Reference materials for fire testing
– a pre-study

Nordtest Project No. 4025
Reference materials for fire testing – a pre-study

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Abstract

A pre-study has shown that it may be a difficult task to find a proper material to be used as a reference material for fire testing. The study has focused mainly on the fire test method EN ISO 11925-2 “Ignitability of building products subjected to direct impingement of flame”.

The project gives guidance on how to develop a reference material for the method. Documents giving instructions about how to develop a reference material as well as demands for reference materials for fire testing are presented.

A literature survey on existing reference materials for fire testing has been carried out. Materials from an inter-laboratory trial on EN ISO 11925-2 have been studied with respect to being possible candidates for a reference material.

Key words: Small-scale fire test, reference material, building product
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Acknowledgement

This work was sponsored by Nordtest (Project No. 4025), which is gratefully acknowledged.

Danish Institute of Fire and Security Technology (DIFT), Denmark, Norwegian Fire Research Laboratory (SINTEF NBL) in Norway, VTT Building and Transport, Fire Research (VTT) in Finland, and Fire Research Centre, Fire and Rescue Department under the Ministry of Interior (GTC) in Lithuania were partners in the project. Martin Pauner at DIFT, Bjarne Kristoffersen at SINTEF NBL, Henry Weckman at VTT, and Andrius Lukošius at GTC, led the work at each of the participating laboratories.

Marina C Andersson, Patrick Van Hees and Brith Månsson at SP are acknowledged for their support in the work on performing tests and giving valuable criticism to the report.

Mats Alfredsson and Anders Persson, LGC Promochem, Sweden, gave valuable information about production and distribution of reference materials.
Sammanfattning

En förstudie har visat att det kan bli en svår uppgift att finna ett material som kan vara lämpligt som referensmaterial för brandprovning. Studien har huvudsakligen fokuserat på brandprovningsmetoden EN ISO 11925-2 “Ignitability of building products subjected to direct impingement of flame”.

Projektet ger råd om hur ett referensmaterial bör tas fram. Flera dokument som ger instruktioner om hur man tar fram referensmaterial och vilka krav som bör ställas på ett referensmaterial för brandprovning presenteras.

En litteratursökning efter referensmaterial för brandprovning har genomförts. Material som användes vid en jämförelseprovning med EN ISO 11925-2 har studerats utifrån möjligheten att de skulle kunna fungera som referensmaterial.
1 Introduction

Reference materials are widely used for validation of test methods. However, reference materials are not very much used within the field of fire testing. A literature survey has shown that there are very few certified reference materials (CRF) available especially for fire testing. This project was started since the harmonization within the fire field rise increasing demands on accredited fire-testing laboratories to guarantee that the tests give repeatable results.

The quality assurance standard EN ISO/IEC 17025 [1] demands that accredited laboratories have control over measurement uncertainty for the methods used within the laboratory. The laboratories must also assure the quality of the test methods they use with respect to repeatability and reproducibility.

The reason for focusing on a fire test method like EN ISO 11925-2 “Ignitability of building products subjected to direct impingement of flame” [2] where the result of the test is “the material ignites/does not ignite”, is that it is very difficult, if not impossible, to determine the total uncertainty for the test result from this method based on common practise for uncertainty estimation [3]. In cases like this the quality of the method is probably better controlled if repeated tests on a reference material could be performed.

EN ISO 11925-2 [2] is part of the European classification system for building products. For reaction to fire EUROCLASSes have been introduced. The classification system includes seven EUROCLASSes, A1, A2, B, C, D, E, and F for building products in general. There is a similar classification especially for floorings. The EUROCLASSes are then called A1FL, A2FL and so on. In Table A1 and A2 in Appendix A the seven classes that are included in the system are listed. As can be seen EN ISO 11925-2 is used for testing products for classes B – E for all types of building products. The method is a secondary method for all classes not counting class E. In most cases the main method, i.e. EN 13823 (the SBI test) and EN ISO 9239-1 (the Radiant Panel test), gives the classifying results, while the tests according to EN ISO 11925-2 only give complementary information.
2 The test method EN ISO 11925-2

EN ISO 11925-2 [2] is an ignitability test method. It consists of a specially designed cabinet, see Figure 1. The test specimen is mounted vertically in a holder. An ignition flame of a preset size is impinged either towards the surface of the specimen, as is visualized in the figure, or towards the bottom edge during a specified time period. The classification criteria to be fulfilled at the test as given in EN 13501-1 [4] are that the flames may not spread above 150 mm from the point of impingement within a certain time period.

There are several parameters that describe how the method shall be operated. Any of them can of course influence the test result. A selection of these parameters is listed here together with comments about what type of poor performance that can occur:

1. The ignition flame shall be adjusted to a height of 20 mm. For that a specially designed measuring device is used. The tolerance of this device is ±0.1 mm. There is still a possibility that the flame height can vary by more than that since it is the operator's decision to judge if the flame height is the same as the height of the device.
2. The distance between the burner and the surface of the specimen when the flame is applied at the surface shall be 5 mm. No tolerances are given to this distance. Also here the operator has to judge how well the distance is adjusted.
3. The distance between the burner and the bottom edge of the specimen when the flame is applied at the bottom edge shall be 16 mm. No tolerances are given to this distance. Also here the operator has to judge how well the distance is adjusted.
4. The application time for the ignition flame shall be either 15 or 30 s. No tolerances are given to this time. There is a possibility that the operator withdraws the burner at a time that is either shorter or longer.

Some other test parameters that also accidentally could be poorly controlled and thus influence the test result are the draught in the cabinet, and the quality and the pressure of the gas. Thus, a reference material must give such test results as to detect any anomalies in the set up of the test method.

Figure 1 The test apparatus for EN ISO 11925-2
3 Guidelines for development of reference materials

There are several documents giving instructions about how to develop a reference material. ISO, co-operation organizations for accreditation in Europe and worldwide, and the European Commission have published guides giving detailed information about the processes that are connected to reference materials. A summary of what the most important documents contain is given below, starting with the ISO documents.

The document gives terms and definitions that are used in connection with reference materials. Special attention is drawn to terms used in certificates and corresponding certificate reports.

The difference between a reference material (RM) and a certified reference material (CRM) is explained. A certificate must always accompany a certified reference material.

The document guides the producer of a certified reference material on the preparation of clear and concise certificates. A certificate should contain not only the name of the material and the properties of it, but also a description of the material and its use. Instructions for how to use the material are also given in the certificate.

The certified value of the properties of the reference material should always be given together with the uncertainty of the value. The traceability of the property values to an accurate realization of the unit should also be established.

As the title indicates, this document mainly addresses issues of interest for analytical chemistry.

ISO Guide 33, Use of certified reference materials [8]
The document discusses the use of certified reference materials for measurement traceability. The role of the CRM to transfer a property value from one place to another is discussed as well as how a CRM can be used to assess a measurement process. Advises on how the results can be used on a statistical basis are given.

ISO Guide 34, General requirements for the competence of reference material producers [9]
The document gives the general requirements, which the producers of reference material have to implement into their quality system. It contains similar items as the quality assurance standard EN ISO/IEC 17025 [1], but with special attention to the production of reference materials. It is described how the homogeneity and the stability of a reference material are assessed.

The document was the first one to be published in the ISO series of guides about reference materials. Thus the definition of a certified reference material does not fully comply verbally with the definition that has been established later. The document contains comprehensive instructions about general and statistical principles that must be understood in the process of evaluating a reference material before it can be certified.
It is described how the homogeneity of the material compared to the measurement error shall be assessed. Thus, when the certification of a reference material shall be based on a definite method, the method must have high scientific status. The actual accuracy of the method should be validated by international intercomparisons.

**ILAC-G12, Guidelines for the Requirements for the Competence of Reference Material Producers** [11]
This document is published by the International Laboratory Accreditation Cooperation. It focuses on producers of both reference materials and certified reference materials. It gives management system requirements and technical requirements for the producer. It is based on all those documents that give the important instructions for production, characterisation and use of reference materials. Thus it contains relevant elements of the ISO guides listed above, of ISO/IEC 17025 and of ISO 9000 [12]. It also gives cross-references to these documents.

**EA-04/14, The Selection and Use of Reference Materials** [13]
This document is published by the European co-operation for Accreditation. It gives short, simple and user-friendly guidance about reference materials. It is directed to people who are inexperienced in this topic. Some misunderstood issues are explained. Although it is based on the requirements of chemical measurements it can also be used for areas such as fire testing.

**BCR/01/97, Guidelines for the production and certification of BCR reference materials** [14]
This document is to be regarded as a toolbox to be used when a proposal for a BCR certification project is to be written or when reference materials are prepared. BCR is the Bibliographical Centre for Research and is under the wings of the IRMM (Institute for Reference Materials and Measurements). The Institute for Reference Materials and Measurements (IRMM) is one of the seven institutes of the Joint Research Centre (JRC), a Directorate-General of the European Commission (EC). The document contains three parts. The first part gives recommendations to proposers for BCR certification projects. The second part gives guidelines for the implementation of BCR certification projects. The last part gives instructions for the preparation of BCR certification reports. More information can be found on [www.irmm.jrc.be](http://www.irmm.jrc.be).
4 Demands for reference materials

4.1 Demands for reference materials for fire testing in general

Although quite obvious to fire testers it probably needs to be explained that most fire test methods aim to determine the fire behaviour of a solid product. The products that are tested are for instance building products of diverse types, products used on board ships or in vehicles, or products used in furniture. Most methods prescribe a certain specimen design. This implies that the tested product should be possible to cut into a certain shape. Thus, the first requirement of a reference material for fire testing is that it shall be solid and available as boards.

Paints or different kinds of liquids that will end up as a solid product are also included among products that are fire tested. For that kind of products variations in how the preparation has been done may affect the fire behaviour. Other types of products where the preparation can influence the results are very thin products, which have to be applied to a substrate before they can be tested. A warning is therefore issued regarding using such a product as a reference material. If the reference material shall be used only to control the quality of the test procedure itself, a product whose preparation influences the result should be avoided as a reference material. If, on the other hand, the reference material shall be used to control also the quality of the preparation procedure, then such a product could be a very good choice.

Many fire test methods where intercomparisons have been carried out have shown repeatability and reproducibility values of 10-40% of the great mean value received in the comparison. There are many reasons for such a high value as 40%. One could be that the mean value of the parameter is very low compared to the standard deviation. Another reason could be that the products that have been chosen for a round robin not necessarily have been chosen for their stable results. A product could very well have been chosen because of its instable result, to be able to show the robustness of the method and of the classification criteria for the method. If the method and its classification criteria manage to grade the products into different classes even if there is quite a great spread then the method traditionally is considered to be robust.

For a material to be of value as a reference material it should when tested in an inter-laboratory trial (round robin) receive a reproducibility coefficient of variation (COV(sR)) of at least not more than 20% of the great mean value. The repeatability coefficient of variation (COV(sr)) should accordingly then be less than 10%. However, the values discussed here should be considered as the very upper acceptable limit of COV(sr) and COV(sR). It should always be tried to attain a material giving lower values than that.

Common requirements for reference materials must of course also be met. Thus the test result of the material must be stable over time and it should not require too complicated storage. For a reference material to be certified extensive testing to determine the uncertainty limits of the material is needed.

For a future reference material, if it concerns a non-certified reference material, it may also necessary to consider the possibility of replenishing the store of material in case a too small amount is purchased at the first event. Thus if for instance a product that normally is used for other purposes than just being a reference material is chosen, e.g. a building material, then it may be important to consider the risk that the product will disappear.
from the market if it is no longer "popular". Certified reference material are normally produced in very large amounts and thus stored for a long time period.

### 4.2 Demands for a reference material for EN ISO 11925-2

The first requirement of a reference material for EN ISO 11925-2 is that it must ignite when the ignition flame is applied to the test specimen. After ignition it should burn rather slowly. Ideally the flames should go out before they reach the criterion limit, which is the 150 mm line.

There are two different modes of application (edge or surface) and two different times of application (15 or 30 s) which makes the span of the ignitability quite large. On the other hand, the request that the flames should go out before 150 mm limits the choice of materials to a large extent.

Since the basic need for a reference material for this test method is the quality control of the method the material must of course also be able to indicate possible test method errors. This implies that when the test parameters described in chapter 2 are varied, the spread in the results should be greater than the repeatability and reproducibility values. We know from the European round robin that was conducted 1997 [17] that the values for the repeatability and reproducibility coefficients of variation (COV(s) and COV(sR)) were quite large (see chapter 5.2). It is difficult to determine how much of the recorded variations that emanates from the method itself and how much that depends on the fire behaviour of the products.

It is evident that a candidate for a reference material must be evaluated with great care. Although some of the products tested in the 1997 activity showed a better result than the total mean variations, there are still quite high values for COV(s) and COV(sR) for many of the products. If we look at the damage of the pine wood (see Table 3) we see a value of COV(sR) of 46%. This must be considered as impossible with respect to a reference material.

Also for EN ISO 11925-2 it can be concluded that for a material to be of value as a reference material the product should receive a value of COV(sR) of at least less than 20% (see discussion in chapter 4.1). It is probably not likely to believe that COV(sR) can be reduced to a lower value than that, if we look for a material where the flames will go out below the 150 mm line. If, on the other hand, it is decided to go for the PMMA, and to use only the bottom edge application of the ignition source, then lower values could be expected. In the 1997 activity the PMMA showed values of COV(s) of 4-5% and of COV(sR) of 14% of the time for flames to reach the 150 mm line.
5 Survey of reference materials

5.1 Certified reference materials used for other fire test methods

To investigate the availability of existing reference materials for controlling the quality of fire test methods some databases for reference materials were searched. Although there are several databases available not very many of them list reference materials for fire test methods. Such materials were only found in the COMAR [15] and NIST [16] databases.

A search there for material used for any type of fire test method made in April 2005 gave as result the materials listed in Table 1. The table gives the information about six certified reference materials that all are available from NIST in USA.

<table>
<thead>
<tr>
<th>Material description</th>
<th>Test method</th>
<th>Property tested</th>
<th>Producer</th>
<th>Material ID</th>
<th>Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mm tempered fibrous-felted hardboard</td>
<td>ASTM E162</td>
<td>Flame spread index I Heat evolution factor Q</td>
<td>NIST, USA</td>
<td>SRM 1002d</td>
<td>320 USD</td>
<td>4 sheets 15,2 cm x 45,7 cm</td>
</tr>
<tr>
<td>0.76 mm plastic sheet</td>
<td>ASTM E662</td>
<td>Maximum specific optical density, flaming exposure</td>
<td>NIST, USA</td>
<td>SRM 1007b</td>
<td>333 USD</td>
<td>3 sheets 25,4 cm x 25,4 cm</td>
</tr>
<tr>
<td>1.6 mm cellulose paper</td>
<td>ASTM E662</td>
<td>Maximum specific optical density, non-flaming exposure</td>
<td>NIST, USA</td>
<td>SRM 1006d</td>
<td>768 USD</td>
<td>9 sheets 17,2 cm x 25,4 cm</td>
</tr>
<tr>
<td>Kraft paperboard</td>
<td>ASTM E648</td>
<td>Critical radiant flux</td>
<td>NIST, USA</td>
<td>SRM 1012</td>
<td>259 USD</td>
<td>3 sheets 104 cm x 25,4 cm</td>
</tr>
<tr>
<td>0.76 mm plastic sheet</td>
<td>Cup Furnace Smoke Toxicity Method</td>
<td></td>
<td>NIST, USA</td>
<td>SRM 1048</td>
<td>374 USD</td>
<td>8 sheets 16 cm x 16 cm</td>
</tr>
<tr>
<td>Nylon 6/6</td>
<td>UPI Smoke Toxicity Method</td>
<td></td>
<td>NIST, USA</td>
<td>SRM 1049</td>
<td>222 USD</td>
<td>150 g granules</td>
</tr>
</tbody>
</table>

Although the materials listed in Table 1 have been developed for other test methods it could be valuable to try at least the plastic sheets in a future project. To give some background information a minor investigation was conducted at SP and SINTEF NBL on the plastic sheets referenced SRM 1007b. One single test run was carried out according to EN ISO 11925-2 at these two laboratories to get an idea about how the material behaved.

The tests showed that it could be worthwhile to investigate this material further even if the two single test runs to some extent gave deviating results. In one of the test runs the flames reached the 150 mm line after about 40 s. In the other, the flames never reached the 150 mm line. Even if these results are discouraging, the fact that the material burned rather slow after ignition, could make it worth to perform an investigation more in depth with this material or a material with a similar composition.
5.2 Materials tested in EN ISO 11925-2

Twelve building products were tested in an inter-laboratory trial performed 1997 among European laboratories [2, 17]. The results were studied from the view of finding possible candidates for reference materials. As discussed in chapter 4.2 the first requirement is that the material must ignite. Thus most of the results are not presented here since many of the materials did either not ignite or they gave very irreproducible results when they ignited. A few products though received 100% yes on the question whether they ignited or not. They are listed in Table 2 and Table 3. Table 2 gives the time to reach 150 mm for the products where the flame front passed that line. For those products where the flame front did not pass the 150 mm line the extent of damage is given in Table 3. The results regarding the damage are in the latter case given in two ways: as height of damage and as flame spread.

Table 2 Time to reach 150 mm for materials where the flame front passed 150 mm

<table>
<thead>
<tr>
<th>Material description</th>
<th>Flame application</th>
<th>Mean value, s</th>
<th>COV(s)_1, %</th>
<th>COV(s)_R, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 mm clear PMMA</td>
<td>15 s, bottom</td>
<td>35</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>30 s, bottom</td>
<td>38</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>40 mm PUR foam with aluminium foil facing</td>
<td>15 s, bottom</td>
<td>11</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>30 s, bottom</td>
<td>13</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>0,5 mm PVC coated polyester fabric</td>
<td>15 s, surface</td>
<td>9</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>30 s, surface</td>
<td>21</td>
<td>24</td>
<td>46</td>
</tr>
<tr>
<td>40 mm PUR foam with bitumen paper facing and aluminium foil interlayer</td>
<td>15 s, surface</td>
<td>4</td>
<td>28</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>30 s, surface</td>
<td>4</td>
<td>24</td>
<td>75</td>
</tr>
</tbody>
</table>

1 Repeatability coefficient of variation, i.e. repeatability standard deviation as percentage of general mean value
2 Reproducibility coefficient of variation, i.e. reproducibility standard deviation as percentage of general mean value
3 Tested on back side (PUR)

Table 3 Extent of damage on materials where the flame front did not pass 150 mm

<table>
<thead>
<tr>
<th>Material description</th>
<th>Flame application</th>
<th>Type of parameter</th>
<th>Mean value, mm</th>
<th>COV(s)_1, %</th>
<th>COV(s)_R, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mm pine wood</td>
<td>30 s, bottom</td>
<td>Height Flame</td>
<td>80</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>72</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>0,5 mm PVC coated polyester fabric</td>
<td>15 s, bottom</td>
<td>Height Flame</td>
<td>70</td>
<td>20</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>30 s, bottom</td>
<td>Height Flame</td>
<td>78</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height Flame</td>
<td>79</td>
<td>15</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>94</td>
<td>18</td>
<td>34</td>
</tr>
<tr>
<td>40 mm PUR foam with bitumen paper facing and aluminium foil interlayer</td>
<td>15 s, bottom</td>
<td>Height Flame</td>
<td>48</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>44</td>
<td>12</td>
<td>47</td>
</tr>
<tr>
<td>40 mm PUR foam with bitumen paper facing and aluminium foil interlayer</td>
<td>15 s, bottom</td>
<td>Height Flame</td>
<td>111</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>30 s, bottom</td>
<td>Height Flame</td>
<td>129</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height Flame</td>
<td>121</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>132</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

1 Height = Extent of damage in height direction, Flame = Extent of upwards flame spread
2 Repeatability coefficient of variation, i.e. repeatability standard deviation as percentage of general mean value
3 Reproducibility coefficient of variation, i.e. reproducibility standard deviation as percentage of general mean value
4 Tested on back side (PUR)
An analysis of the results shows that most of the products received a very high value of COV\(sR\). As discussed in chapter 4.2 this therefore makes them unsuitable as reference material.

The results of the PVC coated fabric may need some further explanation. It received a flame spread to the 150 mm line when the ignition source was applied to the surface but no ignition when it was applied to the bottom edge. The reason for no flame spread at the bottom edge exposure is that the material shrunk away from the igniting flame. Thus there was no stable ignition and flame propagation for that test mode.

The clear PMMA that was tested in the European round robin was also further investigated by Andrius Lukošius [18]. He has found that this type of PMMA could be a possible candidate for a reference material. The material is homogeneous, simple and stable to store, and simple to mount in the test apparatus. It also shows rather stable results.

The problem with this material is that it does not ignite for the surface exposure. Surface exposure is the most important mode of application of the ignition flame mainly because it is the only mode used for testing floor coverings. Andrius Lukošius also concludes that the flame spread in the upper region of the 150 mm zone of evaluation was somewhat unstable and therefore difficult to interpret. It should also be noted that in the round robin this material showed unstable results for the surface exposure: only 70 % of the reported results was a "yes" to the question whether it ignited or not.

It can be concluded that PMMA is a possible candidate for a reference material for EN ISO 11925-2 on the conditions that it can be modified to ignite for the surface application of the ignition source.
Evaluation of a possible reference material for EN ISO 11925-2

6.1 General planning

The evaluation of a possible reference material should be conducted in a number of steps. First it must be identified that the material really has the ability to indicate test method errors. Then it must be shown that the material gives stable results in the correctly run test. Looking at the results received in the European round robin [17] it is obvious that there can be a substantial uncertainty built into the results of a specified material itself. If that depends on the material or on the uncertainty of the test method is very difficult to conclude.

The first identification of the ability to indicate test method errors can probably be performed according to a fractional factorial design [19, 20, 21, 22, 23]. Such a test planning will reduce the number of necessary tests to a great extent, and still give enough information about which of the test parameters that have the highest influence on the test result (see also chapter 6.2). If the number of tests is not reduced the study will end up in an enormous amount of testing. If for instance 7 factors are to be changed that would end up in $2^7 = 128$ test runs!

The final evaluation of the reference material that has been found to be most suitable after such an exercise must of course be done according to the guides described in chapter 3. It should be performed in the way of a round robin to get a correct value of the repeatability and the reproducibility of the test result of the material.

The first identification according to the fractional factorial design would probably only have to be conducted at one laboratory. There might also be a need to carry out parts of the fractional factorial designed tests among a group of more laboratories for a confirmation of the initial results from the first laboratory.

The variation in test results received from the fractional factorial tests should be compared with the repeatability and reproducibility results from the round robin. It is obvious that there should be a clear distinction between the results received in the fractional factorial tests and in the round robin.

6.2 Test parameters

A number of test parameters that can influence the test results are described in chapter 2. It is suggested that each of them are varied separately and one by one when the suitability of a reference material is evaluated. The result should ideally be different when each of them is varied compared to when the test is run correctly. Such an exercise will probably show that not all parameters are crucial for the final test result. Table 4 gives a suggestion on how each of them could be varied to show if the test is run incorrectly. The varied levels are given in two steps. The first step reflects a variation that is at the uncertainty limits or close to the nominal values for parameters where no such limits are given in the test standard. The second step could be used as an alternative if it is found that the first variation of parameters gives too small errors in the test results.
Table 4  Suggested variation of test parameters to show that the test is run incorrectly

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Nominal value</th>
<th>1st variation</th>
<th>2nd variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignition flame</td>
<td>20 mm</td>
<td>±1 mm</td>
<td>±5 mm</td>
</tr>
<tr>
<td>Distance to surface</td>
<td>5 mm</td>
<td>±1 mm</td>
<td>±2 mm</td>
</tr>
<tr>
<td>Distance to bottom edge</td>
<td>16 mm</td>
<td>±2 mm</td>
<td>±5 mm</td>
</tr>
<tr>
<td>Application time</td>
<td>15 s, 30 s</td>
<td>±1 s</td>
<td>±2 s</td>
</tr>
<tr>
<td>Draught</td>
<td>0.7, 0.2</td>
<td>±0.2</td>
<td>Shut off</td>
</tr>
<tr>
<td>Flame spread distance</td>
<td>150 mm</td>
<td>±1 mm</td>
<td>±5 mm</td>
</tr>
</tbody>
</table>
7 Conclusions

Finding a proper material to be used as a reference material for fire testing is a difficult task. Fire testing includes much more uncertainties compared to other testing fields and the way to proceed towards finding a reference material is more difficult in comparison to areas such as chemical analysis. Finding a reference material for EN ISO 11925-2 is even more difficult since it is evident from an inter-laboratory trial performed 1997 that the repeatability and the reproducibility values for certain products were quite high.

This project has focused on trying to find a reference material for EN ISO 11925-2 since there is a high need for such a material due to that it is very difficult, if not impossible, to determine the total uncertainty for the test result from this method. It would be very feasible if performing repeated tests on a reference material could control the quality of the method. The project has unfortunately shown that it could be a difficult task to find a suitable reference material for that test method. From this study it becomes clear even that the method maybe needs a lot more improvement in order to reduce a number of uncertainties in the method itself before one can proceed to the development of a reference material.

The project however gives guidance on how to develop a reference material for the method if resources are found for such an activity. A number of proposed testing ranges were given.

The project also showed that there may be a large need for reference materials for other fire test methods such as EN ISO 1182 (non combustibility test), ISO 13823 (SBI Test), EN ISO 9239 (Radiant Flooring panel). A project containing the development of reference materials for all these test methods would require intensive resources and should preferably be run at European level.
8 References


## Appendix A  The EUROCLASSes

The EUROCLASSes for reaction to fire performance for construction products as published officially by the Commission on February 8, 2000 are listed in Table A1 – A2.

### Table A1  Classes of reaction to fire performance for construction products excluding floorings

<table>
<thead>
<tr>
<th>Class</th>
<th>Test method(s)</th>
<th>Classification criteria</th>
<th>Additional classification</th>
</tr>
</thead>
</table>
| A1    | EN ISO 1182 (1);  
and                                      | $\Delta T \leq 30 ^\circ C$; and  
$\Delta m \leq 50 \%$; and  
$\tau_f = 0$ (i.e. no sustained flaming)                                           | -                          |
|       | EN ISO 1716                                        | PCS $\leq 2.0 \text{MJ.kg}^{-1}$ (1); and  
PCS $\leq 4.0 \text{MJ.m}^{-2}$ (1) (2); and  
PCS $\leq 2.0 \text{MJ.kg}^{-1}$ (1)                                                | -                          |
|       |                                                    | EN ISO 1716 PC$S \leq 2.0 \text{MJ.kg}^{-1}$ (2) (2a); and  
PCS $\leq 1.4 \text{MJ.m}^{-2}$ (2); and  
PCS $\leq 2.0 \text{MJ.kg}^{-1}$ (2)                                                | Smoke production(5); and    |
|       |                                                    |                                                          | Flaming droplets/ particles (6)                                                    |
| A2    | EN ISO 1182 (1);  
or                                   | $\Delta T \leq 50 ^\circ C$; and  
$\Delta m \leq 50 \%$; and  
$\tau_f \leq 20s$                                                            | -                          |
|       | EN ISO 1716;  
and                                      | PCS $\leq 3.0 \text{MJ.kg}^{-1}$ (1); and  
PCS $\leq 4.0 \text{MJ.m}^{-2}$ (1); and  
PCS $\leq 3.0 \text{MJ.kg}^{-1}$ (1)                                               | -                          |
|       | EN 13823 (SBI)                                     | FIGRA $\leq 120 \text{W.s}^{-1}$; and  
LFS < edge of specimen; and  
THR$_{600s}$ $\leq 7.5 \text{MJ}$                                              | Smoke production(5); and    |
|       |                                                    |                                                          | Flaming droplets/ particles (6)                                                    |
| B     | EN 13823 (SBI);  
and                                      | FIGRA $\leq 120 \text{W.s}^{-1}$; and  
LFS < edge of specimen; and  
THR$_{600s}$ $\leq 7.5 \text{MJ}$                                              | Smoke production(5); and    |
|       |                                                    |                                                          | Flaming droplets/ particles (6)                                                    |
|       | EN ISO 11925-2(2a):  
Exposure = 30s                                      | Fs $\leq 150\text{mm}$ within 60s                                                   | -                          |
| C     | EN 13823 (SBI);  
and                                      | FIGRA $\leq 250 \text{W.s}^{-1}$; and  
LFS < edge of specimen; and  
THR$_{600s}$ $\leq 15 \text{MJ}$                                              | Smoke production(5); and    |
|       |                                                    |                                                          | Flaming droplets/ particles (6)                                                    |
|       | EN ISO 11925-2(2a):  
Exposure = 30s                                      | Fs $\leq 150\text{mm}$ within 60s                                                   | -                          |
| D     | EN 13823 (SBI);  
and                                      | FIGRA $\leq 750 \text{W.s}^{-1}$                                                  | Smoke production(5); and    |
|       |                                                    |                                                          | Flaming droplets/ particles (6)                                                    |
|       | EN ISO 11925-2(2a):  
Exposure = 30s                                      | Fs $\leq 150\text{mm}$ within 60s                                                   | -                          |
| E     | EN ISO 11925-2(2a):  
Exposure = 15s                                      | Fs $\leq 150\text{mm}$ within 20s                                                   | Flaming droplets/ particles (6)                                                    |
| F     | No performance determined                        |                                                                                     | -                          |

(*) The treatment of some families of products, e.g. linear products (pipes, ducts, cables etc.), is still under review and may necessitate an amendment to this decision.

(1) For homogeneous products and substantial components of non-homogeneous products.

(2) For any external non-substantial component of non-homogeneous products.

(2a) Alternatively, any external non-substantial component having a PCS $\leq 2.0 \text{MJ.m}^{-2}$, provided that the product satisfies  
the following criteria of EN 13823(SBI) : FIGRA $\leq 20 \text{W.s}^{-1}$; and  
LFS < edge of specimen; and  
THR$_{600s}$ $\leq 4.0 \text{MJ}$; and s1; and d0.

(3) For any internal non-substantial component of non-homogeneous products.

(4) For the product as a whole.

(5) $s_1 = \text{SMOGRA} \leq 30 \text{m}^2.\text{s}^{-2}$ and TSP$_{600s}$ $\leq 50 \text{m}^2$;  
s2 = SMOGRA $\leq 180 \text{m}^2.\text{s}^{-2}$ and TSP$_{600s}$ $\leq 200 \text{m}^2$;  
s3 = not s1 or s2.

(6) d0 = No flaming droplets/ particles in EN13823 (SBI) within 600s;  
d1 = No flaming droplets/ particles persisting longer than 10s in EN13823 (SBI) within 600s;  
d2 = not d0 or d1; Ignition of the paper in EN ISO 11925-2 results in a d2 classification.

(7) Pass = no ignition of the paper (no classification); Fail = ignition of the paper (d2 classification).

(8) Under conditions of surface flame attack and, if appropriate to end–use application of product, edge flame attack.
### Table A2 Classes of reaction to fire performance for floorings

<table>
<thead>
<tr>
<th>Class</th>
<th>Test method(s)</th>
<th>Classification criteria</th>
<th>Additional classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1FL</strong></td>
<td>EN ISO 1182 (1); and</td>
<td>$\Delta T \leq 30^\circ C$; and $\Delta m \leq 50%$; and $t_f = 0$ (i.e. no sustained flaming)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>EN ISO 1716</td>
<td>$PCS \leq 2.0 \text{ MJ.kg}^{-1}$ (1); and $PCS \leq 2.0 \text{ MJ.kg}^{-1}$ (2); and $PCS \leq 1.4 \text{ MJ.m}^{-2}$ (3); and $PCS \leq 2.0 \text{ MJ.kg}^{-1}$ (4)</td>
<td>-</td>
</tr>
<tr>
<td><strong>A2FL</strong></td>
<td>EN ISO 1182 (1); or EN ISO 1716; and</td>
<td>$\Delta T \leq 50^\circ C$; and $\Delta m \leq 50%$; and $t_f \leq 20s$</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>EN ISO 9239-1 (1)</td>
<td>Critical flux ($q_f$) $\geq 8.0 \text{ kW.m}^{-2}$</td>
<td>Smoke production ($s_1$)</td>
</tr>
<tr>
<td><strong>BFL</strong></td>
<td>EN ISO 9239-1 (1); and EN ISO 11925-2(8): Exposure $= 15s$</td>
<td>Critical flux ($q_f$) $\geq 8.0 \text{ kW.m}^{-2}$</td>
<td>Smoke production ($s_1$); $Fs \leq 150\text{mm}$ within 20s</td>
</tr>
<tr>
<td><strong>CFL</strong></td>
<td>EN ISO 9239-1 (1); and EN ISO 11925-2(8): Exposure $= 15s$</td>
<td>Critical flux ($q_f$) $\geq 4.5 \text{ kW.m}^{-2}$</td>
<td>Smoke production ($s_1$); $Fs \leq 150\text{mm}$ within 20s</td>
</tr>
<tr>
<td><strong>DFL</strong></td>
<td>EN ISO 9239-1 (1); and EN ISO 11925-2(8): Exposure $= 15s$</td>
<td>Critical flux ($q_f$) $\geq 3.0 \text{ kW.m}^{-2}$</td>
<td>Smoke production ($s_1$); $Fs \leq 150\text{mm}$ within 20s</td>
</tr>
<tr>
<td><strong>EFL</strong></td>
<td>EN ISO 11925-2(8): Exposure $= 15s$</td>
<td>$Fs \leq 150\text{mm}$ within 20s</td>
<td>-</td>
</tr>
<tr>
<td><strong>FFL</strong></td>
<td>No performance determined</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) For homogeneous products and substantial components of non-homogeneous products.
(1') For any external non-substantial component of non-homogeneous products.
(1") For any internal non-substantial component of non-homogeneous products.
(1")' For the product as a whole.
(1") Test duration = 30 minutes.
(1")' Critical flux is defined as the radiant flux at which the flame extinguishes or the radiant flux after a test period of 30 minutes, whichever is the lower (i.e. the flux corresponding with the furthest extent of spread of flame).
(1") s1 = Smoke $\leq 750\%$.min; s2 = not s1.
(1")' Under conditions of surface flame attack and, if appropriate to the end-use application of the product, edge flame attack.

**Symbols. The characteristics are defined with respect to the appropriate test method.**

- $\Delta T$: temperature rise
- $\Delta m$: mass loss
- $t_f$: duration of flaming
- PCS: gross calorific potential
- FIGRA: fire growth rate
- THR$_{60s}$: total heat release
- LFS: lateral flame spread
- SMOGRA: smoke growth rate
- TSP$_{60s}$: total smoke production
- Fs: flame spread
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SP is a EU-notified body and accredited test laboratory. Our headquarters are in Borås, in the west part of Sweden.