DATA SHEET
FIRE RETARDANTS & FIRE RETARDED FABRICS

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Theater curtains and drapes must be fire-retarded. Even costumes, wigs, props, and set elements should be fire retarded if cigarettes, flame effects or pyrotechnics are used on stage. The Summer 2002 edition of the Technical/Production News Digest, Opera America, carried the following item:

> *SINGER CATCHES FIRE AT ROYAL OPERA*
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> *Soprano Susan Chilcott has escaped unharmed after her dress caught fire on stage at London's Royal Opera House. The singer was performing in Tchaikovsky's THE QUEEN OF SPADES when a candle set fire to the train of her dress.*

Fire and pyrotechnic effects have caused problems for actors from Michael Jackson's hair catching on fire to the Wicked Witch of the West in the Wizard of Oz movie receiving serious burns when her costume ignited. Many fires also are started by curtains igniting from such effects.

WHAT ARE FIRE RETARDANT CHEMICALS?

Whether you work with materials that have been treated by the manufacturer or whether you apply the fire retardants yourself, it is unlikely that you will ever know the exact identity of the chemicals protecting your materials. Most of the manufacturers of fire retardant products withhold the identities of the chemicals as "trade secrets" or they identify them as a general class of chemicals rather than being specific.

However, you can make some pretty good guesses about the types of fire retardants you use if you know that, in the US, the majority of these chemicals fall into six different categories.

% BY WEIGHT of those made in USA	**TYPE OF FIRE RETARDANT CHEMICAL**
32 %	Bromine based-e.g., the polybrominated biphenyls
20 %	Antimony oxide and related antimony compounds
17 %	Chlorine based-e.g., complex chlorinated hydrocarbons
17 %	Phosphorus based chemicals
11 %	Alumina trihydrate
3 %	Others: including magnesium hydroxide, boron-, moldybdenum-, nitrogen-based compounds

CHLORINATED FIRE RETARDANTS

This class of fire retardants originally contained the highly toxic polychlorinated biphenyls, better known as PCBs. Years ago, PCBs were common ingredients in paints, plastics, transformer oil, and many other products. PCBs were banned for almost all uses in the 1970s when they were found to be highly carcinogenic and persistent in the environment. Their environmental persistence is borne out by the fact that today you and I and every person on the planet are carrying small amounts of a many different PCBs in our bodies.

The PCBs were replaced by other classes of chlorine-containing organic chemical fire retardants. One of these groups, the chlorinated paraffins, was studied and also found to be cancer-causing. Most of the other chlorinated fire retardants have not been tested for chronic toxicity so there may be more bad actors in this group.

BROMINATED CHEMICALS

The most common fire retardants are complex hydrocarbons that contain bromine instead of chlorine. The most well-known of these chemicals was TRIS(tris(2,3-dibromopropyl)-phosphate). Originally, this chemical was thought to be so safe that it was even used in children's sleepware. Then animal tests showed it was a potent carcinogen and it was banned from children's sleepware and other uses in which skin contact is anticipated.

Recently, two other brominated fire retardants were tested and found to cause cancer. These are 2,2-Bis(Bromomethyl)-1,3-Propanediol (TR-452) (CAS 3296-90-0) and 2,3-dibromo-1-propanol (CAS 96-13-9). The problem is there are dozens of different brominated fire retardant chemicals that have not been tested and may well be cancer-causing, too,

Worldwide, eight chemical corporations manufactured about 300 million pounds of brominated fire retardants each year, of which about 80 million pounds are members of a class known as the polybromodiphenyl ethers, or PBDEs. These chemicals are currently used in a multitude of products, including plastic housing of electronics and computers, circuit boards, and the foam and textiles used in furniture. Many experts think that the PBDEs will be found to be as toxic and as damaging to the environment as their cousins, the PCBs.

The PBDE fire retardants have been discovered worldwide in breast milk, in human blood, in food, remote rural air, and wildlife. One study found the highest amount of PBDEs in breast milk of women in California. This was one of the reasons that in 2003 California banned products containing more than 0.1% of two PBDEs, pentabromodiphenyl ether and octabromodiphenyl ether effective in 2008. Now US manufacture of all of the PBDEs except decabromodiphenyl ether (decaPBDE) have been discontinued.[1] However decaPBDE is often used in curtains, drapes and upholstery. It is very likely that the fire retardants in your materals contain this PBDE or other brominated retardants.

ANTIMONY BASED RETARDANTS

These fire retardants are also highly toxic. They can cause damage to the kidney, liver, blood and central nervous system. These chemicals also should be treated with great care.

If your fire retardants contain antimony, it will probably say so on the MSDS because antimony compounds are regulated by OSHA.

OTHER INORGANIC RETARDANTS

Fire retardants containing phosphorus, alumina trihydrate, magnesium hydroxide, and compounds based on boron, molybdenum, ammonium chloride, and nitrogen vary in toxicity, but most are less toxic than the other groups of fire retardants. There is considerably more knowledge about the toxicity of these chemicals and there are occupational air quality standards for most of them as well.

A number of the theatrical products are based on boron compounds which are one of the least toxic groups of inorganic fire retardants. Boric acid and other soluble boron compounds are used as pesticides and they can be toxic to people in large doses. Exposure can occur if soluble boron compounds are absorbed through broken skin or the dust of the compounds is inhaled. Protect your skin and avoid inhaling the dust or spray mists that contain boron compounds.

The boron compounds are water soluble, so washing or spraying with water (e.g. to take wrinkles out of treated back drops) will reduce the effectiveness of the fire retardant. Many scene shops send a notice with drops and curtains stating that spraying with water or washing will void any guaranties.

READING THE MSDS

Under the OSHA regulations, every workplace should have MSDSs on all their potentially toxic products including fire retardants. When reading them, I have the following suggestions.

1. **CHEMICAL IDENTITY.** Look at the section (usually section II) in which hazardous chemicals must be listed. Good MSDSs will provide a distinct chemical name and Chemical Abstract Service number (CAS #) here. It is more likely that the MSDS on your fire retardant product will say that the chemicals are "proprietary" or "trade secret." Or your MSDS may simply say the ingredients are in one of the classes above. For example, if the MSDS says it is a brominated compound, this narrows the identity to about 100 chemicals your product could contain.

2. **AIR QUALITY STANDARDS.** In the Hazardous Chemical section or in the Health Hazards section of the MSDS there should be a space where the manufacturer is supposed to enter the OSHA Permissible Exposure Limits (PELs) and the American Conference of Governmental Industrial Hygienists threshold limit values (TLVs). If your fire retardant contains inorganic compounds of aluminum, antimony, boron, or molybdenum there should be standards listed here. OSHA and/or ACGIH have standards for these metal compounds.

If the MSDS says there are no standards for the chemicals, it means these are some of the hundreds of chemicals in those other categories of fire retardants.

Watch for blatantly incorrect information. For example, one popular fire retardant's MSDS states:

> *No constituents of this mixture have OSHA established permissible exposure limits (PEL) or ACGIH established threshold limit values (TLV).*

Yet under precautions this same MSDS says:

> *Provide sufficient ventilation to maintain emissions below recommended exposure limits.*

Obviously, this advice cannot be followed because there are no recommended exposure limits. Worse, the manufacturer hasn't even told you what the chemical components are so you can't make a rational judgement about exposure or look up more data.

3. **USING OTHER MSDS DATA.** Sometimes the chemical identity can be teased out of other data on the MSDS. For example, under Hazardous Decomposition Products, the manufacturer must list those chemicals that will be released during high temperature incineration of the product. Under high temperature burning, certain elements will remain unchanged and will be emitted. For example, a chlorinated or brominated chemical will always release chlorine or bromine under these conditions. And the inorganic metals such as antimony and boron also will be emitted during incineration.

4. **WHEN IN DOUBT** about the MSDS, you are welcome to send a copy of the MSDS to ACTS and we will help interpret it.

CERTIFICATES FOR FIRE-RETARDANT FABRIC

There are tests to verify material has been successfully retarded. The best way for shops to address the problem is to have fire retarding done and certified by a third party. If this is not possible, the next best procedure is to send samples of the material to a laboratory for testing. These certified labs will want strips of fabric to test, so always treat more fabric than you will need.

The last option is to have an employee become certified to do the flame tests and have this employee certify the work as fire-retarded. Certification can be obtained by contacting your local Bureau of Fire Prevention. Here in New York, people can apply for a Certificate of Fitness for "C-15 Supervise Flame Proofing" by contacting the Bureau of Fire Prevention, 9 Metro Tech Center, Brooklyn NY 11201-3857. They apply in writing and are given a study packet. Then they submit a letter of recommendation on their employer's letterhead, take the test, pay the fee, and get a certificate.

The person signing the certificate for each fire-retarded item incurs personal liability for this item. Its better to send it out to a third party to protect the individual workers and the company's liability.

THE FIELD TEST. While the lab test requires special equipment, the field test which can be used by employees holding a Certificate of Fitness for supervising flame-proofing can do a field test. The following is from the Certificate of Fitness study materials:

> *Three sample strips, at least ½ inches wide by 4 inches long, must be tested individually in a safe and draft free location. The material must be suspended with the long axis vertical (ideally the sample strip should be suspended using a steel tongs). Then the flame from a common wooden match must be applied to the center of the bottom edge of the sample strip for 12 seconds. The effect of the flame on the sample strip must be carefully observed and recorded. In order to pass the field flame test, the material must meet the following criteria:*
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> - *The flame must not spread rapidly over the entire sample*
> - *The sample must not continue to burn for more than 2 seconds after the match has been removed*
> - *Flaming materials must not break or drip from the sample and continue to burn when they reach the floor*
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> *Although the field test is not as accurate or as reliable as the small scale test, it serves as a good indicator of whether the materials are adequately flameproofed or noncombustible. Enforcement action may be taken against the Certificate of Fitness holder if a material fails a field test conducted by a Fire Department Inspector. Enforcement actions may include fines and/or the revocation of the Certificate of Fitness. When a material fails the flameproofing test, the material must be re-flameproofed or removed from the premises.*

The study materials also teach the applicant how to create the affidavits which must accompany the flame retarded materials.

MAKING YOUR OWN FIRE RETARDANTS

A common recipe for making fire retardants for drops, curtains, costumes, and other fabrics calls for 1.5 cups of ammonium chloride (sometimes called sal ammoniac), 1.5 cups of borax and 3 gallons of water. However, making your own fire retardant raises a number of quality, regulatory and legal questions.

DO WE NEED AN MSDS? The suppliers of borax and ammonium chloride can supply material safety data sheets (MSDSs) on each separate chemical which should be kept in the workplace. However, if these two chemicals are mixed to make a fire retardant, the employer needs to write another MSDS that reflects the use of this new mixture. Legally, the employer whose workers mix up this product is the "manufacturer" of the fire retardant.

CAN THE PRODUCT HARM EMPLOYEES? Borax and other boron compounds are used to kill roaches, but it takes a great amount to harm us. Contact with broken skin should be avoided since it can absorb through broken skin. Ammonium chloride is primarily an irritant to the skin and respiratory system. All in all, these are not very toxic chemicals. But illnesses could result if a worker has a severe allergy to a component or inhales significant amounts of the chemicals such as during spraying or mixing the powders.

Employers should be aware, however, that if an employee is somehow injured by the use of the product on the job, the employee does not have to go through the Workers' Compensation system for assistance. The employee can sue his/her employer as the "manufacturer" of the product under product liability laws.

IS HOMEMADE AS GOOD AS COMMERCIAL PRODUCTS? We can't know if the in-house manufactured borax/ammonium chloride retardant works as well as the commercial products without testing. Commercial fire retardant manufacturers have independent laboratories test their products to assure that they meet the National Fire Protection Association standard NFPA 701, and the American Society of Testing and Materials standard ASTM E84. To protect themselves from liability, employers would need to do similar tests.

And I suspect the home made retardant is not as good after one shop supervisor told me that their painters like it "because it tends to be less oily than commercial products...." But this greasiness may have an important function--it may bind the ammonium chloride and borax to the fabric.

A binder is necessary because when borax and ammonium chloride are dissolved in water and put on a fabric, the two chemicals simply re-crystallize when the water evaporates. Some of the crystals are small and will stay in little spaces between the fibers. But if you really shake the fabric out, a significant amount probably will fly out as a dust. And of course, water will just wash it away again.

ADDITIONAL LIABILITY. If there is a fire involving any materials retarded with a mixture that is "manufactured" by the scene shop employer, the insurance companies and lawyers will probably try to pursue actions against the shop under both general liability and product liability. The employer probably will have to: a) prove that the retardant was properly applied by the workers; b) the retarded fabric was tested and performed well on laboratory burn tests; and c) the product itself performs to the standards that apply to other commercial fire retardants.

And if the shop also conducts burn tests in-house rather than sending the material out to an independent testing lab, the lawyers may consider the shop employer as a "self certifier," which brings in more liability issues.

SHOULD WE MAKE OUR OWN? If you look only at the health of the worker mixing and applying the home made, it would be a good idea. The chemicals are not very toxic and you know exactly what it is, unlike the trade secret commercial products you can buy--some of which are much more toxic. But it is a bad idea when you consider the quality of the final product, the many liability issues for the employer, and the safety of others that will depend on the product's performance for fire safety. On the whole, I recommend against it.

FABRIC SOFTENERS DECREASE EFFECTIVENESS OF FIRE RETARDANTS

In 2001, 65 year-old Janine Humblet of Quebec, died by fire. Her terry cloth robe ignited, most likely from a cigarette. The coroner reported that evidence suggests her robe was made more flammable after being laundered with fabric softener. The coroner believes that fabric softener made the robe burn 7 times faster than normal.

Fabric softeners make fabrics more flammable in two ways: 1) by increasing their fluffiness and, hence, the amount of air in the fabric; and 2) building up a softener residue coating on the fabric's fibers, especially if too much softener is used over a period of time.

SOFTENER REGULATIONS

In both Canada and the US, many types of clothing and bedding must be fire retardant. In the US and Canada, liquid softeners (not dryer sheets) are supposed to carry a warning not to use them on fire-resistant clothing. However, a call to the US Consumer Product Safety Commission (CPSC) revealed that the CPSC puts the onus on fabric softener manufacturers to test their own products to see if they affect fire retardancy–the CPSC does not verify either that the tests are being done or that the tests used are adequate.

***CONSUMER REPORTS* TESTS.** In 2000, *Consumer Reports* magazine published data on fabric softeners.[2] Their tests indicated that greater fluffiness increases the rate at which fabrics burn. As they put it: "Fluffy burns faster than flat" and they recommended:

> *...avoiding liquid fabric softener with all-cotton clothing made of fleece, terry cloth, or velour. If you want a fabric softener, use a dryer sheet. (To avoid static cling almost entirely--a big reason consumers use fabric softeners--hang synthetics to dry instead of machine drying them with other fabrics.)*

CPSC WASHING TESTS

Fire retardancy of fabrics is also reduced by repeated washing. The CPSC requires manufactures of fire retardant products to pass washing tests. These CPSC wash tests were instituted in 1953 and are shockingly outdated. They employ detergents and washing machines that aren't on the market any more. Worse, they require hanging the clothes outdoors to dry which few people do anymore. And the modern machine dryers used today also contribute to making fabrics fluffier and more flammable. To account for these facts, the CPSC has proposed updated tests in which modern machines driers, and detergents are used.[3]

The CPSC also did a few tests of the effects of softeners and found that "one polyester fabric did show reduced flame resistance when a liquid fabric softener was used."[4] Nevertheless, the CPSC's proposed new wash test procedures do not include any provisions for assessing the effects of fabric softeners. I have submitted formal comments to the CPSC on this and other oversights.

DRYER SHEETS

The dryer sheets such as Bounce® are not regulated by CPSC. However, the sheets themselves are flammable. In fact, Bounce® is no longer sold on rolls because arsonists were using them! They would fling the roll around a few times to spread this flammable material around and light one end with a match or lighter. The flame would then run the length of the unwound spool.[5] So it is reasonable to assume that dryer sheets may also affect fabric flammability to some extent.

ADVICE FOR THEATRICAL FABRIC & COSTUMES

When clothing ignites, every second counts. I am especially concerned about fire retarded costumes and fabrics used in shows in which on-stage fire effects such as pyrotechnics, torches, braziers, cigarettes, or candles are used. Our advice is:

* Washable fabrics sold as fire retardant today that have passed the old CPSC tests should not be trusted to be fire retardant after even one modern washing and machine drying with or without a fabric softener.
* Current data are so limited and regulations are so vague and unenforced, that no type of fabric softener or dryer sheet, should be used on fire retarded fabrics used on stage with fire effects.
* When possible, use fabrics that are naturally fire resistant such as wool, modacrylic or saran. These fabrics ignite but will stop burning when the source of ignition is removed.
* Since fire retardants wash out in time and the CPSC's current and proposed tests do not extend beyond 50 washings, new fire retarded clothing should be retreated after 50 washings. Old, second hand, and thrift shop costumes should be treated at once.
* Costumes treated with theatrical spray or liquid fire retardants should be laboratory tested and retreated frequently. Avoid skin contact or inhalation of retardant chemicals. Many are toxic.
* Retesting for flammability should be done whenever any additional treatments are used such as paints, dyes, spot resisters, wrinkle relaxers, etc.

Footnotes

1. 69 FR 70404-12, Dec 6, 2004
2. www.consumerreports.org. & http://www.apparel.ca.magazine.2000march/Flammability.pdf
3. 64 FR 13126-13141
4. 67 FR 57770-57773
5. Seth M. Robbins, MEd, ATC. CSCS, ETM, in a message to a National Fire Protection safety list on 12/3/03 from FirefighterFDMT@comcast.net.