

RIP (Resin Impregnated Paper) Bushing for EHV Class Power Transformer

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Abstract—The overall reliability of a power transformer depends to a great extent on the sound operation of bushing. The OIP (Oil Impregnated Paper) Bushing is conventionally used in power transformer. Now a days a new technology has arise which has replaced OIP bushing with RIP (Resin impregnated paper) bushing. The RIP bushings are gaining popularity worldwide because of its advantages over OIP bushing. This paper deals with construction, features, price, reliability & availability of RIP Bushings and their advantages/ disadvantages vis-à-vis OIP Bushings.

Keywords— Power Transformer, OIP, RIP, Bushing & Failure.

I. INTRODUCTION

Bushings are very vital component of transformers. Based on CIGRE WG-12 Report-1983, Bushings (14%) are 3rd major source of transformer failure after OLTC (40%) & Winding (35%).

Bushing is a device that enables one or several conductors to pass through the grounded transformer tank and insulates the conductor from it. Broadly EHV class bushings can be categorised in following two types based on their material, manufacturing & design:

- i. OIP (Oil Impregnated Paper) Bushing
- ii. RIP (Resin Impregnated Paper) Bushing

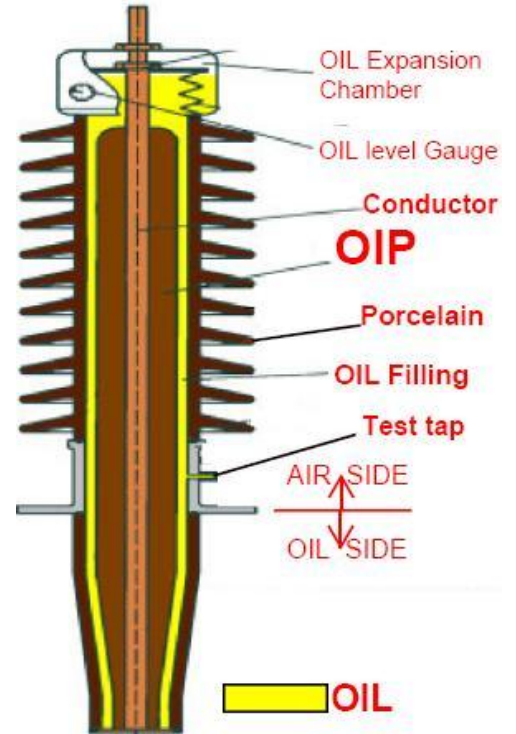


Fig. 1 Cross sectional view of OIP Bushing

II. OIL IMPREGNATED PAPER (OIP) BUSHING

The traditional OIP bushing technology uses oil as its basic insulating medium. Use of oil has many severe drawbacks in bushing life, such as being susceptible to moisture ingress and oil leakage due to worn out seals. In turn greater vulnerability in an OIP bushing exists to lightning strikes or other factors that can trigger explosive failure. Additionally, excessive filling of oil reservoirs in horizontal mount applications can lead to severe operational problems. Unusually high operating temperatures on an OIP bushing can comprise its bushing life and again lead to severe operational problems.

Fig. 1 shows the cross sectional view of OIP Bushing. In OIP bushing the core is wound from paper and subsequently treated and impregnated with an insulating liquid, generally transformer oil. The core is contained in an insulating envelope (generally “Porcelain”), the space between the core and the insulating envelope being filled with the same insulating liquid as that used for impregnation. Bushings are also provided with Oil level gauge & Test Tap. In the centre stem is provided which connects the Overhead conductor to transformer winding, this is usually made of copper.

III. RESIN IMPREGNATED PAPER (RIP) BUSHING

Recently a revolutionary new class of insulating material called resin impregnated paper (RIP) with superior thermal and electrical performance has been developed.

Fig. 2 shows the cross sectional view of RIP Bushing. In RIP bushing the major insulation consists of a core wound from paper and subsequently impregnated with epoxy resin. The casting and curing of this insulation is a carefully controlled process. A resin-impregnated paper bushing can be provided with an insulating envelope (generally “Silicone Composite insulator”), in which case the intervening space can be filled with an insulating liquid or another insulating medium like polyurethane foam, gel etc.

Based on the above, it can be said that the major difference between Resin Impregnated Paper (RIP) bushing technology and Oil Impregnated Paper (OIP) bushings is that in OIP technology the condenser cores are impregnated with transformer grade mineral oil that remains in a liquid phase throughout its entire life whereas in RIP bushings the impregnation is carried out via a curable epoxy resin to form a solid conde

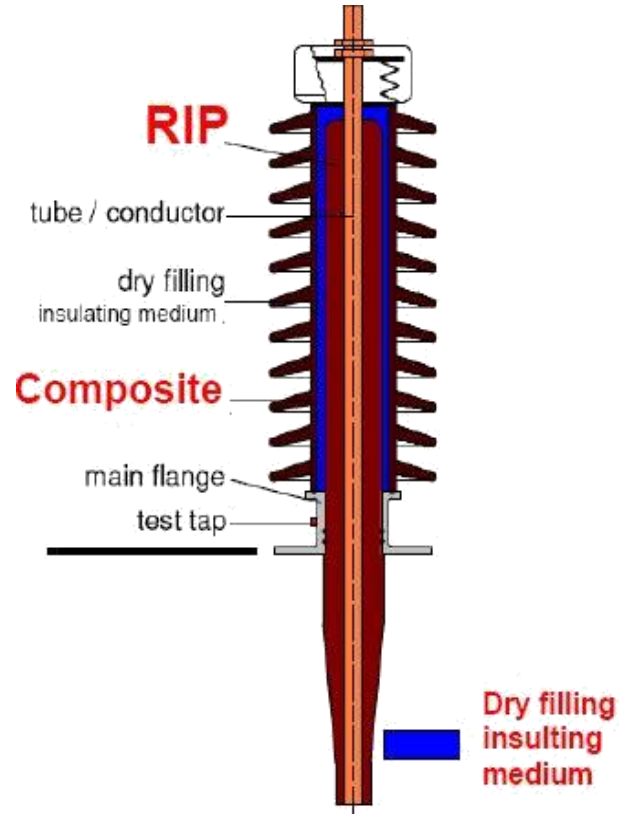


Fig. 2 Cross sectional view of RIP Bushing

IV. COMPARISON BETWEEN RIP & OIP EHV CLASS BUSHING

- A. *Partial Discharge Level:* Generally observed PD level in RIP bushings are lower compare to OIP bushings. In RIP PD level generally observed are less than 2 pC, however in OIP it is less that 5 pC.
- B. *Tan Delta Value:* Tan delta values are also lower for RIP bushings, it is in the range of 0.35% or lower but in case of OIP it is 0.45 % or lower usually.
- C. *Insulation Class:* As per IEC standard 60137, insulation class of RIP bushing is Class-E (upto 120 °C) & in OIP bushing the insulation class is Class-A (upto 105 °C).
- D. *Weight & Transportation:* Composite RIP bushing weight is approximately 50% of Porcelain OIP Bushing due to this the handling, transportation & installation becomes easier in case of RIP bushings. Also OIP bushings are more susceptible to damage from vandalism, shipping, handling, and installation.
- E. *Seismic Withstand capability & Mechanical Strength:* As per IEEE 693-2005 standard RIP

bushing have proven very high seismic performance level. However OIP bushings have very low seismic performance withstand capability. Also mechanical strength of RIP bushing is very high compared to moderate strength of OIP bushing.

F. *Installation & Commissioning:* Following are the advantages during installation of RIP Bushings over OIP bushings:-

- i) RIP bushings can be installed Vertical as well as horizontal at any angle. However in case of OIP bushings there is a restriction during installation i.e. upto 30o from vertical only.
- ii) Lowering of transformer oil is required during removal/installation of OIP bushing, the same is not required for RIP bushings.
- iii) RIP bushings installation time is also very less compare to OIP bushing.

G. *Maintenance Aspect:* RIP requires fewer maintenance checks compare to OIP due to absence of oil and porcelain.

H. *Flammability & Explosion Risk:* RIP bushing are made without any use of insulating oil which makes it non flammable. This property also makes it a non-explosive type bushing, however in case of OIP chances of explosion are very high due to insulation failure/arcng which can lead to huge explosion & may also be dangerous due to the outer porcelain envelop which is brittle in nature.

I. *Cost Aspect:* RIP bushing are costlier than OIP bushing by 20-50% high due to the recent technology & less demand, however it becomes cost competitive for higher voltage class & larger quantities. But in future as the market demand increases it may become equivalent to OIP bushing.

V. WHY RIP BUSHINGS ARE REQUIRED?

Like the insulator, the bushing is another of those critical components which comprise all electrical networks and whose failure can have very serious economic consequences.

Although many in the electric utility industry still regard it as nothing more than a hollow piece of porcelain with a conductor running through it,

notwithstanding its simple appearance, the task performed by a bushing is actually quite extraordinary. This is because, for apparatus operating at many thousands or even hundreds of thousands of volts, it is almost a Herculean task to adequately isolate the current carrier effectively.

As mentioned above that Power Transformers failure rate are 14% due to OIP bushings (as per CIGRE 1983 report). Following are the major causes of OIP bushing failures:-

- i. Oil leakage
- ii. Test Tap unearth
- iii. Irregular maintenance
- iv. High Electrical Stress
- v. Crack in the Porcelain
- vi. Improper Installation/handling
- vii. Insulation deterioration (high PD/Tan Delta)
- viii. Manufacturing /Material defect

Consequences of bushing failures can lead to explosion due to the presence of oil & porcelain. Also it may severely damage the associated equipment (like Transformers etc). It may also affect the adjacent equipment due to explosion of porcelain. Most importantly it may lead to an accident.

In India, the failure rate of Power Transformers due to OIP bushings failure is approximately 25% which is very high compared to worldwide figure of 14%. Here some utilities experiences of OIP bushing failures are mentioned:

- a) In various NTPC projects like Auraiya, Khalagaon, Talcher, Vindhyachal, Rihand, dadri, Unchahar & Singrauli have experienced many failures of GT/ICT/Reactor due to direct /indirect (explosion of OIP due to fire) involvement of OIP HV bushing.
- b) In Power Grid many failure in many Inter Connecting Transformers (ICTs)/Reactors are caused by bushing failures.
- c) In NHPC & various electricity boards also critical transformers like Generator Transformers are failed due to bushing failure & it caused the heavy revenue loss due to unit tripping.

To overcome almost all the bushing failure cause, increase the system reliability & human safety, RIP bushing is one of the best solution available today. Resin impregnated paper (RIP) bushings are the source of reliable oil-free service for the most demanding applications. When it is combined with a silicone rubber insulator instead of porcelain, it provides a self cleaning, non-brittle, non flammable, non-explosive, low mass and high mechanical strength design increasing network reliability during severe weather conditions, contamination and earthquakes.

VI. EXPERIENCE ON RIP BUSHINGS

RIP bushings were developed in Europe in way back in early 1950's, also IEC 60137 & IEEE C57.19.00 bushing standards are available for RIP bushings.

RIP bushings are already popular in abroad & upto 550 kV class RIP bushings have been installed world wide for various EHV class transformers of thermal & hydro projects. Manufacturers claim that about 50% of bushings presently manufactured are RIP type. Till date not any significant failure reported due to RIP bushing by any Transformer Manufacturer.

RIP Bushing is also gaining popularity in India. In fact it has already been supplied to various EHV class transformers of hydro projects across India like NHPC-Parvathi HEP, APGENCO (HEP) etc. No issue has been raised due to use RIP bushing by above utilities.

In various upcoming NHPC & NTPC Hydro projects like Tapovan Vishnugarh, Loharinagpala etc are being proposed for use of RIP bushings (Oil to SF6) for Generator Transformers of 400 kV class.

Also various other utilities like Power Grid, Electricity Boards, Reliance Energy, TATA-Power, ESSAR, VEDANTA, ADANI, Torrent Power etc are exploring the reliability of using RIP bushing in place of OIP bushing for EHV class Transformers.

VII. CONCLUSION

In today's world, power system reliability is the major concern and one of the main causes of Power Transformers failures is OIP Bushing.

In order to reduce the OIP bushing failures & to overcome the disadvantages of OIP bushing, Rip bushing is one of most appreciated & latest solution available today.

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