

Application for LEED Innovation & Design Points

Liquid-Filled Transformer Technology: Mineral Oil vs. Silicone Oil vs. Natural Esters

Environment:

For liquid-filled transformers the fluids occasionally enter the environment when transformers are damaged or leak. While most PCB oil filled transformers have been retrofilled or replaced with PCB-free mineral oil or alternate fluids, the replacement fluids are also of environmental concern. The most common transformer fluid is mineral oil, which is a petroleum hydrocarbon. According to the California Environmental Protection Agency (Cal/EPA), the International Agency for Research on Cancer (IARC) has identified certain mineral transformer oils as a carcinogen based on experimental data for animals [1]. A less common transformer fluid is silicone oil. Silicone oil has been linked to reproductive problems based on experimental data on animals. Silicone has been found in estuaries and there are reports that such silicone can combine with mercury to form very hazardous and bio-accumulating compounds [2].

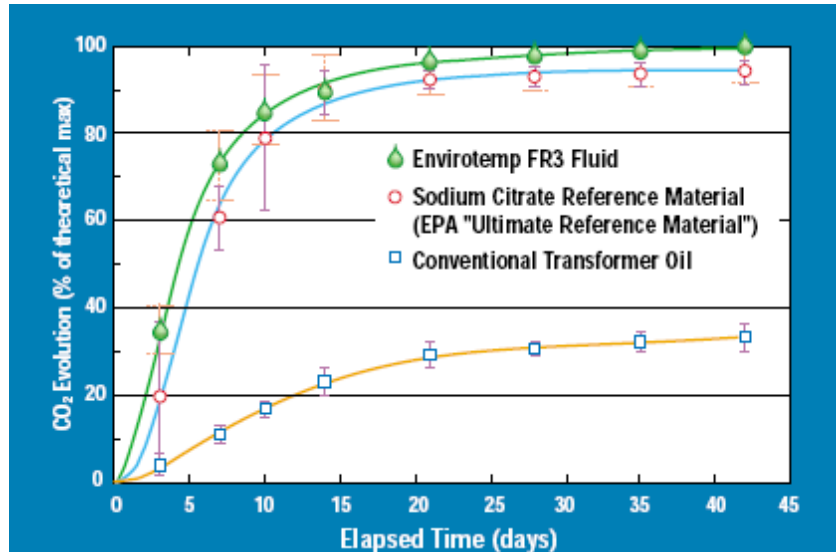
New and innovative transformer fluids have been recently developed made from natural-ester fluids such as Envirotemp® FR3™. These vegetable-oil-based fluids do not contain petroleum hydrocarbons, silicones, or halogens. They are made from food grade ingredients and are not subject to Federal Regulation of Used Oils (Title 40, No. 279). FR3 is a renewable resource made from 98% soybean oil (26 states have a significant soy-growing community [3]).

Two of the most differentiating environmental features are natural-ester fluids' rapid biodegradation rate and non-toxicity. Both features have been evaluated and validated by the US EPA [1]. Natural ester fluids are non-bioaccumulating, non-carcinogenic, and can be recycled into other uses like bio-diesel.

Biodegradation:

Biodegradation can take place when there are adequate amounts of water, oxygen, organisms, and heat. Inside a sealed transformer, these elements do not exist together in sufficient quantities to promote biodegradation. Outside a transformer, FR3 fluid biodegrades rapidly, for which the byproducts are essentially carbon dioxide and water.

This chart illustrates the results of the tests including comparisons to other materials. FR3 fluid biodegraded faster than the EPA baseline reference material of sodium citrate and subsequently qualifies as an EPA-defined “ultimate biodegradable material.”



In 21 days, mineral oil biodegrades just 25% while FR3 fluid

biodegrades in excess of 99%. So the mineral oil cannot even be EPA classified as “readily biodegradable”, which is a lower classification than “ultimate biodegradable” material. Silicone oil does not biodegrade.

Non-Toxicity:

Substance toxicity is measured by how harmful it is to living organisms. FR3 fluid has been tested for toxicity by third parties in accordance with standard aquatic toxicity test methods defined by the Organization for Economic Co-operation and Development (OECD) and Environment Canada. These tests utilized very young rainbow trout that are particularly susceptible to toxins. During the four-day exposure tests, there was zero trout mortality. The EPA has subsequently issued an affirming statement through the Environmental Technology Verification Program (ETV) [1]. No mineral oil or silicone oil based dielectric coolants currently feature the ETV certification.

Fire Safety:

FR3 natural ester fluid has the highest firepoint of any transformer fluid currently available. This fluid has a higher firepoint than R-Temp Fluid (594°C) which has a 30-year, 100,000 unit installation record of no reported pool fires.

Summary:

Envirotemp® FR3(tm) natural-ester fluid-filled transformers are being used for this project instead of other (more common) non-renewable, poor biodegradable, toxic, carcinogenic fluids like mineral oil or silicone oil. Natural-ester fluid-filled transformers contribute to affordable, sustainable engineering/building practices.

Dielectric:	Firepoint:	Renewable:	Biodegradation in 21 days:	Breakdown Products:	Food Grade:
FR3 Natural Ester	360°C	Yes	<99%	H ₂ O, CO ₂	Yes
Mineral Oil	165°C	No	25%	H ₂ O, CO ₂ , Petroleum intermediates	No
Silicone Oil	343°C	No	0%	N/A	No

Additional Supporting Documentation:

[1] “The Environmental Technology Verification Program”, U.S. Environmental Protection Agency, Washington, DC, VS-R-02-02, June 2002. [Online] http://www.epa.gov/etv/pdfs/vrvs/06_vs_cooper.pdf

[2] “Silicones Not So Inert in Environment As Thought”, Chemical & Engineering News, September 1986

[3] <http://www.soygrowers.com/membership/affiliates.htm>

Electricity Today, Issue 8 2004, “Seed-Based Transformer Dielectric Fluids Provide Safety, Environmental Responsibility, and Longevity”
http://www.electricity-today.com/download/issue8_2004.pdf

Cooper Power Systems, Bulletin 00006, “Rethinking Transformers for Safety, Performance, and Value – Transformer Selection Guide”
<http://www.cooperpower.com/Library/pdf/00006.pdf>