

Fire-study to increase the fire safety of furniture

Over the past two years, the Federation of the European Union Fire Officer Associations (FEU) has studied the need to increase the fire safety of furniture¹ and mattresses in homes in Europe and the options for how to achieve this. This article provides further details about this process and the results of this project.

Furniture and mattresses in residential fires

Fires claim between 5,000 and 6,000 human lives in the European Union every year. The majority of these deaths (more than 90%) are due to fires in the home.

Homes contain lots of flammable materials such as sofas, beds and armchairs, all of which contribute to the total fire load in the home. Statistics from several different countries² have shown that fires often start in furniture or mattresses and that fires which originate in these products actually contribute to a high number of fatal casualties in homes. For example, some 25% of all fatal residential fires started in upholstered furniture or a mattress. These statistics could actually be higher, since the object in which the fire started is not known in 32% of the total number of cases.

Looking at the different sources of ignition, it has been found that about one fourth of all fatal residential fires was ignited by a cigarette. A smaller number of fires (7%) was ignited by candles or another small open flame. As in the case of the object where the fire originated, these percentages might actually be higher given the large percentage (21%) of cases where it is unknown how the fire was ignited.

Baseline measurement

Previous studies by the Institute for Safety (the Netherlands) have shown that fires which start in furniture and mattresses can develop very quickly. As part of a study 2014, fire tests were conducted in working class houses in the Dutch municipality of Zutphen. To simulate the real-life situation as closely as possible, the homes had been fitted out with the furniture that was customary in the Netherlands in 2014. This furniture was bought from three different furniture chain stores, focussing on the 'inexpensive' price segment, bearing in mind the financial situation of a young family. Six different fire tests were conducted as part of this fire test, with fires being lit in different locations (living, bedroom or kitchen) and with varying scenarios of doors in the home being open or closed. Variables such as temperature, heat radiation, carbon monoxide and the height of the smoke layer were measured during these tests.

These tests showed that the fire growth and the chance of escaping and survivability depend on many factors. Here 'escaping' means that a victim can and wishes to escape until this is no longer possible. 'Survivability' means the limit above which it assumed that the chance of surviving reduces greatly and that there is a significant likelihood of long-term damage to health. This implies that, once this limit is exceeded, the chance of surviving is not '0', but it is limited.

The Zutphen tests did not give a definite indication of the reaction of the upholstery of the furniture and mattresses alone to fire and the chance of escaping and survivability for these residential fires³. To get a better impression in this respect, it was decided that different further tests should be carried out to study the reaction of furniture and mattresses to fire, and the chance of escaping and survivability. For these further tests, only the furniture and mattresses were placed in an otherwise completely empty room, enabling the reaction of these products to fire to be studied. This study both gave a better understanding of the reaction to fire of the two best sold mattresses and upholstered sofas of a major furniture factory and of the chance of escaping and survivability in a residential environment when exposed to different common sources of ignition (cigarette, small open flame and a larger open flame).

¹ Here 'furniture' is taken to mean upholstered furniture such as sofa sets and armchairs

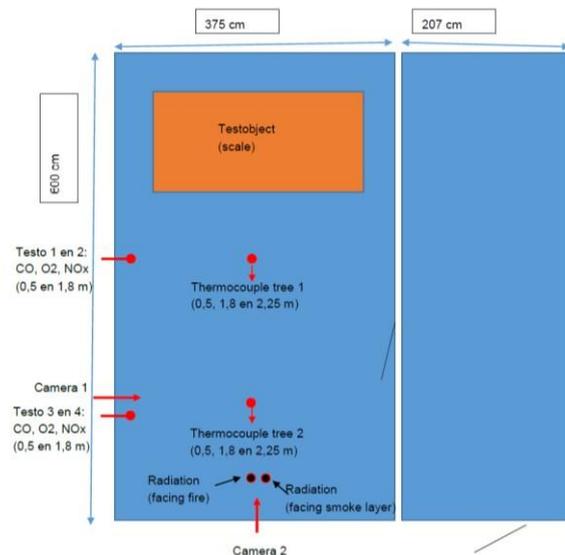
² The Netherlands, Sweden, Finland, Spain and Denmark

³ The full 'Het kan verkeren' report can be downloaded via www.brandweeracademie.nl.

The experiments were carried out at the Crailo fire service practice centre in the Netherlands. In the grounds of this centre, there are some small, single-person, two-storey homes. The load-bearing structure is concrete and its inside is protected by plasterboard. All the windows feature single glazing. In every test, one item of furniture (sofa or mattress) was placed in the living area of the home. This was then ignited using one of the sources of ignition used in official fire safety tests: a cigarette, a small flame and /or a small wooden setup ('crib 5'). Temperature, heat radiation, carbon monoxide (CO), oxygen (O₂) and nitrogen oxides (NO_x) were measured during the experiments.



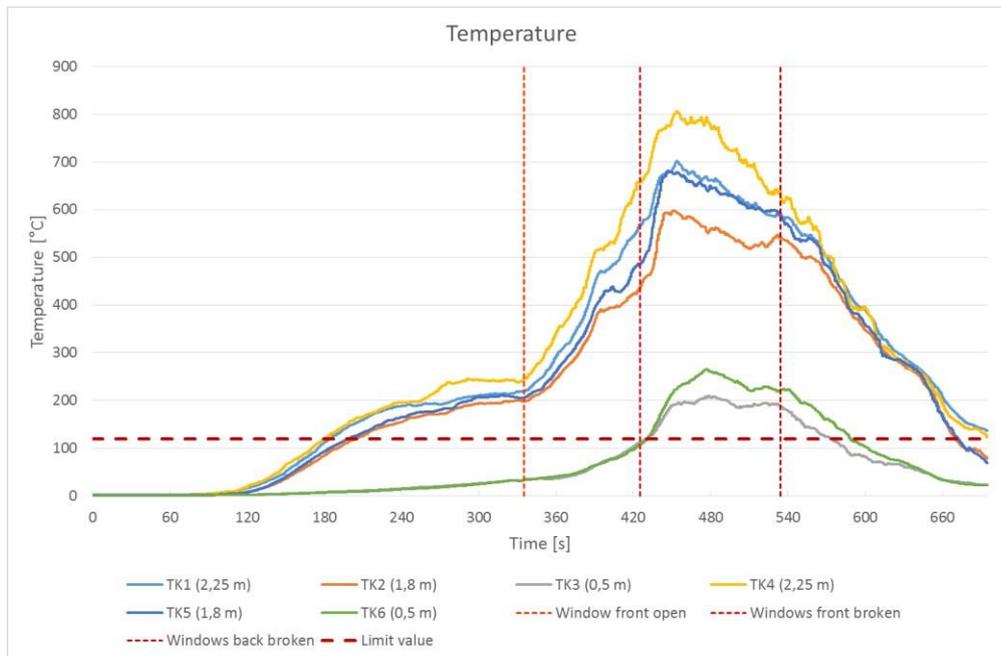
The front of the house where the experiments were conducted



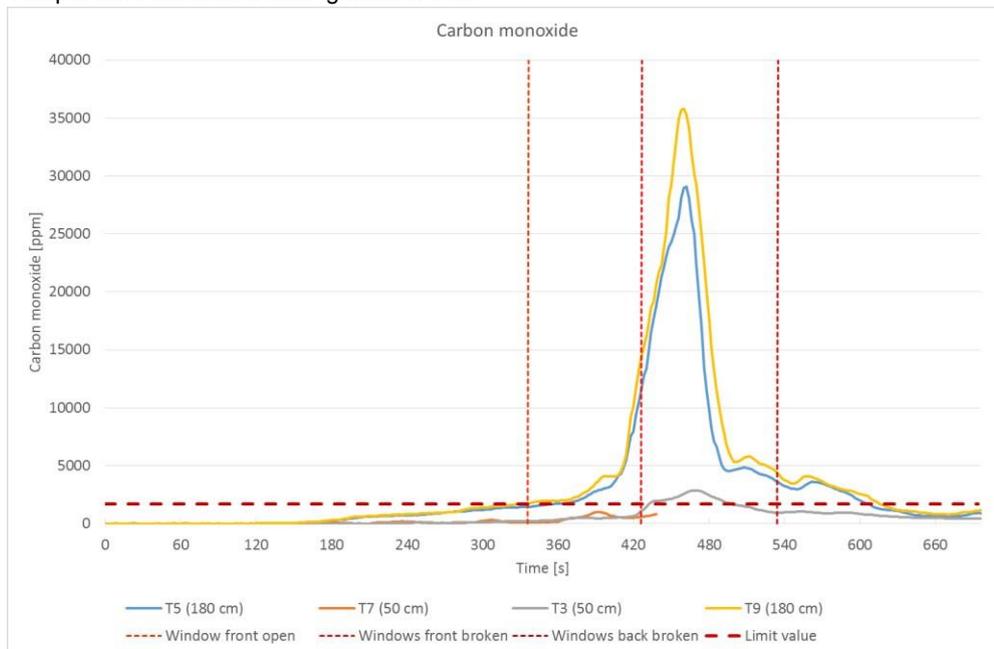
Test set-up

The experiments have led to the conclusion that the sofas and mattresses tested are resistant to being exposed to a smouldering ignition source such as a cigarette. These objects are not resistant to being exposed to a bigger ignition source, such as an open flame (candle) or a crib 5 (comparable to a burning newspaper). Once the object is burning, the fire will spread rapidly in all directions and a lot of heat and smoke is produced in a short time (within 10 minutes). The heat produced by the objects tested is sufficient to cause a flashover in a furnished living or bedroom, if sufficient oxygen is available for combustion. It can also be concluded that, once the object is burning and a window breaks, the temperature is the decisive factor for both the chance of escaping and the chance of survival. The tests in Zutphen showed that, if the window does not fail, CO is the decisive factor for the chance of escaping or surviving. If only a sofa is burning, the chance of escaping is very low in the test environment after 4 to 6 minutes, and if only a mattress is burning it is very low after 7 to 8 minutes. Survivability in the test environment is very low after 7 to 8 minutes if only a sofa is burning, and it is very low after 9 to 10 minutes if only a mattress is burning. The thresholds for the other parameters (CO, O₂ and NO_x) were exceeded later or were not exceeded at all during the tests⁴.

⁴ The full 'Impression tests upholstered furniture and mattresses' report can be downloaded via www.brandweeracademie.nl.



Temperature measured after ignition of sofa



CO values measured after ignition of sofa

Advice of the fire service

Since there are no laws and regulations on upholstered furniture and mattresses in Continental Europe at present, but the influence of these products on fire growth and on the chance of escaping and survivability is very significant, it was decided that a project would be started to arrive at providing advice about test methods for upholstered furniture and mattresses. Or: what does the fire service think that should happen in order to increase the fire safety of these products? This study, conducted under the auspices of the FEU, was carried out by a task force of experts on the fire service, fire safety and test methods. Seven different countries were represented in this task force⁵. The issues presented in this article were mapped out through several different meetings and with talks with furniture producers and experts on the fire safety of furniture. This has led to recommendations on what should be done in order to increase the fire safety of upholstered furniture and mattresses and how these recommendations can be achieved.

⁵ Belgium, the Netherlands, UK, Sweden, Finland, Spain and Poland

Considerations for test methods

In order to be able to draw up an advice on test methods for furniture and mattresses, an opinion had to be formulated in respect of some aspects regarding the test methods.

Fire scenarios and test methods

There are five relevant fire scenarios to take into account, each of which can be tested using certain test methods⁶:

1. Scenarios for ignition by cigarettes
2. Open flame ignition by another fire: the scenario where the item of furniture is the main item that contributes to the fire spread, but was not the first item to be ignited.
3. Ignition by sparks or heat from electrical control devices.
4. Ignition by a small open flame: ignition by a candle, match or lighter.
5. Smouldering ignition by hot ashes or a non-classified hot or smouldering object.

The above scenarios can lead to fire and smoke spreading. This can be divided into three phases. Phase 1 in the figure below is the incipient part of the fire, phase 2 is the fire growth, flashover and fully developed combustion of the object, and phase 3 is the period in which the fire is extinguished or self-extinguishes.

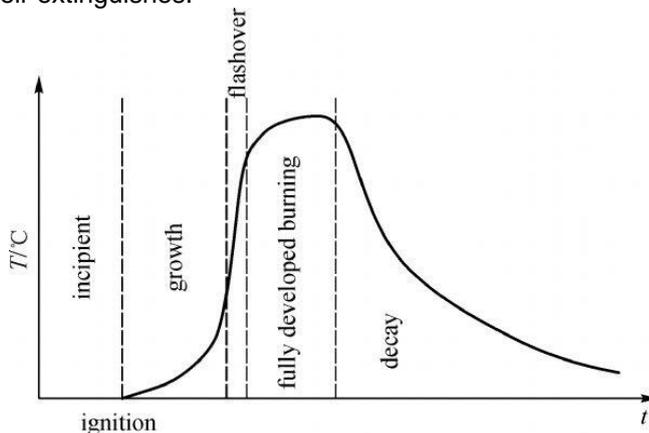


Figure XX. Fire development curve of the object

All these phases influence the circumstances in the home. The first phase says something about how hard the object is to ignite. Ignition can be avoided or at least slowed down if the object can resist a rather substantial source of ignition. The second phase takes place after the object has been ignited. Depending on the speed of the fire growth and of the moment when flashover occurs, this can affect the fire and smoke production in the actual room, as well as in other parts of the house.

Since the intention is to improve the options of survivability and the chance of escaping in homes, it seems logical to focus on phases one and two. However, for practical considerations, it was decided to only focus on phase one since phase two would require large-scale tests which are currently not feasible for the furniture industry. Besides this, there are so many variables that play a role in phase 2 and phase 3 that it is virtually impossible to draft a good test standard for this. The opportunities of escaping and survivability can also be increased by preventing or slowing down the ignition of the furniture and mattresses. This might be achieved by using a source of ignition like a cigarette and a match during the tests. However, in order to also represent the bigger sources of ignition that can be found in a home, and, for example, to reduce the contribution of a sofa to the growth of a fire that started in another object, the FEU believes that a source of ignition such as crib 5 is necessary also. The FEU concluded that the focus on increasing the possibility of escaping and the chance of surviving should be reached by setting requirements in order to prevent that furniture and mattresses catch fire. The FEU therefore recommends the following sources of ignition for test methods:

⁶ National Fire Protection Association, 'White Paper on Upholstered Furniture Flammability,' NFPA, 2013.

- 1. Ignition by a cigarette**
- 2. Ignition by a small open flame**
- 3. Ignition by a small wooden structure (crib 5)**

It is the FEU's opinion that recommendations 1 and 2 are now feasible for most furniture. The FEU also wants manufacturers to state that they will be working on satisfying crib 5 or a comparable test in the near future.

Test methods

Full-sized furniture and mattresses can be tested, or small-scale tests can be done on a smaller model or on samples of the fabric, the intermediate layer or the stuffing of the item of furniture. The advantage of small-scale tests is that less material is needed and that the costs, including the transport costs, are lower for the manufacturer. However, this does not always accurately represent the fire safety of the final product.

Small-scale tests can also be conducted by testing every product component separately (component test) or by assembling the different components of the end product and testing this (composite test). However, the component tests are often carried out by testing the different components in combination with standardised materials and this therefore fails to give a representative view of the flammability of the end product.

The FEU's conclusion is that, given the many possible combinations, full-sized testing is not realistic and that composite testing is the best alternative. The test shall be carried out on a small scale, but with the same combinations of materials as in the end product. If many combinations of materials are available, they can be grouped and tests can be done on the worst-case combinations.

In summary, the FEU recommends that furniture be tested as follows:

- 1. Test the composite product**
- 2. Test the combination of materials as used in the end product**
- 3. Test the representative combinations**

Mattresses are always tested in the combination used in the end product, regardless of whether it is a full-sized mattress or a smaller model. Using smaller models in tests is more convenient, and the costs of materials and transportation will probably be less for manufacturers. However, producing smaller scale models is hard for some manufacturers, especially if the mattress in question has a wooden frame and a spring system. Therefore, the FEU does not give any specific advice as to the size of the mattress during the tests. The ignition test can be done on a full-sized mattress or on a smaller model.

In summary, the FEU recommends that mattresses be tested as follows:

- 1. Test full-sized products or smaller models**
- 2. Test the representative combinations**

Advice on behalf of the fire service

In order to reduce the effect of fires and save lives, the FEU wants to focus on the incipient phase of the fire curve: i.e. to prevent ignition or at least extend the time until ignition. It has been concluded that, in order to achieve this, furniture and mattresses in a residential environment have to be resistant to several different sources of ignition, such as cigarettes or a small open flame. Where testing furniture is concerned, the FEU has come to the conclusion that testing full-sized furniture is not realistic and that composite testing is the best alternative. The test is then carried out on a small scale, but with the same combinations of materials as in the end product. If many combinations of materials are available, they can be grouped and tests can be done on the worst-case combination. For mattresses, the ignition test can be carried out on a full-sized mattress or on a small-scale model. This has led to the following advice on test methods for furniture and mattresses. When preparing these recommendations, a study has been made as to which existing standards would be suitable for use, since developing new standards takes a lot of time.

Object	Ignition source	Test method from
Furniture	Cigarette	EN 1021-1
	Open flame	EN 1021-2
	Crib 5	NEN 5852
Mattresses	Cigarette	EN 597-1
	Open flame	EN 597-2
	Crib 5	NEN 6807

According to the FEU, most current furniture and mattresses in Europe will pass the cigarette and small open flame tests. The FEU also wants manufacturers to state that they will be working on satisfying crib 5 or a comparable test in the near future.

The FEU addresses these recommendations to authorities (for legislation) and manufactures so that the latter will use these tests to improve the fire safety of their products without being under a statutory obligation to do so.

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(Both authors work at the Fire Service Academy in the Netherlands and they have written this article on behalf of the FEU)