

Natural Ester Insulating Fluid

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<http://www.endeavourenergy.com.au/aspPortal/webengine/au/com/ee/asp/Standards/Standards>.

For any enquiries relating to the content of this document please contact the Standards Coordinator on 13 10 81.

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Contents

1. Purpose	4
2. Scope	4
3. References	4
4. Definitions and Abbreviations	6
5. Technical Requirements	7
5.1 Specific requirements	7
5.1.1 Suitability of insulating fluid	7
5.1.2 The permissible limits	7
5.1.3 Test certificates	9
5.2 Health, safety and environment (HSE) requirements	9
5.2.1 Special environmental requirements – toxicology safety	9
5.2.2 Safe working systems	10
5.2.3 Life-cycle assessment	10
5.3 Transportation	10
5.3.1 Documents and labelling	10
5.3.2 Transport, delivery and packaging	11
5.3.2.1 Drum delivery	11
5.3.2.2 1000 litre containers	11
5.3.2.3 Bulk delivery	11
5.4 Product approval and audit form	12
5.4.1 Product approval and audit form	12
5.4.2 Product approval process	12
5.4.3 Additional information	12
6. Authorities and Responsibilities	13

1. Purpose

To set out in detail Endeavour Energy's technical and physical requirements for the supply of new natural ester insulating fluid for use in specific transformers in Endeavour Energy's network.

2. Scope

This specification covers the supply and delivery of natural ester insulating fluid manufactured from vegetable crops. It includes supply of 205 litre drums, 1000 litre containers or bulk fluid to:

- Endeavour Energy's storage depots;
- Substations within Endeavour Energy's franchise area;
- Supply to transformer manufacturers' factories within Australia; or
- For collection from the contractor's Sydney bulk store.

The contractor shall supply insulating fluid in order to meet Endeavour Energy's needs as they arise over the contract period.

All supplied fluid shall be manufactured and tested to the standards with the year of publication listed below. Endeavour Energy will consider fluid to other recognised international standards provided the standards are at least equivalent to Australian and/or IEC standards referenced and as approved by the Asset Engineering Manager.

In some circumstances, based on local network experience, this specification is more stringent than that of the Australian and International standards; in this circumstance the requirements of this specification shall take precedence.

The tenderer should state any non-compliance with the specification in the tender submission and any alternative offers should be submitted in full and separately from the main offer. Any proposed variations from this specification shall be referred to the Asset Engineering Manager for approval prior to acceptance.

3. References

External Regulations		
Work Health and Safety Act 2011 (NSW)		
ENA National Electricity Network Safety Code (Doc 01-2008)		
Endeavour Energy Network Management Plan December 2013 Review		

External Standards		
Standard No.	Year	Title
AS/NZS ISO 9001	2024	Quality systems requirements
ASTM D1500	2024	Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

Natural Ester Insulating Fluid

ASTM D3300	2020	Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids under Impulse Conditions
ASTM D5837	2015(R2023)	Standard Test Method for Furanic Compounds in Electrical Insulating Liquids by High-Performance Liquid Chromatography (HPLC)
ASTM D971	2020	Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
IEEE C57.147	2018	IEEE guide for acceptance and maintenance of natural ester fluids in transformers
IEC 60156	2025	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 60628	1985	Gassing of insulating liquids under electrical stress and ionization
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 coulometric Karl Fischer titration
IEC 61125	2018	Insulating liquids - Test methods for oxidation stability - Test method for evaluating the oxidation stability of insulating liquids in the delivered state
IEC 61198	1993	Mineral insulating oils - Methods for the determination of 2-furfural and related compounds
IEC 61619	1997	Insulating liquids - Contamination by polychlorinated biphenyls (PCBs) - Method of determination by capillary column gas chromatography
IEC 61620	1998	Insulating liquids - Determination of the dielectric dissipation factor by measurement of the conductance and capacitance - Test method
IEC 62021-3	2014	Insulating liquids - Determination of acidity - Part 3: Tests for non-mineral insulating oil
IEC 62535	2008	Insulating liquids - Test method for detection of potentially corrosive sulphur in used and unused insulating oil
IEC 62697-1	2012	Test methods for quantitative determination of corrosive sulfur compounds in unused and used insulating liquids - Part 1: Test method for quantitative determination of dibenzylsulfide (DBDS)
IEC 62770	2024	Fluids for electrotechnical applications – Unused natural esters for transformers and similar electrical equipment
IEC 62975	2021	Natural esters - Guidelines for maintenance and use in electrical equipment
ISO 3675	1998	Crude petroleum and liquid petroleum products – Laboratory determination of density – Hydrometer method.
ISO 3104	2023	Petroleum products - Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity

Natural Ester Insulating Fluid

ISO 2592	2017	Determination of flash point and fire point – Cleveland open cup method
ISO 2719	2016	Determination of flash point - Pensky-Martens closed cup method
ISO 3016	2019	Petroleum products – Determination of pour point
AS 14025 (ISO 14025)	2017 (2006)	Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006, MOD)
ISO 14040	2019	Environmental management - Life cycle assessment - Principles and framework
ISO 14044	2019	Environmental management - Life cycle assessment - Requirements and guidelines
OECD 201	2011	OECD guidelines for testing of chemicals: Freshwater alga and cyanobacteria, growth inhibition test
OECD 203	2019	OECD guidelines for testing of chemicals: Fish, Acute Toxicity Test
OECD 301	1992	OECD guidelines for testing of chemicals: Ready biodegradability

Company Policies and Procedures

Company Policy 9.2.5	Network Asset Design
Company Procedure (Environment) GPE 0075	Storage, handling and transport of oil and oil-filled equipment
Branch Procedure PAE 1004	Product Approval Process
Branch Form FAE 3213	Natural ester insulating fluid – Product approval and audit form

Company Standards

Environmental Management Standard EMS 0007	Waste management
Substation Maintenance Instruction SMI 121	Storage and handling of insulating oil

4. Definitions and Abbreviations

Term	Definition
Additive	A suitable substance that is deliberately added to an insulating liquid, in small proportions, in order to improve certain characteristics
Natural Ester	Vegetable fluids obtained from seeds and fluids obtained from other suitable biological materials and comprised of triglycerides
Neutralisation value	A measure of the acidic constituents or contaminants in the fluid.

Natural Ester Insulating Fluid

Readily biodegradable	An arbitrary classification of chemicals which have passed certain specified screening tests for ultimate biodegradability; these tests are so stringent that it is assumed that such compounds will rapidly and completely biodegrade in aquatic environments under aerobic conditions.
Water content	A measure of the quantity of moisture dissolved in insulating fluid

5. Technical Requirements

5.1 Specific requirements

5.1.1 Suitability of insulating fluid

Endeavour Energy's requirements include the supply of natural ester insulating fluid manufactured from vegetable crops. Insulating fluid shall not contain any known or suspect carcinogenic substances.

The natural ester insulating fluid shall be suitable for use in transformers as an electrical insulating and cooling medium and to provide a means for condition assessment of network equipment (that is, dissolved gas analysis). Transformers are located in transmission, zone and distribution substations within Endeavour Energy's franchise area and have applied voltages 22kV and below. The natural ester insulating fluid shall be used in sealed distribution transformers only.

The manufacturer/supplier shall provide the type of vegetable used to manufacture and list the chemical composition of all the additives used.

Fluid supplied under the contract shall comply with all relevant requirements of IEC 62770 and this specification. In some circumstances based on local network experience, this specification is more stringent than the above standard, in this circumstance the requirements of this specification shall prevail. Any proposed variations from this specification should be referred to the Asset Engineering Manager for approval prior to acceptance.

5.1.2 The permissible limits Evert

The permissible limits for the natural ester insulating fluid, (as received from suppliers), shall be as shown in Table 1.

Table 1: Permissible limits of new natural ester insulating fluid (as received from manufacturer/supplier)

Property	Test Method	Permissible limits for measured characteristics
Physical and chemical properties		
Appearance	AS 60296	Clear, free from sediment and suspended matter
Colour	ASTM D1500	0.5
Density @ 20 °C	ISO 3675	≤ 1 kg/dm ³

Natural Ester Insulating Fluid

Viscosity: @ 40 °C @ 100 °C	ISO 3104	≤ 50 mm ² /s ≤ 15 mm ² /s
Water content	IEC 60814	≤100 mg/kg (ppm)
Soluble acidity	IEC 62021-3	< 0.06 mg KOH/g
Interfacial tension	ASTM D971	≥ 25 mN/m
Corrosive sulphur	IEC 62535	Not corrosive
DBDS content	IEC 62697-1	Not Detectable (< 5mg/kg)
Furan content (2-FAL) (2-furfural) and similar compounds such as 5M2F, 2ACF, 2FOL and 5H2F	IEC 61198/ASTM D5837	Not detectable (< 2 mg/kg)
PCB (polychlorinated biphenyls) content mg/kg	IEC 61619	Not detectable (< 2 mg/kg)
Oxidation stability (test duration 48 hours) a) Viscosity at 40 °C b) Neutralisation value (acidity) after 48 hours c) Dielectric dissipation factor after 48 hours @90 °C	IEC 61125 Method C	≤ 30% above initial value < 0.6 mg KOH/g Max 0.5
Gassing tendency	IEC 60628: Method A	Gas absorbing or gas evolving (to be specified by the supplier).
Total additives	IEC 60666	≤ weight fraction of 5%
Flash point	ISO 2719	≥ 250 °C
Fire point	ISO 2592	≥ 300 °C
Pour point	ISO 3016	≤ -10 °C
Biodegradation	OECD 301	Readily biodegradable
Toxicity	OECD 201-203	Non-toxic
Electrical properties		
Dielectric Dissipation Factor @ 90 deg. C and 40-60 Hz	IEC 60247	Max. 0.05
Dielectric breakdown voltage (gap between electrodes 2.5 mm ± 0.05 mm) – before / after treatment	IEC 60156	≥ 70 kV

Natural Ester Insulating Fluid

Impulse voltage (@ 25° C, 25.4mm gap)	ASTM D3300	≥130kV
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Endeavour Energy reserves the right to carry out further tests prior to accepting the fluid.

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

5.1.3 Test certificates

The supplier shall provide a test certificate for each delivery or collection. For bulk delivery, the certificate shall provide adequate proof of the quality of the fluid in the storage vessel immediately prior to departure from the supplier's site to Endeavour Energy.

In the case of drums/containers, the certificate shall provide adequate proof of the quality of the fluid in the drums/containers. Endeavour Energy reserves the right to independently test the fluid and reject the delivery if the fluid does not comply with Endeavour Energy's minimum requirements. As a minimum, the data provided in the certificate shall include:

- batch number;
- fluid filled date (for drums and containers);
- supplier's brand description;
- water content;
- neutralisation value;
- corrosive sulphur;
- Furan levels;
- PCB level;
- dielectric dissipation factor;
- breakdown voltage;
- impulse voltage;
- interfacial tension;
- density; and
- viscosity.

Test certificates must be provided to the Asset Engineering Manager to check and confirm compliance with the Endeavour Energy specification. Ester Fluid failing to meet the guaranteed values shall not be accepted. The contractor shall be responsible for all additional cost associated with the complete removal/replacement of such non-complying fluid with complying fluid.

5.2 Health, safety and environment (HSE) requirements

5.2.1 Special environmental requirements – toxicology safety

The supplier shall provide with the offer, full details, including composition and toxicological information, regarding the health and safety aspects of all the materials offered in their offer.

Natural Ester Insulating Fluid

Recommended procedures shall be provided for the safe handling, safe operation and maintenance of products supplied. Material safety data sheets (MSDS) shall be provided, with copies available on site, for materials that are supplied and subject to safety considerations in handling and use.

The means of disposal of the materials shall be clearly stated.

The insulating fluid, drums, containers, packaging and all other accessories provided shall be asbestos free.

The insulating fluid shall not contain any known or suspect carcinogenic substances.

The above information is required as part of the offer and will be reviewed as part of the tender process.

5.2.2 Safe working systems

Prior to any site work (where required), a comprehensive risk assessment of all hazards shall be carried out and mitigation measures identified and implemented. The work site hazard and risk assessment shall be provided to Endeavour Energy for approval 7 days prior to any commencement of work on site. Endeavour Energy reserves the right to specify additional mitigation measures, other than the mitigation methods specified by the supplier to determine that the work site hazards are controlled.

Works performed on or near Endeavour Energy's network shall be performed in accordance with Endeavour Energy's Electrical Safety Rules, Authorisations procedures and all relevant Safe Work Methods Statements (SWMS) and Safe Work Codes of Practice.

5.2.3 Life-cycle assessment

The supplier shall provide a Life Cycle Assessment (LCA) for the supplied fluid, covering life cycle stages from raw material extraction through to delivery to site (modules A1 to A4). The LCA must be conducted in accordance with ISO 14040 and ISO 14044.

Where available, the LCA should be presented in the form of a verified Environmental Product Declaration (EPD) developed in accordance with AS 14025. An EPD is a standardized and third-party verified summary of LCA results and is considered an acceptable format for meeting this requirement, provided it includes the relevant life cycle stages.

5.3 Transportation

The supplier to this specification is responsible for the transportation between a manufacturer's works and the site nominated by Endeavour Energy within Endeavour Energy's franchise area. The costs, risks and responsibilities for transportation are the responsibility of the supplier and shall be agreed prior to contract acceptance. This includes the responsibility for the load profile for each transport mode, transport route, the means of transport, any necessary route alteration, statutory approval or licenses, shipping reservations and documentation or any other requirement concerning the delivery of the insulating fluid to the nominated site.

5.3.1 Documents and labelling

All documents supplied shall be in English and in metric units unless otherwise requested.

In addition, the titles shall include the contract number.

Labels are to be highlighted in a contrasting colour and attached on the top and side of each container and drum. Text in the labelling shall be clearly legible, having a minimum text height of 10mm.

Each label shall include the supply company name, fluid identification code/name, type of fluid, fluid filled date, batch and contract number.

5.3.2 Transport, delivery and packaging

The contractor shall provide suitable storage for transport, clearly marked and deliver all components to the nominated location. The following shipping marks, approximately 75mm high, are to be clearly marked on all containers and packages:

- manufacturer's brand name;
- volume;
- mass;
- ENDEAVOUR ENERGY;
- CONTRACT NO.....; and
- CONTRACTOR'S NAME.

5.3.2.1 Drum delivery

Drums shall be suitable standard sized durable containers, as approved by Endeavour Energy.

Drums with significant damage will be rejected.

Drums shall be sealed with a screwed plug and crimped drum cap seal to make them waterproof and leak-proof.

The storage of drums shall comply to the requirement of section 5.3.1 of Substation Maintenance Instruction SMI 121.

5.3.2.2 1000 litre containers

1000 litre containers shall be suitable durable containers, as approved by Endeavour Energy.

Containers supplied with significant damage will be rejected.

Containers shall be sealed with a screwed plug and crimped cap seal to make them waterproof and leak-proof.

Nitrogen or other dry inert gas blanket shall be filled. Where the tank is sealed, the tank shall be capable of withstanding the positive and negative forces due to expansion and contraction of the fluid.

5.3.2.3 Bulk delivery

Bulk delivery shall be made in suitable containers as approved by Endeavour Energy. Containers dedicated to transport natural ester fluid are preferred.

All bulk containers shall be free of all contamination including traces of cleaning detergents, solvents, motor oil and moisture, prior to the introduction of new fluid.

Endeavour Energy will be responsible for the off-loading of bulk fluid into equipment or storage vessel (unless stated in the individual equipment contracts (eg transformer contract)).

The bulk container shall have Camlock fittings for the removal of fluid.

5.4 Product approval and audit form

5.4.1 Product approval and audit form

The tenderer shall complete information of the natural ester insulating fluid on the product approval and audit Branch Form (Primary Systems) FAE 3213 Natural ester insulating fluid – Product approval and audit form.

5.4.2 Product approval process

The insulating fluid shall be evaluated under the product approval process set out in Branch Procedure (Primary Systems) PAE 1004 – Product Approval Process. The Asset Engineering Manager will approve the insulating fluid for use in the network.

5.4.3 Additional information

The following information shall also be submitted:

- details of support and technical back-up facilities available;
- details of the history of use of the insulating fluid, including how much in service, where, and for what period, plus reference contact names and numbers; and
- documents on transportation, storage and handling of the insulating fluid.

6. Authorities and Responsibilities

Listed below are the positions or groups of positions that have specific authorities and responsibilities associated with this policy/procedure.

General Manager Future Grid and Asset Management has the authority and the responsibility for:

- approving major changes to this instruction in accordance with Table 4 of GAM 0001;
- making all decisions concerning compliance with this instruction
- delegating any of these authorities and responsibilities to the Head of Asset Management and Digital.

Head of Asset Management and Digital has the authority and responsibility for:

- approving minor changes to this instruction in accordance with Table 4 of GAM 0001;
- making recommendations to the General Manager Future Grid & Asset Management for major changes in respect to this instruction.

Asset Engineering Manager has the authority and responsibility for:

- reviewing this technical specification for suitability in Endeavour Energy's network;
- making recommendations to the Head of Asset Management and Digital based on industry best practice; and
- reviewing fluid supply compliance in respect to this specification.

All Endeavour Energy employees, project managers and purchasing officers have the authority and responsibility for:

- purchasing fluid that meets this specification from an approved source.

Manufacturers/suppliers have the authority and responsibility for:

- confirming awareness of their responsibilities under this specification;
- providing suitable training to contractor/s under their control to enable them to safely perform works to this specification;
- implementing an effective safety, environmental and quality auditing system;
- 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 a test certificate for fluid delivery to Asset Engineering Manager to check and verify compliance with the Endeavour Energy specification.

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