Electrical Insulating Materials

International Issues

Marcelo M. Hirschler, editor

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Foreword

This publication, *Electrical Insulating Materials: International Issues,* contains papers presented at the symposium of the same name held in Seattle, Washington, on 15, March, 1999. The symposium was sponsored by ASTM committee D27 on Electrical Insulating Liquids and Gases and D09 on Electrical and Electronic Insulating Materials. The symposium Chairman was Marcelo M. Hirschler.

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Overview

The *ASTM Symposium on Electrical Insulating Materials: International Issues (1999)* took place in Seattle, WA, on March 15, 1999, and led to this STP. It was sponsored by Committee D09, on Electrical and Electronic Insulating Materials, in cooperation with Committee D27 on Electrical Insulating Liquids and Gases, to commemorate the 90th anniversary of the creation of Committee D09 (in 1909), which in turn was the source of Committee D27 fifty years later.

Electrotechnical products rely on electrical or electronic insulating materials to provide the protection required for the safety of people and the insulation of conductors from one another. Solid electrical insulations are often based on plastic materials, either thermoplastic, thermoset, or crosslinked, and they represent a major use of such materials. Electrical insulating liquids and gases are, however, also essential when used singularly or as combinations as electrical insulation or as an environment for electrical insulation. Standards have been issued, both in the United States and internationally, dealing with specifications for such materials, and with test methods for assessing a variety of properties for those materials. In particular, such standards may address a variety of safety issues which help to ensure the proper protection of the public. Moreover, international harmonization of electrical standards has profound effects on international trade and may present opportunities for export as well as removing barriers to trade. The sympsoium was intended to address all of these issues. In effect, it addressed five major types of issues: standards, properties of electrical insulating fluids, fire properties, and electrical issues.

Standards: The first section of this STP addresses writing standards and contains five papers. The first paper, by Kenneth Mathes, a winner of the prestigious Arnold Scott award and one of the most senior members of the committee, addresses the history of committee D09, and mentions the creation of committees D20, on plastics (in 1937), and of committee D27, on Electrical Insulating Liquids and Gases (in 1959). The history of ASTM D09 is associated with the rapid and increasing development, evolution, and complexity of the overall electrical industry, which depends on ASTM D09 for standard tests and specifications. This paper includes a list of those having received honors and awards from ASTM and from D09. David Baker discusses the present-day structure of committee D09, which now administers almost 150 standards, within 17 subcommittees. Interestingly, the 1999 membership of the committee barely exceeds the number of its standards. Joseph Kelly describes the activities of committee D27, which promotes knowledge pertaining to insulating liquids and gases, whether of synthetic or natural origin, and develops standards and specifications pertinent to these materials. The fluid materials covered include oils of petroleum origin, synthetic liquids, and halogenated and other gases used as electrical insulation in transformers and other electrical equipment. The paper gives examples of the work undertaken by the committee. Standards for electrical insulating materials are written by organizations outside of ASTM, both internationally and in the USA. International organizations include the International Electrotechnical Commission (IEC), while the National Electrical Manufacturers Association (NEMA) is a US trade association producing standards. Nicholas Maennling and Daniel Strachan, respectively, explain the process by which IEC TC89 (Technical Committee on Fire Hazard Testing) and NEMA develop standards and give an overview of the standards available (and under development) in 1999. IEC TC89 is a technical committee addressing

the reduction of the risk of fire in electrotechnical products. It is a "horizontal" committee within the IEC, with a safety pilot function which helps other committees in search of fire safety answers through its nine working groups. IEC TC89 standards are of particular interest nowadays with the globalization of trade and the consequent need for harmonization of requirements outside of the North American borders. The importance of IEC standards is heightened by the fact that ASTM D09 bylaws now specify that every new standard should carry a statement addressing whether it is, or is not identical or even technically similar to some IEC standards. The paper explains that NEMA has a history of issues that are of particular interest to ASTM D09, including military specification conversions for electrical materials and the New York State smoke toxicity data base for electrical materials and products.

The remaining sections of this STP deal with specific individual issues, ranging from electrical insulating fluids, to fire issues and electrical issues. The papers cover a broad range of investigations, giving a thorough overview of active research on electrical materials. The issues include testing (for moisture content, fire properties, discharge properties, thermal endurance, physical stability), biodegradability, transformer maintenance, and new materials and products for the associated industries (including new electrical cables and new additives for cable materials).

Electrical Insulating Fluids: The second section of this STP addresses electrical insulating fluids and contains five papers addressing a variety of subjects. Clair Claiborne, T. V. Oommen, and E.J. Walsh explain the development of a fully biodegradable dielectric fluid based on a vegetable oil (with high oleic acid content) for use in electrical equipment, and its implications. A consequence of developing a novel material with different advantages is that specifications for the existing materials are often unsuitable for the new material which can hinder its commercialization until new standards are created. In this case, the existence of biodegradable insulating fluids is leading ASTM to work on new standards specific to such liquids to permit their field application to electrical transformers. Marius Grisaru gives six case histories in which transformers were withdrawn from service in Israel, by a power utility. The decisions were analyzed afterwards by the Central Chemical Laboratory who looked at the transformer's operational conditions based mainly on the concentration of gases and on the operation of Bucholtz relays. Based on this consideration it was found that four transformers had been properly removed from service and showed real faults while the other two had been removed prematurely. The two other transformers were then opened, tested, and returned to service. Samuel Margolis discusses an analytical technique to test for moisture using the Karl Fischer method in petroleum products. The paper explains that the results are affected by the method (volumetric or coulometric) used to make the measurement, the composition of the solution in the titration vessel, the degree of solubilization of the oil in the solvent, and the presence of trace amounts of materials in the solvent. The results are, however, independent of the ability of the instrument to titrate the water in a water standard. The investigation also suggests that the measurement of a falsely reduced moisture content is likely to be related to the ability of the undissolved oil in a heterogeneous system to sequester the water in a form that is not accessible to the Karl Fischer reagent. John Sabau and Rolf Stokhuyzen propose a new test to diagnose faults in high-voltage transformers. The test determines the physical stability of insulating oils by measuring changes in the absorption spectra and free radical concentration of transformer oils after they have been subjected to ionization in a discharge cell. Existing tests tend to be based on the analysis of gaseous degradation products which are thought to result from incipient electrical failures inside the windings. Paul Griffin, Joseph Kelly, and Thomas Rouse review the specifications for electrical insulating mineral oils, as well as the more common such products available. Emphasis

is placed on comparisons between the ASTM and IEC standards (ASTM D 3487 and IEC 60296, which address physical, electrical, and chemical properties of the fluids.

Electrical Tests: The third section of this STP contains three papers dealing with test methods for properties of electrical interest. Hans-Jörg Mathis, Martin Baur, Rudolf Blank, Rudolf Woschitz, and Thomas Überfall introduce a test method for assessing disruptive discharge in lquid and gaseous insulation. The dielectric breakdown voltage is a variable with a statistical distribution of results so that any test procedure must be based on a set of single test sequences with minimal effect of one sequence on others to get reliable results. The article describes new ways to recognize dielectric breakdown voltages as well as new switching-off techniques. The article also discusses the advantages and disadvantages of various test methods. Ray Bartnikas addresses standardized testing procedures in partial discharge measurement. This comprehensive review has about 60 references and presents a comparison of the different standardized methods of discharge detection and measurement on electrical components, apparatus and cables. In particular, the standard methods from ASTM, IEC and IEEE (Institute of Electrical and Electronic Engineers) are compared. The ASTM approach is shown to constitute the basis for most standards, with the exception of those on rotating machines and compressed gas cables where very high frequency test methods are employed. Stephen Giannoni and Gian-Carlo Montanari present a study on accelerated aging of organic electrical insulating materials, particularly those used at elevated service temperatures. They determined long-term thermal endurance using traditional accelerated aging techniques alone and in combination with isothermal differential scanning calorimetry measurements of oxidation induction times. As there are practical limits on the maximum test temperatures for traditional aging, and as there is always an interest in decreasing test times while ensuring an accurate representation of the service degradation of the material, the combined DSC-aging technique results in a reduction in test times without compromising the accuracy of the determined service limit.

Fire issues: The final section of this STP has three papers addressing the response of electrical materials and products to fire. Ronald Markezich discusses the flame retardancy of various nylon (Nylon 6 and Nylon 66) and poly(butylene terephthalate) (PBT) insulation materials (with and without glass reinforcement), using mixtures of flame retardants which contain a chlorinated material. He addresses the various options available with special emphasis on the use of synergists. The paper also discusses effects of the additives on the electrical properties, especially the comparative tracking index which is improved by some of the systems used. Richard Whiteley and David Gardner present a study on ways of decreasing the mass and volume of electrical cabling systems, which is particularly important for transportation environments. The size and weight of wire and cable installations can be decreased by moving from thick and medium wall insulations to thin wall insulations. The paper compares the various fire properties of a number of wires based on ignition resistance, reaction to fire, and the production of smoke, acid/corrosive gases, and toxic fire products, together with the functional properties of the wires. Marcelo Hirschler presents a review of fire tests for electrical materials and products, both in the USA (ASTM, National Fire Protection Association, NFPA, and Underwriters Laboratories, UL) and internationally (International Organization for Standardization, ISO, and IEC). The properties discussed in this review (with almost 70 references and a large bibliography of fire standards) include ignitability, flame spread, heat release, (now considered to be the most critical fire property) and smoke release (smoke obscuration). Smoke toxicity and smoke corrosivity are also addressed to some extent, as is the need to conduct overall fire hazard assessments to get the best understanding of the potential problems associated with any electrical system.

Much goes into organizing a symposium and its documentation into an STP. The editor acknowledges and extends his thanks to Monica Siperko and Kathy Dernoga (of ASTM's publications group), Pat Picariello (staff manager to both committees ASTM D09 and ASTM D27), Dorothy Fitzpatrick (of the ASTM Symposia group), Joseph Kelly (chairman of committee ASTM D27), Loren Caudill (chairman of subcommittee ASTM D09.97, on planning), Thomas Robertson and David Baker (past and present chairman of committee ASTM D09, respectively) and Mark Marcus (from the Committee on Publications), as well as all of the authors.

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