Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
I. Oil		
A. Conventional	• Low Transformer Cost • Lower Viscosity at Low Temperatures • Liquid Dielectric Performance • Low Maintenance Cost • Biodegradable/Low Toxicity Fluid • Preventative Maintenance (DGA) per IEEE C57.104 • Loadbreak Operations • Long Service Life Expectancy • Typically Self-Healing Under Temporary Dielectric & Thermal Overstress • Easy to Reprocess/Dispose • Pour Point < -35°C	• Requires Vault per NEC® Article 450-C (Indoor) • Higher Installation Cost • Relatively Low Fire Point • Not Favored by Insurance Companies • Containment with Absorption Bed May Be Required • Deluge Extinguishing System May Be Required • Longest Clearance Distances • Excessive Minimum Clearance Distance May Be Required (Outdoor) • Fire Barriers May Be Required (Outdoor) • Not Classified as Edible Oil • Non-Renewable Resource Based
II. Less-Flammable Liquids		
A. Fire-Resistant Hydrocarbons (R-Temp® Fluid)	• **Flawless Safety Record Since Introduction (1975)** • Excellent Loadbreak Performance • Excellent Dielectric Properties • Field Proven Through 550 kV BIL • Biodegradable • Widest OEM Acceptance • Low UL Fire Hazard Value (4-5) • Essentially Non-Toxic to Humans • Excellent Compatibility • Not Listed as Hazardous Waste • Easy to Reprocess/Dispose • Good Stability/Essentially Non-Sludging • UL Classified - Bayonet with CL Fuses Allowed • FM Approved • UL Classified • Lower Cost	• Higher Viscosity at Low Temperature • Liquid Containment Means Required per NEC 450-23 (Indoor) • Higher Cost than Conventional Mineral Oil • ≈ 3% Mineral Oil Contamination Reduces Fire Point < 300°C • Not Classified as an Edible Oil • Pour Point –21°C

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COOPER Power Systems

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Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
A. Fire-Resistant Hydrocarbons (cont'd)	• Low Maintenance Cost • Available in Listed Transformers • Excellent Very High Temperature Stability (Aramid Paper Aging Test Passed at 250°C, 4000 Hours) • Preventative Maintenance (DGA) per IEEE C57.104 • NEC Recognition Since 1977 • NESC Safeguard Recognition Since 1993 • Listed Transformer Option Available • Long Service Life Expectancy • Typically Self-Healing Under Temporary Dielectric & Thermal Overstress • Fully Miscible with Conventional Transformer Oil, Natural and Synthetic Esters and Most Askarel Substitutes	
B. Natural Ester (Envirotemp® FR3™ Fluid)	• **Flawless Safety Record Since Introduction (1997)** • Time to Kraft Paper End-of-Life Improvement 5-8 Times • Excellent Dielectric Properties • Excellent Clarity • Rapidly and Completely Biodegrades • Low Viscosity • Best Lubricity • Non-Toxic • Generally Good Compatibility • Not Listed Hazardous Waste • Essentially Non-Sludging • Low Maintenance Cost • Preventative Maintenance (DGA) • Food Grade Ingredients • Renewable Resource Based • Low UL Fire Hazard Value (4-5)	• Higher Cost than Mineral Oil • Liquid Containment Means Required Per NEC 450-23 (Indoor) • Some Material Incompatibilities (Certain PVCs) • Pour Point –21°C

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Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
B. Natural Ester (cont'd)	• Ease to Reprocess/Dispose • Good Stability • UL Classified – Bayonet with CL Fuses Allowed • FM Approved • UL Classified • NEC & NESC Safeguard Recognition • Listed Transformer Option Available • Long Service Life Expectance • Typically Self-Healing Under Temporary Dielectric & Thermal Overstress • Complies with Edible Oil Act • Fully Miscible with Conventional Transformer Oil, High Molecular Weight Hydrocarbons and Most Askarel Substitutes	
C. Synthetic Ester (Envirotemp® 200 Fluid)	• **Flawless Safety Record Since Introduction (1984)** • Excellent Loadbreak Performance • Excellent Dielectric Properties • Essentially Non-Toxic • Rapidly Biodegrades • Lowest Viscosity of Less-Flammable Fluids • Best Lubricity • Generally Good Compatibility • Not Listed Hazardous Waste • Essentially Non-Sludging • Low Maintenance Cost • Preventative Maintenance (DGA) • Long Service Life Expectancy • Typically Self-Healing Under Temporary Dielectric & Thermal Overstress • NESC Safeguard Recognition Since • Very Low Pour Point (-55°C)	• High Cost • Liquid Containment Means Required per NEC 450-23 (Indoor) • Some Material Incompatibilities (Certain PVCs) • Not Listed by UL or FM

Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
D. Silicone (Dienthylsiloxane)	• Overall Good Fire Safety Record • Lowest Viscosity at Low Temperatures • Very Low Pour Point • Excellent Stability (<150°C) • Excellent Clarity • NEC Recognition Since 1977 • NESC Safeguard Recognition Since 1993 • Low UL Fire Hazard Value (4-5) • FM Approved • UL Classified • Wide OEM Acceptance	• Non-Biodegradable • Persistence Potential in Environment • Produces Hazardous By-Product Particulates When Combusted (Oxides of Silicon, 80% of Liquid Weight) • Higher Viscosity at Nominal Operating Temperatures • Material Non-Compatible (Silicone & Standard Gaskets, Petrolatum, etc) • Not Compatible with Most Loadbreak Operations • Poor Lubricity • Silicone Contamination (ppm) Can Cause Conventional Oil Foaming Under Vacuum • Special Concern for Paint Line Contamination • Very High Cost • Disposal Difficulties & High Cost • UL Classification Doesn't Allow Bayonet Fuses in Silicone • Containment Means Required Indoor • Adjudicated Liability on Adverse Health Effects of Silicone Implants • Non-Self Healing Under Temporary Dielectric & Heat Overstress (Can Form Semi-Conductive Bridging) • DGA Per IEEE C57.104 Not Applicable • Not Miscible with Conventional Transformer Oil, Natural or Synthetic Esters, or High Molecular Weight Hydrocarbons

Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
E. Synthetic Hydrocarbons (Polyalpha Olefins)	• Excellent Dielectric Properties • Good Low Temperature Viscosity • Excellent Lubricity • Essentially Non-Toxic • Biodegradable • Typically Self-Healing Under Temporary Dielectric & Thermal Overstress	• High Cost • Limited OEM End-Users
III. Non-Flammable Liquids/Gases		
A. Perchloroethylene	• No Fire Point • Used for Retrofilling PCB Transformers (Interim and Permanent) • FM Approved • UL Classified • Low Viscosity	• **No Longer Offered in New Transformers in USA** • Hazardous Material • Suspected Carcinogen • Listed Carcinogen, State of California • Limited Equipment Manufacturers • Banned for Transformer Applications by US Corps of Engineers & Others • Extreme Concern for Thermal Decomposition By-Products, e.g. HCL, Trace Dioxin, Phosgene • Severe Environmental Restrictions in NEC (Section 450-24) • EPA Listed Hazardous Air Pollutant
B. Trichlorobenzene	• No Fire Point • Used in Retrofilling PCB Transformers (Interim) • Low Viscosity	• **No Longer Offered in New Transformers** • Hazardous Material • Suspected Carcinogen • Limited OEM Acceptance • Extreme Concern for Thermal Decomposition By-Products, (Dioxin) • Severe Environmental Restrictions in NEC (Section 450-24) • EPA Listed Hazardous Air Pollutant

Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
C. Freon	• No Fire Point • Low Viscosity	• **No Longer Offered in New Transformers** • Chlorofluorocarbon (CFC) Based • Tied to Ozone Depletion • Future Availability Uncertain • Leaks Can Go Undetected • Special Maintenance Concerns • Unusual Physical Dimensions • Severe Environmental Restrictions in NEC (Section 450-24)
D. Sulphur Hexafluoride (SF_6)	• No Fire Point • Ease of Code Compliance • No Liquid Containment Needed • Excellent Dielectric Withstand	• Extreme Concern for Arcing Thermal Decomposition By-Products (e.g. S_2F_{10}) • Most Potent Green House Gas Evaluated by EPA • Environmental Persistence Measured in Tens of Thousands of Years • Larger Footprint • Poor Cooling Medium • High Cost of Special Transformer Design • Higher Noise Level • Susceptibility to Harmonic Currents • DGA not Available • Heat Output Stresses HVAC • Lower Standard Overload Capacity • Escallating Pricing • Odorless, Oxygen Displacing Gas • Typically Requires Remote Heat Exchanger

Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
IV. Dry		
A. Open Dry	• Low First Cost • Many Manufacturers • Ease of Code Compliance • No Liquid Containment Needed	• Subject to Contamination • Higher Standard Energy Losses • Require Periodic Cleaning • Reported Fires • Higher Noise Level • Lower Standard BIL Levels • High Enclosure Temperature • Standard Enclosure Does Not Pass Wire Probe & Pry Test (ANSI/IEEE C57.12.28) • Special Outdoor Enclosure Affects Load Capacity & Increases Cost • Greater Susceptibility to Harmonic Overheating • Lower Standard Overload Capability • BIL Subject to Degradation Due to Contaminants (Dust, Lint, Etc.) • Larger Footprint • DGA Preventive Maintenance Not Available • Heat Output Stresses HVAC (Indoor) • Non-Self Healing Insulation
B. Cast Resin	• Better Resistance to Contamination Than Open Dry-Type • Ease of Code Compliance • No Liquid Containment Needed • Better Short Circuit Withstand Than Open Dry	• Long Term Reliability Not Proven • Higher Standard Energy Losses • High Cost • Difficult to Repair Coil (Cost/Lead-Time/Limited Sources) • Low Standard BIL Levels • DGA Preventative Maintenance Not Available

Transformer Options For Fire Sensitive Locations

Type	Advantages	Disadvantages
B. Cast Resin (cont'd)		• Greater Susceptibility to Harmonic Overheating • Reported Explosions and Fires • Epoxy Cracking Concerns (Thermal Cycling) • Non-Recyclable Coils - Landfill Disposal • Larger Footprint - Heavier • Heat Output Stresses HVAC • Requires Periodic Bus Bar Cleaning • Relatively Few Manufacturers & Repair Facilities

To the best of our knowledge, the information in this bulletin is accurate at the time of printing. Supporting documentation available upon request.