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Frequently Asked Questions on the Use of Polyphenyl Ether Connector Lubricants

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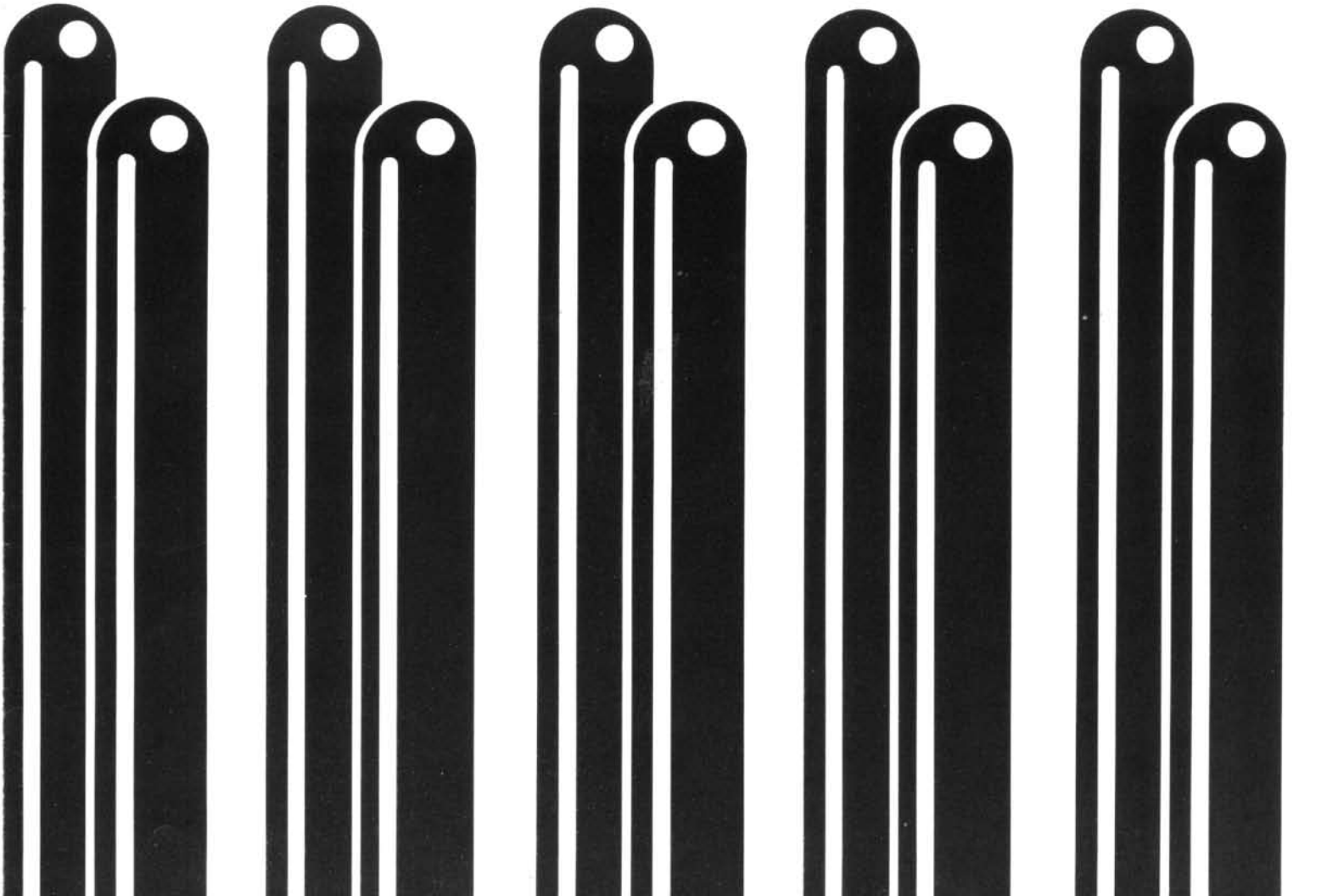
Presented at the 20th Annual Connectors &
Interconnection Technology Symposium October, 1987



ABSTRACT

Polyphenyl ethers have been used for nearly twenty years as lubricants for long life, high reliability connectors. Recently their use has expanded to a number of manufacturers unfamiliar with the products and their use. This paper is a compilation of frequently asked questions on the use of these fluids. Emphasis is on material handling, solvents, applications, film characteristics, safe procedures, and disposal.

INTRODUCTION

The polyphenyl ethers (PPE's) in use today as connector lubricants were developed in the 1950's for use as high temperature turbine lubricants. Their chemical structure consists of five or six phenyl groups, connected by oxygens. This stable structure imparts superior thermal and oxidative stability to the molecule, giving it the ability to resist breaking down in the presence of high heat, ionizing radiation, and harsh chemical environments. A major use for the five-ring PPE has been as a diffusion pump fluid because of its low vapor pressure. The use of PPE's as electronic connector lubricants is a result of the work of Dr. Morton Antler of AT&T Bell Laboratories. Connectors lubricated just once at the time of manufacture are expected to retain that film for 20 to 40 years. Hundreds of mating cycles are performed during that time with no circuit failures.

This paper is organized in a question/answer format to describe how PPE lubricants are selected, applied, handled, and used in the connector industry. These are questions frequently asked by individuals who use, or are about to use PPE's in their manufacturing process.

APPLYING POLYPHENYL ETHER LUBRICANTS

Why Lubricate a Connector?

There are three basic reasons why lubricating connectors is desirable. First, noble metal alloy connectors are prone to galling and excessive wear of the surface when given hundreds of mating cycles in typical reliability tests. A good lubricant film can dramatically increase the life of connectors subject to this condition. Second, corrosion can be a severe problem for connectors in harsh environments. Even in moderate environments, gold-plated alloys are subject to corrosion caused by atmospheric moisture, due to the actual porous nature of the alloy surface. Third, insertion forces can be reduced by the application of a lubricant. This can be important in certain connectors where pin counts number in the hundreds, yet design requirements call for low overall insertion force.

Why Choose Polyphenyl Ether Lubricants Over Other Types?

PPE's have many distinct advantages over petroleum based lubricants. They out perform hydrocarbons in the areas of coefficient of friction, thermal and oxidative stability, and lifetime of the lubricant film, as measured by how many mating cycles can be performed with one application of the lube. The properties of PPE's have been thoroughly studied and widely reported.[1]

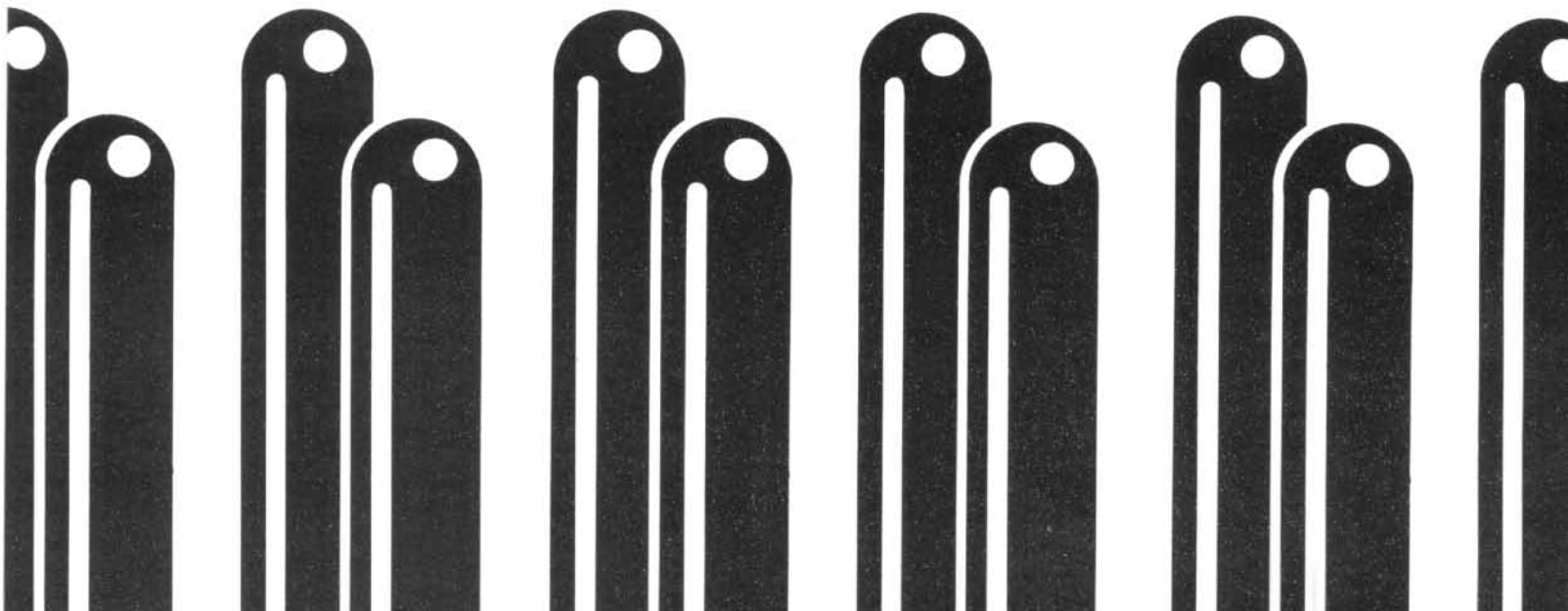
How Are PPE's Applied to a Connector?

Polyphenyl ethers are never applied full strength. They are very viscous fluids, and only a thin film is required on the metal surface. The fluid is therefore diluted in a volatile solvent at a concentration of only 2 percent by weight. The connector is then dipped into this mixture, the solvent quickly evaporates, and a thin film of the lube is left behind. As an alternative, this lubricant solution can be sprayed on. There are currently several commercially available aerosol formulations containing PPE's.

What Solvents Can Be Used to Dilute PPE's?

The ideal solvent for this purpose would have a fast, but not extreme, evaporation rate. It would have no human health, or environmental hazards, and would be nonflammable. Unfortunately, no such solvent exists. 1,1,1-trichloroethane has been in use for many years.

Concerns about health effects, however, have led some to use fluorocarbons, such as Freon® 113. (DuPont trademark.) Fluorocarbons, however, are not completely free of health concerns either, and their extremely rapid rate of evaporation can cause problems in the manufacturing process. An open container containing a 2% solution used for dipping will



quickly concentrate as the fluorocarbon evaporates. Eventually the solution will reach the saturation point and the PPE will come out of solution. This occurs when the concentration reaches 18% by weight. This makes the process much more costly as excess PPE is applied unnecessarily. Another solvent that evaporates at a more normal rate is propylene glycol methyl ether. This solvent has the advantage of no known health hazards. It has a reasonable flash point (100°F), but obviously must never be used near spark or flame. Regardless of which solvent is used, there must be adequate ventilation and other precautions to ensure safe operation.

What Equipment is Needed to Apply PPE's?

Most installations are very simple. Electronic devices usually require a manual final assembly step. This is where PPE's are applied, usually by the dipping method where the assembler uses an open vessel of the lubricant solution. Other operations, such as maintenance and repairs, make use of aerosol spray formulations. Automated spray application is only recently becoming of interest, where manufacturers intend to produce large numbers of devices on an assembly line with no manual operations.

This will require normal industrial grade process spray equipment, made of materials that are compatible with the solvent used. PPE's are compatible with all metals.

Can the Concentration of the PPE Solution be Varied?

Yes. One percent by weight is the minimum level of PPE in solvent that should be used. On noble metal surfaces, 2% wt. is considered optimum for economy and fluid film life. Higher concentrations are unnecessary on noble metals, but may be desirable on tin solder. Tin solder, being a soft metal, tends to form new surface easily when mated. It helps to have plenty of fluid available to fill in these areas when they are formed. For such systems, concentrations as high as 20% are not unreasonable. Fluorocarbon solvents, however, should not be used with high concentrations due to solubility limits.

What About Reclamation and Disposal?

Polyphenyl ethers are very expensive, and are not normally discarded. If they do become contaminated with undesirable solvents, they can be reclaimed by vacuum distilling the contaminant away. If this becomes impractical, disposal can be made by sending the material to a commercial liquid waste incinerator.

Are There Different Kinds of PPE's?

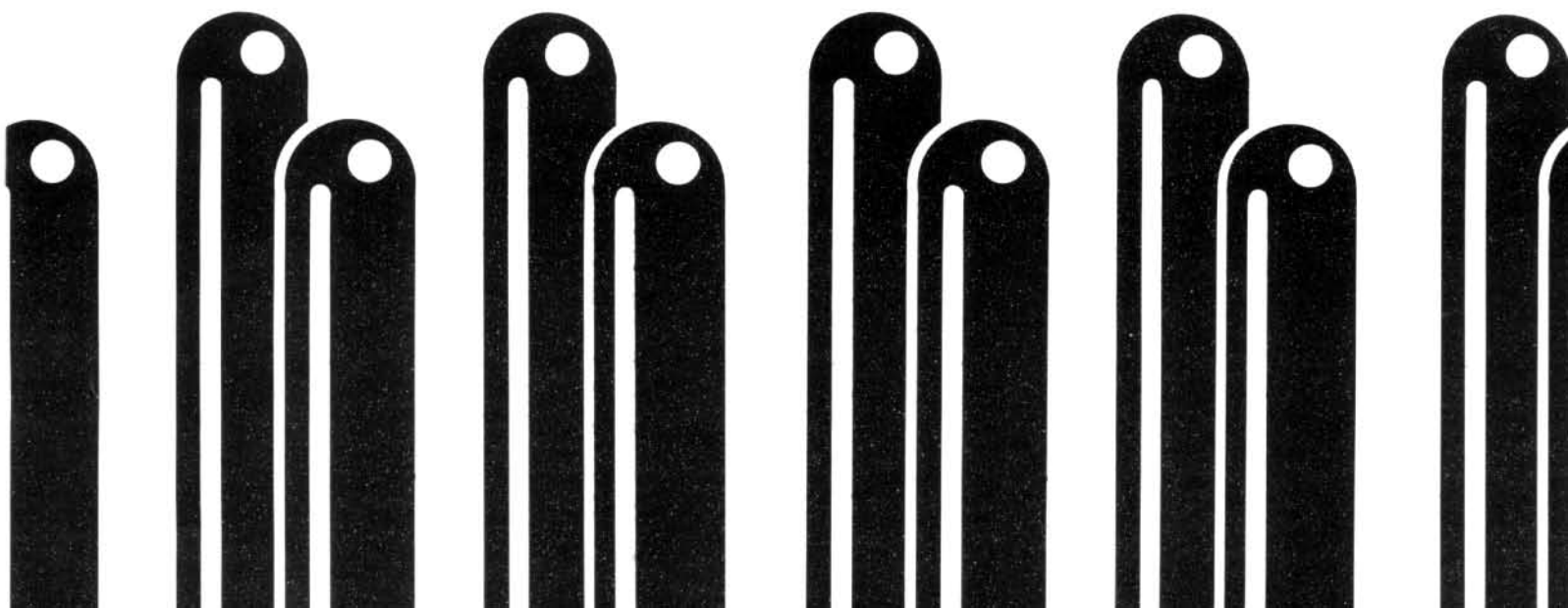
Yes. The five-ring PPE that has been in common use for 20 years is a specially selected mixture of isomers to impart liquidity at room temperature. The mixture has a pour point of 5°C. While pure mmm isomer is available commercially, its freezing point is 41°C, making it unsuitable for use as a connector lubricant.

A six-ring PPE is another connector lubricant in use today. It has a lower vapor pressure than the five-ring PPE. It too is a mixture of isomers, with a 10–15°C pour point. Both products are considered equal in lubricity and corrosion protection. They differ only in film life.

PROPERTIES OF POLYPHENYL ETHER LUBRICANT FILMS

How Long Will a PPE Film Last?

The life of these lubricant films has been rigorously studied.[2] The 5-ring PPE is thermally and oxidatively stable to 600°F and even higher when properly inhibited. The problem with thin films, however, is the high vapor pressure of the fluid at these temperatures. Evaporation rates are such that for the 5-ring PPE to give a 20-year film life, ambient temperatures must not exceed 60°C. The 6-ring PPE is now being used in equipment that must withstand temperatures of up to 110°C for 20 or more years. Higher temperatures will result in shorter film life.



Will Residues Form From Fluid Evaporation?

No. Pure 5 and 6-ring PPE products are distilled materials, and leave no residues behind when they evaporate. Even at elevated temperatures, the PPE will evaporate cleanly, long before there is a chance of any chemical decomposition. The same cannot be said for petroleum based lubes. When petroleum oils are heat stressed in the presence of air, coking starts to occur, forming tarry residues.

Does the Lubricant Film Affect Contact Resistance?

No. The PPE fluid performs neither an insulating, nor a conducting function. Normal metal to metal contact is made when a lubricated connector is joined. The fluid fills in the microscopic voids that are present on the metal surface. The fluid performs its lubricating function when the two surfaces slide against each other. In this dynamic condition, the surfaces do not really touch; they slide on a thin fluid film.

Does the Lubricant Film Migrate Along Surfaces?

No. One of the great advantages of PPE's over other lubricants is that they are non-migrating. They have a high surface tension which prevents them from wetting a surface. This contributes to long film life, and avoids contaminating nearby electronic components for which a lube coating might be harmful.

But Isn't "Wettability" Desirable in a Lubricant?

Not necessarily. PPE greases have been used successfully for many years on bearings located in high radiation environments. The 5-ring PPE has also been used successfully for 20 years as a jet engine turbine lube. What really counts in the field of lubrication is coefficient of friction, not wettability.

Does the Lube Film Cause a Low Normal Force Connector to "Float"?

No, unless the two surfaces are in constant sliding motion, as with a slip ring. Still, PPE's are used to lubricate slip rings.

For higher speed applications, a 4-ring PPE can be used where the 5-ring PPE is too viscous. For a normal, stationary, back plane or board edge connector, floating does not occur.

How Does the PPE Inhibit Corrosion?

Since it fills in the microscopic voids between two mated metal surfaces, all air is excluded. The absence of air and moisture prevents corrosion from occurring. In harsher environments, such as salt fog, acid mists, environmental pollutants, PPE's offer significant protection as well. This is an area that is currently under study.

Do PPE's Affect any Materials of Construction?

PPE's are compatible with all metals, and almost every elastomer and plastic. Only one plastic, polyphenylene, has been considered by one manufacturer to be unsuitable. In a total immersion test the material was found to swell. In connector lubrication, however, the object is to coat the pins, not the plastic. Thin film residues of PPE on polyphenylene have never been shown to be harmful.

What is the Shelf Life of PPE's?

Monsanto Co. assigns a nominal shelf life of 5 years to its PPE products. But that is because of limitations on the packaging, not the fluid. Properly stored and handled, the fluid should last almost indefinitely.

Safety, Toxicity

Polyphenyl ethers are considered to be practically nontoxic. The manufacturer's material safety data sheet should be obtained and read before making final judgements on this subject. PPE's possess no toxicologic properties which would require special handling other than the good hygienic practices employed with any industrial chemical.

BIOGRAPHY

David K. McCollum, Senior Research Engineer, Monsanto Co., works in Marketing Technical Service for the company's hydraulic fluids and specialty lubricants group. He received his B.S. degree in Chemical Engineering from Virginia Polytechnic Institute and State University in 1976.

1. M. Antler, "Sliding Studies of New Connector Lubricants," Proceedings E.C.S.G. Connector Symposium, pp. 1-13, October 1986.

2. M. Antler, "Electronic Connector Contact Lubricants: The Polyether Fluids," Proceedings IEEE Holm Conference on Electrical Contracts, pp. 35-44, October 1986.

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MCCSC-8-010