

Equipment Technical Specification

Regenerated mineral insulating oil

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EQUIPMENT TECHNICAL SPECIFICATION

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ETS 0029 – Regenerated mineral insulating oil

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1.0 PURPOSE

To set out in detail Endeavour Energy's requirements for processing and re-use of oil (regeneration) of insulating oil in power transformers installed in the network.

2.0 SCOPE

This specification covers the regeneration of insulating oil processed on-site by a service provider. The contractor shall regenerate insulating oil in order to meet Endeavour Energy's needs as they arise over the contract period.

The supplier to this specification and its subcontractors shall supply, deliver, offload and assemble all equipment required, re-generate oil and test all works to the nominated site, and remove all equipment following the finalisation of works at their own expense. The supplier shall pay all duty, freight, cartage and all other charges in the process. All network access, business hours, insurances, traffic control, stakeholder management, site access and duties require to safely meet these requirements are the arrangement responsibility of the supplier and shall be coordinated with Endeavour Energy as detailed in the general terms as part of any tender.

3.0 REFERENCES

- Company Policy 9.2.5 - Network Asset Design
- Company Procedure GPE 0075 - Storage, handling and transport of oil and oil-filled equipment
- Division Procedure GNV 1037 – Guide to on-site oil regeneration in power transformer
- Branch Procedure (System Operations) NCB 0642 – Protection withdrawal authority
- Branch Procedure (Primary Systems) PAE 1004 – Product Approval Process
- Branch form FAE 3210 – Regenerated mineral insulating oil - Product approval and audit form
- Environmental Management Standard EMS 0007 - Waste management
- Substation Maintenance Instruction SMI 121 - Storage and handling of insulating oil
- Network Management Plan December 2013 Review
- ENA National Electricity Network Safety Code (Doc 01-2008)
- *Building Code of Australia (BCA)*
- *Work Health and Safety Act 2011 (NSW)*
- AS/NZS ISO 9001 - Quality systems requirements
- ASTM D1500-12 : Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
- ASTM D5837-12 - Standard Test Method for Furanic Compounds in Electrical Insulating Liquids by High-Performance Liquid Chromatography (HPLC)
- ASTM D971-12 - Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
- IEEE C57.106:2002 - IEEE guide for acceptance and maintenance of insulation oil in equipment
- IEC 60156:1995 - Insulating liquids - Determination of the breakdown voltage at power frequency - Test method
- IEC 60247:2004 - Insulating liquids - Measurement of relative permittivity, dielectric dissipation factor (tan d) and d.c. resistivity
- IEC 60296:2012 - Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
- IEC 60666:2010 - Detection and determination of specified additives in mineral insulating oils
- IEC 60814:1997 - Insulating liquids - Oil-impregnated paper and pressboard - Determination of water by automatic colourimetric Karl Fischer titration

- IEC 61125:1992 - Unused hydrocarbon based insulating liquids - Test methods for evaluating the oxidation stability
- IEC 61198:1993 - Mineral insulating oils - Methods for the determination of 2-furfural and related compounds
- IEC 61620:1998 - Insulating liquids - Determination of the dielectric dissipation factor by measurement of the conductance and capacitance - Test method
- IEC 62021-2:2007 - Insulating liquids - Determination of acidity - Part 2: Colourimetric titration

4.0 DEFINITIONS AND ABBREVIATIONS

Adsorption	A process in which one substance attracts and holds the other substance persistently to its surface area.
Activated Alumina (Bauxite)	Material that principally consists of hydrated aluminium oxide which is activated by thermal treatment.
Additive	A suitable substance that is deliberately added to an insulating liquid, in small proportions, in order to improve certain characteristics.
DBPC	Inhibitor used as an anti-oxidation for 2,6-ditertiarybutyl-para-cresol.
DDF	Dielectric dissipation factor
Inhibited oil	A mineral insulating oil that contains an anti-oxidant (inhibitor additive).
Inhibitor	Antioxidant additive of the phenolic- or amine- type, such as DBPC and DBP as 2,6-ditertiarybutyl-para-cresol, or 2, 6-ditertiary-butyl phenol, or both, are sometimes added to petroleum insulating oil to improve its oxidation stability.
Neutralisation value	A measure of the acidic constituents or contaminants in the oil.
Passivator	Metal passivator additive used primarily as electrostatic charging depressant, but which may also improve oxidation stability
Water content	A measure of the quantity of moisture dissolved in insulating oil.
Volatile acidity	A measure of acidic materials released from the oxidising oil in to the gas stream over the time of the oxidation test. It is used as a measure of the oxidation process.
Induction period	The time taken (to the nearest hour) for a test oil sample to develop a volatile acidity corresponding to a neutralisation value in mg KOH/g oil.

5.0 ACTIONS

5.1 Specific requirements

5.1.1 Suitability of regenerated insulating oil

Endeavour Energy's requirements include the regeneration of old insulating oil in power transformers installed in the network to acceptable physical and electrical values set out in this specification. The regeneration process shall not introduce any carcinogenic substances in the insulating oil.

The regeneration process shall include addition of anti-oxidant and metal passivator additives such as inhibitor and metal passivator respectively. The inhibitor used shall be DBPC (2, 6-di-tert-butyl-p-cresol) and the passivator additive used shall be Nypass (N-N-bis(2ethylexyl)-4-methyl-1Hbenzotriazole-1-methylamine) or Igramet 39 (1H-Benzotriazole-1-methanamine, N,N-bis(2-ethylhexyl)-ar-methyl-) or equivalent alternative as approved by the Network Substations Manager.

The supplier to this specification will receive electrical and physical details of the mineral insulating oil proposed for regeneration. The oil regeneration process shall continue until the physical, chemical and electrical properties of this specification are met. If the supplier to this specification based on experience cannot achieve these limits, this shall be stated in writing with the limits that can be achieved prior to beginning the re-generation process for approval by the Network Substations Manager on a site-by-site basis.

5.1.2 Oil regenerating plant

The contractor shall be responsible to transport an oil regenerating plant to carry out the regeneration process on a power transformer nominated by Endeavour Energy.

The regenerating plant shall be in excellent working condition. The noise generated from the plant in substations shall comply with the provisions of the Building Code of Australia and NSW Department of Environment and Climate Change (DECC) environmental protection manual. At site, the contractor shall be responsible for managing acoustic noise throughout the course of the regeneration process.

The contractor shall be responsible for any oil spill containment and environmental measures for management.

5.1.3 Preparation for the oil regeneration process

The oil regeneration process is usually carried out on-line. Endeavour Energy will provide information to the contractor if a power transformer requires off-line oil regeneration.

All parts of plant and equipment used in the oil processing system require temporary bunding if not contained or fitted within the transformer's bund. Temporary bunds must be erected around all hoses connecting to the transformer. All hoses used must be clean, robust and in good working condition for the duration of the test.

Power transformers shall be taken out of service for preparation. Works such as repair of minor oil leaks, connection and disconnection of hoses and Buchholz relay stability check shall be made during the outage.

The Buchholz relay shall be operational (trip and alarm functions) at all times during the regeneration process. In situations where the pumps motors are not fitted with appropriate soft-starters, the trip function of the Buchholz relay may be de-activated only for the duration when the pumps are starting or stopping. Relay stability checks shall be performed to ensure spurious tripping is avoided.

All oil-regeneration works shall be performed after informing the Senior System Operator and any approval to take protection out of service at any time of the on-line works shall be done in accordance with Branch Procedure NCB 0642 – Protection withdrawal authority.

5.1.4 Safety measures and precautions

As a minimum, the following safety measures and precautions must be incorporated for the oil regeneration on energised transformers:

- Using fit for purpose equipment.
- Employing competent workers' (provided by the contractor).
- Safeguarding against possible gas or air bubble formation in the transformer through proper use of a gas trap and vacuum de-gasification.
- A properly designed system that minimises stirred-up contamination in the transformer due to movement of particulate matter and chemical contaminants that will reduce the dielectric strength.

- At all times a spill kit must be kept for emergency oil spill purposes. A spill kit with a minimum of 100 litre absorbing capability is recommended.
- The processing must use loss of oil alarms, along with immediate shutdown of the systems. Automatic emergency shutting solenoid valves for loss of oil must be incorporated in the systems. The processes require round the clock supervision (24 hours a day for the whole duration) to ensure no oil leakage.
- Safeguarding against possible oil leaks during the process (a significant drop in the main tank oil level may expose energised parts and lead to a flashover and failure).
- Inspection/checking of presence of any free water at the bottom of transformer main tank. Slowly drain the free water.
- Processing plants used in on-site on-line regeneration shall be equipped with the appropriate gas trap and vacuum degasification system; and
- The oil flow rates must not affect the protection of the transformer. The transformer protection must remain enabled during the process including the alarm function of the Buchholz relay. The rate of flow must be restricted to prevent damage to transformer and the relay.

The supplier under this specification shall provide all safety and environmental response plans to the Network Substations Manager prior to agreement under this specification.

5.1.5 Oil regeneration adsorbent material

Activated alumina or bauxite is the preferred adsorbent to be used in the oil regeneration process. Other clay materials shall need prior approval from Network Substations Manager.

5.1.6 Emergency automatic shut down

As a minimum, the oil regeneration system used must be equipped with automatic shutdown facilities, such as solenoid valves fitted at the outlet of the oil regenerating plant and at the outlet of the transformer that shuts the process for a loss of pressure (for example: a burst hose), and non-return valves connected at the inlet of the transformer and at the inlet of the oil regenerating plant.

5.1.7 Composite or double layer rubber oil hoses

The regenerating system must be equipped with leak proof multi-layer rubber hoses and end fittings to maintain a leak-free hose assembly. The hoses of assemblies must be inspected for damage or cracks prior to processing.

5.1.8 On-site safe monitoring

On-site monitoring of the plant shall include constant display of alarms, flow rate, pressures, temperature, litres processed and the like for supervision.

The site shall be continuously monitored and supervised round the clock during the oil regeneration processing. The site processing must never be left unattended and all safety requirements of the operation during regeneration must not be compromised.

5.1.9 Quantities of additives (inhibitor and passivator)

The following given quantities of inhibitor and passivator shall be added/circulated in the regenerated oil:

- DBPC inhibitor additive: concentrations of up to 0.4% by weight.
- NYPASS or equivalent passivator additive: concentrations in oil is 100 ppm (mg/kg).

5.1.10 The permissible limits for regenerated insulating oil

After completion of the regeneration process, including addition of inhibitor and passivator into the old insulating oil, the regenerated oil shall be tested for final acceptance. The insulating oil shall comply with the permissible limits set out in the following Tables 1 and 2:

Table 1 – Permissible limits of physical, chemical and electrical properties of insulating oil

Characteristic	Test method	Permissible limits
Physical and chemical properties		
Appearance ¹	IEC 60296	Clear free from sediments and suspended matter
Colour ²	ASTM D1500	≤ 1.5
Density @ 20 °C	ISO 4675	≤ 0.91 kg/dm ³
Flash point ¹	ISO 2719	≥ 140 °C
Viscosity @ 40 °C	ISO 3104	≤ 12 mm ² /s
Water content	IEC 60814	< 10 mg/kg (ppm)
Pour point	ISO 3016	≤ -30 °C
Neutralisation value	IEC 62021	< 0.01 mg KOH/g
Particulates removal 0.2 microns	-	successful
Synthetic anti-oxidant (DBPC) ¹ Wt%	IEC 60666	0.35% ± 0.05%
Interfacial tension ¹	ASTM D971	≥ 40 mN/m
Electrical properties		
Dielectric Dissipation Factor ¹ @ 90 deg. C and 40-60 Hz	IEC 60247	Max. 0.005 ≈ ≤ 5 mrad
Dielectric breakdown voltage ¹ (gap between electrodes 2.5 mm ± 0.05 mm)	IEC 60156	≥ 60 kV
Conductivity ³ @ 20° C	IEC 61620	< 0.9 pS/m

Oxidation stability tests

The regenerated insulating oil shall be tested and proven to satisfy the criteria given in Table 2:

¹ IEC 60296:2012 – Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear

² IEEE Std C57.106:2006 – IEEE guide for acceptance and maintenance of insulation oil in equipment

³ IEC 61620:1998 – Insulating liquids – Determination of the dielectric dissipation factor by measurement of the conductance and capacitance – Test method

Table 2 - Permissible limits of oxidation stability with inhibitor

Test duration 500hrs (refer Note 1)	Test method	Permissible limits for measured characteristics
Sludge after 500hrs	IEC 61125 Method C	Maximum 0.8%
Neutralisation value ⁵ after 500hrs	IEC 61125 Method C	Maximum 1.2 mg KOH/g
Dielectric dissipation factor after 500 hours @ 90° C	IEC 61125 Method C	Maximum 0.5

Endeavour Energy reserves the right to carry out further tests prior to accepting the oil.

The tenderer shall provide regenerated insulating oil that meets the above technical specifications.

Once all test results have been verified to be within acceptable limits the oil regeneration plant must be disconnected with all valves properly tightened and secured.

5.1.11 Test reports

The supplier shall provide a test certificate for each power transformer oil regeneration oil testing.

Test reports must be submitted to Network Substations Manager, Primary Systems to check and certify compliance with the Endeavour Energy specification.

Oil failing to meet the permissible limits shall not be accepted. The contractor shall be responsible for all additional cost associated with the removal/replacement of such non-complying oil with complying oil.

5.2 Standards

All equipment and substances shall comply with the requirements of this specification or appropriate current Australian or IEC Standards. Where this specification or the relative Australian standard or IEC standard conflict, the Endeavour Energy specification shall prevail.

5.3 Product approval

5.3.1 Product approval and audit forms

Complete information of the regenerated mineral insulating oil values shall be provided in technical schedules and guarantees as set out in Branch Form FAE 3210 - Regenerated mineral insulating oil - Product approval and audit form.

5.3.2 Product approval process

The regenerated mineral insulating oil values shall be evaluated under the product approval process as set out in Branch Procedure PAE 1004 – Product Approval Process, The Network Substations Manager, Primary Systems will approve these values.

6.0 AUTHORITIES AND RESPONSIBILITIES

The **Chief Engineer** has the authority and the responsibility for:

- approving technical specifications, including any variations;
- making all decisions concerning compliance in respect to this specification; and
- delegating any of these authorities and responsibilities to the Manager Primary Systems.

The **Manager Primary Systems** has the authority and responsibility for:

- reviewing technical specifications and making recommendations to the Chief Engineer; and
- making recommendations concerning compliance in respect to this specification.

The **Network Substations Manager** has the authority and responsibility for:

- updating this specification in line with industry best practice; and
- reviewing tests results and plans provided from the contractor.

The **Project Managers** have the authority and responsibility for certifying that on-site regeneration of insulating oil is in accordance with the requirements of this Specification.

The **Contractor or Supplier to this specification** has the authority and responsibility for:

- confirming awareness of their responsibilities under this specification;
- maintaining that staff under their control are competent for carrying out on-site oil regeneration processing;
- developing an effective safety, environmental and quality auditing system is in place;
- implementing this specification and keeping Endeavour Energy or other responsible equivalent officers informed of any factors that may prevent them from accepting responsibility for its full implementation; and
- providing test certificates and reports for oil regeneration process to Network Substations Manager, Primary Systems to check and verify compliance with the Endeavour Energy specification.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Substations Manager

Documentation process coordinator: Standards Process Coordinator