



# Envirotemp® FR3™ Fluid

## Storage and Handling Guide

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# Table of Contents

## Envirotemp<sup>®</sup> FR3<sup>™</sup> Fluid Storage and Handling

	<u>Page</u>
Introduction.....	3
Precautions.....	3
Storage .....	3
Pumps.....	4
Pipe, Valves, And Fittings.....	5
Accessories.....	5
Filters .....	5
Tank Truck Unloading.....	6
Drum Handling.....	6
Heaters .....	7
Transformer Filling .....	7
Fluid Receiving.....	8
Transformer Maintenance.....	8
Table I — Recommended Acceptance Values.....	9
Figure I — Viscosity versus Temperature.....	10
Figure II — Fire Point versus Mineral Oil Content.....	10

*This guide neither claims to cover all variations in use, nor provides for every possible contingency in connection with storage, handling, application, or maintenance. Should further information be required or if particular concerns arise which are not covered in this manual, contact Cooper Power Systems, Dielectric Fluids Products.*

## INTRODUCTION

Envirotemp® FR3™ fluid is a biodegradable, fire resistant, edible seed oil-based dielectric coolant. It was developed for applications requiring high margins of both fire and environmental safety. It is fully miscible and compatible with conventional transformer oil. Envirotemp FR3 fluid can be used in many applications where its unique electrical, environmental, and safety properties are an advantage.

## PRECAUTIONS

### Fire Point

Envirotemp FR3 fluid is miscible with conventional mineral oil. Mineral oil content greater than 7 percent in Envirotemp FR3 fluid will lower its fire point below 300°C.

### Static Charge

As with other dielectric fluids, flowing Envirotemp FR3 fluid can produce a significant high voltage static charge during pumping operations. We recommend that all equipment, winding leads, containers, and piping be grounded both during pumping and for one hour after fluid flow has stopped.

### Handling Procedures

Envirotemp FR3 fluid is a natural seed oil-based fluid, and as such is biodegradable and essentially nontoxic. To maintain the optimal fluid properties for its intended use as an electrical insulating fluid, exposure to oxygen and moisture shall be minimized.

### Material Compatibility

Envirotemp FR3 fluid is compatible with most materials used in conjunction with conventional electrical grade mineral oil. Some reaction may occur when used with materials such as PVC, polypropylene, silicone rubber, and polyurethane. Compatibility should be verified with each application.

## STORAGE

Avoid extremes of temperature in storage. Store Envirotemp FR3 fluid in labeled, tightly closed

containers in cool, dry, isolated and well-ventilated areas, away from sources of ignition or heat.

### Location

The location and type of storage tank will depend on the user's physical plant arrangement.

A tank located indoors is ideal. Vertical tanks offer the largest volume per square foot of floor space and the greatest ease of draining and cleaning. An indoor location reduces the need for heating the fluid to maintain proper pumping and filtering temperatures. Storing Envirotemp FR3 fluid near an open fire or flame is not recommended.

Tanks located outdoors where ambient temperatures may fall below 0°C will require heaters to warm the fluid. Tanks placed underground should be below the frost line to minimize the effect of winter temperatures. For new installations, a thermal insulating backfill should be considered to reduce heat loss.

### Storage Temperatures

Envirotemp FR3 fluid can be pumped directly from either indoor or outdoor storage tanks. If suction line lengths or suction lifts are excessive, heating of the Envirotemp FR3 fluid may be desired in order to reduce the viscosity. The temperature of Envirotemp FR3 fluid shall be above 0°C for pumping.

Envirotemp FR3 fluid can be heated to ease pumping through long suction lines or filters, or for introduction into the transformer. Several systems are recommended:

- a) Indirect heating, such as a steam-jacketed storage tank, is preferred. The watt-density of the heating systems should be 12 W/in<sup>2</sup> or less.
- b) A circulating pump and in-line heater having a watt-density of 12 W/in<sup>2</sup> or less can be attached to a storage tank to maintain temperatures of 100°F (38°C) or higher. (A 20 GPM pump with a 10 kW heater will maintain a temperature of 110°F (43°C) in a 5,000 gallon storage tank if heat losses to the environment are not excessive.)

The tank and piping should be insulated for low ambient temperatures in order to minimize heating costs.

## **Tanks**

Standard steel storage tanks, such as those used for conventional transformer oil, are satisfactory. All tanks should conform to local codes and standards.

New tanks are preferred, and should have at least one manhole. Before use, the inside of the tanks should be sandblasted and primed with any coating that is compatible with natural ester fluid (vegetable oils). Primers used for transformer interiors are recommended.

Existing storage tanks used for conventional transformer oil can be used for Envirotemp FR3 fluid if the following conditions are met:

- a) The tank is of proper capacity and the lines for filling and suction are adequate.
- b) The tank is thoroughly cleaned and inspected closely for any rusting condition or leakage.

## **Venting**

We recommend a dry nitrogen or vacuum headspace in the storage tank. If a nitrogen blanket or vacuum is not possible, a dry air headspace is required.

A desiccant-type vent dryer can be installed to minimize the introduction of moist air into the fluid. Proper routine maintenance of the desiccant is essential. When used with a properly sized pressure/vacuum vent valve, the vent dryer can lower the dew point of the air to -100°F (-73°C).

An air filter between the desiccant canister and the tank is recommended. Filtering incoming air to the tank will prevent introduction of considerable quantities of particulate material into the fluid during storage.

Each vent dryer should have an indicator to show when desiccant should be changed. Changes of the desiccant chemical should be planned in advance of the anticipated indicator change.

Freeze-drying (dehumidification) of the air in the storage tank can also be used, but is a more expensive process.

## **PUMPS**

### **Capacity**

The viscosity of Envirotemp FR3 fluid is slightly higher than conventional transformer oil. Therefore, pump selection may require a higher capacity than that used for conventional transformer oil. Determine the maximum flow rate required. Select a pump and motor for use at the lowest temperature (highest viscosity) that will be encountered.

### **Type**

Centrifugal and positive-displacement pumps are commonly used to pump Envirotemp FR3 fluid. A standard iron pump with either a mechanical seal or stuffing box is satisfactory.

When specifying the correct size pump and motor, the pump supplier should be made aware of the viscosity, pumping rate required, suction lift, and discharge head.

For capacities up to 20 GPM, direct driven pumps have proved to be satisfactory. For higher pumping rates, a reduction gear or belt driven pump may be required.

Other pump types used successfully are the air-operated diaphragm pump, progressive cavity pump, and flexible impeller pump.

### **Horsepower**

A problem that may be encountered in pumping Envirotemp FR3 fluid is an undersized electric motor.

If pumps used for conventional transformer oil are used in an Envirotemp FR3 fluid system, it is necessary to check the motor horsepower to make sure it has sufficient capacity. Many times, the existing pump will be entirely satisfactory if a change in the motor horsepower or a lower pump speed is used.

### Caution

*If a larger motor is used, ensure that the pump and drive coupling will withstand the increased horsepower. If a change to a lower RPM is made, ensure that the required pumping rate will be obtained at the lower RPM.*

## **PIPE, VALVES, AND FITTINGS**

### **Pipe**

All piping, valves, and fittings should be properly labeled to avoid cross-contamination and to comply with applicable OSHA guidelines. As a general rule, all piping, two inch and larger, should be welded with flanged connections.

Piping with screw-type fittings should be standard schedule 40 black iron with forged fittings. A good grade Teflon-filled anaerobic pipe compound should be used.

All new piping should be flushed with either hot Envirotemp FR3 fluid or hot standard conventional transformer oil before use in order to remove any dirt or mill scale in the pipe.

### Caution

*If standard conventional transformer oil is used for flushing, the lines should be thoroughly drained afterwards. A mixture of Envirotemp FR3 fluid and conventional transformer oil having 7 percent or more of conventional transformer oil will lower the fire point below 300°C.*

*Due to the higher temperatures that may be required to pump the Envirotemp FR3 fluid, plastic or fiberglass piping may not be appropriate. PVC Material is not recommended for compatibility reasons. For cold weather pumping outdoors, pipes should be heated with either steam coils or electric resistance tracing.*

### **Valves**

Valves suitable for use with conventional transformer oil have been successfully used with Envirotemp FR3 fluid.

### Caution

*A vacuum degassing and dehydration system requires temperatures of 140°F (60°C) to 180°F (82°C). Careful selection of butterfly valve seat composition ensures fluid and temperature compatibility. Consult with the valve manufacturer for the proper selection.*

## **ACCESSORIES**

Accessories such as pressure gauges, thermometers, and flow switches should be compatible with vegetable oils.

Gaskets and packings compatible with vegetable oils should be used. Buna-N and nitrile seals will be satisfactory to about 212°F (100°C). For extended service at higher temperatures, Viton or fluorocarbon-based seals are recommended.

## **FILTERS**

### **Types**

Most types of filters used for conventional transformer oil service can be used with Envirotemp FR3 fluid. The cartridge-type filter is best suited for this service. It is offered in various micron ranges and sizes for either low or high flow rates.

Adsorption filters such as activated Fuller's Earth can be used, but additives may be removed. Contact Cooper Power Systems, Dielectric Fluids Products for advice on reclaiming aged Envirotemp FR3 fluid.

### **Flow Rate**

To obtain flow rates similar to those of conventional transformer oil, larger pore size filters may be required with Envirotemp FR3 fluid.

If filters sized for conventional transformer oil are used, flow rates may decrease due to the higher viscosity of Envirotemp FR3 fluid. Heating Envirotemp FR3 fluid decreases its viscosity. Consult Figure I to determine the temperature needed to obtain the desired viscosity.

## Degree of Filtration

For maximum dielectric strength, filter Envirotemp FR3 fluid just prior to introduction into the electrical apparatus. A filter with a nominal pore size of 1 to 5 microns is recommended.

## Moisture Removal Filters

Ester-based fluids will absorb much more moisture than a petroleum fluid before exhibiting a deterioration of electrical characteristics. This is dissolved moisture, not free water.

If moisture ingress contaminates the Envirotemp FR3 fluid above useable limits, additional treatment is required:

- a) If the moisture is in the form of free water, filter units such as the AMF CUNO Zeta-Plus and HILCO blotter paper cartridge filters can be used effectively. Desiccant packaged filter cartridges should be specified to ensure dryness of the filter media.
- b) Free water can also be removed by raising the temperature of the bulk fluid to 220°F (105°C). Agitation of the fluid will speed this process.
- c) If the dissolved moisture content must be lowered, a high vacuum dehydration system may be required. An advantage of vacuum dehydration is that dissolved air is also removed. (See section on Vacuum Filling of Transformers for details on a dehydration system.)

Molecular sieve filters are also satisfactory if the quantity of moisture to be removed is not excessive. Activated grade 3A or 4A molecular sieves are recommended for moisture removal from Envirotemp FR3 fluid, and are effective over a broad temperature range, provided adequate care is taken in filter selection to ensure sufficient residence time in the filter.

Moisture removal filters should be located upstream of the particulate filter in the fluid handling system.

## TANK TRUCK UNLOADING

### Inspection

The receiving inspection of Envirotemp FR3 fluid should follow procedures similar to those used for conventional transformer oil. Inspection and testing should be completed prior to unloading. Refer to the Receiving Tests section and Table I for recommended tests and acceptance values. In lieu of testing, the product should be visually examined. Draw a sample in a clean, clear, dry glass jar. Check the sample for clarity, color, odor, and viscosity relative to a clean sample known to be Envirotemp FR3 fluid.

If the as-received Envirotemp FR3 fluid does not meet the acceptance specifications, contact your supplier immediately.

### Unloading Envirotemp FR3 Fluid

When received in bulk, Envirotemp FR3 fluid can be unloaded using a pump. If the viscosity is sufficiently low, gravity flow works well. Filtration is recommended during the process of unloading into a bulk tank. This helps prevent the accumulation of particulate contaminants.

### Hoses and Fittings

The unloading hose should be a quality oil resistant hose designed for suction service. The hose length should be kept to a minimum. Dedicated hoses are recommended for use with Envirotemp FR3 fluid to minimize the possibility of contamination. The minimum recommended hose size is 3" ID. Hose fittings should be aluminum or brass, and firmly attached to the hose. Dry-break type quick connector fittings are recommended to reduce spillage and contamination of Envirotemp FR3 fluid. Dust caps and plugs should be used at all times that the hoses are not being used.

If the fluid temperature is so low as to cause fluid handling problems due to increased viscosity, hoses and transfer lines should be heat traced.

## DRUM HANDLING

### Storage

Drums of Envirotemp FR3 fluid are sealed at the factory to protect against foreign material and

moisture contamination during shipping. Tamper-resistant seals over the bung plugs verify that the drum has not been opened.

When storing drums of Envirotemp FR3 fluid for long periods, it is good practice to store them in a dry, heated building. If long-term outside storage cannot be avoided, the drum should be stored horizontally with the bungs of the drum below the fluid level.

A drip pan or basin is always recommended for drum storage.

## Heating

In the event the drums have been stored in a very cold environment, or it is necessary to use cold Envirotemp FR3 fluid as soon as it is received, heating the drum may be necessary to reduce viscosity.

Electric drum heaters may be used when time permits. If heating in a short period of time is necessary, heating ovens can be used.

### Caution

*One of the bung plugs must be loosened prior to heating to relieve internal drum pressures. Immersion heaters or open flame heaters are not recommended.*

## Pumping

Pumps with a positive suction capability are recommended to remove Envirotemp FR3 fluid from the drum. Positive displacement pumps, diaphragm, or air-operated drum pumps are satisfactory. Centrifugal pumps will prove satisfactory if the fluid is heated to obtain a suitable viscosity. This temperature will vary with the size and brand of pump. Contact your pump supplier to make sure that a centrifugal pump is correctly sized for a given viscosity (temperature) of fluid.

## HEATERS

### Types

Indirect heaters such as steam jackets are recommended. Electric in-line heaters, such as Chromalox or Trent brands, may be used for

heating Envirotemp FR3 fluid, provided sufficient fluid flow is present.

Use a heater with a watt density rating of 12 watts per square inch or less. Immersion heaters are not recommended.

### Controls

All heating systems should have a reliable temperature controller. When multiple heaters are used in parallel, a stepping type controller is recommended.

Each heater should also have a high temperature shut-off thermostat set at a maximum of 240°F

In systems where a heater is fed by a pump, a flow interlock must be installed in the heater outlet piping. The heaters must be de-energized when fluid flow is inadequate to prevent potential localized overheating of the fluid.

A time delay on the pump shut-off is recommended to de-energize the heaters prior to stopping the circulating pump.

## TRANSFORMER FILLING

### Vacuum Filling

When possible, fill from the bottom of the transformer tank at a slow rate. If foaming occurs when filling under full vacuum conditions, degas the Envirotemp FR3 fluid.

Degassing should be carried out at a temperature higher than that required for conventional transformer oil. The processing temperature should be at least 175°F (80°C) at a vacuum of 0.5-1.5 mm Hg. This ensures complete degassing and dehydration of the Envirotemp FR3 fluid prior to introduction into the transformer. Degassing and dehydration units are available for processing oils to acceptable levels of dissolved moisture and dissolved air.

After Envirotemp FR3 fluid is degassed, it should be introduced directly into the transformer under vacuum. If this is not possible, a storage tank that can be maintained under a vacuum at least equal

to, or greater than, the vacuum maintained in the transformer, is recommended. Otherwise, the Envirotemp FR3 fluid may exhibit excessive foaming during filling, depending on the amount of air and moisture dissolved in the fluid.

### **Atmospheric Filling**

Vacuum filling, even with only a partial vacuum, is preferable to atmospheric filling. When filling units with Envirotemp FR3 fluid at atmospheric pressure, heating and filtering the fluid are strongly recommended to maximize performance.

Fill the transformers from the bottom at a slow rate to prevent air pocket formation. The filling rate should be limited to a few inches per minute. Fluid temperatures during transformer filling operations at atmospheric pressure should be between 175-200°F (80-93°C).

Use a dry nitrogen blanket during transformer draining and filling operations.

If transformers must be filled under atmospheric conditions, heat both the transformer and the Envirotemp FR3 fluid to about 212°F (100°C) to promote more complete impregnation. For example, a 25 kW in-line heater will allow a fill rate of about 1 1/2 GPM at about 212°F (100°C). A relatively long period of time should be allowed for the transformer insulation to impregnate and cool. The transformer should not be tested or energized before it has cooled to room temperature. Higher voltage rated units will require longer setting times. Setting times should run at least two hours per kV rating of the high voltage winding.

When retrofitting transformers under atmospheric conditions, we recommend that Envirotemp FR3 fluid be filtered and heated to at least 150°F (65°C). For example, a 12 kW in-line heater will allow a fill rate of about 1 1/2 GPM at 150°F (65°C). Setting times of one hour per kV rating of the high voltage winding have been used successfully.

## **FLUID RECEIVING**

### **Inspection**

Each lot received should be inspected for container leaks.

### **Receiving Tests**

Samples should be taken from containers per ASTM D-923, as follows:

- The number of shipping containers sampled should equal at least ten percent of the number of containers received.
- The sampled containers should be chosen randomly.
- If the shipment contains drums from more than one lot, the sample should represent different lots of Envirotemp FR3 fluid. (See the drum label for the lot number of the fluid.)

When material is to be combined for production, samples may be mixed together to create a composite sample for testing. The minimum tests recommended are dielectric strength and visual inspection. A dissipation factor test is also recommended, although not essential.

Acceptance Values are given in Table I.

## **TRANSFORMER MAINTENANCE**

Periodic maintenance tests should be performed on the same schedule as would be used for conventional mineral oil transformers in a similar application. The same type of sampling techniques should be used, and liquid samples should be collected from the sampling valve located on the main drain valve near the bottom of the transformer. Basic recommended tests for Envirotemp EFR3 fluid filled transformers are dielectric strength, moisture content, and fire point.

### **Dielectric Strength**

Although the transformer should operate satisfactorily with a fluid dielectric strength of 22 kV, an Envirotemp FR3 fluid dielectric strength (per ASTM D1816) below 30 kV is an indication of excessive contamination. In this case, the Envirotemp FR3 fluid should be replaced or filtered to remove the moisture or particulate contamination.

### **Flash and Fire Points**

Small percentages of conventional transformer oil or other contaminants may substantially reduce

the flash and fire points of Envirotemp FR3 fluid. The fire point will fall below 300°C if the content of conventional transformer oil goes above 7 percent. If contamination is suspected, the fire point should be measured in accordance with ASTM D92. A fire point below 300°C indicates substantial contamination by lower fire point material.

### Drain and Refill

If it is necessary to drain and refill the transformer, take special care to avoid trapping gas bubbles in the system. Allow sufficient time between refilling and energizing the transformer to dissipate gas bubbles created during the process. See recommendations in Transformer Filling section.

TABLE I: Envirotemp® FR3™ Fluid Recommended Acceptance Values

<u>Property</u>	<u>ASTM Method</u>	<u>New Fluid as Received in Drums or Bulk</u>	<u>Limits for Continued Use of Service Aged Fluid</u>
Dielectric Strength, 0.08" gap (kV)	D-1816	≥ 40	≥ 34
Dissipation Factor at 25 °C (%)	D-924	≤ 0.15	≤ 1.0
Interfacial Tension (mN/m)	D-971	≥ 20	≥ 18
Neutralization Number (mg KOH/g)	D-664	≤ 0.07	≤ 2.5
Flash Point (°C)	D-92	≥ 300	-
Fire Point (°C)	D-92	≥ 340	≥ 300
Viscosity (cSt)	D-445	100 °C ≤ 9	-
		40 °C ≤ 40	-
Pour Point (°C)	D-97	≤ -18	-
Moisture Content (mg/kg)	D-1533B	≤ 200	≤ 400

FIGURE I: Kinematic viscosity of Envirotemp FR3 fluid as measured using ASTM D-445 and after 7 days at temperature.

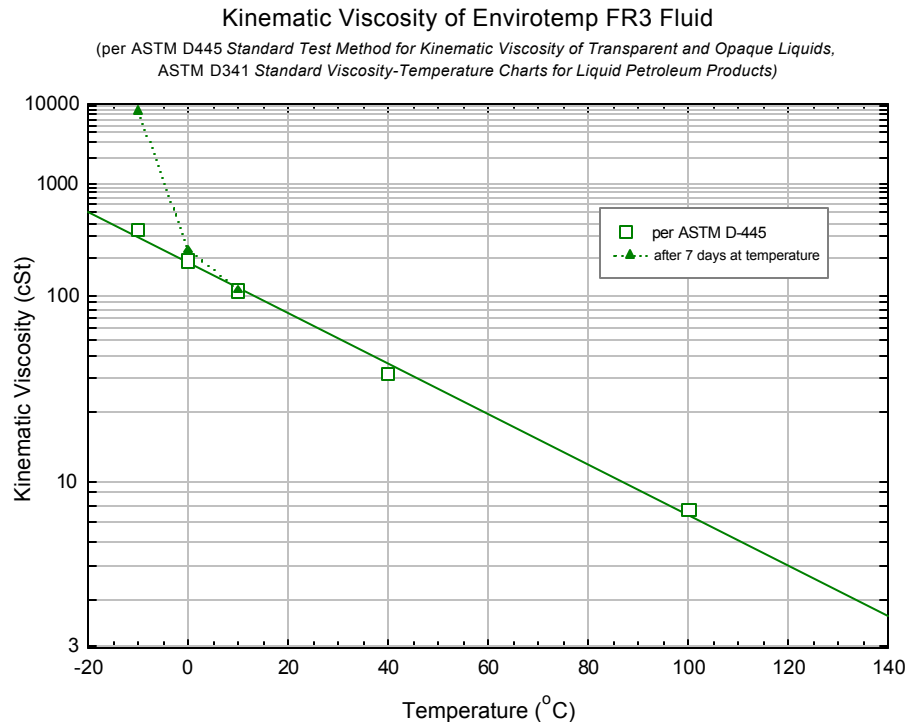


FIGURE II: Flash and fire points of a mixture of Envirotemp FR3 fluid and conventional mineral oil as a function of mineral oil content.

