ABSTRACT

On observation of deterioration of tan-δ value to 1.08 %, i.e., surpassing the limiting value of 0.7 % as defined in IEC60137 for the 420 kV OIP bushing for a 315 MVA, 400 / 220 / 33 kV transformer located at substation Katni (India), a decision was made to replace the bushing. The replacement was risky, and it was a threat of causing the catastrophic failure for the transformer itself and the colossal loss to the neighbouring equipment and structures.

KEYWORDS

capacitive divider, NIFPS, OIP bushings, retrofit, tan δ

The OIP bushing is designed with multiple layers of grading condensers wound concentrically over the central tube of the bushing, using alternate layers of aluminium foil and kraft paper

Retrofitting of a 420 kV draw-lead type bushing with a draw-rod type – Part I

Challenges in replacement of the bushing

Since the same type / make of bushing was not available and limitation of time of shutdown (outage period) due to grid constraints, replacement of bushing was carried out without draining top oil. There was no other option other than to insert new bushing with stress shield at a very accurate and precise angle without damaging bushing stress shield and turret CT (Current Transformer).

Keeping in view our previous experiences of the transformer tripping on harmonic restrain setting of 12 % after taking static winding resistances, a decision was taken to lower the 2nd harmonic restrain setting from 12 % to 10 % and the transformer was energized successfully. Such a decision was taken to avoid any confusion of maltripping, attributing to the retrofitting job of OIP bushing.

1. Introduction

The bushings play an important role by providing insulation to the live leads from the power equipment. The OIP (oil-impregnated paper) bushings are one of the types of bushings for oil to air application for power transformers/shunt reactors in the Air Insulated substation.

The bushings are the very vital and sensitive accessory of any Extra High Voltage transformers from 66 kV to 765 kV. Bushing failure can lead to catastrophic failure of an EHV transformer resulting in a heavy fire causing colossal damage in the substation and system disturbance in the grid network.

The health of bushings is assessed through periodic measurement of tan δ and capacitance values. The limiting value for tan δ is defined by IEC 60137 to be 0.7 % or, in absolute terms, 0.007 (for new OIP bushings) [1]. Keeping this in view, the Madhya Pradesh Power Transmission Co. Ltd has defined the periodicity of recording tan δ and the capacitance value of bushings of EHV transformers as 6 months.

In order to obviate catastrophic failure of the transformers, in the present-day scenario, the Utilities are procuring large transformers equipped with NIFPS (nitrogen injection fire protection system) or any other equivalent fire protection system. Even if saving the transformer from catching fire due to bushing failure through successful operation of the NIFPS system, restoration of the transformer back into service takes a long time as the drained-oil into the oil-sump needs to be filtered and made use-worthy or to be replaced with new oil.

The periodicity (6-month) could not be maintained to evaluate tan δ of the bushings for want of timely shutdowns due to operational constraints of the 400 kV grid system combined with the procedural delays in getting permission from Madhya Pradesh State Load Dispatch Centre.

In view of the deterioration in tan δ value beyond the limiting value of 0.7 %, the chief engineer (T&C) had taken the decision to replace the said bushing.

The health of bushings is assessed through periodic measurement of tan δ and capacitance values where the limiting value for tan δ is defined by IEC 60137 to be 0.7 %

Table 1. In-service records of tan   values of the 1V-phase 420 kV OIP bushing

Date of measurement	Test voltage	Recorded value of tan δ	Recorded capacitance	Oil temperature	Remarks
25 Mar 10	5kV	0.20%	423.78 pF	40.0°C	Routine maintenance
13 May 16	10kV	0.15%	426.3 pF	42.2 °C	Routine maintenance
15 Sep 16	10kV	0.23%	421.71 pF	30.9 °C	*Not available
20 Sep 18	10kV	0.42%	420.87 pF	32.6 °C	Routine maintenance
*Year 2019		*Not available	*Not available	*Not available	Routine maintenance
15 May 20	10kV	1.02%	419.67 pF	35 °C	Routine maintenance

Note: * Due to the unavailability of shutdown, the tan *δ* of the bushings could not be measured in the year 2019.

SECTION- A

2. Concept of condenser bushings

For 66 kV class and above, normally condenser bushings of either OIP (oil-impregnated paper) or RIP (resin impregnated paper) type are used for power transformers. While, of late, commercial use of RIP bushings is gaining popularity, most of the old transformers installed more than a decade ago in India are fitted with OIP bushings only. The condenser bushing is conceptualized keeping in view the principle of uniform potential gradient / grading of the electric field from the live EHV conductor to the fixing flange of the bushing, which is at the earth's potential through a series of condenser layers.

The OIP bushing is designed and manufactured with great precision. It consists of multiple layers of grading condensers wound concentrically over the central tube of the bushing, using alternate layers of aluminium foil and kraft paper, as shown in Fig. 1. To ensure uniform voltage grading between the condenser layers, the inter-layer capacitances are maintained almost equal. In order to ensure the specified low partial discharge (PD) level, each condenser layer is designed for electric stress in the range of typically < 5 kV/mm. Further, in order to fulfil the stringent requirements of quality parameters like tan *δ* 0.3 % to 0.35 % at room temperature and PD <10 pC special quality control measures are taken while oil impregnation under fine vacuum and drying or removal of moisture is in an autoclave, a chamber with heating and vacuum facility. Drying of the bushing core insulation in the oven.

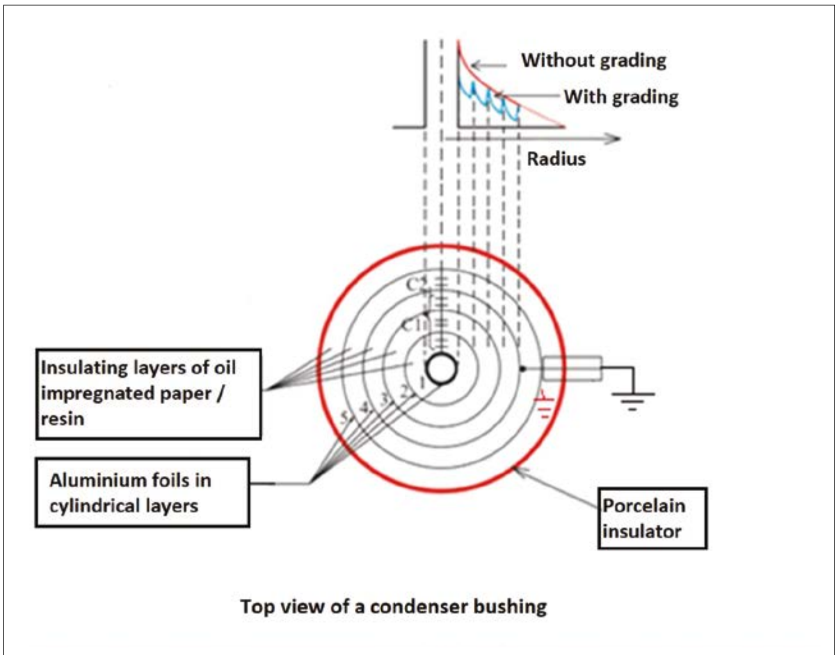

Figure 1. Concept of potential graded condenser bushings

The voltage distribution of graded and ungraded bushings is illustrated in Fig.2. The distribution of potential in the graded bushing from 100 % voltage to 0 % voltage is uniform as compared to that of the ungraded bushing. Graded bushings control longitudinally (axially), resulting in an ultimate reduction in diameter of the bushing, unlike that of ungraded bushings, which need larger diameter (i.e., increase in volume to accommodate more insulating material) and become bulky for the same voltage class.

Note:

a) C1 is the high voltage capacitance of the bushing, which is the total capacitance of all the series-connected condenser layers from the central tube to the test tap. The bushing insulation is either oil-impregnated paper in case of OIP bushing or resin-impregnated paper in case of RIP bushing. The main insulation is between the central tube of the bushing and the test tap.

b) C2 is the low voltage capacitance between the test tap and the flange of the bushing. However, its value is higher than C1. The test tap facilitates the measurement of the capacitance and tan δ (dissipation factor) and the insulation resistance.

Note: The outer-most metallic foil of the condenser C2 is earthed inside the bushing with its mounting flange, as shown in the Fig. 2.

c) **In service condition:** When the test tap cover is screwed on to the socket, C2 gets short-circuited and becomes ineffective (reason: the outer foil of the C2 terminal is already earthed through mounting flange inside the bushing, and the inner foil of C2 is earthed through the earthed Test terminal cap). Thus, only HV capacitance C1 remains in the circuit when the transformer is in service.

3. Significance of bushing tan δ in context to condenser bushings

d) Tan δ or dissipation factor of the bushing is an index of insulation quality and its dryness. Factory dried new bushing displays the lowest value of tan δ. As the insulation is subjected to electrical and chemical stresses during the course of its service, the insulation starts aging (i.e., deterioration of physical and electrical properties), and the value of tan δ would start increasing gradually. When the tan δ value exceeds 0.7 %, the bushing becomes prone to failure anytime. It is therefore advisable to replace the bushing at this stage to ward off the risk

Tan δ or dissipation factor of the bushing is an index of insulation quality and its dryness, and it is better when it is lower

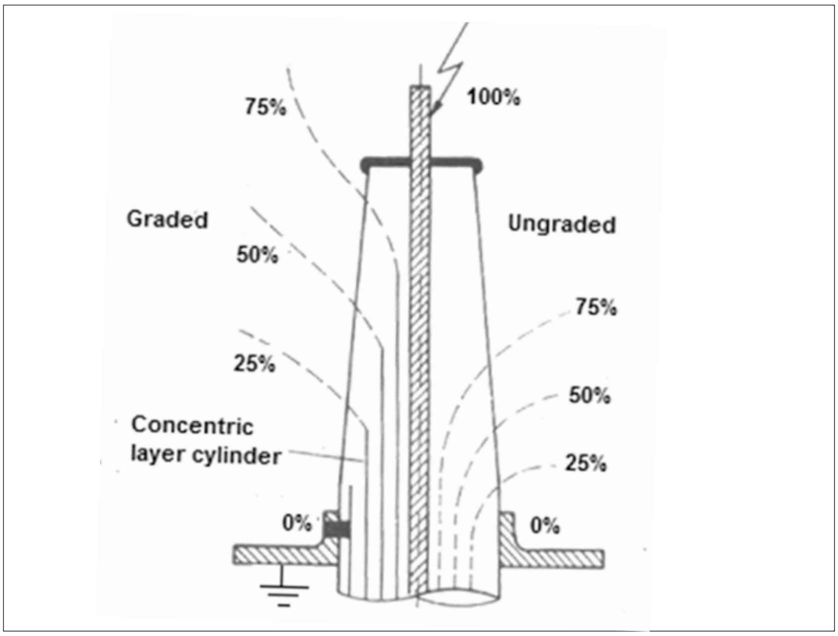

Figure 2. Comparison of potential distribution in graded and ungraded bushings [2]

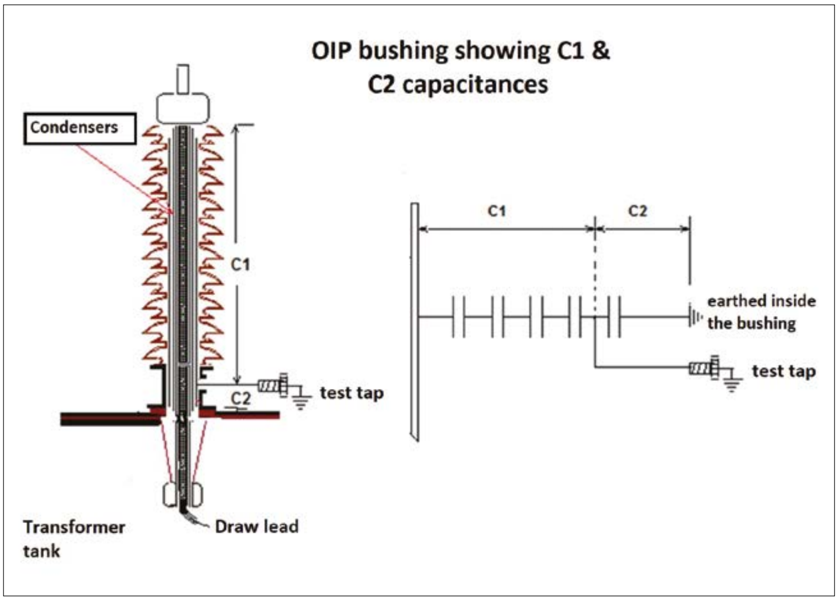

Figure 3. (1) Locations of C1 &C2 in a condenser bushing with a schematic series circuit showing capacitance C1 & C2 in series with earthed inside the bushing while test tap cap is open. (2) C2 gets shorted when the earthed test tap cover is screwed on the socket of the test tap.

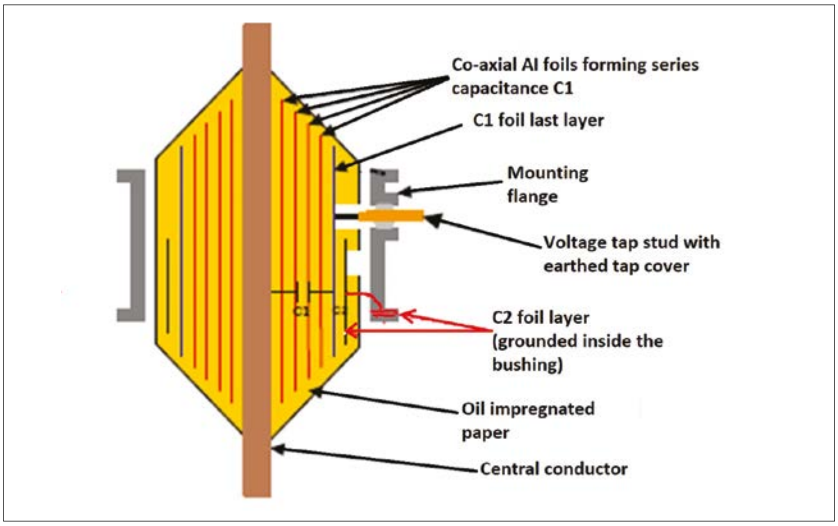

Figure 4. Voltage – tap concept in OIP bushing [3]

of failure, which could cause extended damage to the transformer and other connected equipment.

e) The definition of tan δ and its vector representation is illustrated below.

The AC voltage, when applied to an ideal capacitor, gives rise to a capacitive current which leads the applied voltage by 90°, however since the OIP/RIP bushings inherently possess some impurities, the Ic current vector shall not lead the voltage vector by 90° but shall lead the voltage vector by less than 90°. While in service, the developed impurities shall be restive in nature and form a parallel circuit with the capacitance of OIP bushing. The total current 'I' shall be divided into two parallel paths, one through the capacitors and the other through the resistance (impurity). They are I_C and I_R respectively (Fig. 5 (b)).

According to the vector diagram, the current vector' **I'** no longer leads the voltage vector *V* by 90°, but now it is leading by $\emptyset° = 90° - \delta$ (Fig. 5 (c)).

f) $\tan\delta = \frac{I_r}{I_c}$ i.e., an increase in tan δ value is an indication of deterioration of the insulation (by way of increased impurities).

g) Increase in C1 takes place if some of the condenser layers fail.

If one layer of the OIP bushing is shorted due to some failure, then the total capacitance will increase

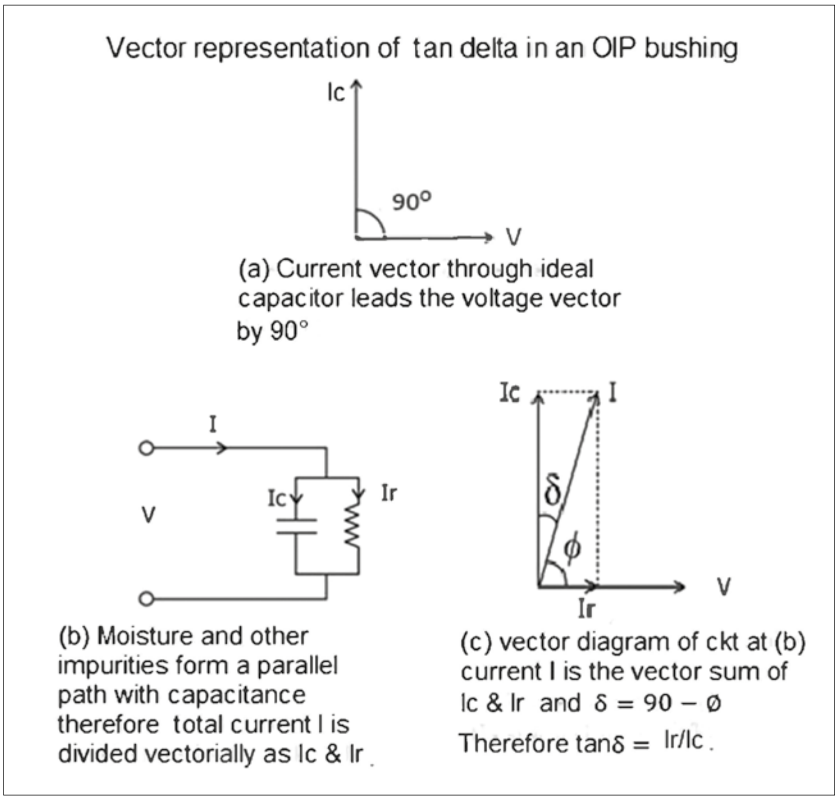

Figure 5. Loss angle δ = (90-Ø shown between the vectors I_C and I)

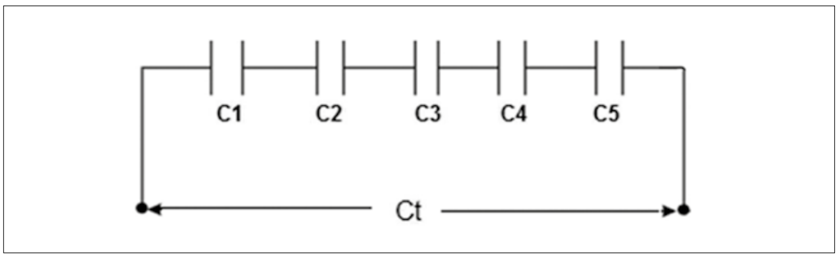

Figure 6. Equal capacitances in series

4. Effect of failure of condenser layers in a series capacitor string (specimen calculation)

$$\frac{1}{Ct} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + \frac{1}{C4} + \frac{1}{C5}$$

Say C_1, C_2, C_3, C_4, and C_5 are having capacitances of 20 pF each.

Therefore, $\frac{1}{Ct} = \frac{1}{20} + \frac{1}{20} + \frac{1}{20} + \frac{1}{20} + \frac{1}{20}$

$\frac{1}{Ct} = \frac{5}{20}$, or $C_t = 4$ pF

Suppose one of the capacitors is shorted, say C3 is shorted then:

$$\frac{1}{Ct} = \frac{1}{C1} + \frac{1}{C2} + \cancel{\frac{1}{C3}} + \frac{1}{C4} + \frac{1}{C5}$$

$\frac{1}{Ct} = \frac{4}{20}$, therefore, Ct= 5 pF

Thus, the total capacitance will increase whenever there is a failure of the condenser in the bushing.

5. Potential causes of failure of the bushings in service

A few of the causes leading to bushing failure are enumerated below:

(i) High dielectric stress due to switching surges and lightning surges,
(ii) Ingress of moisture and other contaminants through deteriorated / aged gaskets and hairline cracks in the bushing porcelain,
(iii) Oil leakage,
(iv) Deterioration of dielectric properties of bushing insulation due to:
  a) Rise in oil temperature consequent to the overloading of the transformers
  b) Loose joint in the leads in the draw lead type bushings / draw rod type bushings, connections giving rise to excess temperature in the bushings.
(v) Failure due to improper earth connection of test taps.
(vi) Improper re-fixing of test tap cap after tan δ and capacitance measurement.

The value of tan δ can be measured offline with the voltage level of 10 kV, utilising the UST mode (ungrounded specimen test mode)

The value of tan δ can be measured offline with the voltage level of 10 kV, utilising the UST mode (ungrounded specimen test mode)

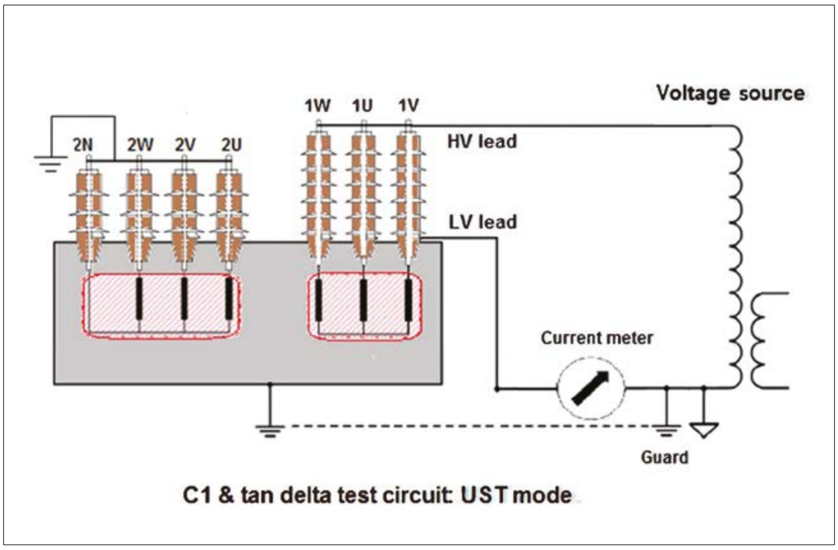

Figure 7. Offline testing arrangement / schematic diagram for tan δ measurement of power transformer bushing in UST mode (ungrounded specimen test mode)

6. Measurement of capacitance and tan δ in service

a) The value of tan δ is measured offline with 10 kV, utilising UST mode (ungrounded specimen test mode) (Fig. 7). The limiting value of tan δ for new OIP bushings is 0.007 or 0.7 % as per IEC-60137 [1].

6.1 Procedure for measurement of tan δ of C1 condenser

The following points are to be taken care of:

Follow the connection for test and test procedures strictly as per guidance narrated in the instruction manual of the kit. Earth the test kit.

For measurement tan δ and C1 select: UST mode

a) In case of the autotransformer:

(i) **HV & IV bushings:** The autotransformers are proved to be economical as compared to conventional two winding transformers if the transformation voltage ratio is less than 2. There is no galvanic isolation between the high voltage side and intermediate voltage side. It has 3 levels of voltages HV (high voltage), IV (intermediate voltage), and LV (low voltage). LV is delta tertiary. Generally, the vector group of autotransformers is described as YNa0d11 or YNa0d1. Please ensure that all other HV, IV, and N (isolated from the earth) bushings are connected to the HV bushing under test and connect the HV lead of the kit to the HV terminal of the bushing and LV lead of the test kit to the stud at the test terminal available after removal of the Test terminal cover. Short all the LV (tertiary) bushings and earth them.

(ii) **IV bushings:** Ensure that all other HV, IV, and N (isolated from the earth) bushings are connected to the IV bushing under test and connect the HV lead of the kit to the IV terminal of the bushing and LV lead of the test kit to the stud at the test terminal available after removal of the Test terminal cover. Short all the LV (tertiary) bushings and earth them.

(iii) **LV bushings:** If LV (tertiary) winding bushings are also OIP ones, then short all the HV, IV & N bushings and earth them. Short all the LV bushings together with the bushing under test, then connect high voltage lead from the test kit to the LV bushing terminal and connect the low voltage led to the stud available after removal of the test terminal cover.

b) In case of two winding transformer bushings:

(i) **HV bushings:** Connect the HV lead of the kit to the HV bushing terminal under test and also connect all HV bushing and HV neutral terminals to the HV bushing under test. Connect LV lead of the kit to the test terminal stud, short all LV bushings and LV neutral, and then earth.

(ii) **LV bushings:** Connect the HV lead of the kit to the LV bushing terminal under test and also connect all LV bushing and LV neutral (isolated from the earth) to the LV bushing under test. Connect LV lead of the kit to the test terminal stud. Short all the HV bushings and HV neutral and earth them.

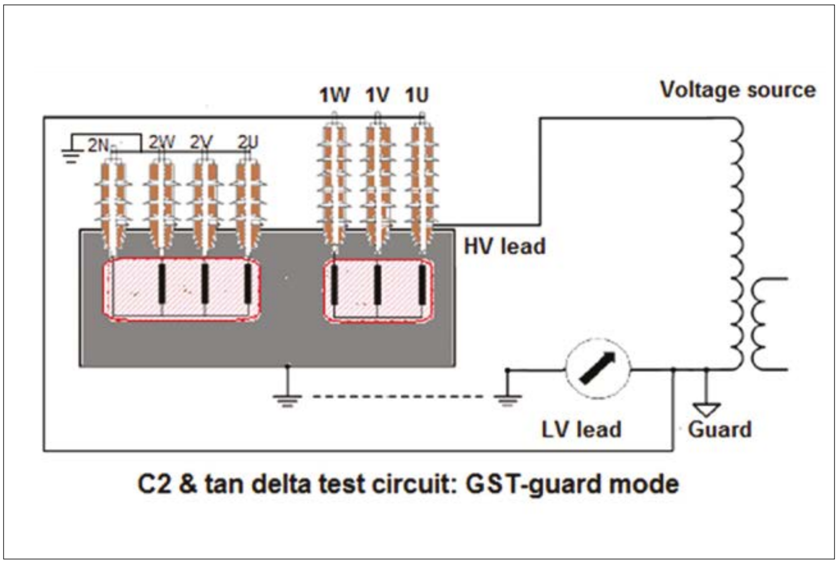

Figure 8. Circuit showing test kit connection for measurement of C2 and tan

After the completion of periodic tests during preventive maintenance shutdowns or otherwise, it is very important to verify that the test tap cap is properly replaced / tightened, and the test tap is firmly grounded

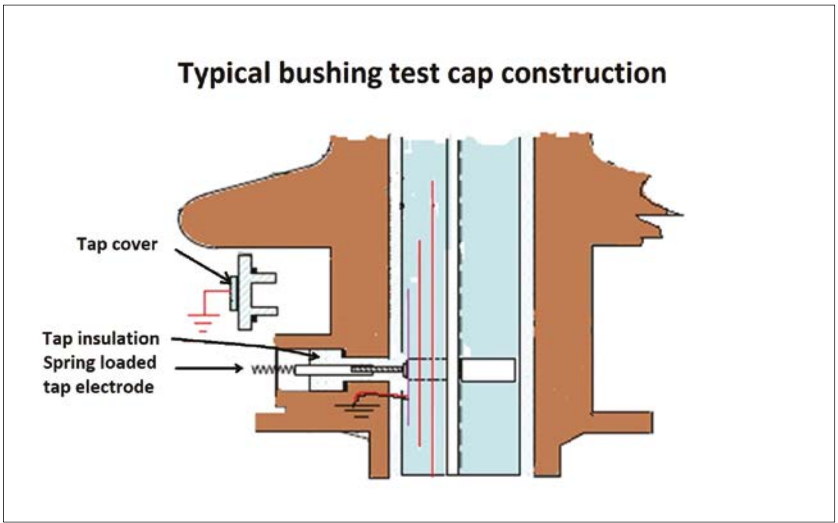

Figure 9. Typical bushing test tap construction

6.2. For C2 and tan δ measurements, select GST grounded specimen test, guard mode:

Guarded LV lead should be connected to the central conductor, and HV lead should be connected to the test tap. However, the test voltage should not exceed 1 kV. The connection circuit diagram is shown in Fig. 8.

Note:

(1) Value of tan δ at C2 is not converted to 20 °C.

(2) The value C2 and tan δ is not very significant as the C2 is shorted in service condition. Thus, many utilities do not measure it at all.

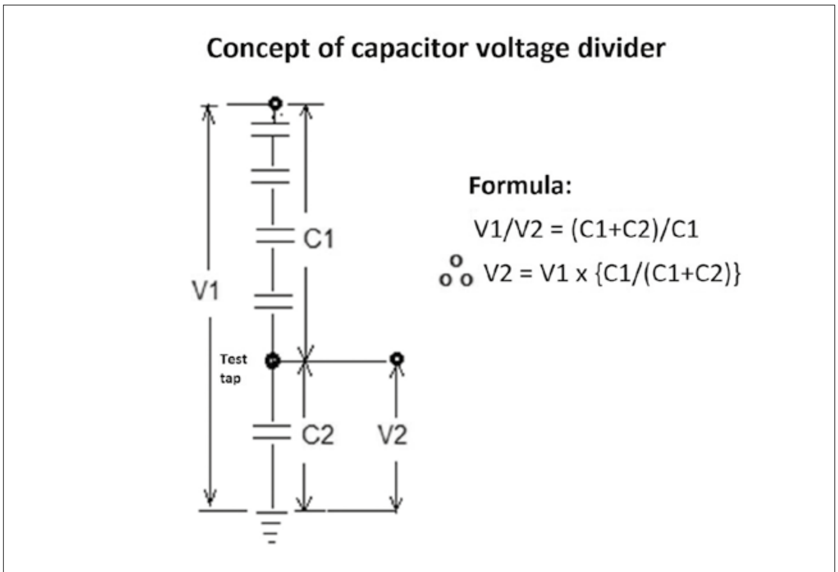

Figure 10. Concept of a capacitor voltage divider

Caution: After the completion of periodic tests during preventive maintenance shutdowns or otherwise, it is very important to verify that the test-tap cap is properly replaced / tightened, and the test tap is firmly grounded. In case the test tap is left open inadvertently, the high voltage will appear at the test tap stem, leading to heavy sparking at the test tap. Sustained sparking could lead to failure of the bushing with possible damage to the transformer and other connected equipment like current transformers and lightning arresters, etc.

7. Concept of a capacitor voltage divider

In a capacitor voltage divider, if capacitors are in series, say C1 and C2, and the tapping point is defined between C1 and C2 and if a voltage is applied across the whole series capacitor, then a voltage shall develop at the tapping point between the capacitors with respect to the common point, which is known as open secondary voltage. With reference to Fig. 10, a voltage of V1 is applied between terminal A and the Earth E, which gives rise to a secondary voltage designated as V2. Such capacitor voltage divider is used in the CVTs (capacitor voltage transformers) which are used in the CVTs lieu of PTs (potential transformers).

The ratio $\frac{C1 + C2}{C1}$ of the capacitor divider corresponds to the ratio of the primary voltage to the open circuit secondary voltage. Therefore, we can write:

$$\frac{V2}{V1} = \frac{C1}{C1 + C2}$$

As per the above formula

$$V2 = V1 \left(\frac{C1}{C1 + C2}\right)$$

7.1. Application of capacitor voltage divider formula in case of condenser bushings

It may be noted that a condenser bushing consists of two capacitors, viz. the high voltage capacitor C1 and the low voltage test tap capacitor C2 as shown in Fig. 3 (it may be noted that C2's outer foil is inherently earthed inside the bushing assembly). The circuit acts as a capacitor voltage divider if the shorting of C2 is lost consequent to losing earthing and acts as a capacitor voltage divider. If the test terminal cap is not duly earthed is either loose or inadvertently left open, the sufficiently high voltage would develop across the stud of the test terminal with reference to the earth. The insulation at the low voltage side can usually withstand only 2 kV.

OIP bushing acts as a voltage divider, so if the test tap cap of tan δ measurement socket is left inadvertently open, a heavy voltage will develop as against its capability to withstand 2 kV and damage its insulation

7.2. Sample calculation

A typical value of a 245 kV OIP bushing to depict the voltage developed at the test tap when the tap cover is loose or inadvertently left open is described hereunder.

OIP bushing details:

Make: CGL, type COT: 1050 kV, rated current: 800/1250 A,

C1 at Un 245 kV: 371.18 pF, C2 = 648.20 pF

Development of voltage at tap-stud with reference to earth in case of the above bushing

Phase to ground voltage V1 would be $\frac{220}{\sqrt{3}}$ = 127 kV,

As per the above formula

$$V2=V1\left(\frac{C1}{C1+C2}\right)$$

$$\text{Therefore } V2=127\left(\frac{371.18}{371.18+648.20}\right),$$

$$V2=127\left(\frac{371.18}{1019.38}\right)$$

$$V2=127\left(\frac{371.18}{1019.38}\right);\ V2=46.24\text{ kV}$$

The test tap is insulated for only 2 kV. If it is left floating, i.e., not grounded, a voltage of 46.24 kV could develop across it with reference to earth, causing heavy sparking within the test tap assembly.

8. Conversion table of tan δ to base 20 °C

8.1. Formula for conversion of tan δ at 20 °C

The temperature correction factor for tan δ of insulation is dependent upon the insulating material, material structure,

The temperature correction factor for tan δ of insulation is dependent upon the insulating material, material structure, and moisture content

Table 2. Tan δ correction factors for OIP & RIP bushings to 20 °C

Range of temp. in °C	Correction factor to 20 °C		Range of temp in °C	Correction factor to 20 °C	
	OIP bushing	RIP bushing		OIP bushing	RIP bushing
0-2	0.80	0.76	43-47	1.25	1.33
3-7	0.85	0.81	48-52	1.30	1.37
8-12	0.90	0.87	53-57	1.34	1.41
13-17	0.95	0.93	58-62	1.35	1.43
18-22	1.00	1.0	63-67	1.35	1.43
23-27	1.05	1.07	68-72	1.30	1.42
28-32	1.10	1.14	73-77	1.25	1.39
33-37	1.15	1.21	78-82	1.20	1.35
38-42	1.20	1.27	83-87	1.10	1.29

There are 3 types of OIP bushing for oil to air application: draw lead type (up to 800 A), Draw rod type (up to 1250 A), and stem type bottom connected (up to 2000 A)

moisture content, etc. The following relationship can be used for a good approximation:

$$\tan\delta 20 = \frac{\tan\delta OT}{K},$$

Where the tanδ20 = tan δ at 20 °C,

tan δ OT = tan δ measured at given oil temperature

K= correction factor.

Sample calculation:

Suppose the tan δ measured was found as 0.0075 at an oil temperature of 45 °C:

- Type of bushing: OIP type
- Conversion factor: from Table 2, K= 1.25 (for temperature range 43 to 47 °C)
- Using formula $\tan\delta 20 = \frac{\tan\delta OT}{K}$
- Tanδ20 $\frac{\tan\delta OT}{K}, = \frac{0.0075}{1.25} = 0.006$

9. Interpretation of tan δ and capacitance values

Values of the dissipation factor (tan δ) and capacitances are compared with one or more of the following:

(i) Rating plate / name plate data.
(ii) Results of the prior tests of the same bushing.
(iii) Results of similar tests on similar bushings.

The value of the dissipation factor of modern condenser bushings is generally of the order of 0.4 % after correction to 20 °C. However, as specified in IEC: 60137 and IS: 2099, the limiting value of new OIP bushing is 0.7 %. [1]

There is no specified acceptance limit on variation in HV capacitance (C1) value for continuance in service. For practical purposes, a capacitance variation up to say +5 % of the nameplate value could be considered safe for the purpose, depending upon the total number of condenser layers.

Example: If 2 layers out of 50 fail in service, the 100 % voltage will get redistributed across the remaining 48 layers; thus, each layer would be stressed by 100/48 = 2.08 % (i.e., overstressed by (2.08 – 2) / 2*100 = 4 %). As the built-in safety margin is 5 %, failure of up to 2 layers of condensers in a 400 kV bushing could be accepted for allowing the bushing to continue in service in an emergency.

10. Types of bushings

There are 3 types of OIP bushing for oil to air application:
(i) Draw lead type, currents 800 A
(ii) Draw rod type, currents 1250 A
(iii) Stem type bottom connected, currents > 2000 A.

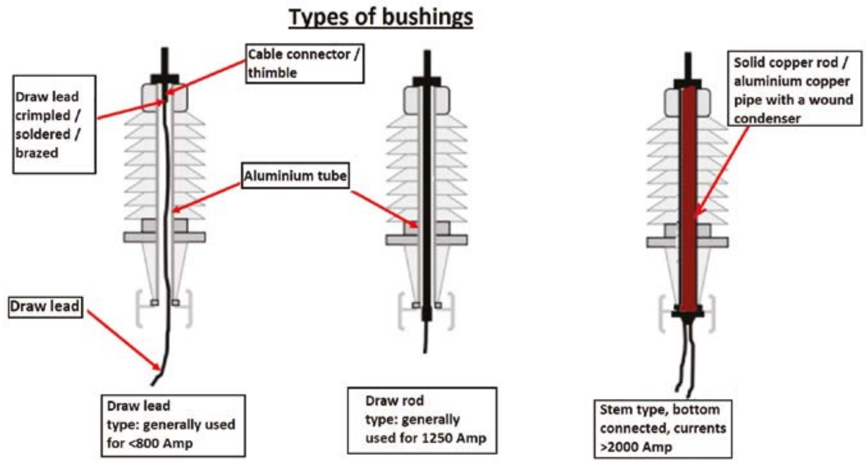

Figure 11. Types of bushings used in conventional power transformers [4]

Table 3. Significance of test values of tan δ and capacitance of condenser bushings – analysis of results / interpretation [3]

S. No.	Tan δ and capacitance – trend of test results	Analysis / interpretation
1	Increase in dissipation factor (between 0.7 % and 1 %) accompanied by marked increase of capacitance.	Indicative of excessive moisture in the insulation.
2	Very high increase in dissipation factor alone (more than 1 %).	Indicative of thermal deterioration, aging, or contamination other than moisture.
3	Low tan δ.	Indicative of weak potential connections.
4	Increased capacitance.	Indicative of possibility of short-circuited condenser layers.
5	Decreased capacitance.	Indicative of possibility of floating ground sleeve, or open or poor test tap connection.
6	Very large variation in tan δ and capacitance values.	Indicative of no oil in the bushing.
7	Negative dissipation factor accompanied with small reduction in capacitance.	May result from external surface leakages or internal leakages resulting from carbon tracking, etc.

11. Main components of OIP bushing

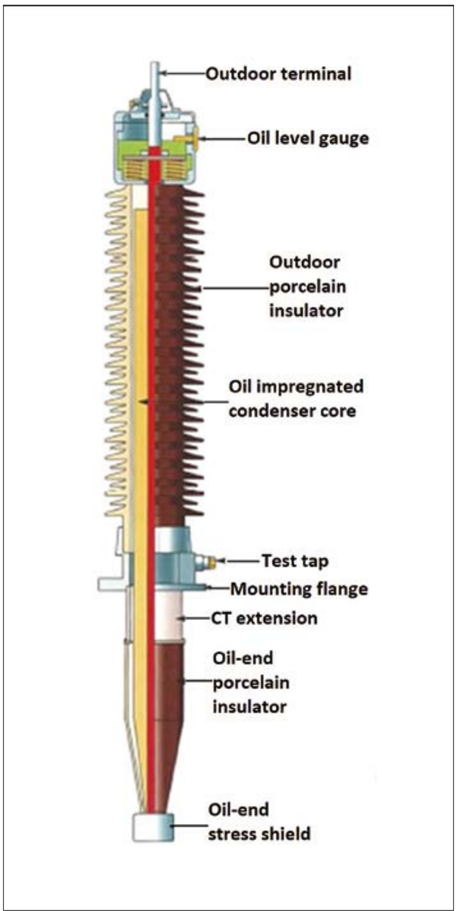

Figure 12. Components of OIP bushing

There is no specified acceptance limit on variation in HV capacitance (C1) value for continuance in service, but for practical purposes, a capacitance variation up to +5 % is acceptable

12. Thermography of bushings

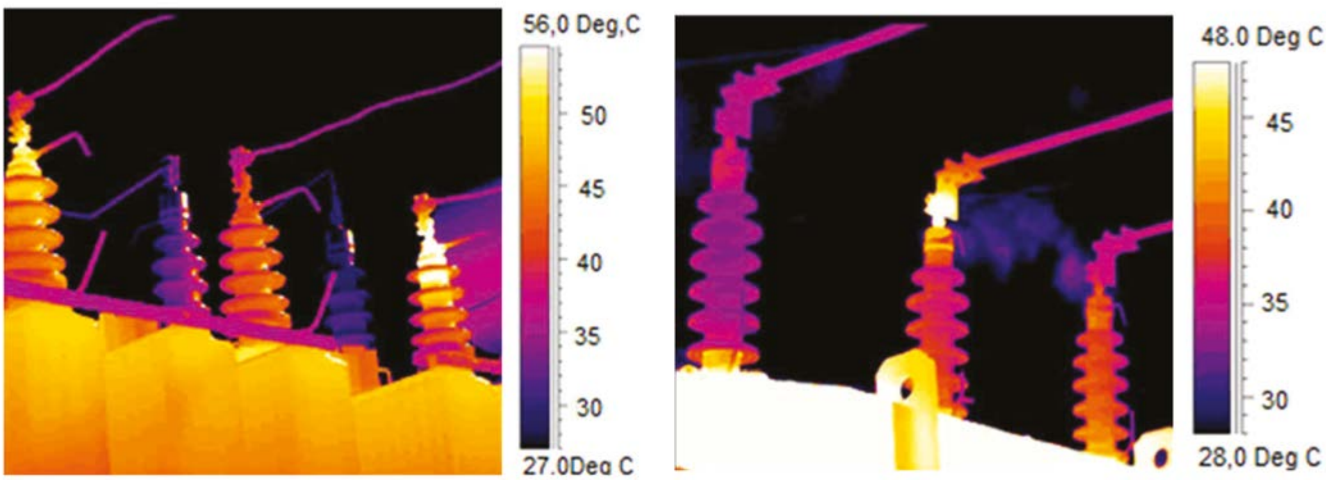

Figure 13(a). Image of hot spot at the top of the extreme right bushing Figure 13(b). Image of hot spot on the terminal clamp of middle bushing

Note: Vertical scale of temperature (variation of colour-wise) is given alongside Fig. 13(a) and Fig. 13(b). Portion with white colour in Fig. 13(a) in the extreme right top portion of the bushing indicates its hot spot temperature is above 53 °C, and in Fig. 13(b), the stud and the clamp of middle phase bushing are seen white in colour, which indicates that the temperature at those points is around 47 °C.

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To be continued in the next edition.

Authors

K. K. Murty (Principal Author) is B.E. (Hons) El. Engg, FIE (India) and CE (India), member of CIGRE India. He is former Chief Engineer and HOD (Testing & Commun.), M.P. Power Transmission Co. Ltd. Jabalpur, having served in MPSEB & MPPTCL, Jabalpur for 33 years at different levels from the Assistant Engineer to the Chief Engineer. He was empanelled as an expert professional on the panel of CPRI, Bangalore and carried out TPI of Power equipment on behalf of CPRI, Bangalore / Bhopal (from 2008 until 2012). Mr. Murty also worked from 2004 until 2006 as an Advisor (Testing) in SOUTHCO, Berhampur, Odisha (a DISCOM in Odisha of Anil Dhirubhai Ambani group). He worked as Metering Consultant to M. P. Electricity Regulatory Commission, Bhopal, for a year in 2005 and as the Course Director for the Graduate Electrical Engineering Trainees, in the Training Institute of MPPTCL, Jabalpur (for two semesters in 2006 and 2007). He is a recipient of plaque in recognition of eminence and contribution to the profession of electrical engineering at the national level by Institute of Engineers India, Kolkata in October 2015.

R. K. Gupta holds a diploma in Electrical Engineering & AMIE. His present post is that of the Executive Engineer of Testing Division, Katni. He has 32 years of extensive experience in operation and maintenance of EHV substations from 132 to 400 kV. Mr. Gupta was felicitated by MD, MPPTCL for promptly arresting the flow of oil consequent to failure of tertiary bushing of 315 MVA transformer at 400 kV S/S Bina and putting the transformer back into service after replacing the tertiary bushing, testing, and replacing the oil in 2005. He was also felicitated by MD, MPPTCL for attending to the OLTC of 63 MVA, 132/33 kV transformer, in the 132 kV S/S Sagar, without the help of OEMs service personnel. Testing Division Katni was awarded the third best performing Testing Division in MP in the 2019-2020 under his able leadership.

C. B. Kushwaha holds a bachelor's degree in Electrical Engineering. He has three years of working experience in design, construction and commissioning of 33/11 kV substations. He is posted as Assistant Engineer (testing) at Katni and has 13 years of extensive experience in testing and commissioning of EHV S/s equipment from 33 kV to 400 kV. He was felicitated by MD MPPTCL for a quick restoration of supply at 132 KV substation Srinagar, under Testing Division II, Jabalpur. His experience includes five 33 kV bays and two 132 KV bays tested and commissioned, along with cable laying and C/R panel erection work, within 72 hours.

S. K. Chaturvedi holds a diploma in Electrical Engineering and bachelor's degree in Technology. He presently works as Assistant Engineer (maintenance) 400 kV S/s Katni, since October 2013 in a 950 MVA, 400/220/132 kV /33 kV AIS he is managing the maintenance and erection / installation jobs independently and successfully of EHV equipment up to 400 kV level. He was felicitated by MD MPPTCL for on spot repairing and installation of EMR make diverter switch on a 24-year-old 160 MVA, 220/132 kV TELK make transformer at 400 kV S/s Katni. He successfully assembled a 400 kV, 125 MVAR bus reactor and all associated equipment for the bay at 400 kV S/s Katni, within minimal time. He obtained ISO 9001-2008 certificate in 2015, for 50-year-old 132/33 kV AIS Kymore, for complete renovation. He successfully performed retrofitting and replacement of 220 kV, 132 kV, 33 kV, 22 old pneumatic circuit breakers / VCBs within minimal time and reconditioning of two 40-year-old 132/33 kV transformers.