

# VG-100® Natural Ester Insulating Liquid for Transformers

Technical Information



# Technical Data Sheet

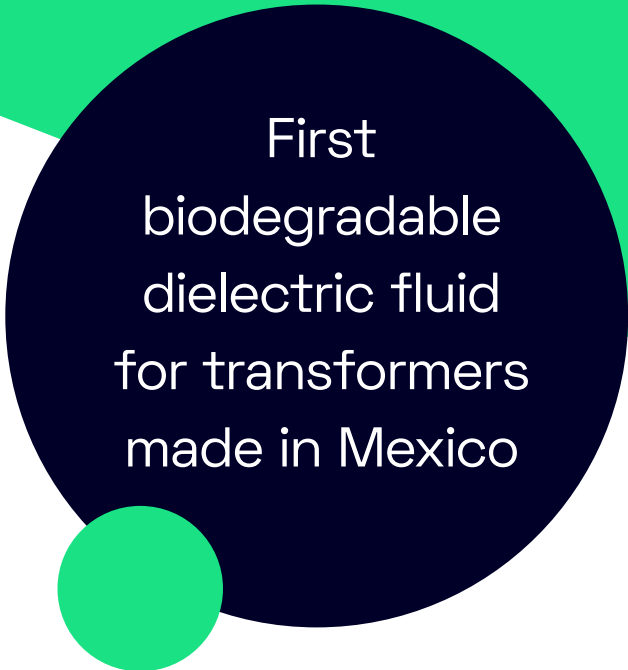
Table 1. Electrical, physical and chemical properties of VG-100® liquid

Properties	Test Method		Requirement		VG-100® <sup>3</sup>
	ASTM	ISO/IEC	ASTM D6871 <sup>1</sup>	IEC 62770 <sup>2</sup>	
<b>ELECTRICAL</b>					
Dielectric breakdown, kV 2mm	D1816	-	≥ 35	-	50-70
		IEC 60156		≥ 35	80-98
Dissipation factor % 25 °C	D924		≤ 0.2		0.05-0.16
	D924	-	≤ 4.0	-	0.29-3.6
		IEC 60247		≤ 0.05	0.011
<b>PHYSICAL</b>					
Color	D1500	ISO 2211	L1.0	-	L0.5
Appearance	visual inspection		bright & clear	bright & clear	bright & clear
Relative density at 15 °C, g/cm <sup>3</sup>	D1298	-	≤ 0.96	-	0.92
Viscosity, cSt 0 °C	D445	ISO 3104	≤ 500	-	180
	D445	ISO 3104	≤ 50	≤ 50	31-33
	D445	ISO 3104	≤ 15	≤ 15	7.4-8.2
Pour Point, °C	D97	ISO 3016	≤ -10	-	-19 to -24
Flash Point, °C	D92	ISO 2592	≥ 275	-	320-340
Fire Point, °C	D92	ISO 2592	≥ 30	-	350-360
<b>CHEMICAL AND ENVIRONMENTAL</b>					
Water content, mg/kg	D1533	IEC 60814	≤ 200	≤ 200	13-50
Acidity number, mg KOH/g	D974	IEC 62021.3	≤ 0.06	≤ 0.06	0.01-0.05
PCB content, mg/kg	D4059	-	not detectable	free from PCB	not detectable
Oxidation stability (48h, 120 °C)	-	IEC 61125-C	-	-	-
Total acidity, mg KOH/g	-	IEC 62021.3	-	≤ 0.6	≤ 0.5
Viscosity at 40 °C, cSt	-	ISO 3104	-	≤ 30%	< 20
Dissipation factor at 90 °C, %	-	IEC 60247	-	≤ 0.50	< 0.2
Corrosive sulfure	D1275		-	-	Non-corrosive
Biodegradability, OECD 301	-	-	Readily biodegradable	Readily biodegradable	Readily biodegradable

1. ASTM D6871. Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus.

2. IEC 62770. Fluids for electrotechnical applications-Unused natural esters liquids for transformers and similar electrical equipment.

3. The listed values are the average of several measurements and should not be considered as acceptance/rejection criteria. For more information, please contact Prolec GE at 1-800-437-7653



# First biodegradable dielectric fluid for transformers made in Mexico

## **Description**

VG-100® is a natural ester liquid (vegetable oil) derived from edible seeds, formulated using a proprietary process for use in electrical transformers– both new and retrofit. It was developed by Prolec GE in 2009 as an environmentally-friendly alternative to existing dielectric fluids. It's made from 100% soybean seeds and does not contain any synthetic antioxidant compounds.

## **Properties**

VG-100® liquid fulfills with international standards and requirements such as ASTM & IEEE. It is also certified by Factory Mutual (FM) and Underwriters Laboratories (UL). VG-100® liquid meets the requirements to be considered as a readily biodegradable and non-toxic substance by international laboratories.

## Storage & Handling

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To maintain the optimal properties of VG-100® liquid is important to take some precautions related to its storage and handling. VG-100® is classified as a less-flammable dielectric fluid by UL-340 and FM-6933 approval agencies, so its fire point overpass of 300 °C allows either indoor or outdoor storage.

VG-100® liquid can be delivered in sealed totes (drums) or tankers. As with mineral oil, and inspection should be done when the product is received, considering the acceptable values established in IEEE C57-147 Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers (Table 2). If the fluid does not meet the required specifications, please contact Prolec GE for further guidance.

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### **Storage considerations**

Drums/totes are shipped with a positive pressure dry nitrogen blanket to prevent fluid contamination by humidity or oxygen inside the container, or other solid or volatile materials.

New liquid should be stored in a dry location, protected from rain, direct sunlight, or high temperatures. When the liquid is received in bulk tankers, it must be degassed, filtered and dried (moisture extraction) to ensure optimal characteristics and benefits. If VG-100® liquid has been stored or received during cold weather, heating the containers may be necessary to decrease the its viscosity.

Storage in a heated warehouse could reduce the amount of heating needed, thus making it easier to pump the fluid into storage containers or to the transformer filling line. It is recommended that the containers be opened before heating to avoid unintended pressure build-up in the containers during this process.

Once opened, a container can be closed and resealed by first filling the headspace of the container with a blanket of dry nitrogen to prevent any contaminant and moisture entrance.

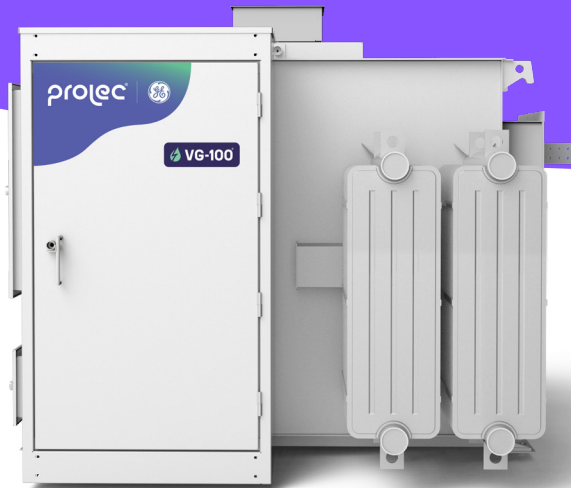


Table 2. IEEE C57.147 Acceptance values for receipt of shipments of natural esters

Properties	Test Method	Requirement	
		MIN	MAX
<b>ELECTRICAL</b>			
Dielectric breakdown, kV 2mm	D1816	≥ 35	-
Dissipation factor, % 25 °C	D924	-	≤ 0.2
Relative density at 15 °C, g/cm <sup>3</sup>	D1298	-	≤ 0.96
Water content, mg/kg	D1533	-	≤ 200
Acidity number, mgKOH/g	D974	-	≤ 0.06
Color	D1500	-	L1.0
Pour point, °C	D97	-	≤ -10
Flash point, °C	D92	≥ 275	-
Fire point, °C	D92	≥ 300	-
Viscosity, cSt	D445	-	≤ 500
			0 °C
			40 °C
100 °C	D445	-	≤ 15

Storage containers/tanks should be made preferably of stainless steel or steel coated with a compatible paint. The use of new and clean containers is highly recommended, making sure the containers are in good condition.

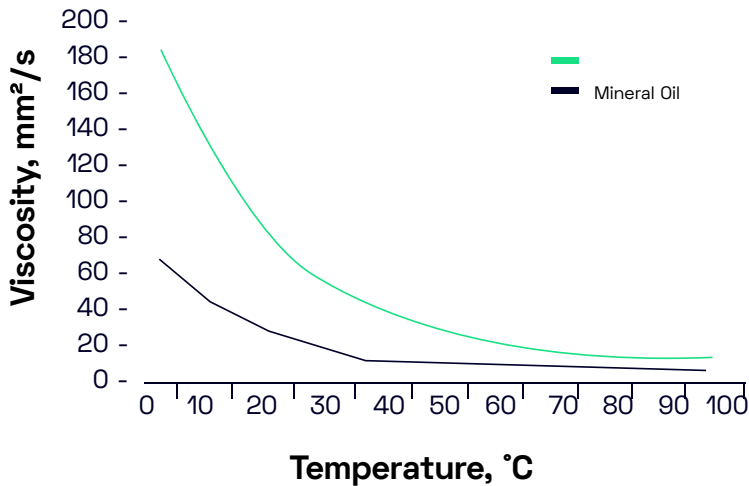


Figure 1. Viscosity behavior of VG-100® at different temperatures

**IMPORTANT**

Store the liquid in a dry location, protected from rain, direct sunlight, and high temperature to assure the optimal properties of the VG-100® liquid.

As indicated previously, it is recommended that the exposure time of the liquid to air and high temperatures be limited, since polymerization reactions can occur in natural ester liquids due to air exposure. However, Prolec GE has determined that exposure of bulk quantities during normal transformer manufacturing processes has no effect on the electrical and physical properties of the fluid.

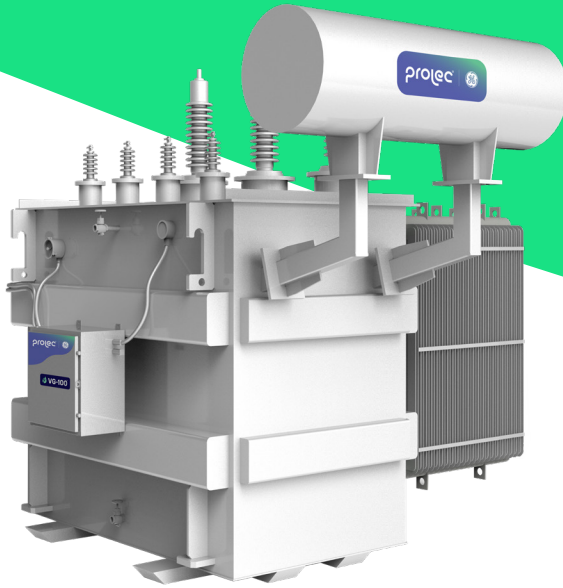
**Handling**

Any equipment that is suitable for transformer oil can be used with VG-100®, although the capacity of the pump should be reviewed because VG-100® liquid has a higher viscosity than mineral oil. The required filling rate, the liquid temperature, and filling pressure will affect the proper pump size. It

is recommended that the lowest operating temperature expected during handling operations be used for this analysis to derive the resulting viscosity of the fluid. Before using, pumping equipment should be cleaned and rinsed with VG-100® liquid to remove dirt, dust or traces of the oils, and the thoroughly flushed with new VG-100® liquid.

**Handling for transformer maintenance, repairs, or retrofills**

In cold weather, VG-100® liquid should be heated to reduce its viscosity and to avoid damage to pump equipment. If pipes, hoses and fittings are thermally insulated, a continuous flow can be maintained. A temperature above 10 °C is suggested for easy handling of the liquid. It is also recommended that the main tank be insulated with thermal sheets in order to minimize the heat



### **IMPORTANT**

Higher temperatures will decrease the viscosity and improve the insulation system impregnation process

released to the ambient and also to reduce the process time. If thermal sheets are not available, polystyrene sheets of 1" thickness can also be used. If heat blowers are available, either electrical or gas, those could be used to heat the ambient around the transformer to keep it heated to help the impregnation of cellulose insulation of the transformer.

Prior to filling the transformer, the liquid should be processed (degassed, filtered and dehydrated) to meet the acceptance levels of applicable standards (ASTM D6871, IEEE C57.147 or IEC 62770). The treated liquid should be placed in a tank under vacuum or directly to the transformer with a previous vacuum step. A target temperature of approximately 80 degrees C will improve the impregnation process of the insulation system. As is the case with any dielectric liquid there is a possibility of static charge accumulation when VG-100® flows through the pumping equipment. Therefore it is important that all pumps, lines and vessels be grounded during pumping operations to prevent this electrical phenomena.

For drying impregnated insulation with VG-100® liquid kerosene vapors or hot nitrogen should be used. A drying process with air is not acceptable as it could lead to liquid polymerization on impregnated materials.

For any work inside a transformer that requires draining of VG-100® liquid it will be necessary to transfer the liquid, to suitable new clean sealed containers to minimize contamination. A positive pressure with a dry nitrogen blanket will help to prevent the admission of humidity or oxygen into the container, keeping the VG-100® in good condition. All equipment used to manipulate the oil (pumps, pipes, hoses, fittings) should be cleaned after use to avoid gelification; thin films of VG-100® or any natural ester liquid over time will polymerize and that could be difficult to remove. This phenomena depends mainly on temperature, time of exposure to the ambient, and sunlight.

# Oxidation performance

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There are some differences in oxidation properties for natural ester liquids versus mineral oils. Vegetable fluids are subject to a polymerization process in the continuous presence of oxygen and elevated temperatures.

However, when it is used in sealed environments, such as in sealed transformers, vegetable liquids are stable. VG-100® meets the IEC requirements for oxidation stability according to IEC 62770 (Table 3).

Table 3. Oxidation stability of VG-100® liquid (IEC 62770).

Properties	Units	Standard	Acceptance Criteria	VG-100® Fluid
Total acidity	[mg KOH/g]	IEC 62021-3	≤ 0.6	< 0.5
Dissipation factor (90 °C)	[tan δ]	IEC 60247	≤ 0.5	0.2
Viscosity at 40 °C	cSt	ISO 3104	≤ 30% increase	< 20% increase

In addition, Prolec GE has conducted testing of VG-100® liquid exposed to oxygen at room temperature which shows that VG-100® liquid does not change its characteristics and does not form oxidation by-products after two weeks of exposure. These results assure that VG-100® liquid can be used in transformer manufacturing-both during production processes and maintenance practices.

The exposure time of impregnated transformer components with vegetable liquids to abnormal conditions such as air flow and/or high temperatures should be limited since polymerization reactions are accelerated under these conditions.

For additional information, please contact Prolec GE at 1-800-437-7653



# Retrofilling

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There are many environmental benefits derived from the use of natural ester liquid in transformers, both for new units and for retrofill applications. All retrofilling processes should be reviewed by qualified personnel. It is important to verify the good condition of the transformers as well as the reliability of their components.

When conducting a retrofill operation using natural ester fluid, the most relevant parameters to take into account are humidity and oxygen content. Humidity decreases the dielectric strength of the insulation system and oxygen content affects the physical and chemical properties such as viscosity, which directly impacts: the transformer thermal performance.

If during retrofilling, the VG-100® liquid was in contact or exposed to water or dust, it is recommended to process the oil as the same as in factory: degassed, filtered and dehydrate. VG-100® liquid is fully miscible with conventional mineral oil, natural and synthetic esters, but it does not compatible with silicone oils.

Once the transformer is drained, the remaining mineral oil needs to be controlled to minimize its volume, since high concentrations of it can reduce the original characteristics of the VG-100® liquid, such as fire resistance, biodegradability, among other. It is highly recommended to have less than 7% of mineral oil to maintain the optimal performance of VG-100® liquid.

The maintenance will be the same for VG-100® liquid and for mineral oil, highlighting that the equipment to be refilled should be non-free breathing, sealed transformer. Some parameters will need to be considered differently compared to those of mineral oil, such as exposure time, oil filtering before filling up the transformer, and others.

## **IMPORTANT**

Mineral oil and dielectric esters liquids are completely miscible with VG-100®

## **IMPORTANT**

Avoid a concentration higher than 7% of residual mineral oil in a VG-100® retrofilled transformer.

# Certifications

VG-100® has different international certifications which ensure optimal operation in the transformer. These certifications include several tests to determine the safety of the liquid without any risk of fire, contamination or with no acute lethality. In Table 5, a list of certifications is shown.

Table 5. List of certifications of VG-100®

Certifications	Organization	Code
Less Flammable Transformer Fluid	FM Approvals	Class number 6933
Less or non-flammable Liquid Insulated Transformers	FM Approvals	Class number 3990
Tests for comparative Flammability of Liquids	UL	UL-340
Dielectric Medium	UL	EOUV
Acute Toxicity Test of Natural Dielectric Oil VG-100® using rainbow trout ONCORHYNCHUS MYKISS [OECD Guideline203]	Bureau Veritas Laboratories	OECD 203
Ready Biodegradability of VG-100® Using the Manometric Respirometry Test	Bureau Veritas Laboratories	OECD 301F





## LOCATIONS

### MEXICO

#### APODACA

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