Upgrade and replacement of an existing bushing

Bushings are important components for power transformers. Bushing replacements provides a cost-effective way of extending the service life of transformers that have reached the mid-life point or beyond. This document describes what needs to be checked before upgrading and replacement.

When considering bushing replacement, the following must be taken into account:

- Electrical data
- Oil-side length
- Oil-side diameter
- Oil-end shielding
- Flange dimensions
- Whether CT space can be used to extend the oil-side
- Cantilever strength and seismic demands
- Air-side clearances
- Air-side insulator creepage distance, and pollution restrictions
- Outer terminal dimensions material and coating
- Distance to line connection
- Current rating and connection system
- For draw lead connection, cable area and current rating
- Whether voltage divider can handle capacity change in C1
- Whether resin impregnated paper (RIP) and silicone insulator are acceptable
Electrical data (Fig. 02)
With the exception of current, the most important electrical data is listed below.

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<thead>
<tr>
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<th>Existing bushing</th>
<th>New bushing</th>
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<td>Rated voltage</td>
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<td>Max. line to ground voltage</td>
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<td>1 min. routine test level</td>
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<td>Lightning impulse</td>
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<tr>
<td>Switching impulse, wet</td>
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<td>1 min. AC, wet</td>
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Engineering data for the bushing is normally based on the 1 minute test and wet switching impulse/1 min. AC wet; see below. If other data is not in compliance, check with the customer if this is acceptable.

Oil-end dimensions (Fig. 03)
Oil-side length must be the same as for the original bushing. These requirements are mainly set by the oil-end shielding, which must be correct for the transformer design. This can be adjusted with the flange extension (CT space) on the new bushing. Note that with longer CT space, the ground will extend further into the transformer. This is not normally a problem, but it should be checked that no high potential components come too close.

If the diameter of the condenser core increases, check that it will fit the current transformers and the hole in the cover.

Flange dimensions (Fig. 04)
The bushing must have a flange or a flange adapter that fits the existing position, and the position of the gasket at the flange must be at least Ra 6.3.
Oil-end shielding (Figs. 05 and 06)
If the original oil-end shielding will not be used with the bushing, it is important that someone with the requisite expertise checks that the new bushing can be used with the new shielding.

The oil-end shielding must be paper-covered. The method below can be used to avoid full drainage of the transformer. The paper-covered oil-end shielding is processed in the workshop and kept in oil during transport to the site. Once at the site, it must be lowered into the transformer oil before being removed from its transport container.

Cantilever strength
If this value is lower than for the original bushing, check with the customer that this is acceptable. If the bushing is installed in a seismic zone, a calculation must be made to ensure that the new bushing fulfils the applicable requirements.

Outer terminal (Fig. 07)
Check the dimensions, material and coating of the original tap. If we cannot supply a similar terminal, check with the customer if our proposal is acceptable.
**Insulator creepage distance**
In polluted areas, the creepage distance on the air-side could be an important factor. A silicon insulator is generally better and can be shorter. Porcelain insulators today can be shorter with the same creepage distance.

**Air clearance (Fig. 08)**
If the air-side insulator is shorter, care must be taken that the air clearance between the bushings or other objects is not too small.

**Distance to line (Fig. 09)**
If the air-side of the bushing is shorter, it is important that the distance to the line is not too long.

**Current rating**
Note that the current rating for the bushing is lower for some connections, such as for the draw lead connection.
**Draw lead connection (Fig. 10)**

It is important to understand that the current rating for the bushing depends on the area of the draw lead and the bushing design. The same draw lead area will result in different current ratings in different bushings.

**Solid conductor**

This must be checked and the upper part replaced in a similar way as with the draw lead. The diameter of the solid conductor must also be checked to ensure that it will fit into the center tube of the new bushing.

A solid conductor can also be use with a GOE and GSB bushing, but special measures must then be taken; check with the bushing design department.

**Draw rod (Fig. 11)**

If the old bushing has a draw rod it should be replaced with either a GOE or GSB, but if the oil-end shield is mounted on the bottom contact or in the transformer, it must be checked that the original oil-end shield can be used with the new bushing. A check should also be made as to whether the bottom contact can be re-used. If the bottom contact or oil-end shielding cannot be re-used, the transformer must be drained.

A draw lead connection can also be converted to a draw rod, but the oil in the transformer must then be drained.
Connection to test tap (Fig. 12)

If the customer has connected something to the test tap, capacitance C1 is likely important to the customer. Inform of the new C1 and C2 value. The figure below shows how a voltage divider is connected, but installation is similar for relative tan δ PD measurement, etc.

When transformer oil must be drained

When does a transformer need to be fully drained? The normal criteria for this is when any part of the paper insulation will be above the oil level. One reason the transformer must be drained is that there is a risk of air becoming entrapped in the insulation if the oil is only topped off. Another is that the vacuum should not be directly released for insulation immersed in oil, as there is a risk of gas bubbles forming and becoming entrapped in the insulation. If the oil is drained and the vacuum released, the gas can easily escape from the insulation before oil is filled.

An alternative for when the insulation is above the oil level is to slowly increase the oil level, although this procedure is not acceptable to all.

Resin impregnated paper (RIP) and silicone insulators are acceptable

Check with the customer that RIP bushings and silicone insulators are acceptable. This could also be what some customers prefer when replacing/upgrading bushings.