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Proposal To

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION
Room 5619 Main Interior Bldg.
18th & C Streets, N. W.
Washington, D. C. 20240

Proposal No.

FIRE RESISTANT TRANSFORMER INSULATION SYSTEM

Submitted by

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WESTINGHOUSE ELECTRIC CORPORATION
Materials & Manufacturing Technology Department
Sharon, Pennsylvania

December 11, 1975

NPC00026376

753713

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FIRE RESISTANT TRANSFORMER INSULATION SYSTEM

1. INTRODUCTION

Present day dielectric liquids must possess a unique combination of electrical and physical properties in order to provide optimum performance in transformers, capacitors and circuit breakers. In certain types of transformers and capacitors, a specialized fluid termed askarel has been used to achieve desirable product performance. The composition of the askarel provides a high flash point, fire resistant liquid which under arcing conditions produces predominately hydrogen chloride and varying amounts of combustible gases depending upon the insulation system. Recent studies have shown that environmental pollution problems are associated with the use of askarels.

Insulation system integrity is probably the most important factor in satisfactory and safe transformer performance. While this proposal is concerned with the development of a new safety transformer insulation system, not having environmental problems associated with askarels (PCB'S), it must be stressed that transformer design principles must be adhered to when developing a new insulation system.

The transformer end user in industry and utilities have four different commercial types of transformer insulation systems to choose from:

1. Liquid cooled systems
2. Dry type air cooled systems
3. Gas cooled sealed systems
4. Air cooled encapsulated systems

Preliminary analysis of these four systems shows that the liquid cooled system permits operation at the highest voltage stresses and under the best heat transfer conditions. Liquid cooled systems also have the greatest short time overload capability.

Present liquid cooled systems use primarily mineral insulating oil as a dielectric fluid, however, certain applications require the use of a non-flammable fluid to reduce fire and explosion risk. Historically askarels (polychlorinated biphenyl, PCB) have been used for these applications.

When considering different alternatives to transformer liquids derived from polychlorinated biphenyls or blends of polychlorinated biphenyls with chlorinated benzene a complex dilemma was encountered. While such liquids are essentially non-flammable, they are very resistant to oxidation even at elevated temperatures. Unfortunately, resistance to oxidation is often accompanied by a comparable resistance to chemical and biological degradation. Persistence in the environment may cause long-term toxicological and ecological effects.

In addition to the dichotomy presented by the undesired persistence in the environment and the desired non-flammability of the transformer liquid, the situation was further complicated by the nature of the decomposition products formed when the liquid was subjected to arcing. Historically chlorinated liquids were selected because when they were subjected to arcing conditions they produced primarily a non-combustible mixture of products, mainly HCl. The need for obtaining the non-combustible gas mixture was to minimize the explosion hazard in transformers located around buildings and people. In this context, askarel liquids are defined as fire resistant synthetic liquids, which, when decomposed in an electric arc, evolve primarily non-flammable gases. This definition has been used in safety standards and codes, especially the National Electric Code and for products listed by Underwriter's Laboratories.

Gas evolution is only one factor in a complex process that takes place under failure conditions. The hazard associated with different insulation systems can best be determined by a systematic evaluation of the materials, transformer components

and total design. Tank rupture and fire spread tests are necessary when evaluating any new insulation system.

Limited testing of insulation systems in the U.S. and Japan has indicated that certain silicone liquids can provide a degree of safety. An evaluation program for silicone liquids to be used in railroad transformers has been carried out in Japan with this liquid having been put into service there. Silicone liquid is the generic name for a series of inert and thermally stable insulating liquids with electrical properties similar to mineral oil. In addition, silicone liquids are generally considered to be of low toxicity and of low flammability depending upon the viscosity. For technical and economic reasons, the development emphasis for transformer application has been placed on the polydimethylsiloxane liquid of 50 cs. viscosity. The system presently in operation in Japan uses this particular type of silicone liquid. While this system has a degree of reliability and safety, it may not be equivalent in safety to the presently used askarels. In the presence of an electric discharge, silicone liquids evolve predominately hydrogen gas, however, the nature of any resultant hazard needs further investigation. This proposal suggests a systematic analysis of the capabilities of silicones for use as new safety liquids. It deals with the testing of existing liquids and also the development and testing of new liquid using the full system evaluation of these materials in models and transformers. Such testing includes complete fire and explosion testing. Some synthetic materials which have the desired electrical and heat transfer properties may also have flammability, toxicity, and stability characteristics which are of interest for this application. Materials such as high temperature oils, silicate esters and others will be considered. Blends of materials such as blends with trichlorobenzene will be screened.

2. OBJECTIVES

The objectives of this project are as follows:

1. Develop an insulation system with good electrical, mechanical and heat transfer properties to provide adequate reliability and efficiency under normal and overload transformer operating conditions.
2. Develop an insulation system that will enable the construction of transformers that are adequately safe from fire and explosion hazard under internal overload, arc or failure conditions as described in Section 3.1.2.2.
3. Develop a transformer insulation system that contains materials that do not present toxic hazard or environmental pollutant danger as measured by movement into the environment, bioconcentration, degradation, and toxicity to animals and fish.
4. Develop a system that is economically acceptable.

3. WORK STATEMENT

3.1.1 PHASE I - DOW CORNING

The following portion of this proposal will cover the work to be performed by Dow Corning.

3.1.1.0 The primary purpose of this effort will be to evaluate silicone liquids for use as transformer coolants. Initially existing liquids will be evaluated. In addition new structures may be proposed and subsequently evaluated. The following are examples of materials which will be considered.

3.1.1.1 Type of materials to be evaluated.

3.1.1.1.1 Polydimethylsiloxane.

3.1.1.1.2 Polyphenylmethyilsiloxanes or copolymers with polydimethylsiloxane.

3.1.1.1.3 Polymethylhydrogensiloxane or copolymers with polydimethylsiloxane.

3.1.1.1.4 Polyalkylmethyilsiloxanes or copolymers based on them.

3.1.1.2 Conventional Evaluation Tests

The following screening tests will be run to verify the acceptability of the materials under study. Materials showing favorable results will be given to Westinghouse for further detailed study.

3.1.1.2.1 Physical Properties. Such properties as flash point, fire point, pour point, viscosity,

viscosity temperature relationship will be evaluated.

3.1.1.2.2 Dielectric Properties. These would include volume resistivity, dielectric constant, dissipation factor and dielectric strength.

3.1.1.2.3 Environmental Effects. Toxicity and potential ecological impact of large volume usage will be evaluated.

3.1.1.2.4 Explosion Characteristics. This study will be relevant to the impact to potential transformer installations.

3.1.1.2.5 Compatibility. This will cover common materials of transformer construction.

3.1.1.2.6 Arcing and Corona. This will include the amounts and types of gases and solids formed during these disturbances.

3.1.1.2.7 Thermal Stability. Systems will be subjected to thermal and electrical stresses over extended periods of time.

3.1.1.2.8 Availability. This will include considerations of quantities, time span and sizes of expansions that are anticipated.

3.1.1.2.9 Cost. Consideration of the cost/volume relationship will be made.

3.1.1.3 Specialized Tests.

3.1.1.3.0 In addition to a thorough evaluation of candidate liquids by the above conventional methods,

other test methods will be developed to more completely define the fluid capabilities and safety properties. These new tests will include:

3.1.1.3.1 Dielectric Breakdown. A test method to determine dielectric breakdown of silicone liquids and combinations of liquids and solids such as kraft paper.

3.1.1.3.2 Arcing Behavior. A test method to study arc behavior and arc quenching in silicone liquids.

3.1.1.3.3 Fire and Explosion Hazards. These tests will assess fire and explosion hazards of silicone liquids under internal arc conditions.

3.1.1.3.4 Maintenance of Silicone Liquids. This work will cover methods used in manufacturing and maintenance of silicone liquids in transformers.

3.1.1.3.5 Manufacturing Tests. These will cover tests used in manufacturing of silicone liquids.

3.1.1.4 It will be necessary, as a final portion of Dow Corning work, to develop the technology necessary to process the liquids in order to make it consistently acceptable for dielectric applications. This includes identification of impurities and techniques for removing and/or controlling these impurities.

3.1.2 PHASE I - WESTINGHOUSE.

The following discussion will cover the Phase I portion of the proposal which will be conducted by Westinghouse.

3.1.2.1 Life Tests.

3.1.2.1.0 Life test units will be built with a dielectric cooling liquid known as Dow Corning Q2-1090. The transformers will have a rating of 25 kVA, type S, 7200 to 120/240 volt, single phase, 60 hertz. Four units will comprise the test set. Three transformers will be standard units, the fourth will contain a thermocouple to control the coil temperatures of the other three units. A load current will be applied to maintain the hot spot temperature at 220°C and normal potentials will be impressed on the windings during aging.

3.1.2.1.1 Cellulose Based Insulation System.

Previous life tests run by Westinghouse have illustrated the excellent stability of a silicone/non-cellulose transformer. These units applied NOMEX, glass polyester and glass silicone in areas where cellulose is normally used. Since cellulose is considerably less expensive than this system, the behavior of a cellulose/silicone unit is of interest.

3.1.2.1.2 Process and Test Transformers.

The test units will be fitted with special covers to permit sampling, processing, pressure and temperature monitoring, dried and filled with the experimental liquids. The test set will consist of 3 units filled with the Q2-1090 liquid, and one unit also with

Q2-1090 and used as a monitor. All transformers except the monitor unit will be given periodic end point test.

3.1.2.1.3 Life Aging and End Point Testing.

End point tests consisting of (1) 85% full wave impulse; (2) 65% applied potential; (3) short circuit, 25 time normal for 2 seconds and (4) over potential, 130% at 400 Hz for 18 seconds at specific time intervals. Transformers that do not fail during the program outlined above will be tested to failure after completion of the final cycle. Using 100% values of the above end point tests and increasing the 65% applied potential in 5% steps until failure.

3.1.2.1.4 Analysis of Gas Samples Extracted from Liquid.

Samples of the Q2-1090 will be taken at the start and periodically during the 10,000 hour life test. Gases will be extracted from the fluid and analyzed. Replacement fluid will be added to each unit after sampling to maintain normal levels in the transformer.

3.1.2.1.5 Analysis of Gas Samples.

At the start and periodically during the test, gas samples from the gas space will be taken and analyzed.

3.1.2.1.6 Inspection of Units.

At the end of the life tests, each of the units will be dismantled and inspected. The failure area will be located if possible and photographs made of the aged units.

- 3.1.2.2 Evaluation of Fire Resistance.

3.1.2.2.0 For an electric insulating material to be suitable from a fire resistant standpoint, two requirements must be met: (1) the material must not burn; (2) the decomposition products produced in the presence of an arc must not be flammable. Considering actual applications, the latter requirement may be altered to state that a material is acceptable as being non-flammable if the arc formed gases, while flammable themselves, are produced in such quantities that no explosive danger exists.

The data collected in this section will actually serve a two-fold purpose: (1) it will provide a comprehensive comparison of askarel, silicone fluid (Q2-1090), and synthetic materials relative to flammability, and; (2) it will provide baseline data from which to evaluate any new candidate materials which Dow Corning will submit.

In view of the flammability definitions noted earlier, the following investigations will be conducted:

1. Flash point - Cleveland open cup
2. Flash point - Mandelcorn test
3. Fire point - Cleveland open cup
4. Flammability of arced formed gases
5. Low pressure spray
6. Relationship between Arcing, Flash Point and Burning of a Liquid
7. Simulated transformer model

3.1.2.2.1 Flash Point - Cleveland Open Cup.

This test is conducted per ASTM D-92. A test cup is filled to a specified level with the sample. The

temperature of the sample is increased rapidly at first and then at a slow constant rate as the flash point is approached. At specified intervals a small test flame is passed across the cup. The lowest temperature at which application of the test flame causes the vapors above the surface of the liquid to ignite is taken as the flash point.

3.1.2.2.2 Flash Point - Mandelcorn.

This test is similar to the Cleveland Open Cup flash point. The difference exists in that the cup has attached to it a thermocouple; after the flame has appeared, the temperature of the liquid under study is lowered until the flame is extinguished. The temperature at this point is noted and compared with other materials.

3.1.2.2.3 Fire Point - Cleveland Open Cup.

This test is also conducted per ASTM D-92. The procedure is the same as the flash point with the additional step of continuing the application of the flame until the material under study is ignited and burns for at least five seconds.

3.1.2.2.4 Flammability of Arced Formed Gases.

This portion of the study will evaluate both the composition of the arc formed gases and their degree of flammability. The gases can be generated many ways. One method involves using two carbon electrodes. The electrodes are mounted such that a gap of varying length can be obtained. Power can be supplied using conventional equipment. As the gas is generated, it can be collected

by displacing liquid in a glass tube on top of an inverted glass funnel.

The gases will be analyzed with a chromatograph to determine the composition. In addition, the degree of flammability will be evaluated by passing a flame over the exit gas port during the arcing.

3.1.2.2.5 Low Pressure Spray.

This test has the designation AMS 3150C. The fluid is sprayed from a Binks Thor No. T paint spray gun (.070 in diameter orifice, 40 Psi air) in bursts over the source of ignition, which may be a gas flame. Any increase or decrease in the flame caused by the fluid mist is observed. This test would simulate ignition caused by contact with a flame of fluid ejected from a transformer under pressure.

3.1.2.2.6 Study of Relationship Between Arcing, Flash Point and Burning of a Liquid.

In this test an arc is generated in the liquid under study. The gases formed during this arcing reach the liquid surface and burn with the help of the arc itself and oxygen supplied from the air. This burning then provides heat to warm the oil. The oil itself then burns when its temperature exceeds its flash point. Therefore, for any one arrangement of electrodes and applied power, different liquids will burn after different periods of arcing governed by their respective flash points.

3.1.2.2.7 Simulated Transformer Model

In this portion of the flammability and safety study a pressure vessel will be constructed to contain the samples and simulate the operation parameters of a transformer relative to arcing and the subsequent generation of gases in the insulating liquid. The arc power and length will be controlled. Partial coils will be constructed using cellulose and non-cellulose conductor insulations with faults introduced to simulate turn to turn or layer to layer type failures. The coils will be processed in the liquids under study.

The set-up will include provisions for measuring parameters to determine, rate of gas generation, pressure rise, rate of pressure rise, arc power, currents and voltages, secondary explosive capabilities and the failure mechanism.

*newest Phase II
Dow will do in plant*

PHASE II - EVALUATION OF NEW CANDIDATE FIRE RESISTANT LIQUIDS

In this phase new fire resistant materials developed by Dow Corning will be evaluated for their suitability for use as dielectric liquids. Initially the following basic tests will be run.

*No more issues
from*

5000

3.2.1 Electrical Properties.

3.2.1.0 The following electrical tests will be run to determine that the candidates pass the basic requirements of insulating liquids, which are Standard ASTM procedures.

3.2.1.1 Dielectric Strength.

3.2.1.1.1 60 Hertz Disk Electrodes (ASTM D-877)

This test is useful in assessing the quality of the liquid as received. It is not sensitive enough for a

processed dielectric liquid used in electrical apparatus.

This property is determined with VDE electrodes.

3.2.1.1.2 60 Hertz VDE Electrodes. (ASTM D-1816)

Because of its sensitivity the VDE method is used to assess the intrinsic breakdown strength of dielectric liquids. Prior to testing, the liquid must be filtered and degassed so that the moisture content will be 15 parts per million or less and the dissolved gas content will be 0.5 percent or less by volume

3.2.1.1.3 Impulse. (ASTM D-3300) The impulse strength of dielectric liquids is critical in electrical apparatus. The breakdown strength indicates the liquids ability to resist electrical breakdown under transient voltage stresses (lightening and switching surge). The breakdown is measured using a 1/2 - 40 micro sec. full wave impulse between two electrodes, one a steel phonograph needle and the other a 1/2" diameter round brass hemisphere.

3.2.1.2 Power Factor. (ASTM D-924) This test evaluates the power dissipated in an insulating material (watts) relative to the product of the effective voltage and current when tested under prescribed conditions.

3.2.1.3 Dielectric Constant. (ASTM D-924) This is the ratio of the capacitance of a material measured with a given electrode configuration and spacing; with the material as the dielectric to the capacitance with vacuum as the dielectric. The value of the dielectric constant of insulation components in an electrical system determine the potential stresses on the components,

3.2.2 Chemical Properties.

3.2.2.1 Moisture Content. (ASTM D-1533) This ASTM method will be altered slightly relative to the solvent system to avoid the interference caused by the silanols present in silicone materials. A low moisture content is necessary to achieve adequate electrical strength and low dielectric loss characteristics, to maximize the insulation system life, and to minimize metal corrosion.

3.2.2.2 Neutralization Number. (ASTM D-972) A low acid content (neutralization number) of liquid is necessary to minimize electrical conduction and metal corrosion and to maximize the life of the insulation system.

3.2.2.3 Oxidation Stability. (ASTM D-2440, D-943, D-2112) The development of a sludge or acidity resulting from oxidation during storage, processing, and long service life should be held to a minimum. This minimizes electrical conduction and metal corrosion, maximizes insulation system life and electrical breakdown strength, and insures satisfactory heat transfer.

3.2.3 Physical Properties.

3.2.3.1 Viscosity. (ASTM D-88) Viscosity influences the heat transfer and consequently, the temperature rise of apparatus. At low temperatures the resulting higher viscosities influence the speed of moving parts, such as those in power circuit breakers, switchgear load-tap-changer mechanism, pumps, and regulators. Viscosity controls a fluids processing conditions, such as dehydration, degassification and filtration and impregnation rates. High viscosity may adversely affect the starting up of apparatus, that is, spare transformers and replacements in cold climates. Viscosity measurements will be made throughout the expected

operating range of a transformer.

3.2.3.2 Pour Point. (ASTM D-97) The pour point is the temperature at which complete lack of fluidity exists. This property becomes very important where very low ambient temperatures exist such as North Slope applications. Should the pour point be too high relative to the ambient such mechanisms as tap changers will not operate properly if at all.

3.2.3.3 Color. (ASTM D-1500) A low color number permits visual inspection of assembled apparatus in the tank. An increase in the color with time indicates deterioration of the fluid.

3.2.3.4 Interfacial Tension. (ASTM D-971) A high value indicates the absence of undesirable soluble polar contaminants. This test is frequently applied also to in service liquids as an indicator of the degree of deterioration.

3.2.3.5 Specific Gravity. (ASTM D-1298) The specific gravity of a liquid influences the heat transfer rates and may be pertinent in determining suitability for use in specific applications.

3.2.4 Application Tests.

3.2.4.0 Candidate Materials having acceptable test values from the above evaluations will now be subjected to a second set of tests. These are more involved and complex than those of the initial evaluation and will fully confirm or reject the candidates relative to suitability as a dielectric fluid.

3.2.4.1 Compatibility Studies. These tests are made to determine the effect materials of construction of electrical equipment have on the candidate liquids and also the effect of the liquids on the

materials.

3.2.4.1.1 Short Term. The first series of tests are run at 105°C for one week which can be extended to one month for borderline materials. The condition of the liquid and solid insulation will be compared with their initial condition.

3.2.4.1.2 Long Term. A second type of test is made on enamel conductors for one month at 150°C. Samples of Kraft paper, NOMEX, and electrical steel will be included in the test tanks to represent the general insulation system used in units. Tests on the insulated conductor include dielectric breakdown voltage, scrape, and visual inspection for cracking or crazing of the enamel. Bursting strength tests will be made on the flexible insulation for comparison to similar samples tested in askarels and hydrocarbon oils.

3.2.4.2 Heat Transfer. Since one of the major functions of an insulating liquid is cooling, it is necessary to determine if there is a difference between the candidate liquid and oil or askarels. Tests will be made under carefully controlled conditions to determine the effectiveness of the different insulating liquids as coolants.

3.2.4.3 Thermal Conductivity. (ASTM D-2717) This property is closely associated with heat transfer. Measurements will be made to obtain comparative values with presently used dielectric liquids.

3.2.4.4 Specific Heat. (ASTM D-2766) This physical value as that of thermal conductivity are required for ~~heat transfer~~ cal-

culations and markedly effect the cooling capacity of the liquid.

3.2.4.5 Gas Absorption Characteristics. (ASTM D-2298, D-2300)

The subject of the solubility of gases in a dielectric liquid is of importance in liquid immersed gas covered electrical equipment that operates under sealed conditions. The liquid may become saturated with gas at one pressure and temperature and then tend to evolve dissolved gas as the environmental pressure or temperature is changed. Such gas evolution could impair the operation of the equipment. This study will provide comparative data between candidate liquids and askarel and hydrocarbon oils.

3.2.4.3.1 The gas absorption study will also evaluate the influence of dissolved gas on the dielectric strength of the liquid.

3.2.4.6 Lubricity. Present dielectric liquids while not outstanding as lubricants are effective enough to permit the operation of tap changers, power circuit breakers, pumps and various gear mechanisms. Tests such as the Falex, 4-ball and sliding block tests will be made to show the comparative lubricity of the candidate liquid with those currently in service.

3.2.4.7 Rate of Insulation Impregnation. A vital concern in processing of units is the complete impregnation of the coil assembly and the rate of impregnation. The candidate materials will be evaluated for impregnation rate relative to the accepted liquids of oil and askarel. Assemblies of flexible insulation and conductor will be combined in a test fixture. Varying times of impregnation relative to the standard materials will be run. Dielectric tests

will then be conducted to study the degree of impregnation.

3.2.4.8 Moisture Absorption Characteristics. While drying of units is part of the regular processing, moisture may enter the unit inadvertently due to a gasket leak or other such occurrence. The moisture may also be produced during the normal aging of other insulation components. The behavior of a dielectric fluid in the presence of moisture is, therefore, of considerable importance. The candidate materials will be exposed to varying degrees of moisture corresponding to the levels that are possible in a unit. These values will be compared to the present standard materials of oil and askarel.

3.2.4.9 Coefficient of Expansion. In order to effectively determine the level of the dielectric liquid under operating conditions, the coefficient of expansion is required. This property will be determined per ASTM D-1903.

3.2.4.10 Thermal Aging. The candidate liquid study will be expanded to include temperatures representative of operational temperatures and somewhat higher. These data will be used to determine the effect of temperature on breakdown voltage, power factor, and volume resistivity.

3.2.4.11 Effect of High Temperature on Stability. A study of the behavior of the candidate liquids exposed to 200°C and higher temperatures is required to determine the viscosities of the liquid as a function of time and temperature. (W)

3.2.5 Life Tests.

3.2.5.1 Life test units will be built and filled with the candidate liquids which, by their properties as measured in the tests noted above, appear to be the most promising. The transformers will be 25 kVA, type S, 7200 to 120/240 volt, single phase, 60 hertz distribution units. Four units will comprise a set evaluating each candidate liquid. Three transformers will be standard units, the fourth will contain a thermocouple to control the coil temperatures of the set. The load will be constantly adjusted to maintain a hot spot temperature of 220°C with normal potentials applied to the windings. If necessary, a method of limiting the temperature of the top liquid will be employed.

3.2.5.2 Two insulation systems will be evaluated.

3.2.5.2.1 Cellulose based systems.

3.2.5.2.2 NOMEX based system.

These units will have no cellulose in them; polyester silicone glass, NOMEX will be used wherever cellulose would apply on conventional designs.

3.2.5.3 Process and Test Transformers. The test units will be fitted with special covers to permit sampling and monitoring, dried and filled with the experimental liquids. Each group of four will consist of 3 units with the experimental liquid under study, and one unit also with the experimental liquid to be used as a monitor. All transformers except the monitor unit will be given periodic end point tests.

3.2.5.4 Life Aging and End Point Testing. End point tests consist of subjecting the test units to the following at specific time

intervals: (1) 85% full wave impulse; (2) 65% applied potential, (3) short circuit, 25 times normal for 2 seconds, and (4) over potential, 130% at 400 Hz for 18 seconds. Transformers that do not fail during the above program will be tested to failure after completion of the final cycle. Using to 100% values of the above end point tests and increasing the 65% applied potential in 5% steps until failure.

3.2.5.5 Analysis of Gas Samples Extracted from Liquid. Samples of the dielectric liquid will be taken at the start and periodically during the 10,000 hour life test. Gases will be extracted from the liquid and analyzed. Replacement liquid will be added to each unit after sampling to maintain normal levels in the transformer.

3.2.5.6 Analysis of Gas Samples. At the start and periodically during the test, gas samples from the gas space will be taken and analyzed.

3.2.5.7 Inspection of Units. At the end of the life tests, each of the units will be dismantled and inspected. The failure area will be located if possible and photographs made of the aged units.

3.2.6 Evaluation of Fire Resistance. In the following sections, the areas of study and test to evaluate the candidate liquids will be identical to those outlined in section 3.1.2.2 of Phase I.

3.2.6.1 Flash Point (Cleveland Open Cup)

3.2.6.2 Flash Point (Mandelcorn Test)

3.2.6.3 Fire Point (Cleveland Open Cup)

3.2.6.4 Flammability of arc formed gases

3.2.6.5 Low Pressure Spray

evaluation tests satisfactorily will be submitted to Underwriter Laboratories for approval as a non flammable liquid for electrical applications.

4.4.1 PHASE IV - FULL SIZE TRANSFORMER TESTING.

After Phase III of the program has been completed, it is proposed to build two full size transformers having a rating of 1000 kVA, 13200 volts, 3 phase, 60 hertz with a built in fault, and test by applying high power.

The Westinghouse South Boston Plant will manufacture the transformers and the testing will be performed at the Westinghouse High Power Laboratory. The test conditions such as temperature, power, type of tank and other features will be agreed between Westinghouse and ERDA and then specified by analyzing previous work.

4. PROJECT TIMETABLE

	<u>Time Per Job Step (Man Months)</u>	<u>Est. Elapsed Time (Months)</u>
<u>PHASE I</u>		
Dow Corning	36	
Westinghouse	34	12
<u>PHASE II</u>		
Dow Corning	12	
Westinghouse	34	12
<u>PHASE III</u>		
Dow Corning	12	
Westinghouse	24	6
<u>PHASE IV</u>		
Westinghouse	6	6
<u>FINAL REPORT</u>		
Westinghouse	2	
	160	36

5. PROJECT ORGANIZATION

The project will involve a joint effort by Dow Corning and Westinghouse Electric. Engineering and technical specialists from both companies will participate in the program. The Electrical-Electronic Industry division is the specific Dow Corning group to be involved in the work. For Westinghouse, Materials Engineering and Small Power Design Engineering will be the groups involved, with the Westinghouse Research Laboratories available for consultation on mechanical, electrical or material problems, should such assistance be required.

6. CAPABILITIES AND FACILITIES

6.1 Dow Corning Corporation.

Dow Corning has been the leader in the silicone field since the company was formed in 1943. The company has invested more man-years in silicone technology than all the rest of the world's silicone manufacturers. Laboratories and facilities are available for synthesizing silicone materials and their complete evaluation. The laboratories are fully equipped to perform tests to evaluate chemical, physical and ecological properties of materials. The Dow Corning group involved in the specific area covered by this proposal has the responsibility for silicone applications in the Electrical-Electronic Industry.

6.2 Westinghouse Electric Corporation.

6.2.1 Materials and Manufacturing Technology.

The Materials and Manufacturing Technology Department of the Transformer Divisions is the central location for materials and processing development, supplier approvals, and quality control studies for Westinghouse's five transformer manufacturing locations. The Insulating Materials Section of this department manages the various

insulating liquids for the transformer divisions. The laboratories are fully equipped to perform all types of tests relative to the evaluation of liquid and solid insulating materials and other transformer materials of construction. These facilities include physical, electrical and chemical test equipment, equipment for evaluating oil gassing and oxidation properties and system compatibility studies; and insulation systems evaluation of test transformers under full electrical stress at elevated temperatures to provide accelerated aging.

6.2.2 Small Power Transformer Design Engineering.

The Small Power Transformer Design Engineering Department performs the design and development work involved in the manufacture of small power transformers at the South Boston, Virginia Plant. The majority of the transformers having non flammability requirements are made at this plant. The small power personnel have many years experience in the problems associated with the operation of power transformers. Their personnel will be responsible for providing consultation during the design of the model units in the flammability study of Phase III, and the design of the commercial units for the test in the final Phase IV of this proposal.

6.2.3 Research and Development Laboratories.

As the central research and development activity of Westinghouse, the Research Laboratories maintain a broad capability in engineering and science. One of its main functions is to provide an effective consulting service to all divisions.

7. PROGRAM MANAGEMENT AND PERSONNEL

The proposed program as performed by Dow Corning and Westinghouse will have the following approximate percent participation:

F

Dow Corning 35%

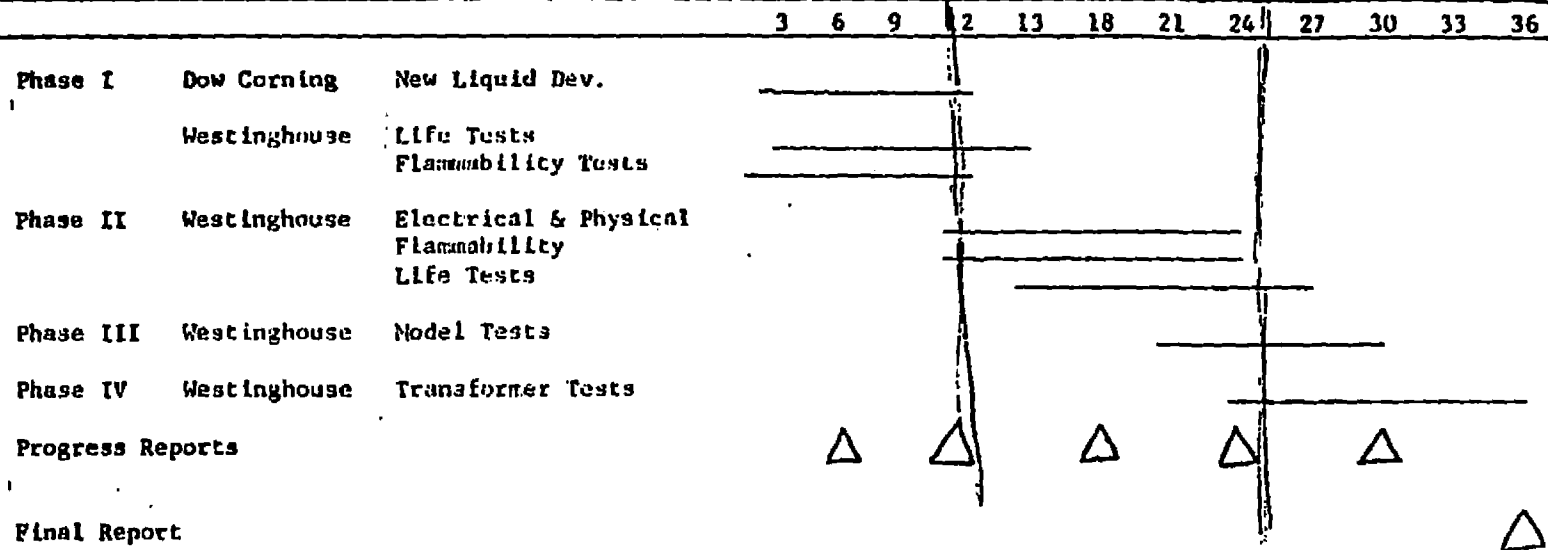
Westinghouse 65%

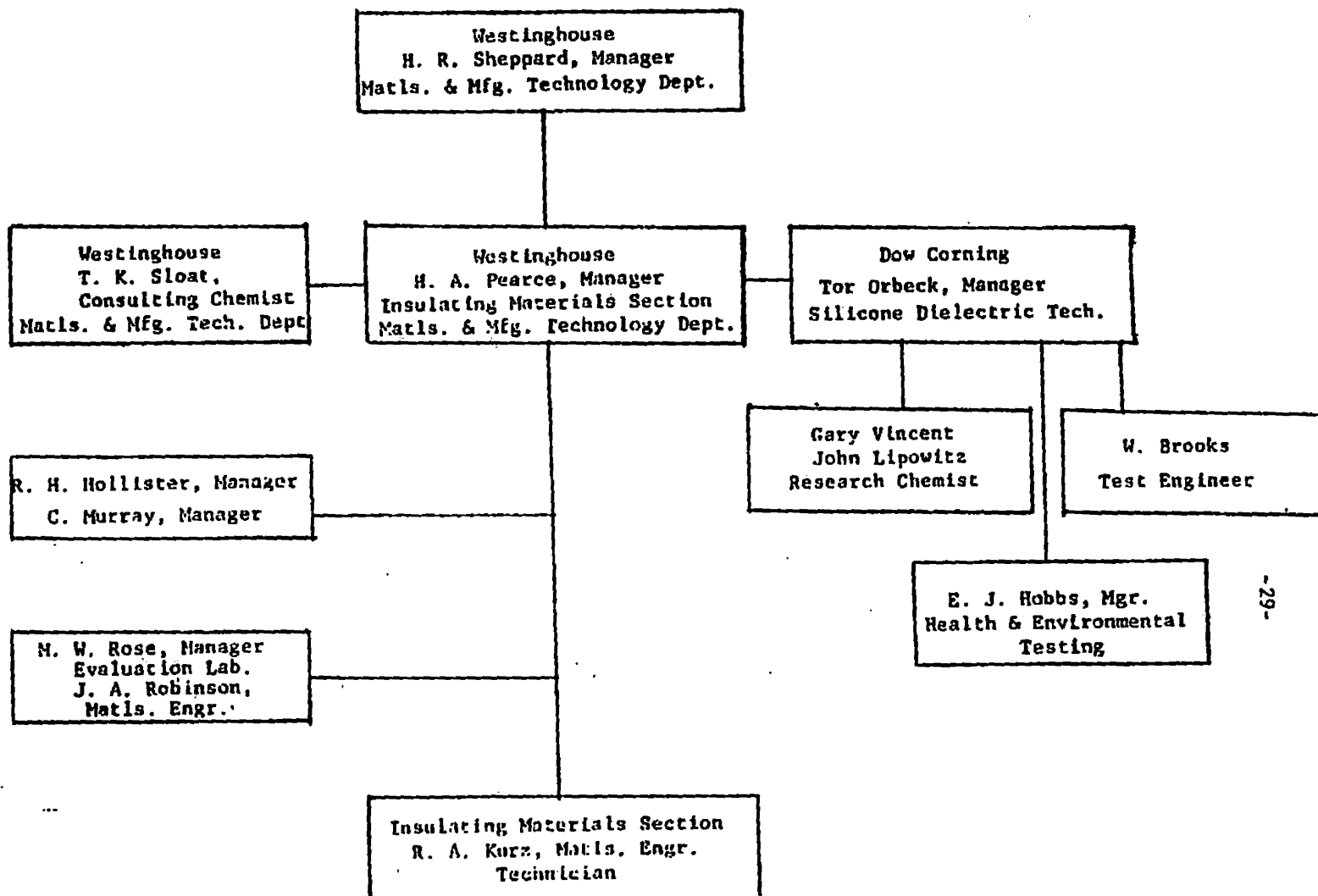
Westinghouse will be considered the prime contractor with the proposed program under the general guidance of the Materials and Manufacturing Technology Department, Mr. H. R. Sheppard, Manager. For Dow Corning the prime representative will be Mr. Tor Orbeck.

The project manager will be Mr. H. A. Pearce, Manager of Insulating Materials Section of Materials and Manufacturing Technology Department.

This section provides biographical information on the professional personnel who are expected to actively contribute to the proposed study.

Time Schedule





H. R. Sheppard
Manager, Materials & Mfg. Technology
Transformer Divisions
Sharon, Pennsylvania

BS, Chemical Engineering
Carnegie Institute of Technology

Senior Member - IEEE
Senior Member - AICHE
Vice President - IEEE Administrative
Committee on Electrical Insulation
Member - American Chemical Society,
American Society for Testing Materials
Member - IEEE Coordinating Committee No. 4
and 4.1
Chairman Pro Tem - NEMA Ad Hoc Committee
on Electrical Insulating Oil Crisis

Professional Engineer - Pennsylvania

A Chemical Engineering graduate of Carnegie Institute of Technology, Mr. Sheppard undertook engineering graduate studies at Brooklyn Polytechnic Institute and the University of Pittsburgh. His early research and development work was done at Mellon Institute of Industrial Research. Since joining the Westinghouse Electric Corporation in 1951, he has devoted his efforts principally to the management of materials engineering and manufacturing engineering organizations. Although devoting considerable effort to the electrical insulation field, he has also had management responsibility for lubricating, organic finishing, electrochemical, metallurgical and magnetic materials. In addition, he has organized multimillion dollar annual facilities programs for improving transformer manufacturing efficiency and capacity.

Mr. Sheppard's publications have been largely directed toward insulation evaluation and standardization for motors, generators and transformers. He holds patents on insulating materials and systems for switchgear and transformers.

Mr. Sheppard has served as chairman for the National SPI Conference on reinforced plastic materials. He has served as National NEMA-IEEE Electrical Insulation Conference director and division chairman. He is the 1975 Technical Chairman of the Electrical Insulation Conference.

The Materials & Manufacturing Technology Department, which he now manages, provides service to five domestic transformer divisions of Westinghouse as well as fourteen world-wide affiliates and licensees.

H. A. Pearce, Jr.
Manager, Insulating Materials Section
Materials & Manufacturing Development Dept.
Transformer Divisions

BS Chemical Engineering
Grove City College, Grove City, Pa.

Member - American Chemical Society
Member - IEEE

Chairman - Program Committee - Local
Chapter of IEEE

Mr. Pearce graduated from Grove City College in 1953 with a BS degree in Chemical Engineering.

After two years at Goodyear Atomic Corporation, he joined Westinghouse in 1953 as a Materials Engineer. He spent about ten years in the areas of solid insulating materials and then for the past ten years has been involved in development programs and application studies with electrical insulating fluids. He has been active in the area of the analysis of gases in transformers and in the extracting of gases from transformer oil.

Mr. Pearce has a patent issued on transformer cooling and has two patents pending on the separation of gases from transformer oil. He collaborated with Dr. Sleat on the preparation of a booklet entitled "Protective Maintenance of Transformers by Gas-Oil Analysis".

The Insulating Materials Section, which he now manages, provides service for the five transformer divisions of Westinghouse in the areas of solid and fluid insulating materials.

T. K. Sloat, Consulting Engineer
Materials & Manufacturing Technology Dept.
Transformer Divisions, Sharon, Pennsylvania

BS - Pennsylvania State University
MS - Pennsylvania State University
PhD - Pennsylvania State University

Member - American Chemical Society
Senior Member - IEEE
Member - Insulating Fluids Subcommittee
of IEEE Transformer Committee
Chairman - ASTM D-27 Committee on Elec-
trical Insulating Oil and Gases
Chairman - Subcommittee on Fluids of IEEE
Committee G-32
Member - ANSI C-107 on Use and Disposal of
Askarels

Professional Engineer - Pennsylvania

Dr. Sloat, who was born in 1914, received his education at Pennsylvania State University, earning the BS degree in Chemistry in 1936 and the MS and PhD degrees in organic chemistry in 1937 and 1940 respectively.

He joined Westinghouse in 1940 and spent his first year at the Research Laboratories working on the development of improved insulating fluids. He moved to the Transformer Divisions at Sharon in 1941, continuing work on the same subject. In 1945 he moved up to supervision of various laboratory functions. Since 1955, Dr. Sloat has been a section manager, responsible for the development and testing of insulating fluids. In 1974, he was made a Consulting Engineer.

He has authored ten technical papers or articles and has been extremely active in the establishment of industry-wide standards on insulating oils through his chairmanship of the ASTM D-27 Committee and through his work in IEEE and ANSI committees.

R. H. Hollister, Section Manager
Development Engineering
Small Power Transformer Division
South Boston, Virginia

BEE - Electrical Engineering
University of Louisville

Member - IEEE, IEEE Transformer Subcommittee
Insulation, IEEE Working Group Short Circuit,
IEEE Working Group Users Guide, ANSI
Alternate C57.12.1

Mr. Hollister began his professional career with Westinghouse in 1953 on the Westinghouse Graduate Student Program. He joined the Transformer Division at Sharon, Pa. in 1954. As a design engineer he worked in commercial order design of rectangular and circular core form liquid filled transformers of various types up thru 15 000 KVA, 69 K.V. He also worked on dry type transformers thru 3750 KVA. In addition, he worked one year in the Cost Control Department.

In 1965 he joined the rectangular core form development group. In 1966 he was appointed Section Manager of the Small and Medium Core Form Development. In 1967 he was appointed in his present capacity, Development Section Manager, of the Small Power Transformer Division.

He has authored several technical papers and holds two patents.

NPC00026410

753747

G. R. Murray
Customs Order Engineer
Westinghouse Electrical Corporation
South Boston, Virginia

B.E. Electrical Engineering - Banderbilt
University
Additional Graduate studies - Electrical
Engineering - University of Pittsburgh.

Senior Member - IEEE
Chairman ANSI Subcommittee on Underground
and Secondary Network Transformers (C57.12.4)
Member Joint Section Unit Substation
Member IEEE Transformer Committee

Registered - Professional Engineer - State
of Virginia and State of Pennsylvania

Mr. Murray worked in commercial design development application in small and medium power transformers for twenty-five years. Transformers range through 5000 kVA and 69 kV class applied to utility and industrial systems. Application consists of substations, networks, pad mount and primary and secondary substations.

Mr. Murray presently is responsible for commercial design of transformers built at Westinghouse Small Power Transformer Division located at South Boston, Virginia.

Patents

Transformer having series multiple linings (3,717,831)

Technical Publications

Application of Power Center and Unit Substations - Westinghouse Electric
Utility Conference - Sharon, Pennsylvania, 1955

Pad Mount Transformer - Design Consideration, Complexity and Standardization
Westinghouse Electric Utility Conference - Pittsburgh, Pennsylvania, 1973

IEEE - P.E.S Underground Transmission and Distribution Conference - 1974

Transformer for Mining Duty - Open Pit Mining Association - Kansas City,
Missouri, 1975.

M. W. Rose
Manager, Evaluation Laboratory
Materials & Manufacturing Technology Dept.
Transformer Divisions

Grove City College, Grove City, Pa.

Member - IEEE
Registered Professional Engineer (Pa.)

Mr. Rose attended Grove City College and completed all of the technical courses leading to a B.S. Degree in Applied Science. Major subjects included Mathematics, Physics, Electrical Engineering and Mechanical Engineering.

He participated in several University of Pittsburgh Extension Courses covering such subjects as Heat Transfer, Industrial Electronics and Statistical Analysis. Penn State Extension Courses, Engineering in Training Review and Professional Engineering Review were also taken.

Many local Westinghouse and IEEE courses were taken. These included Public Speaking, Transformer Insulation, Computer Programming, Solid State Devices, Transformer Design and Design of Experiments.

Westinghouse Headquarters courses taken included Creativity In Manufacturing, Management Techniques, Principles of Management and Management Functions.

Work experience ranged from machinist to engineer for the Grove City Heat Exchanger Company where the majority of experience consisted of building and running tests on experimental heat exchangers.

Westinghouse work experience included thirteen years of designing, building and testing equipment for quality control, testing of transformer components, torpedoes, reactors and transformers ranging in size from radar to large power transformers. Sixteen years were spent in the Materials and Manufacturing Engineering Department developing and building test methods, transformer auxiliary apparatus and machine design. The past seven years has been spent as Section Manager of Evaluation Laboratory Section of the Materials and Manufacturing Technology Department.

Two patents have been obtained covering transformer apparatus and test equipment.

One magazine article, two technical papers and one Doble Conference Paper have been prepared.

Technical activities included Chairman of Sharon Section of IEEE, member of IEEE Power Group and member of the IEEE Working Group on Thermal Evaluation of Power and Distribution Transformers.

NPC00026412

753749

J. A. Robinson, Sr. Materials Engineer
Materials & Mfg. Technology Department
Transformer Divisions, Sharon, Penna.

Mr. Robinson joined Westinghouse in 1941 in the Sharon Transformer Division and, except for a time serving in the U.S. Navy in Radar Electronics, has held various positions concerned with electrical measuring, design, application, safety, repair and construction covering transformers, components and test equipment. The most recent major responsibility has been to conduct functional life test of transformers and models representing a range of insulation systems.

He has completed (1) a Radio Engineering Course through DeForests Training Institute, (2) the Navy Radar Course at Naval Research Laboratories, Washington, D.C., (3) the Professional Engineering Course through ICS, (4) several Pennsylvania State University extension courses covering industrial, electrical and electronic engineering, and business management.

Mr. Robinson has taken many local Westinghouse and IEEE courses covering transformer design, differential and integral calculus, design of experiments, public speaking, computer programming, MATS program and pre-supervisory training, and a (W) Headquarters course in problem solving.

His work experience covers electrical testing of instrument transformers, distribution and special apparatus for 13 years, and electrical evaluation of materials, components, complete transformers, and design of control equipment for 20 years.

NPC00026413

753750

R. A. Kurz
Materials Engineer
Transformer Division, Sharon, Pa.

BS - Washington University, St. Louis, Mo.

Mr. Kurz was born in 1937. He attended Washington University in St. Louis, graduating in 1959 with a BS degree in Chemical Engineering.

He came to Westinghouse that same year and after completion of the graduate student program, joined the Transformer Division at Sharon, Pa. as a materials engineer. For three years, he worked with dry type transformers. In this area, he evaluated and applied new varnishes, layer and turn insulations.

For the next 11 years, he was involved in epoxy casting projects. During this time, he had the responsibility, from a materials standpoint, of initiating three casting lines. The items cast were an epoxy distribution transformer, outdoor bushings for pole type transformers and a line of bushings for pad mount units. Along with design engineering, he also developed and put into production a line of cast condenser bushings for 25 - 69 KV service.

For the last year he has been involved in the evaluation and development of insulating fluids. He is also responsible for the engineering involved in chromatographic analyses of transformer gases, PCB content in plant effluents and analysis of plant environments for solvent contaminants.

Mr. Kurz holds four patents on various insulation materials and methods and has authored six technical papers or articles on this subject.

NPC00026414

753751

T. Orbeck
Dow Corning Corporation

(A'59) received degrees in electrical engineering from Gothenburg Technical Institute, Gothenburg, Sweden, in 1955, and Carnegie Institute of Technology, Pittsburgh, Pennsylvania, in 1962

Chairman - IEEE G-32 Subcommittee on Electrical Insulating Aging Phenomena and the ASTM D-9 Subcommittee on Thermal Aging
Associate Editor for the IEEE transactions in electrical insulation

In 1955 Mr. Orbeck joined ASEA as a Junior Lab Engineer in the Insulating Materials Lab in Vaesternas, Sweden. After a study visit in France in 1958, he joined the Large Rotating Apparatus Division of Westinghouse as an Insulation Development Engineer. In 1962 he returned to Scandinavia to become Section Supervisor for HV Insulation Development in ASEA Central Research. During 1965-1967, he served as Manager of the Insulating Materials Lab in Central ASEA Research. At the end of 1967 he joined the Dow Corning International Market Department in Brussels, Belgium, as a Staff Specialist. In 1970 he transferred to Dow Corning's Technical Service and Development Department in Midland, Michigan, where he has served as a Specialist and Coordinator of Insulating Materials Development and Testing.

NPC00026415

753752

G. A. Vincent
Dow Corning Corporation

Born April 26, 1939 in Saginaw, Michigan
Married, no children and resident of
Midland, Michigan

B. S. in Chemistry from University of
Michigan (1961)
M. S. in Organic Chemistry from Michigan
State University (1966)

Nominated member Sigma Xi/RESA
Member - IEEE
Member - ASTM (D-27)
Member of organizing committee and session
chairman for 1976 IEEE International Symposium
on Electrical Insulation

Work Experience

July 1961 - August 1963 - Research Chemist at Dow Corning. Principle activity
was the synthesis of novel pentacoordinated silicone compounds.

February 1966 - January 1971 - Research Chemist at Dow Corning. Principle
interest was the synthesis of fluorosilicone monomers and polymers.

January 1971 - Present - Research Chemist at Dow Corning. Principle interest
has been the synthesis and testing of silicone fluids for use as dielectric
liquids, and the development of test methods for evaluating silicone dielectrics.

Publications and Papers

One publication related to M.S. thesis work

Two publications related to pentacoordinated silicone

Three publications resulting from presentations at Conferences on Electrical
Insulation and Dielectric Phenomena

Three papers resulting from presentations at IEEE Power Engineering Society meetings.

Four papers presented at American Chemical Society Meetings but not published.

Patents

Holder of two patents on silicone fluids for use as capacitor dielectrics.

NPC00026416

753753

W. T. Brooks
Dow Corning Corporation

BSME - University of Southern California
in 1959
Graduate of the Test Pilot Training School,
NATC Patuxent River, Md., and the School
of Aviation Safety, University of Southern
California

Mr. Brooks enlisted in the United States Navy in 1946. He was designated as a Naval Aviator in 1949 and commissioned as an Ensign, USN in 1950. He served in various anti-submarine and fighter squadrons and staffs and as an experimental test pilot in the Carrier Suitability Branch, Flight Test Division, NATC Patuxent River, Md. After retirement from the United States Navy in 1968, he joined the Dow Corning Corporation. Work assignments have been primarily in electrical materials development and biocide evaluation and development. Recent experience has been primarily in the field of development of silicone based capacitor fluids.

NPC00026417

753754

Edward J. Hobbs
Born: June 14, 1934 in Chicago, Illinois
U. S. Citizen
Married - Three children

Education

1958 - B.S. in Pharmacy at Ferris State College, Big Rapids, Michigan

Experience

Head - Health and Environmental 1973 to present - Dow Corning
Toxicologist - 1963-1973 - Dow Corning
Pharmacist - 1960-1963 - Dengler Drugs
Pharmacist - 1958-1960 - Russell Drugs

Membership

Society of Toxicology
American Industrial Hygiene Association
Toxicology Committee AIHA

Registration

Registered Pharmacist, State of Michigan

Publications

Hobbs, E.J., Sancher, O.E., and Calandra, J.C. - "Effect of Selected Organopolysiloxanes on Male Rat and Rabbit Reproductive Organs" - Toxicology and Applied Pharmacology, Volume 21, No. 1, January, 1972, Pages 45-54.

Pallazzalo, R.J., McHard, J.A., Hobbs, E.J., Sancher, O.E., Calandra, J.C.
"Investigation of the Toxicologic Properties of Phenylmethyldimethylsiloxane"
Toxicology and Applied Pharmacology Volume 21, 1972, Pages 15-28

Hobbs, E.J., Keplinger, M.L., Calandra, J.C. - "Toxicity of Polydimethylsiloxanes in Certain Environmental Systems" - Environmental Research, Accepted for Publication 1975.