



G2050

Functional Specification Guide

# FUNCTIONAL SPECIFICATION FOR NEW NATURAL ESTER LESS-FLAMMABLE TRANSFORMER DIELECTRIC COOLANT.

## SCOPE

This specification describes a non-toxic\*, biodegradable\*\*, fire resistant, bio-based\*\*\* natural ester dielectric fluid. It is intended for use in electrical equipment as an environmentally preferred, lessflammable insulating and cooling medium.

## REQUIREMENTS

### Fluid Manufacturer

Fluid manufacturer shall have a minimum of ten (10) years' experience producing and testing dielectric coolants. Manufacturer shall have at least two operating production sites to assure continuity of supply. Manufacturer upon request should provide AC withstand and impulse withstand for both transformer relevant fluid gaps from 3mm to 150mm and insulation creep from 3mm to 35mm.

### Dielectric Coolant

The dielectric coolant shall be bio-based, biodegradable, be Factory Mutual Global Approved Less Flammable fluid, and be UL® Classified EOVK "less-flammable liquid" Transformer Fluid. It shall meet the property limits listed below. The base fluid shall be 100% oil from plants and/or seeds.

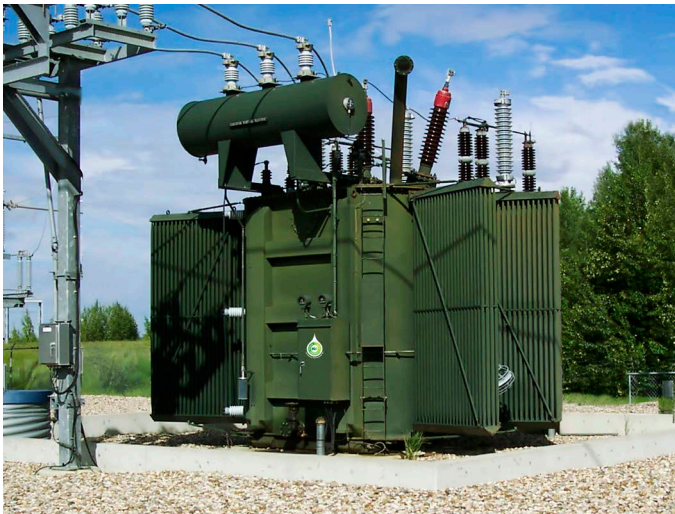
The dielectric coolant should have undergone accelerated aging studies via sealed tube and Locke test methods, and have published its A & B factors.

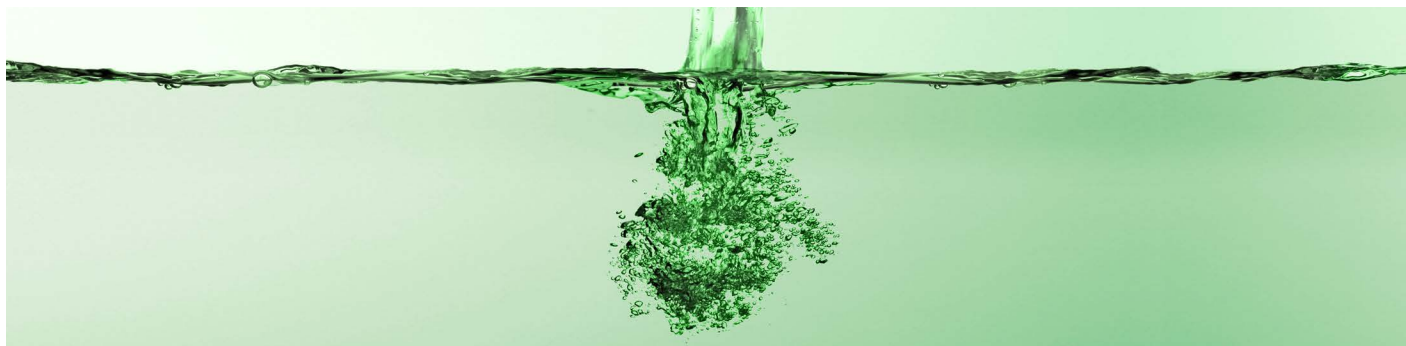
### Environmental and Health Third Party Validations

The fluid shall have a U.S, EPA Environmental Technology Verification (ETV) Statement and be a USDA Certified Biobased Product. The fluid shall meet the following test limits:

Table 1  
FR3 fluid's environmental attributes

Attribute	Results	Method
Biodegradation	>99%	Comprehensive analysis
Readily Biodegradable	Readily	U.S. EPA OPPTS 835.3110 or OECD 301B, C, or F
Acute Aquatic Toxicity	Non-toxic	OECD 202 and 203
Acute Oral Toxicity	Non-toxic	OECD 420
Biobased Material Content	>95%	USDA BiopREFERRED Program
Total Life Cycle Carbon Footprint	Carbon Neutral	Department of Commerce NIST BEES V4.0
Overall Environmental Impact	1/4 impact of mineral oil	Department of Commerce NIST BEES V4.0





## Acceptable values for receipt of shipments of Cargill FR3 fluid

**Table 2**  
FR3 fluid values and specification limits for natural ester fluid and mineral oil

		Standard test methods		ASTM D6871/IEEE C57.147	IEC 62770	FR3 fluid
PROPERTY		ASTM	ISO/IEC	As-received new fluid property requirements	Unused new fluid property requirements	TYPICAL
Physical						
Color		D1500	ISO 2211	≤1.0	–	0.5
Flash Point PMCC (°C)		D93	ISO 2719	–	≥250	260-270
Flash Point COC (°C)		D92	ISO 2592	≥275	–	320-330
Fire Point (°C)		D92	ISO 2592	≥300	>300	350-360
Pour Point (°C)		D97	ISO 3016	<-10	≤-10	-18 to -21
Density at 20°C (g/cm³)		–	ISO 3675	–	≤1.0	0.92
Relative Density (Specific Gravity) 15°C		D1298	–	≤0.96	–	0.92
Viscosity (mm²/sec)						
	100°C	D445	ISO 3104	≤15	≤15	7.7 - 8.3
	40°C			≤50	≤50	32 - 34
	0°C			≤500	–	190
	-20°C					650*
Visual Examination		D1524	IEC 62770 4.2.1	bright and clear	clear, free from sediment and suspended matter	clear, light green
Biodegradation		OECD 301B		readily biodegradable	readily biodegradable	readily biodegradable
Aquatic and Oral Acute Toxicity		OECD 202, 203, OECD 420		non-toxic	non-toxic	non-toxic
Electrical						
Dielectric Breakdown (kV)		D877	–	≥30	–	>45
Dielectric Breakdown (kV)						
	2mm gap	D1816	–	≥35	–	60-70
	2.5mm gap	–	IEC 60156	–	≥35	70-80
Dielectric Breakdown under Impulse (kV)		D3300		>130		140
	25.4mm gap					
Gassing Tendency (µl/min)		D2300	–	≤0	–	-79
Dissipation Factor						
	25°C (%)	D924	–	≤0.20	–	0.010 - 0.15
	90°C (tan δ)	–	IEC 60247	–	≤0.05	0.01 - 0.03
	100°C (%)	D924	–	≤4.0	–	1.00 - 3.85
Chemical						
Corrosive Sulfur		D1275	IEC 62697	non-corrosive	non-corrosive	non-corrosive
Water Content (mg/kg)		D1533	IEC 60814	≤200	≤200	4 - 50
Acid Number (mg KOH/g)		D974	IEC 62021.3	≤0.06	≤0.06	0.01 - 0.05
PCB Content (mg/kg)		D4059	IEC 61619	not detectable	free from PCBs	not detectable
Total Additives		–	IEC 60666	–	Max weight fraction 5%	<2%
Oxidation Stability (48 hrs, 120°C)		–	IEC 61125 IEC 62770			
	Total Acidity (mg KOH/g)	–	IEC 62621.3	–	≤0.6	0.1 - 0.3
	Viscosity at 40°C (mm²/sec)	–	ISO 3104	–	≤30% increase over initial	17% - 23% increase
	Dissipation Factor at 90°C (tan δ)	–	IEC 60247	–	≤ 0.5	0.1
Oxidation Induction Time 130°C/500psi (min)		D6186**				62±2 min

\* Measurement of viscosity near pour point may be inaccurate.

\*\* A more specific version of the test indicated by ASTM D6186 is under development.

NOTE: Specifications should be written referencing only the defined ASTM or IEC industry standard acceptance values and test methods. The listed 'typical' values are average values summarized from a significant number of data points over many years; they are not to be identified as acceptance values.

ASTM D6871 Standard Specification for Natural (Vegetable Oil) Ester Fluids Used in Electrical Apparatus. IEC 62770: Fluids for electrotechnical applications – Unused natural esters liquids for transformers and similar electrical equipment. A transformer filled with FR3 fluid complies with the transformer temperature operating range requirements defined in IEEE C57.12.00 and IEC 60076-1.

This document is provided for your information and convenience only. All information, statements, recommendations and suggestions are believed to be true and accurate but are made without guarantee, express or implied. WE DISCLAIM, TO THE FULLEST EXTENT PERMITTED BY LAW, ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE and FREEDOM FROM INFRINGEMENT and disclaim all liability in connection with the storage, handling or use of our products or information, statements, recommendations and suggestions made by Cargill. All such risks are assumed by you/user. The labeling, substantiation and decision making relating to the regulatory approval status of, the labeling on and claims for your products is your responsibility. We recommend you consult regulatory and legal advisors familiar with applicable laws, rules and regulations prior to making regulatory, labeling or claims decisions for your products. The information, statements, recommendations and suggestions contained herein are subject to change without notice. Tests conducted by Cargill labs unless otherwise noted.



Packaging

The electrical insulating fluid shall be furnished in sealed vessels suitable for the purpose, including 19 liter containers, 208 liter drums, 1,250 liter totes, 21,000 liter bulk (ISO) tanker, or in 75,000 liter rail car.

RECOMMENDED CUSTOMER RECEIVING  
QUALITY CONTROL

Inspection

Each lot received shall be visibly inspected for container integrity, and no leaks are visible.

Receiving Tests

Samples shall be taken from containers per ASTM D-923 Section 2.2, as follows:

Lot Size (liters)	Number of Containers Sampled
2275 or less	1
2276 to 11,360	2-6
11,361 or more	6 minimum (10% of quantity of containers recommended)

IMPORTANT INFORMATION

Storage

Do not store drums and totes outdoors. Extreme temperature variations can stress the integrity of container protective seals. Exposure of totes to sunlight can cause fluid discoloration. See the FR3 fluid Storage and Handling Guide.

Intended Use

The use of electrical insulating and cooling fluid is generally dictated by the engineering design of the electrical apparatus. The electrical insulating fluid covered by this specification is intended for use as an insulating and cooling medium in electrical equipment.

Fluid Transfer

When transferring electrical insulating fluid from its original container, take precautions to prevent contamination with moisture, dust, and foreign matter. These impurities can cause deterioration of the dielectric strength and electrical performance.

Partial Containers

Provide a nitrogen blanket for partially filled containers, and properly seal to prevent contamination.



When fluid will be combined for production, samples may be mixed together in equal proportions to create a composite sample for testing. Minimum tests required are water content, dielectric strength and visual inspection. Dissipation factor test is highly recommended, although not essential.

Applicable Specifications or Reference  
Standards

All characteristics, definitions and terminology, except those specifically covered in this specification shall be in accordance with the latest revisions of the following documents:

IEEE / ANSI DESIGN

- IEEE C57.12.00 – General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
- IEEE C57.147 – Acceptance and Maintenance of Natural Ester Fluids in Transformers
- IEEE C57.154 – Design, Testing, and Application of Liquid-Immersed Distribution, Power, and Regulating Transformers Using High-Temperature Insulation Systems and Operating at Elevated Temperatures

IEC DESIGN

- IEC 60076-1 – Power Transformers – Part 1: General
- IEC 60076-14 – Power transformers – Liquid-immersed power transformers using high-temperature insulation materials
- IEC 62770 – Fluids for electrotechnical applications –Unused natural esters for transformers and similar electrical equipment

## REFERENCES AND FOOTNOTES

\* Per OECD 203 Method B and OECD 420

\*\* Per US EPA OPPTS 835.3100 and US EPA OPPTS 835.8110 (ii)

\*\*\* Per USDA BioPreferred minimum bio-based content for Fluid-Filled Transformers - Vegetable Oil-Based FR3® is a valuable trademark of Cargill, Incorporated.

IEEE Std C57.12.00™, IEEE Std C57.147™ and IEEE Std C57.154™ standards are trademarks of the Institute of Electrical and Electronics Engineers, Inc., (IEEE). These products are not endorsed or approved by the IEEE.

IEC Std 60076-7™, IEC Std 60076-14™, and IEC Std 62770 standards are trademarks of the International Electrotechnical Commission (IEC).

These products are not endorsed or approved by the IEC.

IEC® is a registered trademark of the International Electrotechnical Commission

UL® is a registered trademark of the Underwriters Laboratories Inc.

FM Global® is a registered trademark of Factory Mutual Insurance Company

OPPTS 835.3100, OECD 203 and OECD 420 are copyrights of the Environmental Protection Agency (EPA).

---

Contact us -  
FR3fluid.com