



Reduce Risk Exposure for Substation Transformers

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The aging of the substation infrastructure in the United States is causing increasing concerns for risk management. The rate of installation of new units is currently very low. Compounding the problem, the load demand on existing units continues to grow, however slowly. One report by a major insurance group predicts substation transformer failures to rise by 500% within ten years as many units installed in the heyday of the 50s and 60s are exceeding their expected operational life cycle. Another insurance group reported that in a recent study period, the operational life cycle appears to be decreasing. The failures, due to insulation deterioration, occurred in transformers with an average age of just 17.8 years vs. the average expected life of around 40 years.

Unfortunately, a small but significant percentage of substation transformer failures occur in an “eventful mode,” resulting in ruptures and/or fires. In spite of established safeguards, such as deluge systems, separation distance requirements, and firewall barriers, significant fires have been reported. One insurance company reported 25 substation transformer failures costing over \$100,000 each in just one year. But often the real cost is not the damaged transformer, but rather consequential damages. For example, just this past January, two transformer substation fires were reported nationally, one at a nuclear power plant and one at a petrochemical plant. Production

downtime, lasting weeks, was estimated to cost approximately one million dollars per day for each incident. Other potential eventful failure costs include the potential for damage to adjacent equipment and property, casualties and resulting liabilities, potential environmental risk exposures, and unfavorable publicity that often accompany such eventful failures.

Fortunately, there is a practical and proven means to significantly reduce, if not eliminate the risk of substation fires: The replacement of mineral oil with fire-resistant, ester-based dielectric coolants for new and aged power transformers. Factory Mutual Global has now increased the amount of fluid volume by a factor of ten eligible for significant reduction in fire protection safeguarding for transformers containing the fire-resistant fluids.

The recent revision of the Factory Mutual Global **Property Loss Prevention Data Sheets 5-4** for transformers, has two major changes: Reduction in minimum separation distances for medium power transformers and increase in fluid volume

threshold before containment is required for highly biodegradable fire-resistant fluids.

The reduction in minimum separation distance appears in both **Tables 2a, Separation Distance Between Outdoor Liquid Insulated Transformers and Buildings** and **Table 2b, Outdoor Fluid Insulated Transformers and Equipment Separation Distance**. In the previous version of the LPDS (Revision Jan. 2001), the minimal horizontal distance for FM Approved, fire-resistant, dielectric fluid-filled equipment was 5 feet to non-combustible construction, and was limited to transformers containing 1,000 gallons. The volume has been increased to allow transformers containing up to 10,000 gallons with this clearance. This compares to the limit of less than 500 gallons for conventional mineral oil transformers with a minimum of 15 feet to non-combustible construction. In addition, the distance is measured from the transformer for the FM Approved fluids, but for mineral oil units it typically must be measured from the outside edge of the required containment means.

Table 2a Separation Distance Between Outdoor Liquid Insulated Transformers and Buildings

Liquid	Approved Transformer or Equivalent	Liquid Volume, gal (m ³)	Horizontal Distance			Vertical Distance ft (m)
			Two Hour Fire Resistant Construction, ft (m)	Non-combustible Construction, ft (m)	Combustible Construction, ft (m)	
Less Flammable (Approved Fluid)	Yes	N/A	3 (0.9)			5 (1.5)
	No	≤10,000 (38) >10,000 (38)	5 (1.5) 15 (4.6)		25 (7.6) 50 (15.2)	25 (7.6) 50 (15.2)
Mineral Oil or (Unapproved Fluid)	N/A	<500 (1.9)	5 (1.5)	15 (4.6)	25 (7.6)	25 (7.6)
		500-5,000 (1.9-19)	15 (4.6)	25 (7.6)	50 (15.2)	50 (15.2)
		>5,000 (19)	25 (7.6)	50 (15.2)	100 (30.5)	100 (30.5)

Table 2b Outdoor Fluid Insulated Transformers Equipment Separation Distance

Liquid	Approved Transformer or Equivalent	Fluid Volume, gal (m ³)	Distance ft (m)
Less Flammable (Approved Fluid)	Yes	N/A	3 (0.9)
	No	≤10,000 (38)	5 (1.5)
		>10,000 (38)	25 (7.6)
Mineral Oil or (Unapproved Fluid)	N/A	<500 (1.9)	5 (1.5)
		500-5,000 (1.9-19)	25 (7.6)
		>5,000 (19)	50 (15.2)



Significant transformer fires have been reported despite established safeguards

For example, consider a 100 MVA unit with a total of 10,000 gallons in the main tank and LTC compartment. The new minimum required horizontal distance between its tank and the next closest equipment or non-combustible construction wall is 5 feet if the dielectric coolant is FM Approved. For mineral oil filled transformers, the minimum separation is the distance from the tank to the edge of the containment area, plus 50 feet.

The bases of the above changes are primarily due to both the fire safety record of less-flammable fluid and recent “worst case” fire testing performed at the Thomas A. Edison Technical Center in Franksville, Wisconsin. Previous high fault primary and secondary testing has shown that it is essentially not possible to ignite liquid less-flammable fluids by arcing as the ignition source. The more recent testing has shown that another ignition means, glowing hot metal, easily and quickly ignites conventional transformer mineral oil, but does not ignite fluids with fire points greater

than 300°C under the same operational conditions. There have been no reported fires involving any of Cooper Power Systems’ fire-resistant fluids since the introduction of the first such dielectric coolant, R-Temp® Fluid, in 1975.

The other major revision in the new FM LPDS for transformers involves changes in the threshold volumes requiring fluid containment for environmentally preferred dielectric fluids such as Envirotemp® FR3™, the natural vegetable oil based fluid. Transformers filled with fluids certified as biodegradable by the EPA, containing less than 2640 gallons where the release of such a fluid does not expose navigable waterways, may be exempt from the FM Global containment requirement. The threshold for mineral oil is 500 gallons or less, depending on exposure to buildings.

The US EPA has certified the biodegradability of Envirotemp FR3. When tested per the EPA Method OPPTS 835.3100, its biodegradation

rate and completeness slightly exceeds that of a material the EPA classifies as “Ultimate Biodegradability.” Because the US EPA has published its verification of our published environmental claims of Envirotemp FR3 fluid, transformers with the fluid can bear the US EPA ETV logo. ETV is the acronym for Environmental Technologies Verification. Envirotemp FR3 is the first transformer material to receive the US EPA ETV status.

Both initial and maintenance cost for containment and fire protection at a substation can be very high. The new FM Global requirements offer high potential savings by substituting alternative fluids for mineral oil. For complete details on the revised FM Global Loss Prevention Data Sheets-Transformers, please visit their website at www.fnglobal.com. To get additional information on Envirotemp FR3 fluid, visit www.cooperpower.com/longlife.

THE LINE

Benefits of the New Envirotemp FR3 Dielectric Coolant in Power Transformers

- Reduced Fire and Environmental Liability, Insurance Costs
- Reduced Clearances to Equipment and Buildings
- Permits Shorter Bus Runs, Reducing Energy Losses and Materials
- Reduction in Physical Space Requirements
- Reduction in Aging Rate of Insulation System
- Operational Life Extension
- Increased Overloadability
- Prevents Moisture Buildup in Insulating Paper
- Essentially Eliminates Vapor Formation Under Sudden Overload Conditions
- Significant Reduction in Voltage Stress Gassing Tendency
- Field Retrofill Experience through 50 MVA
- Elimination of Sludge and Copper Coking