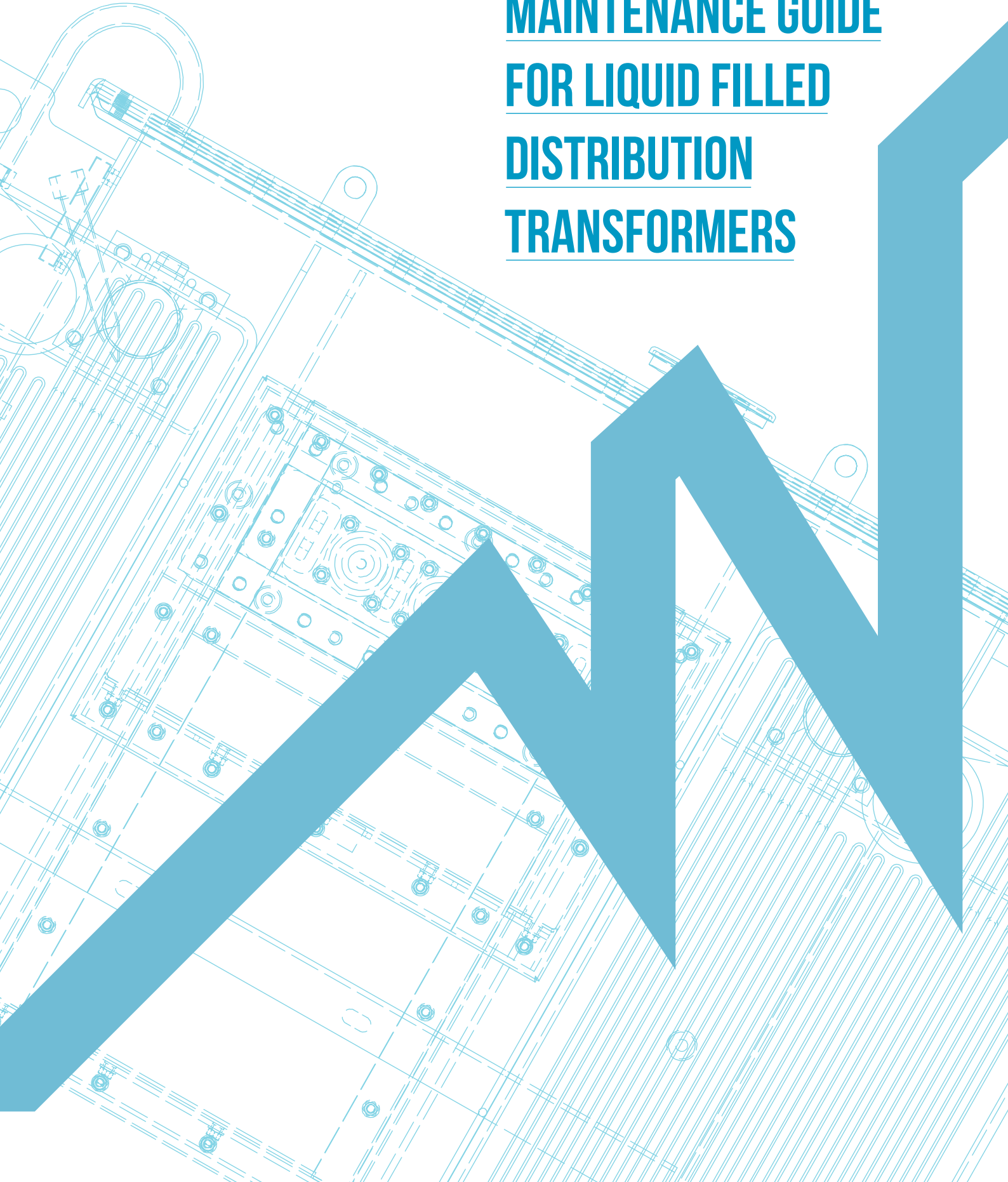




WILSON
POWER SOLUTIONS

Responsible Power Engineering

DISTRIBUTION TRANSFORMERS
MAINTENANCE GUIDE
FOR LIQUID FILLED
DISTRIBUTION
TRANSFORMERS



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1. INTRODUCTION

All transformers supplied by Wilson Power Solutions (WPS) UK, are designed, manufactured and tested with the latest technology and under strict quality controls, in order to provide you with a long and trouble free service.

To secure a long lifespan for the transformer it is important to follow proper installation, commissioning and protection procedures and to ensure that timely maintenance is carried out during transformer operation.

The purpose of this Maintenance Manual is to provide guidance on required and recommended maintenance of liquid-filled (mineral and synthetic ester) transformers.

This guide is necessarily generic in nature, so specific features or parts listed in this guide may be missing from your transformer, and accessories or auxiliary units on your transformer may be omitted from this guide.

In the event of any doubt, arising questions or any irregularities / deviation from IEC / BS (or equivalent) standard observed, please refer to WPS for clarification and assistance.

The transformer, along with all its accessories and fittings, should be installed, commissioned and operated under the supervision of a competent electrical engineer in accordance with relevant statutory requirements and good engineering practice, as well as being operated within the terms of the specification.

For the UK and International Standards, reference should also be made to the current edition / publication of BSI: Standards Catalogue, ENA-TS, and IEC: Catalogue of Publication, etc.

1.1 CAUTIONARY NOTE

No transformer should have rated service voltage applied to it until all preliminary work and pre-commissioning tests and checks have been satisfactorily completed.

No high voltage tests should be applied to any transformer without making reference to the original supplier (WPS).

A transformer which has been commissioned and then removed from service for any length of time should be re-checked to the same standard as when it was first commissioned prior to being re-energised and placed back into service.

1.2 HEALTH & SAFETY

Materials or components that are liable to be exposed or handled in normal operation and maintenance and could present a hazard to health are covered here.

Electricity at Work Regulations - 1989 applies to the UK Electrical Installation as per 'Memorandum of Guidance on the Electricity at Work Regulation' from HMSO.

Also, refer to the 'Regulations for Electrical Installation' BS: 7671 for installation up to 1000V AC and 'Safety in Electrical Testing' HS (G) 13 from HMSO, ISBN 011 883 283 0.

In addition to the instruction given in this manual, BS / IEC / equivalent standards and local regulation should also be referred for other details regarding the design, materials and performance.

Excessive or prolonged skin contact with transformer oil (mineral oil) should be avoided. For further information regarding oil handling, please refer to 'Effect of Mineral Oil on the Skin [SHW295]'

A list of standards applicable to distribution transformer is given as below:

- Power Transformers IEC:60076 and all relevant parts therein.
- Distribution Transformers: ENA 35-1

2. TRANSFORMER COMPONENTS

This section helps the user to identify individual parts of the transformer which will be referred to throughout this document. The following images will indicate the approximate location and style on several different designs.

Items labeled with a letter (A, B, C etc.) indicate standard components are present on all standard transformers, numbers (1, 2, 3 etc.) indicate optional extras or accessories that may not be on your version.

STANDARD COMPONENTS AND ACCESSORIES:

- A.** Connection point for air dehydrating breathers (Figure 1a)
- B.** LV connection (standard cable connection) (Figure 1a)
- C.** Marshalling Box (Figure 1a)
- D.** Drain valve (Figure 1a)
- E.** De-energised tap-changer (Figure 1a & Figure 2)
- F.** Thermometer pocket (Figure 1a)
- G.** Rating plate (Figure 1a)
- H.** Jacking points (Figure 1a)
- I.** Transformer lifting eyes (Figure 1b)
- J.** Tank earthing terminals (Figure 1b)
- K.** Transformer lid lifting eyes (Figure 1b)
- L.** Radiators (Figure 1b)
- M.** HV connection (standard cable connection) (Figure 2)

OPTIONAL COMPONENTS AND ACCESSORIES:

- 1.** Oil temperature indicator (OTI)/ Winding temperature indicator (WTI) (Figure 1a)
- 2.** Ring main units/ACB/ other connections (Figure 1a)
- 3.** Thermometer, to install on the thermometer pocket (Figure 1a)
- 4.** Pressure relief device (PRD) (Figure 1b)
- 5.** Current transformer connection box (Figure 1b)
- 6.** Conservator (Figure 1b)
- 7.** Buchholz relay (Figure 1b)
- 8.** Off circuit dual ratio changer (Figure 2)
- 9.** Oil level indicator (Figure 2)

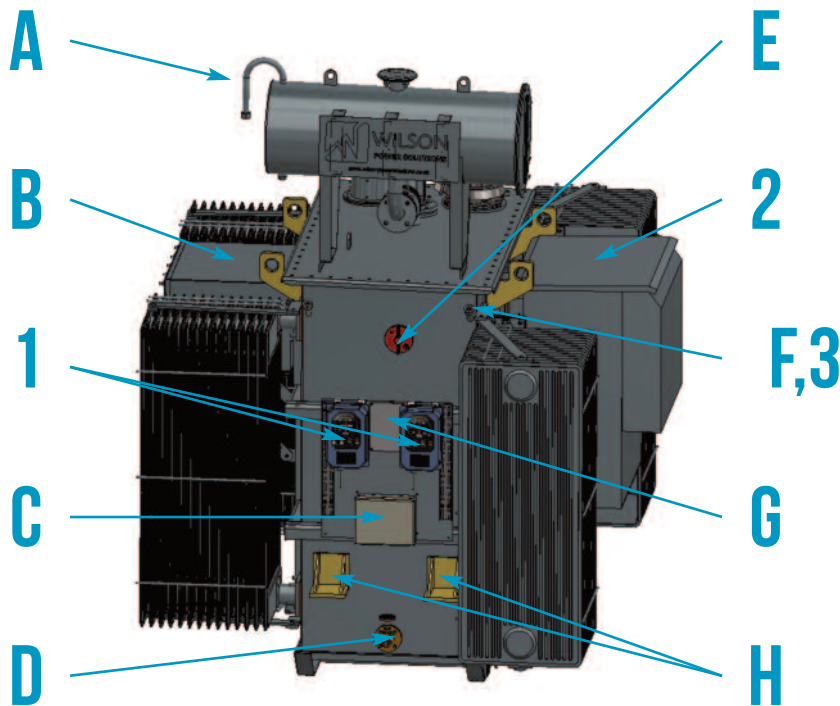


Figure 1a - Transformer View from Tap Switch End

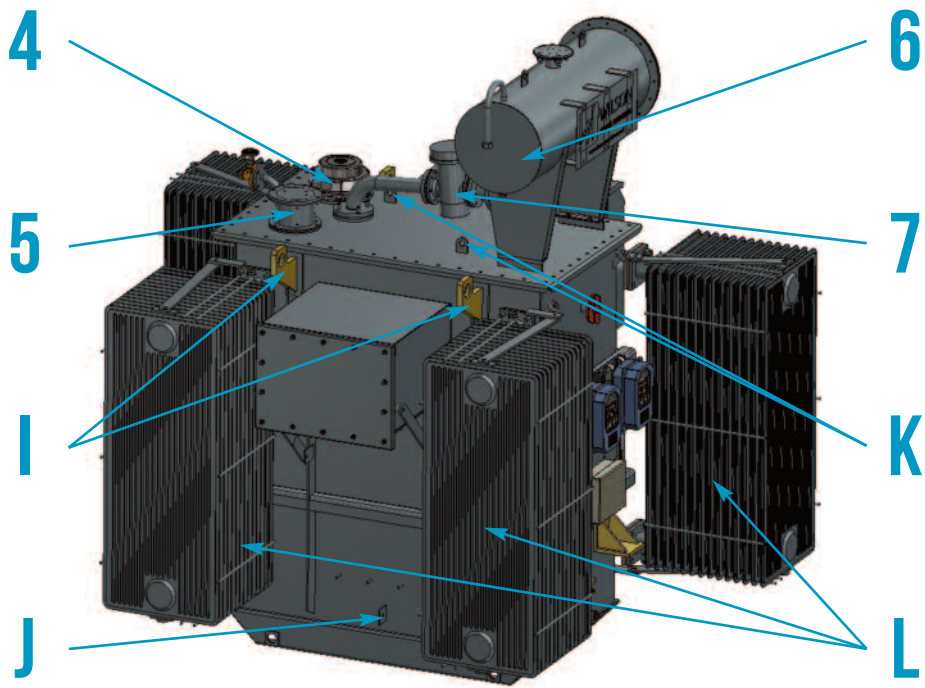


Figure 1b - Transformer View from LV Side

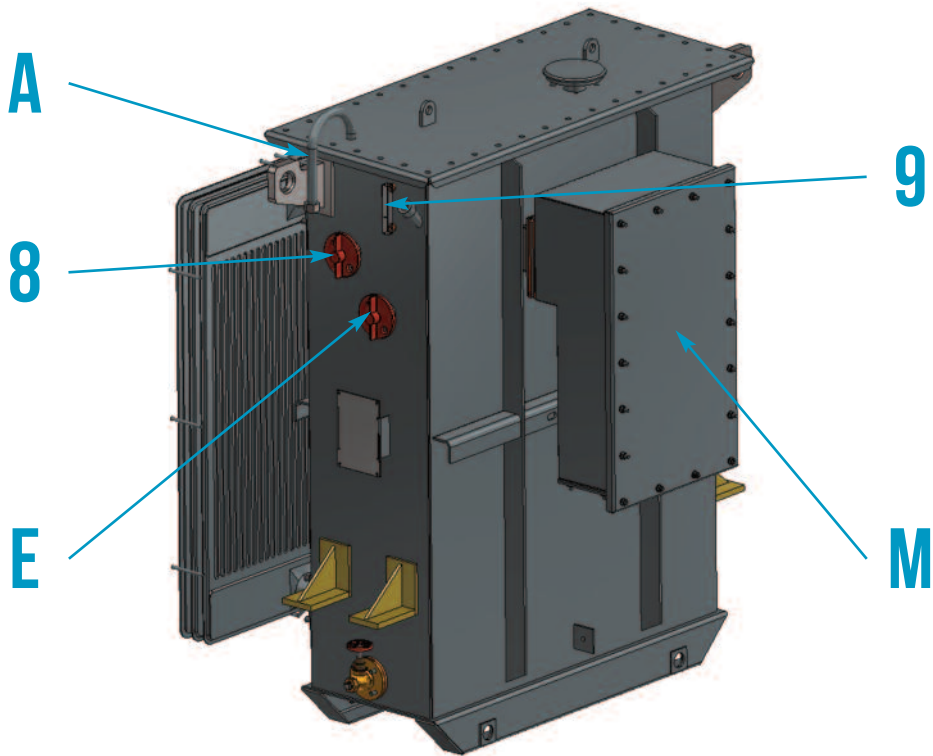


Figure 2 - Dual Ratio Transformer

3. BASIC MAINTENANCE PROCEDURES

If a transformer is to give long and trouble-free service, it should receive a reasonable amount of necessary maintenance

As a guide, following the CIGRE 'Guide for Transformer Maintenance', published in 2011, alternative methods given below could be chosen or selected to achieve a satisfactory result for a given transformer. Alternative methods that should be considered are:

- Time Based Condition Monitoring
- Condition Based Monitoring
- On-Line Condition Monitoring
- Time Based Maintenance

Time Based Condition Monitoring (TBCM)

To be TECHNICALLY feasible a condition assessment should have the ability to detect initial changes in condition for any items that are relatively small compared to the deterioration necessary for failure. This requires that measurement or inspect intervals that are smaller than fail point to allow detection **before failure occurs**. This may be too complex for transformers of smaller power rating.

Condition Based Monitoring (CBM)

Condition Based Monitoring (CBM) - simply monitoring the change in condition of any item on an 'as & when' basis, long term experience being the main governing principal coupled with perceived usage, i.e. loading, particularly if any overloads. A FAIL condition may occur with this approach.

On-Line Condition Monitoring (OLCM)

On-Line Condition Monitoring (OLCM) – data, measurements or samples are collected whilst the subject transformer is energized by visit to site. This can be developed to continuous monitoring by provision of suitable equipment to capture real time data to provide information of developing trends in transformer condition. This will develop further because of the appearance of 'smart transformers', resulting in the appearance of so-called 'smart systems'.

Time Based Maintenance (TBM)

Time Based Maintenance (TBM) - this has been to this point in time the most popular form of maintenance, mainly because many or most substations operate in reasonable isolation to each other with little feed back of information to any central control. It consists of regular, programmed inspection, followed by any testing required and reconditioning when necessary. Records should be kept giving details of any abnormalities during service, also any periodic test results noted & any necessary actions arising. This demonstrates compliance with the general requirements of ISO:9000. A FAIL condition may occur with this approach.

3.1 THE MAIN OBJECTIVE OF ANY MAINTENANCE IS TO PRESERVE THE ORIGINAL PROPERTIES OF ALL MATERIALS USED IN GOOD WORKING CONDITION.

Moisture, dirt, excessive heat / over-loading, mishandling, etc., are the main causes of INSULATION deterioration. Corrosion due to severe environment and weathering cause paintwork to deteriorate leading to rust formation particularly serious for cooling radiators/fins. Terminal Bushings can become damaged particularly if outer porcelain shell is used. The list is extensive.

A combination of all four techniques can be used or only one e.g. TBM. It depends on the level of RISK associated with the transformer which can be defined as

- $RISK = \text{Likelihood of Failure} * \text{Failure Consequence}$
- Likelihood of Failure can be represented by the 'Health Index' of the unit (service history, general condition, whether obsolescent etc.)
- Failure Consequence can be mitigated by various control measures.

A Risk Level can be allocated to any transformer if this will help flag up the particular need for frequent maintenance because of the importance of the particular unit to the general network.

3.2 NO MAINTENANCE WORK SHOULD BE DONE ON THE TRANSFORMER, UNLESS ALL THE EXTERNAL CIRCUITS ARE DISCONNECTED / MADE DEAD AND THAT ALL THE WINDINGS ARE SOLIDLY EARTHED.

There are, however, situations where the equipment may still be 'live'. Qualified personnel ONLY following specific rules to ensure safety at all times shall be permitted to work in these circumstances.

3.3 FACTORS THAT CAN INFLUENCE MAINTENANCE PRACTICE & EFFORT

- the subject transformer characteristics & specifications
- the required duty of the transformer – load, OLTC operation etc
- the transformer working environment – temperature, humidity etc
- historical failure rate for transformer type & consequences of unavailability.
- availability & costs of skilled labour
- the presence of a maintenance optimisation programme

3.4 IN BROAD TERMS TRANSFORMER MAINTENANCE EFFORT IS RELATED TO COMPONENT SELECTION REGARDING

- Bushings
- Oil Preservation systems
- Cooling Systems
- Gaskets
- Gauges, indicators & relays
- Control cabinets
- Current Transformers
- On Load Tap Changers
- Off Circuit Selectors
- Surge Arresters
- Transformer Active part
- All sensing & monitoring devices

3.5 ALL OR ANY MAINTENANCE WORK NECESSARY SHOULD BE ACCURATELY RECORDED TO FORM THE ESSENTIAL HISTORY OR VERIFICATION THAT A GIVEN TRANSFORMER HAS BEEN SUBJECT TO THE RELEVANT PROCEDURES.

IF IN DOUBT RECORD for without accurate records it becomes increasing difficult over time to confirm what maintenance procedure(s) have occurred or whether time related maintenance has been performed correctly.

4. MAINTENANCE - THE PROCESS

4.1 LIQUID FILLINGS FOR TRANSFORMERS

Some liquids other than traditional insulating oil, have a very high flame ignition point & are considered environment friendly – any leakage of traditional insulating oil MUST be contained to prevent contamination of surrounding area. These alternative fillings tend to be used when the subject transformer is to be located inside buildings such as a block of offices or places of manufacture particularly where food of any kind is produced. Fire precautions or need to contain in event of leakage are not as strict hence resulting in potential reduced costs. Basic recommended procedures to maintain the original properties of any liquid filling used with transformers manufactured by WPS are given in the following sections.

4.2 MINERAL INSULATING OIL

4.2.1 Mineral insulation oil functions as a coolant, dielectric (insulant) & helps to extinguish any currents arcs in the subject transformer. So keeping the oil in good, specified condition will help prevent/slow deterioration of the paper & other such solid insulation materials immersed in it. Oil will deteriorate gradually with time – e. g. contact with air causes oxidation, a process accelerated by contact with metals such as copper & iron. Longer term, particularly if a given unit operates at higher than normal temperature chemical reactions – decomposition & polymerization - occur producing solids that are not dissolved & can collect within the core/winding structure. This is called sedimentation or sludge formation. Another cause of deterioration is moisture or humidity. Hence it is usual to fit a dehydrating breather to limit entry of moisture into a free breathing tank (it is important to ensure the dehydrating medium is active at ALL times).

Other disadvantages are a relatively low ignition (fire) temperature & oil is now regarded as environmental contaminant because of limited biodegradability which in the event of any leakage MUST be contained by suitable means.

4.2.2 IEC:60422/2013 – ‘Insulating Oil – Supervision & Maintenance’ gives recommendations in detail for the preservation of insulating oil. A few short notes on the subject are given as below;

- a) Oil level should be checked at frequent intervals and any excessive leakage of oil must be investigated thoroughly. There may be a slight loss of oil by evaporation; this need not cause concern if the tank is topped up at regular intervals.
- b) All minor leaks or sweating should be repaired as quickly as possible.
- c) Oil shall be topped-up as per instruction of this manual. It is once again emphasized that any new oil to be added will preferably be from the same source as the original oil. New oil from a different source may be added as make-up only but not exceeding about 10% of existing oil volume. In this latter case, suitable records must be kept.
- d) Samples of oil should be tested at regular intervals and results are to be recorded & retained. Reduction in voltage withstand capability, increase in moisture & acidity content can then be recognised & treated. In addition a sample can be sent for DGA which can highlight other unwanted phenomena occurring.
NOTE : Dielectric strength alone does not give a true indication of oil condition. If dry, even highly deteriorated oil can indicate a high dielectric strength.
- e) Normal oil filtration methods can maintain the dielectric strength, but may not cater for the overall potential deteriorated condition of the oil. It is NOT advisable to rely solely on the dielectric strength of oil by periodic test, without verification of chemical contamination.
NOTE ; Reconditioning by centrifugal separation or filtration does not remove any acidity content from a given oil but will remove moisture, sludge, dust, dirt, etc. and so tend to retard the process of deterioration. Filtration with Fullers Earth will help to reduce acidity in oil and additionally improve the resistivity value of the oil.
- f) If the dielectric strength is below 30kV(rms), the oil should be reconditioned by passing it through either a centrifugal separator or a filter. After reconditioning, the dielectric strength should be such that oil can withstand a minimum of 40 kV(rms) in a standard test cell.
- g) If acidity value is 0.5 to 1.0 mg KOH per gm of oil, it is recommended that the oil be kept under observation. If the acidity is increasing rapidly, or exceeds 1.0 mg KOH per gm of oil, the cover should be removed to ascertain the condition of the interior of the tank and of the core & windings. Oil is then to be treated or discarded, if sludge or corrosion is evident. Advice should be obtained from the suppliers.
- h) One of the most important & useful diagnostic tools is Dissolved Gas Analysis (DGA).
 Gases commonly measured;
 Hydrogen, Methane, Ethane, Ethylene, Acetylene, Carbon Monoxide, Carbon Dioxide, Oxygen & Nitrogen

Analysis is based on both gassing rates & dissolved content of the different gases. Commonly certain gas ratios are used to match the DGA gas profile obtained to that established by years of thorough analysis on faulting transformers. Depending on this profile gassing may be associated with:

- Thermal faults of low temperature
- Thermal faults of medium temperature
- Thermal faults of high temperature
- Discharges of low energy
- Discharges of high energy
- Partial discharge activity

It is frequently possible to identify with reasonable accuracy the position/location of a fault or faulty component within the transformer using ratios provided by various gases. The relative ease with which taken oil samples can be analysed & interpreted make this the most important aid available to assess oil condition & to detect early notification of fault development. It is highly recommended by WPS as an effective tool for assessing the existing condition of any transformer at a given point in time & with sampling performed at different points in time will enable any deterioration to be detected BEFORE actual failure occurs.

Refer to section following 4.3 re technique for taking oil samples for test with minimum contamination

4.3 ALTERNATIVE LIQUIDS TO MINERAL INSULATING OIL

4.3.1 There are 3 main variations:

- Silicone, fully synthetic (IEC 60836)
- Esters, derived chemically, synthetic (IEC 61099)
- Esters, derived naturally, plant seed oils (IEC 62770)

All function as a coolant & dielectric (insulant). All offer higher flash/fire points than mineral oil, silicone in particular also exhibits a self-extinguishing behaviour & the best thermal stability. However silicone has disadvantages such as poor lubrication properties & it readily absorbs moisture which affects its insulating properties (hence it is normally protected/contained in a sealed tank). Finally, environmentally it has very limited biodegradability. For these latter reasons it is not normally used by WPS.

Esthers, synthetic

Are used fairly extensively by WPS being available for over 45 years as an alternative to PCB's. They offer low temperature capability, high temperature oxidation stability & good moisture tolerance (better than mineral oil). Finally it offers a great advantage – it is readily biodegradable hence environmentally friendly. However it is strongly hygroscopic so may be housed in either a 'free breathing' tank with effective dehydrating breather or sealed tank depending on client preference. The IEC Specification given applies to the unused fluid whereas the maintenance guide. Is available as IEC 61203. Reference to the latter Standard is recommended.

Esthers, natural

Unlike their synthetic counterparts, natural esthers have been developed considerably later entering commercial usage in the United States in the year 2000 or thereabouts. Whereas there is a guide for the 'Acceptance & Maintenance of Natural Ester Fluids in Transformers' published in the U S in 2008 there is no corresponding IEC Std. at the time of writing. It is reported that the natural ester results in a reduction in insulating paper aging when compared to mineral oil, shows higher flash & fire points than the synthetic ester. It shows the best biodegradability of all the liquids mentioned – hence again environmentally friendly.

Of the fluids mentioned, other than mineral oil, the only other fluid in reasonable usage is the synthetic ester usually as Midel 7131 or as alternative SE-A from alternative source. Some of the disadvantages listed for Mineral Oil do not apply, i.e. some of the chemical reactions listed & a greater tolerance of water content without loss of di-electric capability. It is however the flash/fire points & the ability to be biodegradable which make the fluid attractive for internal locations.

4.3.2 IEC:61203/1992 – ‘Synthetic organic esters for electrical purposes – Guide for Maintenance of transformer esters in equipment’ gives recommendations in detail for the preservation of the fluid. A few short notes on the subject are given as below;

- a) Fluid level should be checked at frequent intervals and any excessive leakage of fluid must be investigated thoroughly. There may be a slight loss of fluid by evaporation; this need not cause concern if the tank is topped up at regular intervals.
- b) All minor leaks or sweating should be repaired as quickly as possible.
- c) Fluid shall be topped-up as per instruction of this manual. It is once again emphasized that any new fluid to be added will preferably be from the same source as the original. New fluid from a different source may be added as make-up only but not exceeding about 10% of existing oil volume. In this latter case, suitable record must be kept.
- d) Samples of fluid should be tested at regular intervals and results are to be recorded & retained. Reduction in voltage withstand capability, increase in moisture & acidity content can then be recognised & treated. In addition a sample can be sent for DGA which can highlight other unwanted phenomena occurring. IF contamination is severe the fluid must be returned to the original manufacturer for possible treatment to recover alternatively the subject unit washed with fluid & refilled using new/recovered fluid to the same specification. **NOTE : Dielectric strength alone does not give a true indication of fluid condition.**
- e) Normal oil filtration methods can maintain the dielectric strength, but may not cater for the overall potential deteriorated condition of the fluid. It is NOT advisable to rely solely on the dielectric strength of oil by periodic test, without verification of chemical contamination. **NOTE ; Return to Producer for treatment to recover essential characteristics.**
- f) If the dielectric strength monitored is below 30kV(rms), the oil should be reconditioned by passing it through either a centrifugal separator or a filter. After reconditioning, the dielectric strength should be such that oil can withstand a minimum of 40 kV(rms) in Std. Test Cell. IF after attempting reconditioning the fluid is still in unsatisfactory condition then return to the Producer for suitable treatment (as e) above).
- g) Again as with mineral insulating oil one of the most important & useful diagnostic tools is Dissolved Gas Analysis. Gases commonly measured: **Hydrogen, Methane, Ethane, Ethylene, Acetylene, Carbon Monoxide, Carbon Dioxide, Oxygen & Nitrogen** Analysis is based on both gassing rates & dissolved content of the different gases. Commonly certain gas ratios are used to match the DGA gas profile obtained to that established by years of thorough analysis on faulting transformers. Depending on this profile gassing may be associated with:

- Thermal faults of low temperature
- Thermal faults of medium temperature
- Thermal faults of high temperature
- Discharges of low energy
- Discharges of high energy
- Partial discharge activity

Although the history of results is not as comprehensive as with mineral insulating oil it is still frequently possible to identify with reasonable accuracy the position/location of a fault or faulty component within the transformer using ratios provided by various gases. The relative ease with which taken fluid samples can be analysed & interpreted make this the most important aid available to assess fluid condition. It is highly recommended by WPS as an effective means of assessing the condition of any synthetic ester fluid filled transformer (provided facilities exist to take samples of fluid).

Refer to section below re taking oil (liquid) samples from a transformer

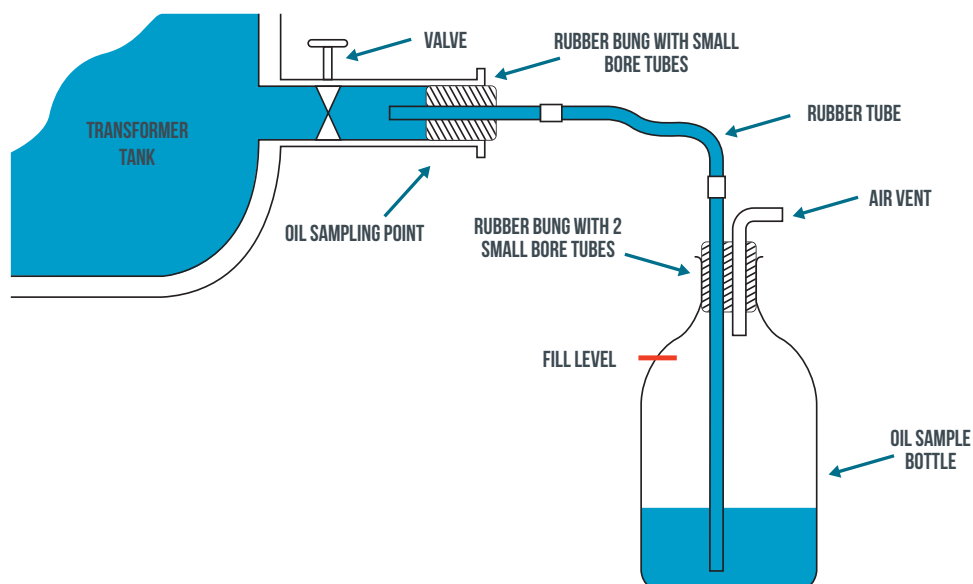
Taking oil (liquid) samples from a transformer

The results of any test or analysis of sample(s) taken it is essential to ensure the correct sampling procedures are followed viz:

- ALL apparatus used for sampling must be clean & free of moisture, fibres & any other contaminant. Before use all apparatus should be carefully inspected & flushed with clean oil.
- Cotton rags/paper towels should NEVER be used, only use clothes that are guaranteed not to shed fibres – use in clean condition free of any contamination
- Before removing covers or breaking any gasket style joints etc. of unit to be sampled, take precautions to exclude any ingress of dust, loose deposits or other contaminants.
- Outdoor sampling should preferably be done in dry weather. In inclement weather (wet) precautions must be taken to ensure sample(s) are not affected by ingress of moisture.
- Ensure that oil dielectric & sampling equipment is at same temperature as ambient air. The temperature of the oil sampled must be taken & recorded.
- Sample bottles should be amber glass or if clear then they should be covered with black polythene or similar post sample. Bottles must be capable of being sealed gas tight with a hard plastic screw cap which houses a conical polythene seal.
- Bottles of 500 or 1000ml volume are typically used. The bottle should always be filled to a level of 8/10 mm below the rim (leaving sufficient space for expansion).
- Thieve tubes should be made of glass (no sharp corners to trap contaminants).
- The blanking flange or cover of the valve from which the sample is to be taken should be removed & the sampling point cleaned to remove all visible dirt etc.
- Any rubber or plastic tubing used for connection to a sampling vessel should be as short as possible, suitable to use with fluid being sampled & impermeable to gases.
- A thermocouple is placed in the end of the tube & the temperature of the fluid being sampled is taken & recorded as approx. 1 litre of fluid is allowed to drain to waste. **NOTE : inspect for the presence of free water**
- Allow the sampling bottle to fill slowly in a quiet manner, displacing the air gently hence causing the minimum disturbance to the fluid being taken. Allow some overflow & slowly withdraw tubing with the fluid still flowing.
- Close the sampling valve & disconnect the tubing.
- Tilt the sample bottle to allow the fluid level to fall to 18/20 mm from the rim & then screw the bottle cap securely in position.
- Label any sample bottle(s) immediately with relevant details & carefully store/pack particularly if being sent away for testing (e.g. DGA)..

Sampling of Insulating Oil from Transformers for Labatory Analysis.

This sampling kit uses an oil proof rubber bung with approximately 5mm metal tube for insertion into the tap in a tank.



4.4 TRANSFORMER CORE & WINDINGS

4.4.1 It is recommended that the core & windings ONLY be removed from the tank for visual inspection if PARTICULARLY necessary (e.g. an internal fault involving coil or coils is detected). **IMPORTANT : If removed, on replacement a full test procedure must be performed PRIOR to recommission to ensure transformer connections etc. are satisfactory for further service.**

4.4.2 Following draining all oil from the tank, internal inspection should be done via opened top cover or side inspection cover openings. DO NOT USE NAKED FLAME OR LIGHT but a suitable SAFETY LAMP for internal inspection. IF inert gases are present in the tank it will be necessary to employ suitable breathing apparatus – in NO circumstance must any person attempt to enter a tank where it is suspected inert gases, e.g. nitrogen, is present without aids to survival.

4.4.3 Before lifting the core & windings from the tank it is necessary to disconnect the winding connections from terminal bushings inside the tank and the earth connection between the core body and the tank. The core and windings must be removed with great care, and when removed be stored under proper cover and in a dry place.

4.4.4. IF removed from tank, windings should be examined to ensure that no sludge/dirt has been deposited to block the oil ducts / opening passages.

4.4.5 Off circuit selector (OCS) terminals shall be thoroughly cleaned and ensure no welds / dents exist at tapping contacts. And that all the tapping leads are properly insulated / supported without any loose sag. Also ensure smooth & full operation of OCS throughout tapping range.

4.4.6 Any loose nuts & bolts should be tightened and main clamping checked for tightness.

4.4.7 After completion of examination, CHECK to ensure no foreign items have been left inside the tank.

4.4.8 On replacement of core & windings within the containing tank, replacement of covers etc & refill with oil it is necessary to retest the transformer using reduced test voltage levels (as detailed in the relevant standard specification). IF coil(s) have been replaced it may be necessary (or desirable) to perform a load loss test to verify the replacement coil(s).

4.4.9 AS an alternative to this 'time consuming process', a regular DGA (Dissolved Gas Analysis) of oil will give effective indication of any potential problems beginning to occur. Also video camera technique can be used to carry out an internal inspection quickly and with minimum problems, (camera suitable for use under oil). This technique avoids the need for a full test procedure as core/windings remain in position – if any connections are removed/reconnected some low voltage test technique WILL be required.

4.5 EXTERNAL – OUTDOOR / INDOOR TERMINAL BUSHINGS

4.5.1 Outdoor Porcelain insulators and rain sheds should be cleaned at regular intervals. A metallic scrubber can be used effectively to remove dirt / stains provided surface NOT damaged. Intervals between cleanings will be very dependent on the degree of contamination in the immediate area. The rate at which contamination occurs will have to be gauged by regular observation in first instance.

4.5.2 During cleaning process, the outdoor porcelain (or moulded) bushings should be examined for oil leakage, cracks or other defects and defective ones should be replaced.

4.5.3 Arcing horns, if fitted, shall be checked for any arcing dents / welds and correct gap setting, Any arcing horn suffering distortion etc. is to be replaced or rectified.

4.5.4 Indoor Porcelain Insulators, usually placed inside the cable box, should not require cleaning under normal circumstances & are very reliable whether in air or under oil. Composite/moulded Insulators entering service have not established long term reliability. Some early examples have suffered from surface deterioration

4.6 CABLE BOXES

4.6.1 In the case of a compound filled cable box, check regularly for leakage at weatherproof plugging / sealing with bituminous compound, which shall be free from any cracks. Likewise for any oil filled box or disconnect chamber when oil seepage is detected.

4.6.2 In case of air-filled cable box (for Heat-Shrink / Push-On / other such dry termination), though no maintenance is required, it is advisable to check regularly for cleanliness, any damage to the bushings, tightness of termination, etc. & ingress of moisture

4.7 CONSERVATOR & OTHER MEANS OF OIL PRESERVATION

4.7.1 A conservator acts as an expansion space for a working transformer & is normally placed above the related main containing tank. It tends to minimise surface area of oil in contact with outside air. It is normal to provide some form of dehydrating device to connect to the outer atmosphere – this commonly contains gel but in some cases may be a refrigeration device. working on a freeze (trapping moisture)/ melt (disposing of entrapped moisture) cycle.

4.7.2 Conservators are arranged so that the lower part acts as a sump into which any impurities entering the conservator will tend to collect. A valve is fitted at the lowest point of the conservator for draining and sampling. When sampling, care must be taken to run off any such sludge before taking oil sample for testing.

4.7.3 The inside of the conservator should be cleaned at intervals and a removable end is provided on each conservator to allow access for this purpose.

4.7.4 Some conservators may be fitted with a flexible diaphragm or bag to ensure that the oil within the transformer does not come into contact with air. This allows for the expansion of oil but avoids contact with air. Refer to special instruction supplied with subject transformer.

4.7.5 For some transformers, lower power ratings e.g. distribution, a sealed, expansion space is provided at the top of the main containing tank & acts in a similar role as 4.5.4

4.8 COOLING SYSTEMS - RADIATORS

4.8.1 Cooling Radiators are produced by a number of manufacturers, & although similar in general style one with another tend to differ slightly in the detail. It is preferable (but not mandatory) that the radiators fitted all come from the same source/supplier.

NOTE : In event that repair/refit is required it may be convenient to use radiators from differing sources.

4.8.2 Cooling Radiators should be frequently checked for any oil leakages along all the welded joints, gasket joints, plugs, etc.

4.8.3 Any bend, dents, etc., should be suitably rectified as soon as possible. Also replace protecting surface paint. Refer to WPS in the circumstance that a galvanised finish is provided.

4.8.4 Cooling Radiators or fins cater for ONAN cooling (natural cooling) but extra cooling can be achieved by use of forced air. The principal is simple, fans are used to increase the air quantity moving thro' the panels thereby increasing the cooling effect. Fans can be arranged to blow air in an upwards direction (from the coolest to the hottest point in each radiator). Alternatively a single fan could be used to blow thro' a set of radiators – thereby saving a quantity of fans, an increased resistance results in the fans selected having to overcome an increased 'back pressure'.

This is known as ONAF cooling indicating the mass of air available for cooling is increased by action of the fans.

An additional effect may be obtained by use of an oil pump in the oil pipework, usually the cooled oil return connection, to speed up the velocity of the oil employed in cool process. This is known by the designation of OFAF. The use of forced cooling to increase the power transmission thro' put is commonplace even for distribution ratings by means of forced air.

4.8.5 Radiators may need to be cleaned from time to time particularly when located in areas subject to dust contamination, dirt/deposits hamper heat transfer to surrounding cooling air. Compressed air should be a suitable vehicle for cleaning in majority of instances.

4.8.6 Other means of cooling uses water instead of air, suitable means are required to either cool the heated water or transfer it to waste. Accordingly use of this means of cooling is virtually unknown for distribution ratings

4.8.7 All means of additional cooling impose particular requirements to ensure performance is maintained.

4.9 SEALING GASKETS

4.9.1 Gaskets have several important jobs to perform

- a gasket must create an effective seal & hold it over a long period of time.
- it should be impervious & not contaminate the insulating oil or air/gas above oil.
- it should be easily removed & replaced.
- it must be elastic enough to flow into imperfections on the surfaces to be sealed.
- it must withstand temperature variation & remain resilient to cope with joint movement, contraction & vibration.
- it must be resilient enough to avoid taking a 'set' even when exposed for a long period to applied pressure variation.
- it must maintain its integrity under handling or installation.

Failure to meet any of the above criteria will result in a leak or leaks.

4.9.2 Gasket material used by WPS is Cork – Nitrile (classified TD1120). It has a shelf life of approx. 2 years. It can often be re-usable in the short term unlike Cork – Neoprene which is not recommended for use. An alternative which is also used in certain situations is Nitrile (buna N). It must be protected from sunlight, otherwise it will deteriorate e.g. relief vent ring gasket.

4.9.3 Gaskets sometimes shrink during service & require replacement. Before doing so check the tightness of all bolts fitted with gaskets. The bolts should be tightened evenly around the joints to avoid uneven pressure, follow recognised tightening procedures. Damaged gaskets (for whatever reason) should be replaced as soon as possible.

4.10 GAUGE(S), INDICATORS & RELAYS

4.10.1 The simplest format of oil level gauge is just a reinforced glass or plastic window or block thro' which oil level can be seen. A label giving expected Cold Oil level (minimum) & Hot Oil level may be fixed into position. It is also possible to include a 'low oil' contact for protection (separate item) if needed. Any oil gauge, if glass, should be kept clean and any damaged glasses should be replaced immediately or without undue delay.

4.10.2 An alternative is an oil gauge of the visual magnetic type fitted with an operating arm having a float attached. As oil level increases, the float rotates a magnet inside the tank or conservator. Outside the tank another magnet follows (rotates) which moves the pointer of the oil gauge. High & low level points to indicate level changes (oil expands when hot). This is a simple method of check – determine the top oil temperature & then look at the level gauge, the pointer should be at a reasonable level corresponding to the determined top oil temperature. It is normal practice to indicate 'cold' oil level to ensure the unit is correctly filled with req'd oil. The oil gauge may incorporate electrical switches for alarm or trip purposes in the event that the tank level falls.

NOTE : It is IMPORTANT not to damage or distort this operating arm if the parent conservator vessel is opened or entered.

4.11 TEMPERATURE INDICATOR(S)

4.11.1 The simplest form of temperature measurement is provided by the alcohol thermometer (note not mercury in glass) placed into a thermometer pocket or well located in the tank wall near the top of the tank IN the oil. This will provide for the occasional reading.

4.11.2 For convenience to indicate top oil use a typically sealed spiral bourdon tube dial type with liquid filled bulb sensor. Again the bulb is accommodated in a thermometer pocket or well in a suitable position in the tank wall. As oil temperature increases, liquid expands which expands with the spiral tube. The tube is attached to a pointer that indicates temperature, also incorporating electrical contacts to trigger alarms or start cooling fans as operating temperature increases.

4.11.3 The companion to 4.11.2 is the winding temperature indicator based on a similar construction with the addition of a heating coil placed around/adjacent to the operating pointer This is intended to simulate load amps taken in 1 phase of the transformer. The heating coil is supplied by a single phase current transformer – primary rated for load amps relevant to the rating of the transformer. The net result is an instrument reading top oil temperature PLUS an additional component relating to the load amps supplied by the transformer. The thermometer monitors the approximate average working temperature of the coil from which it receives supply hence called a 'thermal image' device. Some means of adjustment to calibrate performance to approximately match the subject transformer is provided. As for 4.11.2 the instrument incorporates electrical contacts to trigger alarms, start cooling fans or pumps or supply information re temperature reading to a remote point.

4.11.4 Both oil & winding temperature indicators should be check calibrated at intervals & the functioning of the switches checked as operational.

4.11.5 The level of oil in the thermometer pockets should be checked and the oil replenished if required (to ensure good contact between indicator bulb & internal tank oil). The capillary tubing should be fastened down again if it has become loose. Dial-glasses of temperature indicators should be kept clean and, if broken, replaced. Temperature indicators, if found to be reading incorrectly, should be re-calibrated with standard thermometer immersed in a hot oil bath or other calibrated reference.

4.12 BUCHHOLZ RELAY

4.12.1 This is only suitable for use with transformers fitted with conservators. Consists essentially of 2 oil filled chambers equipped with floats & contacts; one to give an alarm the other a trip signal. It relies on the fact that gas(es) are produced by various conditions in the transformer such as local overheating or partial discharge etc. A slow build up of gas affects the top float & eventually an alarm signal will be generated. If however there is a rapid evolution of gas (such as would be produced by a specific fault) the other float will be activated to give a trip signal e.g. to cause the relevant switchgear to operate).

4.12.2 During service, if the relay is operated due to an accumulation of gas and not due to fall of conservator oil level the accumulated gas can be analysed. Any internal faults can be identified to a great extent by a chemical analysis of gases collected. Sometimes, on analyzing the gas, it may be noticed that the gas collected is only air. Providing this is not a frequent occurrence it may be that the contained oil is releasing any absorbed air due to oil filtration or due to change in temperature.

4.12.3 The relay should be routinely inspected and the operation of relay is ensured by injecting air into the relay and check that floats are able to fall / rise freely and that the mercury / magnetic switches are making / breaking the contacts correctly.

4.13 EXPLOSION VENT OR PRESSURE RELIEF DEVICE (PRV)

4.13.1 In an explosion vent, the diaphragm is fitted at the exposed end of the vent, which should be inspected at frequent intervals and replaced if found deteriorated / damaged. Failure to replace the defective diaphragm quickly may allow the ingress of moisture, which will contaminate the oil. If the diaphragm has broken due to an internal fault, a full inspection should be made to determine the nature and cause of the fault BEFORE replacing & re-energising the transformer. NOTE : this style of PRV is obsolete being replaced by the spring loaded resettable device.

4.13.2 In a spring loaded 'blow-off & self or manual reset' type Pressure Relief Device, a set of springs are held in compression by a cover & press on a disc which seals the opening in the tank top. If the pressure in the tank is caused to exceed the set operating pressure the disc moves upward & relieves pressure. As pressure decreases, the springs re-close the valve (to prevent ingress of air/moisture). To indicate operation a brightly coloured flag is exposed, & can only be reset manually. If the indicator, usually a flag, has operated then an inspection should be made to determine the cause of any fault BEFORE cancelling indication & re-energising the transformer (PARTICULARLY if disconnected from supply) e.g. send oil sample(s) for DGA so that suitable remedial measures can be taken.

4.14 DEHYDRATING BREATHER

4.14.1 Normally used when transformers are classed as 'free breathing'. It is important to keep out insects & small rodents & prevent excess moisture from entering the tank (i.e. rain). Excess water does not help the insulating properties of insulating oil & is to be avoided hence some means of drying any air entering the tank, due the natural expansion/contraction of oil, is used. A breathing device filled with a quantity of desiccant is used to fulfil this function.

4.14.2 The dehydrating breather should be regularly checked for colour of desiccant. When the majority of gel becomes saturated, the same shall be replaced or reactivated. Also oil in the oil seal, if used, should be maintained up to the level marked on the cup.

4.14.3 The frequency of inspection depends upon local climate and operating conditions. More frequent inspections are needed when the climate is humid and when the transformer is subject to fluctuating load.

4.14.4 As an alternative to the above a refrigeration device may be used. This works on a freeze/thaw cycle basis & does not contain gel that regularly needs to be replaced.

4.15 CONTROL CABINETS

4.15.1 If the subject transformer is provided with a control cabinet this will be the marshalling point for all connections to other places whether local or remote

4.15.2 It will also contain items like the temperature indicators, cooler control (if provided), any specialised control/monitoring equipment required (specific to customer requirement), terminal blocks to marshal all connections whether local auxiliary or for connection to remote points.

4.15.3 It will normally be to a weatherproof standard containing anti condensation heater & light/switch for convenience. The internal will normally be finish coated in an anti-condensation coating. The door is normally fitted with a viewing window/windows.

4.16 CURRENT TRANSFORMERS

4.16.1 Any current transformers will be normally mounted over internal bar work or interconnect leads inside the tank of the transformer. Secondary connections will be brought to moulded type terminal blocks for external connection of auxiliary wiring for connection to a common collect point.

4.16.2 Current transformers provided for protection or metering purposes are normally located adjacent to the terminal bushings they intended to protect or meter. On occasion this may be external to the main containing tank e.g. in a separate external compartment.

4.16.3 In the event that malfunction is suspected normal basic test procedure applicable to current transformers should be followed (e.g. check ratio test).

4.17 ON LOAD TAP CHANGERS

4.17.1 Always sourced from others, the particular manufacturer's maintenance instructions should ALWAYS be followed. There are two main types

- the traditional mechanical switching arrangement
- the more recent vacuum or electronic methods of switching

4.17.2 For the former oil located in a compartment where current making/breaking occurs will need examination to ascertain when it should be changed or renewed with fresh oil.

Likewise with the contacts making/breaking current (amps) will eventually need renewal due to thousands of operations, actual as recommended by manufacturer.

4.17.3 For the former other associated equipment should prove reliable but contactors initiating tapchange may require some maintenance. ALWAYS follow original manufacturer instructions. WPS will provide corresponding literature that applies.

4.17.4 For the latter ALWAYS follow original manufacturer instructions. WPS will provide corresponding literature that applies.

4.18 OFF CIRCUIT SELECTORS (OCS)

4.18.1 Will come from a variety of manufacturing sources including the UK, some more established than others. If used correctly little should go wrong – the operative form is selector NOT switching. IF used to switch (i.e. subject transformer still energised) this process can be dangerous due to the stimulation of current arcing that the action of changing tap position will cause to occur. In extreme circumstances personnel have been injured & equipment has caught fire.

4.18.2 The only maintenance required – on a yearly basis de-energise the transformer & operate the selector thro' its complete range 3 or 4 times finally re setting onto the desired tap connection. Once the desired tap connection is selected & protecting padlock fitted the transformer can be re-energised.

The purpose of this procedure particularly if the subject transformer operates on a fixed tap position is to prevent/clear any film build up which may occur eventually causing a high resistance contact to develop. In such circumstance the three phase selector would need to be replaced.

4.19 SURGE ARRESTORS

4.19.1 These may be provided particularly if outdoor terminal bushings are fitted to prevent sudden voltage surges (caused by lightning affecting transmission lines during storms or switching surges etc.)

4.19.2 The recommendations made under 4.5 regarding Outdoor Terminal bushings will be applicable e.g. cleaning outer porcelain etc.

4.20 PROTECTION FUSES

4.20.1 Where an auxiliary transformer, having considerably lower power rating than the main power unit, is mounted directly onto and deriving its supply from the same it is normal to provide a set of fuses on the incoming side of the same.

4.20.2 The fuses should be checked to ensure serviceability – any fuse appearing unserviceable must be replaced with identical or equivalent unit(s) and correctly clamped into position. If immersed under oil then any oil removed for convenience of replacement must be placed in a clean container which can then be sealed and finally replaced.

IMPORTANT Any suspected or actual failure should be fully investigated PRIOR to re commissioning the subject transformer.

4.21 AUXILIARY TRANSFORMER

4.21.1 The procedure to be followed is essentially as given in Sects 4.1 -4.14 & 4.18 -4.20.

4.22 VALVES

4.22.1 All valves should be checked for any leakage and for open / close operation. Blind caps should always be kept fitted on them if provided.

4.22.2 Valves that are faulty should be changed as soon as possible.

4.23 BOLT, NUTS & FASTENERS

4.23.1 All bolts, nuts, fasteners, etc., shall be thoroughly checked for proper tightness and any deteriorated parts should be replaced.

4.24 PAINT-WORK

4.24.1 During storage and service, the paint-work should be inspected once a year, especially at the welded seams / joints, and where necessary, repainting or retouching carried out. If the metal surface is exposed and becomes dirty, rusty or greasy because of delay in repairing the paint-work, the surface must be thoroughly cleaned with a wire-brush or similar abrasives, before repainting to ensure a good bond between metal and paint.

4.24.2 If paints recommended by supplier are not available, any good quality alkyd resin-based paint may be used.

4.25 ANTI VIBRATION PADS

4.2.1 Anti Vibration Pads should require little or no maintenance as they will remain unaffected unless specific solvents which act to dissolve or attack vulcanized rubber or similar are introduced to the substation support base. In such an unlikely event, replacement would become necessary (the whole Transformer would require lifting or jacking to allow this to occur).

4.26 GENERAL NOTES

IT IS ESSENTIAL TO KEEP A RECORD OF OBSERVATIONS MADE REGARDING OPERATING CONDITION, ANY TEST PARAMETERS & TEST RESULTS OBTAINED. IN CASE OF ANY ABNORMALITY OCCURRING DURING SERVICE, ADVICE FROM THE SUPPLIERS SHOULD BE OBTAINED, GIVING THEM NAME-PLATE PARTICULARS AND COMPLETE DETAILS AS TO THE NATURE & THE EXTENT OF OCCURRENCE.

MAINTENANCE SCHEDULE

Maintenance Schedule for the attention required under average conditions is given below;

SL. NO	FREQUENCY OF INSPECTION	ITEMS TO BE INSPECTED	INSPECTION NOTES	ACTION REQUIRED FOR UNSATISFACTORY CONDITIONS
01	Hourly / Daily	Ambient Temp.	For reference	-
02	Hourly / Daily	Oil / Winding Temperature	Check that temp rise is within normal range	For any abnormal temp. rise trip, investigate the cause.
03	Hourly / Daily	Load Voltage & Current	Check against the rated figures	For any abnormal tripping, investigate the cause.
04	Hourly / Daily	Noise emitted by unit	Assess whether appears reasonable	Check tap position, incorrect can cause over fluxing
05	Weekly	Dehydrating Breather	Check desiccant colour & oil seal	Replace the desiccant or make up the oil, as required.
06	Weekly	Oil level in Main Tank or conservator, if fitted	Check the observed level against oil temperature	If low, investigate for oil leaks & top up with dry oil.
07	Weekly	Buchholz Relay	Check for gas collection	Analyse, take action to prevent any potential fault.
08	Weekly	Gasket Joints & Radiators	Check for tightness & no oil leakage	Re clamp or replace / repair as required.
09	Weekly	Explosion Vent / Pressure Relief Device	Check for proper sealing/ indication of operation	Rectify / Investigate the damage / malfunction.
10	Weekly	External condenser bushing if fitted, oil level	Check to req'd level	Low oil, measure tan d & capacity. Advise supplier
11	Weekly	Full External	Check for any discolouration, maybe local o/heat, also paintwork	If o/heat suspected, investigate as req'd to establish cause(s), retouch paintwork.
12	Quarterly	Fluid fill (Oil etc.)	Check dielectric strength, also moisture etc.	Take suitable action to restore quality of oil/fluid.
13	Quarterly	Cable Box / Termnl. Bushings	Check for tightness / dirt / damage	Tighten if req'd, clean as needed, replace where damaged.
14	Half Yearly	Earthing Terminals	Check tightness & Earth Resistance measurement	Investigate / correct if resistance to earth is high.
15	Half Yearly	Oil / Unit quality, dissolved gas analysis	Take sample(s) for test as required	Monitor result(s), take corrective as / if needed.
16	Half Yearly	Accessories / Auxiliary Circuits	Check operation & switching contacts.	Clean the components, if necessary, replace the item.
17	Yearly	Buchholz relay / Surge relay Pressure Relief device / rusting/ damage	Mechanical inspection /function	Check floats, contact switches operation etc. If faulty, correct or replace.
18	Yearly	Unit Insulation Resistance	Check IR values using Megger or similar	If low investigate & take action to restore insulation.
19	Yearly	Off Circuit Selector	With unit de energised, operate thro' range 5 x	Operation OK, no further action. Operation suspect, replace if needed.
20	Yearly	Sample batch, fasteners, screws, clamps etc.	Check for tightness	Tighten as req'd or replace.
21	Yearly	Temperature Indicator (s)	Check oil level in bulb Pockets. Check operation & contacts	Replenish oil if needed. Adjust or replace as needed.
22	Yearly	Paint-work	Check for peelings / rusting/ damage	Suitably clean, treat & repaint, as required.
23	Yearly	Marshalling box, c/t terminal box	Check waterproof seal, all connections O K, verify I R, aux cables	If needed, replace seal, verify cause of any low I R. Correct if needed.
24	Two Years	On Load Tap Changer (if used)	Check active contacts re arc burn / wear also oil condition (switching)	Clean the components, if necessary, replace as req'd.
25	Two Years	Oil Gauge	Check operation & switching contacts.	Clean the components, if necessary, replace the item.
26	Two Years	Oil conservator	Internal inspection	Clean if necessary
27	3-5 Years	Overall paint-work	Check for deterioration	Consider full repaint to original specification
28	3-5 Years	HRC Fuse Links	Check for arcing / Displacement etc.	Replace / Repair defective components as necessary
29	3-5 Years	Core & Windings	Check for tightness / cleanliness	Replace / Repair defective components as necessary.



IMPORTANT The above is a recommended schedule highlighting items to be checked under average operating conditions. The suggested time scales may be variable depending upon the PARTICULAR site conditions & loading regularly seen.

5. TESTING OF THE TRANSFORMER

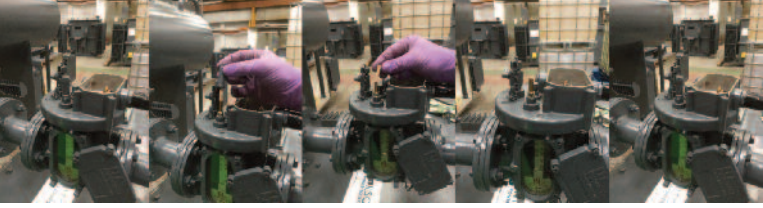
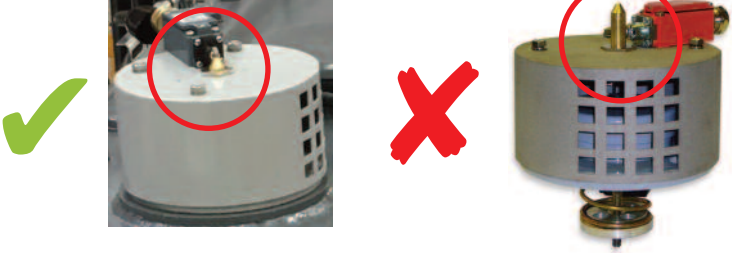

IMPORTANT: All checks to be carried out by a suitably qualified technician or engineer.

CHECKLIST

5.1 TRANSFORMER CHECKS THAT MAY BE REQUIRED:

PART	ITEM TO BE CHECKED	Y/N
De-energised Tap Changer	The transformer was delivered with the tap position on the principle tap, you may alter this if another tap setting is required. Once the desired tap has been chosen it must be locked and the key must be stored in a safe place to reduce the chance of maloperation.	
Tank Earthing Terminals	Ensure that your earth mat is still connected to the transformer via the tank earthing terminal.	
Thermometer Pocket	Ensure that all thermometer pockets are fitted with appropriate equipment (such as a temperature sensor) or closed off via a cap. 	
Drain Valve	The transformer will be delivered filled with insulating fluid, with the drain valve closed and a cap covering it as shown below. The valve may be used to take oil samples from the transformer. 	
Breather	Confirm the breather has been installed correctly and is functional.	
Oil temperature indicator (OTI)	The transformers will be delivered with a preset alarm and trip as shown below: OTI: Alarm 90oC, Trip 100 oC Check and maintain selected alarm and trip settings. If other alarm and trip values are required, refer to their product manuals for installation guidelines.	
Winding temperature indicator (WTI)	The transformers will be delivered with a calibrated, preset alarm and trip as shown below: WTI: Alarm 100oC, Trip 110 oC Check and maintain selected alarm and trip settings. If other alarm and trip values are required, refer to their product manuals for installation guidelines.	

CHECKLIST

PART	ITEM TO BE CHECKED	Y/N												
Buchholz relay	Visually check that the device is completely filled with oil. 													
Pressure relief device	Ensure the device has not been operated. If operated, investigate. The brass coloured pin should be in the down position, as illustrated below: 													
Dual primary voltage changer	The transformer will be delivered set to the lower voltage unless requested otherwise. If lower voltage is not what you require, ensure the tap is changed to the appropriate setting. The number that corresponds to the tap position is indicated on the rating plate "SELECTOR SWITCH CONNECTION" and "SWITCH POSITION" as shown below: <table border="1" data-bbox="481 1258 721 1447"> <thead> <tr> <th colspan="3">SELECTOR SWITCH CONNECTION</th> </tr> <tr> <th>HV VOLTAGE</th> <th>SWITCH POSITION</th> <th>TAPS JOINED</th> </tr> </thead> <tbody> <tr> <td>11000</td> <td>HV1</td> <td>3-4</td> </tr> <tr> <td>6600</td> <td>HV2</td> <td>1-4 & 3-5</td> </tr> </tbody> </table> Once the correct voltage has been chosen, check that the switch has been secured into that position.	SELECTOR SWITCH CONNECTION			HV VOLTAGE	SWITCH POSITION	TAPS JOINED	11000	HV1	3-4	6600	HV2	1-4 & 3-5	
SELECTOR SWITCH CONNECTION														
HV VOLTAGE	SWITCH POSITION	TAPS JOINED												
11000	HV1	3-4												
6600	HV2	1-4 & 3-5												
Oil level indicator	The oil level indicator can either be a magnetic oil gauge (right) or a standard visual indicator (left). Make sure that the oil is in line with the expected temperature. If no oil level can be determined stop all activities and inform WPS. 													

5.2 TRANSFORMER TESTING FOLLOWING NECESSARY MAINTENANCE

CHECKLIST

INSULATION RESISTANCE (IR) TEST

COMMISSIONING PROCEDURE

Y/N

Before starting this test ensure that all power terminal bushings have been thoroughly cleaned with a clean, dry piece of cloth.

During IR test, no external power lines / cables, lightning arresters, neutral earthing, etc., should be in the power circuit. Ensure that the transformer is completely isolated at both HV & LV sides and that all non-current carrying conductors are earthed.

The IR values of windings to earth (and between windings) shall be measured for all tap positions.

Between HV Winding and Earth use 5000V or 2500V Insulation Tester (Megger)

Principle Tap Value:_____

Between HV and LV Winding use 5000V or 2500V Insulation Tester (Megger)

Principle Tap Value:_____

Between LV Winding and Earth use 1000V or 500V Insulation Tester (Megger)

Value:_____

The IR values obtained should be similar to those indicated in the manufacturers' test reports and other records. Be aware that in humid conditions IR values obtained may be lower due to condensation on the terminal bushings.

If IR values are very low (Minimum value is 1000ohm per volt service voltage), then it may be necessary to filter the oil / dry-out the winding till the insulation reaches satisfactory values.

BREAK-DOWN VOLTAGE (BDV) TEST

PROCEDURE

Y/N

Oil samples should be carefully taken from the tank bottom and tested for BDV value.

BDV value of oil should be more than 50kV (rms) for 1 minute in standard test cell.

Value:_____

If the BDV value is very low and unacceptable (30kV (rms) or less for 1 minute) then it may be necessary to dry-out & clean the oil until the insulation reaches satisfactory values.

Note: For very low IR values and low BDV values, it is recommended to contact WPS for a suitable recovery procedure based on available facilities at site.

CHECKLIST

VOLTAGE RATIO TEST

PROCEDURE

Y/N

Apply 3-Phase, 433V/415V AC or a single phase 240V/230V AC supply on the HV side and record the Voltage Ratio at all tap positions. This can be derived using a suitable precision voltmeter connected to the LV side. A ratio meter, if available, can be used for a more accurate measurement.

Tap 1 ratio: _____

Tap 2 ratio: _____

Tap 3 ratio: _____

Tap 4 ratio: _____

Tap 5 ratio: _____

Tap 6 ratio: _____

The Ratio values obtained should be similar to those indicated in the manufacturer's test report, which will have been furnished with the handing-over documents.

WINDING RESISTANCE (OR CONTINUITY) MEASUREMENT TEST

PROCEDURE

Y/N

Winding Resistance of every phase of each winding should be measured using suitable DC Resistive Bridge or similar. Alternatively check continuity of each winding.

HV U Value: _____

HV V Value: _____

HV W Value: _____

LV u Value: _____

LV v Value: _____

LV w Value: _____

Winding Resistance values obtained should be similar to those indicated in the manufacturer's test report, which will have been furnished with the handing-over documents. NOTE: In order to achieve a result with some accuracy only measure when a transformer is in a stable condition e.g. ambient temperature. Potential large errors can occur when attempting to define an average coil temperature.

CHECKLIST

MARSHALLING BOX SCHEME CHECK

PROCEDURE

Y/N

All the auxiliary wiring from the various accessories to the marshalling box shall be checked against the marshalling box scheme drawing provided.

Operation of all the alarm / trip contacts should be checked by simulating the alarm or trip condition, checking that the alarm or trip signal appears at the correct terminal at the marshalling box.

BUCHHOLZ RELAY TEST

PROCEDURE

Y/N

The Relay operation for alarm and trip contacts should be checked by injecting air through the test petcock. The air injected into the relay will allow the alarm float / flap and trip float / flap to fall thus operating their respective switches.

TEMPERATURE INDICATOR TEST

PROCEDURE

Y/N

Indicator operation for alarm and trip contact shall be checked by manual stimulation.

OFF CIRCUIT SELECTOR (OCS)

PROCEDURE

Y/N

During maintenance the OCS is not separated from the transformer, so it is not necessary to recheck the internal connections of tapping and internal mechanism.

Means of protecting the OCS from unauthorised operation is provided by using pad locking arrangement at designated tap position.

FLASH TEST ON WINDING (ON THE REQUEST OF THE CUSTOMER)

PROCEDURE

Y/N

If a flash test is required then it must be performed at reduced voltages only, which is value calculated by subtracting the service voltage from the original test voltage as tested as per the manufacturer's test certificate, halving the obtained value and then adding the service voltage as explained in this example:

Service Voltage 11kV

Half of Difference Voltage

Recommended Test Voltage at site $(17 / 2 = 8.5\text{kV}) + 11 = 19.5\text{kV}$

5.3 POST-MAINTENANCE RECOMMENDATIONS

It is recommended that the transformer is initially energised at No-load only and is checked for any abnormalities for the next 6 to 8 hours.

After switching on No-load, if the primary side circuit breaker is tripped, investigate the cause thoroughly and re-energise the transformer only after ensuring that any fault is properly identified and cleared.

If satisfactory (transformer on No-Load) then apply load gradually and observe for any abnormalities for the next 6 to 8 hours.

If the transformer is satisfactory on-load up to 50% for the first 4-8 hours, shut-down the transformer and ensure that all air-release plugs of tank, radiator, conservator, buchholz relay, bushings, etc., are free of air pockets which might have developed during initial loading.

5.4 TRANSFORMER LIFE CYCLE

Transformers are made from a mix of ferrous and non-ferrous metals which are widely recyclable, as is the insulating medium. We recommend that end of life units are disposed of by means of recognised waste handlers / dismantler. This product does not come under WEE regulations.

NOTE: Suitable financial value can be obtained, particularly for copper. Alternatively, aluminium may be used as a winding conductor.

5.5 WARRANTY CONDITIONS

The manufacturers warranty is provided subject to the following conditions being met:

- All warranty seals are intact and untampered with
- Recommendations given in this maintenance schedule are followed
- Proof of maintenance activities can be provided
- Any work external to the transformer needs to be carried out by a suitably qualified professional engineer
- Where this work is carried out unsupervised WPS reserves the right to declare the warranty void

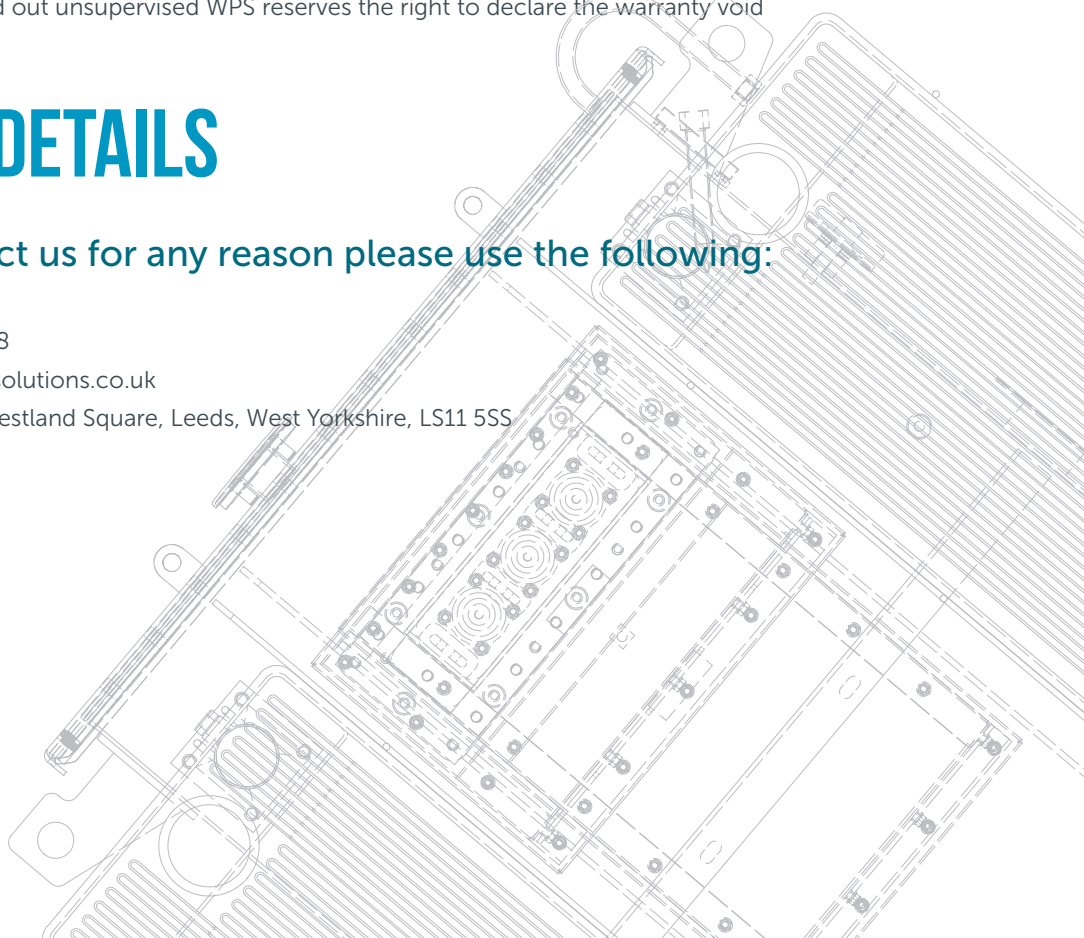
6. CONTACT DETAILS

If you need to contact us for any reason please use the following:

TELEPHONE : +44 (0)113 271 7588

EMAIL : info@wilsonpowersolutions.co.uk

ADDRESS : Westland Works, Westland Square, Leeds, West Yorkshire, LS11 5SS



OUR VISION

To be a family company with a conscience providing innovative, sustainable energy infrastructure solutions.

OUR MISSION

We are committed to growing our business by continuing to deliver customer driven, tailored solutions and outstanding levels of service, whilst investing in the development of new and improved power distribution products and services.





7. ABOUT US

Wilson Power Solutions is based on a unique customer and professional approach that has been developed over 70 years in the industry.

Today, Wilson Power Solutions is managed by the third generation of the Wilson family who like their business to remain agile and friendly. Dedicated to helping customers find the best power distribution solutions for their individual needs, we are passionate about our expert knowledge and committed to giving advice with our customers' best interests at heart.

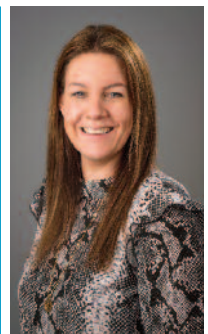
We treasure our heritage and know that our hard-earned reputation for service excellence and superior product performance has grown out of 70 years of experience in the power engineering sector.

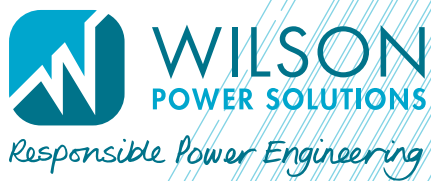
THE BEST SOLUTION FOR YOUR POWER NEEDS

Recognising the importance of integrity and reliability, we believe in building lasting partnerships with our customers that are based on a unique service based on technical knowledge, superior product performance and mutual trust.

“ We believe in building lasting partnerships with our people, our customers, suppliers and our communities, both locally and internationally.

ERIKA WILSON MANAGING DIRECTOR





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