

Envirotemp® FR3™ Fluid - Frequently Asked Questions (FAQs)

This resource provides answers to frequently asked questions about Envirotemp® FR3™ Fluid regarding Fire Safety, Environmental, Performance and Commercial considerations.

Fire Safety FAQs

Q: Why do you claim that FR3™ fluid is so much safer than mineral oil? It can still burn, can't it?

A: Simply put, mineral oil transformer fires are a daily occurrence. Even a single incident can cost property owners tens of millions of dollars. CPS has never received a report of an oil fire involving any of our fire-resistant fluids.

While the energy from electrical arcing often ignites mineral oil, (fire point approx. 160° C), numerous tests by FM Global show that the same arc energy is not sufficient to ignite dielectric coolants with fire points at or above 300° C.

With the highest flash and fire points of any dielectric coolant, (330° and 360° C, respectively). FM considers it extremely unlikely for a pool fire to develop for FR3™ fluid. They're so confident that they have reduced recommended minimum clearances to as low as 3 feet.

Q: What other independent agencies have verified the fire safety of FR3™ fluid?

A: Test results from Factory Mutual Global Underwriters Laboratories, Doble Engineering and the US EPA have also verified the key fire safety properties of FR3™ fluid. It is an FM Approved, UL Classified fluid for indoor and outdoor installations per NEC 450-23 and meets the criteria as a "high fire point fluid" per NESC.

Q: But aren't dry types safer?

A: Not according to fire incident reports. Dry types, including cast resins, can and have failed catastrophically due to flammable vapors produced by the vaporization of metal. Furthermore, dry types

do not have the preventive maintenance tool of DGA (Dissolved Gas Analysis) to predict unseen problems. As mentioned above, there have been no reported oil fires involving any CPS fire-resistant fluid in its quarter century of experience. And units that meet the UL and FM listed transformer requirements help prevent tank rupture from internal arcing as well.

Q: Does FR3™ fluid auto-ignite if it reaches its 360° C fire point?

A: No, even at 360° C it will not ignite without an external ignition source. It is extremely unlikely for the dielectric coolant in a severely overloaded transformer to exceed 130° C, so the margin of safety is very high.

Q: After retrofilling a transformer, what fire safety concerns should remain due to residual mineral oil?

A: As incredible as it seems, even with a contamination of up to 7.5% mineral oil, FR3™ fluid key properties remain unaffected and maintains a fire point of over 350° C, including maintaining a fire point rating of over 350°C. (Proper retrofilling should result in less than 5% residual mineral oil.)

Q: Does the use of FR3™ fluid eliminate the need for fire safeguards that are required when using mineral oil?

A: Typically yes, and the savings can be very substantial. This includes protective barriers like safety walls, as well as deluge systems and other fire suppression equipment. It also includes significantly reducing the minimum clearance distance between transformers and buildings.

Environmental FAQs

Q: Our environmental compliance department has advised us that the US EPA considers all oil to be equal - with common compliance requirements. Is that right?

A: Not exactly. There are different requirements for different jurisdictions of the EPA. For example, FR3™ fluid would be exempt from the Federal Regulation of Used Oils. Furthermore, within the 2002 edition of the SPCC (Spill Prevention Control and Countermeasures), two of the three key requirements are the same: “volume threshold for compliance” and the “minimum response time.” The EPA is considering further revisions as well as different remediation actions depending on the volume and site specifics. Remember: SPCC is only applicable to installations where there is exposure to navigable waters.

Q: Why should my company use FR3™ fluid in place of mineral oil if there is no significant relief from the US EPA SPCC rules.

A: Because it is the right and responsible thing to do. Since FR3™ fluid-filled transformers have a favorable life cycle cost and a virtually non-existent potential for oil fires, why not use a fluid that is much more friendly to the environment? In a very sensitive OECD

test method, trout fry were exposed to FR3™ fluid for 96 hours; the mortality rate was zero. The biodegradability rate meets the highest EPA classification, while mineral oil has the lowest. The US EPA has verified our environmental claims. Their document states: “These select mineral oil-based fluids listed a hydrotreated light naphthenic petroleum distillate, which is an IARC confirmed carcinogen.”

Because FR3™ fluid is biobased and made of edible oils, it meets the intent of the Edible Oil Act of 1995, this supports current and future environmental regulatory relief. However, spill reporting and remediation may still be required by the authorities having jurisdiction, particularly for large volume spills into surface water.

Q: One of the conditions needed to meet SPCC requirements for remediation is that there must be a visible iridescent sheen on the water. Does FR3™ fluid create a sheen similar to petroleum oils?

A: FR3™ fluid does not create an iridescent sheen. Unlike mineral oil, it also tends to break up and disperse rather than maintaining a large-area sheen; it also biodegrades much faster than mineral oil. FR3™ fluid is so safe that fish farms actually use similar edible vegetable oils for feeding.

Q: Which environmental tests for FR3™ fluid were verified by the US EPA?

Table 1: Evaluations of Envirotemp® FR3™ fluid environmental properties and associated test methods.

ENVIRONMENTAL HAZARD

Property	Test	Method
Toxicity	Acute Aquatic Acute Lethality using Rainbow Trout	OECD 203 Environment Canada
Biodegradation	Aquatic Biodegradation Aerobic Aquatic Biodegradation Ready Biodegradation Biochemical Oxygen Demand (BOD5)	CEC L-33-A-93 OPPTS 835.3100 OPPTS 835.3110 SM 5210B

SITE ASSESSMENT

Property / Test	Method
Total Petroleum Hydrocarbons Fuel Hydrocarbons	SW-846 Modified 8015B
Total Recoverable Petroleum Hydrocarbons Spectrophotometric	600/4-79/020 418.1
Total Recoverable Oil and Grease Gravimetric Spectrophotometric	600/4-79/020 413.1
Target Compound List	600/4-79/020 413.2
Semi-Volatile Organics Volatile Organics	SW-846 Method 8270C SW-846 Method 8260B
Toxicity Characteristic Leaching Procedure 7000 series 3510, 8270 5030, 8260	SW-846 Method 1311 SW-846 Method 1311 SW-846 Method 1311
Total Threshold Limit Concentration 7000 series	SW-846 Methods 6010

ASSESSMENT-RELATED PROPERTIES

Property	Test	Method
Heat of Combustion		ASTM D240
Ignitability	Pensky-Martens Flash Point Setaflash Flash Point	SW-846 Method 1010 SW-846 Method 1020A
Total Organic Halides (TOX)	Extractable Organic Halides	SW-846 Method 9020B
Leachable Fluoride		600/4-79/020 340.2
Cyanides	Reactive Cyanide Cyanides in Waste	SW-846 7.3.3 ASTM D5049
Sulfides	Reactive Sulfide Sulfides in Waste	W-846 7.3.4 ASTM D4978
Soil and Waste Ph		SW-846 Method 9045C
Specific Gravity		SM 2710F
Odor, Color, Appearance		ASTM D4979

Q: Do any states provide preferential relief for FR3™ fluid spills that are not under SPCC jurisdiction?

A: Most states do not officially address edible oil spills to soil. Several use “total petroleum hydrocarbon” (TPH) levels as the basis for remediation requirements. FR3™ does not register or test as a TPH. Mineral oil does. While several state agencies will selectively consider allowing FR3™ fluid spills to biodegrade naturally, there are some states that regulate edible oils and petroleum products equally.

Q: Is there anything in FR3™ fluid that would negatively impact ground water quality?

A: Although it’s unlikely that the fluid would ever reach ground water, because of viscosity and other

characteristics, there is nothing that will significantly affect the quality of the ground water. In fact, the USDA has conducted studies using vegetable oils to remediate fertilizer-contaminated well water.

Q: How long will it take for FR3™ fluid to “disappear” if it is spilled?

A: In EPA testing, FR3™ fluid completely biodegraded within 28 days. It’s important to note however, as with any biodegradable material, biodegradation rate is dependent upon climatic and environmental conditions.

Q: Does the FM Global Loss Prevention Sheet for transformers, actually differentiate containment requirements for FR3™ fluid?

A: Yes, with FR3™ fluid, as well as other fluids that are non-toxic and quick to biodegrade, FM allows a doubling of the threshold volume of other fire-resistant fluids before containment is required (sites

under SPCC jurisdiction excluded). The US EPA “ETV” logo on FR3™ fluid-filled transformers assures compliance with the FM requirement.

Performance FAQs

Q: I’ve heard that the oxidation stability of vegetable oils used in transformers is generally lower than mineral oil. Is this a significant issue?

A: Thin films of vegetable oil, exposed to heat and air flow, do oxidize much faster than mineral oil.

However, in ANSI/IEEE standard designs (not the free breathing type often used in European designs) the exposure to oxygen is insignificant. Additionally, the oxidation byproducts of mineral oil are much more harmful to the performance of a transformer than those from vegetable oil. FR3™ fluid also contains a food grade preservative. Accelerated life tests, Doble Engineering PFVO tests and data from the field all show FR3™ fluid very suitable for the application.

For more details, please refer to Reference Information entitled Oxidation Stability of Envirotemp(r) FR3™ fluid, CPS Document R900-20-2

Q: If FR3™ fluid biodegrades so quickly, should I be concerned about the potential for this material breaking down inside the transformer during a normal product life span?

A: We have no more concern for this than we do with mineral oil. Even though mineral oil has a much slower biodegradation rate, it also biodegrades. Even with transformers lasting 40 plus years, biodegradation has not been a problem. The internal conditions for biodegradation are lacking: this includes free water, unlimited oxygen, oil-eating microbes and thin layers of fluid.

Q: I’ve heard that FR3™ fluid-filled transformers typically produce higher transformer insulation power factor readings than mineral oil filled units. Is this a significant concern?

A: No. Insulation power factor readings of new mineral oil units are sometimes used as an indicator of moisture content in the insulating paper. For operating mineral-oil-filled transformers, power factor readings are an indicator of the amount of polar contaminants within the insulation system.

It’s important to remember however, that the energy loss associated with power factor is insignificant compared to core and winding losses. The more important application is comparing significant changes between power factor readings over time.

Because natural ester fluids have inherently higher dissipation factor values than mineral oils, the insulation system using the esters will result in inherently higher power factor values as well. If a power unit has power factor (p.f.) of 0.5% in mineral oil, the resulting p.f. with FR3™ fluid would be approximately double that value. The difference with distribution transformers would be smaller. The industry first experienced inherently higher power factors with askeral transformers; p.f. values on these units would often reach into the mid-teens, even for distribution with our performance issues class.

For more details, please refer to the Reference Information entitled: Power Factor Discussion, CPS Document R900-20-1.

Q: I’ve heard a lot about transformer life extension using FR3™ fluid. How can it do that? What proof do you have?

A: The consensus in the industry is that there is a direct correlation between transformer life and paper life. Paper aging rate is primarily related to operating temperature. When paper ages, it produces moisture and de-polymerizes. This results in reduced dielectric performance and weaker physical strength. Once this happens, the transformer is less tolerant to voltage impulses and through-faults. Moisture in paper increases the rate of degradation.

FR3™ fluid slows down the aging process in several ways. First, FR3™ fluid extracts more moisture from the paper than mineral oil, which has a much higher moisture saturation value. Second, FR3™ fluid removes dissolved moisture by hydrolysis. Finally, the by-product of that process actually provides additional protection to the aging paper through a

process called transesterification. FR3™ fluid essentially takes the compounding effect of moisture out of the aging equation.

IEEE C57 Standards indicate that when a new insulation system is proposed, it must pass the accelerated life tests of C57.100. The standard includes a full scale test using multiple transformers and a small scale test using multiple samples. The results of this testing showed the insulation system with FR3™ fluid out-last the mineral oil system (4 to 8 times, at the same operating temperature). Peer-reviewed technical papers on the remarkable results of both tests are published by IEEE and are available from CPS.

Q: Is it correct that FR3™ fluid has limitations due to cold temperature operation?

A: It depends on the issue. With a -21° C pour point (similar to R-Temp(r) fluid), FR3™ fluid has higher temperature limits on power switching than standard mineral oil. Typical limits when the switching contacts are immersed in the coolant are -10° C.

Increased viscosity is another issue that needs to be addressed when handling FR3™ fluid at colder temperatures. Cold starting units, with continuous pumping as well as physical jarring of de-energized transformers, should be avoided when temperatures are below -21° C. On the other hand, full load cold start of distribution transformers, chilled to temperatures between -40° C and -30° C, showed no signs of thermal runaway. R-Temp(r) fluid units have been functioning for Arco Alaska, near the Arctic Circle, without any reported problems. Many FR3™ fluid units have also been operating in very cold climates with no reported problems. For operation of power transformers with LTCs in very cold weather (-10° C), we recommend the use of our synthetic ester fluid, Envirotemp(r) 200 fluid in the LTC chamber. The pour point of Envirotemp 200 fluid is below -50° C.

Q: I don't need or want longer life from my transformers. I want to drive them harder. Can I?

A: Probably. Our proven improved paper aging rate allows a choice between longer life, higher overloadability, or a combination. Based on the data obtained from the C57.100 tests described above, the temperature rise for equivalent life between the two insulation systems is 21° C.

Assuming all the other materials can withstand the higher operating temperature, and there is no practical danger to the public regarding touch temperature, a unit designed with FR3™ fluid can run at an 86° C rise vs. a 65° C mineral oil designed unit. This represents approximately a 20% increase in its rating.

For oil retrofills, the increase is somewhat reduced due to the higher viscosity of FR3 fluid. The increase in rating will vary from approximately 14% to 19%, depending on the transformer size and design.

Q: Does the aging rate of insulating paper in older mineral oil-filled transformers change after retrofilling? And, is the aging rate improvement comparable to that seen in accelerated aging tests using new units and paper?

A: Yes, the C57.100 small scale tests were performed using paper initially aged in mineral oil and then further aged in FR3™ fluid. The aging rate changed immediately and the water moisture content of the paper dropped to a low level within 500 hours.

Q: How much life extension can I expect after retrofilling with FR3™ fluid?

A: While there can be no exact answer to the question due to many variables, we do know that the paper aging rate will reduce by a factor between 4 to 8 times. We also know that the moisture level of the paper will immediately start to drop, improving the dielectric performance of the paper. After reviewing our aging data, a major IOU determined that, on average, the remaining life will at least double.

Q: Are there other benefits in retrofilling besides insulation life extension?

A: Yes, particularly in the areas of enhanced fire safety and improved environmental performance. In comparison to mineral-oil-filled transformers, FM Global recently reduced the separation distances as little as one tenth. This is based on their contention that a pool-oil fire is all but impossible with FR3™ fluid. Other advantages over mineral oil include reduced tendencies for coking, gassing and sludging.

Q: What is the recommended procedure for retrofilling?

A: The answer depends on the size, voltage, type of transformer and permissible down time. We do recommend contracting the services of a certified power transformer retrofiller, such as Waukesha Electric Systems Services for medium and large units.

For small power units, distribution units and for the initial retrofills, at least, we recommend contacting CPS Services. Those directly involved with the refilling operation should become familiar with both the Envirotemp® FR3™ Storage and Handling Guide, Bulletin No. 99048, and the Envirotemp® FR3™ Refilling Guide, Bulletin No. 00046.

Q: How does CPS warrant retrofills with FR3™ fluid?

A: Currently we offer our standard warranty which guarantees that our fluid will meet its acceptance values. The condition of the transformer and the refilling process determines the success of the retrofill. CPS will also work with you to structure extended warranties for a premium. Contact the Fluids Products Group for additional information and updates.

Q: How does FR3™ fluid perform in LTCs? Are any special precautions recommended?

A: FR3™ fluid works well as an LTC fluid under most conditions. It has been tested and approved for use in the CPS Quik Drive™ LTCs used in voltage regulators. Tests, under load break operations, have shown FR3™ fluid to better maintain its dielectric strength than mineral oil.

There are two precautions: At temperatures below -10° C, the LTC may not meet its ratings. Either a temperature sensitive lockout or the application of the synthetic ester, E-200 is recommended. The other issue is that many LTC's, especially the modern units, tend to be free breathers. We strongly recommend using E-200 for such designs and making sure that a moisture desiccant is provided and properly maintained for either fluid.

Q: If FR3™ reduces paper aging, why not increase the allowable transformer hot spot temperature rise for new units?

A: The IEEE standard for distribution transformers is 65° C rise, and in some cases 55/65° C. Since 1999, CPS has offered FR3™ fluid-filled transformers for both ratings. In 2004, CPS will offer higher-rise Envirotran™ products for use in substation and pole applications where there will be no public contact potential. Even though IEEE testing with FR3 fluid indicates that paper ages the same rate at 21° C higher temperatures than in mineral oil, other materials need to be analyzed to insure they can also withstand the higher operating temperatures.

Q: Can we use the same equipment for handling and processing mineral oil and FR3™ fluid? Are the fluids miscible? Are any special precautions recommended?

A: FR3™ fluid is miscible with mineral oil and does not create the problems associated with trace contamination of silicone in mineral oil. While it's obviously advisable to totally avoid blending of dielectric materials, it takes more than 7% mineral oil contamination to reduce the fire point of FR3™ fluid. It's especially important to avoid cross contamination to maintain the exceptional environmental properties of FR3™ fluid. Flushing the mineral oil processing equipment and hoses with FR3™ fluid is recommended. FR3™ fluid is also miscible with synthetic esters, synthetic hydrocarbons (PAOs) and R-Temp® fluid.

Refer to Bulletin 99048, Envirotemp® FR3™ Fluid Storage and Handling Guide, for additional information.

Q: Is FR3™ fluid compatible with the other materials used in the transformer?

A: To date, we've concluded that FR3™ fluid has equal or less effect on conventional transformer materials than mineral oil. A power transformer manufacturer has reported similar results with their materials. Aged, brittle gaskets should be replaced whenever practical. If not, additional tightening may be required to seal the gaskets.

Q: Some of our power transformers have conservators that are free breathing design. Can we retrofill such units with FR3™ fluid?

A: Although we've successfully used FR3™ fluid in some free-breathing transformers for over 5 years, we don't advocate this practice until we have further data. Units with free-breathing conservators should be retrofitted with bladders.

Q: Can FR3™ fluid be used to retrofill an askarel (PCB)-filled transformer?

A: Yes, successful retrofills of askarel transformers have been reported. However, due to the leaching of residual PCBs, the environmental attributes of pure FR3™ fluid are impacted and if enough PCBs leach from the paper, the unit may still be classified as a PCB transformer. Also, if the unit was specifically designed to use the low-viscosity askarel material, resulting temperature rise (at a given load) will be higher than that of a retrofilled mineral oil unit.

Q: We rely on DGA (Dissolved Gas Analysis) as a key preventive maintenance tool. Can I use the existing DGA methods with FR3™ fluid?

A: DGA has proven effective with FR3™ fluid for condition diagnostics. The same fault gasses are produced. IEEE C57.104 DGA Guide is applicable, particularly the “condition” and “key gases” methods. Since we do not have a “reported field failures” database, or ratio methods for determining

type of failure, these diagnostic processes are not recommended at this time. The same sampling methods and equipment are appropriate for FR3™ fluid, although the “headspace” is easier and preferred over the “direct injection” equipment. Since we do not have any field failures to obtain data from, the ratio diagnostic methods can not be verified as applicable for FR3™ fluid.

Commercial FAQs

Q: We are not allowed to specify a single source for transformers. Will you sell FR3™ fluid to other transformer manufacturers?

A: Yes, just as we have sold R-Temp® fluid to other manufacturers since 1977.

Q: We are a technologically conservative company that’s never comfortable being first. Do you have many current users? When were the first units installed?

A: The current users list includes hundreds of utilities (investor-owned, public power and rural co-op) as well as governmental, commercial, industrial and institutional end users. Thousands of new and retrofilled units, from small single phase poles to substation power transformers, have been performing flawlessly. While the first field trials began in 1996, the fluid has been successfully applied since 1999 in electrical devices from transformers to transformer/rectifier sets and switchgear to voltage regulators.

Q: Why is FR3™ fluid so expensive compared to mineral oil?

A: To minimize health and environmental concerns, the base oil is a food-grade product. Currently, production costs to make vegetable oil are higher due to harvesting, extraction and refining costs. Our current production volume also prevents us from approximating the economies of scale that apply to petroleum products. When you consider the unique advantages, the total life cycle costs still make FR3™ fluid a bargain.

Q: How can I be sure of product availability?

A: Because the base oils used in FR3™ fluid are “USA commodity oils,” there is no domestic shortage. The additives are also USA produced. CPS has been in the specialty dielectric fluids business since 1976. CPS fluids has made product availability a top priority. We have never missed a shipment deadline based on our standard lead times.

In addition, CPS maintains a sufficient inventory of FR3™ fluid to provide for emergency needs and short shipment requirements. Volumes under 1,000 gallons can be express shipped if necessary.

Q: I understand the technical advantages of the product, but expect management resistance when presenting a product with a potentially higher first cost. What tips can you provide?

A: Using net present value calculations, you can easily make a strong financial case for converting to FR3™ fluid. In fact, the payback period is usually less than 24 months. Cooper Power Systems, in collaboration with our customers, has developed a financial calculator to demonstrate the financial value of FR3™ fluid. This tool is available on CD-ROM and via the web.