
DESIGNED –
VERIFIED
APPROVED
VALIDATED
RECOMMENDED
CONCURRED
DRAWING NAME: TYPICAL DRAWING
DESCRIPTION OF DETAIL DRAWING: TRIPPING – TYPICAL SCHEMATIC DIAGRAM
JOB NO. –
REPLACING DWG.NO.
DWG.NO. TX – TSD – 04
REV. –

WINDING ARRANGEMENT DATA



WINDING DATA	**WINDING 1**	**WINDING 2**	**WINDING 3**	**WINDING 4**
Name of Winding (Series, Common, Tap, TV, LV, HV, etc.)	……………	………..….	…………...	…………...
Winding Width	w1 = …….	w2 = …….	w3 = …….	w4 = …….
Winding Height (Coil Part Only)	h1 = ……..	h2 = ...…….	h3 = ……..	h4 = ……..
Distance from Top Yoke	T1 = ……..	T2 = ……..	T3 = ……..	T4 = ……..
Distance from Bottom Yoke	B1 = ……..	B2 = ……..	B3 = ……..	B4 = ……..
Distance Between Winding		d12 = ….….	d23 = ….….	d34 = ...…..
Distance of Innermost Winding from Core Leg				D1 = …….
Distance of Outermost Winding to Tank Wall				Do = …….
Core Leg Diameter				…..………

NOTE 1. All dimensions are in millimeters.

COIL CONDUCTOR DATA FOR EACH WINDING

Name of Winding (Series, Common, Tap, TV, LV, HV, etc.)				
Type of Winding (Disc, Layer, Helical, etc.)				
Type of Conductor (Rectangular, CTC, Bonded CTC, etc.)				
Number of Turns				
Number of Disk or Layer				
Number of Turns per Disk or Layer				
Number of Conductor or Cable per Turn				
Conductor per Turn Data (Describe) - Total Cross Section Area of Conductor (mm^2) - Number of Strand per Conductor - Conductor Strand Dimensions (mm x mm) - Modulus of Elasticity (E, kg/cm^2) - Stiffness (EI Product) of Stranded Conductor in Percent of Equivalent Solid Copper Bar Note E = Modulus of Elasticity I = Moment of Inertia - Proof Stress with Permanent Elongation of 0.2% ($\sigma_{0.2}$) of Copper (kg/cm^2) - Strand Insulating Paper Thickness (mm) - Cable Insulating Paper Thickness (mm)				
Radial Spacer Block - Number of Spacer Between Disk - Spacer Width (mm) - Spacer Pitch (mm) • at outermost diameter center to center - Total Surface Area Between Disk (mm^2) Axial Spacer Column Under Winding - Number of Spacer Under Winding - Spacer Width x Thickness (mm x mm)				
Winding Resistance per Phase (Ω/Phase at 80°C) Conductor Weight per Phase (kg)				
Are there any axial spacer columns (cooling ducts) between turns or layer? If yes, please show details. For instance, in a disk winding which has 6 turns per disk inserted with cooling duct between every 2 turns shall be specified as 2 / 2 / 2 If yes, please specify mean diameter of the outermost and innermost segment of each winding.				

Table-1

Item	Qty.	Description	Rating	Type	Manufacturer	Catalog or Dwg. No.	Remark (if any)
1	3	HV Bushing					
2	3	LV Bushing					

Table-2

Legend	Qty.	Description	Rating	Type	Location				Manufacturer	Remark (if any)
					RCB	CCC	TCC	DMC		
86A	1	Aux. tripping and lockout relay								

Table-3

Legend	Qty.	Description	Wire size (mm^2)	Number of wire	Terminal mark	Remark (if any)
	1	Winding temp relay	3.5			
	2	HV BCT	5.5			

Table-4

Legend	Description	Operating time (ms.)	Contact type	Current Capacity (A)						Expected Service Life	Manu. of	Remark (if any)
				V AC			125V DC					
				Conti-nuous	Making	Breaking	Conti-nuous	Making	Breaking			
	Winding temp. relay		Mercury switch									
	Buchholz relay		Micro switch									

PHASE TRANSFORMER ANNUNCIATOR

TROUBLE & TRIPPING SCHEDULE

Item	Trouble	Annunciator Window Legend	Tripping
1	Main tank oil temperature high	MAIN TANK OIL TEMP HI	
2	Main tank oil level low	MAIN TANK OIL LEVEL LO	
3	Main tank oil level high	MAIN TANK OIL LEVEL HI	
4	LTC diverter switch oil level low	LTC DIV SW OIL LEVEL LO	
5	Main tank pressure relief device operation	MAIN TANK PRESS RELIEF ALARM	
6	LTC diverter switch pressure relief device operation	LTC DIV SW PRESS RELIEF ALARM	
7	Winding temperature alarm stage 1	WDG TEMP ALARM STG 1	
8	Winding temperature alarm stage 2	WDG TEMP ALARM STG 2	
9	Buchholz relay operation (alarm)	BUCHHOLZ RLY ALARM	
10	Buchholz relay operation (trip)	BUCHHOLZ RLY TRIP	yes
11	Main tank sudden pressure relay operation	SUDDEN PRES ALARM	
12	Conservator rubber bag rupture detector relay operation	RUBBER BAG RUPTURE	
13	LTC pressure relay or oil flow relay operation	LTC PRES RLY TRIP OR OIL FLOW RLY TRIP	yes
14	Loss of three phase AC control power (three phase undervoltage relay)	LOSS OF AC SUPPLY	
15	Loss of DC control power (undervoltage relay)	LOSS OF DC SUPPLY	
16	Branch AC control power ACB trip (ACB alarm contacts)	LOSS OF AC CONTROL PWR	

PHASE TRANSFORMER ANNUNCIATOR

TROUBLE & TRIPPING SCHEDULE

Item	Trouble	Annunciator Window Legend	Tripping
17	Branch DC control power ACB trip (ACB alarm contacts)	LOSS OF DC CONTROL PWR	
18	LTC tap change operation incomplete	TAP CHANGE INCOMPLETE	
19	Group 1 fan motor overload	GRP1 FAN MOTOR OVERLOAD	
20	Group 2 fan motor overload	GRP2 FAN MOTOR OVERLOAD	
21	Group 1 fan motor circuit breaker trip	GRP1 FAN MOTOR BRK TRIP	
22	Group 2 fan motor circuit breaker trip	GRP2 FAN MOTOR BRK TRIP	
23	LTC drive motor circuit breaker trip	LTC DRIVE MOTOR BRK TRIP	
24	Misoperation of the de-energized tap changer	DE-ENERGIZED TAP CHANGE MISOPERATION	yes

COMMON TRANSFORMER ANNUNCIATOR

TROUBLE & TRIPPING SCHEDULE

Item	Trouble	Annunciator Window Legend
1	Low of three phase AC control power (three phase undervoltage relay)	LOSS OF AC SUPPLY
2	Loss of DC control power (undervoltage relay)	LOSS OF DC SUPPLY
3	Branch AC control power ACB trip (ACB alarm contacts parallel)	LOSS OF AC CONTROL PWR
4	Branch DC control power ACB trip (ACB alarm contacts parallel)	LOSS OF DC CONTROL PWR
5	Overcurrent block of LTC operation during tap change	OVERCURRENT DURING TAP CHANGE
6	LTC tap position discrepancy between phases	PHASE TAP DISCREPANCY
7	Parallel operation LTC tap position discrepancy	PARALLEL TAP DISCREPANCY
8	Phase A annunciator operated (annunciator common alarm contact)	PHASE A TROUBLE
9	Phase B annunciator operated (annunciator common alarm contact)	PHASE B TROUBLE
10	Phase C annunciator operated (annunciator common alarm contact)	PHASE C TROUBLE
11	Operation of lock out relay	LOCK OUT OPERATE
12	Cut off switch 86ACO – off position	CUT OFF SW. OPERATE

TRANSFORMER CONTROL CABINET

ANNUNCIATOR TROUBLE & TRIPPING SCHEDULE

(For Three phase transformer)

Item	Trouble	Annunciator Window Legend	Tripping
1	Main tank oil temperature high	MAIN TANK OIL TEMP HI	
2	Main tank oil level low	MAIN TANK OIL LEVEL LO	
3	Main tank oil level high	MAIN TANK OIL LEVEL HI	
4	LTC diverter switch oil level low	LTC DIV SW OIL LEVEL LO	
5	Main tank pressure relief device operation	MAIN TANK PRES RELIEF ALARM	
6	LTC diverter switch pressure relief device operation	LTC DIV SW PRES RELIEF ALARM	
7	Winding temperature alarm stage 1	WDG TEMP ALARM STG 1	
8	Winding temperature alarm stage 2	WDG TEMP ALARM STG 2	
9	Buchholz relay operation (ALARM)	BUCHHOLZ RLY ALARM	
10	Buchholz relay operation (TRIP)	BUCHHOLZ RLY TRIP	yes
11	Main tank sudden pressure relay operation	SUDDEN PRES ALARM	
12	Conservator rubber bag rupture detector relay operation	RUBBER BAG RUPTURE	
13	LTC pressure relay or oil flow relay operation	LTC PRES RLY TRIP OR OIL FLOW RLY TRIP	yes
14	Loss of three phase AC control power (three phase undervoltage relay)	LOSS OF AC SUPPLY	
15	Loss of DC control power (undervoltage relay)	LOSS OF DC SUPPLY	

TRANSFORMER CONTROL CABINET

ANNUNCIATOR TROUBLE & TRIPPING SCHEDULE

(For Three phase transformer)

Item	Trouble	Annunciator Window Legend	Tripping
16	Branch AC control power ACB trip (ACB alarm contacts)	LOSS OF AC CONTROL PWR	
17	Branch DC control power ACB trip (ACB alarm contacts)	LOSS OF DC CONTROL PWR	
18	Overcurrent block of LTC operation during tap change	OVERCURRENT DURING TAP CHANGE	
19	Change-delay of LTC	TAP CHANGE DELAY	
20	Deviation of tap position	TAP DIFF	
21	Group 1 fan motor overload	GRP1 FAN MOTOR OVERLOAD	
22	Group 2 fan motor overload	GRP2 FAN MOTOR OVERLOAD	
23	Group 1 fan motor circuit breaker trip	GRP1 FAN MOTOR BRK TRIP	
24	Group 2 fan motor circuit breaker trip	GRP2 FAN MOTOR BRK TRIP	
25	LTC drive motor circuit breaker trip	LTC DRIVE MOTOR BRK TRIP	
26	Misoperation of the de-energized tap changer	DE-ENERGIZED TAP CHANGE MISOPERATION	yes
27	Breaker for LTC oil filter pump motor failure	LTC OIL FILTER PUMP BKR.	
28	Oil filter pressure switch operation	OIL FILTER OVERPRESSURE	
29	Operation of lock out relay	LOCK OUT OPERATE	
30	Cut off switch 86ACO – off position	CUT OFF SW. OPERATE	

SPECIFICATION OF MINERAL INSULATING OIL
REVISION 7.3.1

1. General

The new mineral insulating oil obtained by refining, modifying and/or blending of original petroleum products is used as an insulating and cooling medium in new and existing power as well as distribution electrical apparatus, such as transformers, regulators, reactors, circuit breakers, switchgears, and attendant equipment where greater oxidation resistance is required. The mineral insulating oil shall be functionally interchangeable, miscible with existing oil, compatible with existing apparatus and with appropriate field maintenance. It shall satisfactorily maintain its functional characteristics in its application in electrical equipment. This specification applies only to new insulating oil which is received before any processing.

2. Property Requirements

The property requirements of mineral insulating oil shall conform to ASTM D3487-2016e1 Type II Mineral oil (see Clause 3.1.2 for definitions of ASTM or IEC60296-2020 Edition 5.0 Type A Mineral oil (see Clause 5.1 for definitions of IEC) and EGAT experiences. Inhibited oil is insulating oil which has been supplemented with2,6-ditertiary-butyl phenol or 2,6-ditertiary-butyl para-cresol or any other specified and acceptable oxidation inhibitor. If other additives are used, they must be identified. Generally, the additive is a suitable chemical substance which is deliberately into the mineral insulating oil to improve certain characteristics. So, the use of all additives, such as pour point depressants, gassing tendency improvers, additives for static electrification, antifoaming agents and other additives, should be specifically identified by class of compounds if the specific information is proprietary, except the additive for this specification must be free from additive for corrosive sulfur.

Property		ASTM D 3487 Requirements	IEC 60296 Requirements	*EGAT Requirements
2.1	Color	0.5, max	L0.5 (less than 0.5)	-
2.2	Flash point, °C	145, min	135, min	-
2.3	Interfacial Tension at 25 °C dynes/cm (mN/m)	40, min	43, min	-
2.4	Pour point, °C	-40, max [B]	-40, max	-
2.5	Relative density (Specific gravity) 15°C/15°C, g/ml	0.91, max		-
2.6	Density at 20°C, g/ml	-	0.895, max	-
2.7	Viscosity, Kinematics cSt (SUS) at 100°C at 40°C at 0°C at -30°C	 3.0 (36), max 12.0 (66), max 76.0 (350), max -	 - 12.0, max - 1,800, max	 - - - -
2.8	Visual examination	clear and bright	-	-
2.9	Appearance	-	clear, free from sediment and suspended matter	-
2.10	Dielectric breakdown voltage VDE electrodes, kV 0.040 in (1.02 mm.) gap 0.080 in (2.03 mm.) gap	 20, min [D] 35, min [D]	 - -	 20, min [A] 35, min [A]
2.11	Dielectric breakdown voltage, kV	-	30, min	See note EGAT Requirements [A]
2.12	Dielectric breakdown voltage, Impulse conditions Negative polarity point, kV	145, min	-	145, min See note EGAT Requirements [B]

	Property	ASTM D 3487 Requirements	IEC 60296 Requirements	*EGAT Requirements
2.13	Gassing Tendency, µl/min	+30, max	-	See note EGAT Requirements[C]
2.14	Power factor (Dissipation factor) at 60 Hz, % at 25 °C at 90 °C at 100 °C	 0.05, max - 0.30, max	 - 0.005, max -	 - - -
2.15	Neutralization number, Total acid number, Acidity mg KOH/g	0.03, max	0.01, max	-
2.16	Oxidation stability (acid-sludge test) 72 hrs: % sludge, by mass Total acid number, mg KOH/g 164 hrs: % sludge, by mass Total acid number, mg KOH/g	 0.1, max 0.3 ,max 0.2, max 0.4, max	 - - - -	 - - - -
2.17	Oxidation stability IEC 61125: Test duration (I) Inhibited oil: 500 h Total acidity, mg KOH/g Sludge, % DDF at 90° C	 - - -	 0.3, max[h] 0.05, max[h] 0.050, max[h]	 - - -
2.18	Oxidation stability (pressure vessel test), (Rotating Bomb), minutes	195, min	-	220, min[D]
2.19	Oxidation inhibitor content % by mass	0.30, max[G]	0.08-0.40	-

Property		ASTM D 3487 Requirements	IEC 60296 Requirements	*EGAT Requirements
2.20	2-Furfural and related compounds content, µg/l	25, max per compound	Not detectable (< 0.05 mg/kg) for each individual compound	25, max[E] (for each individual compound)
2.21	Corrosive sulfur copper strip, 150 °C 48 hrs Potentially corrosive copper conductor wrapped with paper, 150 °C±2°C 72 hrs, evaluation of -copper -paper	Non-Corrosive - -	- Non-Corrosive No deposits	Non-Corrosive[F] Non-Corrosive[F] No deposits
2.22	Dibenzyl disulfide (DBDS), mg/kg	-	Not detectable (<5 mg/kg)	Not detectable (<5 mg/kg)
2.23	Water content, ppm	35, max	30, max	-
2.24	% PCA content (Polycyclic aromatics)	-	3, max	-
2.25	PCB content	Not detectable	Not detectable (<2 mg/kg)	-
2.26	% Total Sulphur content	-	0.05, max	-
2.27	Stray gassing under thermo-oxidative stress	-	Non stray gassing	-

***in case of any test item meets EGAT Requirements, that limit becomes accepted.**

Note:

ASTM D 3487 Requirements

- (B) It is common practice to specify a lower or higher pour point, depending upon climatic conditions.
- (D) These limits by Test Method D 1816 are applicable only to as received new oil.
- (G) Both 2,6-ditertiary-butyl para-cresol and 2,6-ditertiary-butyl phenol have been found to be suitable oxidation inhibitors for use in oils meeting this specification.

IEC 60296 Requirements

- (h) At the end of oxidation stability tests.

EGAT Requirements

- (A) These limits by Test Method ASTM D1816 are applicable only to as received new oil.
- (B) EGAT prefers oil of a 145 kV minimum for certain applications.
- (C) The characteristic should be negative. If the characteristic is positive, the value should be near test report from supplier (±10%). In case the characteristic is positive, this oil cannot be used in Instrument transformer and bushing.
- (D) Good oxidation stability is a principal requirement for long service life of transformer oils.
- (E) The test is for five furanic compounds, 5-hydroxymethyl-2-furfural, furfuryl alcohol, 2-furfural, acetyl furan and 5-methyl-2-furfural. The limit of 25 µg/L maximum applies to each compound.
- (F) Classification of corrosive or non-corrosive shall be made using ASTM copper strip corrosion standards as referred to test method ASTM D130.

3. Container

The mineral insulating oil shall be filled in non-returnable, 200 liters steel drums which shall become the property of EGAT. The filling date of insulating oil shall be declared on each drum.

Steel Drums 200 Liters (Tight Head)

For the packing of	Transformer oil
Nominal Capacity (Litres)	200
Nominal Capacity (Gallon)	55
Max Capacity (Litres)	217
Raw Material	Cold Rolled Steel Spec.: JIS.G. 3141 SPCC-SD (Prime A.)
Thickness Body (mm)	0.9 ± 0.06
Thickness Top/Bottom (mm)	1.2 ± 0.08
Overall Height (mm)	887
Closure (mm)	51 (2") and 19 (3/4")
Surface Inside	Plain steel or Unlined
Surface Outside	Painted with single color or multicolor, Decorated to top, bodies, and bottom
Weight (kg)	17.5

4 oil drums per pallet with secure packaging shall be provided and suitable for transportation. The pallet's dimension shall be 1.20 x 1.20 meters.

4. Acceptance Tests

The mineral insulating oil shall be tested to confirm all characteristics as specified. The number of samples examined for each item is shown in the attachment sheet No.1 and No.2. The oil will be accompanied with a statement form of the Bidder to guarantee its characteristics. EGAT shall have the right to reject all products if the samples do not pass the process of examination. EGAT shall test in some items (item 2.1, 2.3, 2.5-2.12, 2.14-2.15, 2.18-2.23, 2.25) and consider another item (item 2.2, 2.4, 2.13, 2.16, 2.17, 2.24) from product data sheet or technical data sheet of each company.

The sampling of mineral insulating oil shall be performed by the supplier and witnessed by EGAT with the sampling device and procedures according to ASTM D923 or IEC 60567. The supplier shall provide six dry and clean 1000 cc. glass bottles for each sampling

drum. In case of negative test results are from the sampling process or from the sampling device, the supplier shall take the responsibility.

The problem on sampling mineral insulating oil can be caused by unclean and wrong vessel during the sampling procedures so the supplier or trader must be informed of this regard.

The criteria for consideration of test result shall be performed as follows:

- The mineral insulating oil is submitted to EGAT by the supplier.
- When the samplings of mineral insulating oil are taken to test by EGAT and the test results do not become satisfactory, the supplier has to take the mineral insulating oil back immediately without any re-test. In other words, EGAT will perform the test without any charge to the supplier only. If EGAT does not satisfy with the result after the first testing, the suppliers shall take the mineral insulating oil back for improvement or change a new sampling and shall re-submit to EGAT only once. For the second submission, if the supplier wants EGAT to test the sampling again, he shall bear the testing cost as shown in attachment No.2 or if the supplier wants EGAT to send the sampling to be tested by the third-party office accepted by EGAT, he shall bear for any cost that occurs.

5. Product Data Sheet or Technical Data Sheet and Test Report

Bidder shall submit, at the time of bidding, the product data sheet or the technical data sheet from the original maker, together with the latest test report of the proposed mineral insulating oil, according to the EGAT's requirement.

The approved vender shall inform, to EGAT, the number of lots or batches of the mineral insulating oil prior to submitting to be tested. The test report of each lot or batch shall be submitted with the product shipment.