TRANSFORMER BUSHINGS

OIP CONDENSER TYPE
UP TO 420 kV

- ❑ INTRODUCTION
- ❑ APPLICATION
- ❑ DESIGN
- ❑ CONSTRUCTION
- ❑ FEATURES
- ❑ CONNECTION DETAILS
- ❑ TYPE - FORM RATINGS AND DIMENSIONAL DETAILS
- ❑ TESTING
- ❑ RECEIVING AND STORING
- ❑ HANDLING
- ❑ INSTALLATION
- ❑ MAINTENANCE
- ❑ ELECTRICAL INSULATION TESTS

No. T 94 - 007 D

INTRODUCTION

For the first time in India, TELK started manufacture of oil impregnated paper (O.I.P.) type high voltage condenser bushings, in 1970. Since then TELK have manufactured thousands of O.I.P. transformer bushings in the voltage range 52-420 kV, conforming to relevant IS/BS/IEC standards.

APPLICATION

The oil impregnated paper insulated bushings are used to connect overhead lines to transformers. These are mounted on transformers in vertical or inclined position at a maximum inclnation of 30^{o} from the vertical.

DESIGN

Standard condenser bushings are out door immersed self - contained draw - through lead or rod type, with oil filling, suitable for service in heavily polluted atmospheres. The active part of the bushings consists of a condenser body built up around a centre tube using high - quality kraft insulating paper. The paper strips are wound over the centre tube with pure aluminium foils inserted at predesigned locations to get optimum combination of external flashover and internal puncture strength.

CONSTRUCTION

The condenser body is enclosed in a weather resistant housing consisting of a top expansion chamber, an upper porcelain, a welded flange - ground sleeve assembly, a lower porcelain and bottom cap. The annular space between the condenser body and the housing is filled with pure transformer oil. A disc spring assembly (fig. 6) located in the top housing holds all synthetic rubber gaskets and O-rings between porcelain and metal parts under controlled pressure, completely sealing the bushing.

An oil sight window is provided on the expansion chamber for observing the oil level. The space in the expansion chamber above oil is filled with dry nitrogen gas. Due to this hermetic sealing, the bushings are maintenance - free and non- susceptible to aging.

Brown glazed porcelain - insulators of high strength are used as air end and oil end insulators. Air end porcelain is normally provided with a nominal total creepage length of 25 mm per kV of the rated voltage. Oil end porcelain is cone shaped without sheds. Air end porcelain is provided with alternating long and short sheds (Aerodynamic shed profile)

All outside ferrous parts of the bushings will be given glossy light grey enamel paint to shade 631 of IS:5 over a rust inhibitive coat of ready - mixed zinc chrome primer. Steel surface coming in contact with transformer oil will be given a coat of oil-resistant insulating varnish. Galvanized bolts and nuts are used as fasteners.

After assembly the bushings are dried out at a very high vacuum pressure. They are then impregnated with transformer oil. Impregnation is carried out under pressure. The oil level in the bushing is then adjusted and the bushing is sealed. Perfect drying and impregnation guarantee long life with very low dissipation factor (tan δ) and freedom from partial discharge.

FEATURES

(1) Sheild at oil end

For bushings of rated voltage 245kV and above, a stress-relieving shield is provided on the lower cap. The shield (fig. 2) consists of an aluminium shroud insulated with kraft paper or press board moulding. This shield avoids excess electrical stress in oil at the lower end cap and terminal connections, thereby the clearance from bushing tail to earth can be considerably reduced in transformer bushing turrets. The maximum stress in oil at the surface of the shield insulation must be limited to those values normal for insulated conductors and similar components in the same transformer.

(2) Provision for current transformer

If current transformers are to be provided on the bushing, the metal sleeve equipped below the fixing flange may be utilized. The bushing is provided with standard lengths of metal sleeve for this purpose.

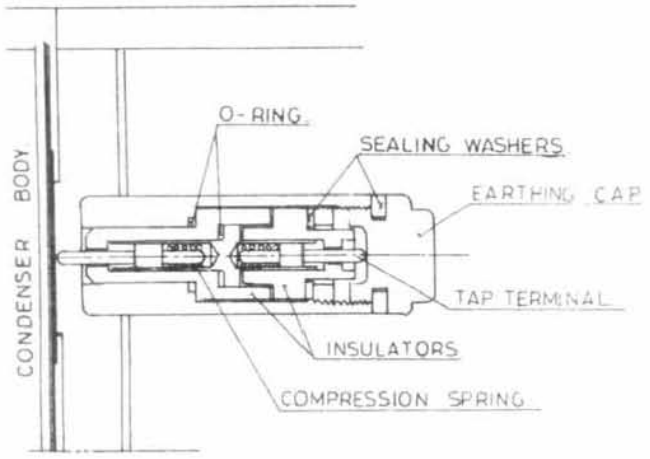


Fig:1 TEST TAP DETAILS.

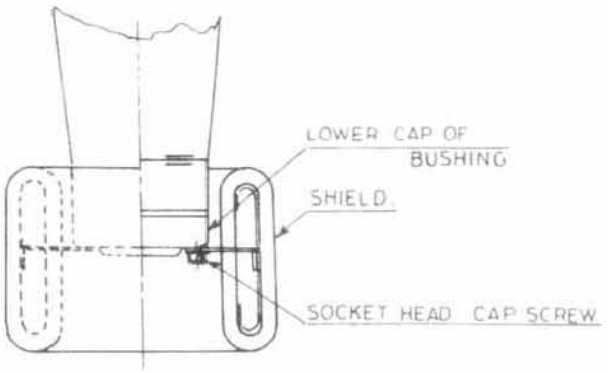


Fig:2 LOWER SHIELD FIXENG DETAILS.

(3) Test tap or measuring tap.

The bushing is provided with an insulated test tap (fig. 1) suitable for measuring bushing-power factor or dissipation factor (tan δ) and capacitance by ungrounded specimen test method. The cover of this tap should be removed from the tap acttachment only for testing purpose. Normally the tap is grounded through the cover and the bushing should not be operated with cover removed. Flash - over of the tap insulator may occur if the cover is not in place when the bushing is operating.

(4) Optional extras

Potential tapping and Adjustable arcing horns can be provided on the bushing against specific requirements.

CONNECTION DETAILS

The oil end connection can be made to the oil end terminal pad (fig 3&4) in the case of soild stem type bushings. Drawlead or rod connection is made in the case of draw through type bushings. A bolted - joint of draw - lead /draw - rod (fig. 5) is located at the bushing fixing flange level. The bottom portion of the joint will be flush with the bottom of the fixing flange.

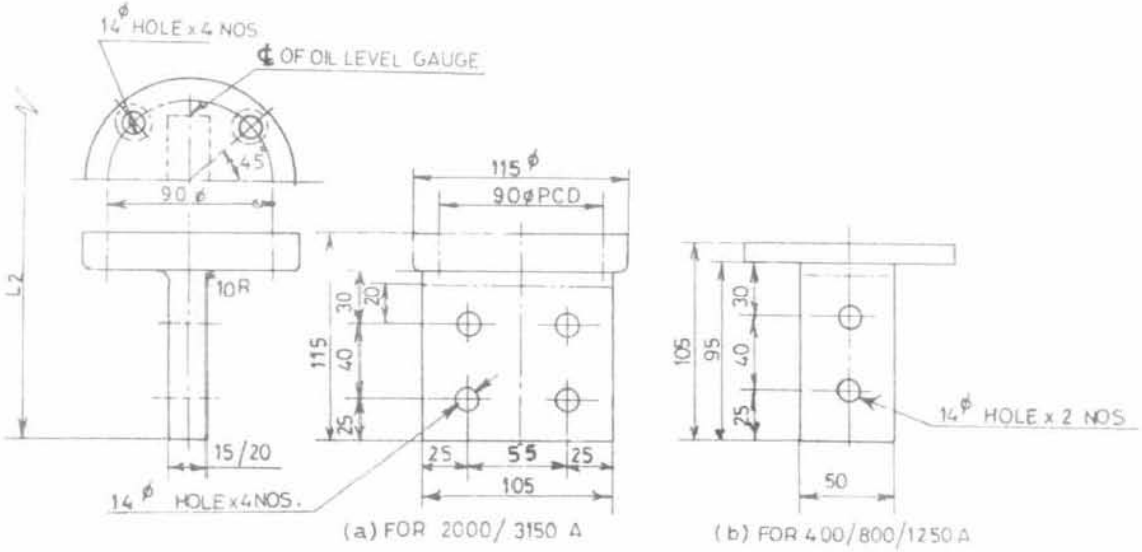


Fig:3 OIL END TERMINAL FOR 52/72.5 KV BUSHING.

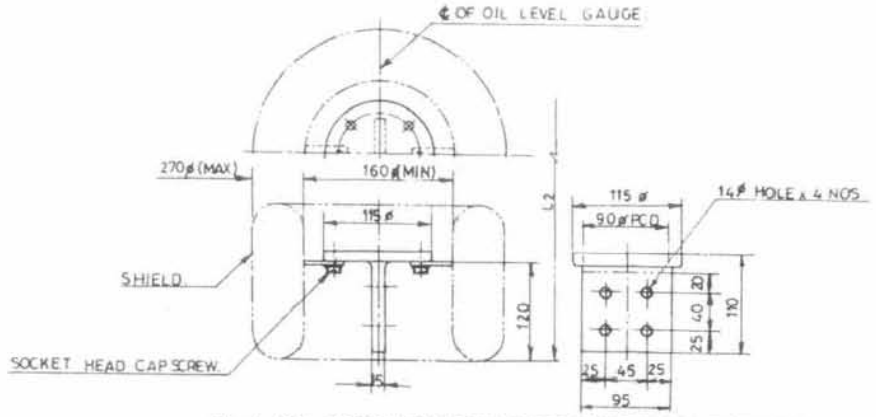


Fig:4 OIL END TERMINAL FOR 245KV 2000A BUSHING.

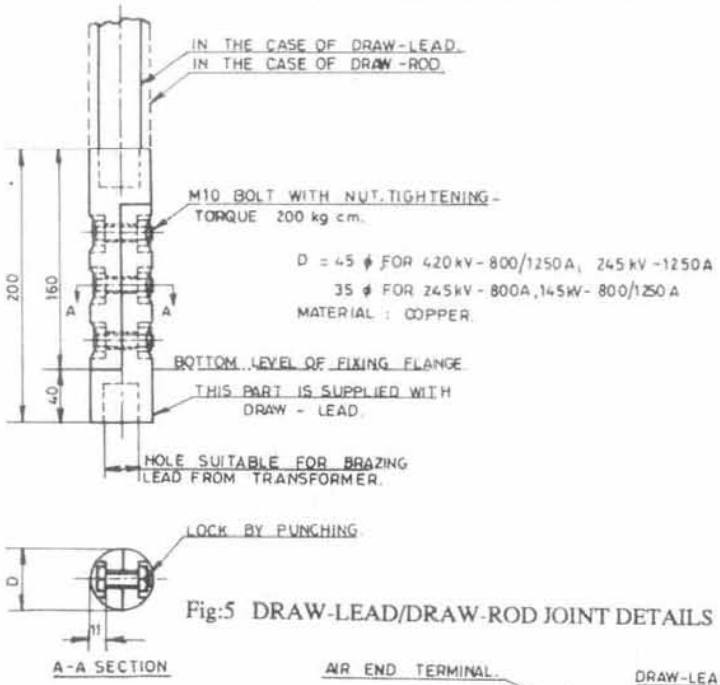


Fig:5 DRAW-LEAD/DRAW-ROD JOINT DETAILS

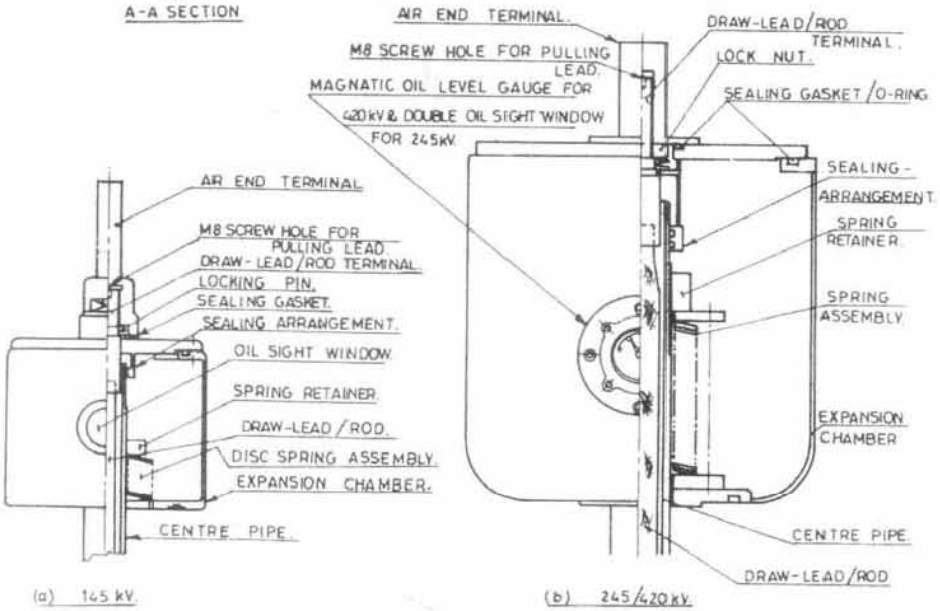


Fig:6 EXPANSION CHAMBER AND TOP TERMINAL ASSEMBLY

The draw-lead or draw-rod connecting the top terminal will be supplied along with the bushing. The complete joint connectors are available with the draw- lead and the free connector is suitable for brazing the lead from the connecting equipment. In the case the draw-rod, the free end is forming the connector.

For the air side connection, rod type terminal is provided for both stem and draw through types (Fig. 6&7)

DIMENSIONAL AND TECHNICAL DETAILS

SL. No.	TYPE - FORM	BIL/RATEDVOLTAGE RATED CURRENT (kVp/kV-A)	1 MIN:AC WITH STAND (kV)	CANTILEVER WITH STAND (N)	L1 (m.m.)	L2 ±5 (m.m.)	L3 MAX: (m.m.)	L4 MIN: (m.m.)	L5 MIN: (m.m.)	L6 MIN: (m.m.)	L (m.m.)	D1 MAX: (m.m.)	D2 MAX: (m.m.)	FIXING FLANGE D3±2 (m.m)	FIXING FLANGE D4±1 (m.m)	FIXING FLANGE D5XN (m.m.xNos)	FIXING FLANGE t (m.m)	D6 MAX: (m.m.)	D7 MIN: (m.m.)	D8 ±0.2 (m.m.)	OIL QUANTITY (ltr.)	APPROX WEIGHT (kg.)	MINIMUM CREEPAGE (m.m.)
1	CST HB	250/52-800	105	1000	905	450	325	460	125	100	1355	200	115	225	185	15x6	10	115	-	30	6	53	1300
2	CST HC					650				300	1555										7	58	
3	CST HB	250/52-2000		2000	950	475				100	1425	240	165	335	290	15x12	13			60	7	72	
4	CST HC					675				300	1625										8	80	
5	CST HB	250/52-3150		3150		475				100	1425										7	74	
6	CST HC					675				300	1625										8	83	
7	CST HB	325/72.5-400	140	1000	1085	495	325	660	125	100	1580	200	115	225	185	15x6	10	115	-	30	8	65	1810
8	CST HC					695				300	1780										9	70	
9	CST HB	325/72.5-800				495				100	1580										8	67	
10	CST HC					695				300	1780									60	9	72	
11	CST HB	325/72.5-1250		1250		495				100	1580										8	77	
12	CST HC					695				300	1780										9	82	
13	CDL HB	650/145-800	275	1250	1805	600	445	1250	125	100	2405	290	165	335	290	15x12	13	165	38	30	13	162	3625
14	CDL HC					800				300	2605										14	169	
15	CDL HC1					1100				600	2905										16	177	
16	CDR HB	650/145-1250		1600		600				100	2405									60	13	169	
17	CDR HC					800				300	2605										14	176	
18	CDR HC1					1100				600	2905										16	184	
19	CDL HC	1050/245-800	460	1250	2815	1130	475	2150	125	300	3945	350	270	450	400	20x12	16	270	48	30	58	465	6125
20	CDL HC1					1430				600	4245										64	485	
21	CDR HC	1050/245-1250		1600		1130				300	3945									60	58	475	
22	CDR HC1					1430				600	4245										64	500	
23	CST HC	1050/245-2000		2500		1230				300	4045								-		60	500	
24	CST HC1					1530				600	4345										68	530	
25	CDL HC	1425/420-800	630	2500	4050	1640	695	3100	125	400	5690	500	350	720	660	24x12	22	350	60	30	136	1030	10500
26	CDL HC	1425/420-1250																		60		1040	

TABLE - 1

TYPE - FORM, RATINGS AND DIMENSIONAL DETAILS

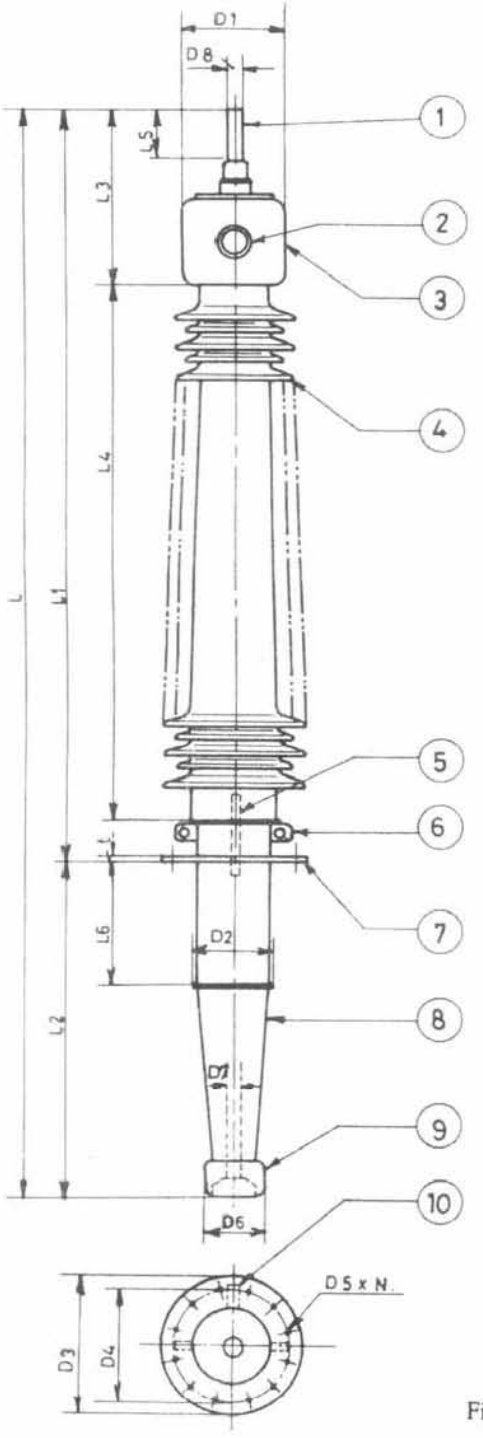
The following Type - Form is used for designating TELK - Condenser bushings (see Table - 1 also)

TYPE, C : Oil impreganated paper condenser bushing with oil filling
DL : Draw through lead type
DR : Draw through rod type
ST : Stem type

FORM H : Suitable for service in heavily polluted atmospheres.
B : Provision for BCT upto 250 mm
C : Provision for BCT above 250, upto 400 mm
C1 : Provision for BCT above 400 mm

Standard current ratings of 400, 800, 1250, 2000 & 3150 A are selected for different bushings.

For the dimensional details Table 1 & Fig. 7 may be referred.



① AIR END TERMINAL.
② OIL LEVEL GAUGE.
③ EXPANSION CHAMBER
④ AIR END PORCELAIN INSULATOR.
⑤ DRAW - LEAD / ROD JOINT.
⑥ LIFTING LUG.
⑦ FIXING FLANGE.
⑧ OIL END PORCELAIN INSULATOR.
⑨ CAP CUM STRESS SHIELD
⑩ TEST TAP.

Fig:7 DIMENSIONAL DETAILS

TESTING

The following routine tests are done on all bushings as per IS: 2099.

1. Test for leakage of internal fillings.
2. Measurement of tangent delta and capacitance upto rated voltage, both for increasing and descreasing voltages.
3. Measurement of partial discharge upto AC test voltage.
4. Dry power frequency withstand voltage test.
5. Power frequency withstand test of test tapping.

Types tests, except wet power frequency withstand test have been carried our on prototype bushings as per IS:2099 and reports are available upon request.

RECEIVING AND STORING

The bushings are transported in wooden crates, ready for installation after factory tests. They can be taken out after removing the upper cover of the crate, fixing bolts and wooden stoppers. The crate shall be opened carefully to avoid any damage to the procelain insulators and other parts.

Immediately on receipt, the bushings shall be inspected thoroughly for any damage in transit. The porcelain surface and the oil level shall be inspected. If any damage or rough handling is evident, a claim shall be lodged with the transporters/ underwriters immediately, and TELK or their representatives nearby contacted.

The outdoor -immersed bushings manufactured by TELK can be stored outdoors for a long time in the packing crates. However, the gasket surface and metal parts below the flange shall be covered with polyethylene of vinyl sheets to avoid rusting. It is preferable to keep the bushings indoors in vertical position on suitable stand.

HANDLING

All the bushings are provided with lifting hooks on the fixing flange. Ropes of hemp or cotton shall preferably be used for lifting purposes. The bushings shall be lifted up as such from the crate, without touching the sides.

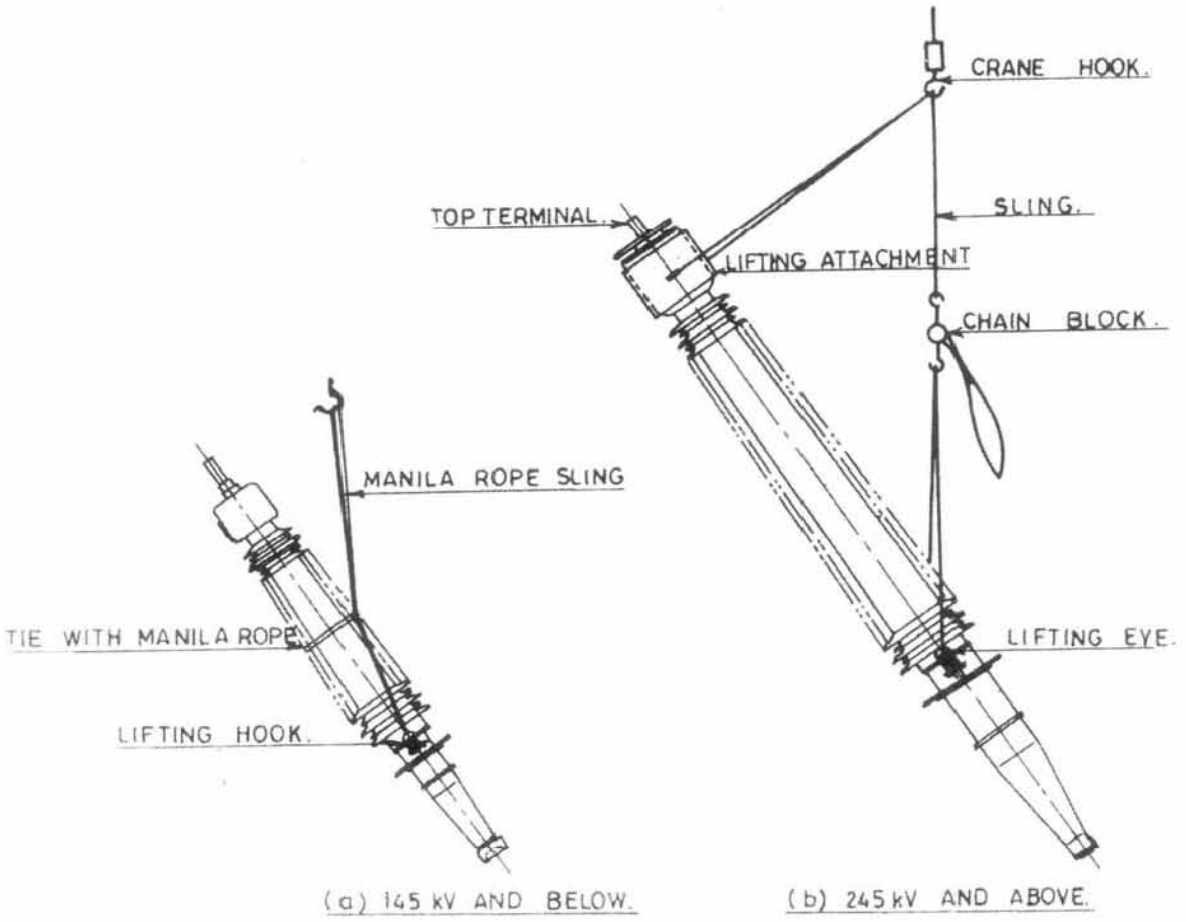


Fig:8 LIFTING METHOD OF BUSHINGS.

For bushings of 145 kV and below, a single point lifting is recommended. Fig .8 (a) shows the method of handling of this type of bushings. The bushing can be kept inclined to the desired angle by adjusting the manila loop along the sheds of upper porcelain insulator.

For bushings of 245 kV and above, a two point lifting arrangement is necessary. Fig. 8 (b) shows the method of handling of this type of bushings. For the 420 kV bushings, a lifting attachment is given at the top head to protect the expansion chamber and to connect the slings. For the 245 kV bushings, a rope can be tied to the upper part of the porcelain insulator, below the first shed. In this case, the inclination of the bushing is adjusted by means of the chain block.

INSTALLATION

Before installation the bushings shall be wiped clean of dust and dirt. The porcelain surface shall be inspected for any scratches or cracks on it. Oil level in the bushing shall be noted and all joints thoroughly inspected for any leakage.

The insulated stress relieving shield shall be processed before fitting on to the transformer bushings. The shield be hot air dried to remove moisture in insulation and then vacuum oil impregnated and shall be kept under oil in sealed containers till the time of installation. The shield shall be fixed to the bushings with minimum exposure time.

The draw-lead or draw-rod terminal, with transformer lead jointed at the level of bushing fixing flange, shall be pulled up using a lifting eye through the centre tube while the bushing is inserting into the transformer tank. M8 hole provided on the draw-lead /rod terminal may be used for fixing the lifting eye. Fix the terminals as shown in Fig. 6.

The bushings shall be kept in vertical position for atleast 72 hrs before energisation.

MAINTENANCE

General

Condenser bushings manufactured by TELK are self contained hermetically sealed and hence practically maintenance free. However failure of bushings can cause costly power breakdown and hence to avoid such situation preventive maintenance is advisable. A regular programme for inspection and testing of bushings to check their soundness may be established. If a bushing is found operating in an unfavourable condition it may be removed from service before it gives trouble and after reconditioning it can be put back. Bushings shall not normally be opened out or topped up with oil without specific instruction or recommendation. Such corrective action when required, shall be taken under advice from TELK.

Frequency of inspection and testing

Depending up on the importance of installation, the frequency of inspection and testing of bushings may be decided. Some bushings require no periodic examination whereas some may require daily inspection, monthly examination and cleaning; and an annual dissipation factor / capacitance test.

Factors likely to influence frequency of inspection and testing include:

1. Condition and age of bushing
2. Importance of continuity of service
3. Operating condition such as unusual over voltage or polluted atmospheres.
4. Accessibility of bushing.
5. Availability of maintenance facilities.

In any case, it is advisable to conduct inspection / testing of the bushing atleast once in a year.

Before attempting to clean or test a bushing, it should be-de-energised and temporarily grounded to remove any electro-static charge from the apparatus and bushing.

Preventive maintenance

(1) Porcelain

Porcelain may get chipped or broken. Glaze finish may become roughened or eroded. Small chips and minor cracks can be repaired using M-seal repair kit to obtain glossy finish. If the body of the procelain insulator is affected by a crack there is possible danger that it can lead to an operating hazard. In such cases the insulator must be replaced.

(2) Metal parts.

Metal parts may be checked for corrosion and, if required, may be painted periodically.

(3) Test tap.

The test tap shall be examined for proper sealing to prevent entry of moisture.

(4) Oil level

Oil level as indicated by the guage glass/level indicators shall be checked periodically. The gauge glasses should be inspected regularly for cracks which might result from any mechanical cause. If there is a leak it should be repaired as per advice from TELK. If there is no leak, but oil level is too low, the problem may be internal and it may be prudent to replace the bushing.

(5) Surface contamination

This is the natural deposits or coating of early morning dew, salt fog in sea coast areas, smog and industrial pollutants on the porcelain insulator. Build up of contamination can cause flash over of bushing at normal voltage. Danger of flash over occurs when the surface coating becomes partly conducting, usually with the presence of moisture.

To prevent contamination flashover of porcelain insulator, the following methods may be used.

- Hand Wiping
- Washing with clean water
- Dry Cleaning with air - blast materials.
- Coating with suitable silicone compounds.

ELECTRICAL INSULATION TESTS

A. Tan δ and capacitance measurement.

Insulation power factor or dissipation factor (tan δ) and capacitance measurement of bushing provide an indication of the quality and soundness of the insulation in the bushing.

For getting accurate results of tan δ and capacitance without removing the bushing from the transformer, a suitable test set capable of taking measurements by the ungrounded specimen test method (UST) shall be used. By this method, the effects of the capacitance between the terminals of the bushing and ground; and the surface resistance of the porcelain are eliminated from the measuring circuit. Tan δ value by this method are not therefore appreciably affected by conditions external to the bushing, but the value varies with temperature, depending on the types of insulation used.

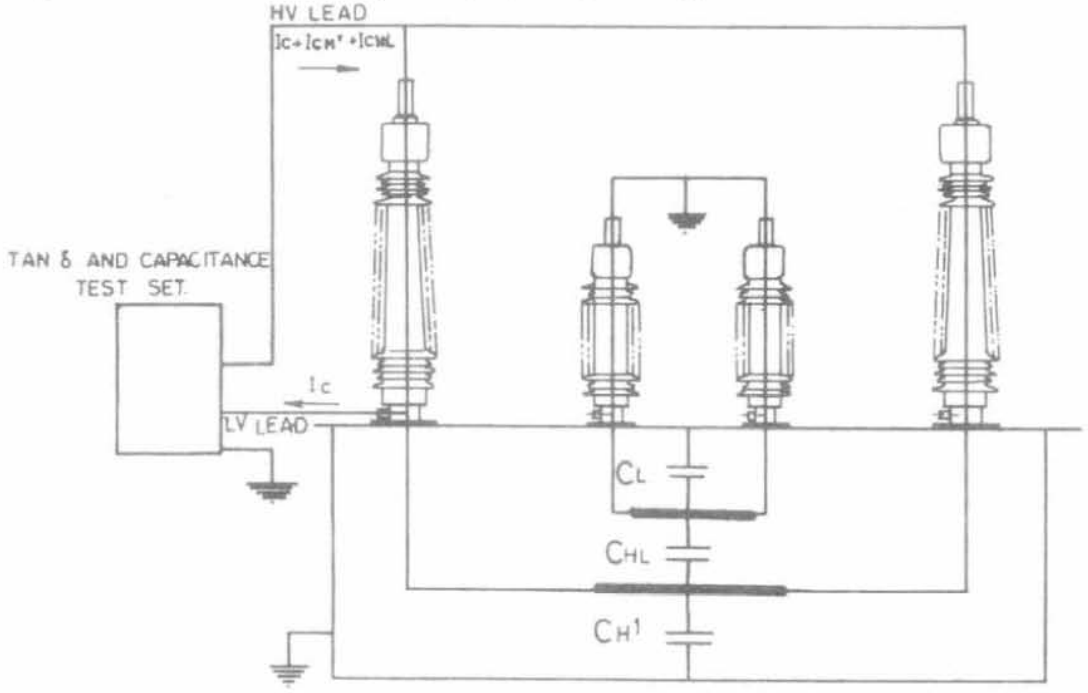


Fig:9 UNGROUNDED SPECIMEN TEST (UST) METHOD OF TRANSFORMER BUSHINGS.

The ungrounded specimen test method is shown in Fig. 9. It utilizes the test tap of the bushing and a Tan δ / capacitance test set. Bushing capacitance also can be measured during the tan δ measurement by the same set up.

Precautions

1. Measurement may be made at low voltages usually below 10 kV. It is desirable to have the test set or bridge frequency different but close to operating power frequency; so that stray power frequency currents do not interfere with the operation of the instrument.
2. Measurements shall be made at similar conditions as that of a previous measurement. In case measurements are made at varying temperatures, correction factors are to be applied, where applicable, However the oil paper insulation combination of TELK bushings exhibit fairly constant tan δ over a wide range of operating temperature.
3. Connections to overhead bus at the bushing need be removed, only if the busline affect the readings appreciably.
4. Porcelain of the bushings shall be clean and dry. Remove any dirt or oil with clean dry cloth.
5. Test shall not be carried out when there is condensation on the porcelain. Preferably, tests shall not be carried out when the relative humidity is in excess of 75%.
6. Terminals of the bushings of each winding shall be shorted together using bare braided copper jumpers. These jumpers shall not be allowed to sag. Transformer windings whose bushings are not being tested shall be grounded.
7. Measure and record the ambient temperature and relative humidity for reference.
8. Safety precautions as recommended by the instrument manufacturer may be followed.

Analysis of test results.

The tan δ of sealed bushings is very low initially and remains low in service if the bushing is in good condition. An increase in power factor is evidence of a change in characteristics of the dielectric, and a continuing trend towards higher power factor is evidence that a potentially damaging condition is developing. Persistently stable power factor readings indicate that condenser body of the bushing is in good condition.

A major change in bushing capacitance usually signifies a serious structure change in the bushing. A moderately increased capacitance, accompanied by increased value of tan δ may indicate presence of moisture.

An increase in tan δ above one percent and capacitance to 110 percent of the original values need attention and corrective action is recommended. Factory test values of tan δ and capacitance as measured at room temperature are normally indicated on the bushing test reports / name plates for reference.

B. Megger test.

In the absence of facilities for tan δ measurement, insulation resistance (IR) test on bushings some times prove useful. However this test require isolation of the bushing from the main equipement. A 2500 V instrument preferably with 20,000 megohm range may be used. Bushing with a reading less than 5,000 megohm should be investigated. IR values do not always indicate the state of inside condenser core. Hence tan δ and capacitance measurements are recommended.

ORDERING PARTICULARS

- ❑ Rated voltage
- ❑ Rated B.I.L.
- ❑ Rated line - to earth voltage
- ❑ Rated current
- ❑ Type - Form
- ❑ Application
- ❑ Special service conditions / applications if any (As per Appendix C of IS 2099-86)
- ❑ Typetests - whether required or not
- ❑ Compliance with national standards other than IS : 2099.

TRANSFORMERS AND ELECTRICALS KERALA LIMITED

A Joint Venture of Government of Kerala & NTPC Limited

ANGAMALLY SOUTH - 683 573, ERNAKULAM Dist. KERALA STATE, INDIA

Ph. : (Offi.) 0484-2510251 (10 Lines)
Fax. : 0484-2452363, 2452873
Website : www.telk.com

TELK - 2012