Bowers Electricals Ltd
Bowers Group of Companies

Distribution Transformers

Operating & Maintenance Manual

2021

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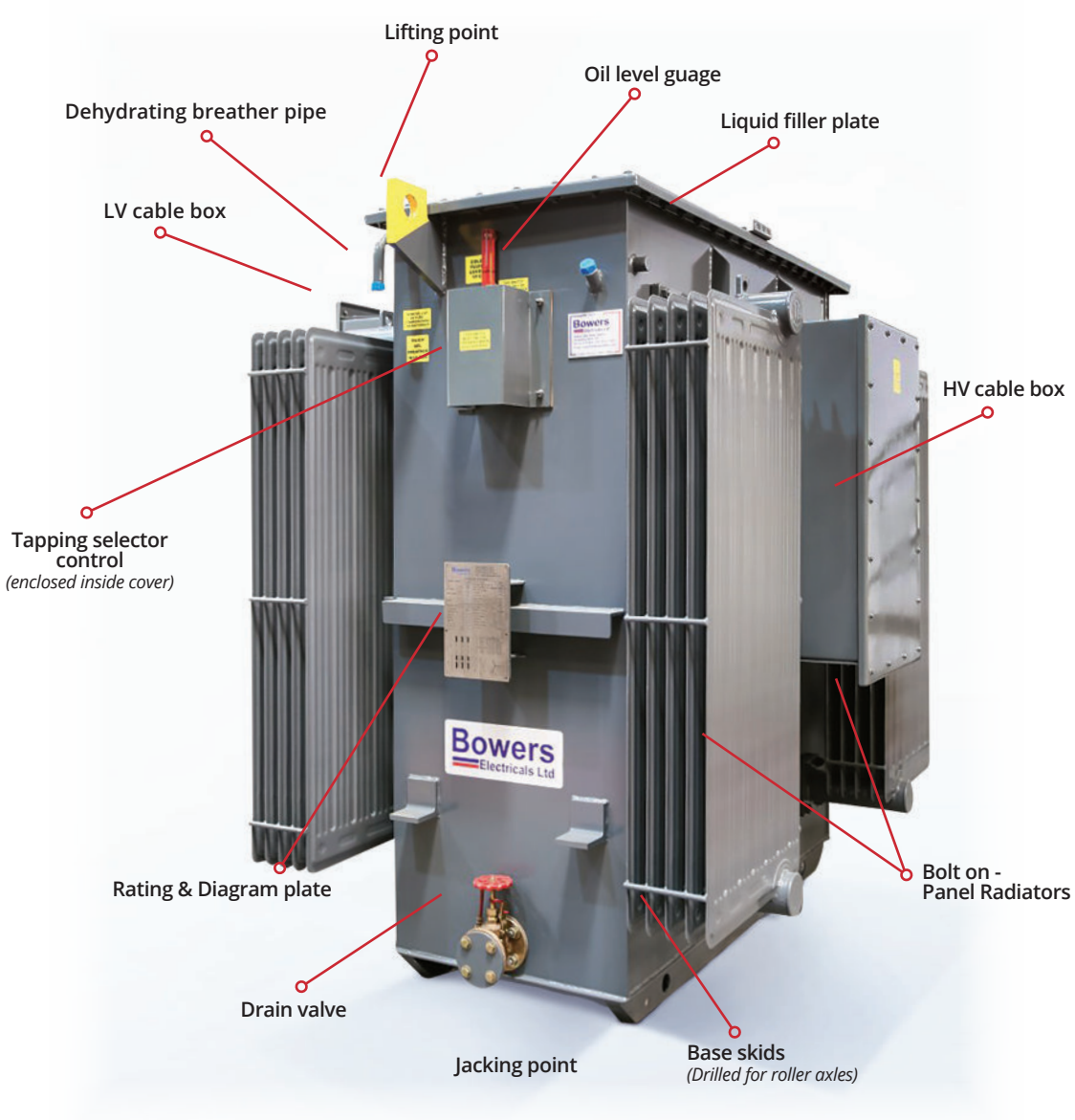


General note to our customers and contractors

This documentation is a general guide, which should cover most of the instructions and commissioning information, relative to the various transformers we provide.

This document covers various specifications of transformers and only certain sections will apply to each transformer in question.

Installation should only be carried out by qualified personnel. This document will provide information to be of assistance, in case of query please contact us via the details below.

Bowers Group of Companies are proud to be members of:

Distribution Transformers

Installation, Operation & Maintenance Manual

CONTENT

1. PREFACE

1.1 **General**

1.1.1 The product to which this manual refers should be installed, commissioned, operated and maintained under the supervision of a competent electrical engineer, in accordance with relevant statutory requirements and good engineering practice, including Codes of Practice, where applicable, and properly used within the terms of the specification.

1.1.2 The contents of this approved manual include advice and instructions to secure safe and satisfactory service. In the event of any doubt, query, or the need for further information, please contact Bowers Electricals Limited.

1.1.3 The product should receive regular inspection in accordance with the manufacturer's guidelines. It is recommended that the transformer should be thoroughly inspected every 12 months, and attention given to maintenance of all items where necessary ***(refer to section 6)***.

1.1.4 In any communication please quote the following information: (see rating plate) serial number, kVA rating, Bowers' job number and year of manufacture.

1.1.5 It shall be noted that any reference within this manual to 'oil' or 'fluid' will be equally applicable to transformer mineral oil to BSEN60296 and synthetic organic Ester eg "Midel 7131" complying with the requirements of EN61099 and natural esters complying with the requirements of EN62770.

1.1.6 Starting from 1 July 2015, all new small, medium and large power transformers placed in the market of the EU Member States are designed according to Commission Regulation (EU) No 548/2014 of 21 May 2014 on implementing Ecodesign directive 2009/125/EC of the European Parliament and of the Council.

1.2 **Specification**

1.2.1 The product has been designed and tested in accordance with the specification and standards quoted in our acknowledgement of the order and any subsequent modifications.

1.2.2 Some of the components referred to in this manual are supplied only when specified and will not be incorporated into all products.

1.2.3 For the relevant UK and International Standards and Codes of Practice, reference should be made to the current edition of the following publications: B.S.I. Standards Catalogue; ENATS 35-1; I.E.C. Catalogue of Publications; I.S.O. Standards Catalogue.

1.3 **Health & Safety**

1.3.1 The Electricity at Work Regulations 1989 supported by Memorandum of Guidance (ISBN 011 8839632) apply to UK electrical installations.

1.3.2 The current edition of the IEE wiring regulations, apply to all installations.

1.3.3 IEC 60364 Low Voltage "Electrical Installations in Buildings" also covers safety aspects.

1.3.4 We would in particular stress the importance of care in: Site selection and design, embodying features which provide adequate ventilation, protection and security and which have taken account of appropriate fire, moisture and explosion hazards.

1.3.7 Excessive or prolonged skin contact with transformer oil (mineral oil) should be avoided. For further information regarding transformer oil handling, please refer to relevant material safety data sheets.

2. CONSTRUCTION AND FITTINGS

2.1 Tank Construction

Tanks are designed to be lifted via the lifting points or jacked via the designated points (***Figure 1***). All transformers have been designed and tested to be oil leak free. All ground mounted transformer tanks are fitted with skid under bases suitable for handling with roller bars. The skids are drilled to accommodate axles and rollers when required.

Radiators, when fitted, are attached to the main tank on naturally cooled (**type ONAN or KNAN**) units. A detachable cover is fitted, the gasket material being synthetic resin bonded cork. (***Figure 2***)

Figure 1.

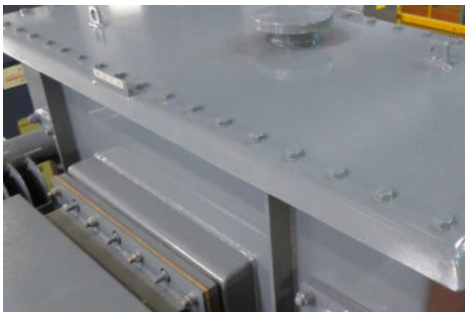


Figure 2.

2.2 Standards Fittings

The "Standard Fittings" listed below are those which are considered to be the minimum for the correct and safe operation of a Bowers Electricals Standard Transformer.

These Standard Fittings conform to the requirements of: **BSEN60076**.

- Diagram and Rating Plate *(illustrated)*
- Off-Circuit Tapping Switch
- Lifting Lugs
- Earthing Terminal
- Oil Level Indicator
- Drain Valve
- Thermometer Pocket
- Jacking facilities
- Dehydrating breather.

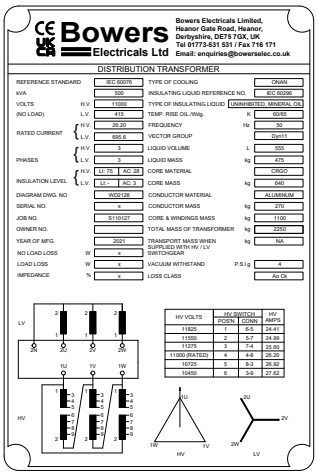


Diagram and Rating Plate.

2.3 **Optional Fittings** - (Fitted only at Customer's request)

- Winding Temperature Indicator
- Oil Temperature Indicator
- Rollers
- Filter Valves
- Gas and Oil (Buchholz) Surge Operated Relay
- Pressure Relief Device *(illustrated)*
- Disconnecting Chambers

Conservators.

Pressure relief device.

2.4 **Terminations**

Transformer power terminations can consist of various designs. The basic design would incorporate outdoor weatherproof bushings to bring the electrical power connections through the main tank steel plate. However, Bowers standard arrangements follows the ENATS requirements of air filled HV cable boxes and air insulated LV cable boxes, having porcelain and /or resin bushings to BS2562, where applicable. The cable boxes are made from sheet steel with a removable front access cover and a metal gland plate (**HV usually steel and LV usually aluminium or steel with a non-magnetic insert**).

3.0 - INSTALLATION

3.1 **Despatch**

On arrival units should be examined and any transit damage reported to Bowers Electricals Ltd.

3.2 **Parts removed for transport**

The transport oil quantity and any parts removed for transport are indicated on the outline drawing supplied. Re-assembly of these parts should be carried out such that the tank is open to atmosphere for the minimum time.

3.3 **Gaskets**

Ensure that the gaskets fitted on all oil and airtight joints are secure and uniformly tightened.

3.4 **Plain pipe breather**

During transport the plain pipe breather is sealed with a cap (***Figure 3***). **Before commissioning the cap must be removed and breather fitted, on removal a small residual amount of oil maybe present.**

Figure 3.

3.5 **Dehydrating breather**

When fitting the Silica-Gel Breather, do not expose the Silica-Gel Charge to the atmosphere for an undue length of time, otherwise the Gel Charge will start to absorb moisture and thus impair it operating property.

The Dehydrating breather is supplied in an assembled ready to use state. To fit, remove the cap from the plain breather pipe fitted to the transformer. Remove the sealing bung from the top of the Dehydrating breather, locate the central thread on the top casting and screw into position by rotating the breather in a clockwise direction. After three complete turns some resistance should be encountered. The charge can then be rotated a further three quarters of a revolution, thus completing the top seal. (**Do not over tighten**)

Remove the clear plastic oil cup from the bottom of the Dehydrating breather by undoing the metal retaining clip, and remove the plastic sealing bung from the bottom of the breather.

Pour a small quantity of transformer oil (to BSEN60296) into the oil cup, up to the oil level mark. Attach the cup on to the bottom of the Dehydrating breather provided with the transformer and secure with the metal retaining clip. The breather is now complete. (***Figure 10***).

3.6 **Gas and oil (Buchholz) surge operated relay -** (*Figure 4*)

Prior to fitting the Buchholz Relay, check that the floats are free. The relay should be fitted in the pipe work between transformer and the conservator such that the arrow on the terminal box cover is pointing towards the conservator and should slope upwards towards the conservator at an angle of 3^{o} to 7^{o} to the horizontal.

It is recommended that the relay should not be taken apart and under no circumstances should any alteration be made to the angle of the flap on the trip element. In order to test the alarm and trip mechanisms, the relay is provided with a petcock, which enables air to be injected into the body of the relay. To test operation of the alarm element, the transit cap should be removed, then dry air from an air bottle should be slowly admitted so that the alarm element gradually falls, until the switch operates. The quantity of air required to operate the switch may be observed on the graduated scale engraved on inspection windows on each side of the relay and should be noted for the purposes of comparison of future tests.

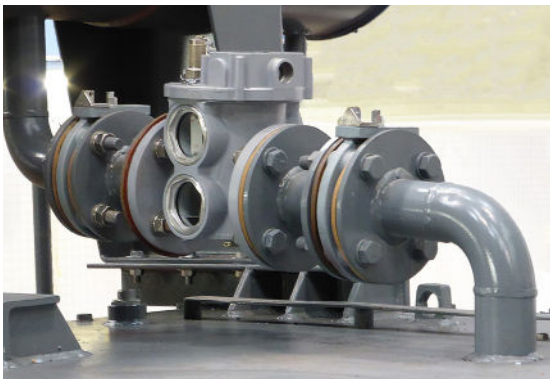


Figure 4.

To test the trip element, the transit cap should be removed, and the valve controlling the air bottle should be opened quickly so that air rushes in, impinges on the flap, depresses it and operates the switch.

The approximate minimum air pressure required to operate the switch should be recorded for the purpose of future comparison.

3.7 Temperature Indicators

Oil and Winding Temperature Indicators are of the rigid stem or capillary type (***Figure 5***).

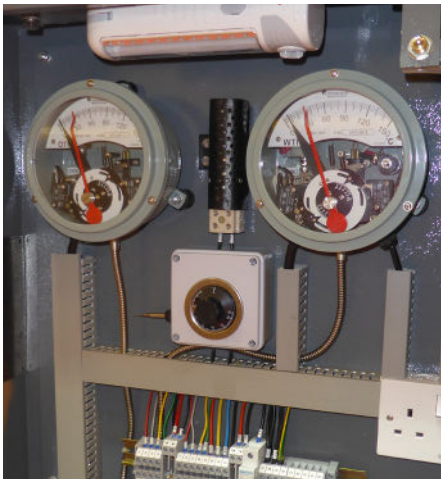


Figure 5.

Care must be taken to ensure that the capillary type instrument is mounted in a vertical position.
Care is needed when running the capillary and sharp bends should be avoided, particularly where it joins the instrument and bulb.
The capillary should be supported by suitable clips at intervals of 300 to 450mm and a suitable length left so that the bulb may be freely installed or removed.

3.8 Terminations

All porcelain and resin insulators should be examined for minute cracks or damage that may have occurred during transit.

3.9 Oil Topping Up

If oil has been removed for transport, top up to the correct level as indicated on the gauge. Trapped air should be released from the various parts of the transformer by carefully unscrewing in turn, all venting plugs indicated on the Outline Drawing supplied with the unit.

The plugs should remain unscrewed while air continues to escape and tightened down when oil begins to overflow. Air should be released from the Gas Operating Relay by opening the top petcock.

After venting, the oil level should be checked (***Figure 6***) and further topping up carried out until the required level is again reached. When installation is complete at least 12 hours should elapse before voltage is applied to the transformer to ensure that all trapped air is released.

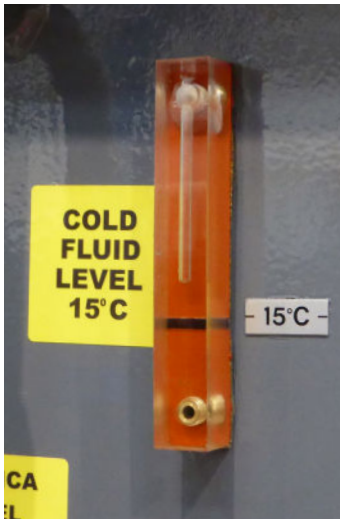


Figure 6.

> ⚠ **IMPORTANT:** Excessive and prolonged skin contact with mineral oil should be avoided. For further details refer to the Manufacturers mineral oil safety data sheet.

For Midel please refer to the safey data sheets found at http://www.Midel.com.

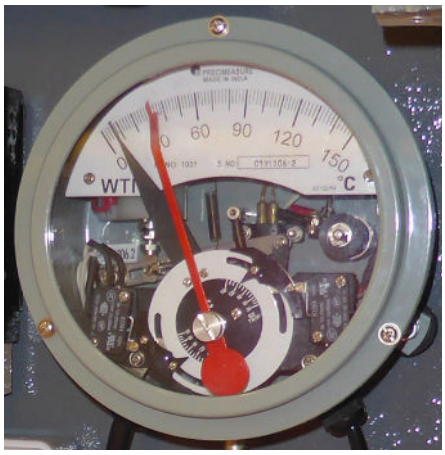
4. COMMISSIONING

4.1 **Switch Adjustment**

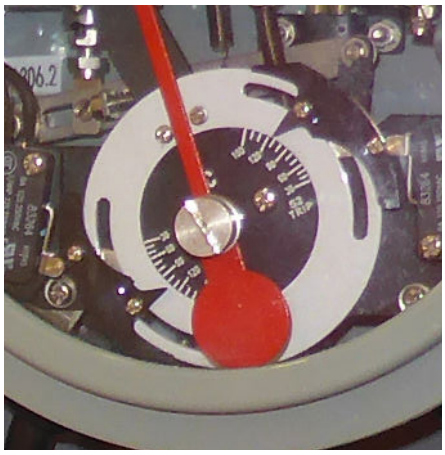
Switches should be adjusted to operate at the required values. Recommended maximum settings are:

	Liquid Temperature	Winding Temperature
Alarm Contact	85 ^{O}c	105 ^{O}c
Trip Contact	95 ^{O}c	115 ^{O}c

To adjust switches, remove the instrument bezel and slacken the switch clamp screw located on the extremity of the switch arm. Adjust the switch to the desired operating temperature on the setting scale and re-tighten the clamp screw (***Figure 7-7a***). When carrying out this adjustment, the switch table should be supported so that excessive pressure is not applied to the Bourdon movement.



Winding Temperature guage (WT) - ***Figure 7.***



WTI Close up - showing alarm / trip - ***Figure 7a.***

4.2 **Dehydrating Breather**

Check that the Silica-Gel charge is orange and in an active stage. (***refer to section 5.2***).

Re-activate if necessary in accordance with the instructions given under the maintenance section.

4.3 **Earthing**

The tank should be effectively earthed before energising the transformer. Earthing pads are provided for this purpose at ground level, their position being shown on the **outline drawing** supplied with the unit, and signified on the transformer with an Earth symbol signage.

4.4 **Recommended Commissioning Tests**

The following Commissioning Tests are recommended:

4.4.1 **Insulation Tests**

The following insulation Tests should be made using an Ohmeter or Ductor tester and the readings noted.

HV winding to earth

LV winding to earth

HV winding to LV winding

Readings below 75 Megaohms (MΩ) should be reported to the manufacturer.

4.4.2 Oil Sampling

Sampling of oil taken from the following positions should be tested in a standard cell at **30kV for 1 minute** in accordance with **BSEN 60296** and instantaneous breakdown values recorded.

Samples prior to erection should be taken from:

Oil Tanker or each **individual drum** containing oil for topping up.

Samples after final erection and filling with oil should be taken from:

Drain valve at **Bottom of main tank** (***Figure 8***) and **Conservator** (***Figure 12***).

Figure 8.

4.5 Safety

Attention is drawn to "HSG 85 Electricity at Work, Safe Working Practices" available from the HSE.

5.0 - OPERATION

5.1 **Oil Level Gauge**

The gauge enables the level of the oil to be clearly observed (***Figure 9***) and the gauge is calibrated to show **15^{o}c** (**cold oil level**).

Figure 9.

Figure 10.

5.2 **Dehydrating Breather**

This is a Silica-Gel visible charge oil seal type and is designed to ensure that air entering the transformer is dry, thus preventing an insulation loss due to condensation. In order to give visual indication of the degree of saturation of the charge, the silica gel is impregnated with an indicating colourant. The silica gel is orange when dry (***Figure 10***) and turns colourless (dependant on supplier) when it has absorbed a certain percentage by weight of water vapour. The change in colour from orange to colourless starts at the bottom of the gel and moves upwards.

When the colourless zone has reached half way up the container, the breather will still be drying air at maximum efficiency but, if continued beyond this point, falling off in efficiency will occur. This change in colour can be observed through the wall of the gel container. Silica gel may turn black if oil vapour is present.

5.3 **Tap Changing**

Is carried out by means of an off-circuit tapping switch. The moving contacts are spring loaded, self aligning roller type and operation is by means of a handle (***Figure 11***) suitably positioned on the tank. The switch has a positive locating action and provision is made for padlocking if required. A position indicator mounted on the operating mechanism shows the tapping position in use at any time. It is important to ensure that before carrying out a change of tap the transformer is isolated on both HV and LV side.

Figure 11.

Figure 12.

5.4 **Conservator**

The conservator (***Figure 12***) where fitted, is designed to take up the expansion and contraction of the oil due to changes of temperature in service and to limit the amount of oil in contact with air. Draining facilities are provided.

5.5 **Oil Temperature Indicator**

A Bi-metallic or Vapour Pressure Expansion Thermometer can be used to indicate the transformer top oil temperature. An indicating pointer typically provides indication over the range of **10^{O}c** to **120^{O}c**. A maximum resettable indicating pointer can be provided to most instruments. Switching for alarm and/or trip is achieved by one or more switches.

5.6 **Winding Temperature Indicator**

A winding temperature indicator works on the same principle as an oil temperature indicator with the addition of a heater coil energised by a current transformer, usually mounted on one of the transformer LV terminal busbars. Operating on the thermal image principle the instrument (***Figure 13***) will indicate the average winding temperature.

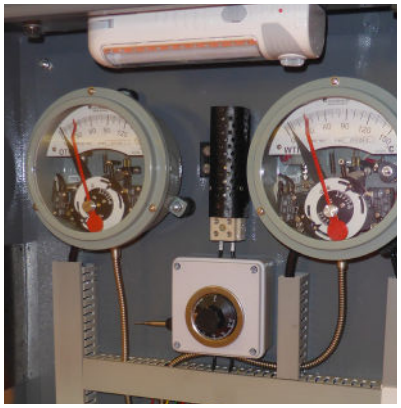


Figure 13.

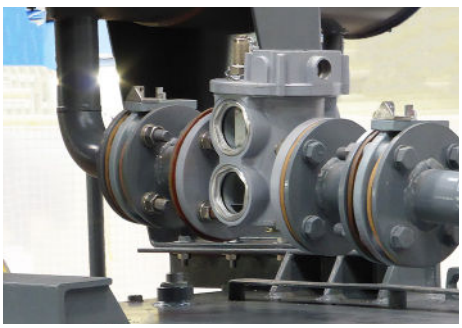


Figure 14.

5.7 **Gas and Oil (Buchholz) Surge Relay**

The relay consists of an oil-tight container fitted with upper and lower pivoted float elements and is situated in the pipe line between the transformer and conservator, (***Figure 14***) so that under normal conditions it is full of oil.

As is generally known, most types of faults occurring within oil filled transformers are accompanied by the generation of gas, which the heat liberates from the oil. The gas-activated relay utilises this phenomenon to provide protection for the transformer.

With an incipient fault, gas is produced at a very slow rate and the upper element and micro switch will operate after a specified volume of gas has collected. By the giving of an alarm extensive damage to the transformer may be prevented. The upper element can also be used for indication of low oil levels. When a major fault occurs, a rapid generation of gas results, which causes a sudden surge of oil up to the conservator.

This oil surge operates the bottom element and closes the switch, which in turn operates the tripping device. The trip element will also operate if a considerable loss of oil occurs.

5.8 **Loading**

Overloads are permitted in accordance with BSEN60076 part 7.

6.0 - MAINTENANCE

Transformers should be thoroughly inspected every 12 months and attention given to maintenance of all items where necessary.

6.1 **Paintwork**

The transformer tank and radiators should be carefully examined to see if rust is forming, especially at the welded seams. If so, it should be completely removed with a wire brush or other means and the metal treated with a coat of appropriate undercoat and finally the finishing coat.

PLEASE NOTE: FOR CLEANING PURPOSES USE ONLY WATER AND A NON-ABRASIVE CLOTH

6.2 **Dehydrating Breather**

Examine the colour of the silica gel charge (***Figure 15***), as moisture is absorbed, the colour intensity decreases from orange to colourless. It is recommended that the charge, be changed for a fully active one, if the colour change is showing half way up the container or higher.

6.2.1 **Charge Reactivation**

Figure 15.

- Remove oil cup and wipe underside of breather body free of oil.
- Unscrew breather body in anti-clockwise direction:
- Empty saturated desiccant out through ¾" BSP hole and fill with dry orange desiccant (1/2 kg) and remount on transformer OR - Replace with fresh breather. The oil breather containing the saturated charge may be reactivated in a thermostatically controlled oven **120 ^{O}c – 130 ^{O}c** until desiccant is again orange.
- Replace blanking plug and seal lower ports until next required.

6.3 **Gas and Oil (Buchholz) Surge Relay**

Check operation of floats. ***(refer to section 3.6)***

6.4 **Temperature Indicators**

Check contacts. ***(refer to section 3.7)***

6.5 **Oil Level**

Check oil level, preferably when cold. Top up with clean dry oil of same type and grade.

6.6 **Oil Tight Joints**

After the equipment has been in service for some time it may be found that the compression gaskets have shrunk a little and that small oil leaks have developed at some of the joints. It is advisable, therefore, to carry out a general tightening of the joints after a period of not more than 12 months after commissioning. The correct method is to tighten each bolt slightly, moving around the flange until the whole joint is perfectly tight. Joints should never be tightened at one point alone, even if the oil leaks appear to have developed at this point. Failure to adopt this method of tightening may result in a serious oil leak, which will be found difficult to check. If, after carrying out the tightening described above, the oil leak still persists, the oil should be lowered below the gasket level and an inspection of the gasket carried out. If damage or deterioration is evident, a replacement gasket should be fitted and, if necessary, the transformer should be vented as described under "Oil Topping Up". **(See section 3.9)**

7.0 - MINERAL OIL MAINTENANCE

The oil supplied with the transformer is a pure hydrocarbon mineral oil conforming to the requirements of BSEN60296 for insulating oil. Attention is drawn to the warning, (***see section 3.9***).

The British Standard BSEN60422 deals comprehensively with methods of sampling, testing and treatment. The maintenance engineer is, therefore, advised to refer to this publication. The oil in a transformer, operating under normal load conditions adequately ventilated and free from moisture, will show little oil deterioration after years of service. If, due to overload or inadequate ventilating condition, the oil temperature is high for prolonged periods, deterioration of the oil will be accelerated. Routine oil sampling and testing should be carried out periodically, so that from the information obtained it may be possible to determine whether the oil is suitable for further service.

7.1 Oil Sampling

Figure 16.

Samples of oil should be drawn from the transformer when the oil is warm. Samples taken on site are frequently found to be contaminated owing to inadequate cleaning of the drain valve (***Figure 16***). It is essential that the valve be first thoroughly cleaned externally and then wiped with clean material reasonablyfree from fibre, (such as thin smooth paper), followed by a similar material soaked in clean oil. Finally, the valve should be flushed by draining off a sufficient quantity of oil to ensure that the sample obtained is representative of the oil at the bottom of the tank. Stoppered glass sampling bottles of one litre size are recommended. They must be absolutely clean and dry and should be rinsed with the first sample drawn. A test should be carried out as soon as possible after drawing a sample.

Figure 16.

7.2 Inspection of Samples

A limited but useful amount of information can be obtained from the colour and odour of the oil and this should be noted for record purposes. Cloudiness in the oil may be due to suspended moisture or suspended solid matter, such as iron oxide or sludge. The moisture can be detected by crackle test. If the oil is dark brown, the presence of dissolved Asphaltenes may be suspected.

If the colour is green the presence of copper soaps is indicated and it may be expected that further deterioration of the oil will be rapid. An acidic smell is indicative of volatile acids, which can cause corrosion and which may render the oil unsuitable for treatment on site; a petrol-like or acetylene odour may indicate a low flash point due to a fault or some other cause.

7.3 Electric Strength

Apparatus in accordance with BSEN60296 is satisfactory for this test, and assuming transformer HV voltage of 11kV the oil should withstand 30kV for one minute without breakdown. If frequent transient sparking occurs, this suggests the presence of foreign matter, e.g. moisture, fibrous material, carbon particles, etc., and the oil should be filtered.

7.4 Crackle Test for Moisture

The crackle test is a simple and useful test for detecting the presence of suspended moisture in oil. A metal rod 12.5mm in diameter heated to a dull redness is lowered to the bottom of the receptacle and used to stir the oil thoroughly. During this stirring process no crackle should be detected. Oil that does not pass this test should be suitably treated.

7.5 Acidity

The pungent odour of the oil will give an indication of acidity. If such odour is present immediate inspection for corrosion of the tank and cover above the oil level should be carried out and steps taken to ascertain the acidity value. The equipment and solutions requested to perform this test may be obtained from suppliers of laboratory apparatus and chemicals; in case of doubt the advice of oil suppliers should be sought.

Suggested acidity limits are as follows:

1. When the acidity is below **0.3mg KOH/g** no action need be taken if the oil is satisfactory in other respects.
2. When the acidity is between **0.3** and **1.0mg KOH/g** the oil should be kept under observation and filtered if necessary.
3. When the acidity exceeds **1.0mg KOH/g** the oil should be reconditioned or discarded. Consultation with the oil supplier may be desirable.

If the acidity is allowed to exceed **1.0mg KOH/g** there is a considerable risk of sludge precipitation and corrosion of metal surfaces above oil level by condensed acidic vapours. It may be possible to retain oil in service with acidity above this figure, provided that frequent internal examination of the transformer is made, but this practice is not recommended since the oil may reach a state at which it is not possible, economically, for it to be re-conditioned.

Regular filtration checks the development of acidity but is not effective in removing acid once it has formed.
To remove acid the oil may be returned to the oil supplier for reconditioning, or new oil may be provided, but in either case the lower the oil condition parameters at the time of changing the oil, the less the new filling will be affected by acid absorption from the core and windings.

7.6 Sludge

Although severe sludge is not frequently experienced in transformer oil in service, it is nevertheless a most serious form of deterioration, not only because of the danger of insulation breakdown owing to the restriction of cooling, but also because a transformer with sludge deposits is difficult to clean thoroughly without dismantling. Although there may be no solid deposit visible in oil samples, it is still possible that sludge may have formed, and that the concentration in the oil has not yet reached a point where deposition is occurring.

When comparison of records as suggested under "Recording of Results" indicates the presence of precipitated sludge it may be necessary, even though the acidity may be within the prescribed limit, to consider applying treatment or changing the oil. When sludge is allowed to accumulate, the oil circulating ducts become choked which results in higher core and winding temperatures with consequent formation of still more sludge, the action being cumulative.

7.7 Flash-Point (closed)

Flash-point tests should be made if the oil has been subjected to a high temperature due to an internal fault, or shows any sign of unusual odour, but they are not otherwise necessary. A slow fall of the flash point of oil in a transformer may occur with increasing age and is not harmful.

A fall exceeding **16.5^{o}c** or a flash-point below **135^{o}c** may indicate unsatisfactory conditions such as electrical discharge, excessively high internal temperature, core faults or foreign matter providing a conducting path between live parts and the frame of the transformer, in which case the unit should be taken out of service for examination.

7.8 Frequency of Testing

Oil in transformer tanks should be inspected annually and, where possible, tested for physicals and dissolved gas analysis. The acidity of the oil should be determined every two years. In special cases, where severe operating conditions are encountered, or it is known that the oil or windings are deteriorating at an abnormal rate, tests may be desirable at monthly intervals to verify the rate of deterioration.

7.9 Recording the Results

It is essential to keep records of all tests. The acidity should be plotted on a graph with time as the base and the records should include relevant operating data such as maximum loads and maximum oil temperatures.

8.0 - TRANSFORMER DE-COMMISSIONING

8.1 Electrical Supply

Ensure ALL Electrical supplies are dead and ALL cable connections **(including Auxiliary wiring)** are removed from the Transformer in question. Refer to HSG 85 Electricity at Work, Safe Working Practices" available from the HSE."

8.2 Dehydrating Breather

Remove the Transformer Breather **(if fitted)** and blank off the breather pipe with a fixed oil tight plug (***Figure 17***). This is required to ensure that **NO** spillages occur during transport.

8.3 **Item Security**

Check round the Transformer and ensure ALL items are securely attached and NO loose items can fall off the transformer in transit.

8.4 **Lifting Points**

Ensure ALL lifting points are sound and NO obstacles will hinder the lift.

8.5 **Waste Permits**

If the unit is to be removed to a waste treatment site, ensure ALL correct permits are in place under a valid Pollution prevention and Control licience or waste management licence. If in doubt contact the Environment Agency.

8.6 **Transformer Removal**

Remove the transformer **(under the correct permits)** on to transport for forward shipment to the waste treatment site.

8.7 **Documentation**

Retain the signed copies of the 'Waste Transfer' documents for inspection as required by law.

9.0 - WARRANTY & CONTACT DETAILS

All the equipment is covered by warranty, for a time period specified in the agreed contract.
The warranty is limited to the repair or replacement of the damaged transformer and / or accessories, excluding transportation. Bowers Electricals Ltd, declines any claims referred to indirect damages caused by any transformer fault.

To report a problem, please contact Bowers Electricals Ltd, providing the following information:

- Serial number of the transformer
- Place of installation and application of the transformer
- Detailed description of the claim, including photographs if possible.
- Your contact details.

Bowers
Group of Companies

Cast Resin &
Earthing Transformers

Installation, Operation
& Maintenance Manual

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