PTFE: An Alternative Carrier of Conductive Materials

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INTRODUCTION

The challenge to today's electronic equipment manufacturers is to provide products that can survive increasingly harsh environments. Manufacturers of products susceptible to the influence of electromagnetic interference (EMI) must now consider the long-term electromagnetic performance and mechanical stability of shielding materials. This has created a demand for an alternative carrier of conductive materials for electromagnetic shielding.

The PTFE polymer combined with different conductive fillers creates a gasket material whose electrical characteristics meet today's EMC standards.

PTFE

One new alternative to existing carriers of conductive materials is polytetrafluoroethylene (PTFE). PTFE, probably the widest known and most versatile fluorocarbon resin, was invented in 1938 by DuPont research scientists, while conducting experiments with an unusual gas, tetrafluoroethylene (TFE). At the conclusion of one of their experiments, they discovered one of the cylinders previously containing the TFE gas was empty except for a solid material on the inside walls. A polymerization or joining together of TFE molecules had occurred in the cylinder and formed the plastic PTFE - better known as TEFLON[R]. This new material, because of its novel combination of properties, would soon revolutionize many industries, including sealants.

The polymerization of TFE can be controlled to produce an extremely high molecular weight material (10^6 - 10^7). This high molecular weight, combined with the chemical bonding of carbon and fluorine (one of the strongest chemical bonds) gives PTFE materials superior chemical, electrical, and mechanical properties not found in other sealant materials.

PTFE-based products are used in a number of applications. As an electronic cable insulator, expanded PTFE dielectrics retain the desirable characteristics of solid PTFE and improve the coefficient of thermal expansion, loss tangent, and dielectric constant, characteristics of vital importance in microwave and other signal transmission lines. It is the basic structure of the PTFE polymer that allows high temperature capabilities, and gives it other superior mechanical and chemical properties. The extremely strong chemical bond linking the fluorine atoms to the carbon atoms within the PTFE structure enables it to resist chemical attack even at elevated temperatures.

Despite the chemical inertness and wide temperature range offered by PTFE sealants, their benefits have only recently been applied to conductive EMI shielding materials. In the past, the primary property that made PTFE an ideal nonstick coating for frying pans (its low surface energy or coefficient of friction), also contributed to its one mechanical flaw - creep and cold flow. In recent years, significant strides have been made in the production of PTFE gaskets that effectively eliminate the long-term creep and cold flow problems of conventional mechanical grade PTFE.

In order for a gasket to provide a long-term tight environmental and EMI seal in a flanged joint, the gasket must be able to withstand and reach equilibrium with the compressive forces that are exerted against it with the tightening of the bolts. All conductive sealant materials (with the exception of metal gaskets) creep and cold flow to some degree under the impact of compressive forces. Alterations to conventional grade PTFE have produced a conductive EMI material that seals with a minimum of creep or cold flow.

The most common alterations to reduce creep and cold flow involve either adding high modulus fillers to PTFE prior to forming it, or introducing an internal structure to the PTFE material. A unique process that introduces an internal structure to PTFE material involves expanding or stretching the structure. Expanded

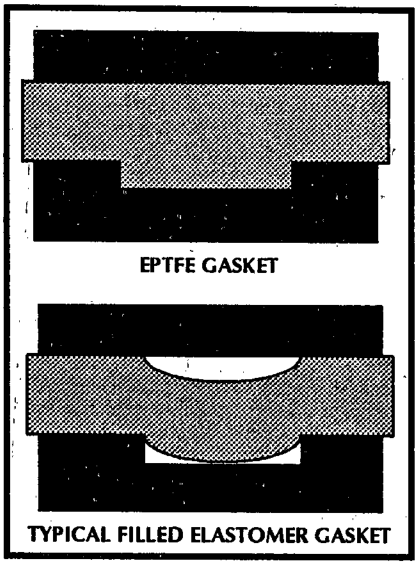

FIGURE 1. *Conformability.*

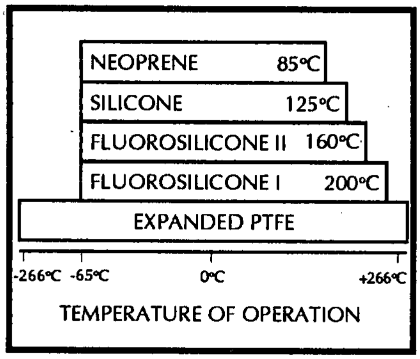

FIGURE 2. *Temperature Range of Conductive Materials.*

polytetrafluoroethylene (EPTFE) is a highly microfibrous PTFE material that is 50 to 80 percent air. The expansion process causes a defined oriented fibril substructure within the PTFE material. This fibrillated structure is essentially a fiber reinforcement that imparts significant structural integrity to the PTFE. Under compression, the fibrillar chain network aids in resisting the debilitating effect of creep and cold flow without altering the chemical compatibility of the PTFE.

EPTFE PROPERTIES AND EMI SHIELDING

The combination of the PTFE polymer with different conductive fillers creates a gasket material whose mechanical, chemical and electrical characteristics are ideal for meeting the electromagnetic compatibility standards and susceptibility requirements found in today's increasingly harsh electrical and physical environments.

Conductive gaskets made from EPTFE-based materials are soft and conformable. Their marshmallow-like texture allows EPTFE gaskets to be used even on damaged or irregular surfaces because they fill and conform to surface imperfections providing an ideal seal (Figure 1). In new applications, flange design and prototyping can be simplified by using conductive EPTFE tape and forming a gasket in place. Because of its conformability, conductive EPTFE can be folded or overlapped and still provide a complete EMI and environmental seal.

EPTFE-based gaskets can have high loadings of conductive fillers and still maintain good mechanical integrity. Conductive EPTFE gaskets are a small fraction of the weight of other conductive gasket materials having typical densities of 0.30 gm/cc compared to conductive elastomers which range from 2 gm/cc to 4 gm/cc. This reduction in weight reduces operating costs on airborne systems, allows more payload on spacecraft, and allows greater range for missiles.

Their temperature range (-260°C to +260°C) makes conductive gaskets formed from EPTFE ideally suited for applications at extreme temperatures. Unlike conductive elastomer materials which have low volume resistivity initially, but which rise in resistivity at elevated temperatures, EPTFE-based gaskets do not exhibit the degradation associated with heat aging (Figure 2). Conductive EPTFE materials continue to perform reliably over a much wider temperature range.

Conductive EPTFE materials are electrically stable during vibration. Conductive particles are captured within the node and fibril matrix-like structure of EPTFE and do not collapse or settle during vibration when tested in accordance with MIL-G-83528A. The structure of EPTFE also prevents gaskets from outgassing, qualifying them for spaceflight applications in accordance with NASA test ASTM-E-595-84. Because of its fluorocarbon structure, the chemical inertness of EPTFE also allows conductive EPTFE products to survive exposure to aggressive chemicals and solvents without degradation.

CONCLUSION

EPTFE-based gasket materials have caused revolutionary changes in the sealant industry. Engines, equipment, and processes operate more reliably and at a lower cost because of the performance properties of EPTFE sealants. The challenge encountered by electronic equipment manufacturer's products to survive in increasingly harsh environments demand that new gasketing materials be employed. A gasketing material of EPTFE polymers has superior mechanical, chemical, and electrical properties to meet the demands of difficult applications and to produce innovative solutions for the future.

RELATED READING

Understanding Fluorocarbon-Type Sealant Materials, Jerry Waterland. W. L. Gore & Associates, Inc., ASM Handbook Fall 1990.

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