.r 355

CITY OF NEW YORK DEPARTMENT OF ENVIRONMENTAL PROTECTION

BUREAU OF AIR, NOISE & HAZARDOUS MATERIALS
59 -17 JUNCTION BOULEVARD,CORONA, NEW YORK 11368
AIR PERMITTING, 9TH FLOOR

AMENDMENT

(TO BE TYPED OR PRINTED)

INSTALLATION: PB008210X

DATE: February 28, 2011

PREMISE ADDRESS: NYC-DOC-Rikers Island, 17-25 Hazen Street, East Elmhurst, NY 11370 Queens (BORO)

ANSWERS TO THE DISAPPROVAL SHOULD BE MADE BELOW. THIS AMENDMENT IS TO BE MADE PART OF THE ORIGINAL PLANS AND IS SUBJECT TO ALL THE CONDITIONS, AGREEMENTS AND STATEMENTS CONTAINED THEREIN. RETURN THIS COMPLETED FORM TO THE BUREAU OF AIR NOISE & HAZARDOUS MATERIALS AT THE ADDRESS ABOVE.

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Approved as noted: items 1, 3, 4, 5, 6, 9, 12 to 25 (please note our addendum to your notes 1 & 2), 26 (partially), 28, 29, 30 (conditional).

Item #2: Clarification is needed; the letter sent to Mr. Gregory McLaughlin on January 28, 2011 was returned to the Department as "unknown".

Response: The DOC address is revised to New York City Department of Correction, 75-20 Astoria Blvd., N.Y., N.Y., 11370.

Item #7: Where in the Title V N.Y.S. Air Permit File with DEC the reasonable available Control Technology (RACT) and not the BACT (the best available control technology)?

Response: The facility will comply with all applicable federal, state, and local air quality regulations and standards. As discussed with Ray Li, the new facility is not subject to BACT but will be subject to RACT, as well as other air quality regulations. BACT applies to a given attainment pollutant if the annual net increase exceeds the PSD (Prevention of Significant Deterioration) allowable significance threshold. None of the pollutants resulting from the new cogeneration facility will be subject to BACT. The NYSDEC has already approved this regulatory evaluation and analysis and as a result will issue a draft Title V permit for the new cogeneration facility.

Response to (ii): Comment noted. No further action is required by NYC-DOC.

P.E. OR R.A. Ramon Li, P.E.		
NAME AKRF, Inc.		
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CITY New York,	STATE NY	ZIP CODE 10016

P.E. OR R.A. SEAL & SIGNATURE

STATE OF NEW YORK
RAMON LI
No. 060357
LICENSED PROFESSIONAL ENGINEER

FOR DEPARTMENT USE ONLY

FEE ENCLOSED: $ ________ ON ________ DATE

AMENDMENT ☐ APPROVED

☐ DISAPPROVED BY: ________

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Item #8: (i) Submit the supplier address of the BioTemp oil; (ii) Fire Protection equipment shall be close to the site and as a suggestion, the transformers to be in fire proof constructed room away from mechanical room.

Response to (i): The supplier is Dow Chemical Corporation, 2040 Dow Center, Midland, MI 48674. ATTACHMENT 1 includes additional information on the BioTemp.

Response to (ii): During the day, the fire equipment is on-island at the fire house next to the Powerhouse. During off-hours, the fire equipment is located off-site in Astoria. There are blast walls and oil containment basins under the transformers, fire will not spread.

Item #10: (i) Would like to see participation, for the plan, by a public/private school, hospital / health center, LaGuardia Airport representatives; (ii) Submit copy of your submittal on 4/14/2010 to DEP Bureau of Environmental Planning & Assessment (BEPA), to out Bureau of Environmental Compliance, attention Nicholas Audi.

Response to (i): The NYSDEC has approved the public participation plan and the NYSDOC is in the process of implementing it. The NYSDEC approval is included as ATTACHMENT 2.

Response to (ii): A copy of the submittal on 4/14/2010 to BEPA was already given to Nicholas Audi on 12/6/2010 in response to previous comments. No further action is required by NYC-DOC.

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Item #11: (i) What is UHC emission mentioned in Table 1 of Attachment 4 of Amendment 2/1/2011? (ii) The 2 Co-Gen turbines are Solar Taurus 70-10801S Case No. 2. Rentech is the designer of the HRSG/WHRB. It is a "special design" to Rikers Island with "economizer" and: evaporator" (no superheater); the steam quality is saturated at 0.05% wet. Heating surface of Economizer is 17,142 ft2; Heating surface of Evaporator is 24,498 ft2; Capacity of the Boiler 35000 lbs/hr from heat recovery only, 70000 lbs/hr from heat recovery + duct burners on. There are 2 (two) Hamworthy-Peabody Model HPC-ECO duct burners burning pipeline natural gas for each HRSG/WHRB capacity of each burner is 19,965 MBtu/hr at lower heating value of the natural gas fuel. Safety design of the burner: NEP A 85. (iii): Table 2 of the attachment 4 did not specify the inside diameter of the bypass flue; the bypass as specified on form of N.Y.S. DEC as 51/2 feet. Table 1 of attachment 4 is for the main stack and is specified as 5 ft. (iv) Is there any reason why the emissions for NOx, CO, UHC, VOC, PM, SO_2 guaranteed by Solar Turbines Inc new attachment 5 of 2/1/11 amendment is measured and then converted to 15% oxygen and not as usually measured at 7% (the pollutant as expressed are diluted!).

Response to (i): As discussed with Ray Li, UHC is unburned hydrocarbons.

Response to (ii): Comment noted. No further action is required by NYC-DOC.

Response to (iii): The bypass stack is 5.5 feet in diameter as specified on the permit application forms.

Response to (iv): The pound per million (ppm) concentrations are expressed in 15% O2 as per RACT and NSPS regulations. The mass emission rates of the pollutants will be the same regardless of the percent oxygen.

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Item #12-25: Please also add to your notes (1) & (2) that the DEP Application PB0082/10X has two identical Co-Gen called Train 1 & Train 2. Each train has 2 emission sources (a gas fired turbine burner and a duct burner for the waste heat recovery boiler belonging to one same train): Train 1 has main stack U0029 & bypass stack U0030. Train 2 has main stack U0031 & bypass stack U0032.

Response: Comment noted. No further action is required by NYC-DOC.

Item #26 (b) (i): Please note that "MMBTU" is 10^9 BTU a billion BTU & MBTU is 10^6 BTU, a million BTU. Correction accepted for the rating of each old boilers 96 MBTU each. (d): New unit replacing old technology shall be replaced by the Best Available Technology (BACT) unless you justify it by using (RACT). (f): "Bypass" and "main stacks" shall be also of a "high temperature" and "medium temperature construction" respectively as per N.Y.C. Building Code.

Response to (b) (i): As discussed, MMBTU/hr is million BTU per hour. There are very few billion Btu/hr boilers operating.

Response to (d): RACT applies. See previous comment for Item #7.

Response to (f): Comment noted. No further action is required by NYC-DOC.

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Item #27: Response to Item 27(i): DEP agreed to review the Co-Gen plant based on its own merit because of lack of information in DEP about the old boilers filing with DEP. But this does not prevent DEP from communicating any information gathered by DEP to NYSDEC. Please also note that NYCDEP regulations are in harmony with N.Y.S. DEC regulations. The strictest one prevails if applicable. (ii) Accepted as noted, if it is acceptable by other city Agencies or Bureaus. (iii) Accepted as noted: that there are no space heaters at the new site.

Response to (i): Comment noted. No further action is required by NYC-DOC.

Response to (ii): Comment noted. No further action is required by NYC-DOC.

Response to (iii): Comment noted. No further action is required by NYC-DOC.

Quick notes on fig. #2: Item 30(a) Accepted as noted the HRSG or the WHRB includes an economizer.

Response: Comment noted. No further action is required by NYC-DOC.

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Item 30 (b): Accepted as noted. Condensate return to the plant was designed for worst case condition of 60%. DEP hopes that the water condensated return to the plant will be much much higher! (c) I assume that you mean no excessive pressure drop in lieu of line losses (no water leaks) (d) I hope to see the make-up water (which is at 70F) will be at 200F when mixed with the return condensate. (e) The old powerhouse has already 3 de-aerators only one of the three de-aerators will be used at any time is acceptable. (problem with maneuver of valves) (f) Justification of the CoGen will be proven by measuring the overall efficiency at time of commissioning at the full load 7.5 MW electrical power + 2 duct burner for one hour run fulfilling the steam demand of the Rikers Island. This will be part of the testing protocol (90% expected).

Response to (b): Comment noted. No further action is required by NYC-DOC.

Response to (c): Comment noted.

Response to (d): Comment noted.

Response to (e): Comment noted.

Response to (f): Comment noted. The overall system efficiency will be maximized by recovering the waste heat from the turbine exhaust and by duct firing. Because there are many system variables, the overall efficiency may be less than 90% at any given time. However, it is possible the 90% can be achieved but it is not required to be attained at all times. The plant will have real-time performance feedback through the Control System that can be submitted in lieu of a peak-performance one hour test for efficiency. It is unlikely that the cogen could be instantaneously loaded for an hour prior to commercial operation. The Contract will not include total plant performance testing prior to commercial operation. The owner will continuously monitor performance through the use of the Control System instrumentation.

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Item 30 suite (a): A waiver from the N.Y.S.D.E.C for stacks emissions testing is required for bypass and main stack for NOx, CO, VOC, SO_2. Suite (b) (ii) and 30 (b) (ii) Approved as requested. Smoke detector in both the main stack and bypass stack are not required.

Response to suite (a): Comment noted. No further action is required by NYC-DOC.

Response to suite (b) (iii) and 30 (b) (ii): Comment noted. No further action is required by NYC-DOC.

P.E. OR R.A.
Ramon Li, P.E.

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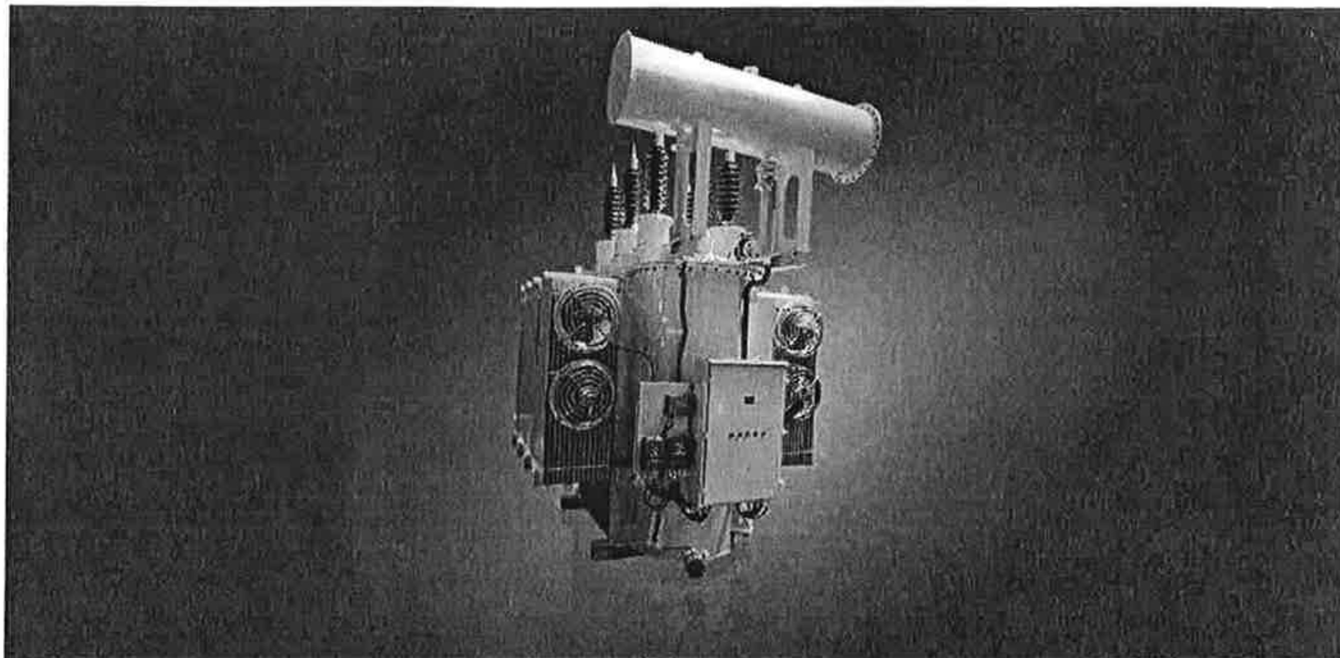
ATTACHMENT 1



Power Products

BIOTEMP®- ABB sensible solution
The superior biodegradable, high fire point dielectric insulating fluid

Power and productivity
for a better world™

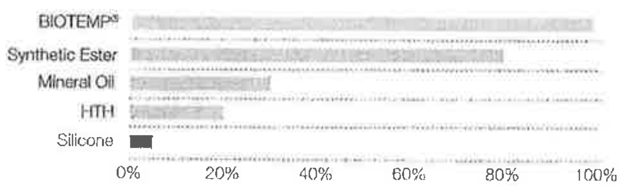
Advantages overview

At ABB, we are entirely dedicated to improving power reliability and efficiency while minimizing environmental impact. Sustainability considerations influence how we design and manufacture products, what we offer customers, how we engage suppliers, and how we behave in the communities where we operate.

In this respect, we developed BIOTEMP® as a superior dielectric insulating fluid combining environmental friendliness, superior fire resistance and high temperature stability with excellent dielectric characteristics.

BIOTEMP® is a natural ester fluid made from renewable and biodegradable vegetable-based oil. Below are some of the environmental, fire safety and operational advantages of using BIOTEMP®:

Biodegradability
(According to the CEC L-33-A 21-day test)



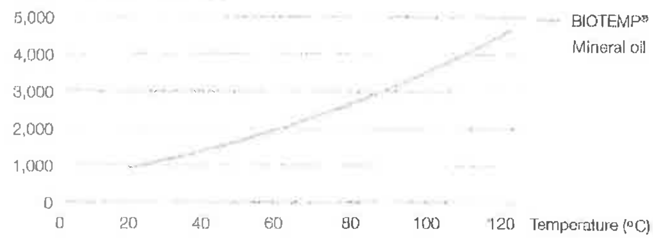
Environmental advantages
- Even though secondary containment is still required, BIOTEMP® spills can be disposed through normal means and not treated as hazardous or toxic waste.
- BIOTEMP® minimizes air pollution by producing only carbon dioxide and water during combustion.
- BIOTEMP® also offers the potential for relief from Government regulatory penalties, resulting in less costly spill cleanups.

BIOTEMP® is listed as a "less flammable" dielectric fluid by Factory Mutual (FM Global) and is classified as a "less hazardous" dielectric medium in respect to fire hazard by Underwriters Laboratories (UL).

Fire safety advantages
- BIOTEMP® offers greater risk mitigation on collateral damage from transformer explosion and fire, potentially lowering insurance premiums.
- Active fire suppression and barrier walls can essentially be eliminated with BIOTEMP® when minimal spacing is maintained.
- BIOTEMP® can alternatively be used safely indoors and in tighter spaces outdoors typically without additional fire safety requirements.

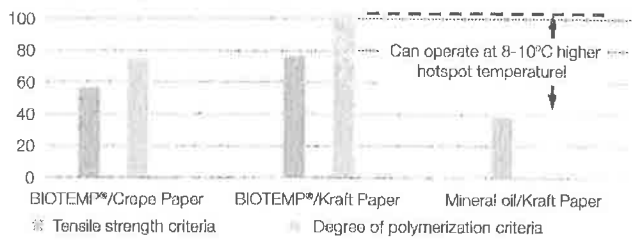
BIOTEMP® has a much greater affinity for water than mineral oil. Consequently, in a BIOTEMP®/paper insulating system, the paper stays drier than in a mineral oil/paper insulating system.

Water saturation point (ppm)



Operational advantages
- BIOTEMP® impregnated paper experiences a much lower aging rate compared to mineral oil impregnated paper leading to an increase in the insulation system lifetime (grid reliability).
- BIOTEMP® impregnated paper can alternatively operate at a higher hotspot temperature and attain the same life expectancy as mineral oil impregnated paper increasing the transformer peak load or overload capacity (energy efficiency).

Life expectancy at 100°C (Years)



Superior advantage
BIOTEMP® was developed as the most stable vegetable-based oil with acceptable electrical properties. It is made from high-oleic oils, such as sunflower and safflower, which contain more than 75 percent of mono-unsaturated fatty acids increasing the oil stability when exposed to air as compared to competing products containing much lower levels (typically less than 25 percent).

Comparative oxidation stability test results (According to ASTM D 2440)
- BIOTEMP® successfully passed the 164-hour test
- Competitor low-oleic oil reached irreversible gel formation after less than 72 hours

Properties, handling instructions and specification guide

[illegible]

Property	Value	Test method
Chemical/environmental		
Biodegradability (21-day test)	97 to 99%	CEC L-33-A
Corrosive sulfur	Non-Corrosive	ASTM D 1275B IEC 62535
Moisture (water) content	<50 ppm	ASTM D 1533 IEC 60814
Neutralization (acid) number	0.03 mg KOH/gm	ASTM D 974 IEC 62021
Oxidation stability Sludge Acid number	after 164 hrs 0.12% per mass 0.36 mg KOH/g	ASTM D 2440 IEC 61125
PCB content	Non-detectable	ASTM D 4059 IEC 61619

Property	Value	Test method
Physical		
Coefficient of thermal expansion	7.50 x 10⁻⁴/°C	ASTM D 1903
Flash point Fire point Pour point	340°C 360°C -15 to -20°C	ASTM D 92 ASTM D 92 ASTM D97 ISO 3016
Kinematic viscosity @ 100°C @ 40°C @ 0°C	 9 mm²/s (cSt) 42 mm²/s (cSt) 276 mm²/s (cSt)	ASTM D 445 ISO 3104
Specific gravity @ 25°C	 0.91 kg/m³	ASTM D 1298 ISO 12185
Specific heat @ 25°C @ 100°C	 0.57 Cal/gm/°C 0.60 Cal/gm/°C	ASTM D 2766
Thermal conductivity @ 25°C @ 100°C	 0.17 W/m K 0.26 W/m K	ASTM D 2717

Property	Value	Test method
Electrical		
Dielectric constant (relative permittivity)	3.1	ASTM D 924 IEC 60247
Dielectric strength 1-mm gap 2-mm gap	 39 kV 76 kV	ASTM D 1816
Dissipation (power) factor @ 25°C @100°C	0.09% 0.19%	ASTM D 974
Gassing tendency	-50 μL/min	ASTM D 2300 IEC 60628
Volume resistivity @ 25°C	 1.5 x 10¹³ Ω cm	ASTM D 1169

Note: The equivalent IEC/ISO test methods listed above are for reference purposes

Material compatibility

BIOTEMP® is not affected by reactions with other materials used in transformer construction and is non-oxidizing and non-corrosive at temperatures considerably above normal operating temperatures.

Storage and handling

BIOTEMP® can be transferred and stored similar to petroleum-based fluids. Transfer equipment and storage vessels should be clean and free of contaminates and moisture. During storage, the vessel should be airtight and is preferably stored under dry nitrogen (to minimize exposure to moisture and oxygen). BIOTEMP® is not an aggressive solvent and is not known to degrade rubber hoses or membranes.

[illegible]

Degassing and refilling the headspace with dry nitrogen after prolonged or frequent exposure to air (totaling more than five hours) is recommended to preserve the life of the fluid. Periodic maintenance tests should follow the same schedule used for mineral oil-filled equipment.

[illegible]

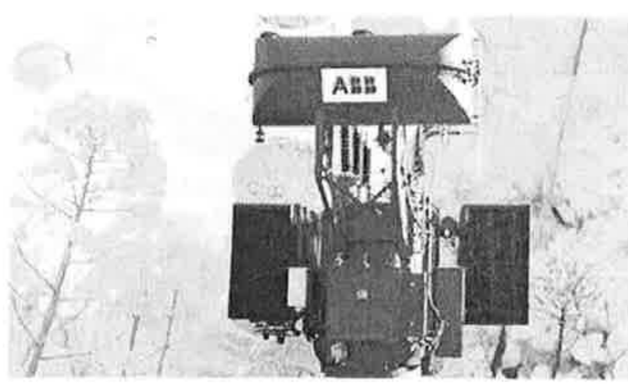
BIOTEMP® mixes in all proportions with mineral oils. Concentrations of mineral oil in excess of seven percent by weight may lower the fire point below 300°C. BIOTEMP® does not mix with silicone fluids.

Areas of application

BIOTEMP® is suitable for application indoors and in outdoor areas of heightened environmental and safety sensitivity.

Specification guide

The dielectric coolant shall be listed as a less-flammable fluid meeting the requirements of National Electrical Code, Section 450-23, including a minimum fire point of 300°C and the requirements of the National Electrical Safety Code (IEEE C2-1997), Section 15. The fluid shall be nontoxic, non-bioaccumulating and biodegradable. It shall be FM Global approved and UL classified, BIOTEMP® fluid or equal.



Contact us

ABB Inc.
Small Power Transformers
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South Boston, VA 24592
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Fax: +1 434 575-2220
E-mail: kent.e.saunders@us.abb.com

www.abb.com/transformers

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FM APPROVED

CLASSIFIED UL

BIOTEMP® classed 4 to 5 times less hazardous than paraffin oil in respect to fire hazard. Flash point (closed cup) 243°C (470°F). Fire point 354°C (670°F). Ignition temperature 426°C (799°F).

BIOTEMP® conforms to the ASTM Std D 6871 and to the IEEE Std C57.147™.

1LUS471050-LTE

Power and productivity
for a better world™

ABB

BIOTEMP®

Biodegradable Dielectric Insulating Fluid

For

DISTRIBUTION AND POWER TRANSFORMERS

Available Technical Data & Further Test Plan Information

2nd Edition

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FOREWORD

The data provided in this technical report were gathered following Consolidated Edison's specifications for required tests and data on synthetic and natural Ester fluids [1], as listed below:

A. General Characteristics
B. Chemical Composition
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E. Thermal Characteristics Including Aging of Paper Insulation in the Fluids
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Data from mineral oil and/or other Ester fluids are also given when available for comparison purpose. Relevant information from additional investigations is also given when appropriate (e.g. Cold Starts tests and Functional Life tests on distribution transformers filled with BIOTEMP®). Ongoing testing as well as future test plan of BIOTEMP® are also mentioned in the course of the document. Finally, a summary and comparative table of some dielectric insulating fluids properties including BIOTEMP®'s is given in Appendix.

A. General Characteristics

The selected properties listed below represent most of the requirements in applicable standards. At this time, only an ASTM standard is available for natural Ester fluids, ASTM D 6871, but other Standards or Guides from IEEE, IEC, etc. are being developed. Some of the properties outlined below are not in the ASTM Standard but are of interest to the users of BIOTEMP®. A detailed summary and comparative list of BIOTEMP® properties is given in Appendix.

A1 Power Factor (Dissipation Factor) per ASTM D 974

Typically measured power factor value:	0.15 % (at 25°C, 60Hz) 2.0 % (at 100°C, 60Hz)
Power factor max limit value per ASTM D 6871:	0.20 % (at 25°C, 60Hz) 4.0 % (at 100°C, 60Hz)

BIOTEMP® reveals a higher power factor than mineral oil (typically ≤ 0.05 %) mainly because of the slightly higher polar nature of its chemical structure as well as of its inhibitor components.

BIOTEMP® power factor measurements at different temperatures (from 25 to 100°C) are currently being conducted by an independent laboratory and are due by mid of 2008.

A2 Water Solubility per ASTM D 1533

Water solubility in BIOTEMP® as a function of temperature is shown in Figure 1 below.

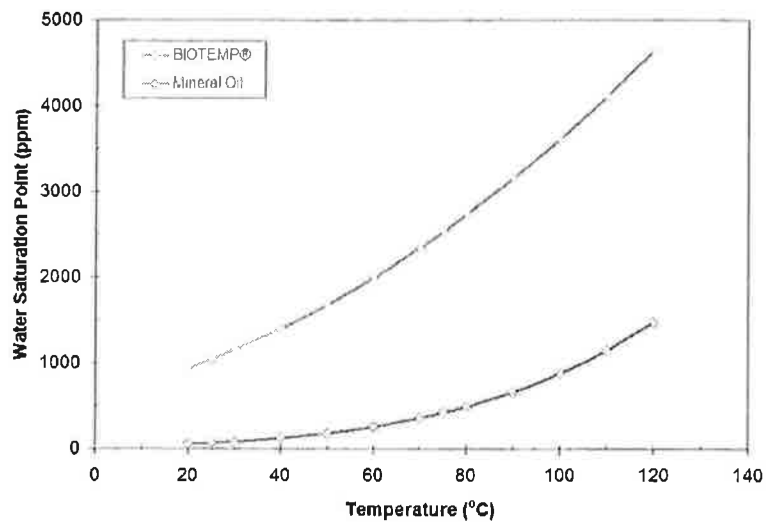

Figure 1 – Water Solubility in BIOTEMP® and Mineral Oil as a Function of Temperature

The data shown in Figure 1 are obtained from the Arrhenius solubility plot obtained from laboratory test data at selected temperatures [2]. The Arrhenius equation for water solubility in BIOTEMP® is:

$$\text{Log } S_{bio} = -802/T + 5.708 \qquad (1)$$

where, S_{bio} is the solubility of water (in ppm) in BIOTEMP® (corresponding to water saturation at 100% relative humidity), and T is the absolute temperature.

Figure 1 above also shows the solubility curve for mineral oil. The water solubility in mineral transformer oil can be expressed by [3]:

$$\text{Log } S_{mo} = -1670/T + 7.42 \qquad (2)$$

where, S_{mo} is the water solubility (in ppm) in mineral oil.

BIOTEMP® has a considerably higher water solubility than mineral oil. Consequently, BIOTEMP® can absorb considerably larger moisture content than mineral oil at a given relative humidity (RH). For example, at 25°C 10 ppm moisture in mineral oil corresponds to 15% saturation (dry oil), and for the same RH the water content of BIOTEMP® would be about 155 ppm.

This higher water absorbing ability has a beneficial effect on the transformer insulation because excess water from the paper produced during aging would be absorbed by the fluid to a great extent, hence prolonging the transformer insulation life.

It is finally worth mentioning that BIOTEMP® is delivered with a typical water content of 35 ppm meeting the ASTM D 6871 max limit value of 200 ppm.

A3 Interfacial Tension per ASTM D 971

Typical measured interfacial tension value: 26 dynes/cm

ASTM has not published an acceptance value limit for interfacial tension of natural Ester fluids. New natural Ester fluids, including BIOTEMP®, have inherently lower interfacial tension than new mineral oils (typically 40 dynes/cm). This difference is mainly due to an inherent difference of Ester and mineral oil chemistry including higher absorption levels for water (see Section A2 above).

Note that this test is used as one means of detecting soluble polar contaminants and products of deterioration in mineral oil. In mineral oil, soluble-contamination or fluid-deterioration products generally decrease the interfacial tension value. However, because of the much lower value of natural Ester fluids, the significance of interfacial tension for diagnostic purposes in this case is not clear at the present time. Referring to IEEE PC57.147, a 40 % or more decrease from the initial interfacial tension value in a fluid as received should nevertheless trigger further investigation.

A4 Specific Gravity (Relative Density) per ASTM D 1298

Typically measured specific gravity value: 0.91 g/ml (at 15°C)

Specific gravity max limit value per ASTM D 6871: 0.96 g/ml (at 15°C)

BIOTEMP® has a specific gravity similar to mineral oil (typically also 0.91 g/ml at 15°C).

A5 Flash Point, Open Cup per ASTM D 92

Typically measured flash point value: 330°C

Flash point min limit value per ASTM D 6871: 275°C

This is typically measured in the US cited in both ASTM D 3487 and D 6871 by the Cleveland Open Cup method ASTM D 92. BIOTEMP® has a significantly higher flash point than mineral oil (typically around 160°C).

The flash point is adversely affected by certain solvents such as Kerosene. Typically, for Ester fluids, mixing a significant amount of mineral oil would lower the flash point appreciably. However, it has been observed that the presence of as much as 10% of mineral oil in BIOTEMP® does not lower its flash point below the ASTM D 6871 minimum limit of 275°C. This is certainly beneficial for retro-fill applications.

A6 Flash Point, Closed Cup per ASTM D 93

Typically measured flash point value: 308°C

Per IEC Standards, this Pensky Martens method also gives a value of 308°C [4]. This method is neither used in ASTM D 3487 nor in ASTM D 6871. The closed cup flash point is typically slightly lower than that for open cup.

A7 Fire Point per ASTM D 92

Typically measured fire point value: 360°C

Fire point min limit value per ASTM D 6871: 300°C

This value was measured internally and by Factory Mutual. Doble Engineering measured 358°C [2] and UL measured 354°C. Here also, BIOTEMP® has a significantly higher fire point than mineral oil (typically around 180°C). It is again worth mentioning that mixing

BIOTEMP® with mineral oil up to 10% will result in a fire point still above 300°C. This is again valuable for retro-fill applications.

A8 Pour Point per ASTM D 97

Typically measured pour point value: -15°C

Pour point max limit value per ASTM D 6871: -10°C

This value was measured internally. Doble Engineering measured a value of -12°C [2]. The pour point of natural Ester fluids is typically higher than of mineral oil and synthetic Esters (typically around -50°C). Note that the standard BIOTEMP® fluid does however not contain any pour point depressant. Its pour point can noticeably be decreased with a small quantity of an acrylic additive, for instance (typically down to -25°C).

The higher pour point of BIOTEMP® may be of concern in cold weather shut downs. Extended exposure pour point could even be higher than the hereby measured pour point. This concern can somewhat be alleviated by the fact that cold temperature startups of frozen distribution transformer units (down to -70°C) had no adverse effect in restarting the units (see Cold Start tests results documented in Section A8.1 below). It can be explained by the fact that BIOTEMP® has several components freezing at different temperatures, and therefore has no cracks developed during freezing. The thawing is also a gradual phenomenon. Numerous transformers in operations filled with BIOTEMP® are known to operate well even in extreme cold weather.

A8.1 Cold Start Tests on Distribution Transformers

In order to analyze the effect of cold temperatures on the thermal properties of a BIOTEMP®-filled transformer under full load, cold start tests were performed on such a transformer. During such tests transformers cooled to extremely cold temperatures are energized at full load. Various temperature measurements are performed as the transformers warmed up under load. In the present case, 25 kVA, 12.5/7.2 kV distribution transformers filled with BIOTEMP® were cooled down to below -70°C and then energized at full load. Figure 2 below shows how temperature typically increases in the windings after a cold start.

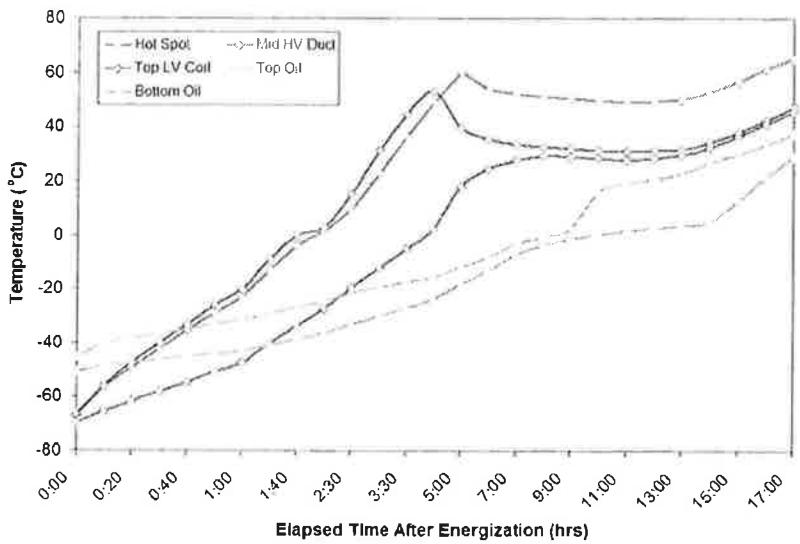

Figure 2 – Cold Start Test Thermal Profile of a BIOTEMP®-filled Unit

These tests demonstrated that a BIOTEMP®-insulated distribution transformer can still operate and be re-energized safely at full load when the fluid has been solidified.

A9 Coefficient of Thermal Expansion per ASTM D 1903

Typically measured coefficient of thermal expansion value: 7.35×10^{-4} /°C

This value was obtained from a temperature range of 25 to 200°C. BIOTEMP® has a coefficient of thermal expansion very close to mineral oil (typically 7.30×10^{-4} /°C).

B. Chemical Composition and Material Compatibility

B1 Chemical Composition

The chemical composition of BIOTEMP® is given in US patent 5,949,017 dated Sep 7, 1999. The formulation highlights are:

- At least 75% mono-unsaturated fatty acid component (i.e. oleic acid ester)
- Less than 10% di-unsaturated fatty acid component
- Less than 3% tri-unsaturated fatty acid component
- Less than 8% saturated fatty acid component

Special anti-oxidants (phenolic and amine compounds) in small quantities are also specified. BIOTEMP® does not contain DBPC inhibitors typically used in transformer oils.

B2 Material Compatibility per ASTM D 3455

This test was conducted internally using the following materials typically used in pad-mounted distribution transformers:

Bare aluminum strap	20 g
Formvar coated Al wire	74.1 g
Ductformer paper	1.5 in.
Diamond kraft paper	1 sheet (4 cm^2)
Pressboard	0.4 g
Crepe paper	1.5 in.
Silicon steel	1 strip (2" x 4")
Nitrile gasket (on tank cover)	1/8 gasket
Copper	1 cm^2
Heat shrunk tubing	0.25 in.

The surface area for each sample should be four times the actual surface area in the unit. Typically 800 ml of oil was used, hence the amount of each material had to be sized down from the actual numbers in a unit. Results of the test analysis are shown in Table 1 below.

Table 1 – Oil Compatibility Test Results

	Reference oil sample	**Tested sample**
General condition	Clear	Clear
Dielectric strength	40.8 kV	37.4 kV
Power factor (at 100°C, 60 Hz)	2.98 %	4.24 %
Interfacial tension	28.7 dynes/cm	30.8 dynes/cm
Color	<1.0	<1.0
Neutralization number	0.106	0.110

The ASTM Standard D 3455 allows qualitative judgments on the test results. The test set does not show appreciable change from the reference sample of BIOTEMP® except for the power factor which cannot be linked to any specific component.

Additional compatibility tests are currently being conducted by an independent laboratory and are due by mid of 2008. They include BIOTEMP® compatibility with additional materials such as different types of rubbers, epoxy paints, adhesives, insulation papers, and other fiber-reinforced materials. Note that compatibility with Kerosene will not be included because it is well known that Kerosene contaminates the insulating fluid. When the transformer goes through vapotherm drying, Kerosene should be removed anyway. If vapotherm is not used, Kerosene becomes irrelevant.

It is finally worth mentioning that another good measurement of compatibility is that field units filled with BIOTEMP® and in place since 1999 have suffered no failures for compatibility or other reasons to date.

C. Dielectric properties

C1 Dielectric Breakdown Strength

Table 2 below lists the dielectric breakdown strength values typically measured during the different tests conducted.

Table 2 – Dielectric Breakdown Strength Test Results

Dielectric breakdown strength[1]		Typical value	Limit value per ASTM D6871
Per ASTM D 877	2 mm gap	48 kV	min 30 kV
Per ASTM D 1816	1 mm gap	32 kV	min 20 kV
	2 mm gap	74 kV	min 35 kV
Per ASTM D 3300 (impulse conditions, needle negative)	25.4 mm gap	134 kV[2]	min 130 kV

Additional dielectric tests are currently being planned with an independent laboratory. They include 60 Hz partial discharge inception, 60 Hz breakdown, and full wave impulse breakdown strength.

C1.1 Dielectric Breakdown Strength vs. Moisture Content

The effect of moisture on BIOTEMP® breakdown strength (per ASTM D 877) has been evaluated at room temperature, i.e. 25°C (see Figures 3 below).

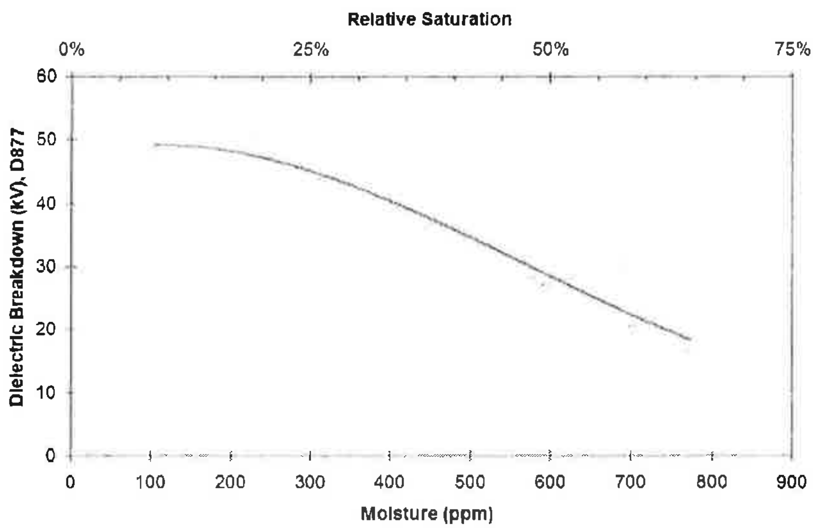

Figure 3 – Breakdown Strength vs. Moisture Content

The curve is very similar to that for mineral oil except that the ppm moisture values for mineral oil are about one-twentieth of the ppm values for BIOTEMP® at the same temperature. In other words, BIOTEMP® at 100 ppm moisture content is equivalent to a mineral oil with a 5-ppm moisture content at room temperature. The breakdown strength versus relative saturation curve shown in Figure 3 should also be applicable at different temperatures.

[1] All breakdown tests were performed at room temperature (i.e. 25°C) and with a 10 % relative water saturation
[2] Measured by Doble Engineering [2]

C1.2 Parallel Cylindrical Electrodes at 25.4 mm Spacing

This parallel electrode test is not in any Standard. The setup needed is not available as a standard item. CIGRE study groups have discussed the use of covered electrodes when conducting VDE tests on oil but no implementation was made to date.

As mentioned above, additional tests are currently being planned with an independent laboratory. These tests will be conducted using a custom designed electrode configuration to minimize the probability of oil breakdown and to make sure that the dielectric stress is directed towards a creep mode of failure.

C2 Impact of Particles on Dielectric Breakdown Strength

This data is not available yet. In order to obtain the required particle concentration, calibration test dust (MTD) may need to be used. This particle concentration may not be typical of what can be found in transformers which comes from a variety of sources but would certainly be suited for a controlled study because of its known size characteristics. Such tests will be part of future investigations.

C3 Creep Strength Tests

This data is not available yet. As mentioned above, additional tests are currently being planned with an independent laboratory. These tests will be conducted so that four different creep distances can be evaluated.

C4 Dielectric Constant (Relative Permittivity) and Power Factor Data

Typically measured dielectric constant value: 3.2

BIOTEMP® higher dielectric constant, when compared to mineral oil (typically 2.2), provides a better match to the dielectric constant of impregnated cellulose (see Table 3 below) [5].

Table 3 – Dielectric Constant Evaluation and Comparison

Dielectric Constant	BIOTEMP®	Mineral Oil
Fluid only	3.2	2.2
Impregnated pressboard	4.7[3]	4.4[3]

This results in the electric stress being reduced in the oil and increased in the cellulose which is beneficial as the oil tends to have the lower dielectric strength.

BIOTEMP® power factor data are already given in Section A1 above. Both BIOTEMP® power factor and dielectric constant measurements at different temperatures (from 25 to 100°C) are currently conducted by an independent laboratory and are due by mid of 2008. These also include the evaluation of the dielectric constant of different insulating papers impregnated with BIOTEMP® at different temperatures.

[3] Determined using Equation (1) given in [5]

D. Oxidation and Stability

Results of the ASTM D 2440 oxidation test are here provided [2,6]. It is worth mentioning that the standard oxidation stability test is recommended for new dry oil. The use of exposed and aged oil may not have much relevance. The scope of the ASTM standards state that both D 2112 and D 2440 methods are for new, unused oils, and are not well defined for used oils.

The method used here consists of checking the formation of sludge and acids in the fluid in the presence of oxygen after 72 and 164 hours. Results of the ASTM D 2440 oxidation test are shown in Table 4 below [2,6].

Table 4 – Accelerated Oxidation Test Results [2]

Oxidation Stability	BIOTEMP®	Limit value per ASTM D 3487[4]
72 hrs, sludge	0.01 % by mass	max 0.1 % by mass
72 hrs, neutralization number	0.10 mg KOH/g	max 0.3 mg KOH/g
164 hrs, sludge	0.01 % by mass	max 0.2 % by mass
164 hrs, neutralization number	0.25 mg KOH/g	max 0.4 mg KOH/g

BIOTEMP® passed the oxidation test by producing a negligible amount of sludge and a reasonable amount of acids after 164 hours (well below the max limit value given by ASTM D 3487 for inhibited mineral oil). From Figure 4 below, it is obvious that BIOTEMP® stayed clear after the oxidation tests (Sample A) whereas another natural Ester fluid which does not have effective oxidation inhibitors tends to gel (Sample B).

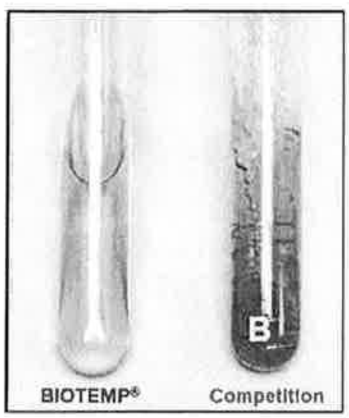

Figure 4 – Oxidation Test Results Comparison

Note however that it is stated in both ASTM D 2112 and D 2440 standards, in slightly different terms, that "this is a control test of oxidation stability of new, inhibited mineral insulating oils for determining the induction period of oxidation inhibitors under prescribed accelerated aging conditions. There is no proven correlation between oil performance in this test and performance in service". Committee ASTM D 27.02 is presently considering a

[4] ASTM D3487 provides property requirements for inhibited mineral insulating oil. There is no such a standard for natural Ester insulating fluid to date

pressure DSC test for oxidation evaluation of natural Ester fluids.

E. Thermal Characteristics incl. Ageing of Paper in BIOTEMP®

E1 Viscosity vs. Temperature

Viscosity values were measured (per ASTM D 445) at several temperatures for both BIOTEMP® and mineral oil (see Table 5 below).

Table 5 – Comparative Viscosity Measurements at Different Temperatures

Viscosity	BIOTEMP®	Mineral Oil	Limit value per ASTM D 6871
0°C	300 cSt	76 cSt	max 500 cSt
20°C	110 cSt	25 cSt	-
40°C	45 cSt	12 cSt	max 50 cSt
100°C	10 cSt	2.5 cSt	max 15 cSt

Viscosity values at other temperatures can be accurately extrapolated using these measured values and the ASTM D 341 chart (see Figure 5 below). For comparison purpose, the viscosity charts of other dielectric insulating fluids are also shown.

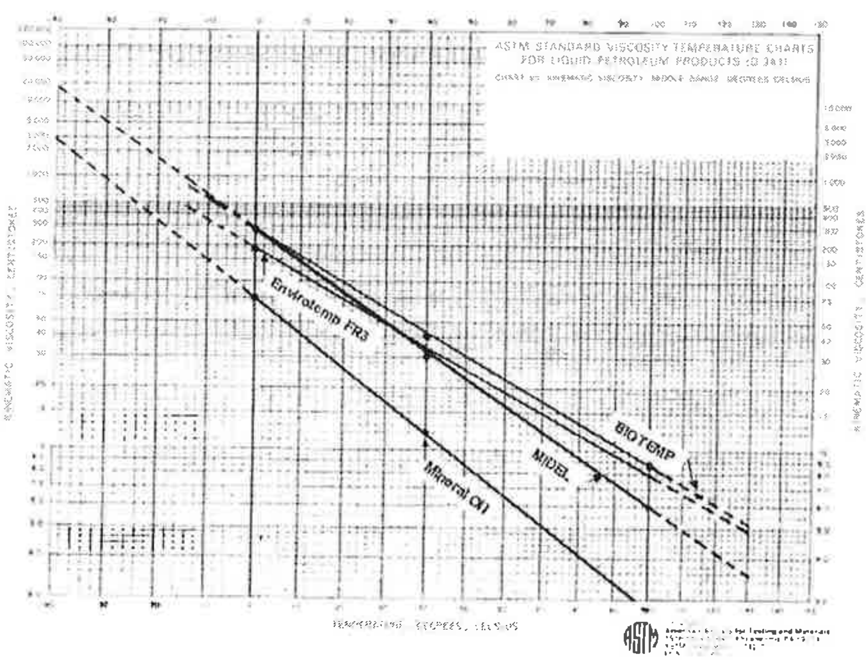

Figure 5 – Viscosity of BIOTEMP® and Other Dielectric Insulating Fluids

E2 Thermal Capacity (Specific Heat) vs. Temperature

Table 6 below shows thermal capacity values obtained (per ASTM D 2766) at several temperatures for both BIOTEMP® and mineral oil.

Table 6 – Comparative Thermal Capacity Measurements at Different Temperatures[5]

Thermal Capacity	BIOTEMP®	Mineral Oil
25° C	2.40 kJ/kg.°C (0.57 cal/g.°C)	2.07 kJ/kg.°C (0.43 cal/g.°C)
100° C	2.50 kJ/kg.°C (0.60 cal/g.°C)	2.37 kJ/kg.°C
200° C	2.64 kJ/kg.°C (0.67 cal/g.°C)	2.77 kJ/kg.°C
300° C	2.80 kJ/kg.°C (0.71 cal/g.°C)	3.17 kJ/kg.°C

The thermal capacity of BIOTEMP® is advantageously higher than mineral oil which would cause the temperature rise of the fluid to be lower than mineral oil for the same amount of losses.

E3 Thermal Aging of Paper Insulation in BIOTEMP®

Accelerated aging study was conducted on thermally upgraded insulation papers impregnated with BIOTEMP®. For comparison purpose, similar studies were conducted with mineral transformer oil.

The following test sets were used in the study:

1. BIOTEMP® + 3 mil upgraded Dennison crepe kraft paper **(Bio/P_1)**
2. BIOTEMP® + 10 mil upgraded plain kraft paper **(Bio/P_2)**
3. Mineral oil + 10 mil upgraded plain kraft paper **(Mo/P_2)**

The aging temperatures were 140, 160, and 180°C. The aging durations were 30, 90, 180, and 270 days. The end point selected was for a degree of polymerization (DP) of the paper of 200, as suggested by IEEE C57.100 and IEEE Loading Guide C57.91 – 1995.

At the elevated temperatures of 160°C and 180°C, the end points were reached within the time limit. A 140°C, the end point had to be obtained by extrapolation using the linear relationship between 1/DP and aging time, and extrapolating it to a DP of 200 (i.e. 1/DP = 0.005). The Arrhenius life time equations and plots are then obtained from the data corresponding to the end points at the selected temperatures:

Bio/P_1 $Log_{10}Life\ (hours) = 6514.42/T - 11.295$
$Life\ (hours) = EXP\ [15000/T] \times 8.0 \times 10^{-12}$

Bio/P_2 $Log_{10}Life\ (hours) = 6514.42/T - 11.097$
$Life\ (hours) = EXP\ [15000/T] \times 5.07 \times 10^{-12}$

Mo/P_2 $Log_{10}Life\ (hours) = 6514.42/T - 11.372$
$Life\ (hours) = EXP\ [15000/T] \times 4.246 \times 10^{-12}$

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[5] BIOTEMP® data was measured internally, while the mineral oil data was given by Exxon UNIVOLT 60

At a reference hot spot temperature of 110°C, the insulation life would be:

Bio/P_1	517,523 hours, which is 3.45 times the IEEE life of 150,000 hours
Bio/P_2	816,450 hours, which is 5.44 times the IEEE life of 150,000 hours
Mo/P_2	433,440 hours, which is 2.89 times the IEEE life of 150,000 hours

The corresponding Arrhenius life plots are shown in Figure 6 below:

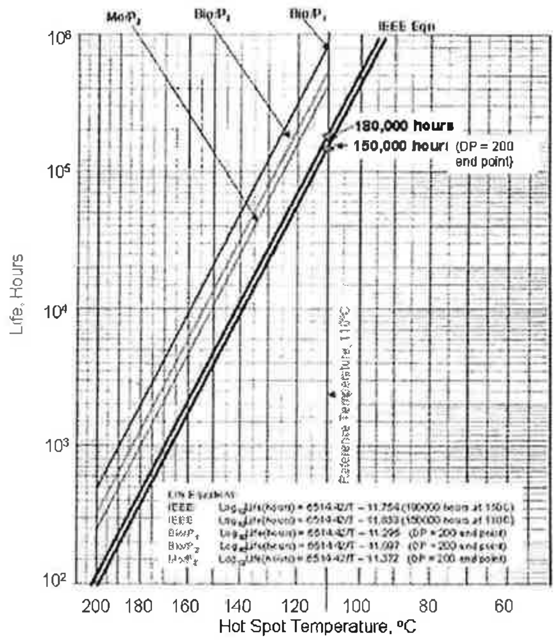

Figure 6 – Arrhenius Life Charts for BIOTEMP® and Mineral Oil Impregnated Papers

The plots reveal that the BIOTEMP®/paper insulation combination can be rated 10-15°C higher than the mineral oil/paper combination. Note that aging studies specified in C57.100 call for only dry paper/oil insulating system. To study the influence of moisture and oxygen, a separate aging study will be needed.

Functional life tests were performed on BIOTEMP®-filled distribution transformers, which showed considerably longer life time than units with a paper/mineral oil insulating system (see Section E3.1 below). IEEE has accepted the life time determined from functional life tests on distribution transformers for power transformers with paper/mineral oil insulation. The C57.100 Standard uses this life test for the accelerated model test.

E3.1 Functional Life Tests on Distribution Transformers

Functional life tests on distribution transformers are specified in IEEE C57.100 Standard. For mineral-oil filled transformers with 65°C rise, the Standard gives the following life time equation:

$$\text{Log}_{10}\text{Life (Hours)} = (6328.8/T)$$

where, T is the absolute temperature. To reach an end point sufficiently fast, accelerated aging is done by selecting elevated hot spot temperatures in the winding. The end point would be reached at different hot spot temperatures as follows:

180°C	503 hours
190°C	251 hours
200°C	129 hours

However, five times this duration is specified to compensate for the limited number of units tests. The total time interval is divided into ten equal intervals and the specified tests are conducted at the end of each interval.

Functional life tests were performed on four 25 kVA, 12.5/7.2 kV distribution transformers. Two of the transformers were aged with a controlled hot spot temperature of 180°C for over 5 times the mandatory hours of 503. The other pair was aged with a controlled hot spot temperature of 200°C for over 5 times the mandatory hours of 129. In both cases, the fluid retained its electrical and physical properties throughout the accelerated aging. Moreover, the liquid did not degrade the other insulating materials in the transformer.

The extended life time of the tested units is believed to be due to the water absorbing ability of BIOTEMP®, which keeps the insulation much drier than otherwise. Accelerated aging, as described above in Section E3, confirmed this finding by showing that the BIOTEMP®/paper insulation life time was enhanced considerably as compared to mineral oil impregnated insulation.

F. Gas Generation from Thermal and Electrical Stresses

F1 Gassing Tendency per ASTM D 2300

The gassing tendency of BIOTEMP® was measured (per ASTM D 2300 Method B) [2] and is compared to that of mineral oil in Table 7 below.

Table 7 – Comparative Gassing Tendency

Gassing Tendency	BIOTEMP®	Mineral Oil	Limit value per ASTM D 6871
	-53 µL/min	-30 to +30 µL/min	max 0 µL/min

The use of gas absorbing (negative gassing tendency) oils can only be beneficial in components where partial discharges can be high. The likelihood of partial discharge failures should therefore be lower with BIOTEMP®-filled units than with some mineral oil-filled units.

F2 Thermal Stresses

Aging studies were conducted at 150°C and 250°C. They showed that gases generated are similar to those generated from mineral transformer oil but with different rates (see Table 8 and 9 below).

Table 8 – Gas Generated after Aging at 150°C for 1 Week under Inert Atmosphere

Gas in oil (ppm)	BIOTEMP®	Mineral Oil
Hydrogen	0	0
CO	0	0
CO_2	84	120
Methane	0	1
Ethane	4	5
Ethylene	1	0
Acetylene	0	0

Table 9 – Gas Generated after Aging at 250°C for 22 Days under Inert Atmosphere (with and without Copper) [2]

Gas in oil (ppm)	BIOTEMP®		Mineral Oil	
	w/o Cu	w/ Cu	w/o Cu	w/ Cu
Hydrogen	442	86	30	64
CO	11,143	10,114	11	104
CO_2	7,579	9,609	533	659
Methane	274	339	179	185
Ethane	165	338	156	136
Ethylene	274	343	34	31
Acetylene	0	0	0	0

The gas generation is significantly higher at elevated temperature. The generation of CO, CO_2, and H_2 from BIOTEMP® is much higher than from mineral oil. At elevated temperature, the Ester bond appears to be breaking and contributing to these gases. At transformer operating temperatures, gas generation is comparable for both BIOTEMP® and mineral oil. Copper does not seem to influence gas generation, except, perhaps, for hydrogen.

Note that the use of standard gas generation charts for transformer oil is not applicable to Ester fluids at elevated temperatures. In addition, standard aging experiments are not practical for thermal decomposition studies at still higher temperatures, e.g. 300 to 1500°C, representing severe hot spot and arcing conditions. There are special methods to generate gases and measure quantities at these ranges. The use of a hot plate or hot Nichrome wire in contact with oil could be attempted, for instance. Special setups are however needed.

F3 Electrical Stresses

Both partial discharge and arcing tests results are presented below.

F3.1 Partial Discharge Test

A partial discharge test was conducted (per ASTM D 3612 Method A) [2] and the results are presented in Table 10 below:

Table 10 – Gas Generated after a Partial Discharge Test [2]

Gas in oil (ppm)	BIOTEMP®	Mineral Oil
Hydrogen	455	973
CO	310	29
CO_2	1,755	121
Methane	264	355
Ethane	29	95
Ethylene	3	10
Acetylene	19	27

The significant difference between the gassing of the two fluids is that BIOTEMP® produced considerably higher quantities of CO and CO_2 than mineral oil. Hydrogen is usually the dominant gas in partial discharge tests but this is not so obvious in the results shown in Table 10 for BIOTEMP®. Here again, the breakup of the Ester bond must be the cause for the high CO and CO_2 in BIOTEMP®.

F3.2 Arcing Test

The arcing test was conducted using a glass cell with electrodes. Test conditions are given below:

Temperature	22°C
Sample volume	210 ml
Voltage	10.8 kV
Electrodes	Spectroscopic grade graphite
Electrode gap	1 mm
Arc duration	3 min 5 sec

This was a low energy arc setup. The volume percent of gases generated are listed in Table 11 below:

Table 11 – Gas Generated after an Arcing Test

Gas in oil (ppm)	BIOTEMP®	Mineral Oil
Total volume of gas collected	*4.2 ml*	*28.4 ml*
Hydrogen	57.7	58.4
CO	13.2	0.10
CO_2	0.32	0.04
Methane	1.42	2.01
Ethane	0.03	0.04
Ethylene	0.84	1.16
Acetylene	23.3	33.1

The total gas generated from BIOTEMP® is only one-seventh of the gas generated from mineral oil. The 'arc quenching' effect of BIOTEMP® is obvious. The composition of the gases does not show appreciable difference between the two fluids except for CO, which is negligible in transformer oil. Again, the source must be the Ester group. The very low oxygen content of the fluids also explains the insignificant amount of CO_2.

F4 High Energy Arc

This data is not available yet. A special setup must be used for high energy arcing test and laboratories have been queried. A candidate lab has now been identified and such a test will be part of future investigations.

G. Environmental

G1 Biodegradability

According to "Merriam Webster's Collegiate Dictionary", *biodegradability* first came into use and/or misuse in 1961 and the most common measure of it, *biological oxygen demand (or BOD),* has been used since 1945. The first uses of these terms were geared toward sewage in water, wastewater, and sludge in water. The term is used scientifically to describe either how fast a substance decomposes or what quantity of a substance is decomposed when placed in the presence of bacterial organisms, thus simulating biological decomposition.

Recently biodegradability measurements have been expanded to cover many varied subjects, some of which have been hydraulic oils and lubricants, in particular marine lubricants such as used in outboard motors. The latter fluid is the subject of a European standard, CEC-L-33-A-94, (a replacement for CEC-L-33-T-82, a much earlier quoted document), which has sometimes been applied to dielectric fluids in the past, even though the standard itself is strictly limited to two-stroke outboard engine oils. This Coordinating European Council (CEC) method appears to be more focused to oil samples than other methods. It basically measures the loss of the starting material by mass balance using sewage to provide a source of microbes to consume the material.

Testing under another set of Standards, those originating with the European Organization for Economic Cooperation and Development (OECD), for instance OECD 301E, utilizes the more classic method of determining how much oxygen is consumed during the test period, in the order of 21 to 28 days. OECD 301B, the so-called modified Sturm test, measures the quantity of carbon dioxide (CO_2), a somewhat different measure, and usually indicates as much as 20% less biodegradability.

American Standards for biodegradability have been in a state of evolution seemingly parallel to the European Standards. Most of the tests in the OECD series have been adopted by the Environmental Protection Agency (EPA) with EPA's own number series. CEC-L-33-A-94 does not have an EPA counterpart although it has been modified for use by ASTM in ASTM D 6006 ("Standard Guide for Assessing Biodegradability of Hydraulic Fluids") and is referenced in several ASTM documents.

The ASTM D 6006 method was first approved in 1996. One of the OECD tests, OECD 301E, which is a screening test, has been incorporated into ASTM D 5864 ("Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components"). In addition, ASTM D 6731-01 ("Standard Test Method for Determining the Aerobic, Aquatic Biodegradability of Lubricants or Lubricant Components in a Closed Respirometer") incorporates OECD 301F.

As of yet, no ASTM standard exists for measuring dielectric fluid biodegradability. When the California EPA/California Department of Toxic Substances Control chose to measure the biodegradability of BIOTEMP®, they selected the CEC-L-33-A-93 test (the immediate predecessor of the '94 version) from among the various tests mentioned above [7].

In this test, a standard oil specified in the test method was compared to the sample of BIOTEMP® in separate flasks. In each flask, an inoculum and the oil specimen were placed. Two parallel additional flasks were prepared with the same contents except with no inoculum and poisoned with 1 ml of mercuric chloride. The extract from these flasks were collected at the start of the test and at the end of the 21-day incubation period. The solutions were analyzed by infrared (IR) spectroscopy measuring the maximum absorption of the carbon hydrogen (C-H) stretch at the ethyl-methyl (CH_2-CH_3) bond (2930 cm^{-1} ± 10 cm^{-1}). Biodegradability was calculated as the percent difference in the residual oil contents between the reference flasks and the poisoned flasks.

The results obtained revealed that the biodegradability of BIOTEMP® was from 98-100 % with an average value of 99 %. This is somewhat slightly higher than what was reported in earlier internally commissioned studies (i.e. 97-99 %). Mineral oil reported by the same agency from literature values (however not directly comparable to the test conducted here) ranged from 28% to 42-49 %. The generally accepted value for mineral oil is approximately 30 %.

Additional tests are currently conducted by an independent laboratory using both the experimental procedure OECD 301B (biodegradability degree) and the CEC-L-33-A-93 test (aquatic biodegradability). There tests are due by mid of 2008.

G2 Toxicity

In the same report, California EPA also conducted a series of tests to assess the acute toxicity of BIOTEMP® [7]. These tests were, as they pointed out, to determine the nature of the fluid as a spent waste. Their study showed that the fluid could be considered to exhibit a toxic characteristic since the results gave a LC_{50} value less than 500 mg/l. This greatly differed from the values obtained by Parametrix, an independent laboratory, contracted by ABB [8]. One of the differences between the methods was that California EPA used fathead minnows instead of the juvenile rainbow trout used by Parametrix. Another major difference between the methods was the use by California EPA of a wrist-action shaker to dissolve the oil in 200 ml of water before adding it to the bioassay fish tank. Parametrix employed a carrier solvent, as listed in the USA EPA method ("Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms").

It is worth mentioning that both ABB and Cooper Power Systems (for its natural ester fluid ENVIROTEMP FR3® also tested by California EPA) filed objections to the California EPA method and the comments from both companies are included in their respective reports [7]. Both companies essentially objected in the same manner. ABB pointed out the differences above and stated the following:

"ABB does not wish to minimize either the hazards or the toxicity of their fluid. The physical hazards are well known and are stated in the Materials Safety Data Sheet. We are principally concerned that the aquatic toxicity is at best exaggerated by the wrist-action shaker method and that an enhanced level of alarm may be construed from this."

REFERENCES

1. Consolidated Edison Company Inc, "Specification for Required Tests and Data on Ester Fluids (Synthetic and natural)", January 2007

2. L. R. Lewand, "Laboratory Evaluation of Several Synthetic and Agricultural Based Dielectric Liquids", Doble Client Conference, 2001

3. T. V. Oommen, "Moisture Equilibrium in Paper-Oil Systems", Proceedings of the 16th Electrical/Electronics Insulation Conference, October 1983

4. Laborelec (Belgium), "Report on BIOTEMP® fluid", June 2001

5. D. Martin, et al., "A Comparative Study of the Dielectric Strength of Ester Impregnated Cellulose for Use in Large Power Transformers", Proceedings of the 9th IEEE International Conference on Solid Dielectrics, July 2007

6. T. V. Oommen, "Vegetable Oils for Liquid-Filled Transformers", IEEE Electrical Insulation Magazine, January/February 2002

7. California Environmental Protection Agency, Department of Toxic Substances Control, Office of Pollution Prevention and Technology Development, "Environmental Technology Verification Report on BIOTEMP®, Vegetable Oil-Based Insulating Dielectric Fluid", (DTSC R-02-03/EPA 600/R-02/043), June 2002 (http://www.epa.gov/etv/pdfs/vrvs/06_vr_abb.pdf)

8. Parametrix Inc, "Toxicity Evaluation of BIOTEMP®", December 1998

APPENDIX – Summary and Comparative Dielectric Insulating Fluids Properties Table

Table 12 below provides a composite list of several key properties of natural and synthetic Ester fluids in comparison to mineral oil. The data is taken from the product literature of the different manufacturers of the fluids and augmented with data from an independent study performed by Doble Engineering [2].

Table 12 – Properties of Dielectric Insulating Fluids

Properties	Units	TEST METHOD	MIDEL® 7131 (Typical)	BIOTEMP® (Typical)	FR3® (Typical)	Mineral oil (Typical)
		Physical Properties				
Fire Point	°C	ASTM D 92	322	360	362	180
Pour Point	°C	ASTM D 97	-60	-15	-21	-40
Flash Point	°C	ASTM D 92	275	330	326	160
Specific Gravity	g/ml	ASTM D 1298 @ 15°C	-	0.91	0.92	0.91
		@ 20°C	0.97	-	-	0.88
Interfacial Tension	dynes/cm	ASTM D 971	-	26	24	40
Kinematic Viscosity	cSt	ASTM D 445 @ 0°C	280	300	180	76
		ASTM D 445 @ 20°C	79	110	72	25
		ASTM D 445 @ 40°C	29	45	34	12
		ASTM D 445 @ 100°C	6	10	8	2.5
Thermal Capacity	cal/g°C	@ 20°C	0.50	-	-	0.38
		ASTM D 2766 @ 25°C	-	0.57	0.45	0.43
Thermal Conductivity	W/m K	@ 20°C	0.144	-	-	0.126
		ASTM D 2717 @ 25°C	-	0.170	0.170	0.140
Expansion Coefficient	/°C	ASTM D 1903 @ 25-100°C	0.000750	-	0.000740	0.000730
		ASTM D 1903 @ 25-200°C	-	0.000735	-	-
		Electrical Properties				
Power Factor	%	ASTM D 974 (25°C, 60Hz)	0.10	0.15	0.06	≤ 0.05
		ASTM D 974 (100°C, 60Hz)	-	2.00	1.85	≤ 0.30
Relative Permittivity			3.2	3.2	3.2	2.2
Volume Resistivity	Ohm-cm	@ 25°C	-	10^{13}	30×10^{12}	10^{15}
		IEC 60247 @ 90°C	$> 5 \times 10^{13}$	-	-	-
Breakdown Strength	kV	ASTM D 1816 (1 mm gap)	-	32	36	≥ 20
		IEC 60156 (2.5 mm gap)	> 75	-	-	-
Impulse Strength	kV	ASTM D 3300 (needle negative)	-	134	164-170	≥ 145
Gassing Tendency	µL/min	ASTM D 2300	(positive)	-53	-81	-30 to +30

Table 12 – Properties of Dielectric Fluids (Continued)

Properties	Units	TEST METHOD	MIDEL® 7131 (Typical)	BIOTEMP® (Typical)	FR3® (Typical)	Mineral oil (Typical)
		Chemical Properties				
Corrosive Sulfur		ASTM D 1275	None	None	None	None
Oxidation Stability		ASTM D 2440 / IEC 61125				
	% per mass	Sludge after 72 hrs	None	0.01	Solid	≤ 0.1
	mg KOH/g	Neut. number after 72 hrs	0.01	0.1	-	≤ 0.3
Neutralization number (Acidity)	mg KOH/g	ASTM D 974	-	0.02	0.02	≤ 0.015
		IEC 61099 9.11	< 0.03	-	-	< 0.03
Water Content	ppm	ASTM D 1533	-	35	20	30
		IEC 60814	50	-	-	-
Biodegradability	%	CEC L-33-A-93	-	99	>99	30
	%	EEC Standard 79/831	83	-	-	-

ATTACHMENT 2

Jennifer Franco

Subject: FW: Rikers Island Cogeneration- Public Participation Plan

From: Elizabeth Clarke [mailto:eaclarke@gw.dec.state.ny.us]
Sent: Thursday, February 17, 2011 11:55 AM
To: Ramon Li
Cc: Stephen Holley; Cicily Nirappel; mmoore@gw.dec.state.ny.us
Subject: Re: Rikers Island Cogeneration- Public Participation Plan

Your 1/21/11 EJ Plan for the Rikers Island facility is approved. Note: Please send the final Fact Sheet to me before distribution for review.

Thanks, Elizabeth

not for release - CONFIDENTIAL>>> Ramon Li <RLi@akrf.com> 1/21/2011 11:28 AM >>>
Elizabeth,
Attached is the plan for the new cogen project.
Please call me or Steve Holley at x9742 with any questions or comments.
Thanks,
Ray

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