Snowy Technical Standards		
SHL-ELE-520	***Transformer Mineral Oil Supervision and Maintenance***	
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1. Executive Summary

This standard sets out the requirements for the acceptability of transformer mineral oil. It provides details of test acceptability criteria for both new and used oil along with an explanation of the purpose of the tests.

2. Scope

Defines the acceptance criteria for new and used transformer oil at Snowy Hydro.

Defines criteria for the evaluation of in service oil parameters.

Defines corrective actions for in service oil that does not meet acceptance criteria.

Defines general guidelines around the maintenance of transformer oil.

Provides context to the meanings of the oil qualities, analysis and diagnostics.

2.1. Applicable Standards

Note: All standards referred to are to be the latest available version wherever practicable.

IEC 60422:	IEC 60422-Mineral insulating oils in electrical equipment – Supervision and maintenance guide.
IEC 60296:	IEC 60296 Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear.
ASTM D3487	Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
IEEE Std 62-	IEEE Std 62- IEEE Guide for diagnostic field testing of electrical power apparatus.
IEEE Std C57.140-	IEEE Std C57.140- IEEE Guide for the evaluation and reconditioning of liquid immersed power transformers.
IEC 60156	Insulating Liquids – determination of the breakdown voltage at power frequency – test Method
IEC 60475	Method of sampling insulating liquids
AS 1767 (all parts)	Insulating Liquids – Test Methods

3. Definitions

Power Transformers	A static piece of apparatus with two or more windings which, by electromagnetic induction transforms from one system voltage to another for the purpose of transmitting electrical power.
Large Transformers	Power transformers with a system highest voltage including and above 72.5 kV.
Small Transformers	Power transformers with a system highest voltage up to 72.5 kV.
Categories of Equipment	Refer to Table 2, IEC 60422
Oil Reconditioning	The removal of insoluble contaminants, moisture, and dissolved gases from electrical insulating liquids by mechanical means. NOTE: The typical means employed are settling, filtering, centrifuging, and hot vacuum drying or degassing.
Oil Reclaiming or Regeneration	The restoration to usefulness by the removal of contaminants and products of degradation such as polar, acidic, or colloidal materials from used electrical insulating liquids by chemical or adsorbent means. NOTE: Reclaiming typically includes treatment with clay or other adsorbents. The methods listed under reconditioning are usually performed in conjunction with reclaiming.

4. Technical Requirements

4.1. Transformer Oil Functions and Requirements

The oil in a transformer has several main functions including cooling, electrical insulation and condition monitoring. There are also a number of secondary functions and properties expected from a quality transformer oil. These include; compatibility with other equipment and materials, aging stability, and so on. Additionally, if managed correctly, the oil must meet all requirements of health, safety and environmental legislation.

4.2. Transformer Oil Property Table.

The following Table lists the properties of Transformer oil in six groups.

COOLING: Viscosity Pour Point Viscosity Index	**LIFE INDICATORS:** Oxidation Stability Inhibitor contents Solubility
ELECTRICAL INSULATION: Breakdown Voltage Dielectric Dissipation Factor (DDF) Impulse Breakdown Resistivity Water Content	**MATERIAL COMPATIBILITY:** Sulphur Content Acidity Corrosive Sulphur Aromatic Content Passivator Content
HEALTH SAFETY & ENVIRONMENT: Flashpoint Electrostatic Charging Tendency (ECT) DMSO Extractable compounds (IP346) Polychlorobiphenyl Content (PCB)	**OTHERS:** Density Interfacial Tension (IFT) Furanic compounds Gassing tendency

4.3. Oil Applications at Snowy Hydro

Large Power transformers in the Snowy Hydro power stations have historically been filled with uninhibited mineral oil. Shell Diala B was used up until late 1990s. When Shell Diala B became unavailable, the equivalent replacement oil was Nynas Nytro 10GBN until mid 2000s. When 10GBN became unavailable, the equivalent replacement was Nynas Nytro Libra. Nynas Nytro Libra is still currently available and preferred for topping up hydro power station transformers.

Inhibited oils are also common in power transformers. It is important to identify what type of oil is used in the transformer so that the equivalent oil can be used to top up. The transformer nameplate or manufacturer's manual should indicate the type of oil in the transformer. Other labels or stickers on the transformer may be present to indicate the addition of passivator for corrosive sulphur mitigation.

Hydrodec Superfine is a re-refined inhibited mineral oil. This oil has been used to retrofil a number of transformers at Snowy Hydro. These transformers are labelled to indicate that they are filled with inhibited oil.

Ester fluids are becoming more common, particularly in smaller transformers but development of the fluids has seen it being used in power transformer with voltage levels above 400kV. The fluid is biodegradable and requires differing handling and diagnostic criteria. Ester Fluids will be clearly indicated on the nameplate (e.g. K class fluid). Another SHL-ELE standard is to be developed for Ester filled transformers and therefore this document does not apply to these fluids.

4.4. Acceptance

For new oil quantity greater than 1,000 Litres, acceptance testing must be performed to the criteria in Table 1 below by a Snowy Hydro preferred oil test laboratory before the oil is unloaded.

For oil quantities of less than 1,000 Litres the manufacturer's test certificate must be provided.

Where oil has been delivered in a vessel other than one that is certified by the oil supplier, acceptance testing must be performed to the criteria in the Tables below by a Snowy Hydro preferred oil test laboratory before the oil is unloaded.

4.5. Delivery

Each new oil delivery shall be accompanied by a document from the supplier specifying at least: supplier designation, oil classification and compliance certificate.

4.6. Key Oil Parameters

4.6.1. Test Limits for Transformer Oil

The oil quality for new and existing equipment is different due to the aging and service life of the oil and equipment. Therefore, the acceptable test limits need to reflect these differences and are given by the two tables below.

4.6.2. Test limits for New transformer Oil

The test limits for new oil is dependent on the type and voltage of the equipment and the following Table 1 is a Guide to acceptable limits for the oil when it has been put into the transformer new but prior to energisation:

Properties for New Oil	Highest Voltage For Equipment (kV)		
	<72.5 kV	72.5 to 145kV	>145kV
Appearance	Clear, free from sediment & suspended matter		
Colour (as per ISO 2019)	Max 2.0	Max 2.0	Max 2.0
Breakdown Voltage (kV)	>55	>60	>60
Water Content (mg/kg or ppm) @ 20ºC	10	<5	<5
Acidity (mg KOH/g)	Max 0.03	Max 0.03	Max 0.03
Corrosive Sulphur	Non-Corrosive (negative)		
DDF @ 90ºC & 50Hz	Max 0.015	Max 0.015	Max 0.010
Resistivity @ 90ºC (GΩ.m)	Min 60	Min 60	Min 60
Oxidation Stability	As per IEC 60296 or AS 60296		
Interfacial Tension (IFT) (mN/m)	Min 35	Min 35	Min 35
Total PCB Content (mg/kg or ppm)	Not detectable (2ppm total)		
Total gas content % (typical)	2	2	1

TABLE 1: Acceptable Limits for New Transformer Oil

4.6.3. Evaluation of In-Service Oil Parameters

Oil parameters are to be monitored via annual routine oil sample testing. More frequent testing may be recommended based on test results and abnormal trends. Consistency of sampling methods and temperature recording is paramount to obtaining long term repeatable trending data.

4.6.4. Test Limits for In Service Transformer oil

Table 2 below gives the test limits for oil that has been in service. The test results should be assessed against these limits and performed by an accredited oil test laboratory. There should be consideration given to the characteristic values of the particular type of oil and the transformer involved. All trends and rates of variation should be monitored and compared to previous test results to determine if any actions are needed.

Properties for In--Service Oil	Highest Voltage for Equipment (kV)		
	<72.5 kV	72.5 to 145kV	>145kV
Appearance and Colour	Clear, without visible contamination		
Breakdown Voltage (kV)	>35	>40	>50
# Water Content (mg/kg or ppm) corrected to 20ºC	<25	<15	<10
Acidity (mg KOH/g)	Max 0.3	Max 0.2	Max 0.15
Inhibitor Content (if Applicable)	>40% of original value		
DDF @ 90ºC & 50Hz	Max 0.5	Max 0.5	Max 0.2
Resistivity @ 90ºC (GΩ.m)	Min 0.2	Min 1	Min 1
Oxidation Stability	As per IEC 60296 or AS 60296		
Interfacial Tension (IFT) (mN/m)	Min 24	Min 24	Min 24
Total PCB Content (mg/kg or ppm)	Not detectable (2ppm total)		

TABLE 2: Acceptable Limits for In-Service Transformer Oil

Note: These moisture values are not corrected for temperature since not enough time will have elapsed to reach equilibrium between oil and cellulose insulation.

The following paragraphs provide a background to the value of each of the key parameters.

4.6.5. Interfacial Tension (IFT)

The Interfacial tension test measures the strength of the interface between oil and water. The interfacial tension depends on the polar groups in the oils. The IFT has little impact on the in-service functionality of the oil but it serves as a good tool for judging the purity of the oil during handling and aging in service. A low IFT can also indicate the start of deterioration of oil quality and generally precedes the increase in acidity.

4.6.6. Dielectric Dissipation Factor (DDF) and Resistivity

The DDF shows how AC field stress affects the oil, while resistivity is a measure of the charge carrying capacity of the oil under DC conditions. The DDF & Resistivity are sensitive to contamination by colloids (emulsions & free-floating particles), aging products and soluble polar & ionisable contaminates. The resistivity is also affected by moisture in oil and oxidation. The allowed limits of DDF and resistivity vary depending on the application and transformer but generally a high DDF and /or low resistivity would imply a low oil insulation resistance and a deterioration of oil quality.

4.6.7. Breakdown Voltage (BDV)

The Breakdown Voltage indicates the ability of oil to serve as an electrical insulator and is sensitive to the presence of contaminants. The BDV is reduced significantly in areas of high electrical stress because these areas attract free water and solid particles. Whilst a low BDV value is a good indicator of the presence of contaminants, oil with a high value can also have contaminates and so this test needs to be reviewed at least with the moisture content value.

4.6.8. Gassing Tendency

Gas is formed in the oil regardless of whether the transformer has a fault or not. Some gas is produced when a transformer is in service but has no fault, this is all due to the electrical field stresses, the operating temperatures and the rate of oxidation. When the oil is exposed to a partial discharge, some oil molecules will break and form hydrogen and methane which can then dissolve in the oil or form new stable molecules. The oil's properties, in this respect, can be tested using gassing tendency tests and information concerning the oil behaviour in service can be obtained.

Negative Gassing tendency (gas absorbing) oils tend to mask or hide the fault indicating gasses and therefore a developing fault may not be detected until it causes a serious problem. Therefore, gas absorbing oils should be avoided where possible. Testing methods for gas absorption are: ASTM Method D3300 (Procedure B) and IEC60628. Currently the oils used in the Snowy Hydro are not gas absorbing.

Stray gassing is a phenomenon that occurs at times and the reason for stray gas generation is not well known. Stray gas formation is not seen as a real problem. The gases generated are generally hydrogen, methane, ethane, carbon dioxide and carbon monoxide. Oils that have less likelihood of forming stray gases are inhibited oils where oxidation stability is high. A noted pattern of stray gassing is that after initial increase a stable level is reached, however this time period and gas level varies greatly.

4.6.9. Corrosive Sulfur

Corrosive Sulfur (CIGRE test) – there are no limits only a positive or negative detection for any corrosive sulphur.

All mineral oils have sulphur components however, some sulphur containing compounds in the oils are active in the oxidation process in that they stop the process by reacting with peroxides and break the oxidation chain reaction. Oil suppliers design the oils with two conflicting things in mind: good oxidation stability based on natural components versus a low interaction with copper and silver materials in the transformer. The majority of newer oils today comply with testing for corrosive sulphur and should not be an issue. The standard tests are in line with IEC 62535 and ASTM D 1275B. There are a number of risk areas which need to be considered with regard to activate corrosive sulphur. An evaluation of the risk category of the equipment needs to be performed to assess vulnerability to active corrosive sulphur. That is, where the transformer is subject to high working temperatures from load/ambient, has high voltage stresses, has non-varnished conductors & extremely low oxygen concentration in the oil. By regenerating the old oils the inhibitors are stripped out and oxidation stability is reduced therefore the probability of corrosive sulphur activity is greater.

If a positive corrosive result is obtained, then remedial actions can be taken. These include: Passivating the oil, possibly some reclamation of the oil & even changing the oil to a non-corrosive oil. Nonetheless, once the damage has been done the process can only be slowed or nearly halted by these actions. The process cannot be reversed.

4.6.10. Inhibitor

IEC 60666 provides details of inhibitors tests for inhibitor concentrations. Inhibitors help reduce the effects of oxidation in the oil. The most common inhibitor is DBPC and usually is supplied in a white powder form. It is to be dissolved in transformer oil at a concentration level of 10% at low temperature levels. The inhibitor needs to be mixed separately to the transformer and then introduced slowly. It must be circulated in the bulk of the transformer oil and therefore an oil circulation pump is required. Oil forced cooling can be used or an external oil pump as the case may be. Where oil has been regenerated inhibitors need to be added to the oil and monitored throughout the remaining life of the oil.

4.6.11. Oxidation Stability

IEC 61125 (method C) - Oxidation is the degradation of the oil at normal working conditions in the presence of oxygen. Oxidation stability refers to the transformer oil's ability to withstand oxidation. For oils in service, an oxidation stability test can provide information on the remaining ability of the oil to withstand oxidation. There is no direct correlation between oxidation stability and remnant life of the oil. Methods to reduce oxidation are to add inhibitors or the utilisation of conservator bags or nitrogen blankets to separate the oil from the atmosphere.

4.6.12. Particles

Particle contamination can affect the dielectric or BDV strength of the oil and they should be considered collectively and not individually. The Standards for the limits of particle count are generally based on new oil and not on in-service oil values. The level of particles in oil can increase with age as the cellulose insulation breaks down. Transformers with a voltage rating above 245kV should have a particle count test performed. The results should be trended with the BDV and any significant rate of rise addressed by filtering the oil.

As stated, the only “limits” for particle count in any standard is for new oil and so this should not be applied to aged oil. The correct method is to review the ratios of the particle sizes in the trends. That is, as the larger particles increase in numbers and the BDV is decreasing then action should be taken. If the Particle counts are relatively stable with a very low rate of rise then no action is required.

4.6.13. Polychlorinated Biphenyls (PCB)

In the past cross contamination of mineral oils with PCB's was widespread due to the re-use of common oil treatment plant. New transformers should be tested to ensure that it is PCB free and the oil should be tested after any treatment or after the use of any oil handling equipment. There are legislative requirements around handling, disposal and personal safety when dealing with PCB contaminated oils.

4.7. Correction Action for in Service Oil

There are two types of oil contamination and deterioration: physical and chemical and they each require different corrective actions. It should be noted that before any corrective action is taken the oil test results should be verified. A simple “one off” test is not a good indicator upon which to base corrective actions and so trends or repeated tests should be used to confirm the results.

It is also advisable that any change of state should be monitored for the rate of change thereby allowing for a planned course of action.

4.7.1. Action guidelines

Corrective actions should be based on guidelines provided in IEC 60244 and SD Myers TMG. When a test result is outside the limits given in the Tables in this Section 5, it should be compared with previous results and with other parameters. A fresh sample must be obtained for confirmation before any other action is taken.

Caution should be used when reclaiming transformer oils. The reclaimed oil will require an oxidation inhibitor and these levels need to be monitored yearly. There is also some evidence (though not conclusive) that there is a link between reclaimed and regenerated oil and active corrosive sulphur at voltage levels above 145kV and so a passivator may be necessary to reduce the risk..

4.7.2. Acid Number

Reclaim or replace the oil. If sludging is suspected, a hot oil clean (reclamation) of the transformer or replacement of the oil if economical to do so.

NOTE: All reclaimed oils require the addition of an oxidation inhibitor before reuse.

4.7.3. Interfacial Tension

Reclaim or replace the oil. If sludging is suspected, a hot oil clean (reclamation) of the transformer or replacement of the oil if economical to do so.

NOTE: All reclaimed oils require the addition of an oxidation inhibitor before reuse.

4.7.4. Dielectric Breakdown

Investigate cause and if necessary recondition the oil using a suitable vacuum filtration and moisture extraction process.

4.7.5. Colour and Appearance

Investigate cause. Appropriate action as dictated by other causes, a change in colour is often triggered by other chemical and aging related causes.

4.7.6. Liquid DDF

Investigate trends. Appropriate action as dictated by other causes.

4.7.7. Water content

Consideration should be given to the use of on-line moisture extraction units. As the transformer heats up moisture migrates into the oil. By filtering the oil through an on line extraction unit the total relative saturation level can be reduced. This is a slower process and less intrusive. It also allows the extraction of moisture from the windings over a period of time. Ideally the extraction should be done over a 3 to 6 month period and then the unit allowed to return to equilibrium over a 1 month period. If needed the process can be repeated until the moisture is at a reasonably acceptable level.

4.7.8. Particle count

If breakdown voltage and water content are near or outside the limit and the particle number is higher than the limits, then filter the oil. The larger particle sizes should be extracted but a filter paper sized for the greater volume of particles is required.

4.7.9. PCB

If PCB content approached the scheduled contamination limit (50ppm) the oil should be replaced with PCB free oil. All PCB contaminated oils must be disposed of according to regulatory requirements.

4.7.10. Corrosive Sulfur

Critical transformers should be treated with a passivator so that the oil passes the CIGRE A2.32.01 corrosive sulfur test. It should be noted that the passivator does not reverse the process of corrosion it will only slow it and so depending on the level of corrosive sulfur a replacement strategy is required.

4.8. Interpreting Moisture Results

4.8.1. Water Solubility, Absolute Water Content, Relative Saturation

The solubility of water in oil (water solubility) depends on the condition of the oil, the temperature and the type of oil. The absolute water content (Wabs) – given in ppm – is independent of these factors. The relative water content (Relative saturation) is defined by the ratio Wabs/ water solubility, and is generally given as a percentage. Water solubility should be determined at the same temperature as the oil sample when it was taken.

4.8.2. Water content in the oil/paper system

In transformers the total volume of water is distributed between the oil and the cellulose (solid insulation), with the bulk of the water in the cellulose. Moisture in oil can be used to estimate moisture content of the solid insulation, however the interpretation should be used with caution as it is based on a number of assumptions, that may not be applicable – in particular the assumption of thermodynamic equilibrium conditions between oil and cellulose. IEC 60422 Annex A provides a guide to the condition of cellulose insulation based on oil percent saturation.

Note: These levels should always be referred to a constant temperature or the levels will be misunderstood. An example is: 10% saturation in oil at 65C may be acceptable whereas 10% at 20C will mean the paper is very wet. This is all due to the migration of moisture away from the paper as the temperature increases and conversely back into the paper as the temperature decreases.

% Saturation water in oil	Condition of cellulose insulation
0% to 5%	Dry insulation
6% to 20%	Moderately wet, low numbers indicate fairly dry to moderate levels of water in the insulation. Values toward the upper limit indicate moderately wet insulation.
21% to 30%	Wet insulation
> 30%	Extremely wet insulation

Source: IEEE C57.106:2002

4.8.3. Effect of water on insulation

Water content in oil and cellulose shortens the life of the insulation and reduces the dielectric strength (breakdown voltage). As a guide, every 1% increase in moisture content of paper, halves remaining life (using 0.5% as a reference). The water increases oxidation and hence the paper degradation. The water content can be managed by the use of conservator bags and by repairing any leaks in the transformer. Both of these help to prevent water entering through free breathing equipment or poor gaskets.

4.8.4. Immediate dielectric failure (IEEE Std 62-1995)

If the moisture in the oil is higher than the desired relative saturation and the transformer is cooled rapidly, then some of the dissolved water can come out of solution as droplets of free water. If these droplets form in areas of high electrical stress, this can cause a dielectric failure. The moisture saturation must not approach 30%

saturation at the lowest temperature that the transformer is exposed to as this presents a high risk of the formation of free water.

4.8.5. Dissolved Gas Analysis (DGA)

Interpretation of DGA results should be as per IEC 60599 (2007). The Duval Triangle method is a preferred method because of its simplicity and reliability of diagnosis, however the method will always give a result for a fault diagnosis and should be reviewed with respect to the level of gas generation. That is, the ratios of the Duval triangle gases have an impact and so small volumes can have the same ratio as large volumes of the same gases and the result will say the same thing. Therefore the result must be read in respect to the total gas volumes being generated.

4.8.6. Response to abnormal DGA result

Any abnormally high oil sample results should immediately be resampled to confirm the result. For additional confirmation, send the sample to a separate, oil test laboratory as well as the contracted oil laboratory. When using an alternate laboratory, ensure that their test procedures are known and that they have a NATA certified test laboratory.

If arcing is indicated in the initial sample, the equipment should be immediately taken out of service while the sample verification is being undertaken.

Upon confirmation of the result, response action should take into account historical levels and trends as well as rates of gas production. Guidance on each of these issues is provided in IEC 60599 (2007).

Action should be undertaken with reference to the recommendations for the oil test laboratory and only with proper engineering judgement.

Warning: There are many documented cases where the test results are abnormal due to the test laboratory errors. Generally, this is observed by one or more gases or physical result being well out of range without other gases or properties being affected. In such cases the laboratory should recalibrate their equipment and repeat the testing.

4.8.7. Total Dissolved Gas (TDG)

Oil that has too high total dissolved gas content is at risk of forming gas bubbles in the oil. These gas bubbles may cause immediate dielectric breakdown if they move into areas of high electrical stress. If the transformer is actively producing combustible gases, the source of the gas generation needs to be identified first and repaired if possible. Once the repairs are completed then the oil should be filtered and de-gassed and a new samples taken at 1 week and again at 1 month after re-energisation to ensure the levels are remaining consistent, the problem is resolved and establish a new baseline.

4.9. Furans

Testing for concentrations of furanic compounds in the oil will help determine the overall degradation for the cellulose within the apparatus being sampled. Furans are mainly generated from normal paper aging processes and accelerated by the overheating of the paper insulation. Furans are removed from the oil by reconditioning processes. Therefore if a transformer has had an oil change out, furans cannot be used to estimate remaining life using Degree of Polymerisation (DP) correlations.

DP testing is used as a measure of the degradation of paper insulation in transformers. DP is the average number of glucose molecules making the cellulose chains. The DP value decreases as the cellulose molecules break and fragment. The rate of deterioration is very dependent on temperature. There is a direct correlation between DP and tensile strength of the paper. It is generally accepted that paper with DP of 200 has reached its end of life due to its loss of tensile strength.

Guidelines for interpretation of furans and direct relationship to the DP are yet to be universally adopted. However S.D Myers Transformer Maintenance Guide provides some recommendations. In general:

0 to 20 ppb (parts per billion) total furans –new transformer

21 to 100 ppb – AC, this represents normal aging

101 to 250 ppb – QU, this represents probable accelerated aging

>250 ppb – UN, this represents significant accelerated aging.

Levels over 1000 ppb represent serious irreversible damage. For transformers that have aged gradually without hot spots, end of life is 2800 ppb.

4.10. Oil Sampling Methods

Oil sampling technique is a major source of errors in the oil analysis, particularly with respect to moisture and dissolved gases. Oil samples should be taken by trained, experienced personnel only, according to the prescribed procedure given in Technical Instruction TI-0012

In addition an oil sampling tutorial video is available via Youtube at
https://www.youtube.com/watch?v=efmUxF_dcro

4.11. PCB Contamination

PCB concentration (mg/kg)	Classification
> 50	Scheduled PCB material
> 2 and < 50	Non-scheduled PCB material
< 2	PCB-free

In general, non-scheduled PCB material can be used until the end of its useful life. At that time, the PCB material must be disposed of using an approved process. Scheduled PCB contaminated material is not allowed to be re-used and must be disposed of in an approved manner.

Always seek advice from the Environment group in relation to specific instances of PCB contamination.

Oil reconditioning and transformer maintenance work is permitted, provided the activity does not increase the concentration of PCBs (e.g by cross contamination) and appropriate personal health and safety measures are taken.

Oil reclamation and PCB decontamination work - This type of work requires a process approved in writing by the DECC. Currently Snowy Hydro does not have approval to process non-scheduled PCB material.

For assets that are recently tested and are classified as non-scheduled PCB material, transformer works may proceed once a documented process is developed and approval from DECC is received.

The CGS procedure SP24-24 describes the process for storage, transport and disposal of PCB contaminated waste.

4.12. Handling and Storage

All oils need to be managed in a safe manner for prevention of personal and environmental risks. Oil suppliers provide material safety data sheets (MSDS) that contain instructions on how to safely handle the oils. As not all oils are the same, methods of handling the oil may vary and it is highly recommended that the manufacturer's guidelines are followed as closely.

5. References

SHL library Call. 621.314 MYE	A guide to transformer maintenance /; by S.D. Myers, J.J. Kelly, R.H. Parrish.
Instruction	Ellipse Technical Instruction TI-0012.
Procedure	SP24-24 Storage, Transport and Disposal of PCB Contaminated Waste