SOLTEX

Soltex, Inc.
www.soltexinc.com

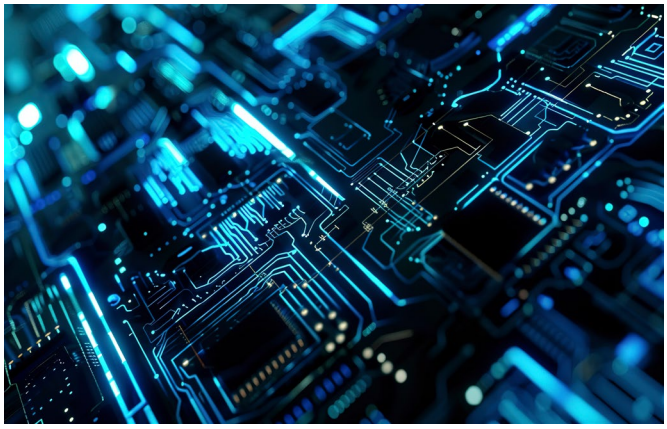
Electrical Insulating Fluids

Application and Handling Guide

Contents

Soltex, an Introduction:

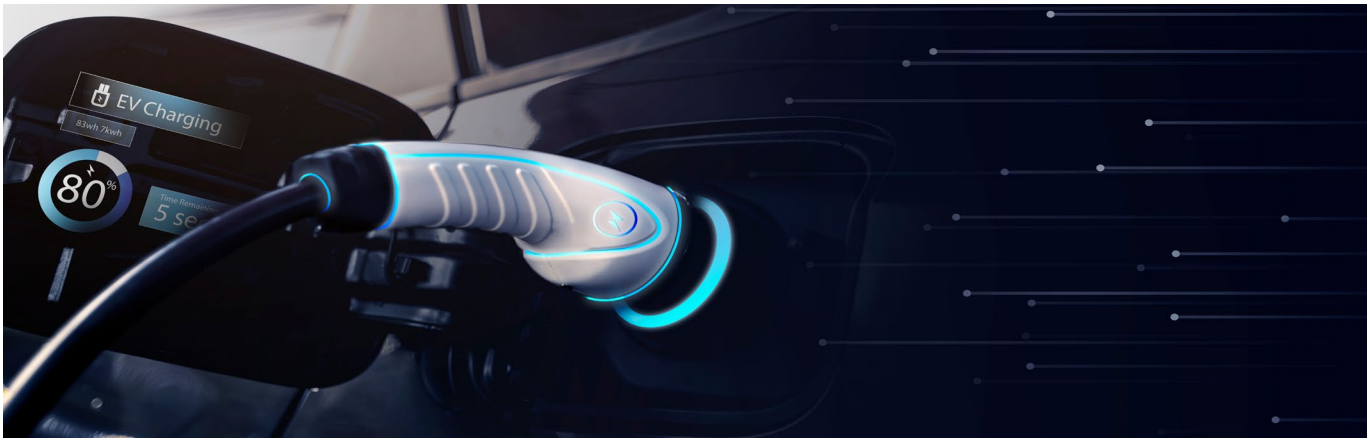
Soltex, Inc. makes oils that cool electrical circuits. Our oils are used in many industries to provide cooling and electrical insulation solutions. Our oils cool power-dense electronic circuits and high torque DC automotive motors. We help companies make better and safer electric batteries. Soltex's oils lower the operating costs of power transformers and protect them against fire and explosion. Our oils cool military and aerospace computer, F1 auto motors, robots, and underwater vehicles. Our highly biodegradable oils can be used in environmentally sensitive applications.



You'll find Soltex wherever electrical circuits are cooled.

Soltex continually develops and introduces new products to take advantage of new materials and to address specific customer and market needs.

With a line of environmentally safe, highly efficient products,
Soltex is positioned to be the leading company in electrical circuit cooling.



Soltex ALPHA-1®

Fire Resistant Insulating Oil

Alpha-1 fluid is a fire-resistant cooling and insulating oil with superior heat transfer and oxidation resistance. Because of its exceptional heat transfer characteristics, it is the industry standard for retrofilling mineral oil transformers. Alpha-1 Fluid is made with synthetic hydrocarbon oils, and has both the best heat transfer characteristics and the best low-temperature properties available.

Alpha-1 pumps easier, is biodegradable, and is compatible with conventional transformer oil and any insulation that is compatible with oil.

APPLICATIONS: Use Alpha-1 fluid in any application for heat transfer fluid where the risk of fire must be minimized. These include power and distribution transformers, motors, batteries and in high voltage switchgear.

Alpha-1 Fluid excels in jobs where operating temperatures need to be minimized. With Alpha-1 Fluid, equipment will run at the lowest temperatures possible. Alpha-1 Fluid has oxidation resistance that is superior to other dielectric oils. This means longer service life. Its electrical characteristics are excellent.

Alpha-1 Fluid is also chosen for use in high temperature transformers, in overloaded transformers, in viscosity-dampened switchgear, and in very low-temperature applications. Alpha-1 Fluid has become the fluid of choice for retrofilling mineral oil filled transformers to upgrade their fire safety.

FEATURES:

- Alpha-1 fluid is
- crystal clear in color. Alpha-1 fluid has a **high dielectric strength**.
- Alpha-1 fluid has an **excellent fire safety rating**
- Alpha-1 fluid **cools transformers efficiently**
- Alpha-1 fluid is an **excellent switching medium**
- Alpha-1 fluid is **compatible with** mineral oil and PCB fluids.

FM APPROVED

Soltex BETA® FLUID

Fire Resistant Insulating Oil

Beta fluid is an insulating oil used to improve fire safety in transformers and switchgear. Beta fluid resists ignition by electrical arc or flame yet maintains excellent electrical characteristics. Beta Fluid is 100% hydrocarbon and biodegradable.

Beta Fluid is the industry standard for fire-resistant dielectric insulating oils. Universally interchangeable with mineral oil, it is an economical way to provide fire resistance to transformers and electrical equipment.

Blended with carefully selected petroleum oils, Beta Fluid is guaranteed to be compatible with other dielectric fluids including Alpha-1 Fluid, mineral transformer oil and fluids containing PCBs or solvents. The base oils used for Beta Fluid are 100% hydrocarbon

APPLICATIONS:

Beta fluid can be used in any application for dielectric fluids. Beta fluid has been used in power and distribution transformers, transformer-rectifier sets, voltage regulators, and in load break and tap changer switches.

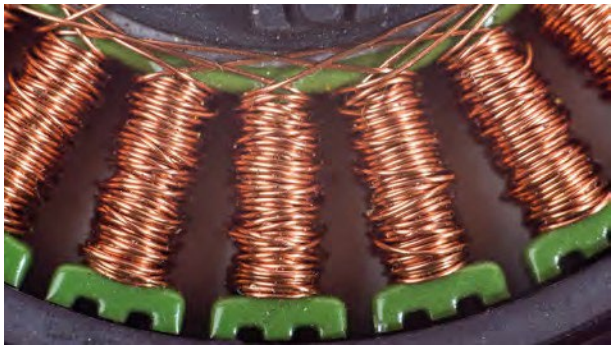
FEATURES:

- Beta fluid has a **high dielectric strength.**
- Beta fluid has **excellent oxidation stability**.
- Beta fluid is **biodegradable and nontoxic.**
- Beta fluid is **compatible** with mineral oil.
- Beta fluid is an **excellent switching medium.**

Soltex ALPHA-2® FLUID

Synthetic Heat Transfer Fluid
for RF Transmitters and Ceramic Poling

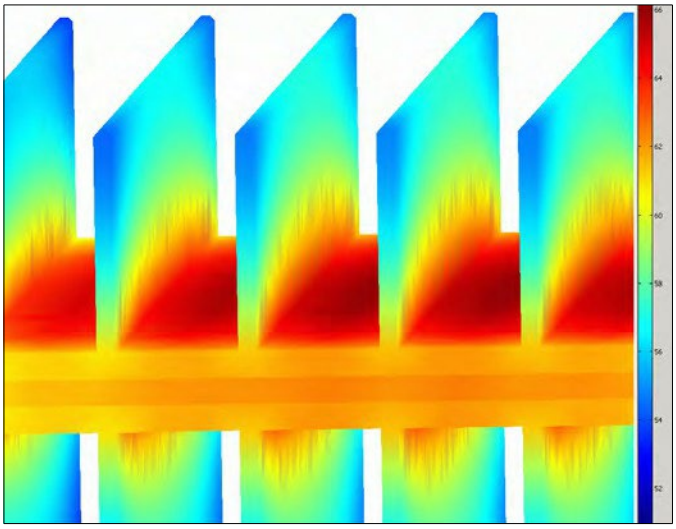
Alpha-2 Fluid is a dielectric and heat transfer oil for special applications where operating temperatures are very high or ambient temperatures are very low. Made with 100% synthetic hydrocarbon oils, it is compounded with the most advanced antioxidants available. Providing excellent heat transfer characteristics and long service life. As Alpha-2 Fluid pours at temperatures down to -65 C, so it can be used at temperature extremes.



Biodegradable and compatible with other oils and with standard insulation materials, Alpha-2 Fluid cools equipment better than other fluids. It has excellent resistance to oxidation and aging, and it maintains its high dielectric strength for years.

Applications

- Cooling of high-power transmission equipment – Radar, RF, VHF, Microwave
- Motor Cooling
- Medical Instrument Cooling
- Poling of ceramics used in high tech piezoelectric cells
- Battery Cooling



Features:

- Alpha-2 Fluid has a low viscosity.
- Alpha-2 Fluid is crystal clear and has no odor.
- Alpha-2 Fluid has a high dielectric strength.
- Alpha-2 Fluid has an excellent fire safety rating
- Alpha-2 Fluid cools equipment efficiently

TYPICAL CHARACTERISTICS OF SOLTEX INSULATING OILS

Property and Test Method	Alpha-1 Fluid	Beta Fluid	Alpha-2 Fluid
Color, ASTM D1500:	Clear	0.5	**Clear**
Kinematic Viscosity, ASTM D445, cSt:			
Temperature, °C			
-40	32650	-	**468**
-20	2980	-	**86.7**
0	510	1950	**27.2**
20	165	380	**11.9**
40	62.9	110	**6.4**
60	24.1	40.3	**4.0**
80	12.2	20.4	**2.7**
100	8.6	10.1	**2.0**
Specific Gravity, ASTM D1298	0.84	0.87	**0.83**
Pour Point, ASTM D97, °C	-55	-21	**-75**
Flash Point, ASTM D92, °C	268	272	**238**
Fire Point, ASTM D92, °C	304	308	**250**
Coefficient of Expansion, /°C.	0	0	**0**
Moisture Content, ASTM D1533, ppm	10	13	**9**

Electrical Characteristics

Dielectric Strength, kV, ASTM 1816	58	63		**42**
Dissipation Factor, 20 C., ASTM D924, %	0.01	0.01		**0.01**
Dissipation Factor, 100C., ASTM D924, %	0.01	0.1		**0.01**
Dielectric Constant @ 20 C., ASTM D924	2.12	2.3		**2.1**
	0	0		**0**
Resistivity @ 20 C., ASTM D1169, ohm-cm				
OXIDATION RESISTANCE				
ASTM D2440 oxidation test	< 0.01	< 0.01	< 0.01	
72 Hours	0	0.14	0	
Sludge, Weight				
percent Acid Value,	0.01	0.06	0.01	
mg KOH/g 164	0.01	0.26	0.02	
Hours				
Sludge, Weight percent				
Acid Value, mg KOH/g				
Rotary Bomb Test, ASTM D2112, minutes	**384**	**230**	**>350**	

Values shown are considered "typical" of Soltex current production. Contact Soltex for more information and for sales specifications.

THERMODYNAMIC PROPERTIES:

For **Specific Heat Capacity** (kw-s/kg-k, also known as J/g/K), use the following equations:

Alpha-1: Cw = 2.046+(.00363 T), where T is the temperature in degrees C.

Beta: Cw = 2.065+(.00452 T), where T is the temperature in degrees C.

Alpha-2: Cw = 2.05+(.00373 T), where T is the temperature in degrees C.

For **Thermal conductivity** in W/m/K:

Alpha-1: L = 0.160-(.0000376 T), where T is the temperature in degrees C. Beta

: L = 0.153-(.0000143 T), where T is the temperature in degrees C. Alpha-2:

L = 0.143-(.000053 T), where T is the temperature in degrees C.

Gassing Tendency, ASTM D2300b, ul/min

Alpha-1 Fluid:	31
Beta Fluid:	20
Alpha-2 Fluid:	26

Gas evolved with arcing:

Beta Fluid has been tested and shown to evolve 50 cc per kw-sec of total arc energy (approx. 8.5% less than conventional transformer oil)

Toxicity: LD50 (oral) for rats: The LD50 for each of Soltex's products is >50 mg/kg bodyweight

Biodegradation: See later section on "Environmental Fate"

Elemental Analysis:

Soltex's products are based on hydrocarbon base oils. The base oil's only constituent elements are hydrogen and carbon. Additives used in Soltex's heat transfer fluid products are "ashless" and do not contain metals, halogens or phosphates.

Stability and Influence of Moisture

Alpha-1, Alpha-2, and Beta fluids are 100% hydrocarbon, and are stable in the presence of moisture. All Soltex dielectric fluids adsorb moisture from the air and other porous insulation at about the same rate as conventional mineral transformer oil. At 20 C., it takes about 80 ppm of water to saturate Alpha-1 or Beta Fluids – about the same as for standard mineral oil.

Compatibility with Equipment Construction Materials

Soltex products are tested and proven compatible with all equipment construction materials that are used with conventional mineral oil. They are less aggressive to paints, varnishes, rubbers, and other materials than conventional oil. Soltex fluids are compatible with all gasket materials that are commonly used with conventional mineral transformer oil.

Some of these materials that are often used are:

Nitrile Rubber	Silicone Rubber
Buna-n Rubber	Viton
Cork	Fluorocarbon Rubber
PVC Wire Insulation	All types of metals
Laminated Circuit Boards	Plastic connectors and plugs

Alpha and Beta fluids are compatible with a wide variety of transformer components, including several types of plastic and paper insulation. Alpha Fluid has been used with many types of phenolic, epoxy and formaldehyde resins. Both conventional and high-temperature application papers (Nomex) have been used in equipment filled with Soltex's fluids. Soltex recommends that any equipment construction materials chosen be tested for compatibility before use.

RECEIPT AND HANDLING OF INSULATING OILS

Recommended Acceptance Values for Alpha-1 and Beta Fluids

Soltex recommends the use of values set by ASTM D5222 (Standard Specification for High Fire Point Mineral Insulating Oils) [2] and IEEE C57.121 (Standard Guide For Acceptance and Maintenance of Less Flammable Hydrocarbon Insulating Oils).[3]

Soltex does not guarantee a value for Interfacial Tension (IFT). We do not recommend the use of the minimum IFT values in ASTM D5222 or IEEE C57.121. This is because the specifications in these guides were written for Group II base oils of the 1980s. Changes in refining technology and crude oil sources have made these values obsolete.

Shipping Containers:

Soltex's fluids are available in five gallon containers, 55 gallon drums, 275 gallon "tote" containers, or tank trailers. Each type of shipping container should be handled according to standard industry practice in order to ensure that the fluid will retain its original characteristics.

Receipt and Inspection of Shipments:

The receipt and inspection of dielectric fluids should follow standard industry practice. Dielectric fluids should be sampled with great care, in clean, glass containers, in order to minimize the possibility of contamination with water, dirt, other oils or greases. ASTM D943, while addressing sampling of power transformers, remains a definitive authority on the subject of sampling procedure. Contact Soltex with any questions.

For bulk shipments, test and inspect the fluid before the fluid is unloaded. For shipments received in drums, a representative sample should be taken from several of the drums and blended together.
The sample should be taken in a clean, clear, dry glass jar. If the fluid does not meet the recommended acceptance values shown above, contact Soltex, Inc. immediately.

For recommendations regarding types of hoses or pumps to be used with our oil products, please contact Soltex, Inc.

Fluid Storage and Drum Handling:

When containers insulating oils are to be stored for a long period of time, store them in a dry, heated building. Outdoors, drums should be stored horizontally, with the bungs below the internal oil level. A drip pan or curb around the storage area should be used to contain any fluid from a ruptured or leaking container. Totes should be covered. Pails should always be stored indoors.

Contamination of Fire Resistant Fluids with Other Materials:

Standard equipment is used for handling and processing Alpha-1 Fluid, Beta Fluid and Alpha-2 Fluid. Dedicated processing equipment is best.

Be sure to minimize the amount of conventional transformer oil that is mixed with any fire resistant fluid. The fire point of the Alpha or Beta fluid will be lowered if they are blended with conventional transformer oil. In order to minimize the amount of transformer oil contamination, flush the fluid handling system with Alpha or Beta fluid before use. The flush oil can be reserved for similar future application, blended into conventional transformer oil, or discarded in an appropriate manner.

PROCESSING DIELECTRIC FLUIDS INTO TRANSFORMERS

Dissolved gases:

Degassing a fluid removes gases and dissolved moisture. It increases the dielectric strength of the fluid and the effectiveness of the saturation of the fluid into the solid insulation of a transformer. The degassing process for a fire resistant fluid should be carried out at higher temperatures than those required for conventional oil. The processing temperature should be at least 175 °F (80 °C) at a vacuum of 0.5 to 1.5 torr (mm Hg). This will ensure complete degassing and dehydration of the fluid.

Filling Equipment with Soltex Dielectric Fluids:

Whether equipment is to be filled under vacuum or atmospheric conditions, heating the fluid will enhance the efficiency of cellulose impregnation. All transfer lines should be flushed thoroughly with clean, processed fluid. Transformers should be filled with insulating oil from the bottom. The filling rate should be limited to a few inches per minute. The temperature of the fluid during this operation should be 175 - 200 °F (80 - 94 °C). Blanket the equipment with dry nitrogen or dry air, if possible. The oil should be warm to prevent condensation of atmospheric moisture and to aid in solid insulation impregnation.

The transformer should not be tested or energized before it has cooled to ambient temperature. Allow at least one and a half times as much time for the insulation to become saturated as you would allow for conventional mineral oil. Higher voltage rated units will require longer impregnation and cooling time than low-voltage units.

If the equipment is being filled with fluid under vacuum, be sure that the vacuum held on the tank does not exceed the maximum tank wall strength.

Other equipment can be filled via pump or gravity. Minimize entrained air and bubbles.

Cleaning:

Alpha-1 Fluid, Alpha-2 Fluid and Beta Fluid can each be easily cleaned from surfaces with aqueous degreasers or soaps.

MAINTENANCE OF SOLTEX FLUID PRODUCTS IN EQUIPMENT

Maintenance Schedules:

Periodic maintenance testing on equipment filled with fire resistant fluids should be performed on the same schedule as used for equipment in a similar application that is filled with conventional transformer oil. Refer to ASTM Standard Method D923 for the correct methods of sampling fluid from equipment. Contact Soltex for recommendations regarding continued use of service- aged Alpha or Beta Fluid.

Dissolved Gas Analysis:

Solid and liquid insulation decompose when exposed to high temperatures. The types of gases produced in this decomposition depend upon the temperatures that are experienced. Analysis of the gases that are dissolved in the insulating oil can help the equipment operator detect and identify problems in the equipment. Hot spots in a transformer's windings, for example, produce different gases than arcing from a loose internal connection. The analysis of dissolved gases in Alpha and Beta Fluid uses the same procedures that are used with conventional mineral oil.

The application is described in ANSI-IEEE Guide C57.104, "Guide for the Detection and Determination of Generated Gases in Oil-Immersed Transformers and Their Relation to the Serviceability of the Equipment". Use C57.104 with Alpha or Beta Fluid. It is important to note that dissolved gas analysis provides only guidelines; it is only able to provide advice with respect to transformer problems and diagnostic direction.

Reprocessing Alpha or Beta Fluid:

Alpha or Beta Fluid can be reconditioned in the same manner as conventional transformer oil. This process cleans oil that has been oxidized or contaminated with water, arc decomposition products or other matter Use the same types of equipment and the same methods as with conventional transformer oil. The oil will flow more slowly through the equipment, because of its higher viscosity.

Water can be removed from insulating oils with a centrifuge, vacuum dehydrators or moisture absorbing filters. Particulate matter may be removed by filtration through a filter with a small pore size (0.5 micron). For specific recommendations regarding reclamation processes for hydrocarbon- based dielectric fluids, consult IEEE Standard 637-1985, "Guide for Reclamation of Insulating Oil and Criteria for Its Use".

SAFETY AND ENVIRONMENTAL INFORMATION

Biodegradation: Alpha-1 Fluid, Beta Fluid, and Alpha-2 Fluid are each "ultimately biodegradable", per industry standards. Soltex's dielectric fluids contain no hazardous or toxic substances such as halogens or metallic compounds They are saturated hydrocarbons, which is one of the simplest and fastest types of compounds to biodegrade. The fluids do not contain carcinogenic substances.

Toxicity:

Alpha Fluid and Beta Fluid are virtually non-toxic. These types of oils are neither mutagenic nor carcinogenic. Testing effects indicate that they pose little risk to personnel when handled with normal handling procedures. LD_{50} values are over 40 grams per kilogram of bodyweight.

Skin contact testing has shown that Alpha and Beta fluids have little effect on intact or abraded skin. Some people experience a slight allergic irritation to oils, which makes their skin redden.

Inhalation of oil mist can irritate your lungs. We advise you to take conventional industry precautions against inhalation of mist or vapors, just as you would be with any oil product.

Spills of Alpha or Beta fluid are not required to be reported to CERCLA.

A spill of any oil on water should be contained with floating dikes and removed with oil-skimmers and wringing equipment. If enough oil is spilled that is visible on the surface of a navigable waterway, the U.S. Coast Guard must be notified. Carbon-ingesting microbes can help to speed the cleaning of an oil spill site. To report a spill, call the National Response Center (a Federally funded office) at 1-800-424-8802.

Spill Control Information:

If a spill of any fluid occurs on land, contain the spilled material with dikes of earth, sand or commercially available spill control pillows. Scoop up excess oil and dispose of it properly. (Put the saturated pillows or sand into drums and have them taken away by a firm licensed to dispose of wastes).

References and Notes:

1. Product characteristics shown in this Guide are considered "typical" of Soltex current production. Contact Soltex for more information and for sales specifications.

2. Please consult www.soltexinc.com for the latest information on product characteristics

3. ASTM Standard D5222 "Standard Specification for High Fire-Point Mineral Electrical Insulating Oils". ASTM.org

4. IEEE C57.121 "IEEE Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers", IEEE.org

Safety Data Sheets

The most current Safety Data Sheets may be obtained at the following links:

Alpha-1 Fluid: https://soltexinc.com/wp-content/uploads/2024/05/Alpha-1-SDS-GHS-10-10-23.pdf

Beta Fluid: https://soltexinc.com/wp-content/uploads/2024/05/Beta-SDS-GHS-Format-R3-10-10-23.pdf

Alpha-2 Fluid: https://soltexinc.com/wp-content/uploads/2024/05/Alpha-2-SDS-GHS-EU-10-10-23.pdf

APPENDIX 1

EQUIPMENT DESIGN FOR FIRE RESISTANT FLUIDS

Heat Transfer Considerations

Soltex's dielectric fluids have proven their ability to perform effectively in thousands of applications. Although both Alpha-1 and Beta fluids cool transformers well, Alpha Fluid's synthetic base oil has superior heat transfer characteristics. Alpha fluid will typically operate at temperatures 2-5°C lower than other fluids in identical equipment, under identical load.

Specific Gravity:

The specific gravity of a material is a ratio of the weight of that material to the weight of an equal volume of water, measured at the same temperature. The specific gravity of Alpha fluid is 0.83. Beta fluid's specific gravity is 0.86.

Electrical Considerations:

Dielectric Strength of Fluids:

Soltex dielectric fluids have dielectric strength that exceeds all specifications for conventional transformer oil. They typically have a dielectric strength of 56 kV when measured by ASTM Method D1816 (0.08" gap) and 43 kV when measured by ASTM Method D877. Transformers using any of Soltex's dielectric fluids are built with the same insulation levels that are used with conventional oil.
Their dielectric strength changes very little in the temperature range encountered in electrical equipment use.

Dielectric Strength of Saturated Insulation:

The dielectric breakdown voltages of cellulose and Nomex insulation saturated with Alpha or Beta fluids are equal to or better than those for conventional transformer oil and silicone oil.

Because of their lower viscosity, Soltex's dielectric fluids saturate, and impregnate cellulose more easily than thicker fluids do. This enhanced saturation results in high dielectric strength of the oil-paper system.

Impulse Breakdown Voltage:

The impulse breakdown voltage (negative polarity needle electrode) of our fluids is excellent. All Soltex dielectric fluids have typical values of >300kV (ASTM Method D3300). As a comparison, the typical minimum specification for conventional transformer oil is 145 kV.

Lubricity:

Although the lubricity characteristics of all of Soltex's dielectric oils are excellent, Alpha Fluid has the best lubricity characteristics of any less-flammable dielectric fluid. This is an important characteristic to consider when considering the use of an insulating oil fluid in switching or tap changer operation. The following table compares the Falex Four-Ball Lubricity test values for several common dielectric fluids. The lower values indicated less wear on the ball bearings used in the test, and so indicate better lubricity properties.

Four-Ball Wear Values (Falex Test)

Fluid Tested	Avg Scar Values
Alpha Fluid	0.54 mm
Beta Fluid	0.66 mm
Alpha-2 Fluid	0.69
mm Conventional transformer oil	0.73
mm Silicone Fluid	1.43 mm

Equipment Design Factors for Fire Resistant Fluids

Transformers Designed for Other Fire-Resistant Fluids

Transformers designed for use with other fire-resistant fluids can be filled with Alpha or Beta Fluid and run without modification. The transformer will perform at a rated temperature or cooler when filled with Alpha Fluid. In addition, Alpha or Beta fluid does not require extra insulation that is commonly used with silicone fluid. Both Alpha and Beta fluids are completely compatible with the materials used with conventional transformer oil and materials that are commonly used with mineral oil.

Design changes are sometimes required when using fire-resistant fluid. Alpha-1's lower viscosity means that fewer changes are required when using Alpha Fluid in transformers that were designed for conventional mineral oil.

These guidelines have been developed through the experience of equipment manufacturers in designing transformers for use with Alpha and Beta Fluids. They are intended only to act as guidelines. Final designs must be optimized for the particular equipment in question.

Insulation Thickness and BIL:

The BIL levels (thickness of solid insulation) that are used with Alpha or Beta Fluids are the same as those for conventional transformer oil. Extra insulation thickness is not necessary. The dielectric strengths of Alpha and Beta fluid are equal to or greater than that of conventional transformer oil.
The impulse dielectric strength of these fluids is greater than that of conventional transformer oil. Both fire resistant fluids have a dielectric constant of 2.2, the same as that of conventional transformer oil.

Oil Temperatures and Heat Transfer:

Each different fire-resistant oil has a unique set of heat transfer characteristics. Because of their increased viscosity, top oil temperatures will be warmer when using any fire-resistant fluid in transformers designed for conventional transformer oil. The amount of the temperature rise will depend on the fluid's heat transfer effectiveness.

Although there are several material characteristics that help to determine the heat transfer effectiveness of a fluid, the one that makes the greatest contribution is its viscosity. The effect of viscosity overrides all of the other characteristics, such as thermal expansion coefficient, heat capacity and thermal conductivity.

The low viscosity of Alpha Fluid gives it excellent heat transfer characteristics. This is illustrated by the following table, which compares the viscosities and Nussult values for different fire-resistant dielectric oils. Nussult values are a measure of heat transfer effectiveness, derived using viscosity, heat capacity, density, coefficient of thermal expansion and thermal conductivity of the fluids, plus heat flux input from the transformer's windings. The more effective the fluid is as a heat transfer agent, the higher the Nussult value.

For further discussion of this subject, please request "A Study of The Relationship Between Insulating Fluid Viscosity and Transformer Cooling Performance", available from Soltex.

Comparison of Heat Transfer Effectiveness of Fire-Resistant Dielectric Fluids

Fluid Type:	Viscosity, cSt @ 100 °C	Nussult Value x 100
Alpha Fluid	8.6	6.5
Beta Fluid	11.2	5.9
Silicone fluid	16.0	5.2

When using fire resistant fluids in transformers that were designed for use with mineral oil, they will run slightly warmer. The top oil temperatures in units up to 500 kVA will be 1 – 3 ° C. higher when these designs are used with Alpha Fluid, and 3-6 °C warmer when using Beta Fluid. In the range from 500 - 2500 kVA, top oil temperatures will be slightly higher. These temperatures will vary with different transformer designs.

Minimum Thickness for Vertical Coil Ducts, when using Alpha and Beta Fluids

Coil Height, mm	Strip Windings	Layer Windings	Maximum heat flux as % of equivalent oil design
400	4	4	100%
650	4	6	95%
900	6	6	89%
1100	6	8	82%

Cooling Design of Transformers for Fire Resistant Fluids

Only minor changes, if any, are required when substituting Alpha or Beta Fluids for conventional transformer oil. Because of the small additional temperature rise, transformers rated less than 500 kVA generally do not require changes in coil design in order to use these oils. In transformers over 500 kVA, it may be desirable to use 4mm (3/16") or 6 mm (1/4") cooling ducts to increase the cooling capacity of the transformer. Larger sizes may also require additional or larger ducts and lower duct watt/inch^2 heat density.

Compared to conventional mineral oil designs, some changes in cooling radiator surface area may be required with fire resistant fluids. The following table gives guidelines for increases that may be...

needed in cooling duct sizes and the surface area of radiators for 65°C rise designs. It should be kept in mind that these guidelines are only approximate; different engineering designs will necessitate changes in these figures.

Many coil designs for transformer oil have insulating collars at the end of the coils, which restrict the flow of the dielectric liquid. The area for fluid flow into and out of the coils should have an opening approximately 12 mm high. The heat flux guidelines shown in the table are for conservative designs; experience with the specific design being built may allow higher heat flux values than those shown. Soltex recommends using the given minimum thicknesses for vertical coil ducts.

The following rules of thumb have been used successfully for designing or modifying transformers for use with Alpha or Beta fluids:

Change the internal ducts in each winding from 3.3 mm to 6 mm radial thickness. It is more efficient to add 2 or 3 mm to the thickness of the vertical coil ducts than it is to add radiator area to get the desired cooling.

If the design engineer has a choice on coil height, use a coil design that is as short as feasible. The flowrate of dielectric fluids decreases as the coil height increases.

Allow a minimum of 12 mm horizontal inlet and outlet space at the ends of the coil

ducts. For more information relating to your specific design, contact Soltex, Inc.