Snowy Technical Standards	
SHL-ELE-521	***Power Transformer Oil Filling***
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1. Executive Summary

This standard sets out the requirements and establishes the procedure and documents used by Project and Maintenance personnel to control all aspects of Transformer Oil Filling.

2. Scope

- This Standard defines the process for oil filling transformers excluding oil top up.
- These requirements apply to all Snowy Hydro power transformers.

This work instruction is relevant to Project and Maintenance staff and the Transformers that they are required to fill with oil. The scope of this document includes full oil filling process, which is applicable for Transformers. Whilst the document primarily applies to mineral oils, the principles apply equally to filling transformers with ester fluids (vegetable oils).

2.1. Applicable Standards

IEC 60422	Mineral insulating oils in electrical equipment – Supervision and maintenance guide. AS60422-2017 & IEC 60422:2013
IEC 60156	Insulating Liquids – determination of the breakdown voltage at power frequency – test Method
IEC 60296	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear

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 above 72.5 kV
Small Transformers	Power transformers with a system highest voltage up to 72.5 kV

4. Technical Requirements

4.1. Safety

Prior to work commencing a Work Method Statement (WMS) plan must be completed as detailed in QP25-16 Operational Risk Management.

4.2. Environmental

There is a significant aspect or impact associated with transformers. These units contain a large volume of transformer oil and would pose a significant threat to the environment if a leak or spill were to occur. Therefore, the methods for sampling and handling of the oil are paramount in preventing any incidents.

4.3. Transformer Oil Filling Procedure

This method is applicable for new transformers and also refilling existing transformer after major work where a transformer has a large volume of oil removed.

All new oil added to power transformers must comply with the international Standard: IEC 60296 Fluids for Electrotechnical Applications – Unused mineral insulating oils for transformers and switchgear.

The test limits of the new oil before it can be added to the transformer must comply with Table 1 in Section 4.4.4 of SHL-ELE-520.

4.4. Site Delivery of Oil

- For oil quantities greater than 1,000 Litres, acceptance testing must be performed to the criteria in Table 1 in Section 4.4.4 of SHL-ELE-520 by Snowy Hydro preferred oil test laboratory before the oil is unloaded.
- For oil quantity less than 1,000 Litres manufactures 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 above criteria by a Snowy Hydro preferred oil test laboratory before the oil is unloaded.

4.5. Transformer Oil Filling

General principals:

- A danger always exists that bubbles will become trapped in the winding; and with high voltage applied to the transformer, high electrical stress could be placed on the insulation around a gas bubble causing partial discharge, and tracking may occur.
- Vacuum filling procedures and standing time after filling are important measures to minimise the risk of air bubbles being trapped in the transformer insulation system.
- Filling (or adding any quantity) of oil into large power transformers must always be done through an appropriately rated filter and vacuum oil treatment plant.
- In General, large power transformers are always to be filled under full vacuum.

- In addition, whenever the oil level has been lowered below the level of the top of the core and coil insulation, the transformer is to be completely drained of oil followed by dry gas. A full vacuum refill process is then required.

- Most large power transformers will have the tank braced to be able to withstand full (100%) vacuum. However, always check the manufacturer's manual and nameplate to confirm vacuum withstand capability of transformer tank and accessories.

4.6. Transformer Leak Test Prior to Filling

Prior to vacuum filling the tank and fittings need to bel be thoroughly checked for leaks. Leakage into high vacuum can introduce harmful amounts of moisture.

Pressure test the entire assembly, at a positive gauge pressure of 20-25 kPa, and examine carefully for leaks using soap solution. If bubbles appear then the gasket is not sealing correctly.

The duration of this test should be at least 60 minutes or the time taken to check all gaskets with soapy water whichever is the greater.

After the positive pressure test, a vacuum of 50kPa absolute pressure should be applied for the vacuum leak test. During this test, with all valves closed, measure the rate of rise of tank pressure over 30 minutes that is, measure the loss of vacuum during the 30 minutes.

An acceptable value for the leak rate is less than 3kPa over the 30minute period. If this value is exceeded, the tank should be rechecked by an additional pressure test for leaks.

Warning: During this procedure the transformer pressure relief device/s (Qualitrol) must be secured. This device is NOT suited to vacuum pressures and can be damaged if not protected. Consult the OEM manual for instructions on how this must be done.

4.7. Vacuum Filling Procedure

After completion of the pressure and vacuum leak tests, the transformer shall then be evacuated to a pressure of 133 Pa or lower, and this pressure is to be kept for at least 4 hours plus one additional hour for each hour the internals of the unit were exposed to atmosphere before the oil filling may commence.

Some transformers are not able to cope with full vacuum without special bracing therefore, in all cases, refer to the transformer original equipment manufacturer (OEM) manual for oil filling procedures. If this is not available, the following procedure can be applied, with approval from the Transformer asset engineer.

- After the transformer erection or re-assembly process is complete the transformer is to have a vacuum pulled on it and then filled with transformer oil. The oil will be pumped into the transformer under vacuum and an oil filtering machine used to ensure the quality of the oil.

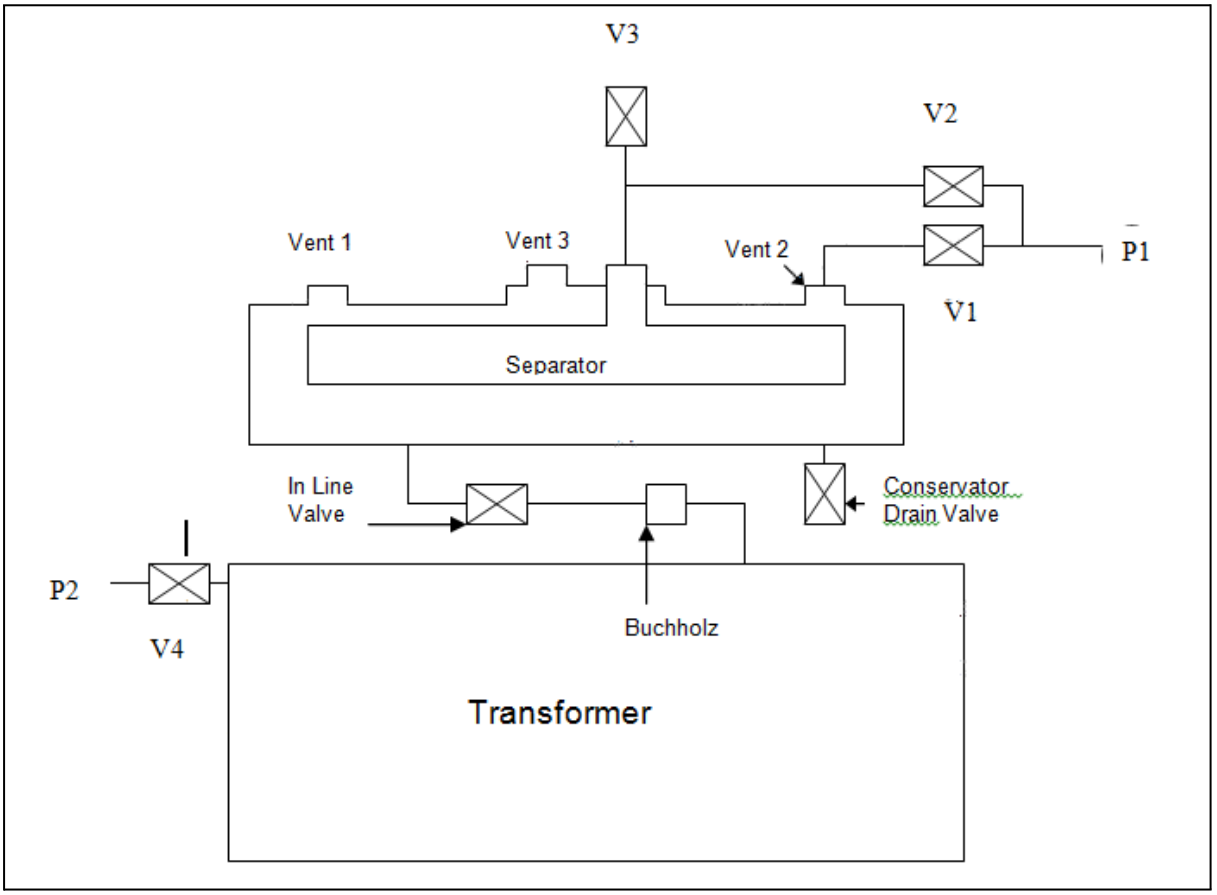
- Sequence for pulling a vacuum and filling Transformer. Referencing to **Figure 1** below

    - Ensure all pressure relief devices are secured for vacuum
    - Equalise pressure between main conservator and OLTC conservator.
    - Open all inline valves (Heat exchangers, pumps, conservator etc)
    - All external valves & vent holes must be closed.
    - Close valves (V1 & V2).
    - Open valve (V2) connected to vacuum pump (P1).
    - Start vacuum in separator to approx. 0.5 kPa absolute.
    - Open valve (V1) and vacuum the tank and conservator to approx. 0.5 kPa absolute.
    - Take an oil sample from bulk oil supply for dielectric and resistive tests for satisfactory results.
    - Connect oil transfer pump (P2) to valve (V4). Open valve (V4) and continuously fill oil up to 15-degree mark on oil gauge.

- Switch off oil pump (P2). Close valve (V4).
- Switch off vacuum pump (P1).
- Close valve (V1).
- Open valve (V3) to allow air inlet to separator to equalise to atmospheric pressure.
- Disconnect valves (V1, V2, V3) and pump (P1).
- Disconnect equaliser connection between the main & OLTC conservators.
- Open vents 1, 2 & 3 on top of main conservator.
- Open valve (V4) and push oil under light pressure into conservator and allow oil to overflow through vent holes 1 & 2.
- Close vents holes 1 & 2 and allow a small amount of oil to overflow through vent 3 to ensure the conservator oil is to the correct level without air pockets.
- Now stop oil filling & close valve (V4).
- Close vent 3.
- Connect breather to separator.
- Drain oil through conservator drain valve until oil gauge shows expected filling level.
- Close drain valve.

NOTE:

- Never open any vent holes once the conservator is filled with oil.
- Never pressurise separator with more than 110 kPa absolute.



P1 = Vacuum Pump P2 = Oil Transfer Pump

FIGURE 1 – Vacuum Filling Diagram

Note: This diagram does not show an OLTC conservator, If fitted then an equaliser pipe connection should be made between the main conservator above and the OLTC conservator. Tee-Off connectors may be used at V1 or V2 to assist with this process.

4.8. Transformer Oil Filling Pre-Commission Checks

- After filling, an oil sample must be taken from the transformer and tested. (Dielectric strength kV and moisture content PPM). Refer to manufacturer's manual for minimum requirements.
- Check heat exchangers and Buchholz valves are in the open position.
- Bleed transformer at points stated in manual.
- Inspect all paintwork and repaint any damaged areas, if required.
- Check tightness of flange bolts and couplings – refer manufacturer's manual for torque settings.
- Check Transformer work site is cleared away of all tools and rubbish.
- Complete all necessary paperwork. For example, "Transformer Quality Verification Sheet AODOCS #.

4.9. Filling Procedure under Vacuum in a Conservator fitted with a Diaphragm

Refer to the transformer OEM manual. If this is not available, follow the following procedure.

The conservator, with its separator, being set up and plugged in above the transformer, is connected to its oil filling reserve by a pipe in its lower part.

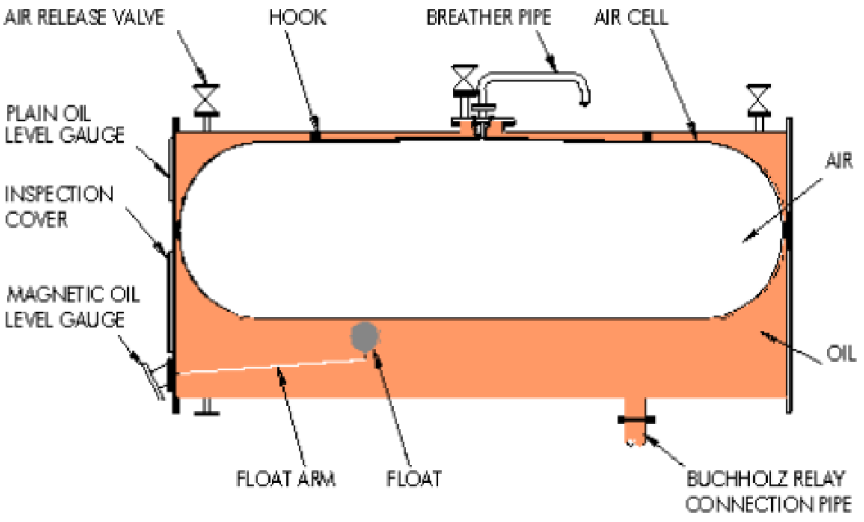


Diagram of Conservator with Diaphragm (Air Cell)

4.10. Proceed as follows:

- Create a vacuum in the Air Cell or Diaphragm.
- With the same source of vacuum, create a vacuum in the conservator.
- Open the oil filling valve of the transformer, this is done because with a vacuum in the conservator, the oil level will rise automatically.
- Stop the oil filling once the required volume in the conservator is attained.

- While maintaining the conservator under vacuum, allow Dry Air or Nitrogen gas to slowly enter into the internal part of the diaphragm. The diaphragm will inflate by itself, and will take all the free space as the conservator was not completely full. It should be noted that during the operation, the oil is going to rise to the top of the conservator.

- Inflate the separator to a maximum as shown on the INSTRUCTION PLATE that should be on the side of the transformer.

- Confirm that there is no more air in the conservator by gently opening the air-release valves to vent excess air and thereby adjusting the oil level. Check the OEM manual for the bleed device and bag rupture indicator device instructions to ensure they are correctly set.

Test Results

After the erection and oil filling of the transformer is complete and before the transformer is handed over for Commissioning, a Transformer Pre-Commissioning Test Sheet shall be completed. (copy given to project site manager) The completed form is to be retained in the project files and saved to AODocs at project completion.

4.11. Handling of Large Transformers

Always consult manufacturer's instruction manual.

Transformer must be fully assembled before the final oil treatment is done.

The oil in a transformer which has been standing oil filled, not in service, for 12 months or more shall be circulated using a vacuum oil treatment plant, for at least a sufficient time to pass the total quantity of oil in each tank or compartment through the treatment plant three (3) times.

The conservator shall never be drained through the main tank as this may introduce contamination into the main tank. Water or sludge may form in the bottom of the conservator and therefore, draining the conservator separately is a must.

When removing radiators, mark or number the exact location of each individually on the transformer, this includes the valves if fitted.

4.12. Handling of Small Transformers

For auxiliary transformers and large voltage transformers the same general principles shall apply as in the handling of larger transformers.

Before commissioning, the transformer oil shall be circulated for at least a period of four (4) hours using a vacuum oil treatment plant, and applying the allowable degree of vacuum to the main tank. Care must be taken to close off the conservator and replace the diaphragm of the explosion vent or PRD during the time vacuum is applied. Electrical strength and moisture tests must always be carried out before and after the filtering.

4.13. On Load Tap Changers

All diverter switch work/maintenance to be strictly in accordance with the manufacturer's recommendation. Empty any compartment oil into dirty oil drums as the oil is likely to have high concentrations of carbon and so should not normally be reused.

After work/maintenance completely hose down carefully all diverter switch parts and the interior of the compartment with clean oil which should be then drained into the dirty oil drums.

Fill/refill the compartment by pumping in from clean oil drums which have been filled and effectively sealed, preferably on the same day but at least with no more than 3 days intervening, from either the oil treatment plant or the central clean oil tank.

After allowing ½ hour for the oil to settle three (3) samples are taken and tested for electrical strength and moisture.

Bleed at all appropriate points.

It is desirable to follow up, within 24 hours of completion of work to bleed the Buchholz relay (if fitted) and check the oil levels.

The transformer should not be placed (back) in service until at least one (1) hour after completing the filling of the diverter switch compartment.

Any wiping down necessary on equipment or inside the compartment should only be done with good quality chamois, or cheesecloth which has been boiled to remove loose strands. Normal cloths should never be used as they leave lint fibres which can cause internal flashovers.

4.14. Taking Oil Samples

After oil filling and processing work has been completed on the transformers an oil sample shall be taken for testing. Where major work has been undertaken, a further sample may be required 1 week after the unit has been placed back in service or at least 1 month after the unit is in service. These samples are required to ensure there are no internal abnormal conditions and to reset the baseline for trending of future oil sampling and condition monitoring.

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