

Fire safe furniture without chemical fire retardants

Upholstered furniture represents a fire hazard by burning intensely and by releasing large amounts of dark and toxic smoke during fire. Fire safety of these products can be improved, but it must be done in an environmentally friendly way.



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Upholstered furniture represents a fire risk

In the community working with fire safety it has been well known for decades that upholstered furniture, like couches and armchairs, represents a high fire risk. Such furniture often contains relatively large amounts of easily ignitable and very combustible materials. It is commonly the foam used for the padding that is the primary challenge with regard to fire, because the upholstery foam often releases large amounts of heat and toxic smoke when burning.

A majority of fire fatalities are related to dwelling fires and some groups of people are more at risk in a fire situation than others. Furniture that does not allow a small fire to grow into an uncontrollable situation is therefore a powerful measure to prevent fire spread, and will prolong the time available to escape from a fire.

▼ **Test of an upholstery material combination in the cone calorimeter. The surface of the test specimen is 10 cm x 10 cm.**



Image courtesy of SP Fire Research

Stricter requirements to the fire behavior of upholstered furniture would certainly lead to a higher fire safety level in homes, health care institutions, prisons, hotels and in other applications. In the UK there has been quite high requirements to fire properties of upholstered furniture since 1988, and the Department for Business, Energy & Industrial Strategy concluded in 2016 that the Furniture and Furnishings (Fire) (Safety) Regulations 1988 (FFRs) have played an important role in the prevention of house fires and concomitant injury and death. An extensive fire research program called Combustion Behaviour of Upholstered Furniture (CBUF) was performed for the European Commission in the 1990's, but in spite of the many promising results in the final report, CBUF did not lead to any common regulations in the EU. We believe the time is ripe to move forward in this field. The harmonization of fire safety test methods and classification for construction products in the European market has been successful, and a corresponding system for furnishing could be an option.



Images courtesy of Thore K. Adoffin, Norwegian Fire Protection Association



◀ Fire tests of two qualities of the same model of an upholstered armchair 5 minutes after ignition of the fire source crib 5. The photo to the left shows a chair purchased on the Norwegian market, and the photo to the right shows a chair purchased on the British market.

Flame retardant chemicals may improve the fire behaviour of furniture

An upholstered item of furniture is composed of different types of materials. Polyurethane foam is often used as padding. The cover fabric can be different qualities, e.g. leather, cotton, wool, polyester or blends of different textile fibres. Underneath the cover fabric there may be a thin layer of wadding that helps the cover to look good without wrinkles and folds. In between the wadding and the foam a textile functioning as a fire barrier may be placed, to protect the foam from ignition.

One way of meeting relatively stringent fire safety requirements is to add flame retardant chemicals to the materials, either to the foam, to the cover or both. The purpose of adding a flame retardant chemical can be to reduce the risk for ignition or to prevent or delay further fire development after ignition. Different types of flame retardants may work in different ways, like by cooling the ignited material, by producing a protective layer or by releasing non-reactive (inert) gases that dilute the combustible gases produced in the pyrolysis process (i.e. the degradation of the material during the heat exposure). Some flame retardants react in the gas phase and change the combustion process, they may form a protective layer on the surface, or they may form an insulating char layer that protects the material from further heat exposure.

Some flame retardants represent a risk for health and environment

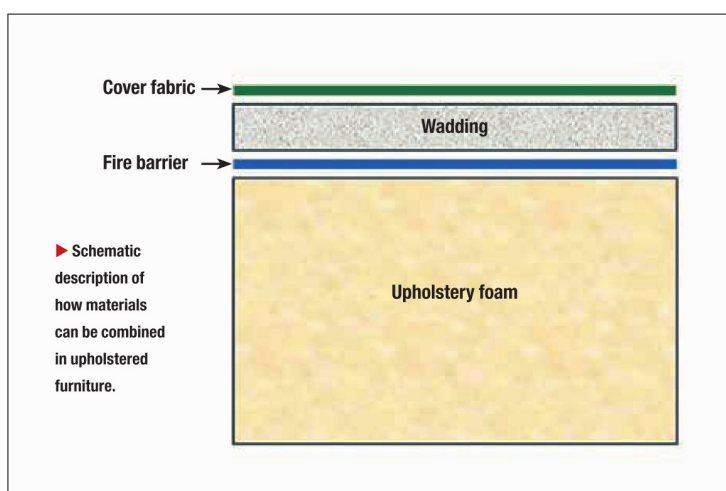
It has, however been shown that some flame retardants are harmful to human and animal health and to the environment, and there is a concern that stricter requirements would lead to a greater use of flame retardant chemicals with such adverse effects. Some fire retardant chemicals may pollute soil and water, accumulate in biological systems and lead to chronic and fatal diseases, mutations and other undesirable effects. There are types of fire retardant chemicals without such negative effects, and the development of health- and environment friendly fire retardant chemicals are most welcomed.

However, we wanted to study if it is possible to achieve upholstered

furniture with sufficient fire safety properties without the use of flame retardant chemicals. Our objective has been to minimize the conflict between the production of fire safe furniture and the potential negative effects on health and environment that the use of flame retardants may have during the furniture's life cycle. It has been shown in previous studies that fire properties can be improved by a conscious choice of materials in the furniture, and we wanted to use this as the main strategy.

Tested materials and test methods

We included products that are common in the Scandinavian market and cooperated with Swedish suppliers to select materials for the study. We tested a total of seven cover materials which varied from natural leather, polyester, different blends of textile fibers, to artificial leather. Two types of polyester wadding and three different materials for use as fire barriers between cover and foam were tested. The same type of non-fire-retardant polyurethane foam was used as filling in all material combinations. The use of a fire barrier material to protect the filling from being ignited is a simple way to improve the fire properties of upholstered furniture. It is often argued that fire barriers are costly



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Images courtesy of SP Fire Research

to add, and that they reduce the comfort of the furniture. We therefore wanted to explore the fire performance of very light and not too costly textiles as fire barriers. In this limited study we had two glass fibre scrim fabrics available for the testing, one with an area density of 80 grams per square meter, and a considerably lighter one, weighing only 25 grams per square meter.

Various combinations of cover materials, fire barriers and foam were tested in the small scale test apparatus called the cone calorimeter according to the international standard ISO 5660, in order to examine which combinations of materials that could have the potential to contribute to good fire properties in upholstered furniture. In this context, good fire behaviour means that the furniture releases small amounts of heat and produces little smoke after being ignited. Naturally, it is also an advantage if the material combination is difficult to ignite. Based on the results from this screening, material combinations were chosen for medium scale testing in a corner mock-up assembly. The material combinations in the mock-up were exposed to a small gas flame and to a wooden crib corresponding to crib 5 in the British standard BS 5852:2006 Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources. Upholstered furniture in the UK

market shall comply with certain criteria when tested using crib 5, which is much stricter than the requirements of resistance against a cigarette ignition source which is common in many European countries including Norway and Sweden.

Results and conclusions – and the way forward

The tests showed that the heat release from the set of materials can be reduced by using a fire barrier between the cover and the foam. The barrier with the greatest area density supplied the most significant impact while the effects of the lightest barrier were more dependent upon the cover material it was combined with. Based on the results of the experiments, we are convinced that it is possible to improve fire safety of upholstered furniture without the addition of chemical flame retardants to the materials. This requires however, a conscious choice of materials in the combination. We have noted that there are several interesting products on the market, of which many have very different application areas than for use in upholstered furniture, and which could be further investigated in possible future studies.

We recommend that development of a system for fire classification of upholstered furniture should be considered. This would be useful for both private households and for purchasers of furniture for commercial

▲ Model chairs 5 minutes after start of test with ignition source crib 5. The foam and the cover fabric was identical in the two test objects, however the chair in the left photo had an 80 g/m² glass fibre fabric between the polyurethane foam and the cover, while the chair in the right photo had no such fire barrier material.

and government applications (hotels, hospitals, prisons, ships, offshore, etc.). Some countries already have strict regulations for furniture in selected types of buildings and a ranking system like this would make the purchase of products easier. The system could be voluntary and should include a way of labelling the products with the fire safety level they have obtained. In some areas where the fire risk is assessed to be low, e.g. in offices, the requirements do not need to be very high, and a lower level of fire performance would be sufficient. In other types of applications the fire risk is high, either because fires regularly occur or because the consequences of a fire will be high. In such cases a high fire performance level should be required.

The project was commissioned by the Swedish Contingencies Agency (MSB), and performed in collaboration with SP Fire Research in Sweden.



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