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**FR3<sup>®</sup> fluid**  
**Formulated**  
**for performance.**

**FR3<sup>®</sup>**



# FR3<sup>®</sup> fluid.

# Trusted worldwide two million times over.





With over two million installations across six continents and validated in over 250 tests, Cargill's FR3® natural ester fluid is trusted by our customers to deliver cost-effective solutions that reliably and safely help improve transformer performance.

Our team of dielectric experts is active in the standards community globally and has extensive knowledge of not only dielectric fluid properties but also fluid performance in

application. And they have transformer design experience, too. This means our customers adopting FR3 natural ester technology have comprehensive dielectric fluids support from initial planning stages through best practices implementation and beyond.

Backed by Cargill's global supply chain network, our customers can rely on us to deliver the best solution for their application — when they need it, anywhere in the world.

### With FR3 fluid, our customers can:

- Gain cost efficiencies either on initial cost or total cost of ownership.
- Extend transformer insulation and asset life.
- Optimize load capability.
- Significantly improve fire safety.
- Enhance their environmental footprint and sustainable supply chain initiatives.

# Improve performance with life extension and flexibility.

## Protect insulation life to extend asset life.

Insulation paper is one of the primary factors that determines the life of a transformer. FR3 fluid's unique chemistry absorbs free water and essentially wicks it away from the insulation paper. FR3 fluid has 10 times the water saturation level of mineral oil. This results in extending the insulation life 5-8 times longer than mineral oil.



Insulation aging study comparing thermally upgraded paper using FR3 fluid vs. mineral oil.

- Save significantly on replacement costs by extending the asset life with FR3 fluid.
- Reduce the risk of failure to improve reliability of the transformer.
- Reduce processing maintenance costs, since FR3 fluid does not sludge like mineral oil.

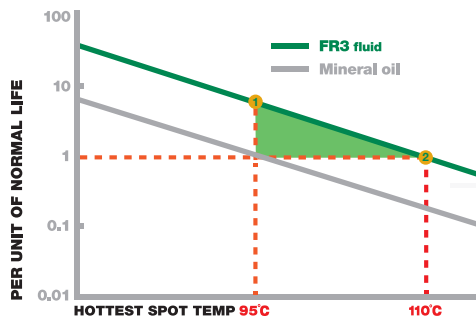
With FR3 fluid’s unique capabilities to extend insulation life and increase load capacity, organizations now have the flexibility to optimize their transformer fleet utilization in order to gain cost savings without sacrificing reliability.

### Leverage higher thermal capability with FR3 fluid.

Historically, standards were written to accommodate a 95°C or 110°C hot spot for cellulose and Thermally Upgraded Kraft (TUK), respectively. However, published high temperature insulation system standards - IEC (60076-14) and IEEE (C157.154) – accommodate a 15°C or 20°C increase in hot spot without sacrificing the life or reliability of the transformer, when immersed in natural ester fluid.

Paper	Dielectric Fluid	Thermal Class	Hot spot	IEEE AWR	IEC AWR
Kraft	Mineral Oil	105	95°C	55°C	65K
Kraft	Natural Ester	120	110°C	65°C	75K

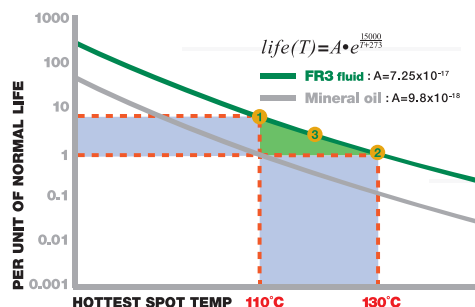
Standard Kraft life curves



- OPTION 1:** Extend asset life at current 95°C hotspot.
- OPTION 2:** Increase load capability up to 15% with 110°C hotspot.

Paper	Dielectric Fluid	Thermal Class	Hot spot	IEEE AWR	IEC AWR
TUK	Mineral Oil	120	110°C	65°C	75K
TUK	Natural Ester	140	130°C	85°C	95K

TUK life curves



- OPTION 1:** Extend asset life at current 110° C hotspot.
- OPTION 2:** Increase load capability up to 20% with 130°C hotspot.
- OPTION 3:** Incrementally extend asset life and increase load capability with 120°C hotspot.

IEC 60076-14 Part 14: Liquid-immersed power transformers using high-temperature insulation materials. Edition 1.0 September 2013.  
 IEEE C57.154 Standard for the Design, Testing, and Application of Liquid-Immersed Distribution, Power, and Regulating Transformers Using High-Temperature Insulation Systems and Operating at Elevated Temperature. Published October 30, 2012.

# Improve fire safety.

# Add more sustainability to your sustainable supply chain.

## Reduce costs while increasing fire safety.

FR3 fluid has the highest fire point of any dielectric fluid (360°C compared to 160°C for mineral oil) making it the ideal choice for densely populated areas where transformers are positioned indoors, underground or in close proximity to buildings and other equipment. FR3 fluid is a K-class, less flammable fluid as certified by Underwriters Laboratory and approved by FM Global.

- Reduce clearance to buildings which saves precious real estate, particularly in space-constrained areas.
- Retrofill older transformers with FR3 fluid instead of replacing or moving them to help comply with current fire code regulations.
- For power transformers, potentially eliminate the need for expensive fire walls and deluge systems (and their ongoing maintenance costs).

## “Being green” also benefits your bottom line.

FR3 fluid not only has best-in-class environmental properties, but with its enhanced thermal capabilities enabling optimized transformer designs, your supply chain just got a whole lot more sustainable.

- More efficient transformer designs:
  1. Use less fluid and construction materials.
  2. Are typically lighter which could make installations easier for work crews and could reduce transportation costs.



## FR3 fluid properties: standard acceptance values and typical values

PROPERTY	Standard test methods		ASTM D6871/IEEE C57.147	IEC 62770	FR3 fluid
	ASTM	ISO/IEC	As-received new fluid property requirements	Unused new fluid property requirements	TYPICAL
<b>Physical</b>					
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/cm <sup>3</sup> )	–	ISO 3675	–	≤1.0	0.92
Relative Density (Specific Gravity) 15°C	D1298	–	≤0.96	–	0.92
Viscosity (mm <sup>2</sup> /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
<b>Electrical</b>					
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
<b>Chemical</b>					
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 (mm <sup>2</sup> /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.

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- Made from a renewable source with global, reliable supply.
- Carbon neutral (according to BEES 4.0 lifecycle analysis).
- Non-toxic and non-hazardous in soil and water.
- Readily Biodegradable per OECD 301.
- Contains no petroleum, halogens, silicones or sulfurs.
- Recyclable.