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Using Fire Retardant Materials

Introduction

Understanding fire retardancy requires knowing how fires work, what fire retardants do, and available types of fire retardants. Basic fire retardant test procedures and some worldwide test methods are also included.

How Do Fires Work?

Fires require heat, fuel, and oxygen. Initially a material (fuel) is exposed to high heat in an oxygen-containing atmosphere. As it gets hotter, it starts to decompose and give off gases and ash or char which act together to form smoke. The flash point occurs when an open flame or spark causes the decomposition vapors to momentarily ignite.

Eventually the heat gets great enough to ignite the material itself, which is known as the ignition temperature.

Take away any of the key three elements at anytime and there will not be a fire. Controlling a fire falls into the three broad areas of:

1. Retarding decomposition and preventing or delaying ignition
2. Self extinguishment once ignited
3. Containment once a fully developed fire starts

What Does A Fire Retardant Do?

Fire retardants make materials harder to ignite by slowing decomposition and increasing the ignition temperature. Once ignited, they offer a degree of "self extinguishment". The most important purpose is stopping the process in the decomposition stage before ignition occurs.

How Do Fire Retardants Work?

Fire retardants function by a variety of methods. Most either absorb energy away from the fire or prevent oxygen from reaching the fuel. Hydrated fillers such as hydrated alumina work in two ways: they absorb energy away from the fire and they release water at a specific temperature.

Halogenated compounds interfere with the breakdown of the polymer and create a heavy gas that lays over the surface cutting it off from oxygen.

Another important fire retardant property is the formation of char. Char formation creates a protective layer that impedes oxygen penetration and creates an insulating layer between the heat and the fuel.

Char helps hold the material together thereby reducing the amount of surface area available to support combustion. It also helps reduce oxygen depletion, and the generation of smoke and toxic gases.

Char does not burn and, therefore, significantly reduces the heat of combustion. Carbon dioxide and carbon monoxide gases result if char is not formed and they release high amounts of heat of combustion, whereas char releases nothing. Phosphorus materials and zinc borate are two of the compounds best for forming char.

Types Of Fire Retardants

Reactive and additive are the two primary types and are often used together synergistically. Reactive types usually involve halogenated resins and hardeners or reactive phosphorus compounds.

The additive type includes alumina trihydrate, antimony oxide, halogenated fillers such as decabromodiphenyloxide, and phosphorus compounds. Antimony oxide and phosphorus compounds are often used synergistically with halogenated materials.

Epoxies often use alumina trihydrate (ATH), halogenated compounds, and zinc borate. A high degree of polymer crosslinking and the use of inert fillers (e.g. alumina, mica) also aid fire retardancy.

If smoke generation is a concern, antimony oxide, brominated resins, and chlorinated resins should not be used. Phosphorus materials are most commonly used when low smoke is a requirement.

Fire Retardant Material Testing

A typical test holds a sample coupon of a given thickness in an open flame for a given amount of time. The specimen is removed from the flame, observed and the results recorded as: no effect, smoke producing, dripping, burning but self extinguishing, burning drips, and if burning, the amount of time to extinguishment.

The tests measures how long a part will burn, how long it glows after flame removal, if the afterflame reaches the specimen holding clamp, and if any dripping, flaming particles ignite the cotton table liners.

The results are heavily influenced by material's thickness, fillers, chemical composition, and melt characteristics.

Fire retardant ratings always list the specimen thickness. Consider the difference between applying a match to a log of wood versus a paper-thin wood shaving. The more effective the fire retardant the thinner the material can be.

Many countries throughout the world have flammability tests for polymers in electrical and electronic applications. The most common ones in the United States are Underwriters Laboratories (U.L.) tests.

The Vertical Burning Test (UL 94V-0, UL 94V-1, UL 94V-2) is used mainly for encapsulants and the Horizontal Burning Test (UL 94HB) for coatings. The UL 94V-0 is the most flame retardant vertical burn rating. The vertical burn test is used for most encapsulants and sometimes for coatings. The U.L. 746C/94 horizontal burn test is used mostly for coatings.

Fire Retardant Testing Around The World

Australia

Standards Association of Australia (SAA) AS 2420: Fire Test Methods for Insulating Materials and Non-metallic Enclosures Used in Electric Equipment

Canada

Canadian Standards Association (CSA) C22.2 No. 0.6-M1982: Flammability Testing of Polymeric Materials.

England

British Standards (BS) BS 6334: Flammability of Solid Electrical Insulating Materials

Germany

Verband Deutscher Elektrotechniker (VDE) VDE 0318 (similar to U.L. 94)

United States

Underwriters Laboratories (U.L.)

U.L. 94: Plastic Materials for Use in Devices and Appliances

U.L. 94 Section 2 94HB: horizontal burn test. Used on materials that fail all vertical burn tests and on coatings.

U.L. 94 Section 3 94V series (94V-0, 94V-1, 94V-2): Vertical burn test.

U.L.-746C: Polymeric Materials, Electrical Equipment Enclosure Flammability (used for coatings)

Electrical Section - voltage transient, dielectric withstand and dielectric breakdown

Environmental Section - environmental cycling, humidity cycling, and thermal cycling

Flammability Section - see U.L. 94

American Society for Testing and Materials (ASTM)

Additional test methods for measuring oxygen index, smoke generation and heat release are available from NBS, FAA (OSU), and ASTM E 906

If you have any questions or need any additional information call Emerson & Cuming Technical Service in Billerica, MA at 1-800-832-4929.

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■ Europe

Nijverheidsstraat 7
B-2260 Westerlo
Belgium

☎ : +(32)-(0) 14 57 56 11

Fax: +(32)-(0) 14 58 55 30

■ North America

46 Manning Road
Billerica, MA 01821

☎ : 978-436-9700

Fax : 978-436-9701

■ Asia-Pacific

100 Kaneda, Atsugi-shi
Kanagawa-ken, 243-0807
Japan

☎ : (81) 46-225-8815

Fax : (81) 46-222-1347