Chapter - 2

Design and Engineering features

(1) Architectural Features, General Arrangement Drawings & Accessories

Working Group Members

Mr. M. Vijayakumaran – ALSTOM Ltd

Mr. P. Ramachandran – ABB Ltd

Mr. Y. V. Joshi – GETCO

Mr. M.M. Goswami – POWERGRID

Mr. T. Vijayan – T&R Ltd

CHAPTER - 2

DESIGN AND ENGINEERING FEATURES

Part 1 - Architectural Features, General Arrangement Drawings & Accessories

INTRODUCTION

In a process of standardisation of transformer from procurement to commissioning, architectural features do have major role. At present, same rating/class transformers are being designed differently even for same user. Even for same specifications, manufacturer reviews design for successive tender considering prevailing market condition and thereby make changes in transformer architectural features and general arrangements. This reviewing activity not even leads to increase in design & manufacturing cycle time, cost, human efforts and inventories but also keep user away from preparing for footprint in his switch-yard.

To resolve all these issues and to define standard architectural features and accessories, this Working Group had 5 rounds of meetings and discussions in the subject matter. However, standardisation refers to limit the variation in terms of layout, general arrangements, interchangeability, accessories selection guide including data sheet, drawings, schematic, mounting arrangement/interface with tank, critical check points for installation and commissioning, etc.

Interchangeability has been referred here mainly to transformers of similar rating, voltage and other technical characteristics, even when they are being purchased from different suppliers under different contracts so as to arrive at common dimensions and layout, to allow physical interchangeability with minimum of adaptation and optimize spare holding inventory. It is possible for transformers purchased earlier to be replaced later by more modern designs, even with larger ratings but designed to accommodate in the same space. Utilities purchase transformers to meet requirements of this kind in order to increase availability and reduce costs by minimising the outage time in the event of a transformer having to be removed from service and replaced by spare/new transformer available. The concept may apply for separately cooler bank mounted transformer in which case the requirement of interchangeability can be even made applicable to the main transformer excluding cooler bank.

This policy will reduce the complexity of the purchaser's stock of transformers, bushings, fittings, tap changer components, etc and will minimize maintenance practice and costs.

- **Aesthetic (Appearance) of Transformer:** Mounting of fittings to be same as far as possible, mounting & location of Cooler bank, Conservator etc. shall be at standard position. A typical plan & section drawing showing accessories like Bushings, Tap changer, conservator, OLTC Drive Mechanism, Neutral Earthing arrangement, Marshalling box, etc. are enclosed in this Manual. Tank mounted radiators are recommended, for ratings up to 100 MVA and they can be separate for higher than 100 MVA.
- **Tank Type**: Bell type, Bolted /Welded construction, Conventional & Form Fit type
- **Cooler**: The Fin thickness of radiator will be minimum 1.0 mm. Only 4 heights are proposed (2.0 M, 2.5 M, 3.0 M & 4.5 M) with number of elements to be 20, 24 & 26. Radiator (external) shall be hot dip galvanized or painted as per Data Sheet of Radiator given in this Manual. For internal surface galvanizing is not recommended. Corrosion resistant paints may be applied on galvanized surface for better appearance.
- **Rail, Roller & Roller Assembly**: It is proposed to remove provision of rail as nowadays transformers are not transported by railway but rails are required for transformers to achieve center line of transformer, provision may be provided for rail. However, Transformers are recommended to put directly on plinth without rollers & roller assembly will be standardised. Only one set of roller is recommended for each substation. Since Roller is casted, hence only Roller assembly is needed to be galvanized.
- **Valve Schedule**: Valve specification, type & application shall be standardised. This will be reviewed with experts and finalized.
- **Conservator**: Main conservator should be with Aircell. OLTC conservator shall be separate to avoid intermixing of oil. Maintenance free type dehydrating silica gel breather may be provided in remote operation substation.

- **Internal Earthing of Metal Parts**: Earthing point shall be robust and made accessible for the inspection to the extent possible.
- **Painting**: Tank, Radiator & Fittings may be of different shades. Epoxy coating to be avoided for outermost layer. It should be PU only. Casting parts not necessarily painted for matching shade. Any fabricated accessory should be either galvanized or outer side PU. Powder coating may be accepted provided it should be sun light / outdoor / UV ray resistant. Being not Eco-friendly, Zinc Chromate is not to be used. Bottom plate of tank may be accepted with water based paint. Internal paint shall be oil resistive with thickness of 25 to 40 micron only.
- **Hardware / Bolts**: Material will be MS with grade 8. To avoid bending High Tensile Steel (HTS) is also recommended. Stainless Steel should not be used in the main tank joint.
- **Gasket**: Since one side of gasket is exposed to the transformer oil of different quality (old, new, inhibited, un-inhibited, Paraffin base oil, Naphthenic base oil & vegetable oil etc.) & other side is water, moisture, humidity, air, oxygen, pollution, saline etc., hence gasket to be reliable & suitable for these applications. Chord (Nitrile Chord) for all flange joints are recommended. Top cover of tap changer to be suitable for O-Ring or chord with interchangeable with older one.
- **Marshalling Box / Common Marshalling Box**: The enclosure (shell) shall be made of cold rolled sheet and galvanized / painted. Stainless steel and Aluminum may also be considered for Marshalling Box.
- **OTI & WTI**: Switches shall be Mercury-free.
- **Breather**: Cobalt is a banned material, hence not recommended to use. Size of silica gel is to be standardised, either it can be one of 100% or two of 100% in parallel. Valve over breather is not recommended.
- **Pressure Release Device (PRD)**: PRD shall be mounted on top cover. One PRD is recommended per every 40 KL oil quantity. The oil discharge chamber and terminal box of the PRD shall be water tight with Protection class IP 56 or better as per IEC 60529.
- **Ladder**: Ladder (Fixed type) with safety locking device to be provided. Provision for fixing safety barriers shall be provided on top tank cover. Ladder for conservator may be provided considering safety for working at height.
- **Fire Protection System (FPS)**: Provision of FPS is recommended in line with CEA regulation, i.e. for 10 MVA & above. It is recommended to keep provision in each transformer.
- **Health, Safety and Environment (HSE)**: All the HSE aspects shall be covered while preparing standard GA drawing. Adequate working space on top of transformer with suitable railing for safety shall be provided.
- **Ratings of Transformer**: Standard ratings considered are as per Annexure 1.2.
- **Rail gauge** shall be standard (1676 mm). Plinth mounted tank design may be adapted, as a specific requirement. Rating wise rail gauge are standardised as below:
  1. **765 kV & 400 kV, 1-Phase Generator Transformer** (having two rails or three rails)
  2. **765 kV & 400 kV, 1-Phase Auto Transformer** (having four rails)

     ***Note**: 3-Phase ratings for above also to be considered depending on size and transportability.*
  3. **400 kV, 3-Phase Auto Transformer** (having four rails)
  4. **400 kV & 220 kV, 3-Phase Generator Transformer** (having two rails)
  5. **220 kV & 132 kV, Power Transformer** (having two rails)
- **Location of OLTC**: The number and location will be as per OLTC type & its specification.
- **Interchangeability & Common Architecture**: The OGA is prepared in the form of block diagram & all important fittings positions are shown (Annexure 2.1). Marshaling Box, Cooler control cabinet and any other cabinet required for any monitoring devices will be tank mounted. Grounding inter phase is considered to minimize.
- **Jacking**: 4 nos. of jacks shall be provided.
- **Cooler bank foundation**: Modular block foundation is to house any make radiator in the standard foundation.
- Maximum Height of Conservator to be standardised to make the firewall uniform.
- The tertiary and neutral bushing shall be provided on top of the tank cover. The provision on side wall of the tank is not recommended in view to avoid lowering of oil level in case of bushing replacement which is time consuming.
- Due to winding capacitances, the tertiary winding faces transferred surge voltages during impulse application on HV/IV winding. Therefore, the bushings of 52 kV rating are provided for 33 kV tertiary winding.

Cooler Bank Design:

- Provision for connecting cooling bank on both sides shall be provided. Pipe work on main tank to be designed in such a way that position of the cooler bank, conservator etc. can be changed at site by simple reconnection.
- Specification for separately mounted radiator bank distance (for oil pipe connection) from main tank to be kept standard or minimum. Position of cooling fan to be bottom of radiator bank but cooler fan support from ground is not recommended.
- Modular block foundation will be explored to house any make of radiator in the standard foundation.
- Tank mounted Unit cooler option for Generating / Large transformers can be considered.
- If more than one unit is provided, the breather for main tank shall be in parallel.
- No. of OLTC and its location will be as per OLTC type & its specification.
- Jacking: 4 - jacks shall be provided and their locations to be decided by the manufacturer such that it will not foul rail, rollers or other accessories.
- Height of Conservator & HV bushing shall be same.
- Hot dip galvanized with a minimum thickness of 70 μm and painting as per the following specification.

ITEM	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thickness (DFT)	Colour shade
Main tank, pipes, conservator tank, oil storage tank etc. (external surfaces)	Shot Blast cleaning Sa 2½*	Epoxy base Zinc primer (30-40 μm)	Epoxy high build Micaceous iron oxide (HB MIO) (75 μm)	Aliphatic polyurethane (PU) (Minimum 50 μm)	Minimum 155 μm	RAL 7035
Main tank, pipes (above 80 NB), conservator tank, oil storage tank etc. (internal surfaces)	Shot Blast cleaning Sa 2½*	Hot oil resistant, non-corrosive varnish or paint or epoxy	-	-	Minimum 30 μm Max 40 μm	Glossy white for paint
Radiator (external surfaces)	Chemical/ Shot Blast cleaning Sa 2½*	Epoxy base Zinc primer (30-40 μm)	Epoxy base Zinc primer (30-40 μm)	PU paint (minimum 50 μm)	Minimum 100 μm	Matching shade of tank/different shade aesthetically matching to tank
Radiator and pipes up to 80NB (internal surfaces)	Chemical cleaning, if required	Hot oil proof, low viscosity varnish	-	-	-	-
Control cabinet/ marshalling box	Seven tank process as per IS:3618 & IS:6005	Zinc chromate primer (two coats)	-	EPOXY paint with PU top coat	Minimum 80 μm	RAL 7035 shade for exterior and interior

Note : * indicates Sa 2½ as per Swedish Standard SIS 055900 of ISO 8501 Part-1.

- The quality of paint should be such that its colour should not fade during vapor phase drying process and shall be able to withstand temperature up to 120 ^{0}C.
- Transformer shall be put on plinth but provision of roller shall be provided. The nos. of jacking points / pads and lifting bollards / hooks / devices shall be 4 only. Location shall be such that it should not interfere with loading and unloading from trailer.

- Internal arrangement drawing of the active part and lead exit to be provided in the Instruction Manual by manufacturer for better assessment of probable fault location when reflected in abnormal DGA results.
- Line diagram for core, core clamp and tank earthing diagram shall be provided in the Instruction Manual.
- Location of OLTC Driving mechanism box, Marshalling box, and optical fiber termination shall be on the same side.
- The main and OLTC conservator shall be integrated type with separate compartments so that they are at same height with no pressure difference. In the case of separate cooler bank or if there is difficulty, OLTC conservator can be separate.

Chapter - 2

Design and Engineering features

(2) Power Transformer Fittings and Accessories - OLTC

Working Group Members

Mr. V. K. Lakhiani	- T&R Ltd.
Mr. R. V. Talegaonkar	- CTR Mfg. Ind. Ltd.
Mr. S. Rajan	- CTR Mfg. Ind. Ltd.
Mr. R. Prakash	- Easun, MR
Mr. Vijayakumaran	- ALSTOM Ltd.
Mr. R. K. Shukla	- On Load Gears
Mr. M. M. Goswami	- POWERGRID

Part 2 - Standard On-Load-Tap Changers for Power Transformers

INTRODUCTION

On Load Tap changers (OLTC) are the most important equipment used in the power transformers for changing the tap of a winding (to vary effective transformation ratio of the transformer) whilst, the transformer is energized or is on load.

Performance requirements of these OLTCs for use in transformers and their routine and type tests are described in IEC 60214-1. Selection criteria of the OLTC, their various types, fittings and accessories etc. are covered in the IEC 60214-2 "Application Guide".

CBIP Manual on transformers (Publication 317) in 'Section GG' gives guidelines for voltage control of Power Transformers employing OLTC.

As a general practice, end user of the transformer gives the requirement of voltage regulation (on HV or LV side), range of percent voltage variation (from maximum voltage to minimum voltage, expressed as % of rated voltage), number of steps, % impedance of transformer at maximum voltage and minimum voltage tap positions in case of parallel operation with existing transformer and other control schematic requirements.

Transformer manufacturer, meeting the above requirement, decides the location of tapping winding (physical as well as electrical), based on his design philosophy and experience and estimates the current and voltages seen by the tapping winding (across range, between steps, to earth and between phases). Based on this data, OLTC supplier provides a suitable tap changer from his available range.

This IEEMA standard on OLTC purports to define the specification requirements and selection criteria of OLTC and recommends the standard parameters of OLTC to be used in transformers of prevalent standard ratings in the country standardised by CBIP.

SCOPE

This standard covers specification requirements and selection of On Load tap changers for Power Transformers in the country.

1.0. **General requirements for selection of OLTC parameters:**

1.1. **Standards Applicable**

The tap changer shall conform to latest edition of IEC 60214 Part1: Performance Requirements & Test Methods; and IEC 60214 Part 2: Application Guide.

1.2. **Tap Changer Specification**

For comprehensive specification of OLTCs, certain data need be specified by the transformer manufacturers depending upon the transformer design & construction, apart from the specifications provided by the end users. These specification requirements are therefore divided in to two parts.

1.2.1. **Specification requirements from end users (Utilities)**

1.2.1.1 Transformer Details

- Number of Phases: Single phase or three phase
- Rated Power: MVA
- Rated Voltage: HV kV / LV kV
- Winding Connection: HV / LV (e.g. Star, Delta, Star Auto)
- % Tapping range of rated winding voltage: (+)……% to (-) ……% for HV (or LV) variation.
- Number of tapping positions (No. of steps and % step voltage)
- Direction of Power flow: Unidirectional/Bidirectional
- Over Loading requirements (if different from IEC 60076-7).

1.2.1.2 Drive Mechanism and control scheme

- Local electrical independent control
- Local automatic independent control
- Remote electrical independent control
- Remote automatic independent control
- Parallel electrical control of two or more transformers
- Parallel automatic control of two or more transformers
- Supervisory control

1.2.1.3 Auxiliary Supply voltage

- For Motor
- For control circuitry

1.2.1.4 Site Operating Conditions

- Maximum & Minimum ambient temperatures

1.2.2. **Specification requirements from Transformer Manufacturer**

1.2.2.1 Type of construction of On Load Tap Changer

- External - out of tank
- Internal - in tank

1.2.2.2 Tap winding arrangement

- Linear, Reversing or Coarse / Fine

1.2.2.3 Position of taps in the winding

- Line end, Middle, Neutral point

1.2.2.4 Highest tap current of the winding

- …………..Amps

1.2.2.5 Highest step voltage

- …………Volts

1.2.2.6 Insulation levels of On Load Tap Changers

- Tap-Changer to earth (Highest voltage between any tap and earth)
- Between phases (Where applicable)
- Across Tap Range and between change-over selector contacts (Highest voltage between the extreme taps)
- Between adjacent contacts of tap selector and selector switch (Highest step voltage)
- Between diverter switch contacts (Highest step voltage)

1.2.2.7 Short Circuit Current

- Maximum value …..kA; and duration 2 Sec

1.2.2.8 Change-over selector Recovery voltage

- The power frequency voltage appearing between opening and closing contacts of change-over selector shall be specified. (Note: OLTC supplier shall also verify / calculate recovery voltage based on winding capacitance furnished by transformer manufacturer).

1.2.2.9 Mounting Arrangements for In-tank OLTCS

- Standard flange or Bell type for OLTC
- Motor drive and shaft arrangements

1.2.2.10 Protective Devices

- Oil Surge Relay
- Rupture disc / Diaphragm with or without trip contact
- Pressure relief device (optional)
- Over pressure Relay (optional)

1.2.2.11 Paint Type and shade

1.3. On Load Tap Changer Ratings and Selection Criteria

1.3.1 Type of construction of On Load Tap Changers

1.3.1.1 Externally mounted - out of tank, oil environment On Load Tap changers

- These OLTCs are available up to 66 kV, 300 Amps, star / delta connected winding, and for 132 kV neutral end applications. Depending on overall economy of the transformer design, this type of OLTC is used.

1.3.1.2 Internally mounted - in tank Oil environment Tap Changers

- These OLTCs are available for all the transformer ratings up to 220 kV line end application, up to 700 Amps neutral end and upto 2100 Amps line end applications. These tap-changers are suitable for high voltage application up to 765 kV Class of transformers.

1.3.2 Operating Principle

The OLTCs covered in this standard are of high speed transition resistor type. On-load tap-changer shall be according to selector switch principle or shall consist of a tap selector and a diverter switch with spring operated mechanism. The diverter /selector switch which arcs during tap change operation shall be so designed to ensure that its operation once commenced shall be completed independently of the control relays or switches, failure of auxiliary supplies etc. The current diverting contacts shall be housed in a separate oil chamber not communicating with the oil in main tank of the transformer.

1.3.3 Rated Through-Current of OLTCs

Rated through current of the OLTC should be more than or equal to the highest value of tap current at the assigned rated power of the transformer. This ensures meeting the overload requirements of transformers as per IEC 60076-7.

1.3.4 Rated Step Voltage of OLTCs

The rated step voltage of the tap-changer is more than or equal to the highest step voltage of the tapped winding.

1.3.5 Breaking Capacity of OLTCs

The breaking capacity requirements are met if the highest tap current and the highest step voltage of the transformer are within the declared values of rated through-current and relevant rated step voltage.

1.3.6 Insulation level of OLTCs

The rated insulation level of the OLTC is checked for Power frequency and Lightning Impulse voltages and switching impulse voltages (if specified) appearing during tests on the transformer. These insulation levels are checked at following points:

- Tap-Changer to earth
- Between phases
- Across Range (Between first and last contact of tap selector or selector switch)
- Between change-over selector contacts.
- Between two adjacent contacts
- Between Open contacts of diverter contact

1.3.7 **Number of tap positions**

The Tap-changers are available up to 21 positions (20 steps) in linear and up to 35 positions (34 steps) in coarse-fine/ reversing arrangement of the tapping winding.

1.3.8 **Winding connection and position of taps in the winding**

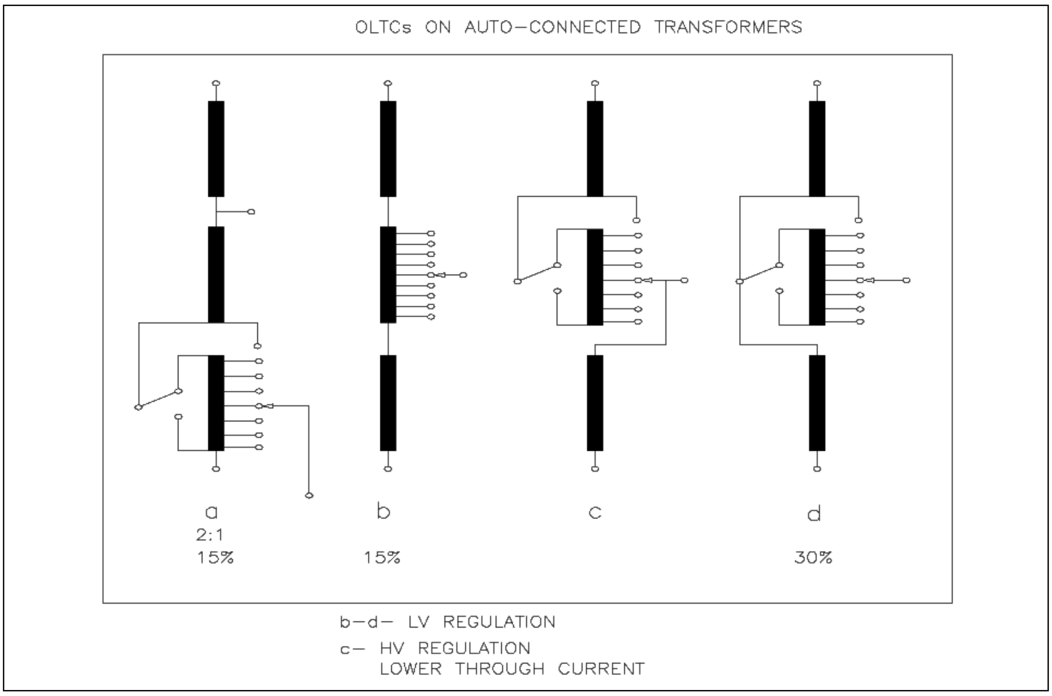
- OLTC in star connected winding:

  For transformers having star connected tapping winding, the tappings are provided at the neutral end of the high voltage winding.

- OLTC in delta connected windings:

  In delta connected windings, 3 pole middle of the winding arrangements is used up to 110 kV Class of transformers. 33 kV windings are mostly used in delta configuration by all utilities. 66 kV windings are also used in delta by some utilities like Gujarat and Karnataka. In some states like Tamil Nadu and Karnataka 110 kV delta systems are also in vogue. Tap-changers are available up to 66 kV class delta arrangement as external out-of-tank construction and up to 110 kV class in in-tank construction.

- Position of OLTC in auto transformer



- Scheme, as shown in (a) in above figure, is used for autotransformer with a ratio 2:1 and for moderate regulating range of say 15%. The advantage of this scheme is that the tap winding is at the neutral end and be designed for graded insulation and a three phase neutral end tap changer can be used. This arrangement is ideally suitable for 765 / 400 kV auto transformers. In this case, VFVV (variable flux and variable voltage) type regulation is foreseen with change in tertiary voltage which is accepted since tertiary is a stabilizing winding in most cases.

- For auto transformers on systems where the medium voltage is regulated, schemes as shown in (b) & (d) are used. For tapping range of approximately 20% and with linear tapings scheme (b) is generally used. Higher regulating range may be achieved with scheme (d).
- For auto transformers where regulation is required in HV voltage, scheme (c) is used. It has the advantage that the through current of the OLTC is lower and allows the use of an OLTC with a lower current rating. It may be noted that in case of arrangement (d) tapings carry IV line current and in case of (b) tapings carry series or common current and in case of (c) tapings carry series current.

1.3.9 Change-over Selector recovery voltage

During change-over operation of reversing switch or coarse tap selector, the tap winding is disconnected temporarily from the main winding. The tap winding receives a potential determined by the winding capacitances. The difference in voltage will therefore, appear during contact operation of the change-over selector as a recovery voltage. The tap-changer manufacturer declares the safe limit for the allowed recovery voltage across change-over contacts. It is ensured that the recovery voltage appearing during change-over operation is within the declared allowed recovery voltage by the tap-changer supplier. In case the recovery voltage exceeds the allowed voltage, the same is specified by the transformer designer. The tap-changer manufacturer then provides additional devices like tie-in resistors or two way change-over selectors to limit the recovery voltage to a safe level.

1.4 Motor Drive Mechanism

The motor drive unit has following features as specified in IEC 60214.

1.4.1 Operation

OLTC gear shall be motor operated for local as well as remote electrical operation. An external handle shall be provided for local manual operation. Interlock shall be provided to prevent electric drive when the manual operating gear is in use.

1.4.2 Housing

Drive mechanism cubicle is mounted as integral part on tap-changer tank in case of external out-of-tank construction or suitable for mounting on transformer tank in case of an In-Tank construction. The motor drive cubicle is in accessible position. It is adequately ventilated and provided with anti-condensation heaters. All contactors, relay coils and other parts are protected against corrosion, deterioration due to condensation, fungi etc. The motor drive cubicle shall meet protection requirement of IP 55 as per IEC 60529.

1.4.3 Step-by-Step Control

This control feature ensures operation of OLTC by one voltage step only even in the case of continuous or repeat signals.

1.4.4 Tap Position Indication

The position of OLTC is indicated locally on motor drive unit preferably by a mechanical device, however, if any electrical or electronic device is used, it is ensured that the tap position is indicated correctly even in the event of a power failure. The tap position is visible clearly even when the motor drive door is closed.

1.4.5 Limiting Devices

There are both electrical and mechanical limiting devices to prevent operations beyond end positions.

1.4.6 Operation Counter

A minimum five-digit non-resettable counter is provided to record the number of operations completed by the tap-changer. In case of electrical / electronic counter it shall be ensured that the counter, is capable of recording local manual operations also.

1.5 Test Requirements

1.5.1 Type tests

The OLTCs and motor drive units are fully type tested in accordance with cl. 5.2 and 6.2 of IEC 60214-1. These tests are as below:

1.5.1.1 Temperature rise of contacts

This test is conducted at 1.2 times the maximum rated through current of OLTC.

1.5.1.2 Switching tests

This includes 50000 test operations at maximum rated through current as service duty and 40 operations at double the maximum rated through current as breaking capacity tests.

1.5.1.3 Short circuit current test

This test is conducted at 20 times the maximum rated through current up to 100 amps and 10 times the maximum rated through current of 400 amps and more. The test current should be interpolated between these two ratings using the slope as per IEC 60214-1. The test duration should be 2 seconds.

1.5.1.4 Transition Resistor test

This test is conducted at 1.5 times the maximum rated through current of OLTC for continuous operation of half cycle (equal to number of tap positions). This ensures suitability of transition resistor design for continuous operations of OLTC under over loading condition of transformers.

1.5.1.5 Mechanical Endurance Test

The tap-changer shall be tested for 5,00,000 operations using complete tap range as per cl.5.2.5.1 of IEC 60214-1.

1.5.1.6 Pressure Test

The diverter switch/ selector switch compartment shall be tested for hot oil pressure test by filling oil inside the cylinder and heating up to 80° C. The cylinder shall be pressurized for a minimum pressure of 10 psi (0.7 kg/cm²) for 1 hour. All joints of the compartment are thoroughly checked for leakages.

1.5.1.7 Dielectric Tests

The tap-changer should be tested across all points as per cl. 1.3.6 of this chapter and insulation levels shall be declared. The tests shall be conducted in line with cl. 5.2.6 of IEC 60214-1.

1.5.2 Routine Tests

OLTC manufacturers shall conduct all the routine tests as specified in cl. 5.3 and 6.3 of IEC 60214-1 on every unit, before dispatch to assure the quality of the product

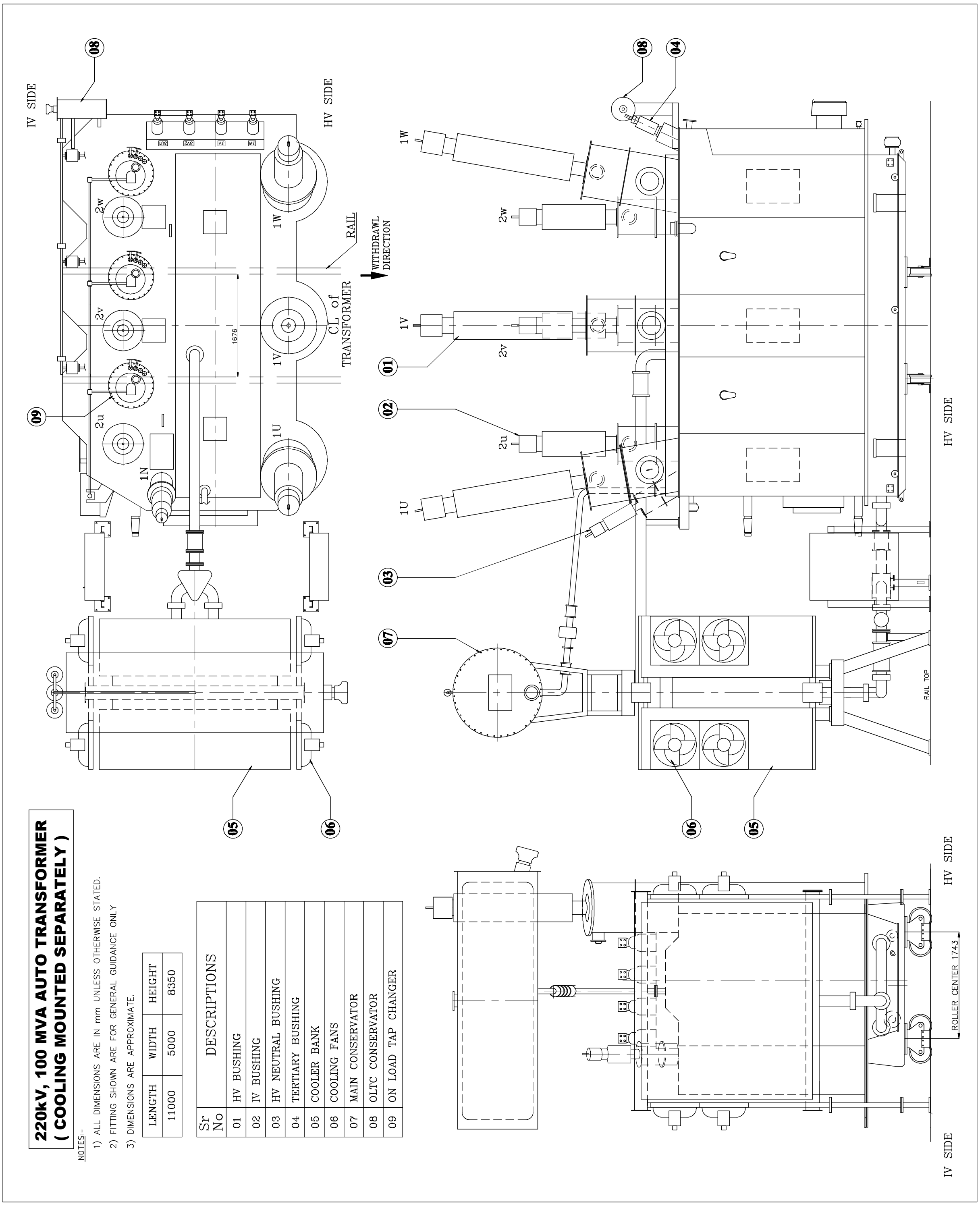
2.0 Standard ratings of OLTCs

- Standard parameters of OLTC based on standard transformer ratings as per CBIP are recommended as given in the attached Annexure 2.2.
- In case the transformer ratings are not conforming to CBIP standard, customers shall specify OLTC requirements as per cl.1.2 of this standard.

3.0 Installation of in-tank tap changers

- Precautions to be taken while installing In-tank tap changer at site are given in Annexure2.4

ANNEXURE 2.1



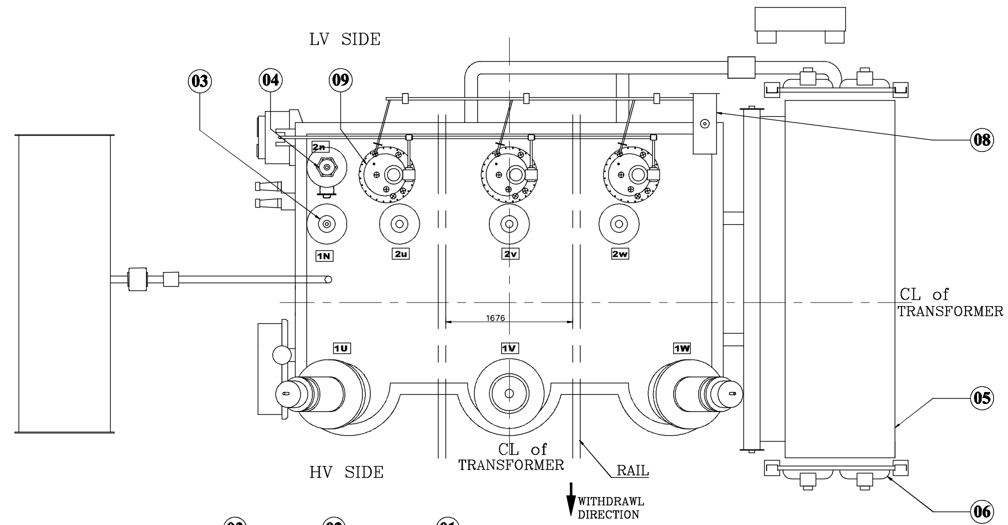
220kV, 100 MVA AUTO TRANSFORMER
(COOLING MOUNTED SEPARATELY)

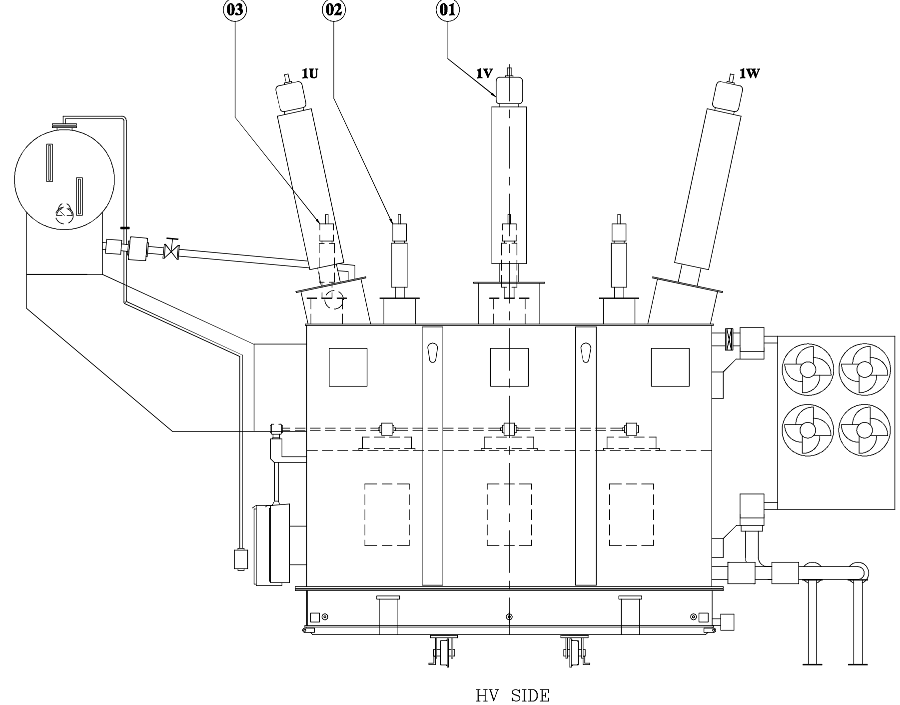
NOTES:-

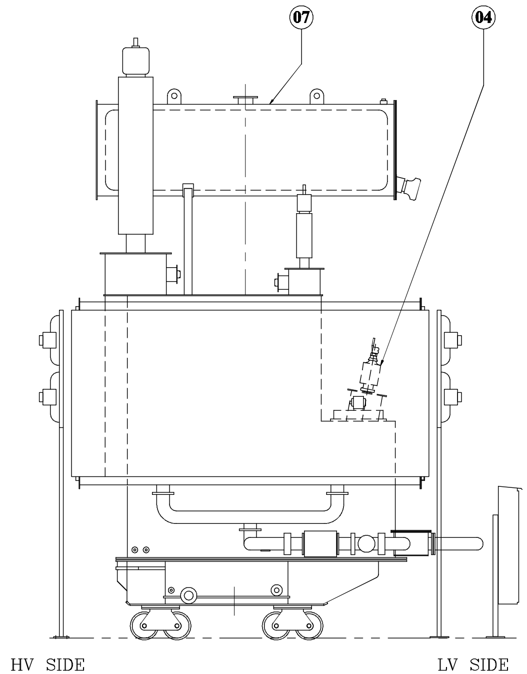
1) ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2) FITTING SHOWN ARE FOR GENERAL GUIDANCE ONLY.
3) DIMENSIONS ARE APPROXIMATE.

LENGTH	WIDTH	HEIGHT
11000	5000	8350

Sr No	DESCRIPTIONS
01	HV BUSHING
02	IV BUSHING
03	HV NEUTRAL BUSHING
04	TERTIARY BUSHING
05	COOLER BANK
06	COOLING FANS
07	MAIN CONSERVATOR
08	OLTC CONSERVATOR
09	ON LOAD TAP CHANGER







220kV, 100 MVA AUTO TRANSFORMER
(COOLING MOUNTED ON TANK)

NOTES:-

1) ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2) FITTING SHOWN ARE FOR GENERAL GUIDANCE ONLY
3) DIMENSIONS ARE APPROXIMATE.

LENGTH	WIDTH	HEIGHT
12000	6500	8100

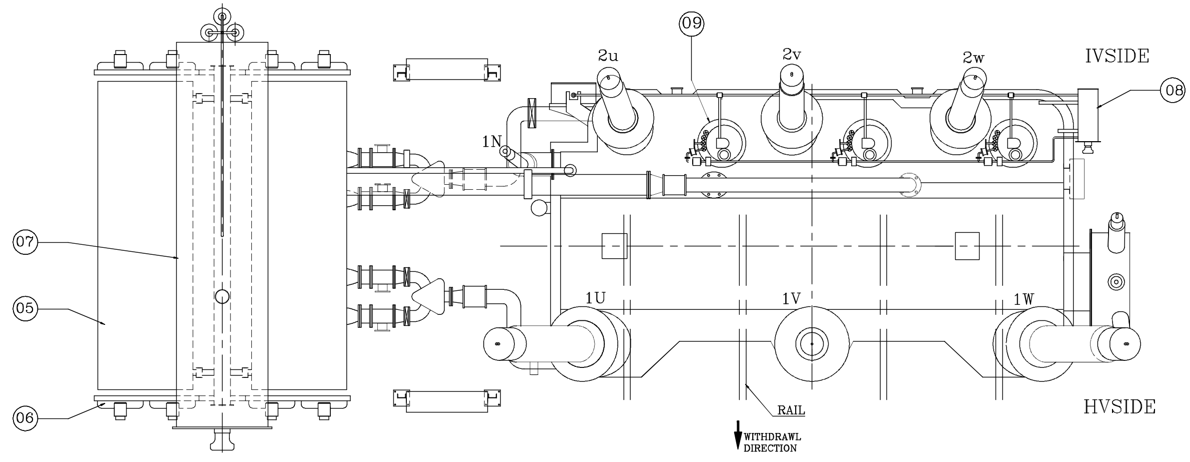
Sr No	DESCRIPTIONS
01	HV BUSHING
02	LV BUSHING
03	HV NEUTRAL BUSHING
04	LV NEUTRAL BUSHING
05	COOLER BANK
06	COOLING FANS
07	MAIN CONSERVATOR
08	OLTC CONSERVATOR
09	ON LOAD TAP CHANGER

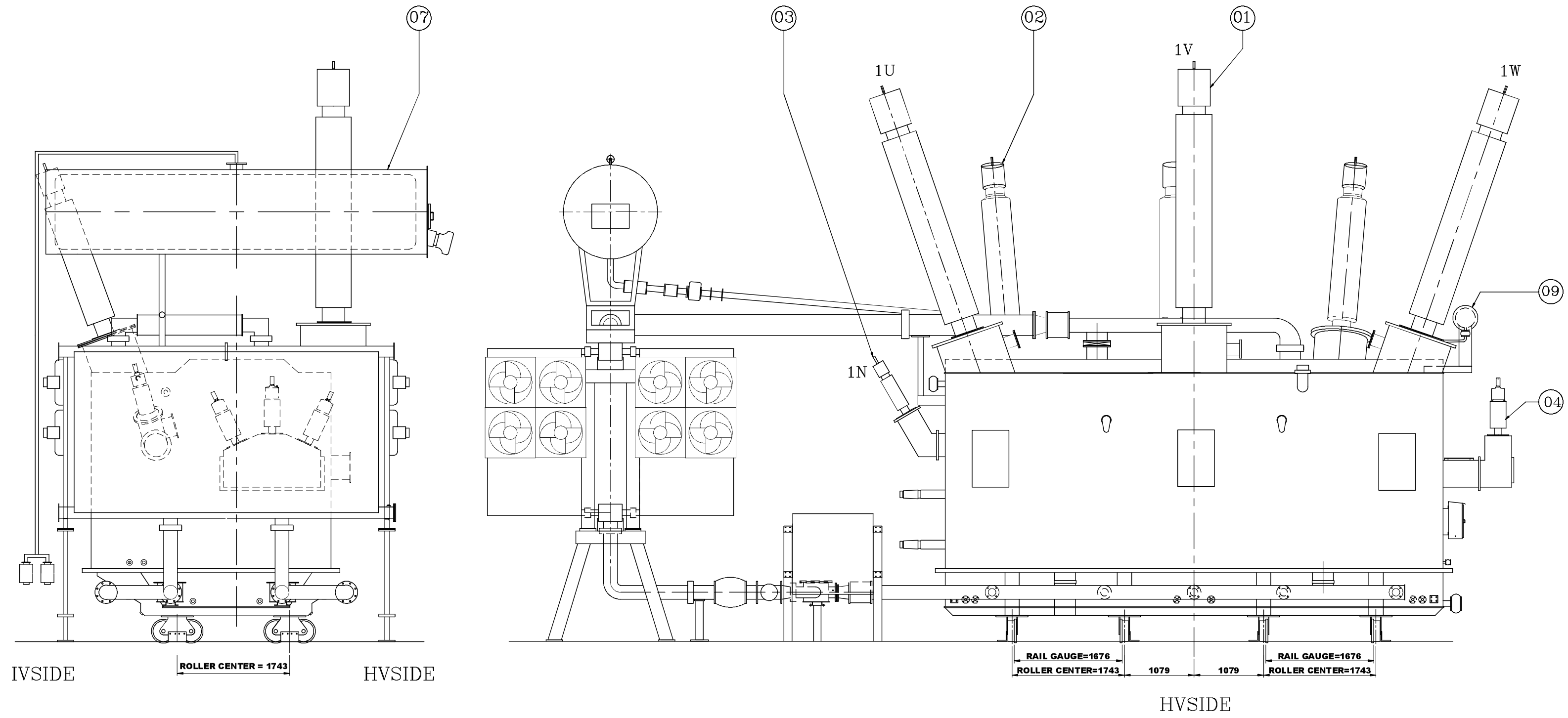
400kV, 315 MVA TRANSFORMER
(COOLING MOUNTED SEPARATELY)

NOTES:-
1) ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2) FITTING SHOWN ARE FOR GENERAL GUIDANCE ONLY
3) DIMENSIONS ARE APPROXIMATE.

LENGTH	WIDTH	HEIGHT
16100	7000	9000

Sr No	DESCRIPTIONS
01	HV BUSHING
02	IV BUSHING
03	HV NEUTRAL BUSHING
04	TERTIARY BUSHING
05	COOLER BANK
06	COOLING FANS
07	MAIN CONSERVATOR
08	OLTC CONSERVATOR
09	ON LOAD TAP CHANGER

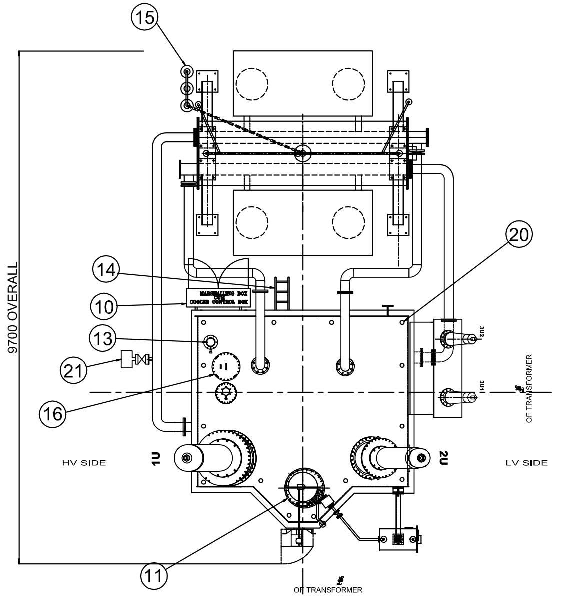


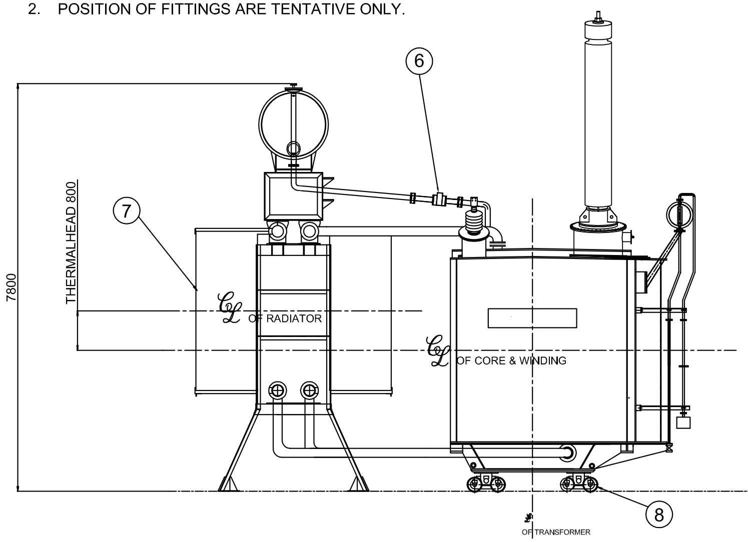


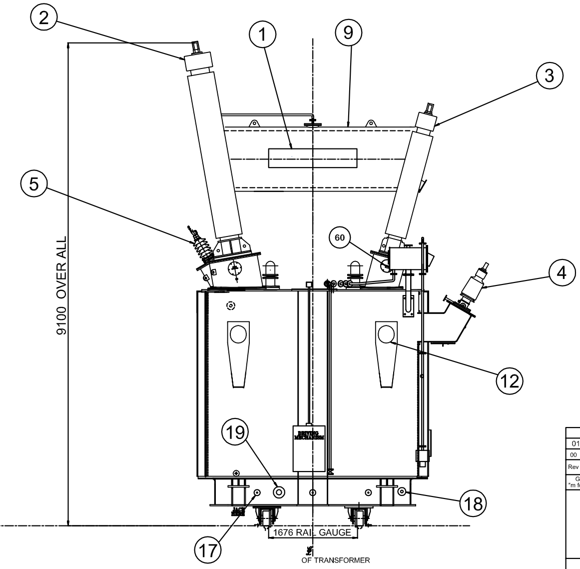
SL. NO.	DESCRIPTIONS
1	MANUFACTURER NAME PLATE
2	HV LINE BUSHINGS 420kV
3	IV BUSHING 245 kV
4	LV BUSHING 52 kV
5	NUTRAL BUSHING 36 kV
6	BUCHHOLZ RELAY
7	RADIATOR WITH FAN
8	280Ø BIDIRECTIONAL FLANGED TWIN ROLLER
9	MAIN CONSERVATOR WITH AIRCELL
10	MARSHALLING BOX WITH INSTRUMENTS & TEMPERATURE INDICATORS
11	ON LOAD TAP CHANGER
12	LIFTING BOLLARDS
13	PRESSURE RELEASE DEVICE WITH SPLASH GUARD
14	LADDER
15	BREATHER
16	INTERNAL EARTHING TERMINAL
17	PROVISION FOR FIRE PROTECTION SYSTEM
18	FILTER VALVE
19	DRAIN VALVE
20	PROVISION OF RAILING FOR SAFETY
21	DGA WITH VALVE

N O T E S :-

1. TOLERANCE ON WEIGHTS AND DIMENSIONS ±10%
2. POSITION OF FITTINGS ARE TENTATIVE ONLY.







Rev	Date	Draw	Chk	App	Description
01	21.04.12	Vipul	PKP	MVK	DRAWING REVISED AS PER WORKING GROUP MEETING Dt. 27.07.2011
00	05.07.11	Dharam	PKP	MVK	Original Issue

General tolerances: ISO 2768 "m for machining; c for fabrication" — Surface texture: ISO 1302 — All dimensions in millimetres unless otherwise stated — CDN

IF IN DOUBT - PLEASE ASK !

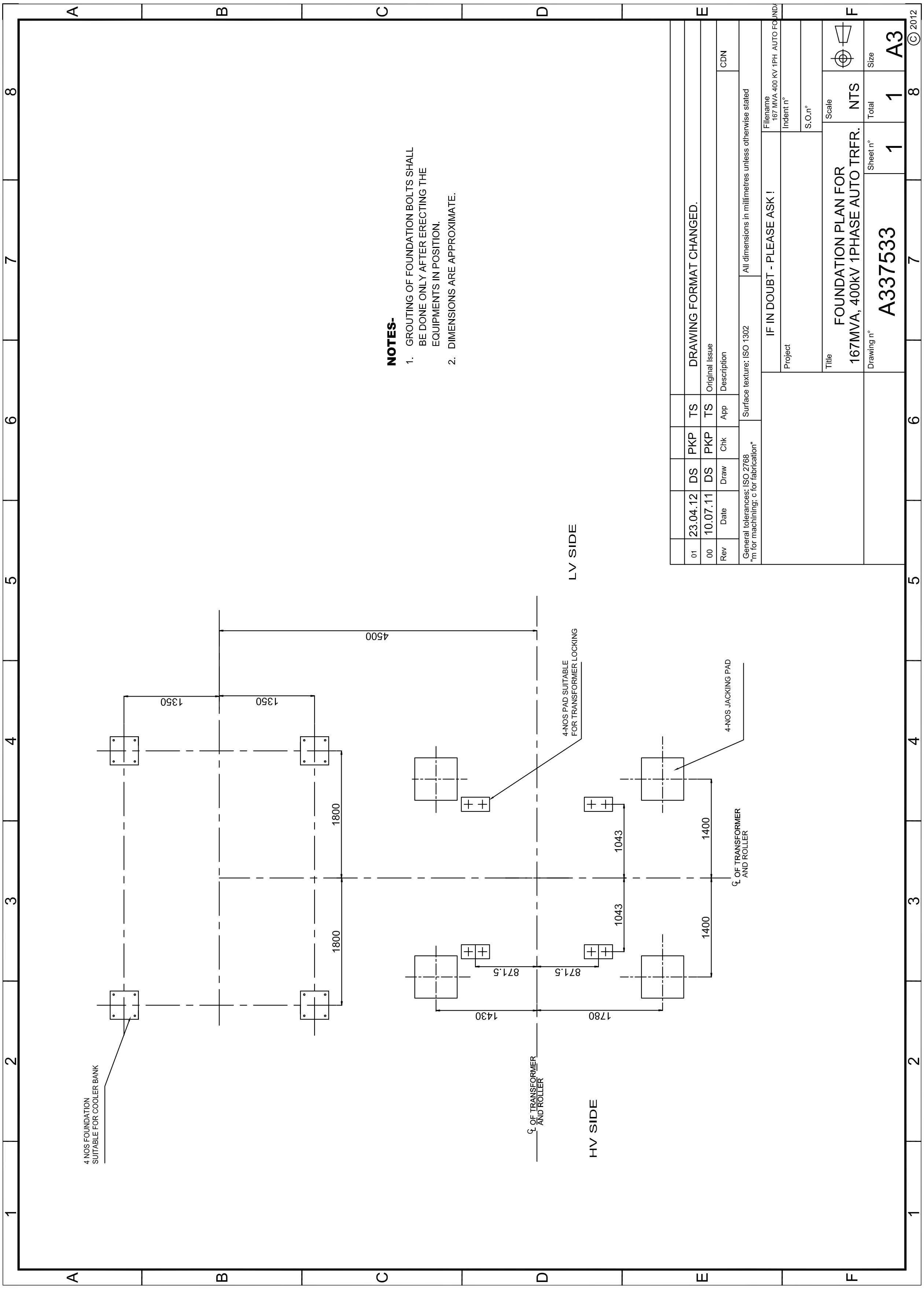
Project: -

Title: OUTLINE GENERAL ARRANGEMENT 167 MVA, 400/√3 /220/√3 /33 kV 1 PHASE AUTO TRANSFORMER

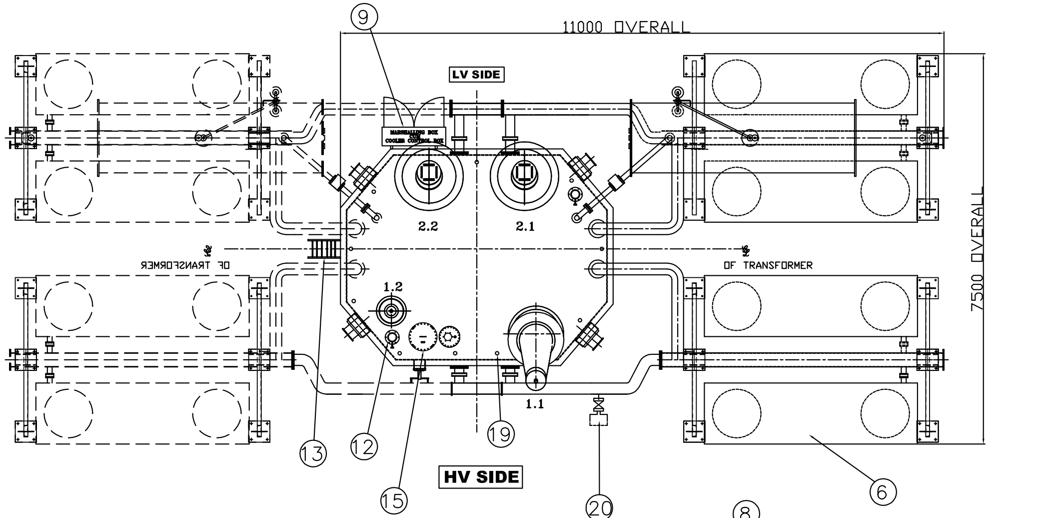
Drawing n°: A122680 — Sheet n°: 1 — Total: 1 — Size: A1

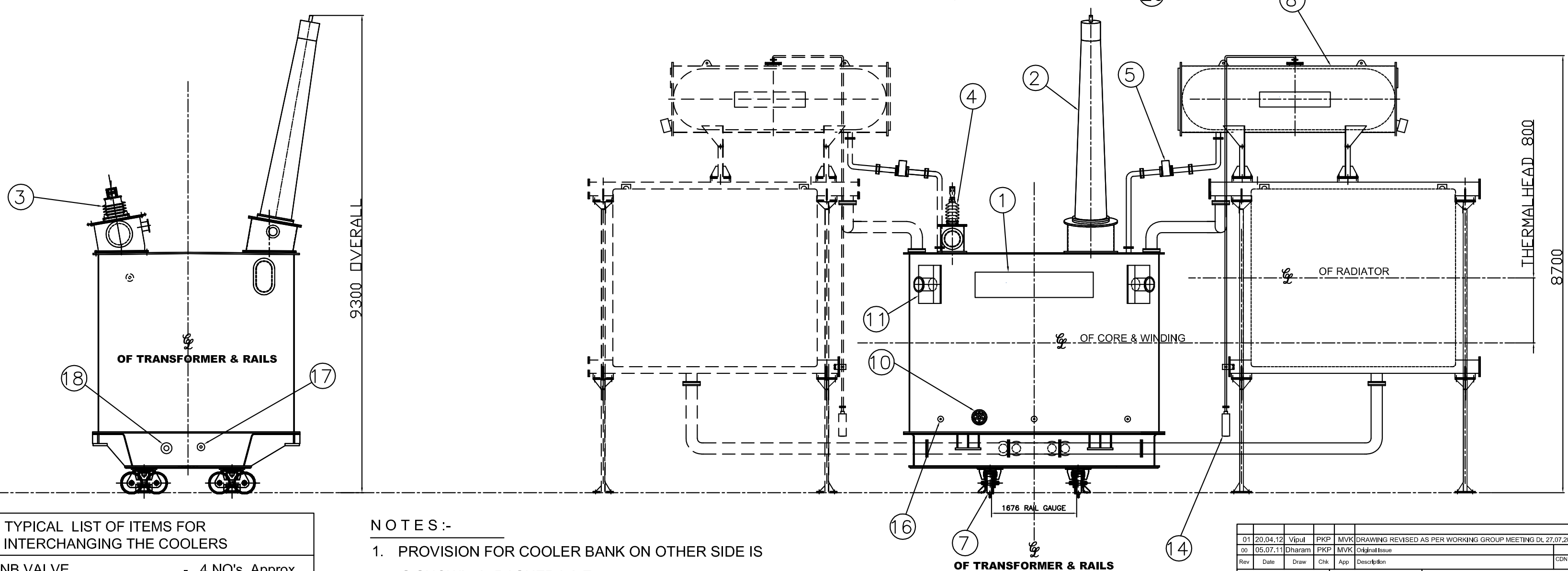
Indent n°: Standard

© 2012


NOTES-
1. GROUTING OF FOUNDATION BOLTS SHALL BE DONE ONLY AFTER ERECTING THE EQUIPMENTS IN POSITION.
2. DIMENSIONS ARE APPROXIMATE.
LV SIDE
HV SIDE
4 NOS FOUNDATION SUITABLE FOR COOLER BANK
4-NOS PAD SUITABLE FOR TRANSFORMER LOCKING
4-NOS JACKING PAD
℄ OF TRANSFORMER AND ROLLER
4500
1350
1350
1800
1800
1043
1043
1400
1400
871.5
871.5
1430
1780
01 23.04.12 DS PKP TS DRAWING FORMAT CHANGED.
00 10.07.11 DS PKP TS Original Issue
Rev Date Draw Chk App Description CDN
General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated
IF IN DOUBT - PLEASE ASK !
Filename 167 MVA 400 KV 1PH AUTO FOUNDA
Indent n°
S.O.n°
Project
Title
FOUNDATION PLAN FOR 167MVA, 400kV 1PHASE AUTO TRFR.
Scale NTS
Drawing n° A337533
Sheet n° 1
Total 1
Size A3
© 2012

SL. NO.	DESCRIPTIONS
1	MANUFACTURER NAME PLATE
2	HV LINE BUSHINGS 420kV
3	LV BUSHING 36 kV ,
4	HV NEUTRAL BUSHING 36 KV
5	BUCHHOLZ RELAY
6	RADIATOR WITH FAN AT BOTTOM
7	380Ø BIDIRECTIONAL FLANGED TWIN ROLLER
8	MAIN CONSERVATOR WITH AIRCELL
9	MARSHALLING BOX WITH INSTRUMENTS & TEMPERATURE INDICATORS
10	OCTC OPERATING HANDLE
11	LIFTING BOLLARDS
12	PRESSURE RELEASE DEVICE WITH SPLASH GuARD
13	LADDER
14	BREATHER
15	INTERNAL EARTHING TRMINAL
16	PROVISION FOR FIRE PROTECTION SYSTEM
17	FILTER VALVE
18	DRAIN VALVE
19	PROVISION OF RAILING FOR SAFETY
20	DGA WITH VALVE





TYPICAL LIST OF ITEMS FOR INTERCHANGING THE COOLERS		
1.	200 NB VALVE	- 4 NO's Approx.
2.	200 NB PIPE WITH FLANGE	- 5 meters Approx.
3.	80 NB PIPE WITH FLANGE	- 3 meters Approx.
4.	80 NB ISOLATING VALVE	- 2 NO's Approx.

N O T E S :-

1. PROVISION FOR COOLER BANK ON OTHER SIDE IS IS SHOWN IN DASHED LINE
2. TOLERANCE ON WEIGHTS AND DIMENSIONS ±10%
3. POSITION OF FITTINGS ARE TENTATIVE ONLY.

Rev	Date	Draw	Chk	App	Description
01	20.04.12	Vipul	PKP	MVK	DRAWING REVISED AS PER WORKING GROUP MEETING Dt. 27.07.2011
00	05.07.11	Dharam	PKP	MVK	Original Issue

CDN

General tolerances: ISO 2768 "m for machining; c for fabrication" | Surface texture: ISO 1302 | All dimensions in millimetres unless otherwise stated

IF IN DOUBT - PLEASE ASK !

Project: - -

Filename: 200MVA GT_400KV_1PH.dwg

Indent n°: Standard

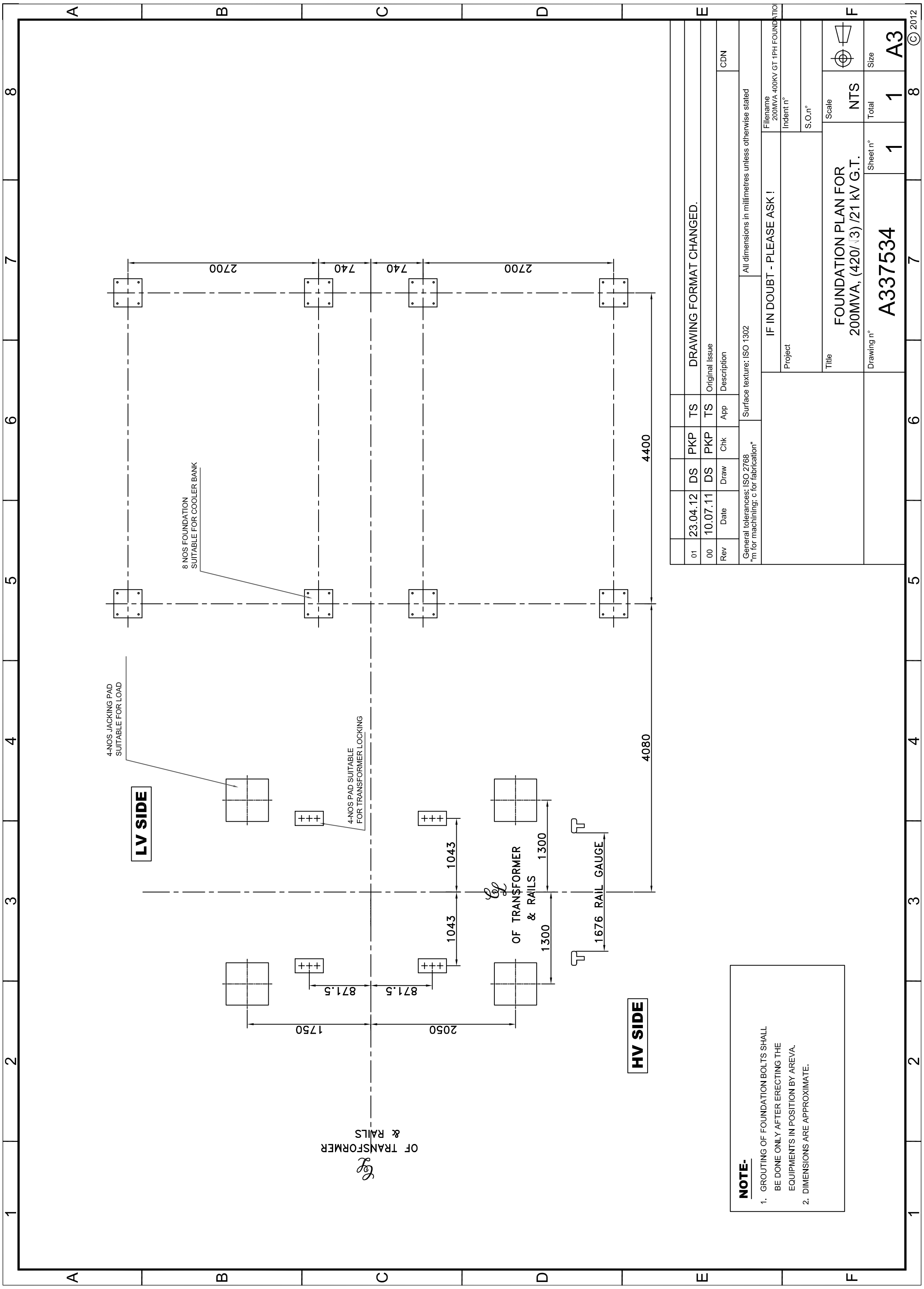
S.O. n°: -

Title: OUTLINE GENERAL ARRANGEMENT 200 MVA, 420/ √3/21 kV 1 PHASE GENERATER TRANSFORMER

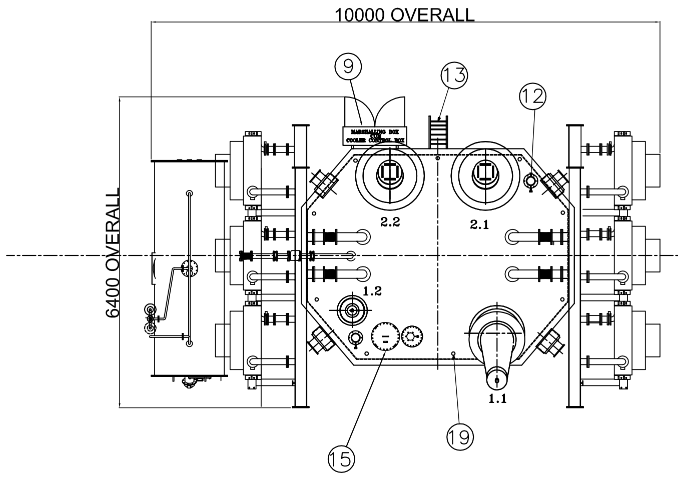
Scale:

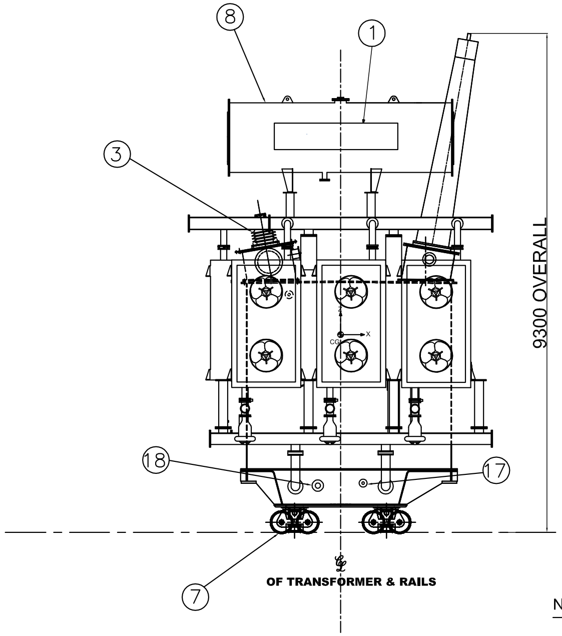
Drawing n°: A122649 | Sheet n°: 1 | Total: 1 | Size: A1

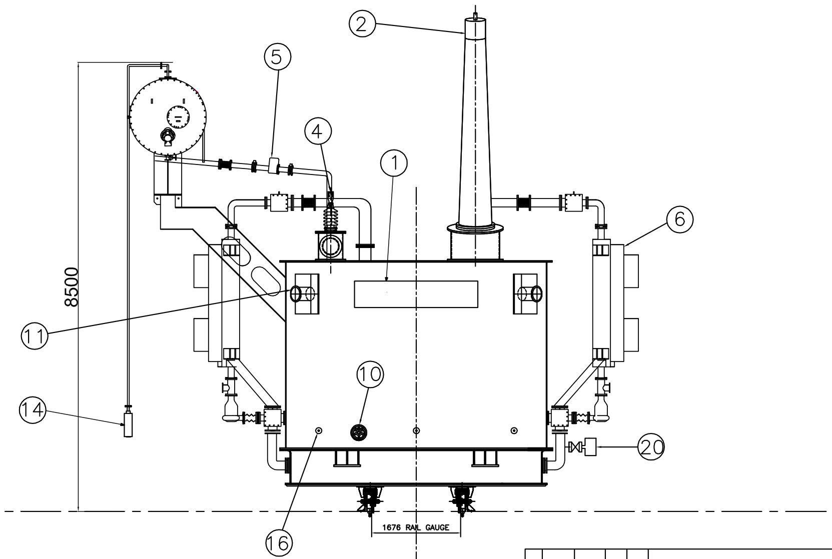
© 2012


LV SIDE
HV SIDE
4-NOS JACKING PAD SUITABLE FOR LOAD
8 NOS FOUNDATION SUITABLE FOR COOLER BANK
4-NOS PAD SUITABLE FOR TRANSFORMER LOCKING
OF TRANSFORMER & RAILS
1676 RAIL GAUGE
2700
740
740
2700
4400
4080
1043
1043
1300
1300
871.5
871.5
1750
2050
NOTE-
1. GROUTING OF FOUNDATION BOLTS SHALL BE DONE ONLY AFTER ERECTING THE EQUIPMENTS IN POSITION BY AREVA.
2. DIMENSIONS ARE APPROXIMATE.
01 23.04.12 DS PKP TS DRAWING FORMAT CHANGED.
00 10.07.11 DS PKP TS Original Issue
Rev Date Draw Chk App Description CDN
General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated
IF IN DOUBT - PLEASE ASK !
Filename 200MVA 400KV GT 1PH FOUNDATIO
Indent n°
Project
S.O.n°
Title
FOUNDATION PLAN FOR 200MVA, (420/√3) /21 kV G.T.
Scale NTS
Drawing n° A337534
Sheet n° 1
Total 1
Size A3
© 2012

SL. NO.	DESCRIPTIONS
1	MANUFACTURER NAME PLATE
2	HV LINE BUSHINGS 420kV
3	LV BUSHING 36 kV ,
4	HV NEUTRAL BUSHING 36 KV
5	BUCHHOLZ RELAY
6	UNIT COOLER
7	380Ø BIDIRECTIONAL FLANGED TWIN ROLLER
8	MAIN CONSERVATOR WITH AIRCELL
9	MARSHALLING BOX WITH INSTRUMENTS & TEMPERATURE INDICATORS
10	OCTC OPERATING HANDLE
11	LIFTING BOLLARDS
12	PRESSURE RELEASE DEVICE WITH SPLASH GUARD
13	LADDER
14	BREATHER
15	INTERNAL EARTHING TRMINAL
16	PROVISION FOR FIRE PROTECTION SYSTEM
17	FILTER VALVE
18	DRAIN VALVE
19	PROVISION OF RAILING FOR SAFETY
20	DGA WITH VALVE







NOTES:-

1. TOLERANCE ON WEIGHTS AND DIMENSIONS ±10%
2. POSITION OF FITTINGS ARE TENTATIVE ONLY.

Rev	Date	Draw	Chk	App	Description
01	20.04.12	Vipul	PKP	MVK	DRAWING REVISED AS PER WORKING GROUP MEETING Dt. 27.07.2011
00	05.07.11	Dharam	PKP	MVK	Original Issue

CDN

General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated

IF IN DOUBT - PLEASE ASK !

Filename: 200MVA GT_400KV_1PH_WithU

Project: -

Indent n°: Standard

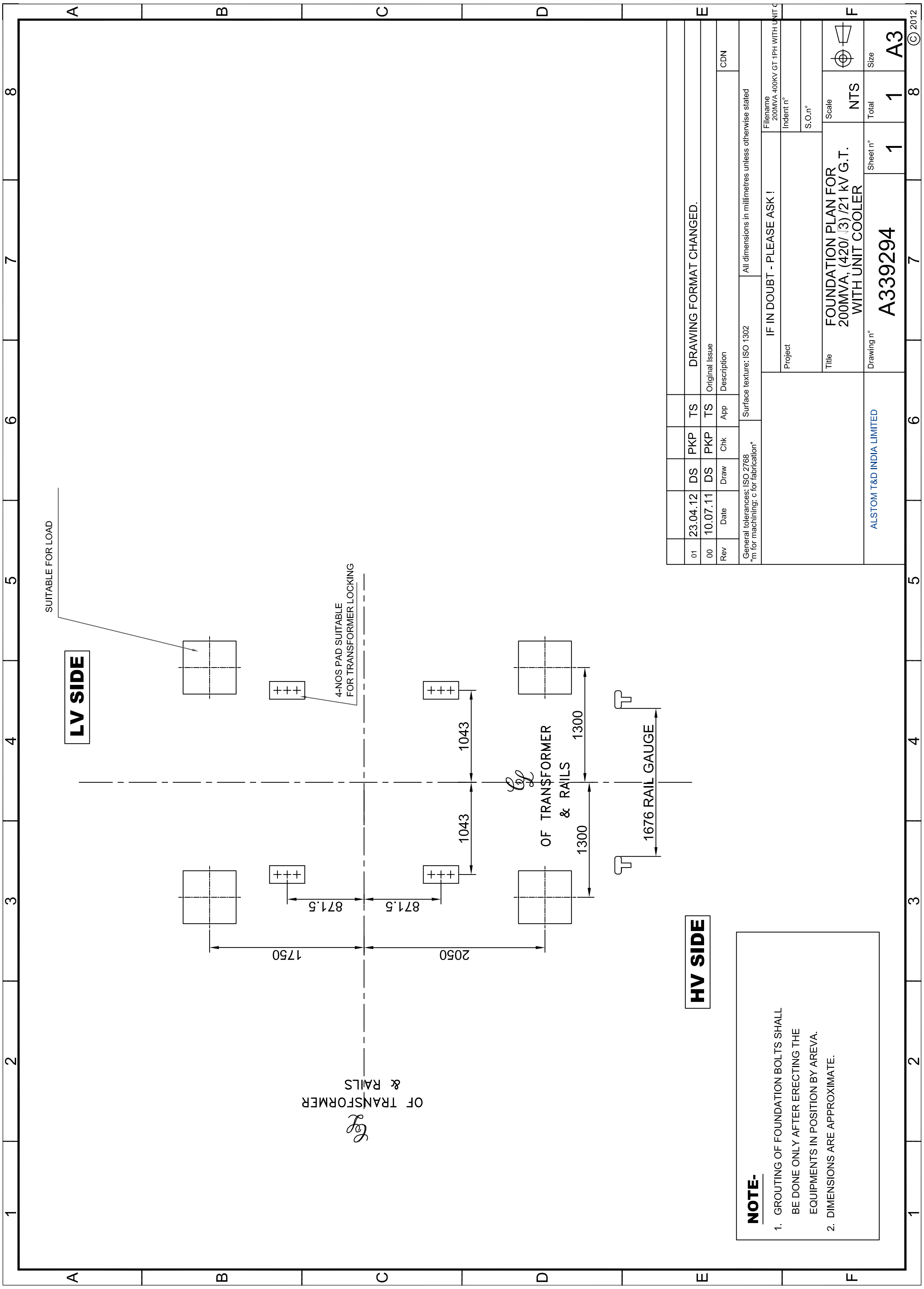
S.O. n°: -

Title: OUTLINE GENERAL ARRANGEMENT 200 MVA, 420/ √3/21 kV 1 PHASE G.T. WITH UNIT COOLER

Scale

Drawing n°: A123186 | Sheet n°: 1 | Total: 1 | Size: A1

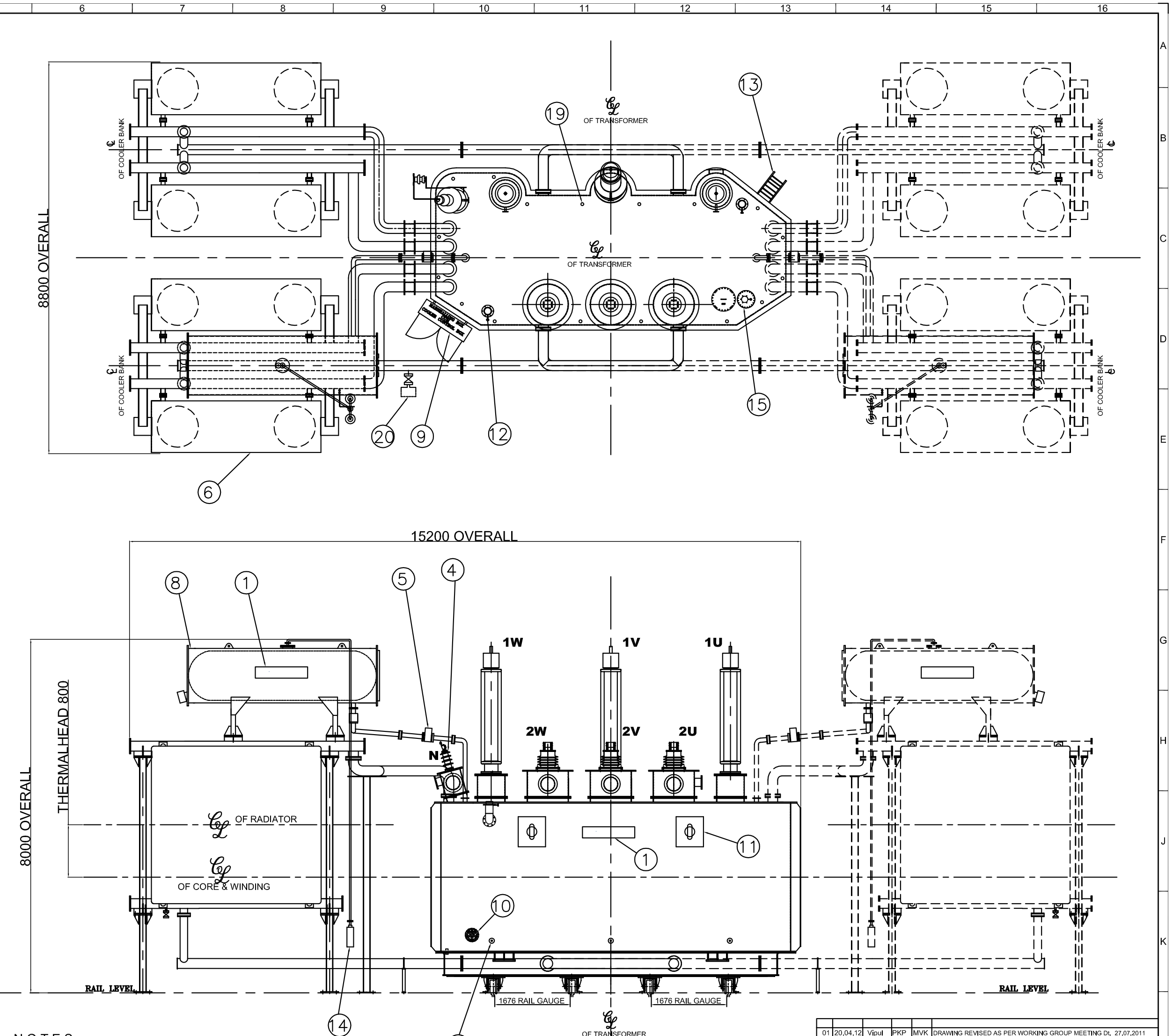
© 2012


LV SIDE
HV SIDE
SUITABLE FOR LOAD
4-NOS PAD SUITABLE
FOR TRANSFORMER LOCKING
1750
2050
871.5
871.5
1043
1043
1300
1300
OF TRANSFORMER
& RAILS
1676 RAIL GAUGE
NOTE-
1. GROUTING OF FOUNDATION BOLTS SHALL BE DONE ONLY AFTER ERECTING THE EQUIPMENTS IN POSITION BY AREVA.
2. DIMENSIONS ARE APPROXIMATE.
01 23.04.12 DS PKP TS DRAWING FORMAT CHANGED.
00 10.07.11 DS PKP TS Original Issue
Rev Date Draw Chk App Description CDN
General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated
IF IN DOUBT - PLEASE ASK !
Project
Title
FOUNDATION PLAN FOR
200MVA, (420/√3)/21 kV G.T.
WITH UNIT COOLER
Drawing n°
A339294
Sheet n° 1
Total 1
Scale NTS
Size A3
ALSTOM T&D INDIA LIMITED
© 2012

SL. NO.	DESCRIPTIONS
1	MANUFACTURER NAME PLATE
2	HV LINE BUSHINGS 245kV
3	LV BUSHING 36 kV
4	HV NEUTRAL BUSHING 36 KV
5	BUCHHOLZ RELAY
6	RADIATOR WITH FAN
7	280Ø BIDIRECTIONAL FLANGED TWIN ROLLER
8	MAIN CONSERVATOR WITH AIRCELL
9	MARSHALLING BOX WITH INSTRUMENTS & TEMPERATURE INDICATORS
10	OCTC OPERATING HANDLE
11	LIFTING BOLLARDS
12	PRESSURE RELEASE DEVICE WITH SPLASH GUARD
13	LADDER
14	BREATHER
15	INTERNAL EARTHING TERMINAL
16	PROVISION FOR FIRE PROTECTION SYSTEM
17	FILTER VALVE
18	DRAIN VALVE
19	PROVISION OF RAILING FOR SAFETY
20	DGA WITH VALVE

TYPICAL LIST OF ITEMS FOR INTER CHANGING THE COOLERS

1.	200 NB VALVE	- 4 NO's Approx.
2.	200 NB PIPE WITH FLANGE	- 5 meters Approx.
3.	80 NB PIPE WITH FLANGE	- 7 meters Approx.
4.	80 NB ISOLATING VALVE	- 2 NO's Approx.



N O T E S :-

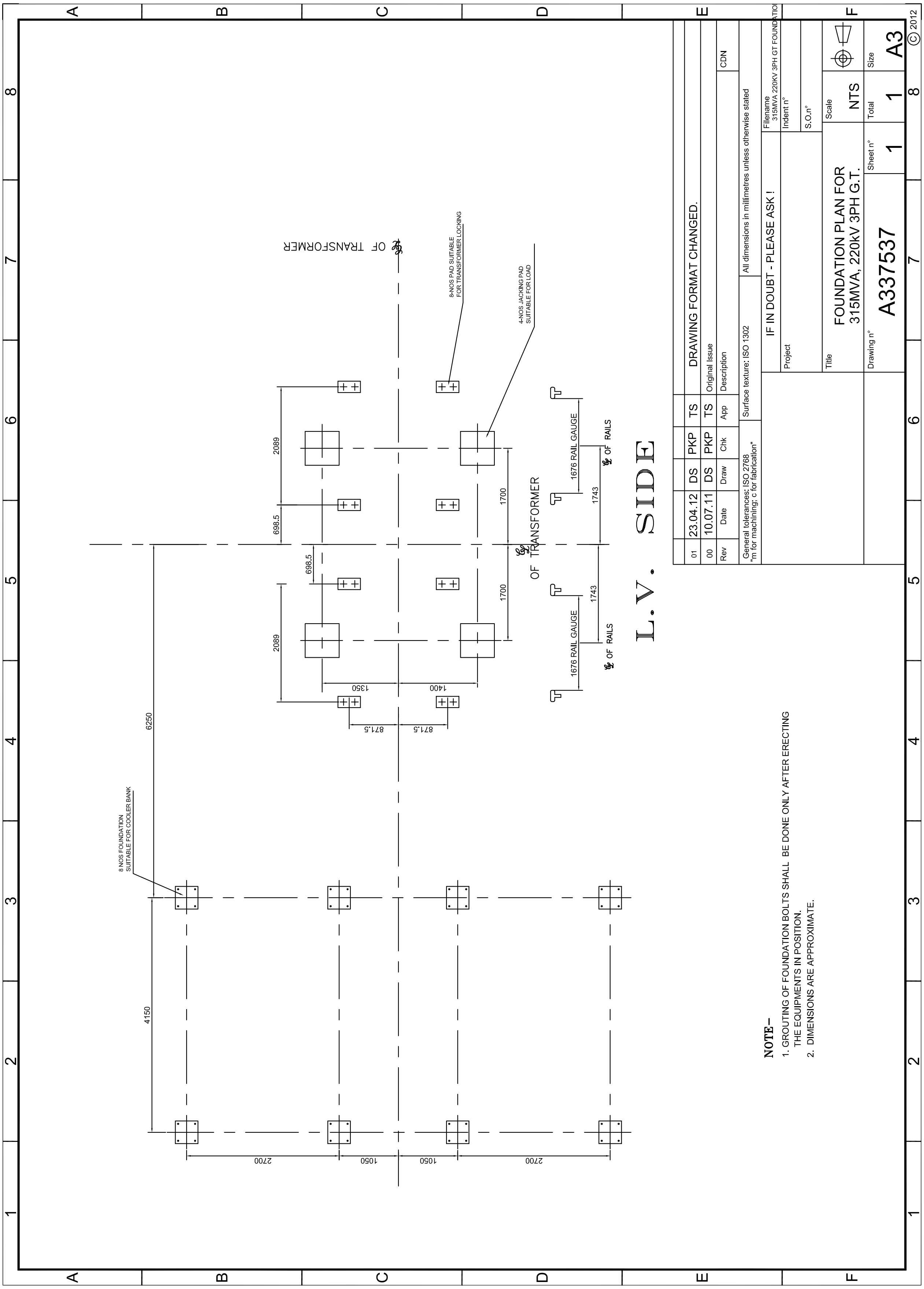
1. PROVISION FOR COOLER BANK ON OTHER SIDE IS IS SHOWN IN DASHED LINE
2. TOLERANCE ON WEIGHTS AND DIMENSIONS ±10%
3. POSITION OF FITTINGS ARE TENTATIVE ONLY.

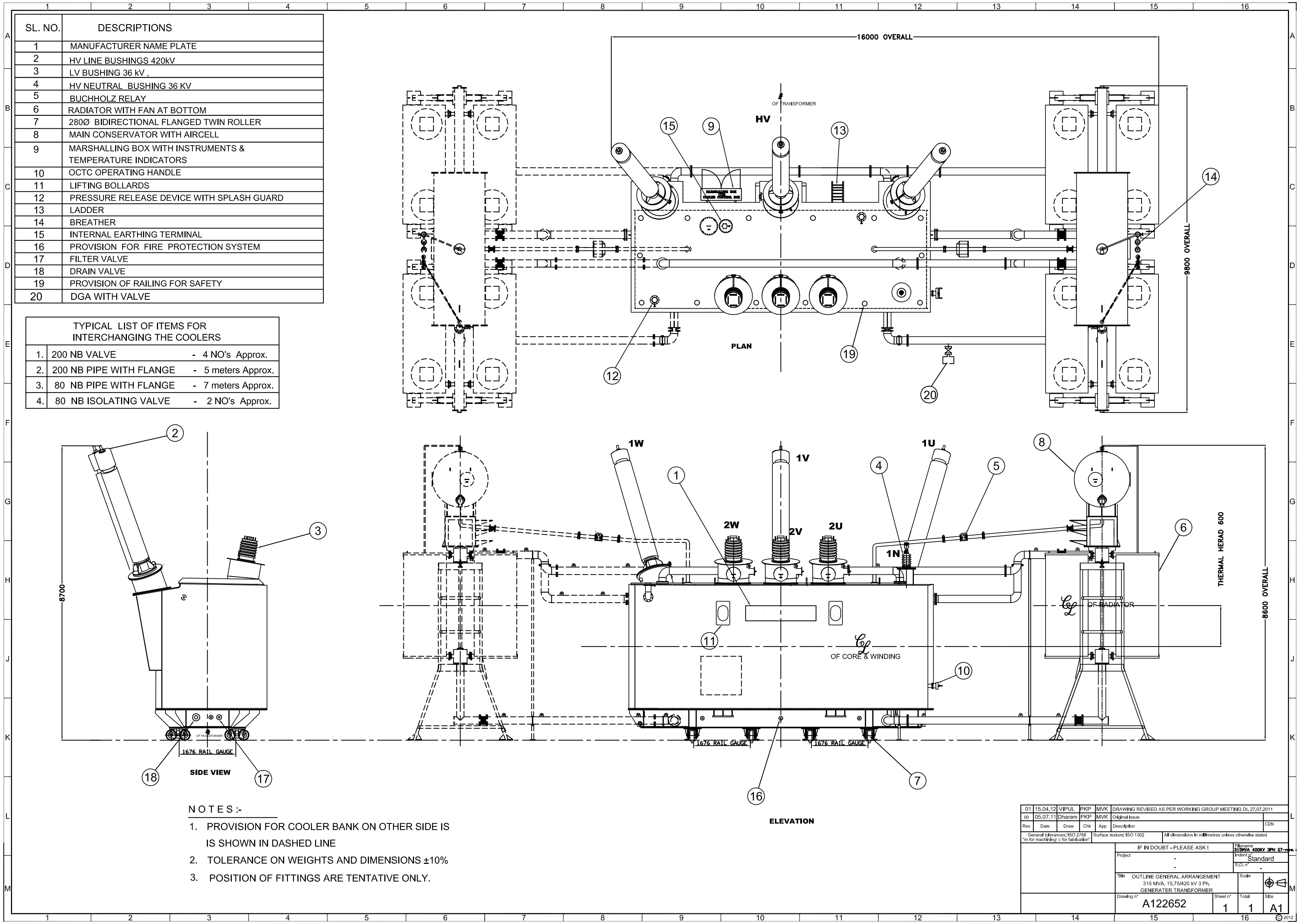
Rev	Date	Draw	Chk	App	Description
01	20.04.12	Vipul	PKP	MVK	DRAWING REVISED AS PER WORKING GROUP MEETING DL 27.07.2011
00	05.07.11	Dharam	PKP	MVK	Original issue

IF IN DOUBT - PLEASE ASK !

Title: OUTLINE GENERAL ARRANGEMENT 315 MVA, 220 kV 3 Ph, GENERATER TRANSFORMER

Drawing n°: A122651 | Sheet n° 1 | Total 1 | Size A1


L.V. SIDE
℄ OF TRANSFORMER
8-NOS PAD SUITABLE FOR TRANSFORMER LOCKING
4-NOS JACKING PAD SUITABLE FOR LOAD
8 NOS FOUNDATION SUITABLE FOR COOLER BANK
1676 RAIL GAUGE
℄ OF RAILS
1743
1700
2089
698.5
1350
1400
871.5
6250
4150
2700
1050
NOTE–
1. GROUTING OF FOUNDATION BOLTS SHALL BE DONE ONLY AFTER ERECTING THE EQUIPMENTS IN POSITION.
2. DIMENSIONS ARE APPROXIMATE.
01 23.04.12 DS PKP TS DRAWING FORMAT CHANGED.
00 10.07.11 DS PKP TS Original Issue
Rev Date Draw Chk App Description
CDN
General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated
IF IN DOUBT - PLEASE ASK !
Filename 315MVA 220KV 3PH GT FOUNDATIO
Indent n°
S.O.n°
Project
Scale NTS
Title FOUNDATION PLAN FOR 315MVA, 220kV 3PH G.T.
Drawing n° A337537
Sheet n° 1
Total 1
Size A3
© 2012



SL. NO.	DESCRIPTIONS
1	MANUFACTURER NAME PLATE
2	HV LINE BUSHINGS 420kV
3	LV BUSHING 36 kV ,
4	HV NEUTRAL BUSHING 36 KV
5	BUCHHOLZ RELAY
6	RADIATOR WITH FAN AT BOTTOM
7	280Ø BIDIRECTIONAL FLANGED TWIN ROLLER
8	MAIN CONSERVATOR WITH AIRCELL
9	MARSHALLING BOX WITH INSTRUMENTS & TEMPERATURE INDICATORS
10	OCTC OPERATING HANDLE
11	LIFTING BOLLARDS
12	PRESSURE RELEASE DEVICE WITH SPLASH GUARD
13	LADDER
14	BREATHER
15	INTERNAL EARTHING TERMINAL
16	PROVISION FOR FIRE PROTECTION SYSTEM
17	FILTER VALVE
18	DRAIN VALVE
19	PROVISION OF RAILING FOR SAFETY
20	DGA WITH VALVE

TYPICAL LIST OF ITEMS FOR INTERCHANGING THE COOLERS		
1.	200 NB VALVE	- 4 NO's Approx.
2.	200 NB PIPE WITH FLANGE	- 5 meters Approx.
3.	80 NB PIPE WITH FLANGE	- 7 meters Approx.
4.	80 NB ISOLATING VALVE	- 2 NO's Approx.

N O T E S :-

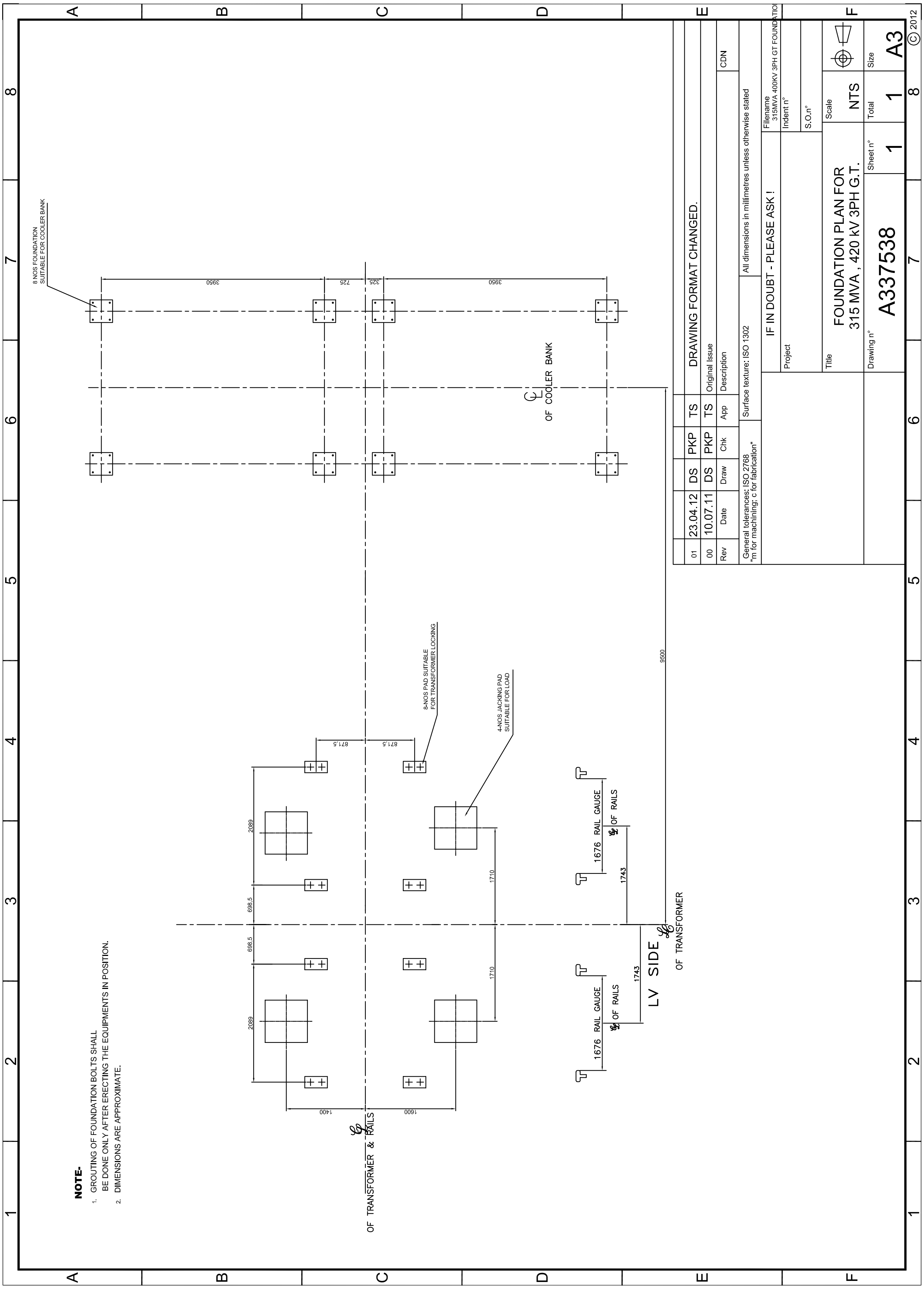
1. PROVISION FOR COOLER BANK ON OTHER SIDE IS IS SHOWN IN DASHED LINE
2. TOLERANCE ON WEIGHTS AND DIMENSIONS ±10%
3. POSITION OF FITTINGS ARE TENTATIVE ONLY.

Rev	Date	Draw	Chk	App	Description
01	15.04.12	VIPUL	PKP	MVK	DRAWING REVISED AS PER WORKING GROUP MEETING Dt. 27.07.2011
00	05.07.11	Dharam	PKP	MVK	Original Issue

IF IN DOUBT - PLEASE ASK !

Title: OUTLINE GENERAL ARRANGEMENT 315 MVA, 15.75/420 kV 3 Ph. GENERATER TRANSFORMER

Drawing n° A122652 | Sheet n° 1 | Total 1 | Size A1 | Standard



8 NOS FOUNDATION SUITABLE FOR COOLER BANK
3950
725
325
3950
℄ OF COOLER BANK
9500
8-NOS PAD SUITABLE FOR TRANSFORMER LOCKING
4-NOS JACKING PAD SUITABLE FOR LOAD
871.5
871.5
2089
698.5
698.5
2089
1710
1710
1400
1600
1676 RAIL GAUGE
℄ OF RAILS
1743
1743
1676 RAIL GAUGE
℄ OF RAILS
LV SIDE
℄ OF TRANSFORMER
℄ OF TRANSFORMER & RAILS
NOTE-
1. GROUTING OF FOUNDATION BOLTS SHALL BE DONE ONLY AFTER ERECTING THE EQUIPMENTS IN POSITION.
2. DIMENSIONS ARE APPROXIMATE.
01 23.04.12 DS PKP TS DRAWING FORMAT CHANGED.
00 10.07.11 DS PKP TS Original Issue
Rev Date Draw Chk App Description
CDN
General tolerances: ISO 2768 "m for machining; c for fabrication"
Surface texture: ISO 1302
All dimensions in millimetres unless otherwise stated
IF IN DOUBT - PLEASE ASK !
Filename 315MVA 400KV 3PH GT FOUNDATION
Project
Indent n°
S.O.n°
Title
FOUNDATION PLAN FOR 315 MVA , 420 kV 3PH G.T.
Scale NTS
Drawing n° A337538
Sheet n° 1
Total 1
Size A3
© 2012

Annexure 2.2: Standard Parameters of OLTC for Standard Transformer Ratings

Trans-former MVA	Voltage Ratio (kV)	Tapping range	Number of tapping positions	Highest tap current of winding	Max. rated through current of OLTC	Step Voltage (Trans-former require-ment)	Rated Step Voltage of OLTC	Winding Connection	Tapping arrangement	Rated Insulation Levels of OLTC Impulse kVrms / kVp			Max. Value of duration of short circuit current	Location of Tapping Winding
								Star / Delta	Linear / Reversing / Coarse-Fine	Tap changer voltage to earth	Across tapping range	Between adjacent Taps		
16	132/33	(+) 5 to (-) 15 of HV	17	82.33	100	953	1200	Star	Linear/ Coarse-Fine/ Reversing	140/325	45/200	15/90	2 KA for 2 sec.	Neutral End of HV Winding
25	132/11	(+) 5 to (-) 15 of HV	17	128.6	200	953	1200	Star	Linear/ Coarse-Fine/ Reversing	140/325	45/200	15/90	3.5KA for 2 sec.	Neutral End of HV Winding
31.5	132/11	(+) 5 to (-) 15 of HV	17	162.1	200	953	1200	Star	Linear/ Coarse-Fine/ Reversing	140/325	45/200	15/90	3.5KA for 2 sec.	Neutral End of HV Winding
50	132/66	(-) 5 to (+) 15 of HV	17	230.2	300	953	1200	Star	Linear/ Coarse-Fine/ Reversing	140/325	45/200	15/90	4KA for 2 sec.	Neutral End of HV Winding
63	132/66	(-) 5 to (+) 15 of HV	17	290	300	953	1200	Star	Linear/ Coarse-Fine/ Reversing	140/325	45/200	15/90	4KA for 2 sec.	Neutral End of HV Winding
140	11/138	(-) 10 to (+) 5 of HV	17	650.8	800	996	1200	Star	Reversing/ Coarse-Fine	140/325	45/265	15/90	8kA for 2 sec.	Neutral End of HV Winding
140	13.8/138	(-) 10 to (+) 5 of HV	17	650.8	800	996	1200	Star	Reversing/ Coarse-Fine	140/325	45/265	15/90	8kA for 2 sec.	Neutral End of HV Winding

250	15.75/138	(-) 10 to (+) 5 of HV	17	1162.14	1200	996	1200	Star	Reversing/ Coarse-Fine	140/325	45/265	15/90	16KA for 2 sec	Neutral End Of HV Winding
50	220/66	(-) 10 to (+) 10 of HV	17	145.8	200	1588	1600	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	3.5kA for 2 sec.	Neutral End Of HV Winding
100	220/66	(-) 10 to (+) 10 of HV	17	291.6	350	1588	1600	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	5kA for 2 sec.	Neutral End Of HV Winding
50	220/33	(-) 10 to (+) 10 of HV	17	145.8	200	1588	1600	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	3.5kA for 2 sec.	Neutral End Of HV Winding
100	220/33	(-) 10 to (+) 10 of HV	17	291.6	350	1588	1600	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	5kA for 2 sec.	Neutral End Of HV Winding
100	220/132	(-5) to (+) 15 of LV	17	460.5	500	953	1200	Star	Linear/ Reversing	325/750	80/350	15/90	8kA for 2 sec.	Line End of IV Winding
160	220/132	(-5) to (+) 15 of LV	17	736.65	800	953	1200	Star	Linear/ Reversing	325/750	80/350	15/90	15KA for 2 sec	Line End of IV Winding
200	220/132	(-5) to (+) 15 of LV	17	921	1000	953	1200	Star	Linear/ Reversing	325/750	80/350	15/90	16KA for 2 sec	Line End of IV Winding
140	11/235	(-) 10 to (+) 5 of HV	13	382.2	500	1696	1800	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	8kA for 2 sec.	Neutral End Of HV Winding
140	13.8/235	(-) 10 to (+) 5 of HV	13	382.2	500	1696	1800	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	8kA for 2 sec.	Neutral End Of HV Winding

Trans-former MVA	Voltage Ratio (kV)	Tapping range	Number of tapping positions	Highest tap current of winding	Max. rated through current of OLTC	Step Voltage (Trans-former require-ment)	Rated Step Voltage of OLTC	Winding Connection	Tapping arrangement	Rated Insulation Levels of OLTC Impulse kVrms / kVp			Max. Value of duration of short circuit current	Location of Tapping Winding
								Star / Delta	Linear / Reversing / Coarse-Fine	Tap changer voltage to earth	Across tapping range	Between adjacent Taps		
250	15.75/235	(-) 10 to (+) 5 of HV	13	682.5	800	1696	1800	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	15kA for 2 sec.	Neutral End of HV Winding
315	15.75/235	(-) 10 to (+) 5 of HV	13	860	1000	1696	1800	Star	Reversing/ Coarse-Fine	230/550	80/350	15/90	16KA for 2 sec	Neutral End of HV Winding
260	24/420/√3 (1ph)	(-) 10 to (+) 5 of HV	13	1191.35	1500	3031	3100	star	Reversing/ Coarse-Fine	325/750	80/350	15/90	24KA for 2 sec	Neutral End of HV Winding
250	15.75/420	(-) 5 to (+) 10 of HV	13	361.75	500	3031	3100	Star	Reversing/ Coarse-Fine	325/750	80/350	15/90	8kA for 2 sec.	Neutral End of HV Winding
315	15.75/420	(-) 5 to (+) 10 of HV	13	456	600	3031	3100	Star	Reversing/ Coarse-Fine	325/750	80/350	15/90	8kA for 2 sec.	Neutral End of HV Winding
200	"21/420 (1 ph)"	(-) 5 to (+) 10 of HV	13	868.2	1000	3031	3100	Star	Reversing/ Coarse-Fine	325/750	80/350	15/90	16KA for 2 sec	Neutral End of HV Winding
100	400/132/33	(-) 10 to (+) 10 of HV	17	160.4	200	2886	3000	Star	Reversing	325/750	80/350	15/90	3.5KA for 2 sec.	220 kV End of Series Winding
200	400/132/33	(-) 10 to (+) 10 of HV	17	320.75	400	2886	3000	Star	Reversing	325/750	80/350	15/90	6KA for 2 sec.	220 kV End of Series Winding

250	400/220/33	(-) 10 to (+) 10 of HV	17	401	500	2886	3000	Star	Reversing	460/1050	100/460	15/90	8kA for 2 sec.	220 kV End of Series Winding
315	400/220/33	(-) 10 to (+) 10 of HV	17	505.2	600	2886	3000	Star	Reversing	460/1050	100/460	15/90	8kA for 2 sec.	220 kV End of Series Winding
500	400/220/33	(-) 10 to (+) 10 of HV	17	802	1000	2886	3000	Star	Reversing	460/1050	100/460	15/90	16KA for 2 sec.	220 kV End of Series Winding
630	400/220/33	(-) 10 to (+) 10 of HV	17	1010	1200	2886	3000	Star	Reversing	460/1050	100/460	15/90	16KA for 2 sec.	220 kV End of Series Winding
167	400/220/33 (1 ph)	(-) 10 to (+) 10 of HV	17	795	1000	2886	3000	Star	Reversing	460/1050	100/460	15/90	16KA/2 sec	220 kV End of Series Winding
210	400/220/33 (1 ph)	(-) 10 to (+) 10 of HV	17	1010.4	1200	2886	3000	Star	Reversing	460/1050	100/460	15/90	16KA/2 sec	220 kV End of Series Winding
210	765/√3/ 400/√3/33	(-) 5.5 to (+) 5.5 of HV	23	500.5	600	2760	3000	Star	Reversing	230/550	100/460	15/90	8KA/2 sec	Neutral End of HV Winding
333.3	765/√3/ 400/√3/33	(-) 5.5 to (+) 5.5 of HV	23	794.34	1000	2760	3000	Star	Reversing	230/550	100/460	15/90	16KA/2 sec	Neutral End of HV Winding
500	765/√3/ 400/√3/33	(-) 5.5 to (+) 5.5 of HV	23	1191.64	1200	2760	3000	Star	Reversing	230/550	100/460	15/90	16KA/2 sec	Neutral End of HV Winding

ANNEXURE 2.3

Precautions required to be taken during installing tank tap-changer at site

1. Check that the unit serial number of drive mechanism, gear boxes are identical to that of tap changer
2. Check that the tap changer and drive mechanism are at same tap position
3. Ensure proper coupling of drive mechanism and tap changer without disturbing gearbox setting to avoid any misalignment. Refer OLTC Manual
4. Connect earth screw of tap changer head and its cover to transformer cover using earth conductor
5. Connect earth screw of motor drive housing to transformer tank using earth conductor
6. Apply vacuum to transformer and diverter chamber
7. Fill diverter compartment with new filtered mineral oil and vent air from compartment and suction pipe
8. Check, if all stop valves between the oil conservator and driving unit (head) of the OLTC are open
9. Check the oil tightness of the seals on the driving unit (head), protective relay and piping
10. Avoid dropping of any parts or objects into the diverter switch oil compartment
11. Operate manually tap changer for one full cycle. Check end limit stops
12. Operate one cycle electrically and ensure motor drive direction of rotation and continuity
13. Check the protective relay mounting and ensure its contacts are connected in tripping circuit of the main circuit breaker

Chapter - 2

Design and Engineering features

(3) Standard Bushings for Power Transformers

Working Group Members

Ms. Elizabeth Johnson	- ALSTOM Ltd
Mr. M. Vijayakumaran	- ALSTOM Ltd
Mr. Manish Jain	- ABB Ltd
Mr. Shailesh Mahajan	- CGL
Mr. Aseem Dhamija	- BHEL
Mr. Sai Prasad	- T&R

Part 3 - Standard Bushings for Power Transformers

INTRODUCTION

Standard Specifications of bushings used in Transformers up to 1200 kV class are given in Section II of CBIP Manual on Transformers (Publication No. 317). The Section also purports to standardise dimensions of condensers bushings from 52 kV to 1200 kV with a view to enable interchangeability with different makes of bushings. These recommendations have also been adopted in IS: 12676.

The dimensional parameters of the bushings up to and including 36 kV voltage class (solid porcelain bushings) have already been standardised in IS: 3347.

Beside standard dimensions, CBIP Manual also recommends standard values of BILs & test levels, creepage distances, current ratings, BCT, top and bottom terminations etc. This IEEMA Standard on bushings addresses selection criteria for bushings for transformers and suggests standard bushings to be used for popular rating transformers standardised by CBIP working group.

These guidelines are prepared to enable user / manufacturer of the transformer to specify / use standard bushings for the transformers. If a non-standard bushing is specified / used, the same shall be subject to mutual agreement.

SCOPE

This standard covers Outdoor type Standard Bushings comprising outdoor Oil Impregnated Paper (OIP) bushings with values of highest system voltage for equipment (U_m) from 52 kV up to 1200 kV voltage class and solid porcelain and oil communicating type bushings for voltage class up to 36 kV for use in oil filled Power Transformers popularly used in the country.

1. **General Requirements and Selection Criteria of Standard Bushings**

- The condenser bushings shall conform to IEC 60137 / IS: 2099 / IS: 12676 and porcelain bushings shall conform to IS: 3347.
- Unless otherwise specified, the glaze of porcelain shall be brown in colour.
- All exposed ferrous metal parts shall be hot dip galvanized, wherever possible.
- No arcing horns shall be provided on bushings unless otherwise specified.
- Any stress shield shall be considered as an integral part of the bushing assembly for external clearances and field plotting.
- Preferred lead arrangements for condenser bushings upto 800 Amps shall be draw lead type, upto 1250 Amps, shall be draw rod and 2000 Amps and above, in all cases shall be stem type. However, 52 kV and 72.5 kV condenser bushings shall be solid stem type for all current ratings as standardised by CBIP .
- For 100 kV and 110 kV class transformers also, 145 kV class bushing is recommended for the purpose of variety reduction.
- Make of the condenser bushings shall be approved by customer. However, dimensionally they shall conform to CBIP Manual section II. Porcelain bushings are generally assembled by Transformer Manufacturers (porcelain and copper parts are purchased separately and assembled, porcelain conforming to IS:3347).
- The standard current ratings have been adopted. Minimum current rating of bushing is greater than or equal to the maximum winding current × 1.2 or as mutually agreed.
- The neutral bushing not intended to carry load between phase and neutral is dimensioned for earth fault current (except single phase transformer) unless otherwise specified by the customer.
- The lead joint in case of draw-lead or draw-rod type condenser bushings shall be as per fig 2 (a) & (b) of CBIP Manual (section II). The bottom portion of the joint shall be in flush with the bottom of the flange of the bushing. The top portion of the lead shall be transported with the bushings. The winding end of the lead joint shall be suitably anchored while transporting the transformer.

- The minimum value of creepage distance specified is 25 mm/kV of the rated voltage of bushing up to 1200 kV class.
- For areas with very heavy or extremely heavy pollution, the minimum creepage distance shall be 31mm/kV or as specified by the user.
- **Bushing Current Transformer** (BCT): To accommodate the bushing current transformers, space provided on various voltage class bushings shall be as under:

Voltage class (kV)	BCT length (mm)
52	100 300
72.5	100 300
145	300 600
245	300 600
420	400
800	600
1200	300

- **Altitude**:

  Bushings corresponding to this standard are suitable for operation at any altitude not exceeding 1000 M. In order to ensure that the external withstand voltages of the bushings are sufficient at altitudes exceeding 1000 M, the arcing distance normally required shall be increased by a suitable amount. The arcing distance correction shall be done as per clause No. 5.2 of IEC 60317.

- Short time current rating of the bushings shall be 25 times of the rated current of the bushings for 2 seconds.

2. **Standard Bushings and their Application**

   a. **Condenser Bushings for line terminals**:

   The basic insulation level, rated voltage, rated current and creepage distances for various voltage class condenser bushings are as under:

Voltage rating (kV)	Insulation Level LI / SI / AC (kV)	Current rating (A)	Type of lead	Creepage distance (mm)	Remarks
72.5	350 / NA / 155	800	Solid Stem	1815	66 kV winding of 20 MVA, 66kV class transformer (also used for neutral of 220 kV class for the purpose of IOV test).
		1250	Solid Stem		66 kV winding of 100 MVA, 220/66 kV transformer
		3150	Solid Stem		66 kV winding of high rating transformers above 100 MVA e.g. 160 MVA, 220/66kV

Voltage rating (kV)	Insulation Level LI / SI / AC (kV)	Current rating (A)	Type of lead	Creepage distance (mm)	Remarks
145	650 / NA / 305	800	Draw lead	3625	132 kV winding of transformers up to 100 MVA, 3 phase. (e.g. 100 MVA, 220/132/11 kV auto transformer and 50 MVA, 132/33 kV two winding transformer)
		1250	Draw Rod		132 kV class transformers up to 200 MVA, 3 phase. (e.g. 200 MVA, 220 / 132 kV auto transformer and 160 MVA 220 / 132 kV auto transformer)
		2000	Solid Stem		132 kV winding of Higher rating (e.g. 250 MVA, 220 / 132 kV auto transformer)
245	1050 / 850 / 505	1250	Draw rod	6125	220 kV class transformers up to 315 MVA, 3 phase. (e.g. 315 MVA, 220 kV GSU or 315 MVA, 400 / 220 kV auto transformers)
		2000	Solid stem		400 / 220 kV class transformers of 500 and 630 MVA, 3 phase.
420	1425 / 1050 / 695	1250	Draw Rod	10500	315 MVA and 500 MVA, 400 kV class, 3 phase, auto transformers
		2000	Solid Stem		400 kV single phase generator transformers of 260 and 315 MVA
		2500	Solid stem		400 kV winding of 500 MVA, single phase, 765/√3 / 400/√3 / 33 kV, auto transformer
800	2100 / 1550 / 970	2500	Solid Stem	20000	500 MVA, single phase, 765/√3 / 400/√3 / 33 kV auto transformer and 260 & 333 MVA, 1 phase, 765 kV class, GSU
1200	2400 / 1950 / 1320	2500	Solid Stem	30000	1000 MVA, single Phase, 1150/√3 / 400/√3 / 33 kV auto transformer

b) **Condenser bushings for tertiary winding**:

- 33 kV tertiary in 400 kV & above kV class transformer is designed for 250 kVp transferred surges. Hence, 52 kV class bushings shall be used in such cases. The standard 52 kV bushings are as follows:

Voltage rating (kV)	Insulation Level LI / AC (kV)	Current rating (A)	Type of lead	Creepage distance (mm)	Remarks
52	250 / 105	3150	Solid stem	1300	a) 33 kV tertiary winding of 315 MVA and 500 MVA, 3 phase, 400 / 220 / 33 kV auto transformer. b) 167 MVA, 1 phase, 400/√3 / 220/√3 / 33 kV, auto transformer.
		5000	Solid stem		a) 33 kV tertiary winding of 500 MVA, 1 phase, 765/√3 / 400/√3 / 33 kV auto transformer b) 33 kV tertiary winding of 1000 MVA, 1 phase, 1150/√3 / 400/√3 / 33 kV auto transformer (2 Nos. per phase)

c) **Porcelain bushings for tertiary winding**

- 11 kV as well as 33 kV class tertiary windings of 220 kV & below class, auto transformers are designed for 170 kVp transferred surges. Hence, 36 kV class porcelain bushing shall be used in such cases.
- In case of stabilizing winding of auto transformer, 1/3rd of equivalent 2 winding rating shall be considered for calculation of bushing current.
- These porcelain bushings are also to be used for 33 kV winding of double wound transformer with and without tertiary winding.
- For 11 kV and 22 kV class, 36 kV bushings only are standardised of current ratings 1000 amps, 2000 amps and 3150 amps.
- In case of stabilizing winding of auto transformer, 4 bushings shall be used for testing. After testing only 2 bushings, forming the corners of the delta, shall be provided. They will be externally shorted and earthed to the tank.
- In case of loaded tertiary only 3 bushings shall be provided for testing as well as for site use.

Voltage rating (kV)	Current rating (A)	Type of lead	Creepage distance (mm)	Remarks
36	1000	Solid Stem	900	25 / 31.5 MVA, 132/22 kV, 132/33 kV, double wound transformers.
	2000	Solid stem		11 & 33 kV stabilizing windings of auto transformers up to 200 MVA. e.g. i) 200 MVA, 220/132/11 or 33 kV, 3 phase, auto transformers ii) 160 MVA 220/132/11 or 33 kV, 3 phase, auto transformers iii) 100 MVA, 220/132/11 kV 3 phase, auto transformers iv) 25 MVA 132/11 kV double wound transformer
	3150	Solid stem		3 phase auto transformers of 160 MVA and above, using 11 kV tertiary. (e.g. 160 & 200 MVA, 220/132/11 kV auto transformer and 50 MVA, 132/11 kV 3 phase, double wound transformer).

d) **Bushings for neutral end terminal**

Voltage rating (kV)	Current rating (A)	Type of lead	Creepage distance (mm)	Remarks
36	1000	Solid stem	900	Up to 315 MVA, 3 phase, transformers (auto as well as double winding)
	2000	Solid stem		3 phase, auto transformers of 500 MVA and above (auto and double winding).

- During testing, 72.5 kV, 800 Amp condenser bushing can be used where neutral receives 1/3rd voltage during IOV test. e.g. 132 and 220 kV class transformers. However, after testing 72.5 kV test bushing is to be replaced by 36 kV neutral bushing. For 400 kV transformer, where ACSD test is specified, neutral test bushing shall be 145 kV, 800 Amp.

e) **Bushings for LV of generator transformers**

- LV voltages of GTs are typically 11 kV, 13.8 kV, 15.75 kV and 21 kV.
- For all these voltages, 24 kV porcelain bushings, oil communicating type have been standardised. The standard current bushings selected are 8, 12.5, 16 & 20 kA. In case of non availability of 16/20 kA bushings, 8/12.5 kA bushings, 2 in parallel can be used.

- In certain cases, high current 36 kV condenser bushings can also be used, subject to mutual agreement.
- When LV bushings are housed in busduct, suitable derating factor to be considered for current rating.

Voltage rating (kV)	Current rating (kA)	Type of lead	Creepage distance (mm)	Remarks
24	8	Solid stem	600	i) 100 MVA, 3 phase, GT with LV winding of 11 kV. ii) 150 MVA, 3 phase, GT with LV winding of 13.8 kV. iii) 82 MVA, 1 phase, GT with LV winding of 15 kV.
	12.5	Solid stem		i) 150, 200 and 250/260 MVA 3 phase, GT with LV winding of 11, 13.8 and 15.75 kV respectively. ii) 200 MVA 1 phase, GT with LV winding of 21 kV. iii) 105 MVA 1 phase, GT with LV winding of 11 kV.
24	16	Solid stem	600	i) 250 MVA 3 phase, GT with LV winding of 11 kV ii) 260 MVA 1 phase, GT with LV winding of 21 kV iii) 315 MVA 3 phase, GT with LV winding of 13.8 kV and 15.75 kV. iv) 400 MVA 3 phase, GT with LV winding of 21 kV
	20	Solid stem		i) 315 MVA 1 phase, GT with LV winding of 21 kV ii) 600 MVA 3 phase, GT with LV winding of 21 kV iii) 315/333 MVA 1 phase, GT with LV winding of 21 kV

3. **Standard ratings of Bushings for transformers**

Standard ratings of bushings for the transformers are as given in Table No.2.1.

Table No. 2.1 Standard Bushings for Transformers

MVA	kV ratio	Tapping range	HV current I_{hv}	$1.2 \times I_{hv}$	HV Bushing	IV current I_{IV}	$1.2 \times I_{IV}$	IV Bushing	LV current I_{LV}	$1.2 \times I_{LV}$	LV Bushing
16	132/33	(-) 15, (+) 5	82.33	98.796	145/800A	NA	NA	NA	279.92	335.904	36/1000
25	132/11	(-) 15, (+) 5	128.6	154.32	145/800A	NA	NA	NA	1312.15	1574.58	36/2000
31.5	132/11	(-) 15, (+) 5	162.1	194.52	145/800A	NA	NA	NA	1653.31	1983.972	26/2000A
50	132/66	(-) 5 , (+) 15	230.2	276.24	145/800A	NA	NA	NA	437.38	524.856	72.5/800A
63	132/66	(-) 5 , (+) 15	290	348	145/800A	NA	NA	NA	551.01	661.212	72.5/800A
140	11/138	(-) 10 , (+) 5	650.8	780.96	145/800A	NA	NA	NA	4242.42	5090.904	29/8000A
140	13.8/138	(-) 10 , (+) 5	650.8	780.96	145/800A	NA	NA	NA	3381.65	4057.98	24/8000A
250	15.75/138	(-) 10, (+) 5	1162.14	1394.57	145/1600A	NA	NA	NA	5291.21	6349.452	24/8000A
50	220/66	(-) 10, (+) 10	145.8	174.96	245/1250A	NA	NA	NA	437.38	524.856	72.5/800A
100	220/66	(-) 10, (+) 10	291.6	349.92	245/1250A	NA	NA	NA	874.77	1049.724	72.5/1250A
50	220/33	(-) 10, (+) 10	145.8	174.96	245/1250A	NA	NA	NA	874.77	1049.724	36/1000A
100	220/33	(-) 10, (+) 10	291.6	349.92	245/1250A	NA	NA	NA	1749.54	2099.448	36/3150
100	220/132	(-) 5, (+) 15	262.43	314.916	245/1250A	460.4	552.48	145/800A	NA	NA	NA
160	220/132	(-) 5, (+) 15	419.9	503.88	245/1250A	736.65	883.98	145/1250A	NA	NA	NA
200	220/132	(-) 5, (+) 15	524.86	629.832	245/1250A	920.8	1104.96	145/1250A	NA	NA	NA
140	11/235	(-) 10, (+) 15	351.43	702.86	245/1250A	NA	NA	NA	7348.1	8817.72	36/12500A

MVA	kV ratio	Tapping range	HV current I_{hv}	1.2 × I_{hv}	HV Bushing	IV current I_{IV}	1.2 × I_{IV}	IV Bushing	LV current I_{LV}	1.2 × I_{LV}	LV Bushing
250	15.75/235	(-) 10, (+) 15	682.4	818.88	245/1250A	NA	NA	NA	9164.3	10997.16	36/12500A
315	15.75/235	(-) 10, (+) 15	859.8	1031.76	245/1250A	NA	NA	NA	11547	13856.4	36/16000A
260	24/420/√3	(-) 10, (+) 15	1191.35	1429.62	420/2000A	NA	NA	NA	10833.33	13000	36/16000A
250	15.75/420	(-) 5, (+) 10	361.75	434.1	420/1250A	NA	NA	NA	9164.29	10997.15	36/12500
315	15.75/420	(-) 5, (+) 10	455.8	546.96	420/1250A	NA	NA	NA	11547	13856.4	24/16000A
200	21/420/√3	(-) 5, (+) 10	868.2	1041.84	420/1250A	NA	NA	NA	9523.8	11428.56	24/12500A
100	400/132/33	(-) 10, (+) 10	160.4	192.48	420/1250A	437.38	524.856	145/800A	1009.09	1210.91	52/3150A
200	400/132/33	(-)10, (+) 10	320.75	385	420/1250A	874.77	1049.724	145/1250A	2020	2424	52/3150A
250	400/220/33	(-)10, (+) 10	401	481.2	420/1250A	656.08	787.3	245/1250A	2525.15	3030.18	52/5000A
315	400/220/33	(-)10, (+) 10	505.18	606.216	420/1250A	826.66	991.992	245/1250A	3181.8	3818.16	52/5000A
167	400/√3/220/√3/33	(-)10, (+) 10	803.5	964.2	420/1250A	1314.78	1577.74	245/2000A	1686.86	2024.232	52/3150A
210	400/√3/220/√3/33	(-)10, (+) 10	1010.36	1212.432	420/1250A	1653.32	1983.98	245/2000A	2121.2	254544	52/5000A
200	21/765/√3	(-) 5, (+) 5	476.65	571.98	800/2500A	NA	NA	NA	9523.8	11428.6	36/12500
260	24/765/√3	(-) 5, (+) 5	619.6	743.52	800/2500A	NA	NA	NA	10833.3	12999.96	36/16000
210	765/√3/400/√3/33	(-) 5, (+) 5	500.5	600.6	800/2500A	909.32	1091.184	420/1250A	2121.21	2545.45	52/3150A
333.3	765/√3/400/√3/33	(-) 5, (+) 5	794.35	953.22	800/2500A	1443.36	1732.032	420/2000A	3366.66	4039.992	52/5000A
500	765/√3/400/√3/33	(-) 5, (+) 5	1191.64	1429.97	800/2500A	2165.06	2598.072	420/2500A	5081	6097.2	52/5000A

Chapter - 2

Design and Engineering features

(4) Power Transformer Fittings and Accessories

Working Group Members

Mr. M. L. Jain	- EMCO Ltd.
Mr. Rabindranath Mahapatro	- EMCO Ltd.
Mr. Bharat Panchal	- EMCO Ltd.
Mr. V. Janardhanan	- Precimeasure
Mr. S. R. Doraiswamy	- Perfect Controls
Mr. Vishal Shah	- Scientific Controls
Mr. Himanshu Choudhary	- Jadhao Engineers
Mr. K. Y. Daftary	- Hi-Tech Radiators
Mr. Jitendra Palnitkar	- Tarang Engg
Mr. Sujit Gupta	- Pradeep Sales & Service
Mrs. J. J. Patel	- EMCO Electronics
Mr. Vinay Gupta	- Atvus Industries
Mr. Atul Bapat	- Sukrut Udyog
Mr. D. M. Jadhav	- CTR
Mr. Rajesh Khanna	- SERGI
Mr. Mahendra Sule	- Lumasense
Mr. Jagdish Sandhanshiv	- Consultant
Mr. S. Paulraj	- Klemmen Engineering

Part 4 - Power Transformer Fittings and Accessories

INTRODUCTION

All external components & fittings provided on the transformer tank form an integral part of the transformer and are essential for its satisfactory performance in service. Some essential fittings, which are mandatorily provided on a wide range of transformers, are listed in IS 2026 Part I. However, depending on the rating, some additional fittings and accessories are also provided on large rating transformers as per the specified requirement.

This section covers various fittings & accessories that are generally provided on the 132 kV & above class of Power Transformers. As components with varying features are available commercially, in the absence of any authoritative guidelines, the users are often unable to clearly specify the items that would address their long term requirements.

This section briefly covers some vital fittings and accessories as listed below, describing broadly the purpose of each fitting, its working principle, the data sheet, the selection criteria, the care to be taken during installation & commissioning, etc. While presently no single Standard comprehensively covers all the fittings and accessories, the British Standard BSEN 50216, which is divided in several parts, covers some of the vital components. Therefore, efforts have been made to broadly align details of the items covered herein with these standards and some other available references. However, for the users a list of some references is appended under 'Bibliography' for further details.

Doc. No.	Type of Accessory	Purpose	Reference Standard
1	Temperature Indicators	These instruments are installed in the marshaling box (in transformer yard) measurement of top oil temperature & winding hot spot indication	BS EN 50216-11
1.1	Oil Temperature Indicator (OTI)		
1.2	Winding Temperature Indicator (WTI)		
1.3	Remote Temperature Indicator (ROTI/RWTI)	This is a repeater dial installed in the Control Room for remote indication of top oil temperature & winding hot spot temperature	BS EN 5021.6-11
1.4	RTD (PT 100) Scheme for ROTI / RWTI	RTD scheme, comprises RTD sensor, transducer and indicator is used for measurement of oil and winding temperatures of the transformers	BS EN 5021.6-11
2	Fiber Optic Temperature Sensor (FOS)	For real time measurement of winding hotspot temperatures	IEC 60076-2
3	Gas & Oil Actuated Relay (Buchholz Relay)	Fitted in the pipe between tank and the conservator to actuate alarm & trip relays in the event of accumulation of gas generated due to fault inside the transformer	BS EN 50216-2
4	Pressure Relief Valve (PRV)	Fitted on the tank cover to limit the tank over pressure on an internal fault, thereby reducing risk of tank rupture or uncontrolled spillage of oil	BS EN 50216-5
5	Magnetic Oil Level Gauge (MOG)	Fitted on the main tank conservator and OLTC conservator for indication of oil level	BS EN 50216-5
6	Oil / Water Flow Indicators (FI)	Fitted in the oil/water cooling pipe line for the control of the oil/ water flow out of the pumps on transformer with forced oil/ water cooling equipment	BS EN 50216-5
7	Air Cell / Flexi-Separator	Installed inside the conservator as a barrier to prevent contact between atmospheric air and the transformer oil	-
8	Conservator Protection Relay (CPR)	Also called 'air cell puncture detection relay', is externally installed on the top of conservator to give alarm in the event of lowering of oil in the conservator due to puncture of air cell in service	-

9	Removable Radiators for oil-immersed transformers	These are directly/separately mounted on the tank to permit flow of hot oil through it for cooling and returning to tank	BS EN 50216-6
10	Automatic Voltage Regulating Relay (AVR)	Provided in the RTCC (Remote tap changers control cubicle) & connected to OLTC to maintain a constant secondary voltage at all times	-
11	Fire Fighting Systems	Installed in the vicinity of main transformer to protect it against catching of fire/spread of fire in the event of internal failure of transformer or external fire in the close vicinity	CEA -The Gazette of India, 2010
11.1	Nitrogen Injection Fire Prevention System (NIFPS)		
11.2	Automatic Water Mulsifier System		
12	Terminal Connector	Used for connection of transformer to the overhead power line.	IS: 5561

Attempts have been made to standardise some vital fittings & accessories used for power transformers to facilitate interchangeability & to rationalize their use such as would be commonly acceptable to manufacturers & users.

It may be noted that the above list is not exhaustive. Some items, like cooing fans, oil/water pumps, pressure gauges, RTD, valves, breathers, rollers, earthing terminals, heat exchangers, unit coolers, etc. are presently not covered here and could be considered in the subsequent revisions in future.

1 Temperature Indicators

1.1 Oil Temperature Indicator (OTI)

1.1.1 Description

This is used to measure the temperature of top oil in transformer.

1.1.2 Principle of Operation

The top oil temperature of oil immersed power transformer is sensed by mMeasuring system based on volumetric expansion of liquid proportional to rise in temperature. A sensing bulb, measuring bellow and a small bore capillary connecting the two form the measuring system which is filled with liquid. When the sensing bulb is exposed to rise in temperature, the liquid inside expands proportionately causing the bellows to expand and drive the linkages for indication and separately, linkages & disc for switch operation. This system is self contained and does not depend on any outside power source for its operation.

Complete ambient temperature compensation on sensing bulb & line / capillary is provided with a second bellow / compensating bellow and a capillary that terminates at head of the sensing bulb. The liquid filled inside this responds to ambient temperature changes. The measuring and compensating bellows are linked in such a way that they cancel out. Thus, the net measuring bellow output is dependent only on the sensing bulb temperature and not on ambient temperature.

1.1.3 Data Sheet

Technical Parameters		
Parameter	**Variant - 1**	**Variant – 2**
Dial Range	0 to 150 °	0 to 150 °
Dial angular sweep	270 °	270 °
Case shape	Rectangular	Rectangular
Paint detail of case	Powder coated, RAL7032	Powder coated, RAL7032
Graduation	2 °C	2 °C

Parameter	Variant - 1	Variant – 2
Accuracy class	±1.5 % FSD	±1.5 % FSD
No. of micro switches	2 Nos. Change over	2 Nos. Change over
Contact rating	15A, 250V AC & 0.25A at 250V DC	15A, 250V AC & 0.25A at 250V DC
Switch differential	6°C to 8°C (Fixed)	6°C to 8°C (Fixed)
Switching accuracy	±4°C of Set Value	±4°C of Set Value
Switch adjustable range	Independently adjustable to close between 30-150°C	Independently adjustable to close between 30-150°C
With built-in RTD (PT100) and CCU	Not Available	Available
External PSU with 2Nos. of 4-20mA DC outputs	Not Available	Available
Bulb	1” BSP with male type union (Fig.2.1)	1” BSP with male type union (Fig.2.2)
Material	**Case** - Cast Aluminum; **Bulb** - Brass with silver joint, natural finish; **Bellows** - Phosphor Bronze, natural finish; **Capillary** - Stainless Steel Armour sheathed copper capillary; **Window** - clear and transparent Polycarbonate	**Case** -Cast Aluminum; **Bulb** - Brass with silver joint, natural finish; **Bellows** - Phosphor Bronze, natural finish; **Capillary** - Stainless Steel Armour sheathed copper capillary; **Window** - clear and transparent Polycarbonate
Capillary & electrical entry	From the bottom of OTI	From the bottom of OTI
Dial marking	Black with white back ground	Black with white back ground
Resettable maximum reading pointer	Red in colour	Red in colour
Degree of protection	IP:55	IP:55
Immune to vibration of switches	Yes	Yes

Notes: *1) 4 to 20mA correspond to 0 to 150 °C respectively.*
2) In case of failure of analog type indicator (Variant-2), PSU will give continuous 4 to 20mA output.

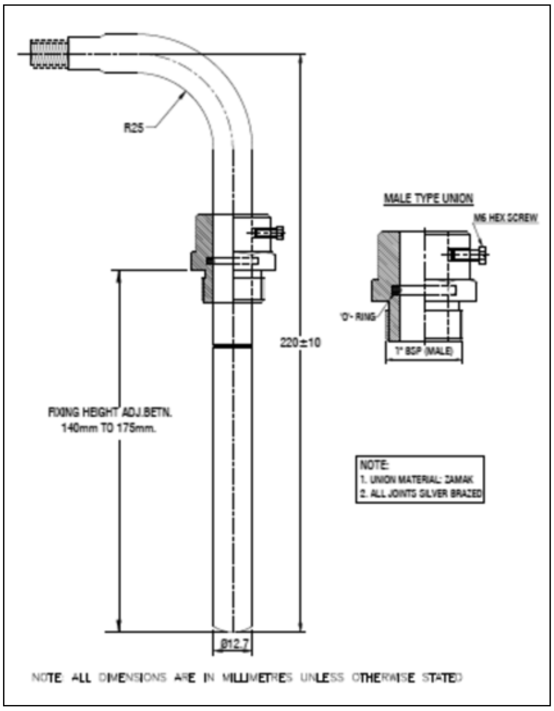


Fig. 2.1: Bulb fitting arrangement for Variant 1

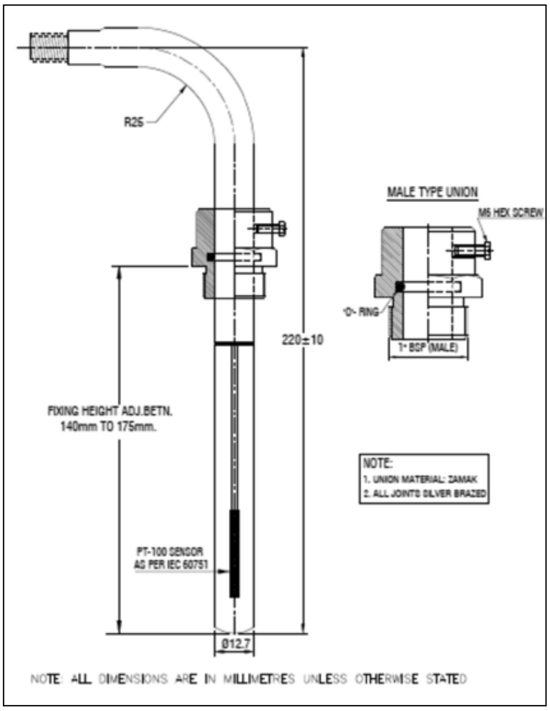
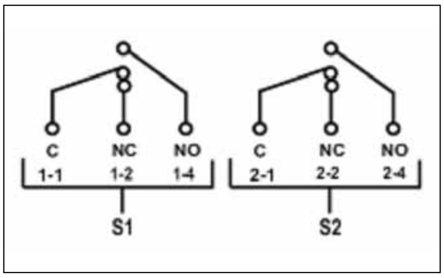


Fig. 2.2: Bulb fitting arrangement for Variant 2

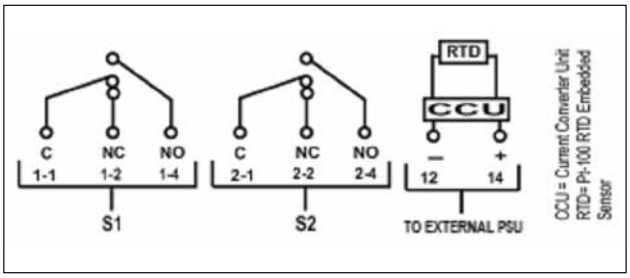
1.1.4 **Standard Wiring Diagram**

Any one of the following terminal configurations can be selected as per requirement.

The contact position shown below is under normal operating condition of OTI.



Variant - 1



Variant - 2

1.1.5 **Selection criteria**

4 to 20 mA output required or not for remote/SCADA indication

1.1.6 **Routine Tests**

a) Mount the temperature Indicator on Test Stand Vertically,

b) Connect as per scheme diagram.

c) Micro switch terminals with multimeter / Buzzer (Continuity test).

d) "Thermal image" bellow heater terminal (CT Terminal) with current source

e) Close the Top cover

f) Set oil bath temperature at 40°C, with reference to the standard Thermometer.

g) Loosen union screw and remove the union (**Ensure minimum immersion length of 140 mm**). Immerse sensing bulb in hot oil bath.

h) Record the instrument temperature after 5 minutes, the bath reaches the steady temperature.

i) Increase the oil bath temperature in steps of 20°C and record the temperature of the instrument after 5 minutes when the bath reaches the steady state temperature.

j) Simultaneously observe and record the switch operation (ON) as instrument temperature rises.

k) Remove the sensing bulb from oil bath and keep in ambient temperature till the instrument reading reaches the ambient temperature.

l) Simultaneously observe and record the switch operation (OFF) as instrument temperature decreases (To check switch differential)

m) Insulation Test (2 kV between contact and earth)

1.1.7 **Installation and Pre-commissioning checks**

i. Before installation, check for possible damages from transport handling.

ii. Do not carry the instrument by holding the capillary line.

iii. Ensure not to twist the capillary line while unpacking, storage or installation.

iv. Avoid sharp bends of capillary line and allow minimum of 50 mm bending radius.

v. Keep the instrument on mounting surface and fix it.

vi. Make sure that instrument is mounted in a vertical position.

vii. Clamp the capillary line along its entire length at approximately 500 mm intervals. The excess length can be wound in spiral with minimum diameter of 100 mm.

viii. Oil is to be filled in the pocket. Insert the sensing bulb through union/ pocket/ flange (insert fully), tighten nut to optimum level. Ensure min. immersion length 140 mm.

ix. Care must be taken that, Sensing bulb is not damaged while tightening.

x. In case of further transport or storage, wind the armor and pack the instrument in the same way as received from the supplier.

xi. Check the connection as per wiring diagram before commissioning.

xii. Cable entry should be through cable gland to avoid dust entering

xiii. Top cover should be put in place and tighten properly to avoid dust. Ensure that the maximum pointer is positioned after the indicating pointer.

xiv. Make sure there are no loose connections.

xv. Test knob, if provided externally, shall be locked properly after testing.

1.2 Winding Temperature Indicator (WTI)

1.2.1 Description

This is used to measure the hotspot temperature of the winding.

1.2.2 Principle of Operation

The top oil temperature of Oil Immersed Power transformer is sensed by measuring system based on volumetric expansion of liquid proportional to rise in temperature. A Sensing bulb, measuring bellow and a small bore capillary connecting the two form the measuring system which is filled with liquid. When the sensing bulb is exposed to rise in temperature, the liquid inside expands proportionately causing the bellows to expand and drive the linkages for indication and separately, linkages & disc for switch operation. This system is self contained and does not depend on any outside power source for its operation.

Complete ambient temperature compensation on sensing bulb & line/capillary is provided with a second bellow/compensating bellow and a capillary that terminates at head of the sensing bulb. The liquid filled inside this responds to ambient temperature changes. The measuring and compensating bellows are linked in such a way that they cancel out. Thus, the net measuring bellow output is dependent only on the sensing bulb temperature and not on ambient temperature.

The winding temperature is simulated by passing CT secondary current (from the transformer line) to an electrical heater coil fitted around the measuring bellows. This simulates the winding to top oil temperature differential which is added to the top oil temperature, being measured by the instrument bulb. The temperature in the hottest part of the winding or hotspot temperature is displayed directly by the instrument. Thus, the instrument functions as a winding temperature indicator. The time constant of the temperature rise will be 63.7% of final temperature rise within 7-8 minutes.

Since the thermal time constant of the heater coil is nearly the same as the transformer winding, the instrument simulates closely the actual temperature of the winding in relation to time.

The primary current of CT feeding the thermal image of WTI shall be of rated transformer current corresponding to lowest tap and secondary nominal output of 2A. The heating system of WTI shall be designed for a winding gradient of 35°C at CT current input of 2A. It shall be designed to operate continuously at 150% of the rated current and shall not suffer injurious overheating with 200% of rated current for a period of 15 minutes. Based on the heat run test data, the parallel shunt resistor to heater coil shall be adjusted by transformer manufacturer such that the current through heater coil will correspond to the winding hotspot gradient as per the heat run test result.

1.2.3 Data Sheet

Technical Parameters		
Parameter	**Variant - 1**	**Variant - 2**
Dial Range	0 to 150 °	0 to 150 °
Dial angular sweep	270 °	270 °
Case shape	Rectangular	Rectangular
Paint detail of case	Powder coated, RAL7032	Powder coated, RAL7032
Graduation	2 °C	2 °C
Accuracy class	±1.5% FSD	±1.5% FSD
No. of micro switches	4 Nos. change over	4 Nos. change over
Contact rating	15A, 250V AC & 0.25A @ 250V DC	15A, 250V AC & 0.25A @ 250V DC
Switch differential	6°C to 8°C (Fixed)	6°C to 8°C (Fixed)
Switching accuracy	±4°C of Set Value	±4°C of Set Value
Switch adjustable range	Independently adjustable to close between 30-150°C	Independently adjustable to close between 30-150°C
With built-in RTD (PT100) and CCU	Not Available	Available
External PSU with 2 Nos. of 4-20 mA DC outputs	Not Available	Available
Bulb	1” BSP with Male type union (Fig.2.3)	1” BSP with Male type union (Fig.2.4)
Material	**Case** - Cast Aluminium; **Bulb** - Brass with silver joint, natural finish; **Bellows** - Phosphor Bronze, natural finish; **Capillary** - Stainless Steel Armour sheathed copper capillary; **Window** - clear and transparent polycarbonate	**Case** - Cast Aluminium; **Bulb** - Brass with silver joint, natural finish; **Bellows** - Phosphor Bronze, natural finish; **Capillary** - Stainless Steel Armour sheathed copper capillary; **Window** - clear and transparent polycarbonate
Capillary & electrical entry	From the bottom of OTI	From the bottom of OTI
Dial marking	Black with white back ground	Black with white back ground
Resettable maximum reading pointer	Red in colour	Red in colour
Degree of protection	IP:55	IP:55
Immune to vibration of switches	Yes	Yes

Notes: *1) 4 to 20 mA correspond to 0 to 150 °C respectively.*
2) In case of failure of analog type indicator (Variant-2), PSU will give continuous 4 to 20 mA output.

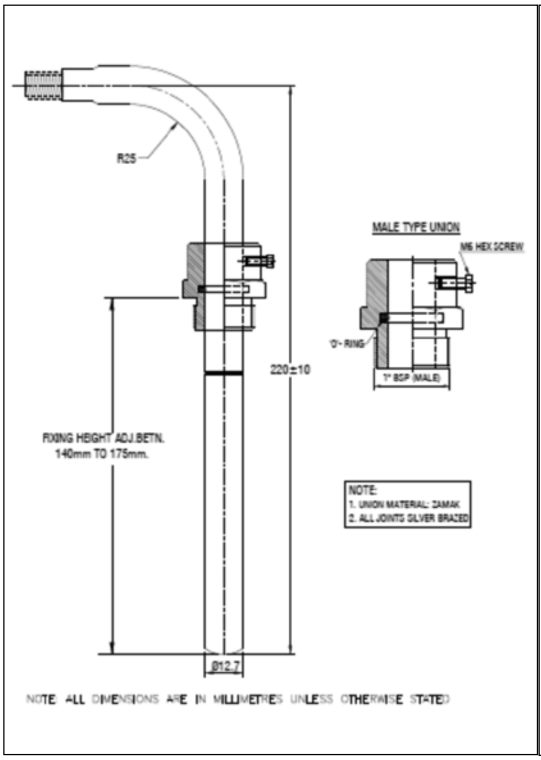


Fig. 2.3: Bulb fitting arrangement for Variant 1

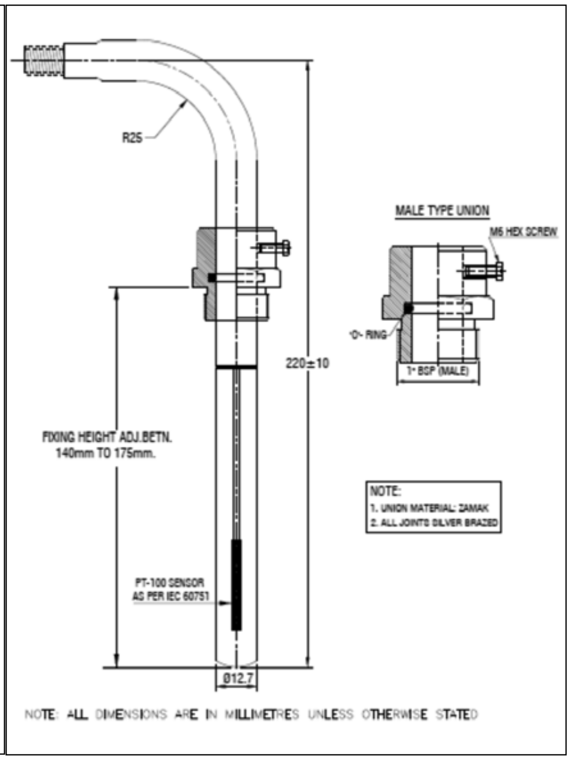
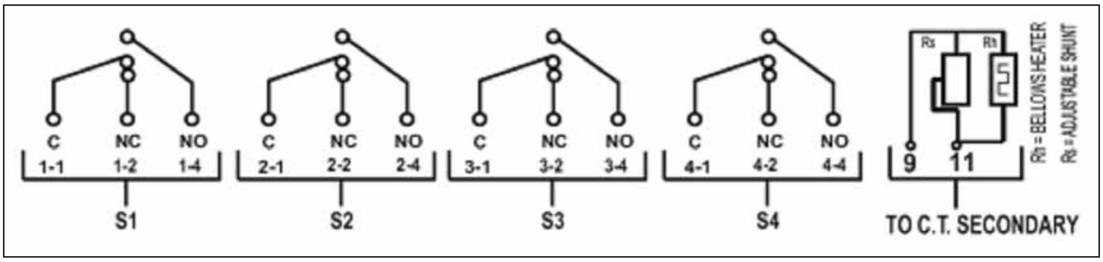


Fig. 2.4: Bulb fitting arrangement for Variant 2

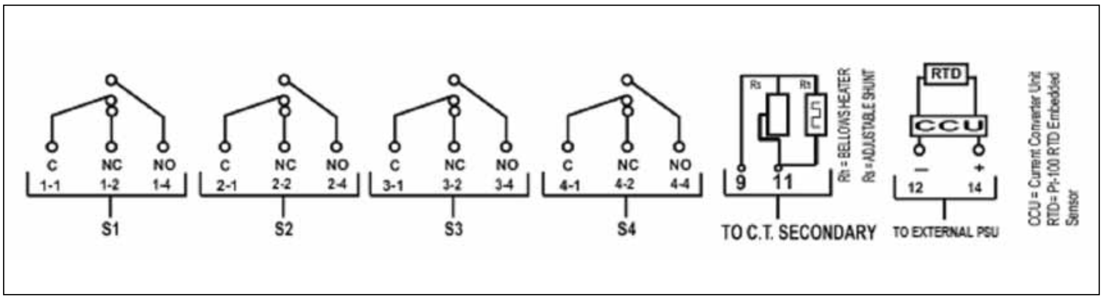
1.2.4 **Standard Wiring Diagram**

Any one of the following terminal configurations can be selected as per requirement.

The contact position shown below is under normal operating condition of WTI.



Variant - 1:



Variant - 2:

1.2.5 **Selection criteria**

4 to 20 mA output for remote/SCADA indication - Yes / No.

1.2.6 **Routine Tests**

a) Mount the temperature indicator on test stand vertically,

b) Connect as per scheme diagram.
  - Micro switch terminals with multimeter / Buzzer (Continuity test).
  - "Thermal image" bellow heater terminal (CT Terminal) with current source

c) Close the Top cover.

d) Set oil bath temperature at 40°C, with reference to the standard Thermometer.

e) Loosen union screw and remove the union (Ensure minimum immersion length of 140 mm). Immerse sensing bulb in hot oil bath.

f) Record the instrument temperature after 5 minutes, the bath reaches the steady temperature.

g) Increase the oil bath temperature in steps of 20°C and record the temperature of the instrument after 5 minutes when the bath reaches the steady state temperature.

h) Simultaneously observe and record the switch operation (ON) as instrument temperature rises.

i) Remove the sensing bulb from oil bath and keep in ambient temperature till the instrument reading reaches the ambient temperature.

j) Simultaneously observe and record the switch operation (OFF) as instrument temperature decreases (To check switch differential).

k) Insulation test (2 kV between contact and earth).

1.2.7 **Installation and Pre-commissioning Checks**

a) Before installation, check for possible damages from transport handling.

b) Do not carry the instrument by holding the capillary line.

c) Ensure not to twist the capillary line while unpacking, storage or installation.

d) Avoid sharp bends of capillary line and allow minimum of 50 mm bending radius.

e) Keep the instrument on mounting surface and fix it.

f) Make sure that instrument is mounted in a vertical position.

g) Clamp the capillary line along its entire (3/4) length at approximately 500 mm intervals. The excess length can be wound in a spiral with a min diameter of 100 mm.

h) Oil is to be filled in the pocket. Insert the sensing bulb through union / pocket / flange (insert fully), tighten nut to optimum level.

i) Care must be taken that sensing bulb is not damaged while tightening.

j) In case of further transport or storage, wind the armor and pack the instrument in the same way as received from the supplier.

k) Check the connection as per wiring diagram before commissioning.

l) Cable entry should be through cable gland to avoid dust entering

m) Top cover should be put in place and tighten properly to avoid dust. Ensure that the maximum pointer is positioned after the indicating pointer.

n) Make sure there are no loose connections.

o) Set the Hot oil bath temperature at 60°C/75°C, Immerse the sensing bulb.

p) Inject the rated current as per requirement or graph for 40 minutes, and check the temperature rise of winding temperature over oil temperature.

q) Test knob, if provided externally, shall be locked properly after testing.

1.3 Remote Oil / Winding Temperature Indicator (ROTI/RWTI)

1.3.1 Description

This is used to measure the temperature of oil / winding at the remote control panel.

1.3.2 Principle of Operation

This system takes 4 to 20 mA, DC analog input from the local OTI / WTI and caliberate the same in terms of degrees C to repeat the temperature of local OTI / WTI on the remote control panel

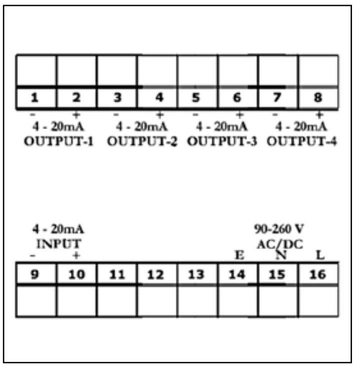
1.3.3 Data Sheet

The different types of Remote Temperature indicators are as follows:

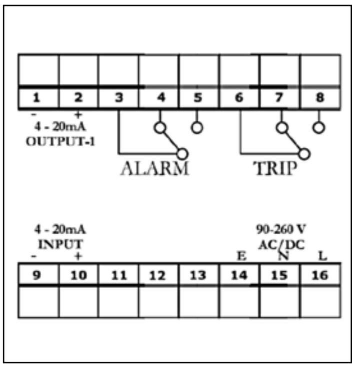
Technical Parameters			
Parameter	**Variant - 1**	**Variant - 2**	**Variant - 3**
Type	Digital (96 sq mm)	Digital (96 sq mm)	Digital (96 sq mm)
Auxiliary Supply	90 – 260V AC/DC	90 – 260V AC/DC	90 – 260V AC/DC
Temperature Range	0 – 150 °C	0 – 150 °C	0 – 150 °C
Temperature Indicator	3½ digits 7-segement LED display red in colour	3½ digits 7-segement LED display red in colour	3½ digits 7-segement LED display red in colour
Accuracy of the system	± 1% FSD (of local OTI / WTI)	± 1% FSD (of local OTI / WTI)	± 1% FSD (of local OTI / WTI)
Warm up time after switching 'ON'	15 Minutes (Minimum)	15 Minutes (Minimum)	15 Minutes (Minimum)
Input	4 to 20 mA DC	4 to 20 mA DC	4 to 20 mA DC
No. of 4 - 20 mA Output	4	1	1
Alarm & Trip Contacts	Not Available	Available (1 No. each)	Not Available
RS485 port module	Not Available	Not Available	Available
Degree of Protection of enclosure	IP 20	IP 20	IP 20
Note: 4 to 20 mA corresponds to 0 to 150 °C respectively.			

1.3.4 Standard Wiring Diagram

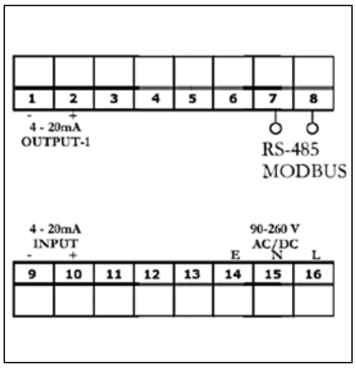
Any one of the following terminal configurations can be selected as per requirement. The contact position shown below is under normal operating condition.



Variant 1



Variant 2



Variant 2

1.3.5 Selection criteria

- No. of 4 to 20 mA output - Yes / No
- Alarm & trip contacts - Yes / No
- RS485 port module - Yes / No

1.3.6 Tests

a) HV Test: All mA terminals shall be tested for 500V AC, 50Hz for one minute. All other terminals shall be tested for 2kV AC, 50Hz for one minute.

b) I.R. Test: Insulation resistance shall be ≥ 20 Meg. Ohms when checked by 500V DC Insulation Tester.

1.3.7 Installation and pre-commissioning checks

a) Check the proper electrical earthing.

b) Use shielded cable for input signals

c) Ensure that input signal and power cables are isolated.

d) Make sure the proper supply voltage is applied.

e) Switch off the power supply while wiring.

f) Ensure tightness of all the contacts.

1.4 RTD (PT100) Scheme for ROTI / RWTI

1.4.1 Description

This scope covers the standard specifications of the PT100 Resistance Temperature Detector (RTD) Oil Temperature indicator (OTI) and Winding Temperature indicator (WTI) for use with liquid immersed power transformers and reactors for indoor or outdoor installation.

1.4.2 Oil Temperature Indicator

The system measures the top oil temperature of oil immersed transformer with the PT100 RTD sensor and transmits the measured values to a remote point by dc current mode signal.

1.4.3 Principle of Operation

The PT100 sensor is mounted in an oil filled pocket located in the hottest oil zone of the transformer. The PT100 resistance in the sensor changes with the change in the top oil temperature. The Transducer (Resistance to Current Converter Unit) measures the variations in the Sensor Resistance (corresponding to the top oil temperature) and produces two independent channels of 4-20 mA dc current output signals directly proportional to the PT100 sensor resistance.

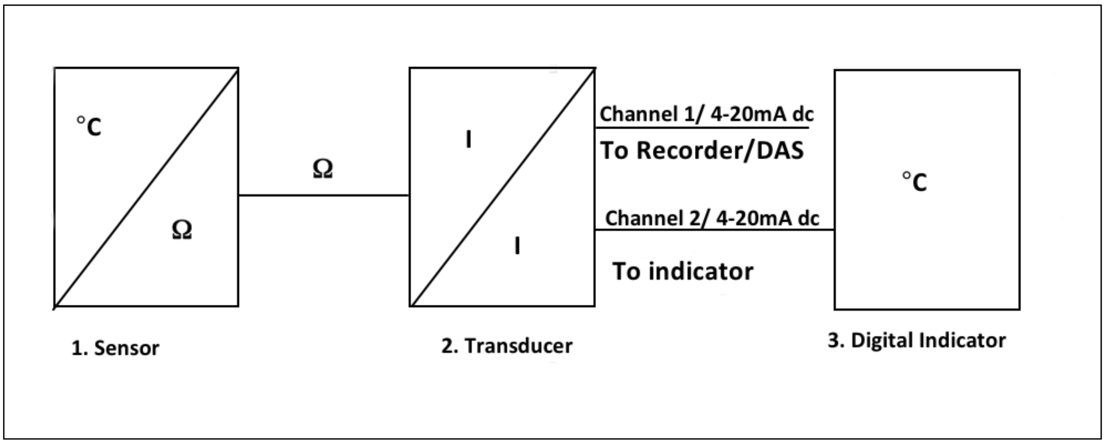


Fig. 2.5: Block Diagram of PT100 ROTI – Dual Output Channel

1.4.4 **Winding Temperature Indicator**

The system measures the Top Oil temperature of oil immersed transformer with the PT100 RTD sensor, simulates the Winding hot-spot temperature with a thermal imaging device & transmits the measured value to a remote point by dc current mode signal.

1.4.5 **Principle of Operation**

Thermal Imaging method:

The PT100 Sensor assembly is mounted in an oil-filled pocket located in the hottest oil of the transformer. A Heater Coil (H) and Shunt (RS) assembly either mounted in the PT100 sensor assembly (as shown in Fig. 2.6) or in the Transducer (as shown in Fig. 2.7) is fed with current from a CT placed in the transformer load circuit. The Heater simulates the hot-spot Temperature rise of the winding over the top oil temperature corresponding to the transformer load current. The PT100 Sensor assembly reacts to this simulated temperature rise in addition to the top oil temperature. To obtain precise thermal image, a portion of the current through the Heater is shunted through a calibrating Shunt Resistor. The thermal time constant of the Heater is nearly the same as that of the transformer winding. Hence, the Sensor assembly simulates closely the actual hot-spot temperature of winding in relation to time.

The Resistance to Current Converter Unit (Transducer) measures the variations in the Sensor Resistance corresponding to top oil plus simulated windings hot spot temperature and produces a directly proportionate two independent channels of 4-20 mA dc current output signals.

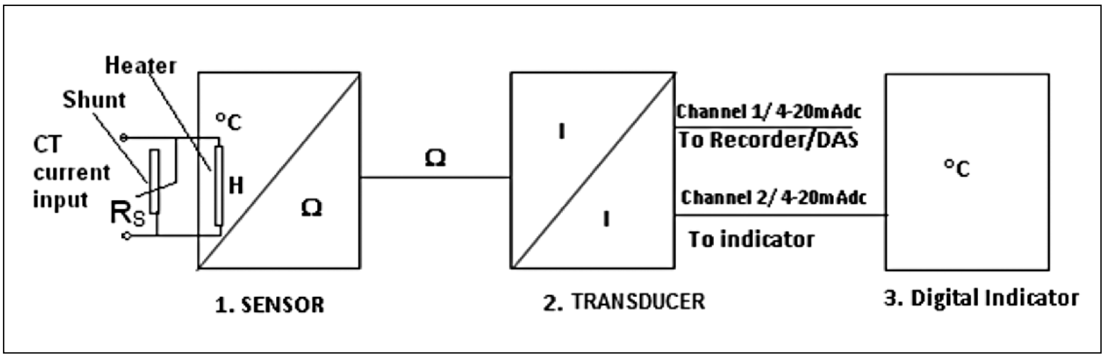


Fig. 2.6: Block diagram of PT100 RWTI – Dual Output Channel Thermal Sensing Method - Scheme 1.

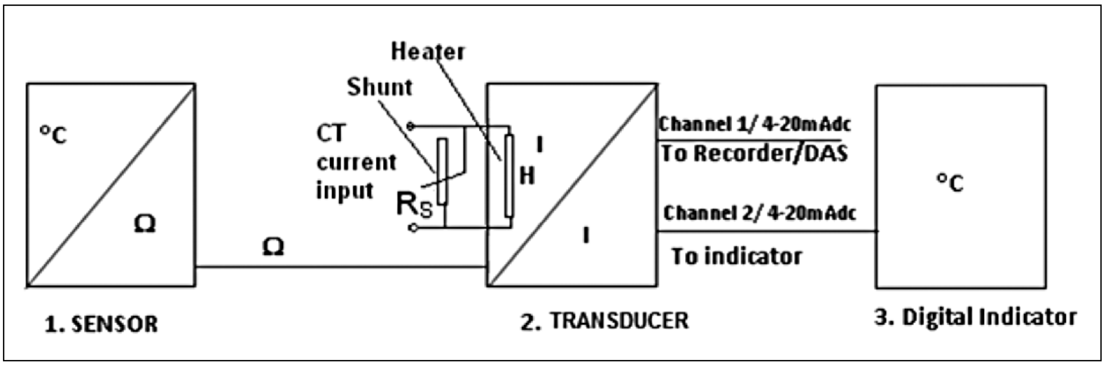


Fig. 2.7: Block diagram of PT100 RWTI – Dual Output Channel Thermal Sensing Method - Scheme 2.

1.4.6 **Data sheet & selection criteria**

Sl No	Description	Specification
1	Sensor	PT100 3-Wire Sensor (Simplex/Duplex)
2	Union	1" BSP Male type union (Fig. 2.8)
3	Sensor	As per figures 2.9 & 2.10
4	Sensing for Winding Hot spot temperature	Thermal Sensing

Sl No	Description	Specification
5	Transducer	Resistance to Current Converter Unit
6	Power Supply	90-260V, ac/dc
7	Analog output	4-20 mA (single / dual optional)
8	Burdon on output	≥ 500 Ω
9	CT input	2 Amp
10	Temperature Rise/Gradient	The standard temperature gradient must be adjustable up to 35°C
11	Accuracy	±0.2 mA at any point of 4-20 mA suitable for 500 Ω burden including loop resistance.
12	Insulation Resistance	≥20MΩ Between Earth to all terminal when measured with 500 V DC Insulation tester
13	Isolation	2500Vrms, AC between Power all terminals to earth for 60 Sec
14	Warm Up time	15 minutes (minimum)
15	Ambient Temperature	0 to 50°C , 45 to 80% RH
16	Storing Temperature	-10°C to 60°C, 25 to 85% RH
17	Range	0-150°C
18	Panel Protection Level	IP40
19	Mounting	DIN Rail / Panel Mounting

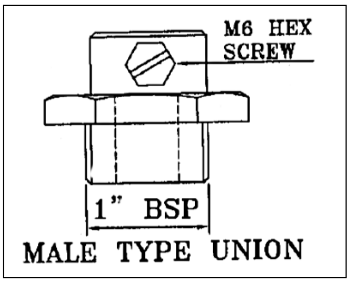


Fig. 2.8

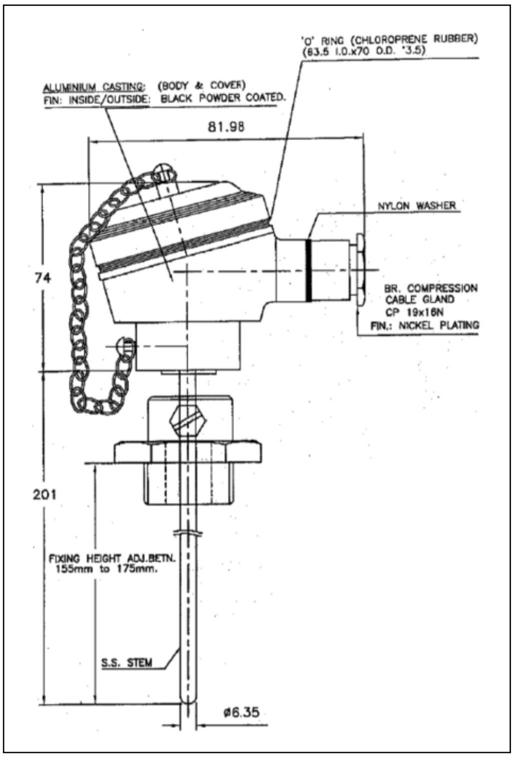


Fig. 2.9 Simplex Type Sensor

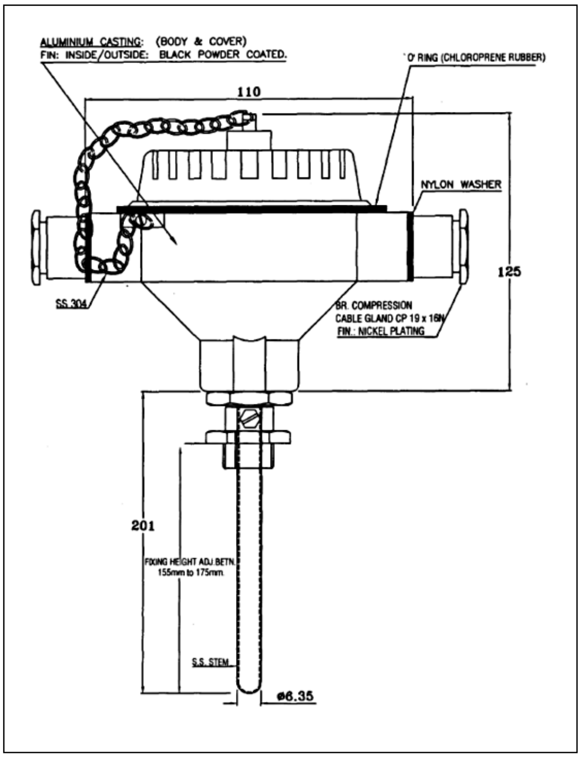


Fig. 2.10 Duplex Type Sensor

1.4.7 Tests

1.4.7.1 Routine Tests

a) Temperature Vs Resistance:

It is checked across PT100 sensor leads from 0-150°C using the test equipment and test procedure as per resistance table Annexed as Annexure 2.4.

b) Temperature Vs Output Signal:

Sensor, heater & shunt connected to Transducer and calibrated to Oil temperature Transmitter to the temperature range 0-150°C Output Signal 4-20 mA DC as per Annexure 2.5.

Accuracy of each channel output signal Q 0.2 mA. Minimum settling time 40 minutes allowed before taking each step reading.

The same system calibrated as Winding Temperature transmitter by passing specified input current through heater & shunt network maintaining bath oil temperature at 80°C constant and allowing 40 minutes settling time as per CT Current Vs Gradient Graph. In the test reports for the system, the bath oil temperature 80°C plus simulated temperature rise for specified input current will be recorded. Accuracy of each channel output signal is ± 0.2 mA.

1.4.7.2 Type Tests

a) High Voltage Test:

Test at 2500 Vrms, 50Hz for 60s.

All Terminals to earth (case)

Power Supply terminals to signal input/output terminals.

b) Insulation Resistance Test:

Measured at 500V dc under normal ambient temperature between all terminals and earth (enclosure) ≥ 20 Mega Ohms.

c) Soak test:

Transducer Unit energized for a period of 72 hrs to simulate normal operating conditions for determining the input and output conditions and the functions performed during this period.

1.4.8 Transportation care

Instruments are to be properly packed with necessary buffers to prevent from any mechanical damage to the Thermal pocket, Transducer enclosure, Terminal block etc

Utmost care to be taken to prevent the instrument from coming in contact with moisture, high temperature and sharp edges.

1.4.9 Storage care

Instrument should be stored in a dry and moisture-free place.

Sensor, Transducer and Digital Indicators should be handled carefully so that they are not subjected to excessive mechanical force / falling down.

Electronic Transducer and digital Indicator are to be stored in cool and dry place away from moisture and heat.

1.4.10 Installation care

PT100 RTD sensor is to be installed in the thermometer pocket of the transformer after filling the pocket with transformer oil in the Pocket up to ¾ level.

Transducer is to be fitted inside the control panel in the DIN rail / Panel mounting.

Digital Indicator is to be fitted on the control panel by inserting it from the front and at the back using the screw fixing clamps.

All the wiring is to be done as per the terminal marking on the instruments.

Recheck the wiring before energizing the transformer specially the power supply connections.

Ensure that the Loop resistance of the interconnecting cables does not exceed the specified burden of the Transducer analog output.

Use independent 2.5 sq. mm cable between PT100 Sensor to Transducer and Digital Indicator.

The 4-20 mA cable from Transducer to Remote indicator/SCADA should not run along with a power cable.

No calibration required to be done at site.

Calibration by user not to be attempted as it may damage the instrument.

2 Fibre Optic Sensors

2.1 Description

Fibre Optic Temperature Monitoring System comprising :

- Fibre optic probes (Installed inside the transformer).
- Tank wall plate.
- External fibre optic extension cable
- Measuring Instrument.
- Instruction Manual.

2.2 Purpose

Direct real time hotspot temperature measurement of windings, oil, and other parts of the core-coil assembly of power transformer.

2.3 Working Principle

Light signal, sent from the FOT instrument excites the sensor mounted at the tip of fibre optic cable (probe). Depending on the temperature at that point, the sensor sends a return signal which is correlated with the corresponding temperature by the FOT instrument and the same is displayed.

2.4 Installations of Sensors

Sensors are placed in direct contact with the insulation of the winding conductors in the regions where the hot-spots are to be measured.

The location for fixing the probes shall be decided by the transformer manufacturer based on the expected location of hotspots and shall be finalized by agreement with the Purchaser.

2.5 Temperature Range

Temperature range of the system should be -30°C to +200°C & accuracy of ± 2°C with no need for recalibration for the entire life time of the FOT system.

2.6 Selection Criteria for number of sensors to be installed

Reference: IEC Standard 60076-2: 2011 (Annex E)

Minimum recommended number of sensors for three-phase transformers						
Rated power MVA	Cooling system	Number and phases of installation				
		Total	On central phase		On each lateral phase	
			HV winding	LV winding	HV winding	LV winding
≥ 100	All system	8	2	2	1	1
From ≥ 20 to < 100	ON - OFF	6	1	1	1	1
	OD	8	2	2	1	1

For single-phase transformers, the minimum recommended number of sensors for each wound column should be those indicated in the table below:

Minimum recommended number of sensors for single-phase transformers				
Rated power MVA	Cooling system	Number of sensors		
		Total	HV winding	LV winding
≥ 50	All system	4	2	2

Besides the above, installation of at least one sensor is recommended for Top Oil temperature measurement.

2.7 **Selection Criteria for Probes**

- The temperature sensing tip along with the fiber optic cable shall be of proven/type tested design.
- They shall withstand exposure to hot kerosene vapour during the transformer insulation drying process (VPD).
- Probes shall be compatible with hot transformer oil.
- The probes shall be partial-discharge-free in the high electrical stress areas inside the transformer.
- Probes shall be all silica, teflon jacketed fibre with perforations / slits in the outer jacket to allow complete oil filling. The fibre with Teflon jacket shall be strong enough to withstand the severe conditions prevailing inside an EHV transformer.
- The Fibre optic cables are to be brought out of the main tank through tank wall plate. The plate shall be welded / bolted on to the tank such that no oil leakage / moisture ingress will occur.
- The tank wall plate shall be covered with a protection-hood to avoid accumulation of dust and water ingress.
- The external fibre optic cable shall then be run to main control cabinet, routed through suitable conduits with large bend radius.

2.8 **Selection Criteria for FOT Measuring Instruments**.

i. **Analog Outputs**
4 - 20 mA output for remote Indication or SCADA.

ii. **Relay Outputs**
Provision of min 6 programmable relays for Alarm/Trip and Cooling Control.

iii. **Communication**
Suitable computer interface and SCADA interface on IEC 61850

iv. **Memory / Data Storage**
Suitable for recording of 3 months data at 1 reading / minute interval.

2.9 **Tests**

a) **At FOS Supplier's Works**

The FOS supplier shall provide the transformer manufacturers with the following test certificates:

Type tests:

- Dielectric tests on probes
- Surge test for FOT measuring instrument as per IEEE C37.90.1-1989

Routine tests:

- Calibration

b) **At Transformer manufacturer's Works during transformer manufacturing**

- Temperature rise (Heat Run) testing if specified by end customer: Measurements shall be made with the FOT measurement system. The equipment shall be operational during temperature rise test and the data shall be recorded.
- Before dispatching the transformer, all probes shall be checked with the same measuring instrument going along with that particular transformer and the temperature data should be recorded.

c) **Inspection and pre-commissioning tests at Site**:

- Check for any physical damage for the entire system.
- Check all probes for functional healthiness and record the temperature readings.

3 Gas & Oil Actuated Relay (Buchholz Relay)

3.1. Description

This is a gas and oil actuated relay for liquid immersed power transformers and reactors with conservator.

The device is intended to detect:

- Gas release from the unit to be protected
- Oil surge from the tank to the conservator
- Complete loss of oil in the conservator

3.2 Principle of Operation

Buchholz relay is completely filled with oil under normal operation of the transformer. In the event of an internal fault in the transformer, gas bubbles are produced in oil, which accumulate in the Buchholz relay. This leads to drop in oil level in the BR, thereby causing operation of the alarm switch contact.

In case the oil continues to drop due to excess gas accumulation, it triggers operation of the trip contact.

3.3 Data sheet

Technical Parameters	
Parameter	Buchholz Relay 80 NB
Mounting arrangement	Ref Fig. 2.12
Liquid in tank	Transformer oil
Operating temperature	-20° to +110° C of oil
Contact system	Magnetic Reed Switch
Type of contact	Ref Fig. 2.11
Contact rating - a.c.	240 V, 2 A
- d.c.	240 V, 2 A
Breaking capacity	400 VA a.c. or 250 W d.c.
Gas volume for alarm	200 to 300 cc
Surge velocity test	120 to 160 cm/s for trip contact
Vibration test	Vibration test at the frequency of 5 to 35 Hz with acceleration up to 6g in all directions.

3.4. Standard wiring diagram

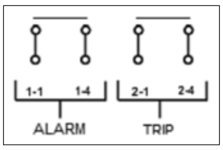
Any one of the following terminal configurations can be selected as per requirement.

The contact position shown below is under normal operating condition of buchholz relay.

3.4.1 Wiring Diagram for Model with 2 NO Contacts

Alarm	1 NO Contact	1 No.
Trip	1 NO Contact	1No.

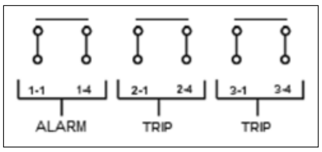
Fig. 2.11



3.4.2 Wiring Diagram for Model with 3 NO Contacts

Alarm	1 NO Contact	1 No.
Trip	1 NO Contact	2 Nos.

Fig. 2.11



3.4.3 Wiring Diagram for Model with 2 Change-over Contacts

Alarm	1 Change-over Contact	1 No.
Trip	1 Change-over Contact	1 No.

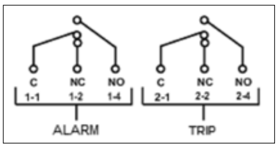


Fig. 2.11

3.4.4 Wiring Diagram for Model with 2 NC Contacts

Alarm	1 NC Contact	1 No.
Trip	1 NC Contact	1 No.

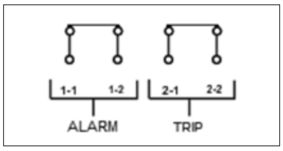


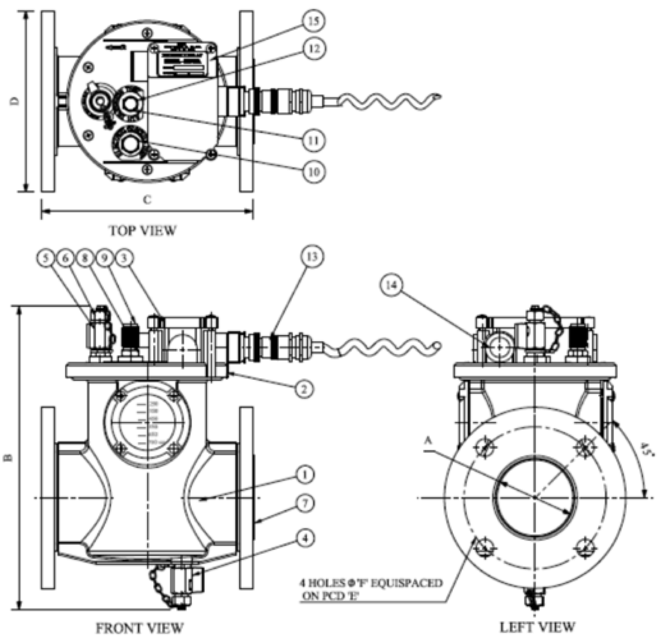
Fig. 2.11

3.5 Selection criteria

- Quantity of oil inside the transformer to be protected

Normally 80 NB size BR is used for power transformers ≥10 MVA rating as per CBIP Publication No. 317.

3.6 Mounting details



BILL OF MATERIAL	
14	Plaster Plug
13	Plug & Socket Assembly
12	Cap for Pneumatic Testing Device
11	Pneumatic Test Device
10	Electric Testing Device
9	Cap for Electric Testing Device
8	Connector 1/8" x 1/8" BSP
7	Plug D83
6	1/4" BSP Cap for Petcock with chain
5	1/4" BSP MX1/4"BSP F Petcock
4	1/4" BSP Petcock
3	Aluminium Terminal Box Cover
2	Aluminium Cover
1	Aluminium Relay Body
Sr. No.	Description

Reference	Pipe Size A	B	C	D	E	F
1	80 NB	312	215	185	145	18

Fig. 2.12: Mounting details

3.7 Tests

3.7.1 Type tests

a) Tests as per IS: 3637

b) Vibration Test at 5 to 35 Hz at 6g acceleration in all directions

c) Degree of protection - IP:67

3.7.2 Routine tests

Test	Test Parameter	Testing Procedure	Pass Criteria
Alarm Test	200 to 300 CC	Gas collection by draining the oil to match reading on scale	As per testing parameters
Trip Test	120 to 160 cm/s	Create the surge to check velocity	As per testing parameters
High Voltage Test	2 kV	a) Applied between terminal to terminal for 1 min b) All terminal shorted with BR for 1 min	No breakdown
Leakage Test / Loss of Oil	Test of Housing with compressed air	To check housing for leakage with compressed air at 2.5 kg/cm^2	No leakage from any point
	Test of assembled Buchholz Relay with Transformer Oil	To check assembled Buchholz Relay for leakage with Transformer Oil at 2.5 kg/cm^2 for 140 hrs	No leakage from any point

3.8 Installation and pre-commissioning checks

a) Transit damage.

b) Dimensional check for installation suitability.

c) Electric contact by operating lever/Push rod provided on the BR.

d) Get all fasteners, gaskets and other tools before taking out BR for the fitment.

e) Check pipe line alignment, gap between pipe line flanges to put BR in position.

f) Hold BR in position with positive inclination of 3° to 7° (see Fig. 2.13 below) to the horizontal axis in the direction of arrow marked on the BR body, provide suitable gaskets and fit the BR with fasteners in the pipe line.

g) Ensure tightness of all the contacts.

h) Connect electrical contacts with battery and check the operation.

i) Fill BR with oil and check tightness of bolted joint for any oil leakage.

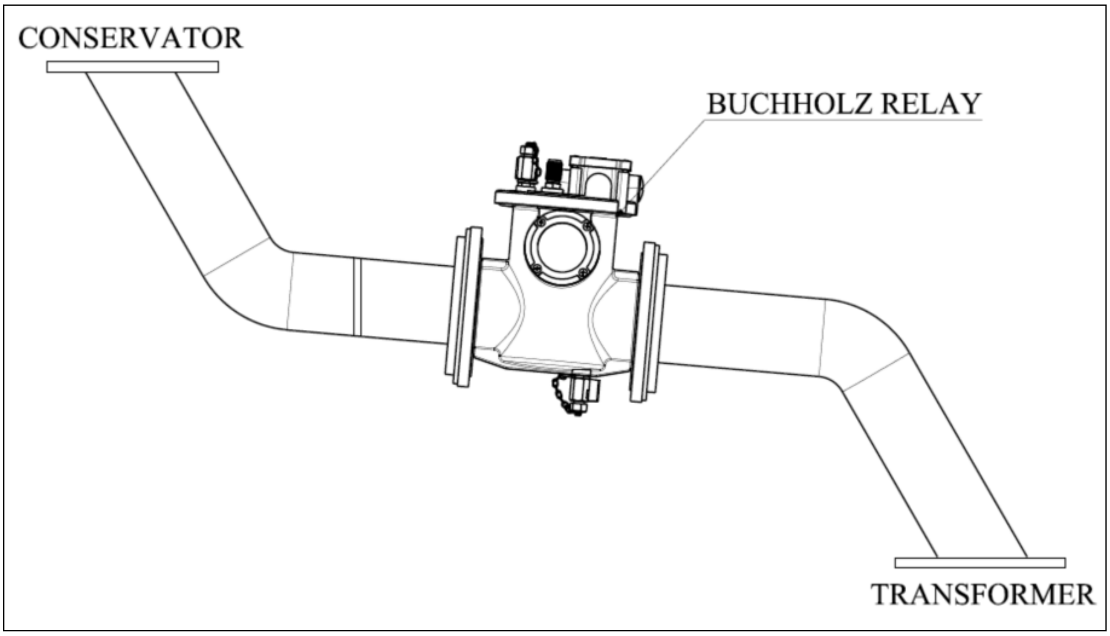


Fig. 2.13: Mounting of Buchholz Relay

4 Pressure Relief Valve (PRV)

4.1 Description

The PRV is suitable for oil filled power transformer. It operates when Pressure in the tank rises above predetermined safe limit and performs the following functions.

No.	Function	Description
1	Relieve Excess Pressure	The PRV instantaneously relieves the oil pressure built inside the transformer tank by lifting the diaphragm resting on the port of about 150 mm diameter and discharges the oil from tank, thus relieving pressure. To avoid oozing of oil, the diaphragm is spring loaded to close the port as soon as the pressure in the tank is relieved.
2	Visual Indication	The PRV gives visual indication of valve operation by raising a flag. Flag remains in operated condition till it is manually reset.
3	Switch Operation	As soon as the PRV is operated it operates an electrical switch (Micro/Limit switch). Switch contacts can be used to give audible alarm or isolate the transformer from circuit. Switch should remain in operated condition till it is manually reset.

4.2 Principle of Operation

A Spring Loaded Stainless Steel diaphragm is used to keep the port opening of about 150 mm diameter of PRV in closed condition. The diaphragm gets lifted from its position as soon as the oil pressure in the tank rises above predetermined operating pressure and releases the oil / vapour to relieve pressure in tank. The lifting of diaphragm operates electrical switch & flag. The Switch & Flag remain in operated condition till they are manually reset.

4.3 Data Sheet

Parameters	Values
Liquid in Tank	Transformer Oil
Mounting	On Tank cover or side wall i.e. Horizontal or Vertical On 6 Studs of M12 Equally spaced on 235 PCD
Port Opening	Nominal 150 mm Diameter with spring loaded Diaphragm.
Operating Pressure	0.42, 0.49, 0.56, 0.7 kg/cm^2 (any one value, shall be specified by the transformer manufacturer)
Operating Tolerance	± 0.07 kg/cm^2
Operating Time	Instantaneous
Valve Resetting	Automatic
Visual Indication	By flag
Visual Indicator Resetting	Visual Indicator Resetting Manually
Operating Temperature	0 to 100 °C (of Liquid on Tank)
Duty	Outdoor / Indoor
Contact system	Micro switch
Type of Switch	2 NO + 2 NC
Rating of Switch	Micro Switch – 5A, 240V AC / 0.2 A , 240V DC
Switch Resetting	Manual
Mounting Gaskets	Nitrile Rubber Gasket of suitable size to fit on PRV Groove
Cable Entry	Hole with 3/4” Conduit threads for cable gland
Degree of Protection	IP 67
Hardware	Stainless Steel
Rain Protection Cover	Metallic Type

4.3.1 **Shroud**

Shroud with pipe connecting flange can be used to avoid spilling of discharge from PRV.

Flange of shroud can be connected through 360 degrees orientation in horizontal plane.

This arrangement can avoid injury to person and also avoids pollution.

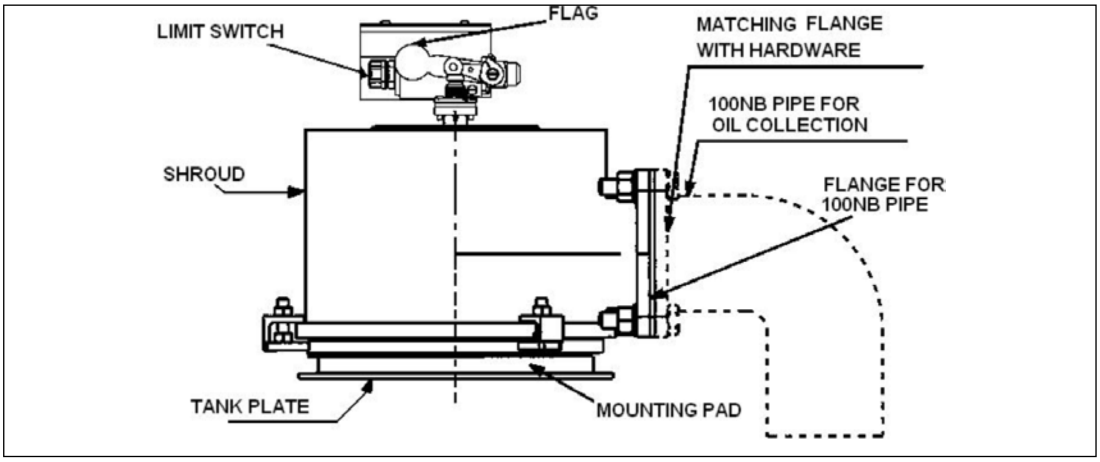


Fig. 2.14: PRV with shroud

4.3.2 **Weather proof plug & socket arrangement for connecting cable** :

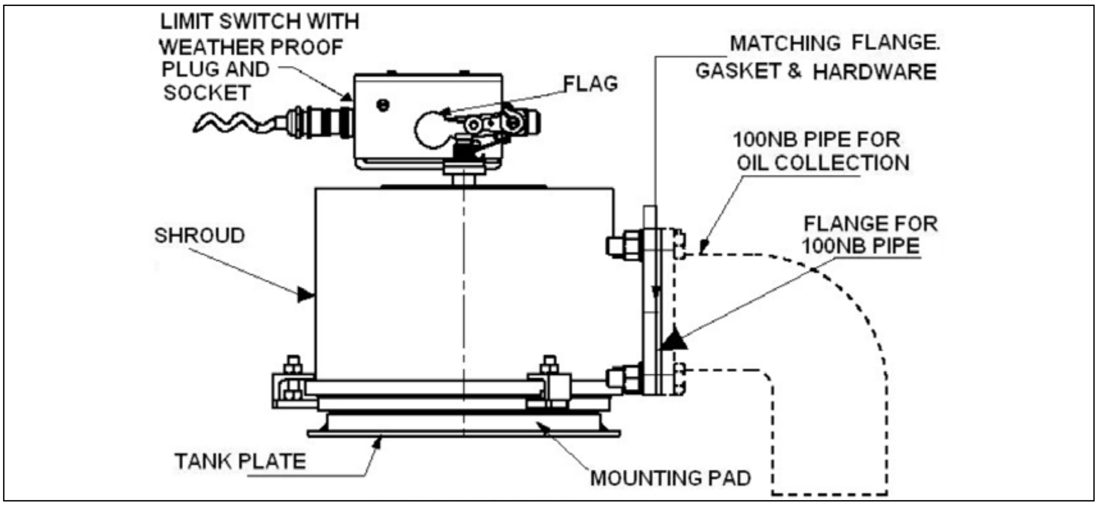


Fig. 2.15: PRV with shroud with weather proof plug and socket arrangement for connecting cable

4.4 **Standard wiring diagram**

Any one of the following terminal configurations can be selected as per requirement.

The contact position shown below is under normal operating condition of PRV.

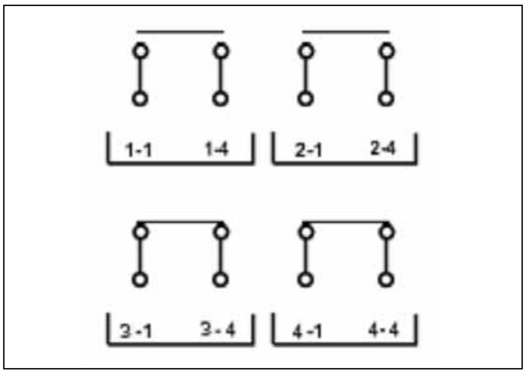


Fig. 2.16: Wiring diagram for Model with 2 NO + 2 NC Contacts

4.5 Selection criteria

- Operating Pressure

4.6 Tests

4.6.1 Routine tests

TEST	DESCRIPTION
Operation of PRV	Operation of PRV at specified Pressure with compressed air
Power Frequency Test	Power frequency test at 2.5 kV, 50 Hz for one minute from switch terminals to other parts of PRV
Insulation Resistance	Test between Terminal to Body –Should not be less than 100 MΩ at 500V
Leakage Test	Leakage test at 75 % of operating pressure with air for 24 hours

4.6.2 Type test

PRV to be tested for IP:67.

4.7 Installation and pre-commissioning checks

Check transit damage
Dimensional check for installation suitability.
Get all fasteners, gaskets and other tools before taking out PRV for the fitment.
Take gasket with 6 holes, 14 diameter on 235 mm PCD
Ensure tightness of all the contacts
Connect electrical contacts with battery and check the operation

5 Magnetic Oil Level Gauge (MOG)

5.1 Description

A magnetic oil level gauge (MOG) is provided on the transformer conservator for indication of oil level in the transformer. A float is used as a device for indication of oil level inside the conservator on a calibrated dial gauge. The dial is marked as "EMPTY", "¼", "½ (or 35°C)", "3/4" and "FULL". Calibration of marks "EMPTY" and "FULL" (Fig. 2.17) is done after leaving 65 mm from the bottom and the top of the conservator to avoid striking of the float to the conservator oil.

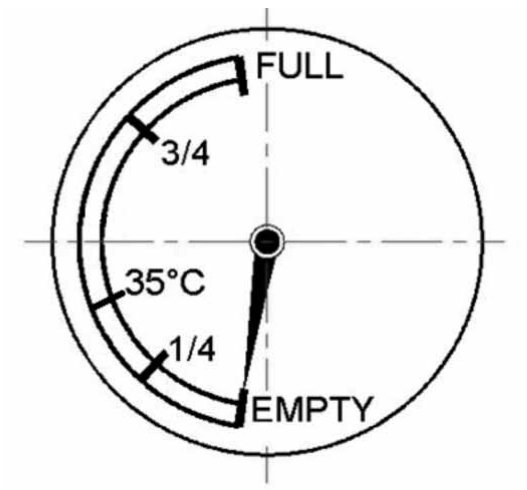


Fig. 2.17

5.2 **Principle of Operation**

Magnetic Coupling: The float touches the oil surface level and it moves up and down with change in the level of oil. Transfer of float movement to the pointer provided on the dial gauge by use of pair of permanent magnets (Fig. 2.18).

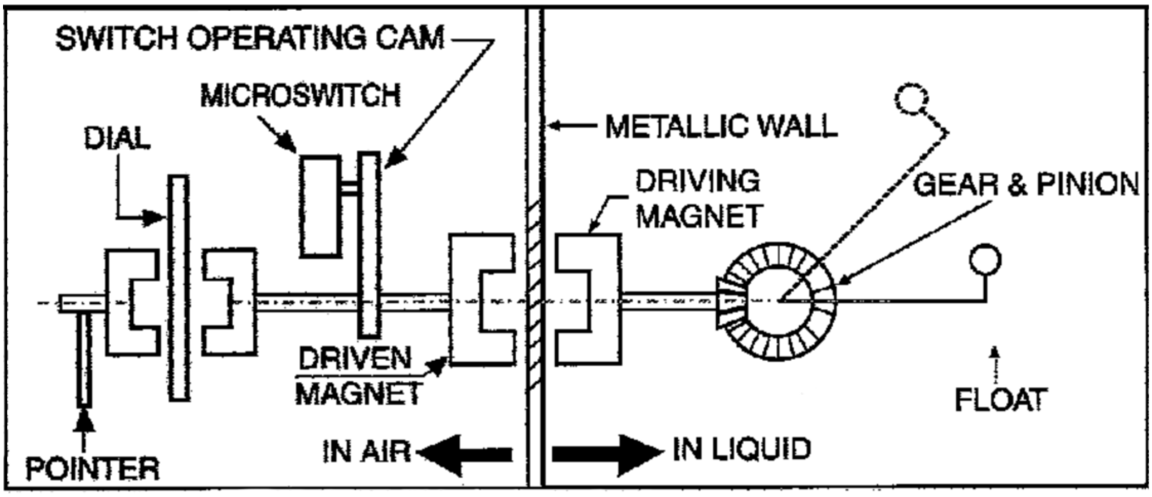


Fig. 2.18

5.3 **Data sheet**

Technical Parameters	
Parameter	**MOG (For Main / OLTC Conservator)**
Liquid in tank	Transformer oil
Dial size	100mm/150mm/250mm
Operating temperature	-30° to +120°C of oil
Pressure	0 to 1kg/cm^2
Contact system	Micro switch
Type of contact	Normally open
Contact rating	240 V, 5 A AC
	240 V, 0.2 A DC
No of contacts	1No. (for LOLA)/ 2 Nos. (for LOLA, HOLA)
Contact Position	Normally Open at Filling Level
Colour of marking	Black markings on white background
Pointer	Black
Material	Float - Brass, Float arm - SS

5.3.1 Mounting:

MOG for conservator with aircell

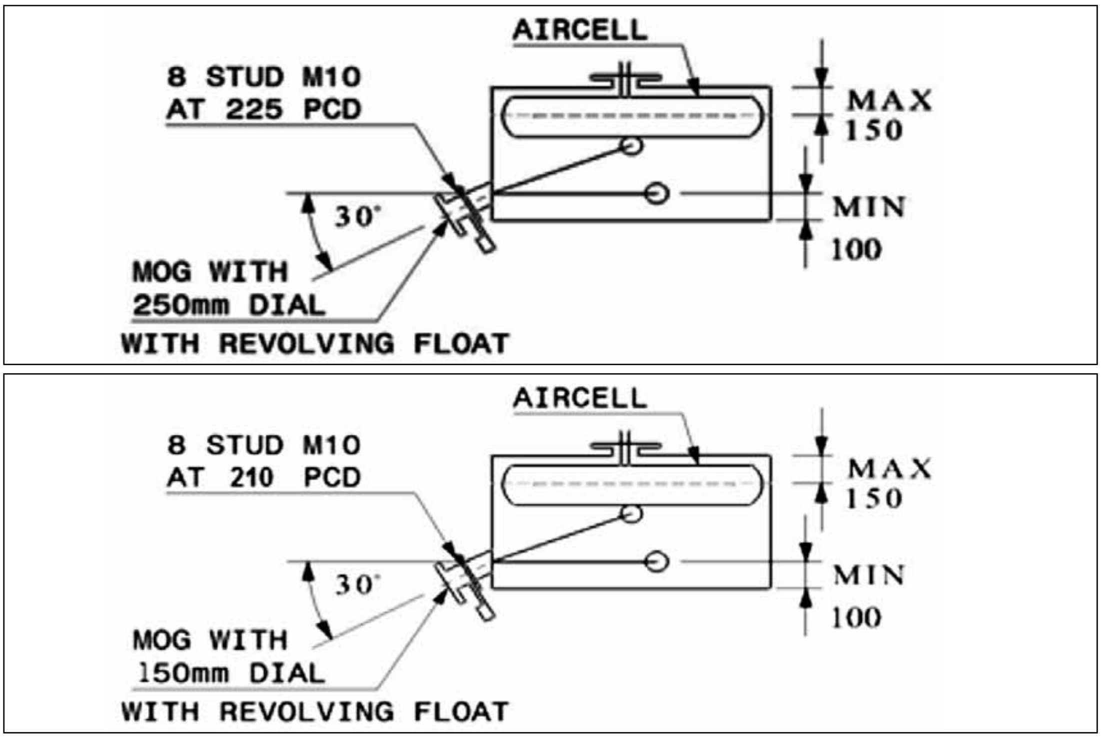


Fig. 2.19

MOG for conservator without aircell

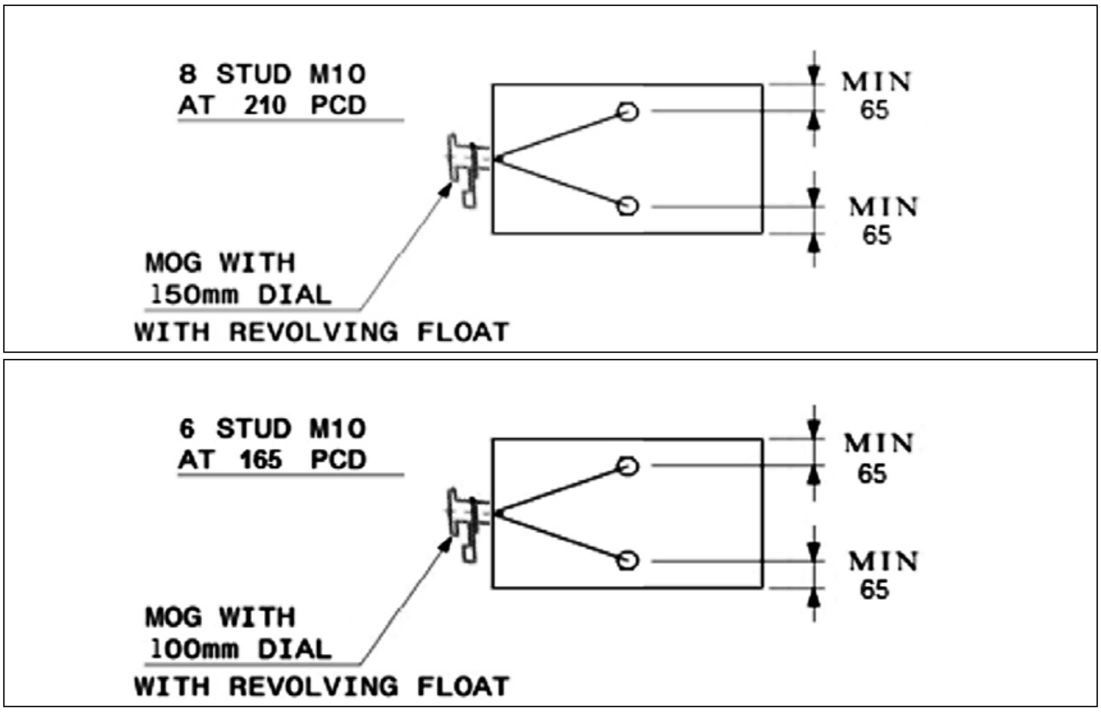


Fig. 2.20

Variable Parameters (to be provided by Transformer manufacturer)

1. Diameter of conservator (in mm)
2. Application : for main / OLTC conservator
3. Average ambient temperature.

4. Float Arm Length (FAL) FAL to be selected from table below

Sr. No.	Conservator diameter Ø	F.A.L. for 30 degree inclined mounting	F.A.L. for vertical mounting
1	350	N/A	156
2	750	707	438
3	800	778	474
4	900	919	545
5	1000	1060	615
6	1200	1343	757
7	1300	1485	827
8	1400	1626	898
9	1600	1909	1040

5.3.2 **Method of Cable Termination**

Weatherproof Plug & Socket arrangement for cable

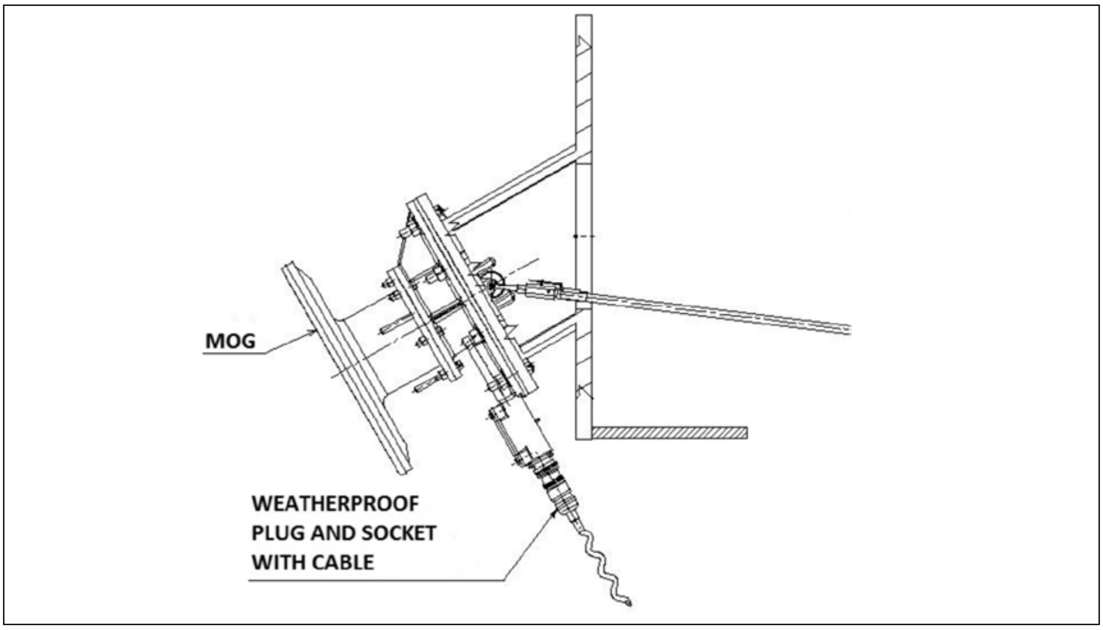


Fig. 2.21

5.4 **Standard wiring diagram**

Any one of the following terminal configurations (Fig. 2.22 and Fig. 2.23) can be selected as per requirement.

The contact position shown below is for normal operating condition of MOG.

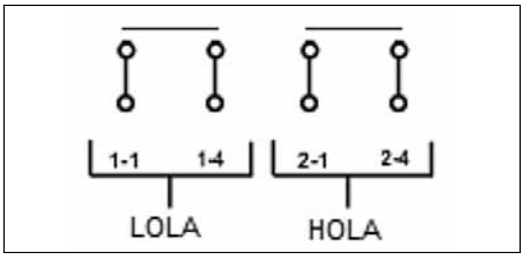


Fig. 2.22: Wiring Diagram for Model with 2 NO Contacts

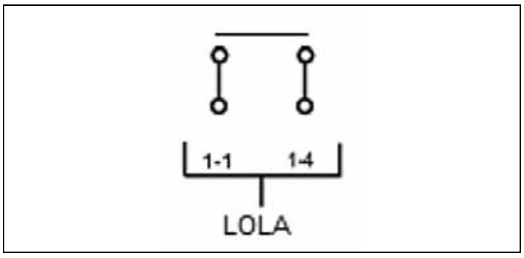


Fig. 2.23: Wiring Diagram for Model with 1 NO Contact

5.5 **Selection criteria**

- Type of conservator (for Main or OLTC conservator)
- Diameter of conservator
- No. of contacts required
- Dial size of MOG

5.6 **Tests**

5.6.1 Routine tests

a) Leak test at 2 kg / sq cm for 2 min. at ambient temperature.

b) Float position shall be calibrated to the diameter of conservator and the dial of MOG.

c) Position of low oil level alarm to be checked.

d) Power frequency test at 2.5 kV, 50 Hz for 1 minute from switch terminals to other parts of MOG.

e) Insulation Resistance Test between Terminal and Body; it should not be less than 100MΩ at 500V.

f) Micro switch at 5 amps, 240 V AC.

5.6.2 Type tests

Degree of Protection - IP67.

5.7 **Installation and pre-commissioning checks**

a) Take 8 studs of M10 with nuts & washers.

b) Take gasket with 8 holes, 12 mm dia on 225 mm PCD.

c) Mount the MOG as shown in Mounting arrangement diagram (Fig. 2.19 and Fig. 2.20).

d) Handle the MOG float & float-arm carefully being delicate items.

e) Ensure tightness of all the contacts

f) Connect electrical contacts with battery and check the operation

6 **Oil / Water Flow Indicators (FI)**

6.1. **Function**

The function of Flow indicator is:

- To indicate the flow of oil / water in pipeline in required direction.
- To operate two switches, first, when the rate of flow drops to 80% & second, when the rate of flow further drops to 70%.

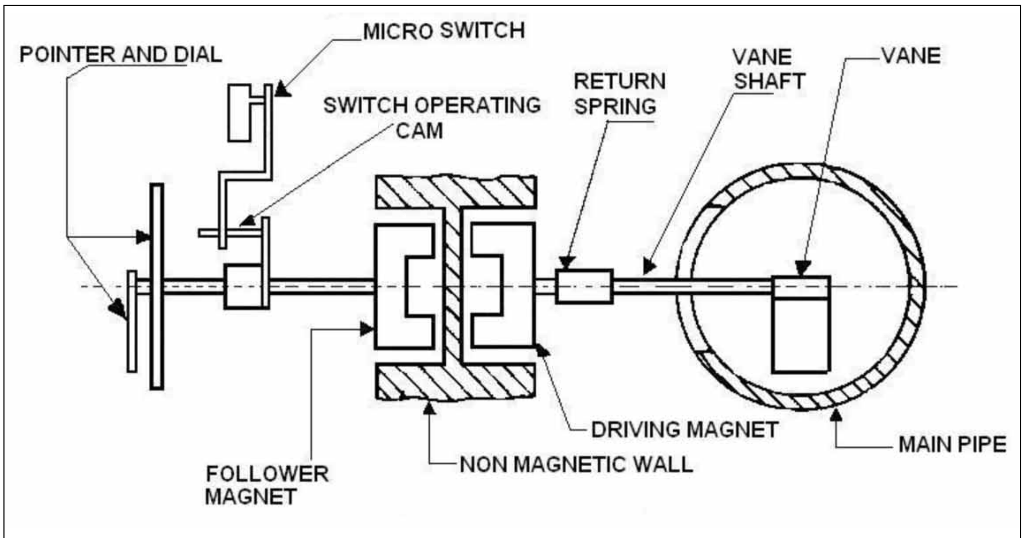


Fig. 2.24

6.2 **Principle of Operation**

Magnetic Coupling

A metallic spring loaded vane is kept suspended in the pipe (Fig. 2.24). The vane deflects, when the flow of liquid strikes. The vane & return spring remain inside the liquid. A pointer is linked to vane with the help of a pair of permanent magnet. Thus, the pointer follows the deflection of vane. Pointer & vane mechanism are separated by a non magnetic metallic solid wall to avoid leakage of liquid in pipe. Two switches are provided which operate at 80% & 70% respectively when rate of flow starts dropping.

6.3 **Data Sheet**

Parameter	Specification
Liquid in pipe	Oil or Water
Rate of full flow	Of liquid in pipe in LPM
Pipe size	Nominal Bore in mm
Direction of flow	Any one from the following - Left to Right - Right to Left - Vertically Up - Vertically Down
No of contacts	Two
Type of contacts	NC (Open at full flow)
Contact rating	5 A, 240 V AC & 0.25 A, 240 V DC
Two micro switches for operation at	80% & 70% of full flow

First and second contacts get closed when flow drops at 80% & 70% of full flow respectively.

6.4. **Dial**

Parameters

- 100 mm round
- Back markings on white dial
- Black Pointer

Markings on dial

- Indication markings: FULL FLOW, NO FLOW (Fig. 2.25)
- Other markings - Pipe size, Value of Full Flow, Liquid in pipe & Direction indicating arrow.

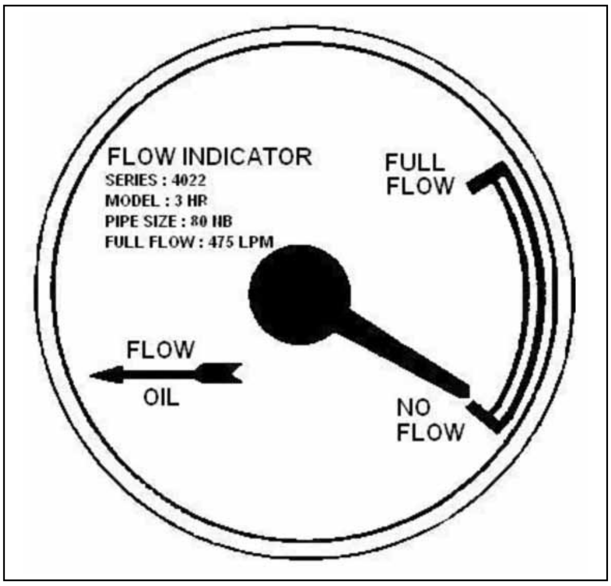


Fig. 2.25

6.5 Standard wiring diagram

Any one of the following terminal configurations can be selected as per requirement.

The contact position shown below is under normal operating condition of flow indicator.

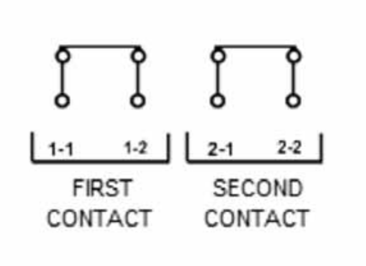


Fig. 2.26: Wiring Diagram for Model with 2 NC Contacts

6.6 Tests

6.6.1 Routine tests

- Leakage test at 7 kg / cm^2
- Flow: Full Flow test as specified by buyer.
- Switch operation at 80% & 70% when rate of flow is dropping
- Power frequency test between live terminals to body at 2 kV for 2 minutes

6.6.2 Type tests

Degree of Protection - IP 67.

6.7 Mounting

6.7.1 "T" Mounting

When a flange matching with holes of FI & projecting from the pipeline, "T" Mounting is provided. The FI is installed on the T mounting. After mounting, the vane of FI is positioned in Centre of pipe.

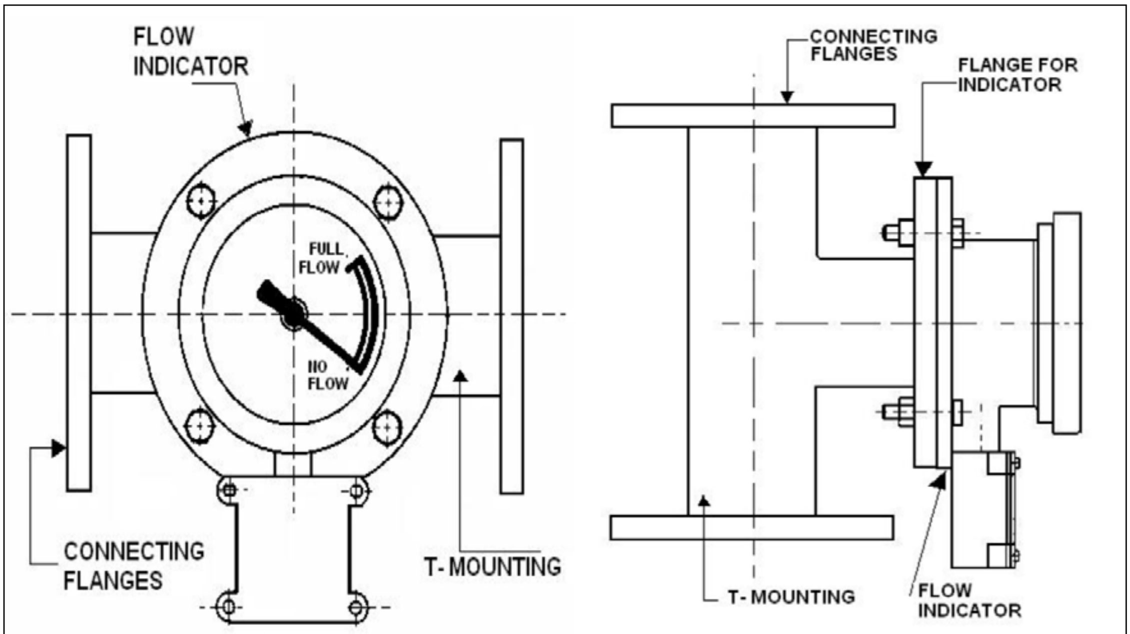


Fig. 2.27

6.7.2 Weatherproof Plug & Socket arrangement for cable

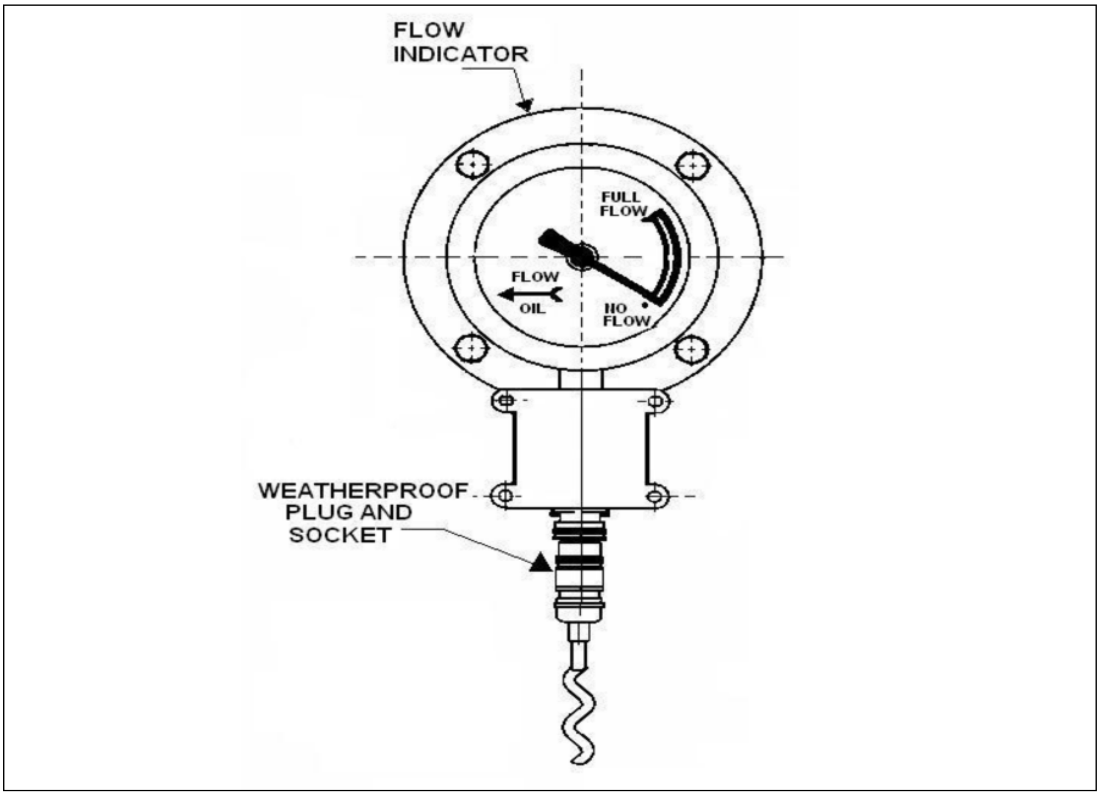


Fig. 2.28

6.8 **Installation and pre-commissioning checks**

a) Take FI with suitable gasket, 4 bolts with nuts & washers of M12

b) Install the FI so that dial is in erect position.

c) Make electric connection with a cable gland

d) Ensure tightness of all the contacts.

7 Air Cell or Flexi-separator

7.1 Description

The flexible separator is a sealed envelope made from nylon fabric coated with synthetic elastomer nitrile and hot vulcanized. The separator is installed inside the conservator and fitted to it through the flange connected to the plate of the manhole.

7.1.1 Schematic diagram of Air Cell

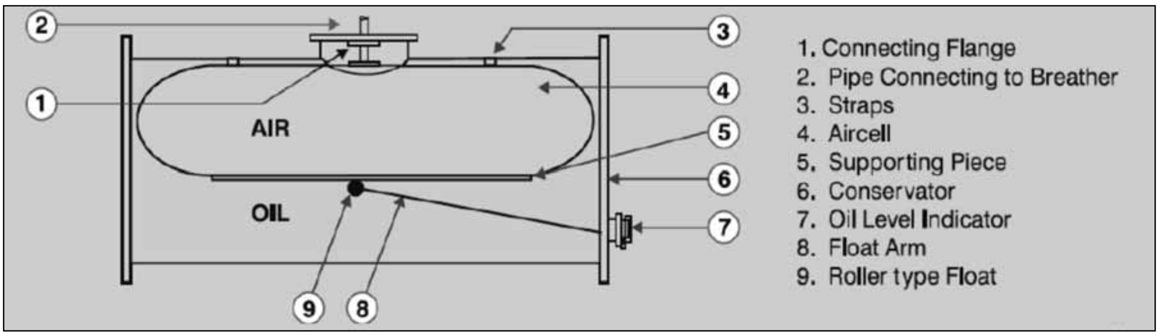


Fig. 2.29: Schematic Diagram of Aircell

7.1.2 Drawing of Air Cell

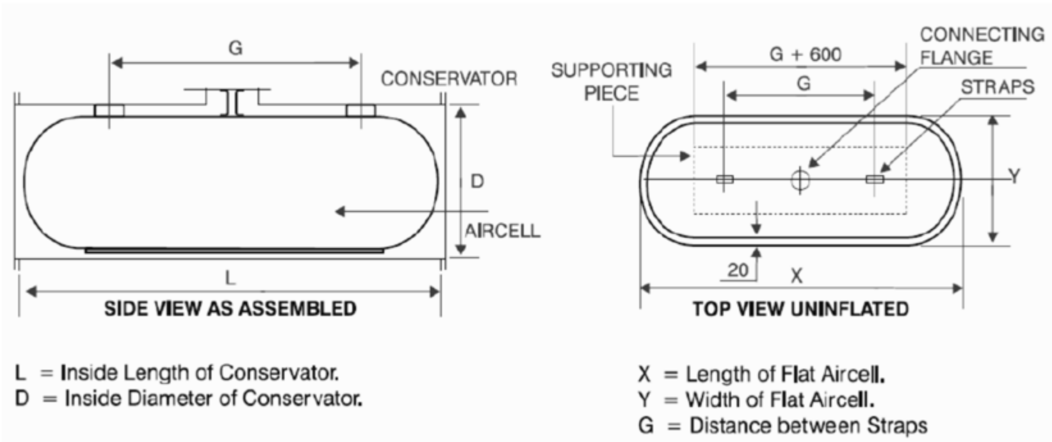


Fig. 2.30: Drawing of Air Cell

7.1.3 Selection of Air Cell

Requirement can be specified by giving dimension of X, Y & G (calculated as per formula given below)

Formula: **Y** = (3.142 x D)/2 + 40 mm, **X** = L - D + Y, **G** = X - Y - 200

Example: For Conservator of 700 dia x 2000 long
Values will be X = 2240, Y = 1140, G = 1100

7.1.4 Connecting Flange

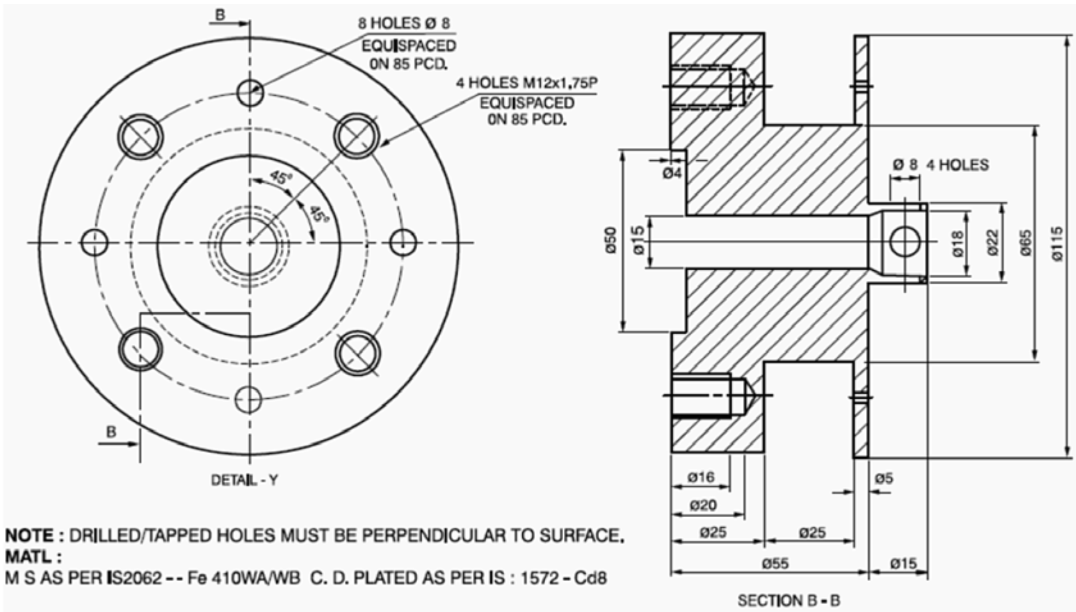


Fig. 2.31: Connecting Flange

7.2 Standard sizes of Air Cell

Standard Sizes of Air Cell								
Sr. No.	F S P - Size	Expansion Volume (litres)	Conservator			Aircell Size (mm)		
			Dia (mm)	Length (mm)	Volume (litres)	Length	Width	"G"
1	500 - 500	500	500	2710	530	3035	825	2010
2	500 - 600	500	600	1970	560	2352	982	1170
3	750 - 600	750	600	2850	810	3232	982	2050
4	750 - 700	750	700	2180	840	2620	1140	1280
5	1000 - 700	1000	700	2830	1090	3270	1140	1930
6	1000 - 800	1000	800	2260	1130	2757	1297	1260
7	1500 - 800	1500	800	3250	1630	3747	1297	2250
8	1500 - 900	1500	900	2660	1690	3214	1454	1560
9	2000 - 900	2000	900	3440	2190	3994	1454	2340
10	2000 - 1000	2000	1000	2880	2260	3491	1611	1680
11	2500 - 1000	2500	1000	3520	2760	4131	1611	2320
12	2500 - 1100	2500	1100	3000	2850	3668	1768	1700
13	3000 - 1100	3000	1100	3520	3350	4188	1768	2220
14	3000 - 1200	3000	1200	3050	3450	3775	1925	1650
15	4000 - 1200	4000	1200	3940	4450	4665	1925	2540
16	4000 - 1300	4000	1300	3450	4580	4232	2082	1950
17	5000 - 1300	5000	1300	4200	5580	4982	2082	2700
18	5000 - 1400	5000	1400	3710	5720	4549	2239	2110
19	6000 - 1400	6000	1400	4360	6720	5199	2239	2760
20	6000 - 1500	6000	1500	3900	6880	4796	2396	2200

7.3 Tests

7.3.1 Routine tests

Coated fabric

- Mass surface
- Tearing strength
- Breaking strength
- Elongation
- Adhesion

Basic fabric

- Breaking strength
- Elongation

Finished Product

- Pressure testing by compressed air
- Leakage testing

7.3.2 **Type tests**

Coated fabrics

- Heat ageing
- Compression test
- Low temperature, flexibility
- Sludge content
- Acidity
- Ozone resistance
- Air permeability
- Bursting strength

7.4 Installation care

7.4.1 Assembly of Air Cell inside conservator

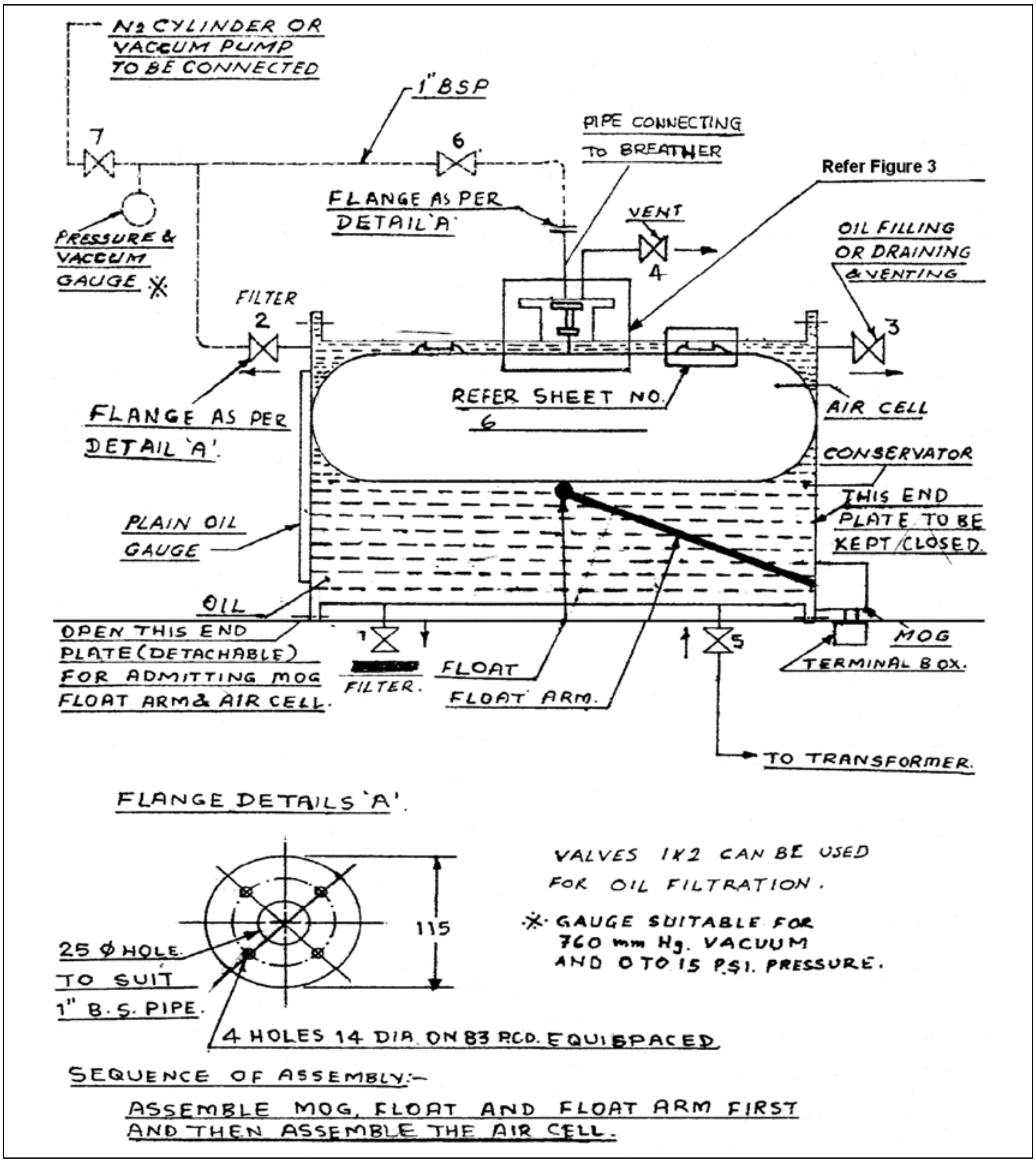


Fig. 2.32: Aircell inside the conservator

Refer Fig. 2.32 for general arrangement of Conservator and Aircell. Valve No. 1, 2, 3, 4 & 5 are fitted with direction marked next to the valve.

Remove the detachable end cover of the conservator as shown in Figure 2.32.

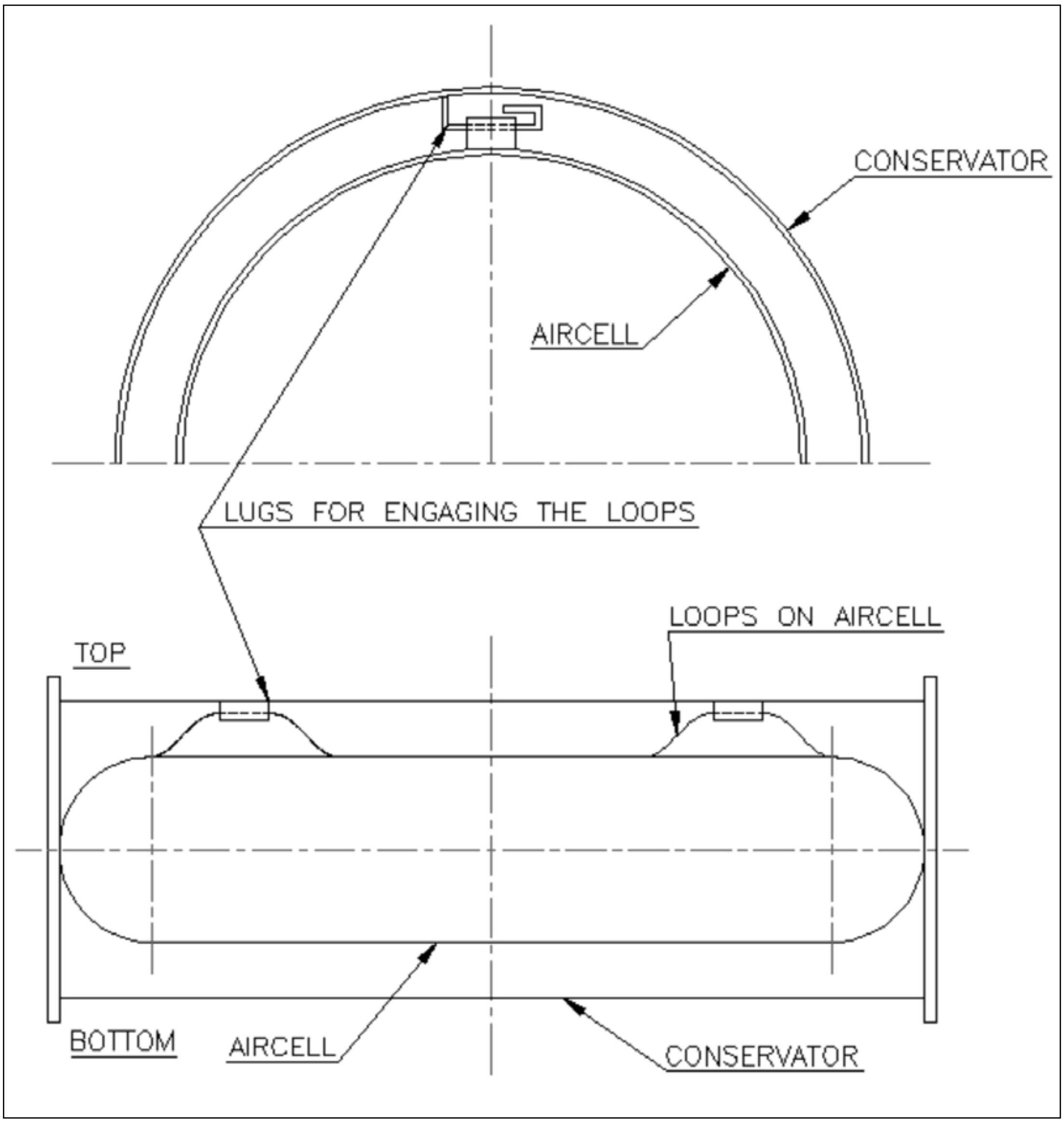


Fig. 2.33: Loops on the Aircell with the hooks inside the conservator

Assemble the Oil Level Indicator (MOG) as shown at location shown in Figure 2.32. Terminal box of the MOG should be vertically below the indicator dial. Carefully attach the float and float arm to MOG. Air cell, MOG, float and float arm are delicate, utmost care should be taken while assembly to avoid even slightest damage.

After the assembly of air cell and MOG are over, clean the conservator inside surface with clean cloth. Do not use cotton waste. Refit the detachable end cover.

Now the conservator is ready for installation in position and also for oil filling.

Before installing in position, check the air cell for any leakage as under.

It is to be noted that pipes, valves, pressure gauge shown in dotted line and N2 cylinder and vacuum pump are not supplied by manufacturer of these instruments. These should be made available at site, keeping in mind that oil filling of the conservator is to be done after installing the same in proper position.

7.4.3 Leakage Test of Air Cell

Inflate (fill) the air cell at a max, of 2 psig through valve 6 (use N_2 gas) while leaving a vent hole i.e. valve 4 open.

Adjust the pressure after 6 hours (i.e. pressure to be retained at 1 psig). Check the temperature and maintain the air cell at that temperature for 24 hours. Watch the possible loss of pressure during that period. If there is no loss of pressure during 24 hours, this means the setting of air cell inside the conservator and also the air cell is considered leak tight. This also ensures that all gaskets joints are leak tight. Assemble the conservator at proper position.

7.5 Oil filling under Vacuum

Use transformer oil for filling. This oil should be same as used for transformer filling.

Fill oil into the conservator upto Filling Level on MOG via 'B' relay pipe, valve 5 by pumping the oil from bottom of the transformers.

Keep air cell open to atmosphere by opening valve 6 & 7 to atmosphere. Open also valve No.2 so that pressure inside the conservator and air cell will be same. Connect valve 7 to vacuum pump. (Valves 6 & 2 open) Valves 3 & 1 closed.

Pull the vacuum up to 760 mm Hg simultaneously to air ell and conservator. When 760 mm vacuum is achieved close valve 2

Push oil through valve No.5 till the MOG shows Full oil level.

Close valve 6, 2, & 3 and connect N2 cylinder to valve 7.

Maintain conservator under vacuum and admit N_2 into air cell at a max, of 1 PSIG through valve 6. Then the air cell inflate by itself and takes all the free space due to the fact that the conservator was not completely full. Fill the conservator till the moment the oil is going to rise to the top of conservator. Continue to admit nitrogen into air cell at one psig and simultaneously drain oil from valve 3.

Drain the oil up to filling level. Immediately close Valve 3 and check that all the valves and openings on conservator except valve 5 are closed.

Connect air cell to silica gel breather.

Caution

When the assembly is ready to work, it is important not to open vent holes / valves on upper part. Plain oil gauges are usually provided on the opposite end of MOG on conservator. These gauges might show full irrespective of oil level in conservator. Hence refer MOG reading for checking the oil level in the conservator.

8 Conservator Protection Relay (CPR) / Aircell Puncture Detection Relay

8.1 Description

Conservator protection relay (CPR), also called Air cell puncture detection relay, is a single-float type relay to provide a signal in case of puncturing of air cell.

8.1.1 Schematic diagram of Conservator Protection Relay

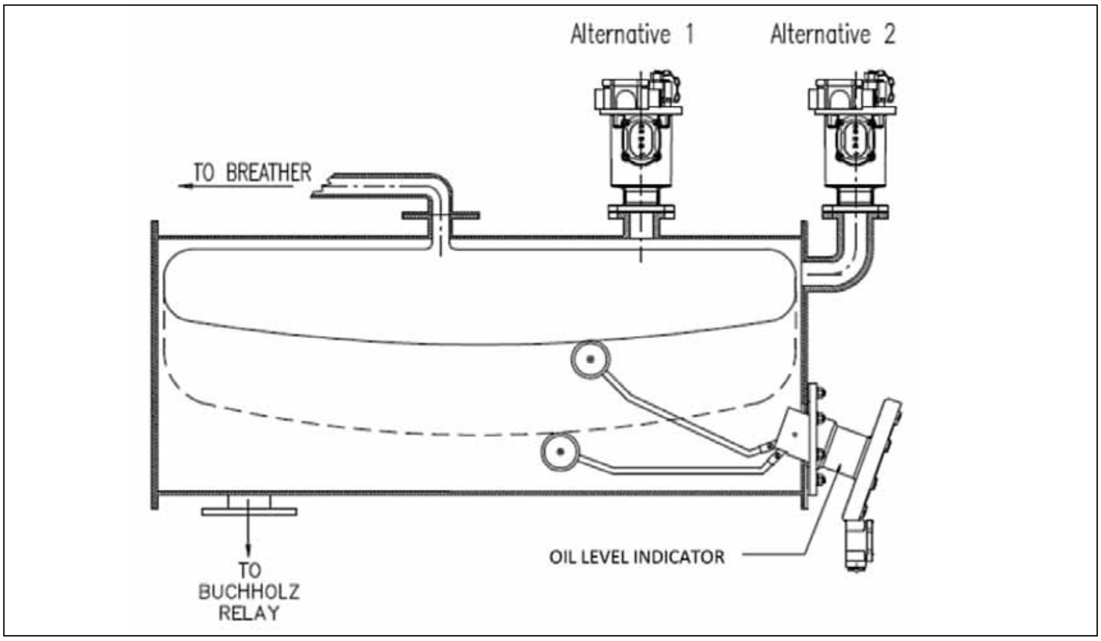
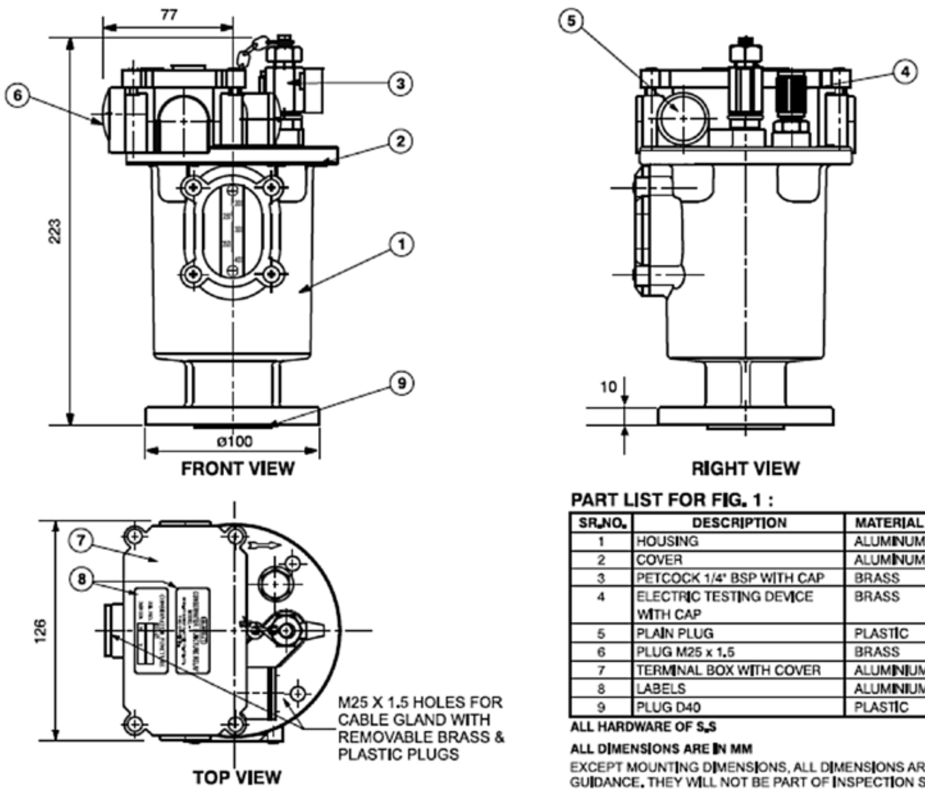


Fig. 2.34: Schematic Diagram of CPR

8.1.2 Drawing of Conservator Protection Relay



PART LIST FOR FIG. 1 :

SR.NO.	DESCRIPTION	MATERIAL	QUANTITY
1	HOUSING	ALUMINUM	1
2	COVER	ALUMINUM	1
3	PETCOCK 1/4" BSP WITH CAP	BRASS	1
4	ELECTRIC TESTING DEVICE WITH CAP	BRASS	1
5	PLAIN PLUG	PLASTIC	1
6	PLUG M25 x 1.5	BRASS	1
7	TERMINAL BOX WITH COVER	ALUMINIUM	1
8	LABELS	ALUMINIUM	2
9	PLUG D40	PLASTIC	1

ALL HARDWARE OF S.S

ALL DIMENSIONS ARE IN MM

EXCEPT MOUNTING DIMENSIONS, ALL DIMENSIONS ARE GIVEN FOR GUIDANCE. THEY WILL NOT BE PART OF INSPECTION SCHEDULE

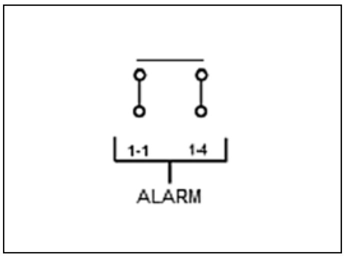
Fig. 2.35: Drawing of Conservator Protection Relay

8.1.3 **Standard wiring diagrams**

Choose any one model out of the following options.

Contact position is shown in healthy condition.

8.1.3.1 **Model with 1 NO contact**



8.1.3.2 **Model with 1 change over contact**

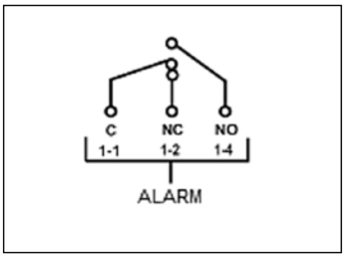


Fig. 2.36: Standard wiring diagram

8.1.4 **Mounting details**

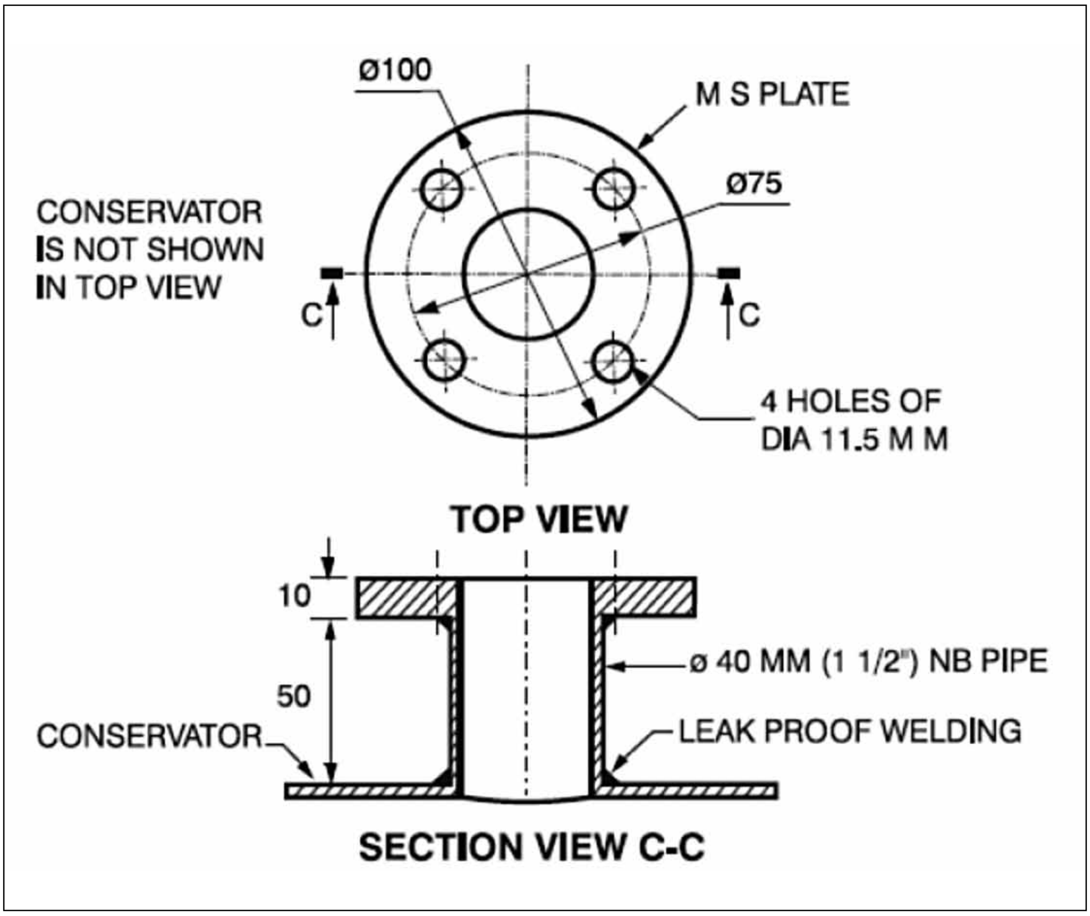


Fig. 2.37: Mounting details of CPR

8.2 Data sheet

Parameter	Specification
Model	Refer Fig. 2.36 Standard wiring diagrams
Mounting arrangement	Refer Fig. 2.37
Liquid in tank	Transformer oil
Operating temperature	-20 °C to +110 °C of oil
Environment	Indoor or Outdoor
Contact system	Magnetic Reed Switch
Type of contact	As per wiring diagram (Figure 2.36)
Contact rating - a.c.	240 V, 2A for point 1.3.1
	240V, 1A for point 1.3.2
- d.c.	240 V, 2 A for point 1.3.1
	240 V, 1 A for point 1.3.2
Breaking capacity	400 VA a.c. or 250 W d.c.
Gas volume for Alarm	400 +/- 50 cc
Ingress protection	IP 67
Vibration test	Vibration test at the frequency of 5 to 35 Hz with acceleration up to 6g in all directions

8.3 Tests

8.3.1 Routine tests

Test	Testing Parameter	Testing Procedure	Observations
Trip Test	400 +/- 50 cc	Gas collection by draining the oil to match reading on scale	As per testing parameters
High Voltage Test	2 kV	a) Applied between terminal to terminal for 1 minute b) All terminals shorted with body for 1 minute	No breakdown
Leakage Test / Loss of Oil	Test of Housing with compressed air	To check housing for leakage with compressed air at 2.5 kg/cm^2	No leakage from any point
	Test of assembled CPR with transformer oil	To check assembled CPR for leakage with transformer oil at 2.5 kg/cm^2	No leakage from any point

8.3.2 Type tests

To be carried out at third party laboratory at an interval of 5 years.

i) Vibration Test.

ii) Ingress Protection Test - IP 67

8.4 Pre-commissioning tests

Following checks/test to be carried out on delivery at site.

i. Transit damage.

ii. Dimensional check for installation suitability.

iii. Terminal connections as per order specification.

iv. Electric contact by operating provided device. (Lever / Push rod)

8.5 **Installation care**

i. Get all fasteners, gaskets and other tools before taking out CPR for the fitment.
ii. Check mounting flange dimensions to put CPR in position.
iii. Mount CPR in such a way that the Glass Window is visible from outer side and fix it with the fasteners.
iv. Connect electrical contacts with battery and check the operation.

9 Removable Radiators for Oil-immersed Transformers

9.1 Description

Radiators, i.e. the thermal exchangers, are used for cooling of transformer oil with natural ambient air circulation. Such radiators are made of several elements with cooling channels connected in parallel.

This specification defines the overall dimensions and ensures the mechanical interchangeability achieving the same thermal performances.

9.2 Reference Standard

BS EN 50216-1:2002 & IEEMA 9

9.3 Data sheet

Material and other general construction shall be as follows:

No.	Technical Parameter	Specification
1.	Section Width / Channels / Flutes	520mm / 21 to 28.
2.	Centre distance between top and bottom header pipes (CC)	- 2000 mm to 4500 mm in step of 100 mm. - Tolerance : ±3 mm - Pipe size : Up to 3000 mm : 80 NB Above 3000 mm : 100 NB
3.	Number of Sections	4 to 40
4.	Pitch	Minimum 45 mm with a tolerance of ±1 mm.
5.	Flanges	STEP Flange of 18 mm thickness.
6.	Bracing Straps/Rods:	- Size : 8/10 mm - Material : Bright round mild steel - No of pairs : 5 pairs for CC 2800 mm to 3500 mm 6 pairs for CC above 3500 mm
7.	Lifting lug Tying lug	- Up to 3000 mm :50x65x12, ϕ 25 mm - Above 3000 mm :100x85x12; ϕ 50 mm - 60x40x8 mm, ϕ14 mm
8.	Materials	a) Radiator Sections: CRCA sheet conforming to Gr D of IS 513 - Up to 3000 mm : 1.0 mm (Tol. ± 0.05 mm) - Above 3000 mm : 1.2 mm (Tol. ± 0.05 mm) b) Header Pipe (Top & Bottom): 90 mm OD pipes of ERW/ CRCA tubes of 2.5 mm thickness (as per IS 1239) c) End Cap : 60x40x8 mm; ϕ 14 mm d) Air Release and Drain plug: 1/2 inch BSP e) Sealing for plug: Teflon washer / Nitrile 'O' ring f) Bracing Bar: 8/10 mm dia weldable structural steel round bars conforming to Fe410WA of IS 2062.
9.	Width-wise top & bottom edge sealing of fin	TIG Welding / GTAW
10.	Header pipe to fin throat sealing	TIG Welding / GMAW
11.	Assembly weld tacking	TIG Welding / GMAW
12.	Leak repairs	Oxy Acetylene gas welding
13.	Surface preparation for painting	SA 2 ½
14.	Painting	a) Internal surface: Flush coated with phenolic-based hot oil- resistant varnish b) External surface: Epoxy Zinc primer – DFT 60 microns PU Finish paint – DFT 40 microns Total (minimum) - DFT 100 microns *Note: Zinc chromate is not recommended as it is carcinogenic.*

Abbreviations: MIG – Metal Inert Gas, GMAW – Gas Metal Arc Welding, TIG – Tungsten Inert Gas, GTAW – Gas tungsten Arc Welding, MMAW – Manual Metal Arc Welding.

9.4 Tests

Description	Test Type	Standard Specification
Type Test	a) Vacuum Test - Vacuum - Deflection b) Pressure Test	 10 Torr Deflection not to exceed +0.5 mm. At 200 kPa for 3 hours at 60 °C (± 5 °C) oil temperature
Routine Test	a) Dimensional b) Leakage	- At air pressure of $2kg/cm^2$ for a minimum period of 30 minutes

10 Automatic Voltage Regulating Relay (AVR)

10.1 Description

AVR is used for regulating the secondary voltage of power transformer with on-load tap changer. The required dead-band settings are set by setting the nominal value and L & R levels independently. The Time Delay setting on the front panel eliminates the relay operations for momentary fluctuations of the regulated voltage, thus reducing the number of operations of the tap changer.

When the regulated voltage falls below the specified Under Voltage limit, the control relays are automatically blocked i.e. there is no voltage correction, and a pair of relay contacts is made available for alarm.

10.2 Principle of Operation

The dead-band (bandwidth) can be set by setting the nominal value (NVA) to the required value and then setting the L & R limits around the NVA.

The desired time delay can be set on the front panel and the control action will take place only if the voltage continues to remain outside the dead-band after the time delay has elapsed. For voltage corrections requiring more than one tap change, time delay is initiated again before further tap change. The relay is reset automatically after the voltage is brought within the selected dead band. The time delay is effectively reduced to provide a voltage time integral response of the regulator for repeated short duration voltage fluctuations on the same side of the dead-band.

Operation of the Raise Control Relay is automatically inhibited when the voltage falls below the specified under voltage limit or it fails. One pair of normally open relay contacts are provided to effect the tap change during Raise and Lower operation and to trigger an alarm in case of Under Voltage / P.T. fail conditions.

10.3 Data Sheet

10.3.1 Option 1: Standard AVR without communication ports

S. No.	Feature	Standard
1	Aux. Supply	90-260V AC/DC
2	PT Supply	110V AC, 2.5VA
3	Nominal Voltage adjustment	+/-10% of PT supply (continuous)
4	Sensitivity (Dead Band)	1 V to 9.9 V (continuous)
5	Time delay setting	Voltage independent, 10 to 120s in steps of 1s
6	Time delay resetting	Instantaneous resetting with voltage deviation in opposite direction
7	Under voltage blocking	Internal blocking at 80% and restoration at 85% of nominal voltage

8	Control relays		One pair of NO potential free contact 5A at 230V AC
9	Control operation		Single pulse operation with 2s (approx.) on-time.
10	Terminal block numbers		Terminal block nos. as shown in Cl. No. 10.4
11	Type of terminal block numbers		Combicon type terminal blocks suitable for 2.5 Sqmm cable (external).
12	Cut-out dimensions		185 (W) x 90(H) mm
13	**Optional Features**		
	13.1	Line drop compensation (optional)	With CT current input of 1A; %R & %X setting to be set in '%'
	13.2	AVR control fail relay	One pair of NO potential free contact 5A at 230V AC
	13.3	Under voltage relay	One pair of NO potential free contact 5A at 230V AC
	13.4	Aux. supply fail relay	One pair of NO potential free contact 5A at 230V AC
	13.5	PT supply fail relay	To be incorporated in control scheme
	13.6	AVR fail **	One pair of NO potential free contact 5A at 230V AC
		** One LED shall be provided for "AVR HEALTHY" display	

10.3.2 Option 2: AVR with communication ports

In addition to the features covered in Option-1, following additional features are to be provided:

a) Communication Interface for SAS (Substation Automation System) - through both RJ45 (Ethernet) & FO Cable with IEC 61850 Protocol.

b) Tap Position No. Display with inputs of both 4-20 mA & Resistance of 1 kilo ohm per step

c) 1 no. 4-20 mA output for TPI.

d) OLTC Operation Counter for each tap at the remote.

e) Real Time Voltage Display (kV) as per the PT input at the remote.

10.4 Termination details

S. No.	Function	Connection Pins
1.	Auxiliary Input	1-2
2.	PT Input	3-4
3.	CT Input	5-6
4.	Auxiliary supply Fail Relay (AFR) (NC)	7-8
5.	Lower Relay (NO)	9-10
6.	Raise Relay (NO)	11-12
7.	Under Voltage (UV) / PT Fail (PTF)	13-14
8.	Control Fail Relay (CFR) (NO)	15-16
9.	1 Kilo Ohms per step input for TPI	17-18
10.	4-20 mA Input for TPI	19-20
11.	4-20 mA Output for TPI	19-20

10.5 Tests

10.5.1 Routine tests

a) Contactor (Raise / Lower) Operation

b) Time Delay Calibration

c) Functional Check of AVR fail / Aux. supply fail relays

d) LDC Module Calibration

e) Burn-in test

f) 2kV Test

10.5.2 **Type tests**

a) Dry Heat test at 50°C for 3 hours.

b) Cold test at -20°C for 3 hours.

c) Vibration test at 10-55 Hz, displacement +/- 0.75 mm (p-p), duration 15 min./axis (X, Y, Z).

d) Bump test (packed condition): Acceleration 40g, Pulse duration 6ms, Normal axis, 1000 bumps.

e) EMI / EMC Test specifications : BS EN61326 : 1998

Set up as per

i. EMI / EMC Test specifications : BS EN61326 : 1998
ii. EMI / EMC Test specifications : BS EN61326 : 1998
iii. EFT : As per BS EN61000-4-4, 1995
iv. Radiated Susceptibility : As per BS EN61000-4-3, 1995

10.6 Installation and pre-commissioning checks

a) Check the proper electrical earthing.

b) Use shielded cable for input signals.

c) Ensure that input signal and power cables are isolated.

d) Make sure the proper supply voltage is applied.

e) Switch off the power supply while wiring.

f) Ensure tightness of all the contacts.

11 Transformer Fire Protection System

11.1 Nitrogen Injection Fire Prevention System (NIFPS)

11.1.1 Description

This standard lays down the specification for Nitrogen Injection Explosion prevention and Fire Extinguishing system for oil cooled transformer/ reactor. Dedicated Nitrogen injection system is used to :

- Prevent transformer tank explosion and possible fire, in the event of internal fault and as such it acts as fire preventer.
- Also act as firefighting system

System comprises Cubicle (installed near the transformer), Control Box (installed in control room), Conservator isolation valve (installed in conservator pipe line), Fire detectors (on transformer top cover), Piping for oil and nitrogen, Copper Cables.

11.2 Reference Standards

a) Central Electricity Authority, The Gazette of India, Extraordinary 2010

b) Technical standards for constructions of sub-stations and switchyards

c) Technical standards for construction of Thermal Generating Stations

d) Safety provisions for electrical installations and apparatus of voltage exceeding 650 volts

e) CBIP Manual on Transformers - Publication no. 317

11.1.3 Principle of Operation

Depressurization process commences through oil drain and simultaneously nitrogen is injected at a pre-determined flow rate to create stirring action and to bring down temperature of top oil below ignition point, evacuates gases formed thereby preventing explosion of tank and in case of fire, it extinguishes fire within minimum 30 seconds. During fault condition, system operates and conservator isolation valve blocks oil flow to isolate conservator tank oil. Also in case of fire, it prevents escalation of fire.

The system comes in to operation automatically / remotely / manually under following conditions.

Auto Mode

a) For Prevention of Fire, signals in series :
   - Differential Relay Operation,
   - Buchholz Relay paralleled with Pressure Relief Valve or RPRR (Rapid Pressure Release Relay)
   - Tripping of all connected breakers (HV & LV side) is a pre-requisite for initiation of system activation.

b) For Extinguishing Fire, signals in series :
   - Fire Detector,
   - Buchholz Relay paralleled with Pressure Relief Valve or RPRR.
   - Tripping of all connected breakers (HV & LV/IV side) is a pre-requisite for initiation of system activation.

Manual Mode (Remote)

- Tripping of all connected breakers (HV & LV/IV side) is a pre-requisite for initiation of system activation.

Manual Mode (Mechanical)

- Tripping of all connected breakers (HV & LV/IV side) is a pre-requisite for initiation of system activation.

The system shall be designed to be operated manually (oil draining and N_2 injection) in case of failure of power supply to the system.

11.1.4 Sequence of Operation

After receipt of operating signals, sequence of operation will be as shown in figure 2.38.

11.1.5 System features

- System shall have interlock to ensure operation of system only after transformer electrical isolation to avoid nitrogen injection in energized transformer.
- Pressure monitoring switch for back-up protection for nitrogen release as redundancy to first signal of oil draining commencement for Nitrogen release shall be provided.
- Nitrogen release scheme shall be designed in such a way that the nitrogen gas shall not enter the energised transformer/reactor tank even in case of passing/leakage of valve.
- System shall have provision of testing during commissioning, during annual maintenance and on live transformers to ensure healthiness at all times.

11.1.6 Selection Criteria

Transformer Rating	Capacity of Nitrogen Cylinder	Depressurization Scheme
Above 10 MVA & below 100 MVA	6/10 m^3 gas at pressure of 150 kg/cm^2	Oil drain pipe size 80mm
100 MVA and below 250 MVA	10 m^3 gas at pressure of 150 kg/cm^2	Oil drain pipe size 125mm
250 MVA and above	20 m^3 gas at pressure of 150 kg/cm^2	Oil drain pipe size 125mm

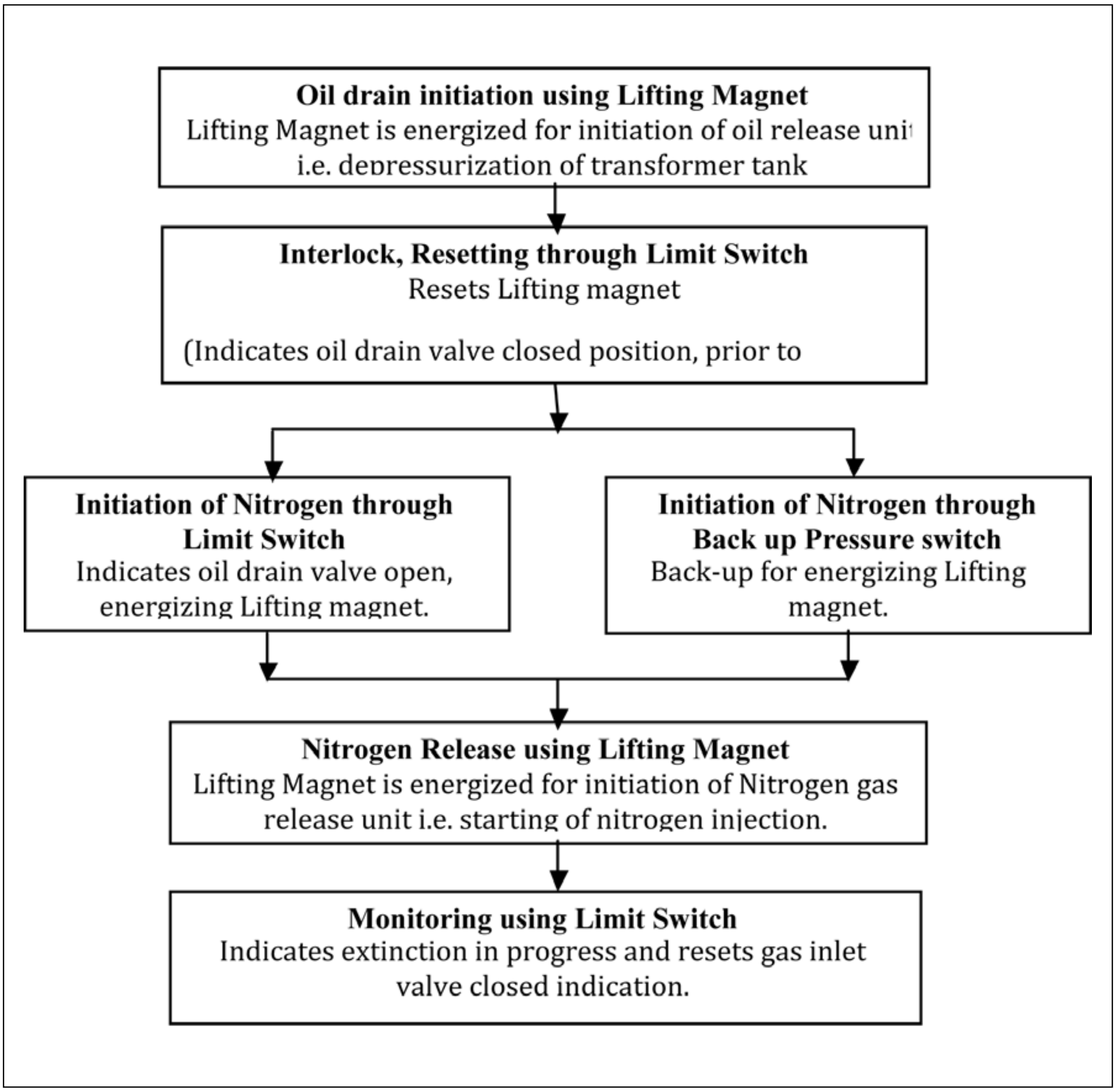


Fig. 2.38: Flowchart showing sequence of operation

11.1.6 Provisions on Transformer tank for Fitting N2 System

Sr. no.	Transformer rating	Oil Drain Gate Valve	N2 Injection Valve	Quartz Fire detector on top cover	Conservator isolation valve arrangement between bu-chholz and conservator.
1	Above 10 MVA and below 100 MVA	Size 80 mm : 1No.	Size 25 mm: 4 to 6 Nos, Maximum	8 to 12 nos.	Dummy pipe 80/50 mm
2	100 MVA and below 250 MVA	Size 125 mm : 1No.	Size 25 mm: 6Nos, Maximum	12 to 16 nos.	Dummy pipe 80 mm
3	250 MVA and above	Size 125 mm : 1No.	Size 25 mm: 6 to 8Nos, Maximum	16 to 20 nos.	Dummy pipe 80 mm

Mounting support/ frame on any tank side wall for signal box shall be provided.

11.1.7 Data Sheet

Sr. No.	Description	Specifications
1.	Type and Model	Nitrogen Injection Explosion Prevention and Extinguishing System for transformer rating a) Above 10 MVA & below 100 MVA b) 100 MVA and below 250 MVA c) 250 MVA and above
2	Details of system equipments	Cubicle, Control Box, Conservator Isolation Valve, Signal Box and Fire Detectors.
3	Cubicle, split door	
3.1	Dimensions (LXBXH) mm	a) For above 10 MVA & below 100 MVA 1200 x 500 x 1900/1700 b) For 100 MVA and below 250 MVA 1200 x 500 x 1900 c) For 250 MVA and above 1600 x 600 x 1900
3.2	Weight	a) & b) 500 kg (Approx.) c) 600 kg (Approx.)
3.3	Capacity and quantity of Nitrogen cylinder	a) & b) Above 10 MVA & below 250 MVA : Minimum 1 no. 10 m^3 gas at pressure of 150 kg/cm^2 c) 250 MVA and above : Minimum 2 no. 10 m^3 gas at pressure of 150 kg/cm^2
3.4	Pressure of Nitrogen filing	Maximum 150 kg/cm^2
3.5	Minimum distance of FE cubicle from the transformer	5 M or beside fire / safety wall
3.6	Method of mounting	Floor / Plinth
3.7	Items provided in the cubicle	
3.7.1	Contact manometer	For showing nitrogen cylinder pressure. Falling pressure, Electrical contact, dual indicator for actual pressure as well as level for low pressure signal.
3.7.2	Pressure Regulator With safety relief valve to increased temperature variation compensation.	Inlet pressure : 150 kg/cm^2 (+/- 10%) Outlet pressure range : 8 to 12 kg/cm^2
3.7.3	Pressure gauge	For showing nitrogen injection pressure.
3.7.4	Oil Release Unit and suitable to operate without power	Electro- mechanical type, operating on substation DC supply as well with provision for operation using manual lever in case of DC supplier loss. It shall have mechanical locking arrangement to ease in maintenance and avoid unnecessary operation during maintenance test.
3.7.5	Gas release unit and suitable to operate without power	Electro- mechanical type, operating on substation DC supply as well with provision for operation using manual lever in case of DC supplier loss. It shall have mechanical locking arrangement to ease in maintenance and avoid unnecessary operation during maintenance test.
3.7.6	Oil drain assembly	Electro- mechanical type, operating on substation DC supply as well with provision for operation using manual lever in case of DC supplier loss.

Sr. No.	Description	Specifications
3.7.7	Pressure monitoring switch as backup in addition to signal from limit switch to initiate nitrogen release simultaneously with oil drain commencement.	Provisions of Limit switch with Pressure Switch (Back up)
3.7.8	Limit switches with No of contacts & spare contacts (NO&NC)	1. Oil drain Valve closed. (G02), 2 NO 2. Oil drain Valve open.(G03), 2 NO 3. Gas valve closed.(G04), 1NO+ 1NC 4. Gas injection started.(G04), 1NO+ 1NC 5. Oil drain unit locked mechanically. (G05) 2NO/1NC+1NO 6. N_2 release unit locked mechanically.(G06) 2NO/1NC+1NO
3.8	Oil drain Valve (above cubicle) for system isolation from transformer	
3.8.1	Material and Type	Mild steel, Butterfly valve
3.8.2	Size	a) Above 10 MVA & below 100 MVA : 80 mm b) 100 MVA and below 250 MVA : 125 mm c) 250 MVA and above : 125 mm
3.9	Nitrogen Injection Valve (above Cubicle) for system isolation from transformer	
3.9.1	Material and Type	Gun metal, Lockable, Stem rising
3.9.2	Size	25 NB
3.10	Oil drain pipe size	a) Above 10 MVA & below 100 MVA : 80 mm b) 100 MVA and below 250 MVA : 125 mm c) 250 MVA and above : 125 mm
3.10.1	Length and Number of openings in the transformer tank	As per site location, Transformer to cubicle & cubicle to oil pit, 1 no.
3.10.2	Material	MS, ERW, Heavy duty for TRS to cubicle & GI, Medium for cubicle to oil pit.
3.11	Degree of protection	IP 55
4	Control Box	
4.1	Dimensions (LXBXH) mm	500 x 270 x 700
4.2	Weight	45 kg maximum
4.3	Type & Thickness of sheet steel	CRCA, 16/14 SWG
4.4	Details of components provided in the control box	MCB, Relays, Hooters, Contactors, Indicating lamps, Operating switches.
4.5	Control voltage	110 / 220 VDC / Substation voltage. AC-DC / DC-DC converter, timer shall not be used for reliable operation.
4.6	Method of mounting	Wall / Frame
4.7	Whether audio and visual alarms provided?	Yes with different volume (dB) levels
4.8	Degree of protection	IP 42
5	Conservator Isolation Valve	
5.1	Type	Operating mechanically on Transformer oil flow rate with visual position indicator.
5.2	Location	Horizontally in the conservator pipe line between Conservator and Buchholz relay.

Sr. No.	Description	Specifications
5.3	Whether suitable for pipe of size 80mm dia	As per transformer conservator pipe size i.e. 80 mm or 50 mm.
5.4	No of contacts & spare contacts (NO & NC)	Normally Open contact shall be provided.
5.5	Padlocking provision for service, filtration / refilling / filling	Required.
5.6	Visual position indicator similar to Buchholz relay for inspection	For physical close indication.
5.7	Transformer Conservator Isolation valve setting for normal operation (valve should not close) to ensure no obstacle for transformer breathing.	40 ltr / minute for 50 mm conservator pipe.
5.8	Transformer Conservator Isolation valve setting for operation during abnormal flow of oil due to rupture / explosion of tank or bushing / oil drain during system operation.	60 L / minute (minimum) for 80 mm conservator pipe.
6	Fire Detectors	
6.1	Type	Quartz bulb, Heat sensing.
6.2	Quantity required	Depending upon Transformer top cover area.
6.3	Method of fixing	Bolting on Fire Detector bracket on Transformer top cover using fire survival, copper cables (capable to withstand 750 °C.)
6.4	Temperature for heat sensing	141 °C
6.5	Number of contacts	2 NO
6.6	Necessity and condition of refilling	After operation.
7	Power Supply	
7.1	For Control Box	For operation : 110 / 220 VDC / substation DC voltage For DC fail alarm : 230 VAC
7.2	For Cubicle	For illumination and heating : 230 VAC
8	Extinction period	
8.1	On commencement of Nitrogen injection	Maximum 30 Seconds
8.2	On system activation	Maximum 3 minutes
9	Other technical details	On line supervision of operating signals, DC supply monitoring, Test facility (excluding CIV, FD) on live transformer, Anti condensation heater for Cubicle, Manual operation in DC supply fail, Separate oil drain and Nitrogen release mechanism.

11.1.9 **Tests**

Functional test of following equipment is to be carried out during inspection and / or prior to dispatch:

a) Cubicle, showing oil drain and nitrogen injection.

b) Conservator isolation valve.

c) Control box.

d) Fire Extinguishing Performance test.

11.1.10 **Typical site layout of Nitrogen Injection Fire Prevention System**

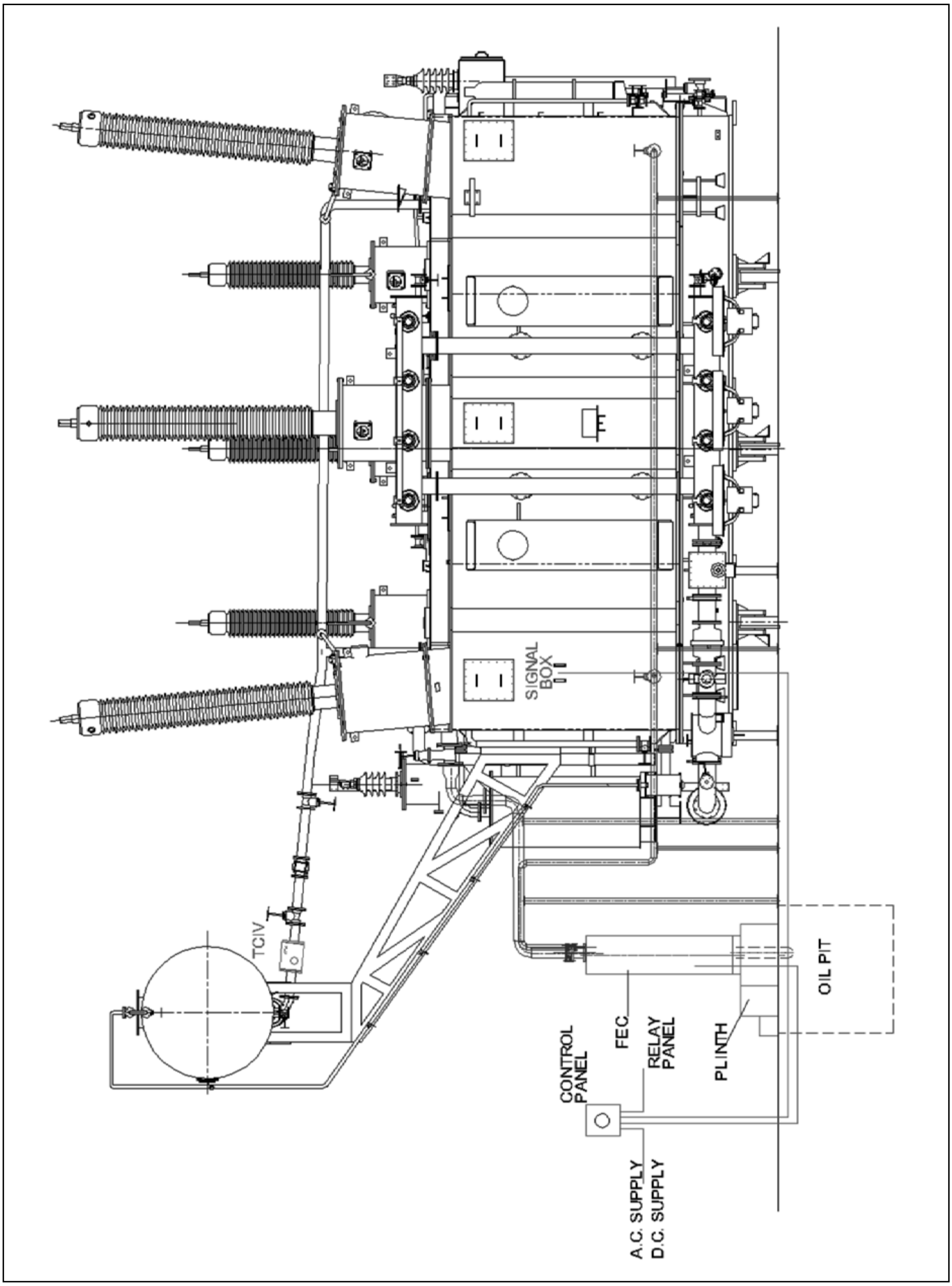


Fig. 2.39

11.1.11 **Ordering Information**

Project / Enduser details :

Transformer details and Quantity :

Manufacturer :	Serial number. :
MVA Rating :	Voltage ratio :

Oil Qty in tank : Litres
Oil Qty in Conservator : Litres

Power Supply (Pl tick √):
Substation/ Control room D.C. Supply : 220V 110V 48V 24V Other
A.C. Supply available : Control room Marshaling box : Single phase, 240V, 50 Hz

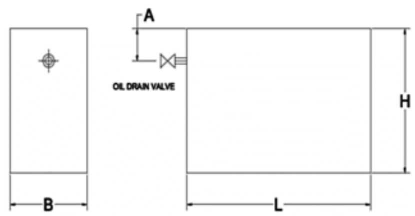
Conservator pipe diameter : mm Conservator pipe angle : degree

Spare contacts in relay panel :

Differential relay trip 1 number NO potential free	RPRR Trip 1 number NO potential Free	Buchholz Trip 1 number NO potential Free	Restricted Earth-fault Relay 1 number NO potential Free
OLTC oil surge relay trip 1 number NO potential free	Master relay Trip 1 number NO Potential free	PRV Trip 1 number NO potential Free	HV & LV circuit breaker trip, 1 number each NC potential free

NO : Normally Open, NC : Normally Close, RPRR : Rapid Pressure Rise Relay

Main Dimensions of tank :
L = mm
B = mm
H = mm
A = mm



Bevelled cover Yes No

Built-in On load Tap Changer : Yes No
Oil Filled Cable Box : Yes No
If Yes : Provide general arrangement drawings

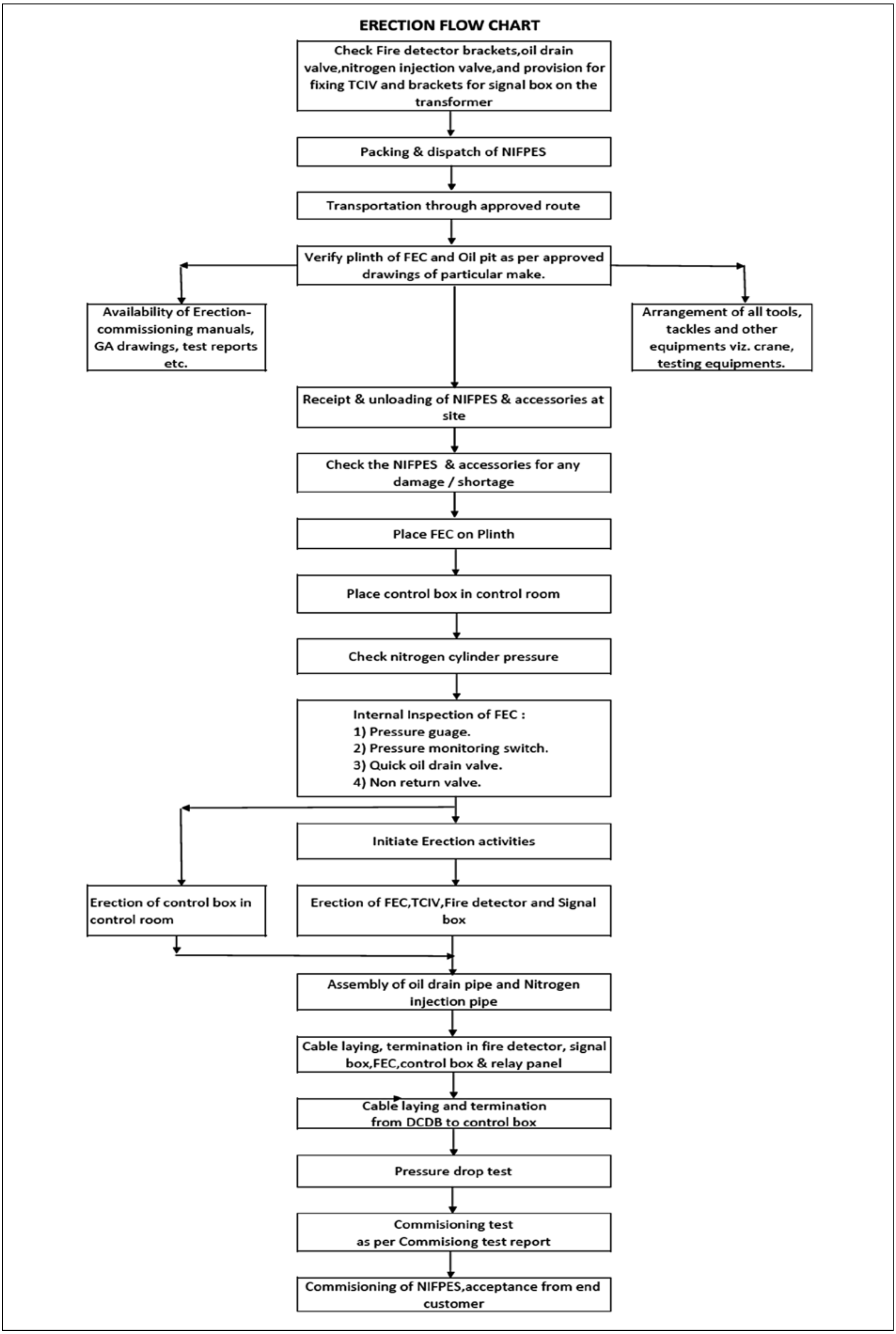
Cooling details :
If OF type Number of pumps : Head : Flow :
KW/HP : Back Flow when Pump Switch off : LPM

Installation : New Post

Distance from Transformer to control room through cable trench : mtrs
Distance from Control room to Relay Panel through cable trench : mtrs

Additional information :

11.1.12 Erection Flow Chart



11.1.13 Erection Check List

PROJECT :	
CUBICLE NO :	SIGNAL BOX NO. :
CONTROL BOX NO:	FIRE DETECTOR NO.
CONSERVATOR ISOLATION VALVE NO. :	

PARTICULARS	PARTICULARS
1.0 **Erection**	Oil drain pipe slope 2 to 3 degree Towards cubicle
1.1 Civil work	Tightness of flange and bolts
CUBICLE plinth as per approved drawing.	External cleaning
	Painting red oxide and P.O. red
1.2 Oil pit / Tank	2.2 Pipe connection from cubicle to Oil pit
Sealing of top cover.	Weld joint
Termination arrangement of pipe to CUBICLE	Aluminium paint at weld joints
Capacity suitable for transformer	Fitment of drain pipe to CUBICLE collar
	Pipe slope 5 to 10 deg .towards oil pit
1.3 Cubicle	2.3 Conservator Isolation Valve
Check oil drain isolation valve above	Mounting as per position marked on
Closed	CIV as per Drg. No.
Check N2 isolation valve above CUBICLE	Tightness of flanges and bolts
Closed	Pump test with one pump
Door opening as per approved	Pump test with two pumps
Alignment	2.4 Fire Detector
Tightness of foundation bolts	Mounting of fire detectors
1.4 Control Box (CB)	Mounting of fire detectors rain guards.
Wall mounting/Frame mounting, alignment	2.5 Earthing
Mounting at eye level	Signal box, CUBICLE, Control box & FD
1.5 Signal box (SB)	2.6 Cable Laying
Mounting at working height	Control box to signal box FRLS 12 core
Fitment	Control box to relay panel FRLS 12 core
1.6 Fire detector (FD)	Control box to CUBICLE FRLS 12 core
FD mounting as per drawing	Control box to DC-DC convertor 4 core
1.7 Conservator Isolation Valve	CIV to signal box FRLS 4 core
Visual crack/damage	Control box to DC source FRLS 4 core
Space availability	Control box to AC source FRLS 4 core
Valve availability for isolation	CUBICLE to AC source FRLS 4 core
2.0 **Installation**	FD to signal box FS 4 core
2.1 Pipe connection from Transformer to Cubicle	2.7 Cable Termination
Weld joint & weld joint fitup	Continuity of cable
Internal cleaning, varnishing & coating	Crimping quality of lugs
No leakage at 3.5 kg/cm^2 for 1 hour	No excess length of cables
Alignment	Dressing and glanding
Pipe support at minimum 5 mtrs interval	Termination as per
Pipe support alignment	Interconnection Drg. No.

11.1.14 Commissioning Check / Site Test Procedure

SR. NO.	DETAILS OF CHECKS/TESTS AND DESIRED RESULTS	PLEASE √ AFTER TEST
1.0 1.1 1.2 1.3 1.4 1.5 1.6	**READINESS FOR TESTS** Transformer is out of service and de-energized. Test equipments available for simulation of Differential relay, RPRR, Pressure Relief Valve, Buchholz, Transformer isolation. All cables are properly connected as per interconnection drawing No.___________________ operation scheme diagram No.______________________ and terminal screws are tightened. Close the isolation valve on oil drain pipe connected above Cubicle. SWITCH ON main power supply 220V DC/110V DC and 230V to control box. SWITCH ON main power supply 230V AC to cubicle	
2.0 2.1 2.2	**CONSERVATOR ISOLATION VALVE(CIV)** Unlock the lever, functional test of Limit Switch by moving lever clock-wise. Alarm 'CIV closed' must be activated on control box. Re-establish original operating conditions by resetting lever.	
3.0 3.1 3.2	**FIRE DETECTORS** Un- screw the heat sensor, alarm 'Fire detector trip' must be activated on control box. Test all fire detectors individually. Re-establish original operating conditions.	
4.0 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8	**CONTROL BOX** Functional test "Lamp Test" Functional test "Differential relay Trip" (COMMAND TO BE GIVEN BY OPERATING DIFFERENTIAL RELAY FROM RELAY PANEL.). Signal shall appear on control box. Functional test "PRV/RPRR Trip (COMMAND TO BE GIVEN BY OPERATING PRV/RPRR RELAY FROM RELAY PANEL.). Signal shall appear on control box. Functional test "BUCHHOLZ TRIP (COMMAND TO BE GIVEN BY OPERATING BUCHHOLZ RELAY FROM RELAY PANEL.) Signal shall appear on control box. Functional test "TRANSFORMER TRIP (COMMAND TO BE GIVEN BY OPERATING HVCB&LVCB/ MASTER TRIP RELAY FROM RELAY PANEL).Signal shall appear on control box. Confirm by operating Transformer protection used in para 4.2, 4.3, 4.4 not interconnected with any other protection Viz. REF, WTI, OTI etc. expect Transformer Trip protection. Lamp indication for "Oil Drain Valve Closed" available. Lamp indication for "Gas Inlet Valve Closed" available. Functional test for "Visual/Audio alarm". Functional test for "DC SUPPLY FAIL" visual/audio alarm by isolating DC supply to control box.	
5.0 5.1 5.2 5.3 5.4 5.5	**CUBICLE** Insert locking pin to lock oil drain mechanically. Alarm for "Out of service" must be activated. Insert locking pin to lock Nitrogen injection mechanically Alarm for "Out of service" must be activated. Nitrogen Cylinder pressure greater than 135Kg/cm2. Adjustment Nitrogen injection pressure as per manufacturer standard setting. Tightness test of nitrogen injection valves, hoses, main gas valve, 2 and 3 way ball valves.	

SR. NO.	DETAILS OF CHECKS/TESTS AND DESIRED RESULTS	PLEASE √ AFTER TEST
5.6	Check sealing of Gas Flow Control Unit is not disturbed.	
5.7	Perform ‘Differential relay trip’, ‘Buchholz/PRV/RPRR trip, and ‘Transformer trip, By OPERATING THE DIFFERENTIAL, Buchholz/PRV/RPRR, HVCB & LVCB/MASTER TRIP RELAY FROM RELAY PANEL (AUTO PREVENTION MODE).	
	Lifting magnet Y01 must be activated.	
	Remove the above connections. Lifting magnet Y01 must be de-energized.	
5.8	Perform ‘Fire Detector trip’, ‘Buchholz/PRV/RPRR trip, and ‘Transformer trip, By OPERATING Buchholz/PRV/RPRR, HVCB & LVCB/MASTER TRIP RELAY FROM RELAY PANEL (AUTO PREVENTION MODE).Lifting magnet Y01 must be activated.	
	Press limit switch G03. Lifting magnet Y02 must be energized.	
5.9	Release limit switch G03. Lifting magnet Y02 must be de-energized.	
5.10	Turn 3 way ball valve in horizontal position (Inspection position. Lifting magnet Y02 must be energized. Remove wire connections mentioned in 5.8. Lifting magnet Y01 must be de-energized. Turn 3 way ball valve in “In service” position (vertical).	
5.11	Perform ‘Transformer trip’ (BY OPERATING THE HVCB AND LVCB/MASTER TRIP RELAY FROM RELAY PANEL and operate S02 for ‘ON’ position, Y01 must energize. Keep S02 in ‘OFF’ position (REMOTE ELECTRICAL MODE).	
5.12	Push lever A for operation of Y01 and push lever B for operation of Y02 (LOCAL MECHANICAL, MANUAL MODE).	
5.13	Unscrew the end of the flexible hose clamps of the gas supply fastened to throttle valve and withdraw the hose.	
	Activate the extinction release device by withdrawing locking pin 2 and lifting magnet Y02 manually – gas will blow out of hose.	
5.14	Alarm for ‘Extinction in progress’ must be activated.	
	Re- set extinction release device and insert locking pin 2 in test position.	
	Fasten the end of flexible hose of gas supply to Gas Flow Control unit and check tightness again.	
5.15	Adjust contact on manometer to the actual pressure line. Alarm for “Cylinder pressure low” must be activated.	
5.16	Reset electrical contact in manometer at______kg/cm² (as per manufacturer standard setting).	
5.17	Visual check of tightness of quick oil drain valve by unscrewing the transparent inspection cover of oil drain pipe in cubicle. Fix inspection cover.	
5.18	Functional test of heater and thermostat operation.	
5.19	Set thermostat operation contact at ___ °c (as per manufacturer standard setting).	
6.0	**GENERAL CHECKS**	
6.1	Cables are well supported at various cable clamps	
6.2	All cable glands are properly tightened.	
6.3	All screws/bolts of piping are properly tightened.	
6.4	Painting of oil drain and Nitrogen pipe line.	
6.5	The embedded oil drain pipe from oil pit fits well into the pipe connection collar of cubicle.	
6.6	Transformer oil drain valves and Nitrogen Injection valves and Isolation valve above cubicle are open.	
6.7	Main Nitrogen cylinder valve is open.	
6.8	Locking pin for oil drain and locking pin for nitrogen release are in operation position.	

11.2 Automatic Mulsifire System

11.2.1 Description

This system is widely used for fire fighting of outdoor transformers. Spray type fire protection essentially consists of a network of projectors and an array of heat detectors used to sense high temperature near the transformer / reactor to be protected. If the temperature exceeds the set value, the automatic mulsifire system sprays water at high pressure through a Deluge valve from the pipe network laid for this system. Fire detectors located at various strategic points are on the surface of the transformer to control fire on any burning oil spilled over.

11.2.2 Subsystems used to make a complete mulsifire system

a) **Main Hydrant**

This is used to carry the water to various parts of the switchyard or transformer substation and forms the backbone of the system. Sturdy corrosion-free pipes and valves are used for this purpose. The materials should be able to withstand fire for a reasonable duration.

b) **Fire Detector**

Fire detectors can either be thermocouples or specially designed bulbs which burst when they experience a high temperature and release any valves or checking device to start the water supply.

c) **Ring Mains and Nozzles**

Ring mains, which surround the transformer are provided to feed the water to the nozzles at various levels. Since the water pressure is high, the ring mains should be designed to withstand this pressure. Nozzles should be located such that the water spray, in the event of a fire, envelopes the entire surface of the transformer. The whole system should be periodically checked to detect any leakages. .

d) **Pumps**

Pumps are provided to fill the hydrants initially and to maintain its pressure. Pumps driven by electrical motors are a standard provision; however, the standby pumps should preferably be diesel engine driven. It is recommended that the main and standby pumps in a pump house be segregated.

11.2.3 Electrical Safety

As per Powergrid specification, from safety considerations, the following electrical clearances are recommended between the mulsifier system pipe work and live parts of the transformer to be protected.

▪ 420 kV bushing	3500 mm
▪ 245 kV bushing	2150 mm
▪ 145 kV bushing	1300 mm
▪ 52 kV bushing	630 mm
▪ 36 kV bushing	320 mm

11.2.4 Installation Care

- Deluge Valve shall be water pressure operated manual reset type.
- Each Deluge valve shall be provided with a local panel from which will enable manual electrical operation of the valve.
- In addition to this, each valve shall be provided with local operation latch.
- Test valves shall simulate the operation of Deluge valves and shall be of quick opening type

12 Terminal Connector

12.1 Selection Criteria

Type of Connector (Construction)

a) Bolted type
b) Crimping type
c) Wedge type
d) Welded type

Type of Connector (Functional)

a) Horizontal / Vertical / Through type
b) Rigid / Flexible type (for Tubular Bus)

12.2 Technical Data Required for Design of Connector

a) System Voltage
b) Continuous current rating
c) Short time rating
d) Ambient temperature & limit of maximum temperature rise
e) Visual corona withstand voltage (for connectors of 220 kV and above)
f) Maximum permissible RIV level at a specified voltage (for connectors of 220 kV and above)
g) Size of Busbar & direction of approach

12.3 Design Criteria

a) To carry the desired current safely
b) To withstand the mechanical loads imposed during erection / during short circuit
c) To offer lowest resistance in the current path
d) To limit the visual corona & RIV within permissible level
e) To avoid sharp edges so that busbar does not get damaged during erection / in service

12.4 Tests on Connectors

12.4.1 Type Tests

a) Carried out on three samples of each type
b) Dimensional check & visual examination
c) Short time current test
d) Visual corona withstand test & RIV measurement (for connectors of 220 kV and above)
e) Temperature rise test
f) Resistance Test
g) Tensile test (Slip test)
h) Galvanizing test on bolts & nuts

12.4.2 Acceptance Tests

Carried out on random selected samples during inspection & to be witnessed by customer's representative (on 0.5% of quantity)

a) Dimensional check & visual examination
b) Tensile Test (Slip test)
c) Resistance test
d) Galvanizing test on bolts & nuts

12.4.3 Routine Tests:

Carried out on 100% quantity by manufacturers

a) Dimensional Check
b) Visual Examination

12.5 Applicable Standard: IS: 5561

ANNEXURE 2.4

PT 100 Resistance
Temerature Vs Resistance
(BS 1904: 1984 & IEC 751: 1985)

TEMP °C	RESISTANCE (OHMS)		
	LOW	NOMINAL	HIGH
0	99.88	100.00	100.12
10	103.76	103.90	104.04
20	107.63	107.79	107.95
30	111.49	111.67	111.85
40	115.35	115.54	115.73
50	119.19	119.40	119.61
60	123.01	123.24	123.47
70	126.82	127.07	127.32
80	130.62	130.89	131.16
90	134.42	134.70	134.98
100	138.20	138.50	138.80
110	141.97	142.29	142.61
120	145.72	146.06	146.40
130	149.46	149.82	150.18
140	153.21	153.58	153.95
150	156.92	157.31	157.70

ANNEXURE 2.5

PT 100
Temerature Vs Output Signal
Temperature Range: 0 - 150 °C
Signal Range: 4 - 20 mA

TEMPERATURE °C	NOMINAL RESISTANCE (OHMS)	OUTPUT SIGNAL RANGE (4 - 20mA)		
		LOW	NOMINAL	HIGH
0	100.00	3.800	4.000	4.200
10	103.90	4.867	5.067	5.267
20	107.79	5.933	6.133	6.333
30	111.67	7.000	7.200	7.400
40	115.54	8.066	8.266	8.466
50	119.40	9.133	9.333	9.533
60	123.24	10.200	10.400	10.600
70	127.07	11.266	11.466	11.666
80	130.89	12.333	12.533	12.733
90	134.70	13.399	13.599	13.799
100	138.50	14.466	14.666	14.866
110	142.29	15.533	15.733	15.933
120	146.06	16.599	16.799	16.999
130	149.82	17.666	17.866	18.066
140	153.58	18.732	18.932	19.132
150	157.31	19.800	20.000	20.200