Ulf Wickström

THE FUTURE OF EUROPEAN TESTING

Ulf Göransson

NORDTEST FULL-SCALE FIRE TESTS

Contributions to the FLAME RETARDENTS 90'
Conference in London, January 17-18, 1990

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ULF WICKSTRÖM: THE FUTURE OF EUROPEAN TESTING

It is time to introduce modern technology in fire testing for classification. Europe shall harmonize testing and classification before the end of 1992. Modern test methods are available based on new technology; a better understanding of the physics has allowed development of an entirely new generation of tests.

The Internal Market in Europe shall be completed before the end of 1992. Before then testing and classification must be harmonized. According to the new approach formulated by the European Commission (CEC), a common European classification shall be available for various essential safety aspects. Local authorities may then require various classes or levels of safety depending on their needs and preferences.

The European Council of Ministers accepted the Construction Products Directive in December 1988. Common classification rules shall thereafter be agreed within 30 months, that is already June 1991. The essential requirements in the Directive require to be translated into terms of performance specifications consisting of test procedures together with European classification system. Translation documents shall give for each test procedure performance levels corresponding to the current requirements in the national codes. The national authorities may then operate their current systems and at the same time specify levels for products coming from other countries.

For testing of wall and ceiling linings three test methods (the 'three sisters') are proposed in a draft mandate to CEN (CEN/TC127 N79), i.e. the French 'Epiradiateur', the German 'Brandschacht', and the British 'Surface Spread of Flame'. To get a certificate, which allows a products to be marketed in every EC countries, it will be neccessary to test according to all these three methods. It will, however, be difficult to establish a common integrated European classification system based on all the three methods. They often rank products in different orders. That is one of several reasons why another solution is needed, at least for the long term.

The problem of fire testing of wall and ceiling linings was intensively discussed at the first meeting of CEN/TC 127 'Fire Safety in Buildings'. The proposal of the 'three sisters' was accepted although several countries voted against it. It was, however, also unanimously agreed to form a Working Group (WG2 'European reaction-to-fire classification') to make a proposal using new methods proposed by ISO. This group has started and has agreed to focus its work on investigating the Swedish proposal of using just the Cone Calorimeter (Figure 1) and the Room/Corner Test (Figure 2) for evaluation of wall and ceiling linings, see below or for further information e.g. [1].

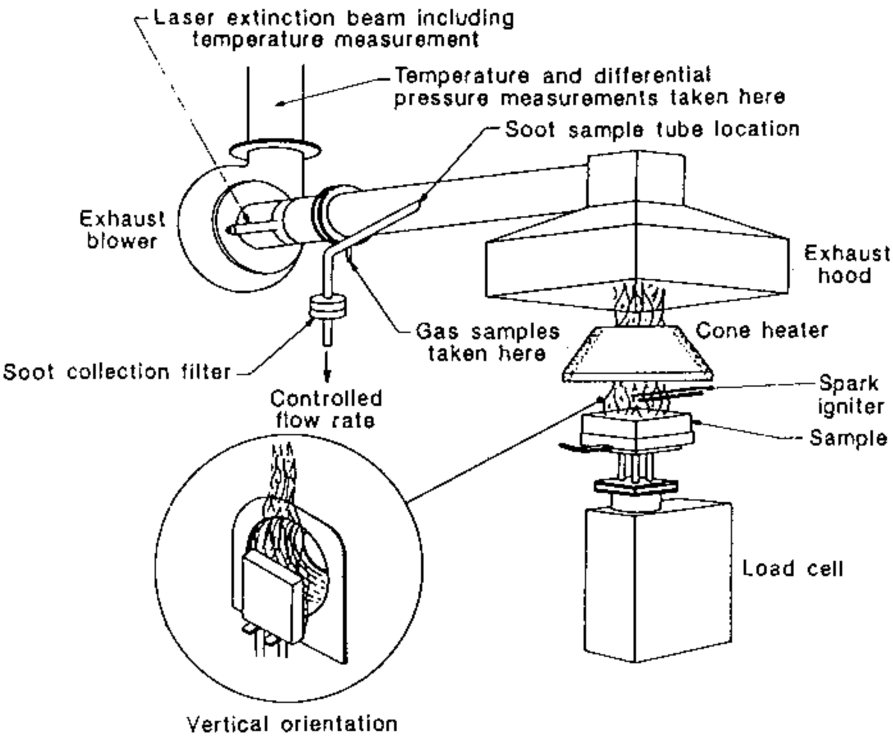

Figure 1 The Cone Calorimeter can be used for classification of building products.

Before a new system can finally be accepted experience of testing of various products are needed. The Nordic countries are coordinating their efforts in a comprehensive R & D programme called EUREFIC. Important work are at the same time being carried out in several other countries. Fire Research Station in the UK studies the Room/Corridor scenario and an Italian laboratory investigates measurements of smoke. The fire laboratory in Dortmund (FMPA) exchange test results and coordinate choices of products to be tested with the EUREFIC programme.

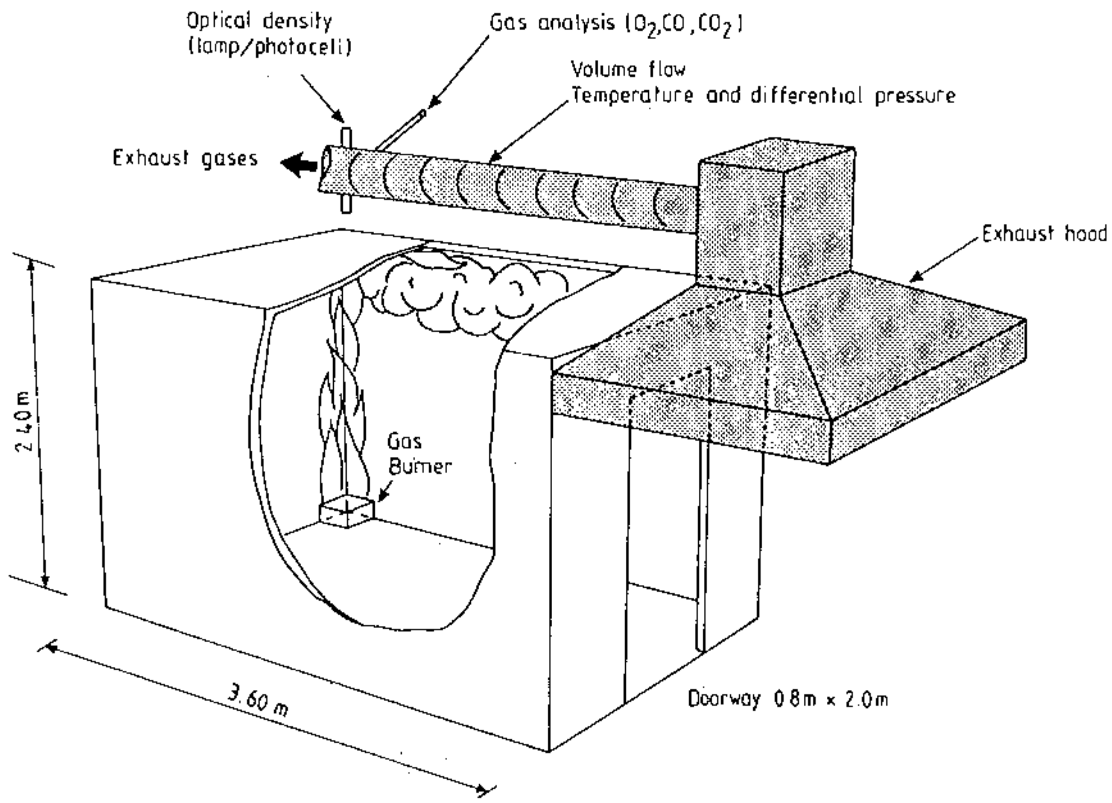

Figure 2 The Room/Corner Test is a reference for classification of surface linings.

1 WHY NOT USE THE BEST TEST METHODS?

There seems to be no objection among fire experts that the Cone Calorimeter is generally the best method available for evaluating reaction-to-fire properties of materials and products. Ignition and burning properties as well as the propensities to produce smoke and toxic gases can be evaluated at the same time. So, why not use the best method when it is available? Approximately 20 Cone Calorimeters are already installed or ordered by fire laboratories in seven or eight European countries. The world population now exceeds 40 and is growing at a rate of about 20 per year with the most significant growth being in Western Europe. ISO has worked with the method and it will soon be put on ballot as a draft international standard.

By definition, however, the best possible estimate of the flammability of products is a full scale experiment. A standardized full scale test is therefore desirable. Thus the Room/Corner Test is about to be completed within ISO. The test simulates an important scernario, a waste paper basket or a piece of furniture burning in a corner of a room. The Room/Corner Test can therefore represent a real fire and can be a reference for small scale test methods. The validity of small scale methods could be proven by using them for predicting the fire behaviour of products in the Room/Corner Test. Methods that cannot be proven to predict the well defined Room/Corner Test can probably not be proven to predict any other relevant scenario either, or can they?

The Room/Corner Test is also needed for products that cannot be tested in small scale for various reasons, e.g. melting materials, composite products or products with joints, which are decisive for their fire behaviour.

Thus both small and large scale methods are needed to allow for consistent and just classification of various types of products. As indicated in the flow chart of Figure 3 small scale testing shall be used when ever possible. The result shall then be translated into expected full scale behaviour according to the Room/Corner Test in which the classification rules are expressed.

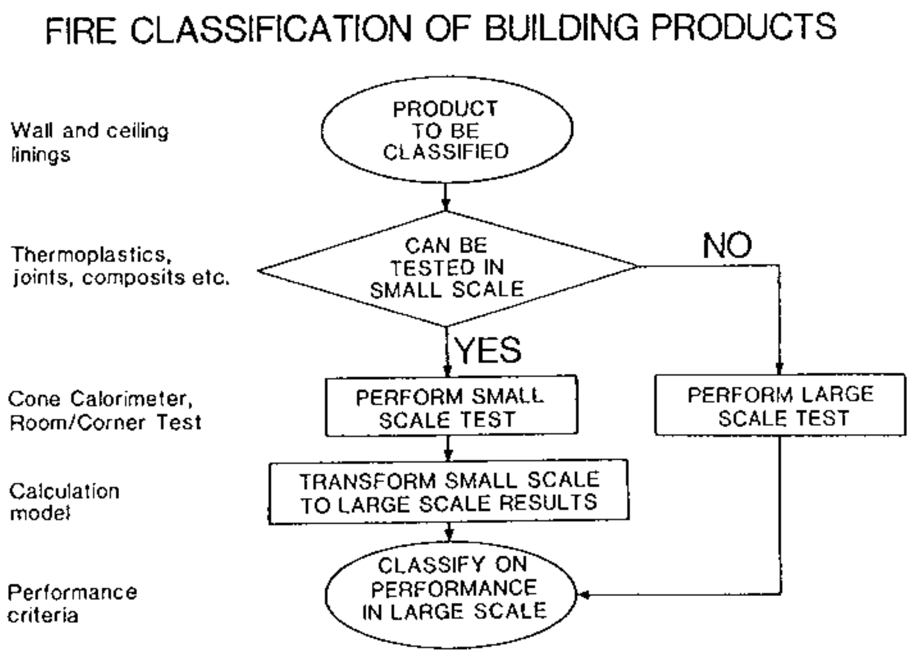

Figure 3 Principles of a testing and classification scheme emplying the Cone Calorimeter and the Room/Corner Test. Large scale testing is only performed when small scale testing is not possible.

A first proposal of such classification rules have been proposed by SP [2]. A translation model of results from the Cone Calorimeter to the Room/Corner Test is worked on. For products yielding flash-over before 10 minutes a numerical model has already been suggested [3]. As an example it is shown in Figure 4 how the heat release rate, when tested in the Room/Corner, can be predicted. Figure 5 shows how the flash-over time of all the nine products of the first test series could be predicted.

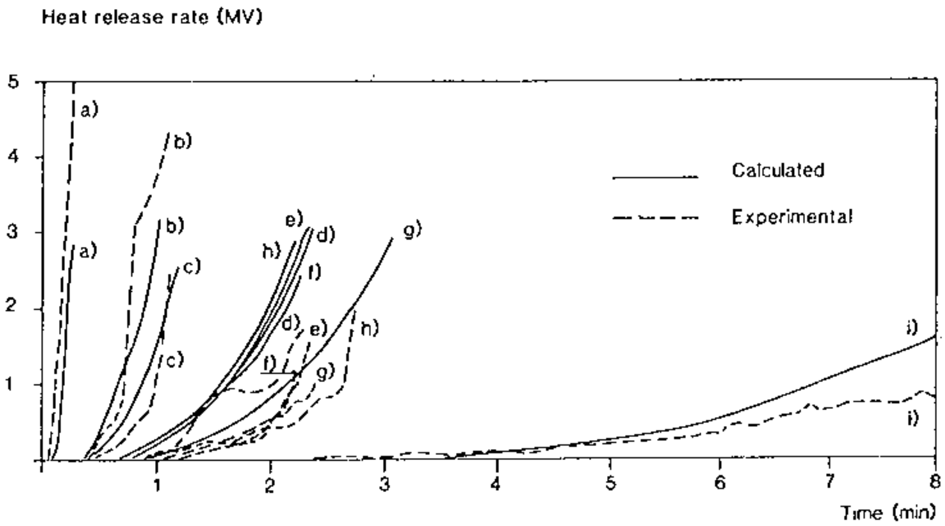

Figure 4 A comparison between predicted heat release rate histories for surface lining materials in Room/Corner Test (based on bench-scale Cone Calorimeter measurements) and actual measured heat release rate histories. The products are a) rigid polyurethane foam, b) textile wallcovering on mineral wool, c) insulating fibre board, f) wood panel, spruce, g) paper wallcovering on particle board, h) particle board, i) melamine-faced particle board.

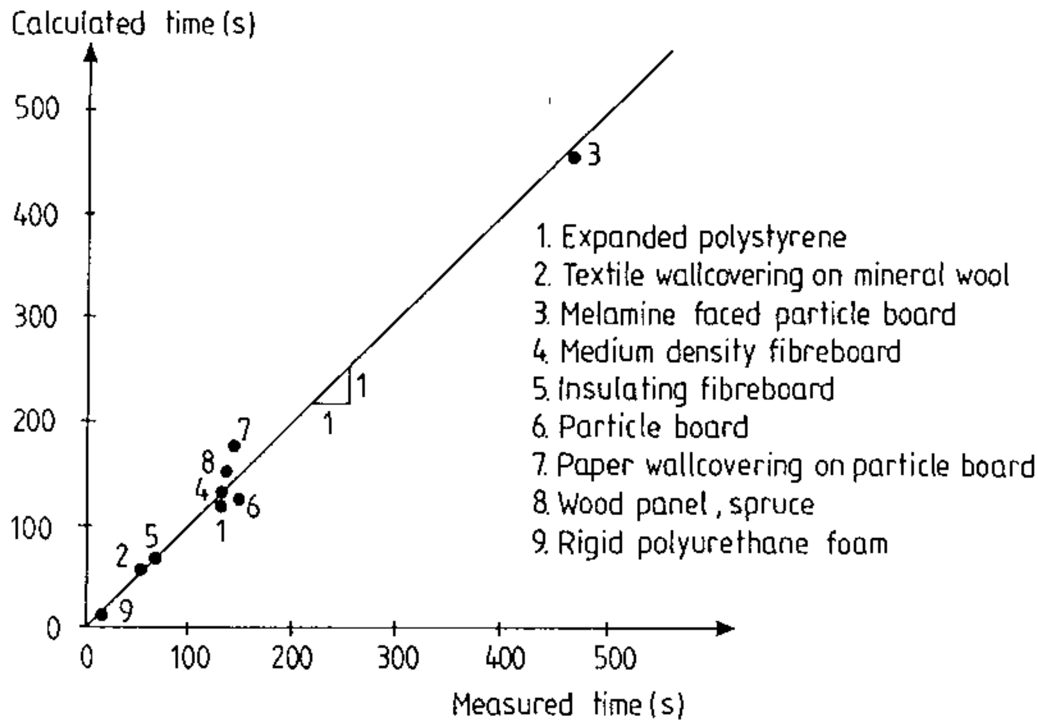

Figure 5 Cone calorimeter results are used to predict times to reach flash-over (1 000 kW) in Room/Corner Tests, a comparison. As can be seen the predictions are very good for all the nine products.

2 THE PROPOSED CLASSIFICATION SYSTEM IS BASED ON THE ROOM/ CORNER TEST

The classification system mentioned above is based on the large scale Room/Corner Test according to ISO DP 9705 with the ignition source as described in the NORDTEST-method NT FIRE 025, that means the ignition source is operated at a constant power rate of 100 kW during the first 10 minutes and thereafter at 300 kW. Some 20 products have now been tested in large scale and grouped into fire classes.

Time to reach flash-over is the main consideration, but also smoke production and average production rates are considered. In Table 1 five classes are defined. Except for Class A the peak rate of heat release (RHR) including the ignition source (the gas burner) is limited to 1 000 kW within given time limits. The same principle is used for smoke.

The RHR of 1 000 kW will just about cause flash-over, i.e. flames emerging out the doorway of the room. Preliminary tests can therefore be carried out by only observing when flames emerge out the doorway without measuring the RHR.

The test results are in general very easy to understand and evaluate also for people who are not fire experts. Time to flash-over is a simple and straight-forward measure. It is also a very relevant entity parameter for determining the potential fire hazard of a product.

In Table 1 the fire proposed classes are defined. Typical products for each class are given below.

Table 1 Proposed classification criteria of lining materials tested in the Room/Corner Test (ISO/DP 9705) [2].

Class	Minimum time (min)	Maximum heat release rate peak (kW)	Maximum heat release rate average (kW)	Maximum smoke production rate peak (ob m^3/s)*	Maximum smoke production rate average (ob m^3/s)*
A	20	600	250	10	3
B	20	1 000	300	70	5
C	12	1 000	230	70	5
D	10	1 000	200	70	5
E	2	1 000	-	70	-

* ob is measure of optical density per metre. One ob corresponds approximately to a visability of 10 m (9).

<u>Class A</u> corresponds to products showing very limited burning; typically mineral wools and gypsum plaster board.

<u>Class B</u> corresponds to products approaching but not yielding flash-over during the entire 20 mintues test period; typically light wall-papers on gypsum plaster board.

<u>Class C</u> corresponds to products not flashing over until more than 2 minutes of exposure to the increased burner output of 300 kW; typically fire resistant coatings on wood and 9 mm gypsum plaster boards on polystyrene foams have shown this behaviour.

<u>Class D</u> corresponds to products flashing over shortly after increasing the burner output to 300 kW; typically heavy wall-papers.

<u>Class E</u> corresponds to products flashing over after more than 2 minutes at a burner output of 100 kW; typically solid wood products.

3 PROTECTED PLASTIC FOAM GETS A REASONABLE CLASSIFICATION

Generally the limit on time averages gives credit to products that contain very little energy and burns only for a short period of time, e.g. thin wall paper or non-combustible substances. Polystyrene foam protected by gypsum plaster board received a Class C classification; it did not flash-over until the plaster board broke up after about 18 minutes into the test. For certain applications this may provide enough safety; there is some time to start fighting the fire and/or escape. When the protection is broken it must, however, be noticed that some products may burn very rigorously. Additional requirements may therefore be needed on the materials involved. Such requirements may be obtained by testing according to the Simple Ignition Test, which is underway in CEN/TC 127.

Production rates of smoke are by and large proportional to the corresponding heat release rates. The criteria limits proposed are not as strict as for the corresponding rate of heat release valued obtained from most products. The restrictions are intended only for products that produce extremely large amounts of smoke without going to flash-over in the Room/Corner Test.

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ULF GÖRANSSON: NORDTEST FULL-SCALE FIRE TESTS

ABSTRACT

All fire test results are a combination of material parameters of the product that is tested. Most test methods also give results that can give a basis for ranking materials or for classification.

Problems occur, however, if you want to make a better, a more adequate evaluation. Then there are two ways to choose between. Either you can put in a big effort in analysing small scale test methods so that you find the parameters that are important in your specific scenario. Or you can test the product in a test method that gives more adequate results. This is where a full-scale test can be valuable.

The fire hazards that we try to protect us from are full-scale fires. Full-scale tests therefore give results that are easy to interpret, even for a non-expert. If the test is well designed, it will also give more adequate information than a small-scale test can give.

Nordtest, which is a joint Nordic organisation, has financially supported the development of a series of full-scale tests. These tests are intended as reference tests or tests for special products.

In the Nordic countries there are Nordtest full-scale test methods for:

a) Surface materials in the room/corner test, NT FIRE 025/ ISO DP 9705.

b) Pipe insulation in the room test. A test method used in Sweden and Norway for classification of pipe insulation, NT FIRE 036.

c) Upholstered furniture, a chair or a sofa is completely burnt in free excess to air, NT FIRE 032.

d) Free-hanging curtains and draperies. A test that is just developed and has not yet been numbered.

These four test methods all use the same hood that collects all fire gases which means that the rate of heat release can be measured with the oxygen depletion technique. Other parameters are measured and observed during the tests as well.

In this paper the four full-scale test methods will be described. The test scenarios are motivated and there is a discussion of what products that can be tested in the different methods.

INTRODUCTION

Several full-scale tests have lately been developed on behalf of NORDTEST, a joint Nordic organisation for testing. The tests all use the oxygen consumption method to calculate the heat release rate as the main indication of the fire hazard.

The tests are developed with the two aims to provide a test method used in a classification system and to help fire modellers and researchers to evaluate the fire risk of a product.

To introduce full-scale tests in regulations does not necessarily have to create problems. It is more a question of being used to the idea that large-scale tests generally give more adequate results than small-scale tests. For most scenarios this is probably true and therefore it is preferable to classify after a large-scale test performance.

Full-scale tests are today used in the Nordic countries. Surface linings have been tested in an older version of a full-scale test for many years that have worked as reference test to the Nordic classification test (NT FIRE 004) for products that are hard to test in small scale. All pipe insulations are tested according to NT FIRE 036 for classification in Sweden and Norway since 1987.

1 WHERE FULL-SCALE TESTS SHOULD BE USED

When interpreting results from fire tests it is very important that there is a connection between the fire test and the fire scenario or threat that you want to be protected from. Often there are more than one fire threat and then it must be investigated if the fire test is good enough to protect you from all threats.

A full-scale test is designed to be a good picture of one scenario and can hopefully also evaluate other large fires well.

Another advantage with a full-scale test is that it yields a lot of information. It can give you information of all parts of fire safety - ignitability, flame spread, smoke production and even products extinguishing properties.

Full-scale tests are especially interesting for people not normally involved in fire testing. As the test is more looking like a real fire, authorities and users can by themselves see what the consequencies are if you choose between products of different fire performance levels or when you decide what performance level that is required.

If the main fire threat is large fires that can kill many people and cost lots of money it is obvious that a large-scale test can describe this scenario better than a small-scale.

As the full-scale test normally is much easier to interpret than a small-scale test, one obvious field of application for a full-scale test is as basis for classification. Tests can still be carried out in small scale as long the results are possible to interpret to a large-scale test performance [1].

The biggest disadvantage of full-scale tests is that they are expensive. The need of material, testing staff and equipment are higher than for most small-scale test. Therefore a full-scale test shall only be a regular classification test for very special purposes. As reference test, a full-scale test is not too expensive, considering that the test costs are only one part of the costs for classification. Compared to the information that is gained a full-scale test is probably quite cheap.

One area where full-scale tests often are used are as ad hoc tests. Here they can show how a fire can develop in a specified scenario. Ad hoc tests can be used to asses the fire risk of one special application but the information is harder to interpret than from a standardized full-scale test as the result analysis cannot be based on experience. Heat release measurement equipment as in the Nordtest methods can, however, be used to make results more valuable.

2 FIRE TEST RESULTS

In almost all testing of materials reaction-to-fire you look to evaluate the burning behaviour and the smoke production from the material tested.

The burning behaviour of a product can be expressed in terms of ignitability and heat release rate. The flame spread properties can probably be considered as a function of the other two.

The properties of the smoke production are accordingly light obscuration, toxicity and volume of produced smoke. Obscuration and production of toxic gases are rather easy to determine in a specified scenario. Two scenarios can, however give very different results. The amount of produced smoke is more a function of burning behaviour than of smoke production properties.

When designing, or choosing, a test method you usually want to get as adequate information as possible of these four properties.

3 CHOOSING TEST PRINCIPLE

To be able to evaluate what information that is adequate you need to choose a test principle. A test can describe one scenario that is important, or one or many tests can give information that can be used to evaluate different fire scenarios. Either of these two alternatives can be used for classification purposes or when evaluating a product for a specified application.

A full-scale fire test is designed to be a good representation of one scenario, a specified ignition source and configuration. For this particular scenario, and for similar scenarios, the full-scale test gives much more adequate results than any other test method.

For a scenario that is very unlike the full-scale test, small-scale test methods can give results that give as much information as the full-scale test. The hardest thing to generalise, both in small and large scale, is the ignition source. Products are sensitive to different ignition sources and how is very hard to anticipate without having performed tests with different ignition sources.

4 NT FIRE 025 - FOR SURFACE LININGS

The full-scale test method that now is most discussed in the Nordic countries is NT FIRE 025, a test method for surface linings, walls and ceiling [2]. It is a room test with a gas burner placed in one corner. Three walls and the ceiling are covered by the tested material. The propane gas burner is a rather big ignition source (100 kW) simulating the fire of a filled waste paper basket.

The main principle of the method is to collect all combustion products that leave the room by a large hood so that gas samples can be taken to analyse contents of O_2, CO etc. The smoke production is measured by a lamp/photocell system. The rate of heat release, calculated from oxygen consumption, production rate of CO and other toxic gases and production rate of smoke can then be given as functions of time.

In the test you can make also many other types of measurements and observations. Radiant heat, gas temperature, flame spread rate etc. It is also possible to calculate an energy balance of the room.

The test method can be used as reference test and thus be used for classification of products not easily tested in small scale [3]. The test method is good as classification basis since the range of materials with different fire properties that can be tested is very wide.

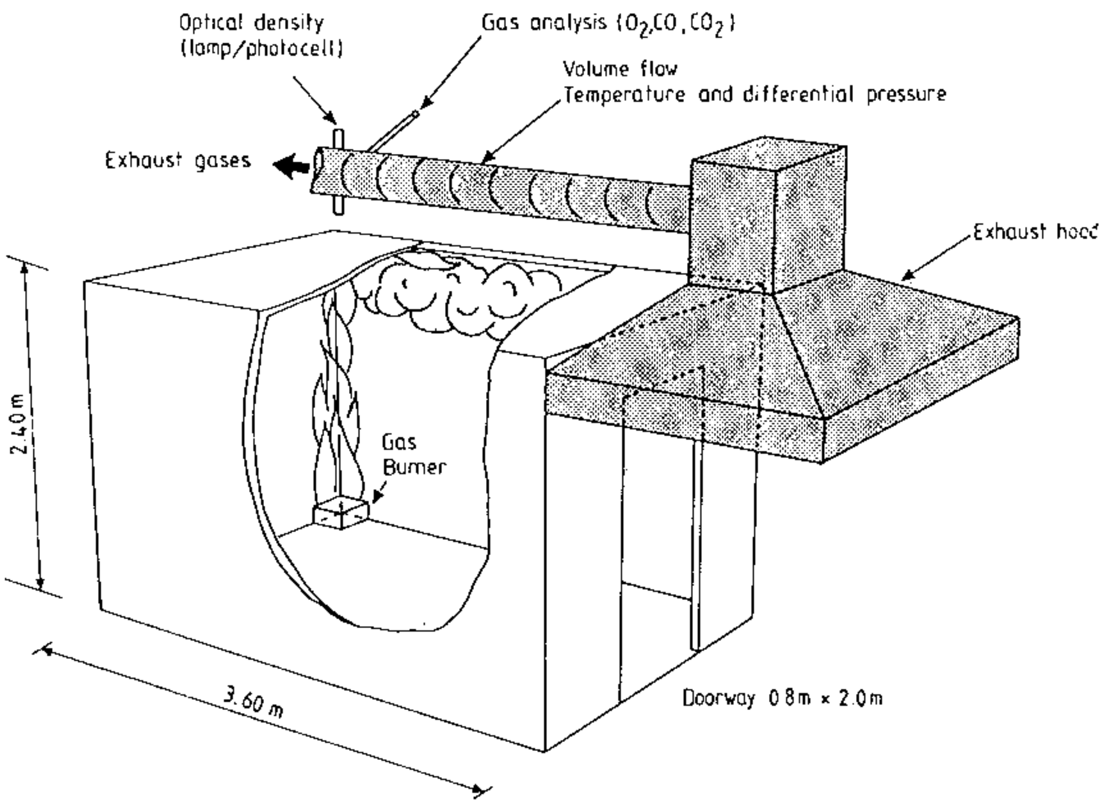

Figure 1 NT FIRE 025 - A full-scale test method for surface linings. The test material is mounted on the walls and ceiling.

The test method can also be used to obtain better information about properties not easily gained in small scale such as smoke and toxic gas production. A third application is when a fire modeller needs input to advanced fire designing and a fourth is for showing people how different materials react in a fire.

5 NT FIRE 036 - FOR PIPE INSULATION

For pipe insulation, a variaty of the NT FIRE 025 has been developed [4]. The method is similar to the surface products test except for the ignition source and the amount of tested material. When testing pipe insulation only the ceiling is covered by test material. The gas burner is placed 1 m above the floor level and has a heat output of 150 kW. The flames impinge on about 1 m² of the ceiling. The burner is moved from the corner to avoid edge effects of the pipe insulation so the heat output have to be raised to get flames large enough to break through a thin protective surface. For this position of the burner no material is needed on the walls to obtain adequate results. This method is since 1987 used in Sweden and Norway as classification test method for all pipe insulations.

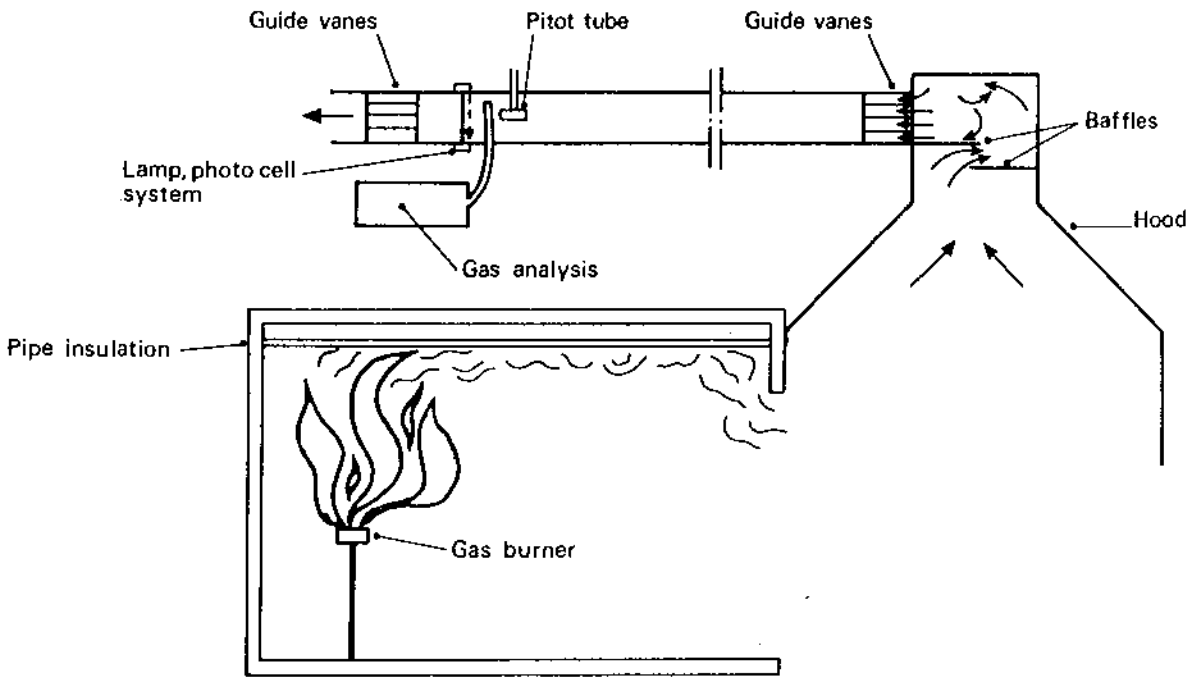

Figure 2 Pipe insulation tested in full scale according to NT FIRE 036. The insulation is mounted on bars 20 cm from the ceiling

6 NT FIRE 032 - FOR UPHOLSTERED FURNITURE

Furnishings represent one of the bigger fire threats in homes and public buildings. If the fire properties are not considered a chair or a sofa can develop a large fire in only a few minutes. Upholstered furniture is as important as surface linings for the fire hazard of a building but the fire safety requirements are usually much lower for furniture.

This full-scale test - NT FIRE 032 - is a test for assessing the fire properties of a piece of furniture in case of a fire [5]. It describes how the burning rate develops and thus how big fire risk the furniture represents. It is not an ignitability test and it could very well be complemented with ignitability test for small ignition sources such as BS 5852.

All types of upholstered furniture can be tested, chairs, sofas and also beds. The only restriction is that you test one item at the time so that you can compare your results.

The basic test principle is the same as in the surface linings test. A rather big ignition source, e.g. BS 5852 crib 7, ignites the product and it is from measurements in the exhaust duct possible to determine burning rate, smoke production rate etc. In this test method the specimen is also placed on a weighing platform which gives information of mass loss rate and net heat of combustion when compared to the rate of heat release measurements.

The test method for upholstered furniture is more general than the surface linings test. The burning rate that is obtained in the test is exactly the same that will occur if the sofa burns in a fairly big room. The results can therefore very well be used in smoke control computer programmes (e.g. HAZARD1, HARVARD) to give an even better analysis of the fire risk of a certain building. Of course the test results are only accurate until the burning item would have interacted with a hot ceiling layer or another burning object.

The full-scale test of furniture is a very good product test that give information of the combination of frame, padding and textile covering.

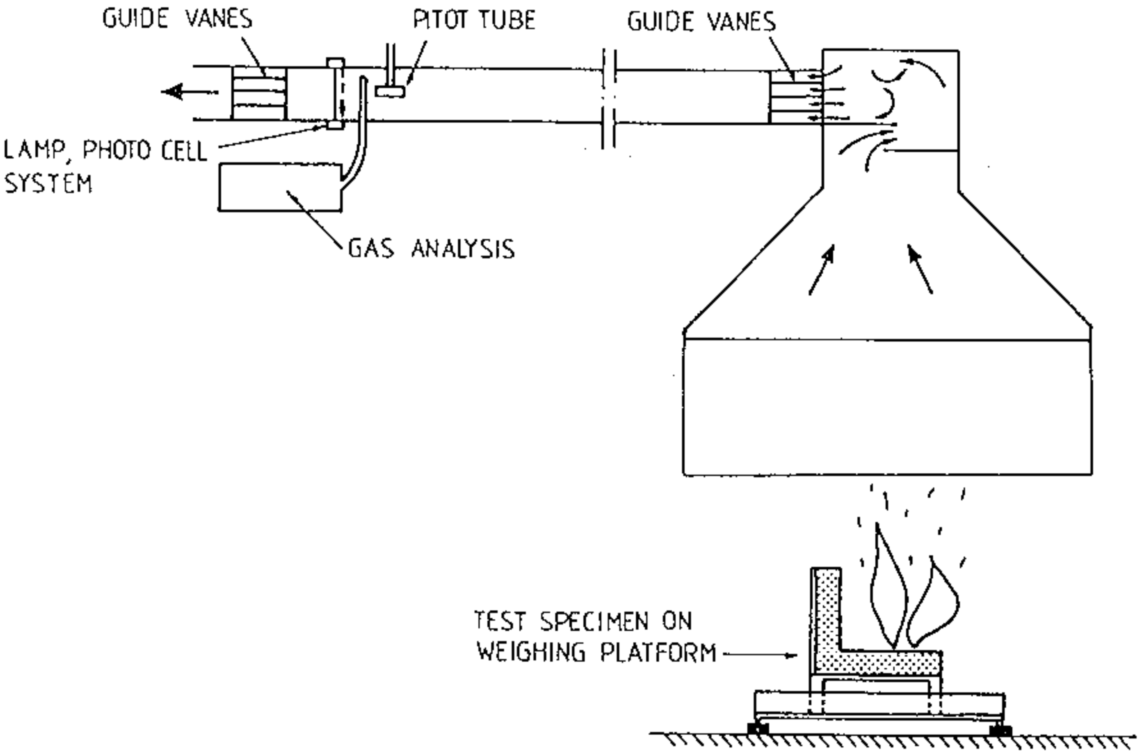

Figure 3 NT FIRE 032 – Full scale fire testing of furniture. The test specimen is placed on a weighing platform so that the mass loss rate can be recorded.

7 A NEW FULL-SCALE TEST METHOD FOR CURTAINS AND DRAPERIES

The test method for curtains and draperies, developed in 1988 [6], is intended for public buildings such as hotels, restaurants and theatres and not primarily for dwellings. The reason for a large-scale test method for textiles is that the present small-scale test methods mostly are ignitability tests for textiles exposed to small flames only. Textiles can, however, have a different behaviour when exposed to larger flames. It is also hard to distinguish between the better products when using a small flame only.

The test method is designed to test a material, not a ready-made product. The test specimen shall be without hems but sewn together to achieve the 3 m by 3 m specimen size.

A reason for a textile test method with a powerful ignition source is also that free-hanging textiles should be able to be compared with surface linings usually tested in tougher test methods given in the building regulations. Especially for textiles used as decorations to cover a whole wall or for theatre and cinema curtains there is need for a large-scale test.

There are two main risks with a burning textile. The flame spread can be very rapid which will involve a large burning area and quite a big heat release rate. The other main risk is that burning drops or parts of the curtain may fall down and ignite other items such as upholstered chairs etc. This could lead to a very serious fire in a very short period of time.

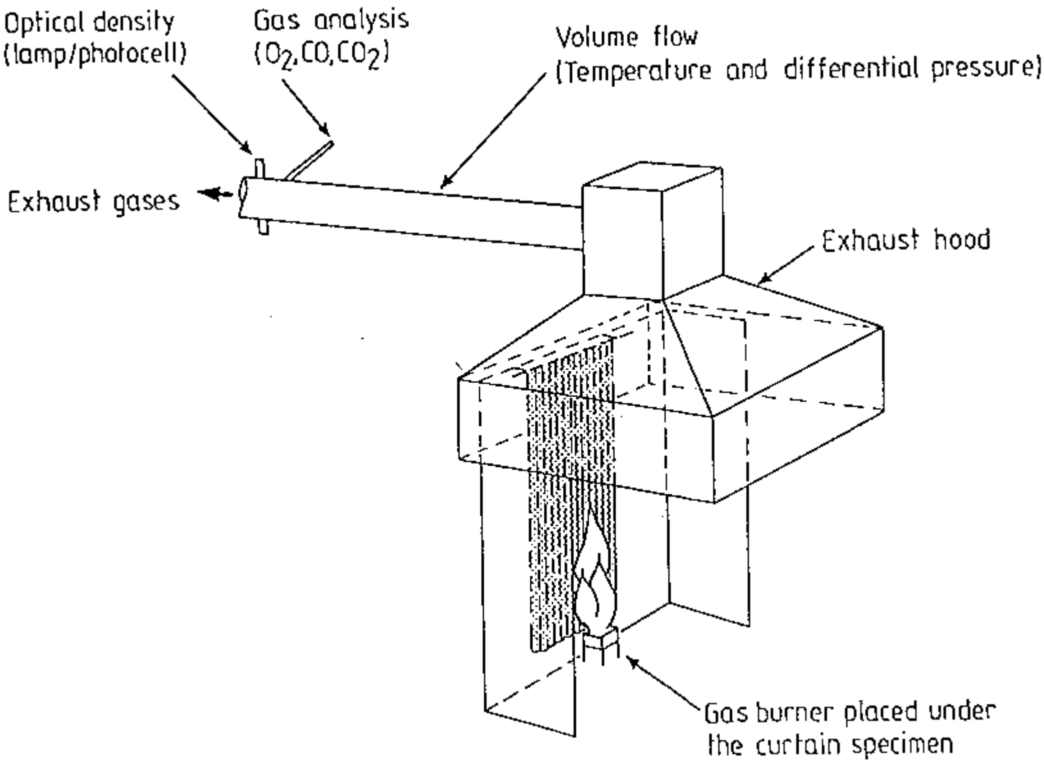

Figure 4 Full-scale fire test method for curtains. The flames reach about half the height of the curtain.

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