

Sustainable Acquisition Success Story

Product Spotlight on Y-12 National Security Complex

Y-12 Chooses Biobased for Transformer Fluid

The Y-12 National Security Complex in Oak Ridge, Tennessee, is committed to increasing the procurement and use of biobased products across its site. In 2020, Y-12 began a new project, to retro fill the site's 20 electric transformers with biobased transformer fluid, FR3[®], which decreases associated environmental risks and increases the lifespan and efficiency of the transformers.



Electric Transformer
Photo Credit: Y-12

To disperse heat from the core, insulate, and prolong the life of the equipment, Y-12's 20 transformers were previously filled using mineral oil, which comes with several hazard risks. Oil spills from mineral oil filled transformers can occur under multiple conditions, including catastrophic failures, fires, spillage, leaks due to corrosion or exposure to inclement weather, and accidents where transformers are damaged. Mineral oil is toxic, and its biodegradation is very low. When it spills or is released into the local environment it can seep into the soil or local waterways, posing toxic hazards to marine life, wildlife, and vegetation, as well

as cause a degradation of soil quality. When running at high temperatures, mineral oil filled transformers pose the risk of accelerated thermal degradation, along with darkening and sludge formation within the oil. In addition, at high temperatures mineral oil is unable to absorb the moisture that migrates from the insulation paper inside the transformer. This causes "bubbling" which poses the risk of dielectric failure. Over time, using mineral oil in transformers at high temperatures accelerates the aging of the insulation paper, shortening the life of the transformer and reducing its overall reliability.

Comparatively, FR3[®] transformer fluid can extend the paper insulation's life span eight times due to its superior moisture handling capabilities. FR3[®] is derived from 100% renewable vegetable oil and is superior to mineral oil in its distribution and power generation within transformers of all voltage classes (both new and retro filled). It is not only suited for transformers but also other power equipment such as voltage regulators, circuit breakers, rectifiers, phase-shifters, and high voltage direct current (HVDC) transformers.



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

Photo Credit: Envirotemp TM Natural Ester Fluid Brochure

FR3[®] is a natural ester dielectric fluid that is reclaimable and recyclable. It's free of petroleum, halogens, silicones, and sulfurs. This biobased product is nontoxic in both water and soil as well as readily biodegradable. In the event of a spill, FR3[®] takes fewer than 28 days to biodegrade and does not require any additional bioremediation. In the event of a spill, FR3[®] provides considerable cost savings when compared to a mineral oil spill. A mineral oil spill requires hazardous waste remediation, which in many cases means excavating and incinerating the contaminated soil. FR3[®], on the other hand, is 100% biobased per ASTM D-6866, non-toxic, and readily biodegradable.

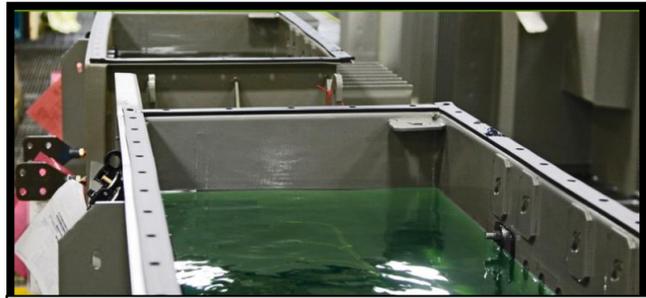
According to the manufacturer, FR3© spills on soil will naturally biodegrade within 28 days. However, the manufacturer recommends spreading active yeast over a spill site, then adding water to activate the micro-organisms. The added yeast will efficiently consume the FR3© fluid, and effectively remove it from the environment.

When compared to traditional mineral oil transformer fluids, FR3© is significantly less flammable. It is fire resistant and non-propagating, meaning it is self-extinguishing and will not continuously burn if ignited, unlike mineral oil which will burn continuously once ignited until all the oil has been consumed.

This also increases the reliability of the power system and reduces requirements for annual testing because FR3© can function at higher temperatures than mineral oils. This can allow for up to a 20% increase in transformer load capacity without compromising the reliability or lifespan of the transformer. FR3© fluids flash and fire points are more than twice those of mineral oil transformer fluid.

The numerous benefits of FR3© were the deciding factors behind Y-12's Utilities Department staff's decision to make the switch from mineral oil. This retro fill project used 17,120 gallons of FR3©, costing \$342,000. In comparison, if Y-12 had continued to use mineral oil for this refill project, it would have cost the site an estimated \$513,600. By switching to the environmentally friendly and sustainable biobased transformer fuel, Y-12 saved \$171,600 in costs.

Y-12 also ensured that the mineral oil would be disposed of sustainably by recycling a total of 19,673 gallons of mineral oil that was removed from the transformers and storage containers.



Vat of FR3 Biobased Fluid
Photo Credit: Cargill Inc,

These efforts did not go unnoticed! In honor of the first-ever National Biobased Products Day, the U.S. Department of Agriculture (USDA) recognized the great work being done to improve sustainability within the Federal Government. Y-12's Sustainable Acquisition and Utilities Team were among the select group recognized by the USDA's Biopreferred Program with the [2022 Excellence in Procurement Award](#).

Keys to Success



Challenges

- Refilling the 20 Electric Transformers in an environmentally and sustainable way.
- Properly disposing of used mineral oil.

Solutions

- FR3© 100% Biobased natural ester dielectric fluid.
- Offsite mineral oil recycling.

Results/Benefits

- FR3© is safer, less flammable, 100% renewable and 100% biodegradable without bio-remediation efforts.
- FR3© can extend transformer paper insulation's life span 8 times due to its superior moisture handling capabilities, which means lower maintenance costs over the lifetime of the product.
- Recycled mineral oil is reused as opposed to becoming a waste product with known environmental concerns.
- \$171,600 in cost savings.

Key Stakeholders

- Y-12
- Y-12's Sustainable Acquisition and Utilities Program Team

Site Contact:

- Janice Jackson (janice.jackson@pxy12.doe.gov)
- Bradley Russell (bradley.russell@pxy12.doe.gov)