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Stefan Särndqvist

 **INITIAL FIRES**

**RHR, Smoke Production and CO Generation
from Single Items and Room Fire Tests**

Research financed by the Swedish Fire Research Board (BRANDFORSK)

Lund, April 1993

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The report was edited in 1998-07-23 and published on Internet by Marcus Larsson

Lund, April 1993

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SUMMARY

This report is to be used as a guide in determining what an initial fire will look like. It is a summary of a large number of full scale tests on different items and under various conditions performed at different laboratories. The results shown are primarily the rate of heat release (RHR), as well as the production of smoke and generation of carbon monoxide. The results are shown as curves in this report, but are also digitally available in a database.

NOMENCLATURE

| | | |
|------------------------------------|------------------------|--|
| CO | [l/s] | Carbon monoxide generation at NTP |
| D | [m ² /g] | Smoke potential (logarithm to base 10) [alt. unit: Bel m ² /g] |
| D ₀ | [obm ³ /g] | Smoke potential (logarithm to base 10) [alt. unit: dB m ² /g] |
| ec | [m ² /g] | Specific extinction coefficient (natural logarithm base) |
| H _C | [MJ/kg] | Heat of combustion |
| H _{eff} | [MJ/kg] | Effective heat of combustion |
| I ₀ /I | [-] | Intensity of a light ray / Intensity of the light ray after passing the distance L through the smoke |
| L | [m] | Distance the light passes through the smoke |
| m | [kg/s] | Mass loss rate |
| m _{CO} / m _{CO2} | [-] | CO/CO ₂ fraction |
| m _{O2} | [g] | Consumed oxygen mass |
| M(x) | [g/mole] | Molecular weight for the substance x |
| n _{CO} / n _{CO2} | [-] | CO/CO ₂ ratio |
| n _x | [mole/s] | Production/consumption of the substance x |
| POD | [obm ³ /kg] | Particulate optical density. 33 000 in flaming mode and 19 000 in non-flaming mode |
| RHR | [kW] | Rate of heat release, including the ignition source |
| S | [obm ³ /s] | Smoke production |
| V | [m ³ /s] | Flow in the exhaust tube at exhaust gas temperature |
| X | [-] | Fraction of m that is converted into obscuring particles |
| | [-] | Combustion efficiency factor |
| \bar{z} | [-] | Carbon/Hydrogen ratio of the fuel |

INTRODUCTION

There are always difficulties in choosing the right data to put into a smoke filling or fire spread model. This report is to be used as a guide in estimating what an initial fire will look like and how fast it will grow. It may also be of some help in determining the rate of production of smoke and toxic gases, such as carbon monoxide. The report is based on results from burning tests at several laboratories, with a large number of different items and under various conditions. The samples cover a wide range of items, from lining materials and pallet systems to chairs, curtains and coffee makers. Most of the results have been published earlier, but quite a few have, until now, been unpublished.

The criterion for the selection of test results in this report is primarily that the rate of heat release is given, as measured by oxygen consumption. This is believed to be the single most important parameter in describing a fire. Furthermore it is necessary to know the burning conditions, for example if the tested item is burning freely or in a room. Other aspects that might be of interest are naturally given when available, such as the smoke production, the generation of carbon monoxide or the effective heat of combustion.

Each test is reprinted with a description of the item or sample, with materials, size, mass, application etc. There is also a brief description of the test procedure, whether the sample burned freely or in a room and a description of the ignition source used. The rate of heat release, the production of smoke and the generation of carbon monoxide are all given in diagrams against the time and other measurements are given as an average value. An example is the effective heat of combustion. In some cases there are also measurements from gases such as CO₂ and NO_x. The reference to the original report can be useful as there is a note of which other measurements were taken, usually the heat flux, the gas temperatures, the mass loss or the burning area.

ACKNOWLEDGEMENTS

The research is financed by the Swedish Fire Research Board (BRANDFORSK). It is a part of the project Fires in Large Industrial and Storage Buildings.

THE BSAB SYSTEM

The tested items are arranged into different groups and subgroups according to their function. A refrigerator will be classified as a technical fitting, and will therefore be placed into subgroup Y1. However, if the refrigerator is stored with others in a pallet system, the classification will be for the pallet system, that is in subgroup Y3.3. The system is called BSAB and is developed by 'Svensk Byggtjänst' to make possible the classification of different construction components /1/. Naturally the system is used with permission. Using a system like this, it is possible to add new test results to the list.

The main groups in the BSAB system are as follows:

- A Marking, testing, documentation etc.
- B Preparatory work, auxiliary work, excavation etc.
- C Filling, reinforcement, piling etc.
- D Earthworks, fixtures above ground etc.
- E 'In situ' concrete structures
- F Brickwork and blockwork
- G Carcassing of precast units
- H Structural elements of miscellaneous materials
- I Pipes and tubes, ducts etc.
- J Electrical conduits and wiring
- K Thermal insulation etc.
- L Building felt, fabric, foil etc. for waterproofing
- M Flat sheet products for roof and facade cladding
- N Tiles, profiled materials etc. for roof and facade cladding
- O Lining etc. of board and sheet materials
- P Plaster, rendering, protective treatment
- Q Covering and cladding products - buildings
- R Apparatus in heating and cooling systems etc.
- S Sanitary fittings etc. in piped and ducted systems
- T Apparatus, ducts, equipment etc. in air handling systems
- U Control and monitoring equipment in technical systems
- V Apparatus, machinery etc. in electrical systems
- W Apparatus, machinery etc. in materials and passenger handling systems
- X Individual objects as secondary elements
- Y Fittings and furnishings etc.
- Z Building sundries of miscellaneous bulk and continuous materials and individual objects

As the list is made to suit the entire building sector, most of the headings are not suitable for this report. With its subgroups, the headings used in the report are:

| | |
|------|--|
| J4 | Wiring, cables etc. |
| K4 | Thermal insulation of building services |
| O1 | Lining etc. of cement and plaster based board |
| O2 | Lining etc. of metal panels |
| O3 | Lining etc. of boards of wood laminates |
| O4 | Lining etc. of boards of organic fibres, wood chips etc. |
| O5 | Lining etc. of boards of inorganic fibres, expanded stone etc. |
| O6 | Lining etc. of sheets of plastics, plastics laminates etc. |
| Y0 | Fittings and furnishings of composite function |
| Y1 | Technical fittings |
| Y3.1 | Closed storage units |
| Y3.3 | Storage units with shelves, pallet systems etc. |
| Y3.4 | Holdings, hangers, hooks, containers etc. |
| Y5.0 | Seating units of composed function |
| Y5.2 | Chairs etc. |
| Y5.3 | Easy chairs etc. |
| Y5.4 | Sofas etc. |
| Y6 | Beds etc. |
| Y7 | Textile units etc. |
| Y8 | Miscellaneous fittings and furnishings |
| Z1 | Building sundries of miscellaneous bulk materials |
| Z3 | Building sundries of miscellaneous individual objects |

In some cases there are difficulties in choosing the right group for a tested item. One example is mineral wool with wall covering. The mineral wool may be classified as thermal insulation in group K, and the wall covering as a protective treatment in group P. However, one could see the mineral wool with wall covering as a board construction, and as it consists mainly of expanded stone it will be put into the group O5.

There are also cases where one may doubt if the item suits any group at all. A tram car is one. It is to be found in the group Z3 with other large individual objects.

To avoid mixing the results in each subgroup, every item has also been given a two-figure number, starting with 10. In the subgroups with different types of objects, each type starts with a different multiple of ten.

Thus, the code Y5.2/11 means that the sample is a piece of furniture (Y), that it may be used to sit on (5), that it is a chair or an armchair (2) and that it has the identity number 11.

DEFINITIONS AND GUIDELINES

The criterion for selection of test results for the report is that the rate of heat release is given, measured by the oxygen consumption. It is believed to be the single most important parameter describing a fire.

In the report, the following abbreviations are used:

| | |
|-----|---|
| FR | Fire retardant / Fire retardant treated |
| GPB | Gypsum plaster board |
| PS | Polystyrene |
| PP | Polypropene |
| PU | Polyurethane |
| PVA | Polyvinyl acetate |
| PVC | Polyvinyl chloride |
| NA | Data is not available |

The furniture dimensions throughout the report are written in the order:
Width x Length x Height

Under the heading 'Also available' there is a note of which measurements are shown in diagrams in the original report.

Unfortunately there are a great variety of terms that are used to describe the same phenomena. The fire growth may be described by either the rate of heat release in kW or by the mass loss rate in kg/s. There are also examples where the same variable is determined, but different units used. The most remarkable one is the smoke production, where one can use the optical units dBm^2/s , obm^3/s or m^2/s . As if that were not enough, the last one can be used with both the base 10-logarithm and the natural logarithm. They differ by a factor of 2.3. There are also some units based on weight, such as g/s. The generation of carbon monoxide can be measured in either l/s, g/s, g/g_{fuel} or g/g_{CO_2} . To avoid misunderstandings, some of the test results have been recalculated in this report so that the same units and logarithm bases are used throughout.

Used in the report are:

| | | |
|------------------|---------------------------|--|
| RHR | [kW] | Rate of heat release, including the ignition source $\text{RHR} = 13.1 \times \dot{m}_{\text{O}_2}$ |
| S | $[\text{obm}^3/\text{s}]$ | Smoke production $S = 1/L \times 10 \log_{10} (I_0/I) \times V$ |
| CO | [l/s] | Carbon monoxide generation at NTP |
| H_{eff} | [MJ/kg] | Effective heat of combustion $H_{\text{eff}} = H_C \times _$ |

In the report RHR, S and CO are plotted against the time in diagrams and H_{eff} is given as a constant. Since the heat release varies within a large range depending on the size of the samples, it is not possible to use the same maxima on the scales. However the same scales are used in each subgroup of samples. Unfortunately it has the effect of making some of the curves very tiny, almost invisible, but in spite of that, they indicate the magnitude of the heat release rate. The scale maxima that are used are, for time 1200, 2400 and 4800 s and for RHR 100, 500, 1000, 2000, 4000 and 8000 kW. The scales of smoke production are always 1/10 of the RHR scale and the CO production 1/100 of the RHR scale. One scale mark always represents 60 s, 100 kW, 10 obm^3/s or 1 l/s, respectively.

THE DATABASE

In addition to the report, there is also a database, with all the data files containing rates of heat release, smoke production and generation of carbon monoxide.

The data base is built up using the same system as in the report, using the same codes. This means that the sofa Y5.4/11 corresponds to data file Y54-11.FIR. The format used is the ASCII text format, within each file four columns; for time, rate of heat release, smoke production and CO generation, respectively. The first row is used for the sample identity code and the second for the column headings. The data is tab separated, and to indicate the end of data, the figure -9 is used in each column. In the event that S or CO is not available, the columns are left empty.

The following example shows the format that is used:

| Y1/40 | | | |
|-------|----------|-----------------|----------|
| T (s) | RHR (kW) | S (obm^3/s) | CO (l/s) |
| 0 | 0 | 0 | 0 |
| 30 | 10 | 0.5 | 0 |
| 60 | 50 | 3 | 0.5 |
| 90 | 100 | 9 | 1 |
| ... | ... | ... | ... |
| -9 | -9 | -9 | -9 |

TEST METHODS

All the RHR measurements in the report are made in calorimeters. There are three types of full scale calorimeters, namely: the room calorimeter, the furniture calorimeter and the industry calorimeter.

They are all based on the assumption that when a material is burning, for every gram of oxygen that is consumed, about 13.1 MJ of energy is released. 13.1 is an empirical constant, which is used for most substances. However, the constant differs slightly for different materials. If the sample is of a known material, it is possible to adjust the constant. Otherwise the error may be as large as +/- 15% depending on the material burning. In addition to this, there is the inaccuracy of the instruments, up to +/- 10% depending on how well the equipment has been calibrated. Thus, the error may be as large as +/- 25%.

It is worth noting that the phase of pyrolysis shows a great variation depending on the ignition source. It varies from when the ignition source is so small so that the sample is not ignited, to the ones that give a very rapid increase in the rate of heat release. A middle form is when the sample is smouldering for some time before the heat release increases. There are four main aspects to consider about the ignition sources; the rate of heat release, the maximum temperature, the time of application to the target and the area of contact. This is important, as the ignition sources used vary from ordinary matches to 1000 kW gas burners.

The test equipment is based on an exhaust hood with a fan, an oxygen meter, a photocell measuring the smoke obscuration, and in some cases there is also equipment analyzing the amounts of CO, CO₂, NO_x etc. in the gases. It is the fan that sets the limits of how large the samples are that may be tested, since it is necessary that all the smoke is exhausted through the hood.

In the room calorimeter, the sample is burned in a room, usually with the size 2.4 x 3.6 x 2.4 m³, with an opening of 0.8 x 2.0 m². The hood is located outside the opening, collecting all the smoke. The room is usually built of lightweight concrete. According to Thomas' flashover correlation, the energy release needed to cause flashover in the room is 1300 kW. The stoichiometric post flashover rate of heat release is 3400 kW. The two correlations are to be found in *The SFPE Handbook of Fire Safety Engineering* /2/. Other room geometries are used as well. The beds Y6/13-21 were burned in a room of a size 3.40 x 3.50 x 2.44 m³, with an opening 0.91 x 2.13 m².

In the furniture calorimeter, the same hood is used as in the room calorimeter. It is usually of the size 2 x 2 m². The sample is placed directly under the hood, in some cases on a weighing platform to make possible measurement of the mass loss.

The industry calorimeter is very similar to the furniture calorimeter, but on a much larger scale. It can easily handle a heat release up to about 10 MW, which is needed, for example for the rack storages.

CONVERSIONS

There are a large number of different computer and paper-and-pencil models that can be used to calculate a smoke filling, fire spread or detector activation process. Almost every model has its own set of data to make possible the calculation. To get the right set of data to put into the models one often needs conversions. The most common ones are as follows:

Burning rate conversions

Conversion to mass loss rate:

$$m = \text{RHR} / (\text{H}_{\text{eff}} \times 10^3) = \text{RHR} / (\text{H}_C \times 10^3 \times _)$$

It is worth noting that if the model is doing a plume calculation, one has to know the fraction of radiation. It is usually in the order 15 - 50 % of the RHR, with the lowest values for substances with a low smoke production and the highest for those producing a large amount of smoke. *The SFPE Handbook of Fire Protection Engineering* /2/ and *Heat transfer in Flames* /3/ discusses this subject in greater detail.

Smoke conversions

Conversion to smoke potentials and specific extinction coefficient:

$$\begin{aligned} D_0 \times 10^{-3} &= 1 / L \times 10 \log_{10} (I_0 / I) \times V / m = S / m \\ D \times 10^{-3} &= 1 / L \times \log_{10} (I_0 / I) \times V / m = 0.1 \times S / m \\ e_C \times 10^{-3} &= 1 / L \times \ln (I_0 / I) \times V / m = 0.23 \times S / m \end{aligned}$$

Calculation of S when m (or RHR) is given:

$$S = \text{POD} \times m \times X$$

The POD has been shown to be 33 000 obm^3/kg for flaming combustion and 19 000 obm^3/kg for non-flaming combustion.

CO conversions

Conversion to CO/CO₂ fraction and ratio - approximation when the CO generation is relatively low:

The oxygen consumption can be calculated from the RHR:

$$n_{O_2} = \text{RHR} / (13.1 \text{ kJ/g} \times 32 \text{ g/mole}) = \text{RHR} / 419 \text{ mole/s}$$

The burning process can be approximated to ($_ = 1$):



The oxygen balance gives the generation of CO₂:

$$2 n_{O_2} = 2 n_{CO_2} + n_{H_2O} = 2 n_{CO_2} + n_{CO_2} / 2 z$$

$$n_{CO_2} = n_{O_2} / (1 + 1/4z)$$

$$n_{CO_2} = \text{RHR} / 419 (1 + 1/4z)$$

The CO generation is needed:

$$n_{CO} = \text{CO} / 24 \text{ l/mole}$$

CO/CO₂ fraction:

$$n_{CO} / n_{CO_2} = (\text{CO} / 24 \text{ l/mole}) / (\text{RHR} / 419 (1 + 1/4z))$$

$$= 17.5 (1 + 1/4z) \text{ CO} / \text{RHR}$$

The approximation is acceptable when $n_{CO} / n_{CO_2} < 0.2$

CO/CO₂ ratio:

$$m_{CO} / m_{CO_2} =$$

$$= (n_{CO} / n_{CO_2}) (M(\text{CO}) / M(\text{CO}_2)) = (17.5 (1 + 1/4z) \text{ CO} / \text{RHR}) (28/44)$$

$$= 11 (1 + 1/4z) \text{ CO} / \text{RHR}$$

The approximation is acceptable when $m_{CO} / m_{CO_2} < 0.1$

DISCUSSION

Tests to be conducted

In writing this report it became quite obvious that some areas of test objects are covered very well, and others hardly at all. Chairs are popular samples, and they are tested in a large number and variety of ways. There are tests performed on both commercial chairs and standardized mock-up chairs with different paddings and covers. In the results you can also find some curiosities, such as the stuffed fox or the christmas trees. Other items appear rarely in the test records. These may be clothes, ordinary cars or stored goods, such as bookcases, all of them known to burn under the right, or shall we say wrong, circumstances.

This means that there is a need for additional tests to be conducted. Some areas to be covered are:

industrial machinery,
vehicles, such as cars, buses, trucks and railroad cars,
storage units up to the size of pallet systems, with different goods and wardrobes, especially larger open wardrobes with clothes.

Choosing a rate of heat release

There are several factors that affect the rate of heat release. One of them is ventilation and how the item is located with respect to walls etc. It may differ by more than a factor of two on the rate of heat release if the item is standing in the corner of a room or is burning with free access to air. Another factor is the ignition source. It is quite obvious that the strength of the ignition source necessary to cause ignition of the item differs greatly between items. An example is lining materials, where one can easily see the time when the burner output is increased. How the ignition source affects the target can be described with four parameters: the maximum temperature, the rate of heat release, the time of application to the target and the area in contact with the ignition source.

One may also find examples of tests that are made with similar objects, under apparently similar conditions, which in spite of that give slightly different results. This means that it is impossible to predict an exact result even if there is a sample that fits most of the conditions.

The conclusion is that it is necessary to see to both the environment and the item itself when assuming a fire progress. Furthermore the user of a computer or paper-and-pencil model has to think for himself and not just use the data as written. In fact, the test method itself is a source of inaccuracy, with its constant 13.1 MJ released energy per gram consumed oxygen. The error of up to +/- 25% is far too much to be neglected. This shows that it is necessary to make an analysis of the sensitivity of the calculations, that is, to assume one rate of heat release that is lower and slower and one that is higher and faster than the proposed, to see if it makes any difference to the results. A number of 20 to 30 different simulations in each scenario is not at all unrealistic.

Warnings

The user of a model is always responsible for how the results are used.

It is necessary to know the limitations of the models used, to avoid using a two-zone-model when clearly not applicable.

In making a simulation, there also has to be an analysis of the sensitivity of the calculations.

When assuming fire progress, the following has to be taken into consideration:

- the access of air
- the location of walls and ceiling
- the ignition source ("strength", application and time)
- the configuration of the sample
- the materials and size of the sample
- and all the other factors that affect the heat release rate.

Which can be summed up by:

- the environment, the ignition source and the sample itself.

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U.S.A 1989

Walton, W. D. & Budnick, E. K.
Quick response Sprinkler in Office Configurations:
Fire Test Results
NISTIR 88-3695
U.S.A 1988

Wetterlund, I. & Göransson, U.
A Full Scale Fire Test Method for Free-hanging
Curtain and Drapery Textiles
Fire Technology
SP Report 1988:45, ISSN 0284-5172
Borås, Sweden 1988

Wetterlund, I. & Göransson, U.
New Method for Fire Testing of Pipe Insulation in
Full Scale
Fire Technology
SP Report 1986:33, ISSN 0280-2503
Borås, Sweden 1986

Williamson, R. B., & Dembsey, N. A.
Advances in Assessment Methods for Fire Safety
Fire Safety Journal, Vol 20 No 1, 15-38
1993

Electric cable with 5 copper wires
 Thickness: Wire: 1.63 mm, insulated wire: 3.30 mm,
 complete cable: 12.7 mm

Z-configuration: 35 cables (single layer, 0.43 x 2.44 m²) on
 Z-shaped ladder rack (0.53 m horizontal, 1.37 m vertical
 and 0.53 m horizontal)
 Vertical configuration: 25 cables (single layer, 0.30 x 2.18
 m²) on vertical ladder rack

10: Z-configuration

Wire insulation: Crosslinked ethylene vinyl acetate
 copolymer with clay (18.9%), antioxidant (2%), processing
 aid (1%), and catalyst (1.5%)

Jacket: Chlorosulfonated polyethylene containing Sb₂O₃.

Elemental content: Cl (12.2%), Sb (2%)

Mass: 17.5 kg

Sample D, test 5,

11: Vertical configuration

Cable identical to sample 10.

Mass: 11.4 kg

Test 19

12: FR, Z-configuration

Wire insulation: Polyethylene crosslinked with ethylene
 vinyl acetate, with clay (28%), chlorinated cycloaliphatic
 fire retardant (38%), Sb₂O₃ (18.9%), antioxidant (2%),
 processing aid (1%), and catalyst (1.5%)

Jacket: Identical to sample 10

Mass: 18.2 kg

Sample K, test 6

13: FR, Vertical configuration

Cable identical to sample 12.

Mass: 11.5 kg

Test 20

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Gas burner, 50 kW at 0-200, 240-600 and
 730-1380 s (sample 10 and 12) or at 0-1200 s (sample 11
 and 13)

| | | |
|-------------------------------|------|------|
| Sample: | 11 | 13 |
| H _{eff} (MJ/kg): | 41 | NA |
| Smoke (obm ³ /kg): | 2800 | 2400 |
| CO (kg/kg): | 0.12 | 0.10 |
| CO ₂ (kg/kg): | 1.61 | 1.04 |
| HCl (kg/kg): | 0.12 | 0.13 |

Reference:

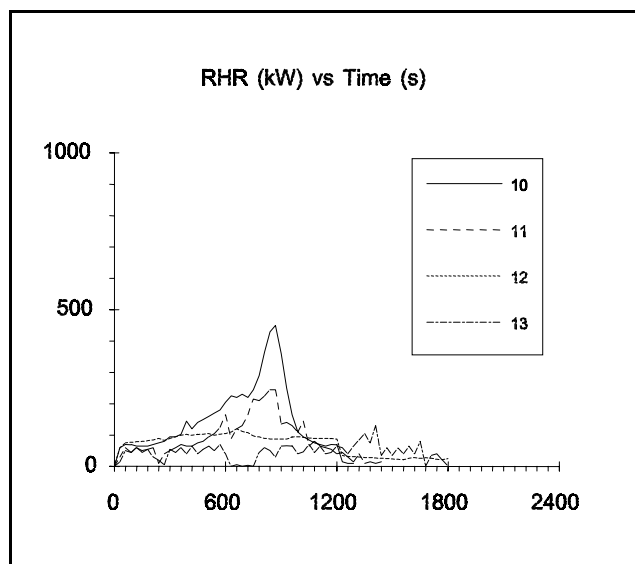
Babrauskas, V. et al.

Fire Hazard Comparison of Fire-Retarded and Non-Fire-
 Retarded Products

NBS Special Publication 749

National Bureau of Standards

U.S.A. 1988



10: Phenol

Glass fibre reinforced

L-shaped

Volume of mat. per ceiling surface area: 0.028 m³/m²

Density: 115 kg/m³

11: Amino plastic

Inner diameter: 15 mm

Thickness: 28 mm

Volume of mat. per ceiling surface area: 0.053 m³/m²

Density: 12 kg/m³

Material of similar kind in sample 12-14

12: PVC

Inner diameter: 22 mm

Thickness: 13 mm

Volume of mat. per ceiling surface area: 0.030 m³/m²

Density: 95 kg/m³

13: PVC/nitrile rubber

Inner diameter: 15 mm

Thickness: 25 mm

Volume of mat. per ceiling surface area: 0.048 m³/m²

Density: 100kg/m³

14: Vinyl rubber

Inner diameter: 22 mm

Thickness: 13 mm

Volume of mat. per ceiling surface area: 0.030 m³/m²

Density: 60 kg/m³

Test procedure:

Method: Room calorimeter. The insulation was mounted on 10 mm diameter steel bars at the distance 0.15 m from underside of the insulation to the ceiling. The insulation covered the entire ceiling.

Ignition source: 150 kW gas burner 1 m above the floor.

Reference:

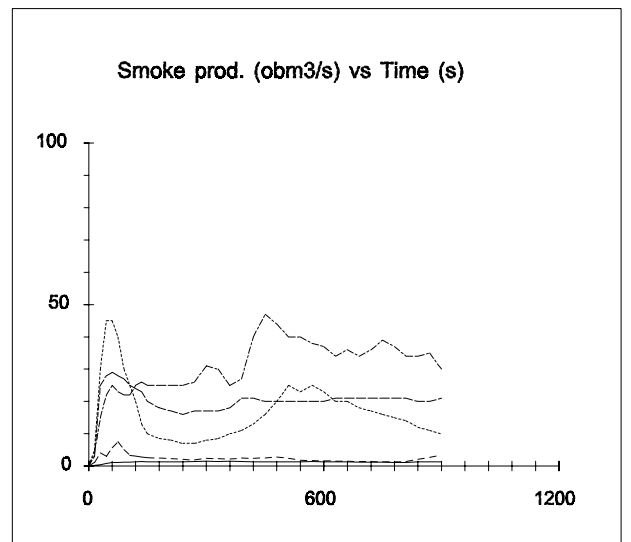
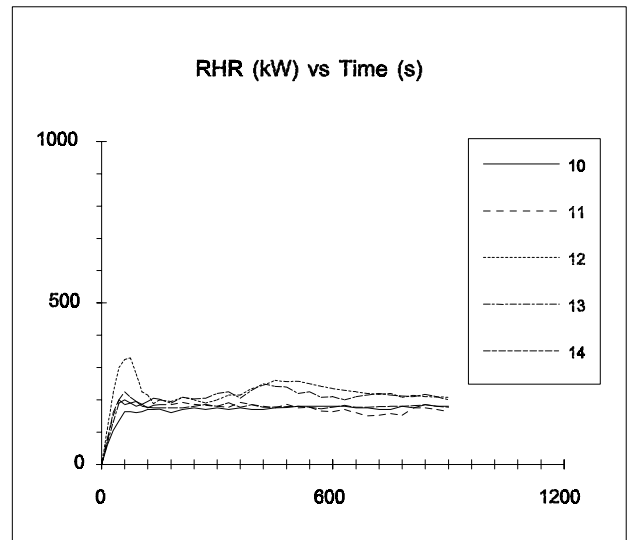
Wetterlund, I. & Göransson, U.

New Method for Fire Testing of Pipe Insulation in Full Scale

Fire Technology

SP Report 1986:33, ISSN 0280-2503

Borås, Sweden 1986



15: Polyisocyanurate

With glass fibre reinforced aluminium foil

Inner diameter: 34 mm

Thickness: 20 mm

Volume of mat. per ceiling surface area: 0.046 m³/m²

Density: 35 kg/m³

Only 1/3 of the ceiling was covered.

Ignition source: 90 kW gas burner

16: PU with paper surface

L-shaped

Volume of mat. per ceiling surface area: 0.028 m³/m²

Density: 80 kg/m³

17: Particle board

Thickness: 10 mm

Volume of mat. per ceiling surface area: 0.010 m³/m²

Density: 700 kg/m³

18: Insulating fibre board

Thickness: 12.5 mm

Volume of mat. per ceiling surface area: 0.013 m³/m²

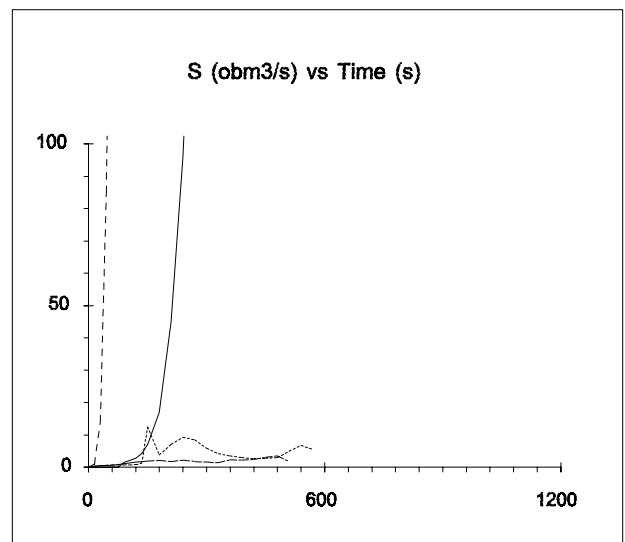
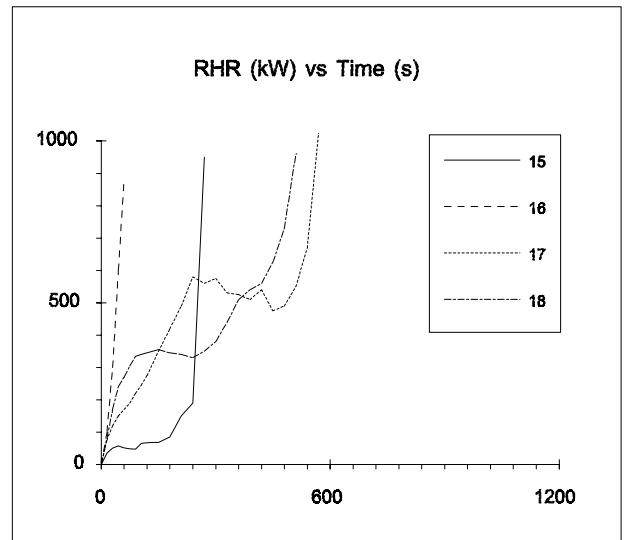
Density: 250 kg/m³

Test procedure:

See page K4/10

Reference:

See page K4/10



10: Gypsum plaster board (GPB)

Thickness: 13 mm

Density: 700 kg/m³

Test 4

11: PVC wallcovering on GPB

Thickness: 0.7 mm

Surface weight: 240 g/m²

Application: Glued

Test 5

12: Paper wallcovering on GPB

Thickness: 0.7 mm

Surface weight: 240 g/m²

Application: Glued

Test 6

13: Textile wallcovering on GPB

Thickness: 0.6 mm

Surface weight: 240 g/m²

Application: Glued

Test 7

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW in 600 s, thereafter 300 kW in 600 s.

Also available:

Gas temp., surface temp., heat flux, mass flow, burning area, and production of CO₂ and hydrocarbons.

Reference:

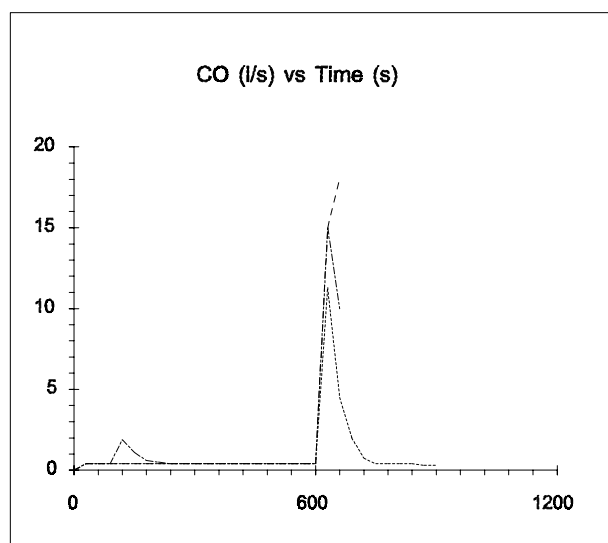
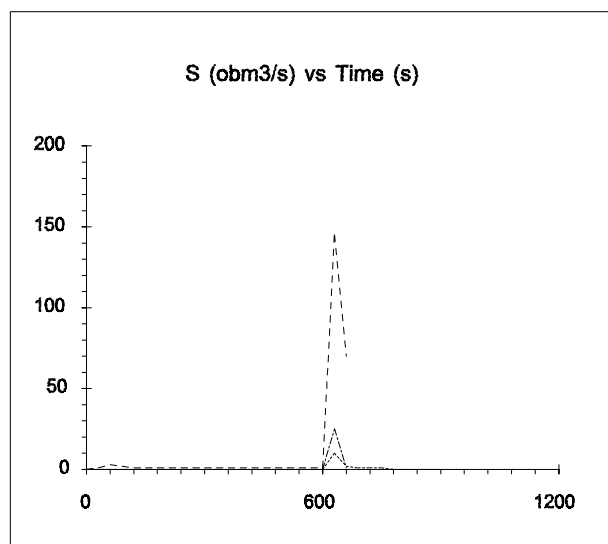
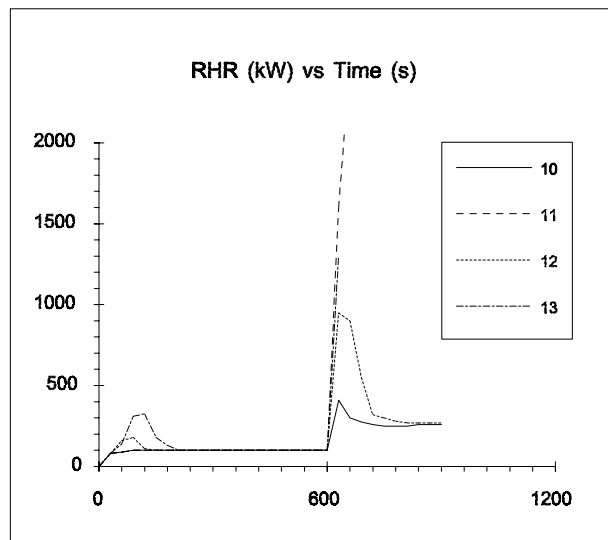
Sundström, B

Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986



Gypsum plaster board
Thickness: 12 mm

14: PVA latex paint on GPB
Surface weight: approx. 100 g/m²
Test 1, PAINT

15: Textile wallcovering on GPB
Thickness: approx. 1 mm
Surface weight: approx. 505 g/m²
Application: Glued
Test 3, TEXT

16: PVC wallcarpet on GPB
Thickness: 0.9 mm
Surface weight: approx. 1250 g/m²
Application: Glued
Test 10, PVC WALL

Test procedure:

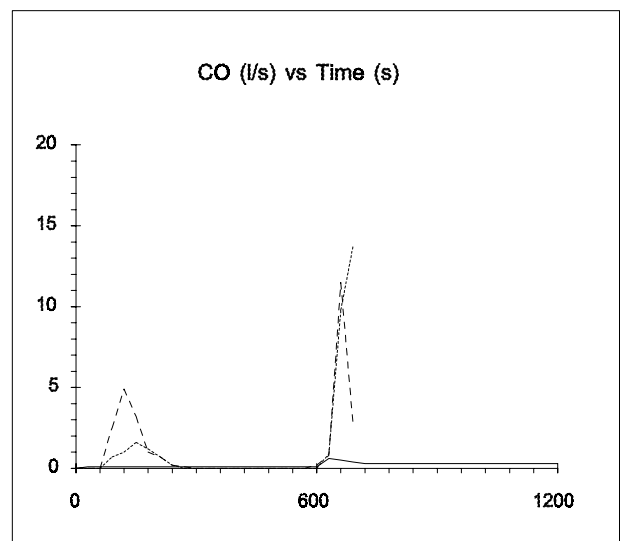
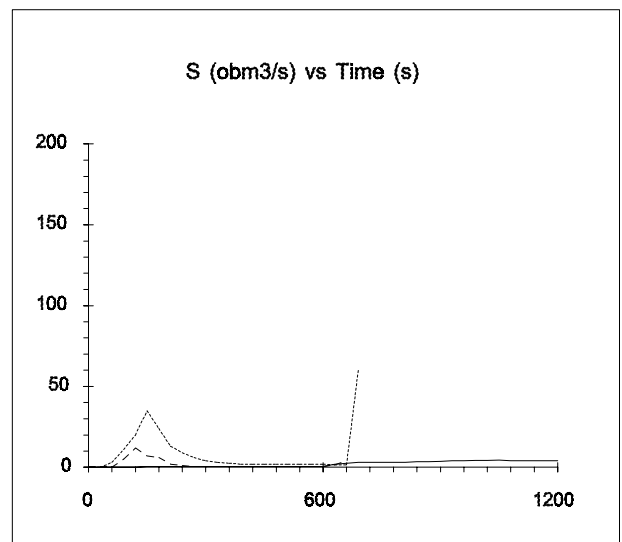
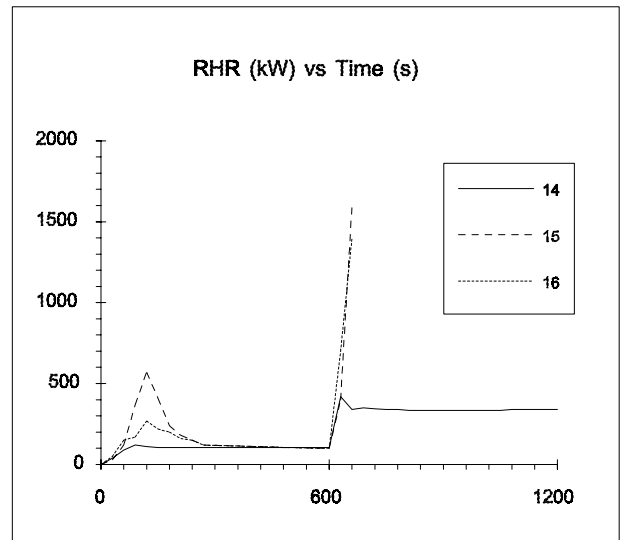
Method: Room/corner test. 3 walls and ceiling covered with material
Ignition source: Gas burner, 100 kW in 600 s, thereafter 300 kW in 600 s.

Also available:

Heat flux, gas temp. and flame spread.

Reference:

Söderbom, J
EURIFIC - Large Scale Tests according to ISO DIS 9705
Fire Technology
SP REPORT 1991:27, ISSN 0248-5127
Borås, Sweden 1991



10: Plastic faced steel sheets on mineral wool

Thickness: 0.15 + 0.7 + 23 mm

Density: 640 kg/m³ (total)

The panels mineral wool was completely enclosed by steel
Test 5, PL.FAC

11: Plastic faced steel sheets on PU foam

Thickness: approx 1 + 80 mm

Density: 160 kg/m³ (total)

Test 9, PU.FOAM

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW in 600 s, thereafter 300 kW in 600 s.

Also available:

Heat flux, gas temp. and flame spread.

Reference:

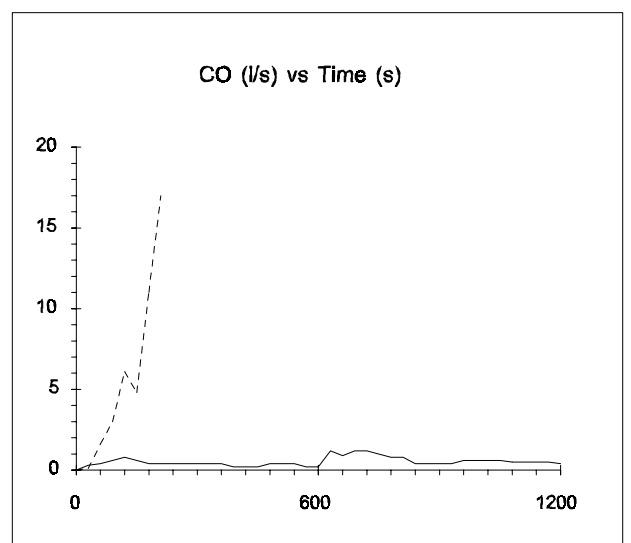
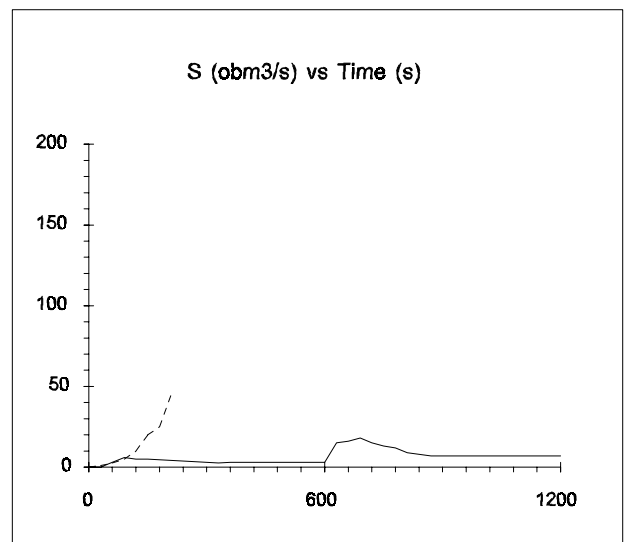
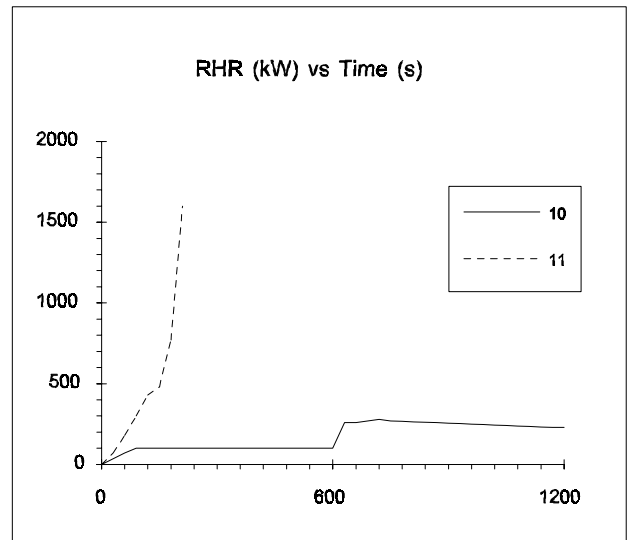
Söderbom, J

EURIFIC - Large Scale Tests according to ISO DIS 9705

Fire Technology

SP REPORT 1991:27, ISSN 0248-5127

Borås, Sweden 1991



10: Wood panel, spruce

Thickness: 11 mm

Density: 530 kg/m³

Moisture content: 10.0%

Test 12

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, burning area and production of CO₂ and hydrocarbons.

Reference:

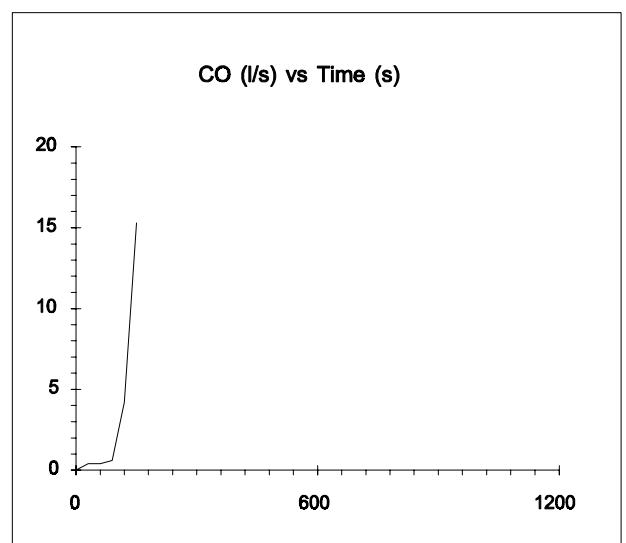
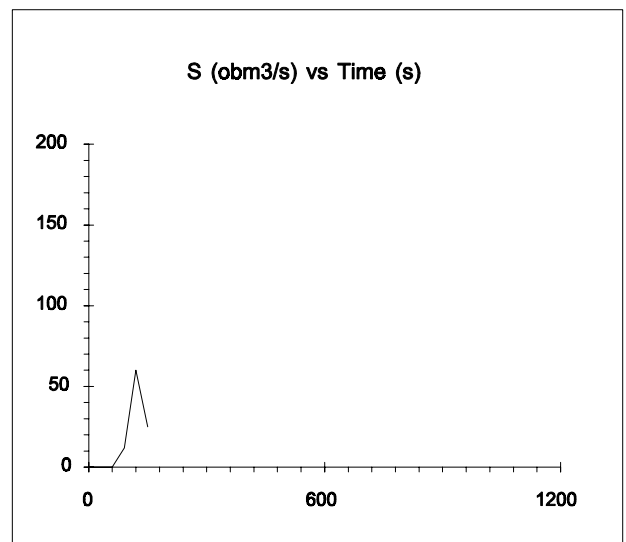
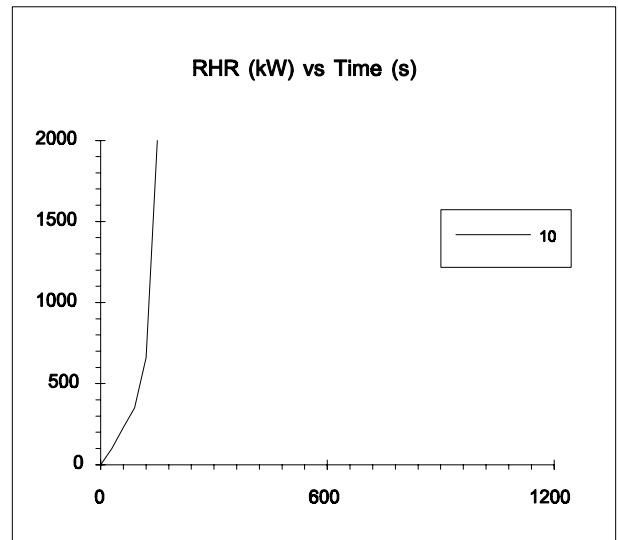
Sundström, B

Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986



20: Ordinary plywood

Thickness: 12 mm

Density: 600 kg/m³

Test procedure:

Method: Room/corner test. 3 walls covered with material

Ignition source: Gas burner, at first 40 kW, thereafter 160 kW

Also available:

Heat flux and gas temp.

Reference:

Söderbom, J

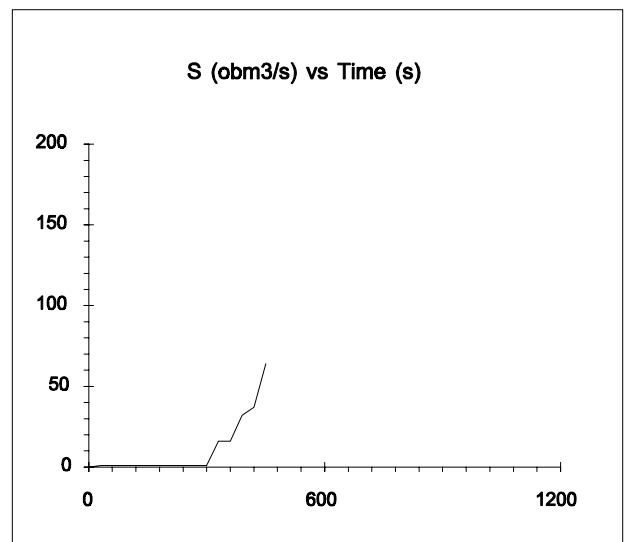
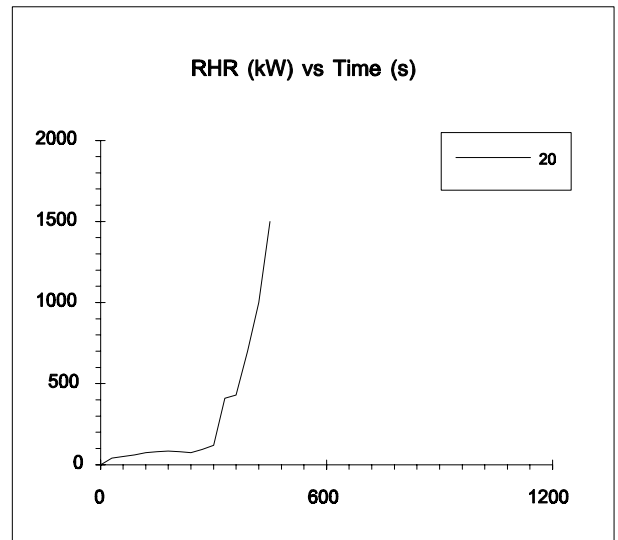
Swedish Results from Interlaboratory Calibration Tests

According to ISO/ASTM Room Fire Test Method

SP-AR 1991:27

Fire Technology

Borås, Sweden 1991



21: Ordinary birch plywood

Thickness: 12 mm

Density: 600 kg/m³

Test 2, PLYWOOD

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Heat flux, gas temp. and flame spread.

Reference:

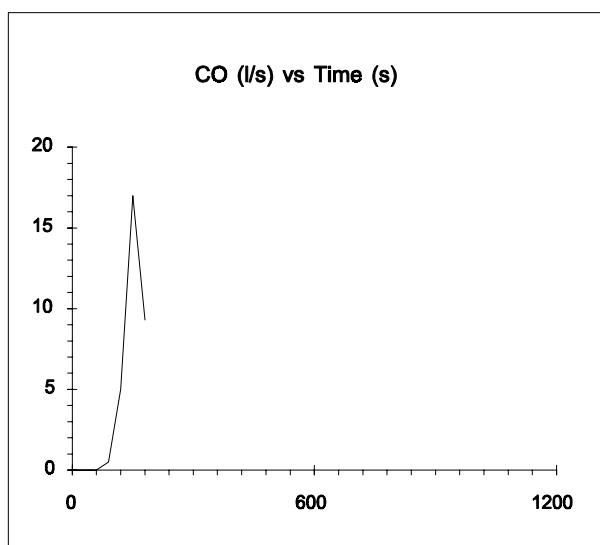
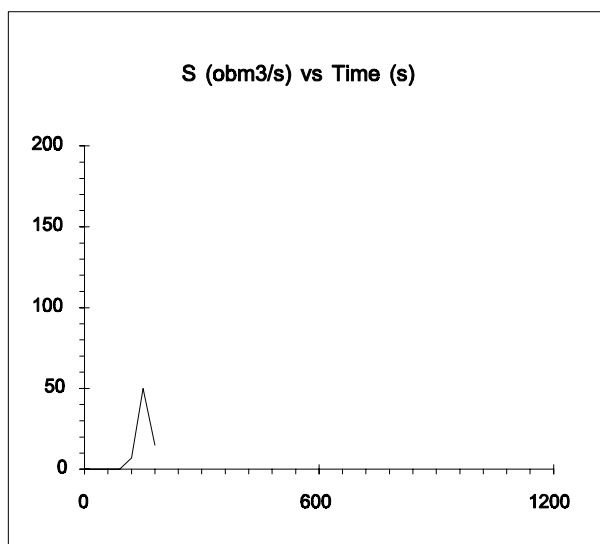
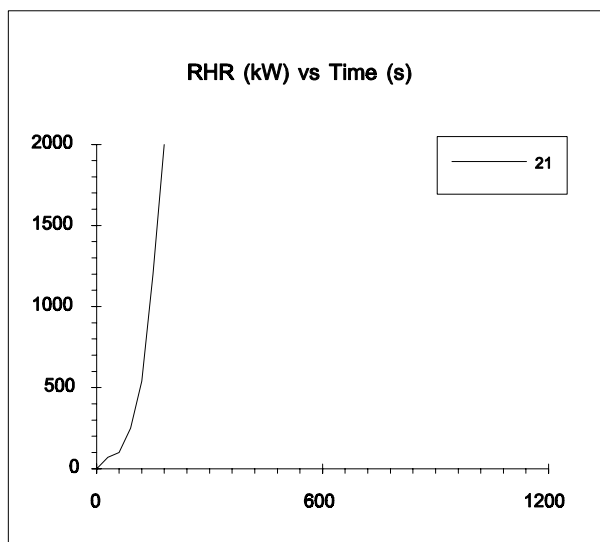
Söderbom, J

EURIFIC - Large Scale Tests according to ISO DIS 9705

Fire Technology

SP REPORT 1991:27, ISSN 0248-5127

Borås, Sweden 1991



10: Insulating fibre board

Thickness: 13 mm
Density: 250 kg/m³
Moisture content: 7.0%
Test 1

11: Medium density fibre board

Thickness: 12 mm
Density: 600 kg/m³
Moisture content: 5.9%
Test 2

Test procedure:

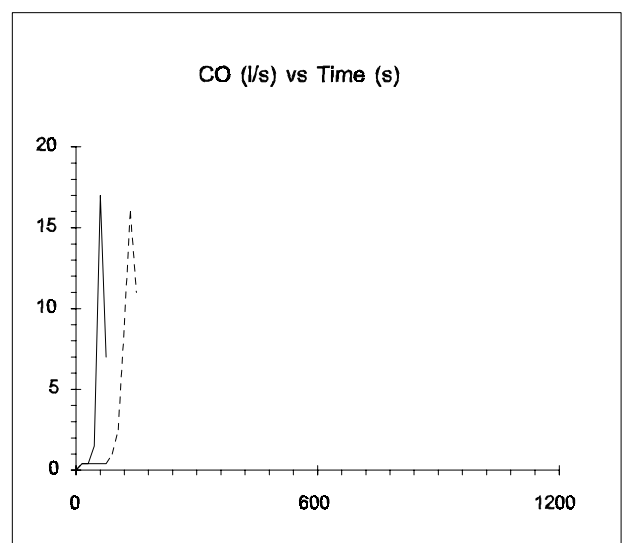
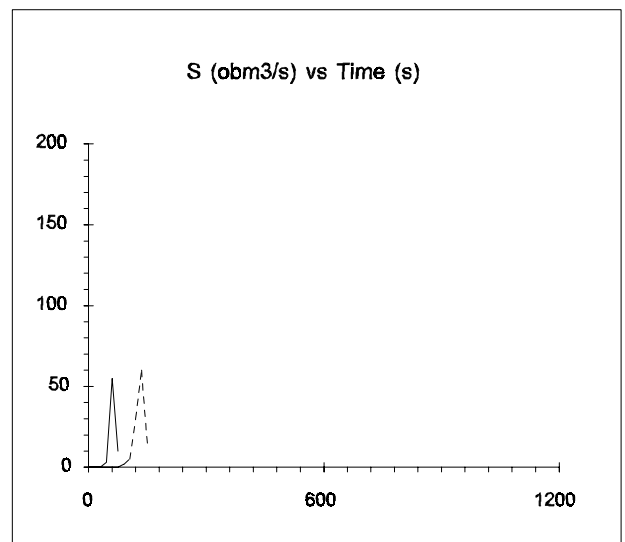
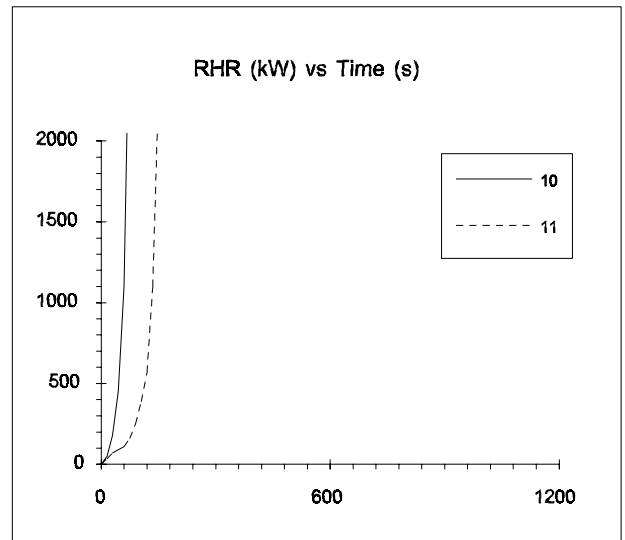
Method: Room/corner test. 3 walls and ceiling covered with material
Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, burning area and production of CO₂ and hydrocarbons.

Reference:

Sundström, B
Full Scale Fire Testing of Surface Materials
Fire Technology
Technical report 1986:45, ISSN 0280-2503
Borås, Sweden 1986



Particle boards

Particle board in sample 20-24:

Thickness: 10 mm

Density: 750 kg/m³

Moisture content: 7.1%

20:

Test 3

21:

Ignition source: 40 kW gas burner

Moisture content: 5.0%

Test 15

22:

Only walls covered with material

Test 16

23:

Only ceiling covered with material

Test 17

24: Paper wallcovering on particle board

Thickness: 0.6 mm

Density: 200 g/m²

Application: Glued

Test 13

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, convective heat flow, burning area and production of CO₂ and hydrocarbons.

Reference:

Sundström, B

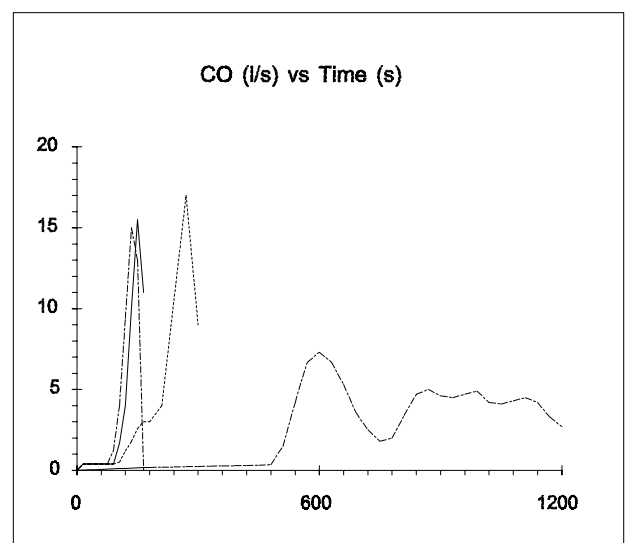
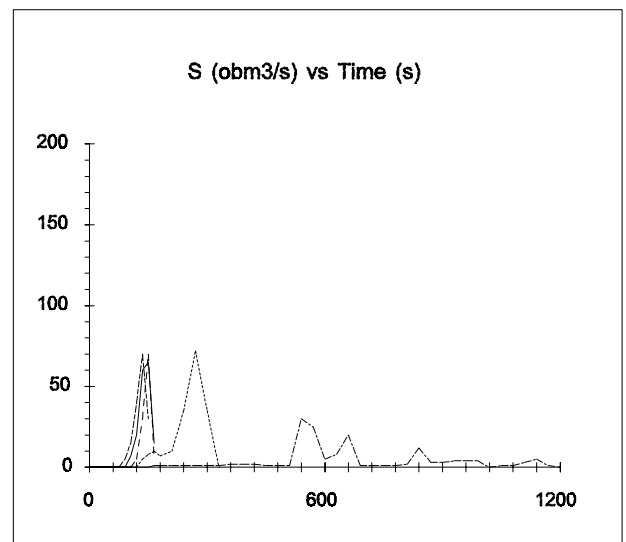
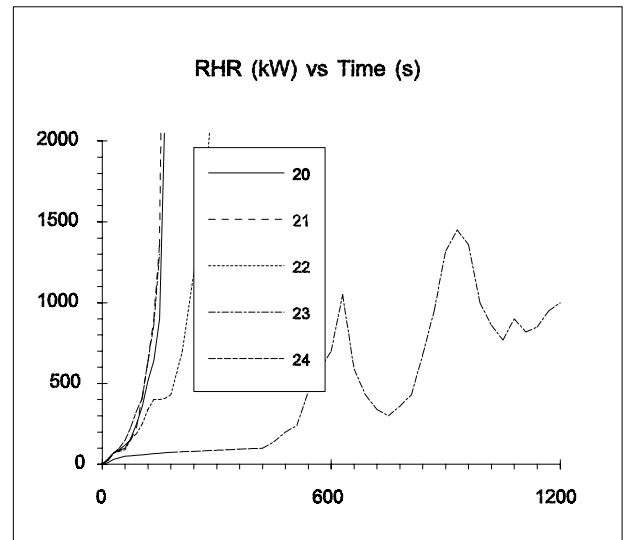
Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986

O4/20-24



Partical boards

25: FR Particle board

Thickness: 16 mm

Density: 630 kg/m³

Test 6, PART.B1

26: FR Particle board

Thickness: 12 mm

Density: 750 kg/m³

Test 8, FR.PARTB

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW in 600 s, thereafter 300 kW in 600 s.

Also available:

Heat flux, gas temp. and flame spread.

Reference:

Söderbom, J

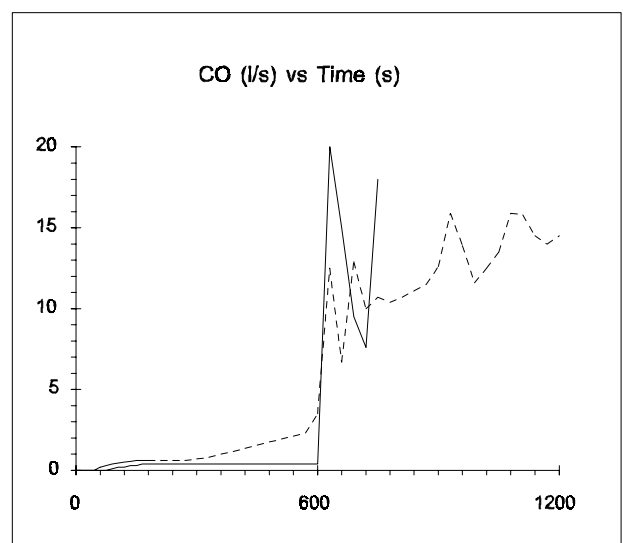
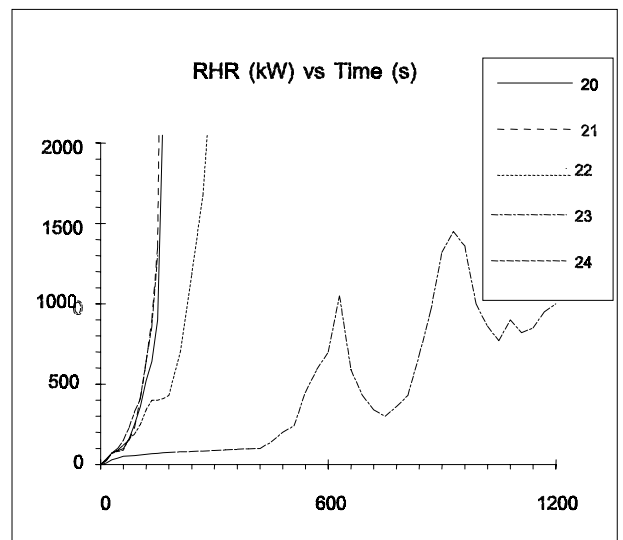
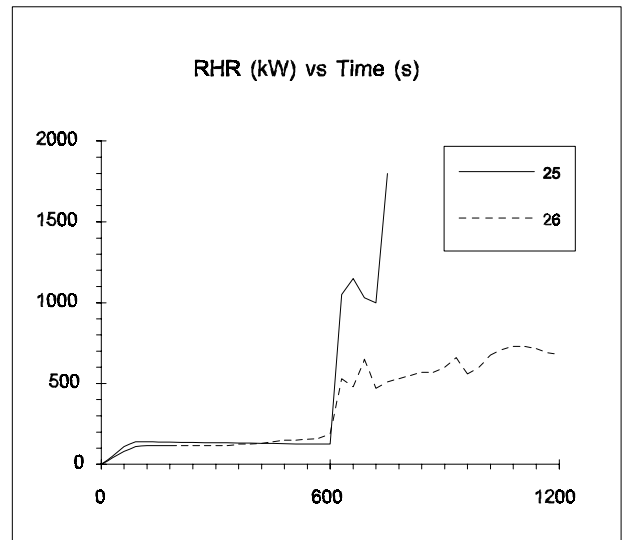
EURIFIC - Large Scale Tests according to ISO DIS 9705

Fire Technology

SP REPORT 1991:27, ISSN 0248-5127

Borås, Sweden 1991

O4/25-26



10: Textile wallcovering on mineral wool

Mineral wool:

Thickness: 50 mm

Density: 100 kg/m³

Textile wallcovering:

Thickness: 0.7 mm

Surface weight: 370 g/m²

Application: Glued

Test 8

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, burning area and production of CO₂ and hydrocarbons.

Reference:

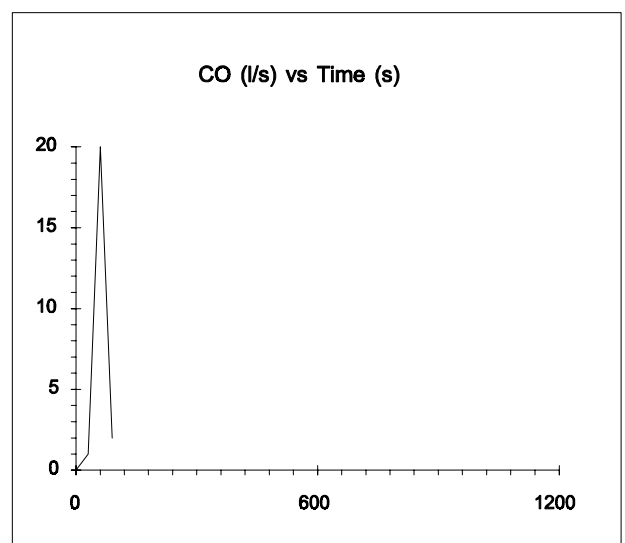
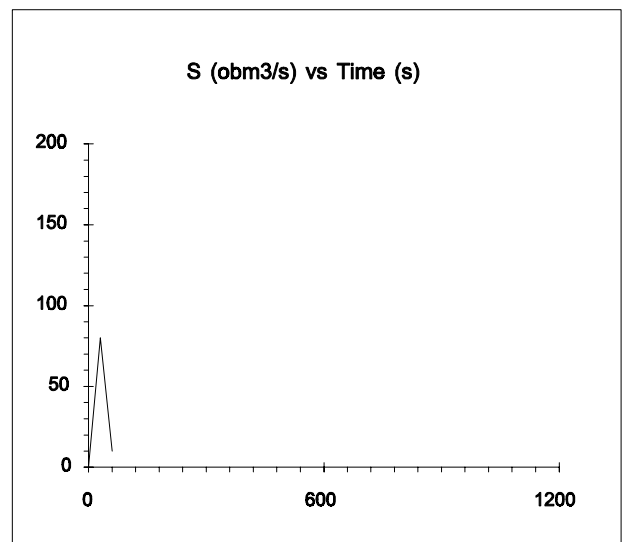
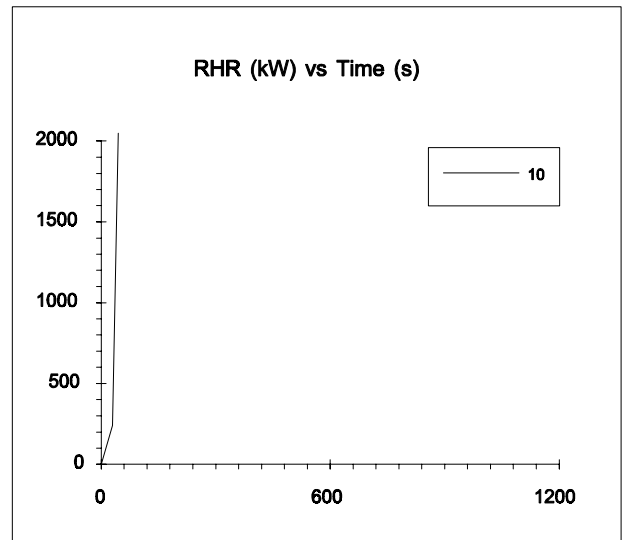
Sundström, B

Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986



11: Combustible faced mineral wool

Thickness: 30 mm
Density: 87 kg/m³ (total)
Test 7, FACED MW

Test procedure:

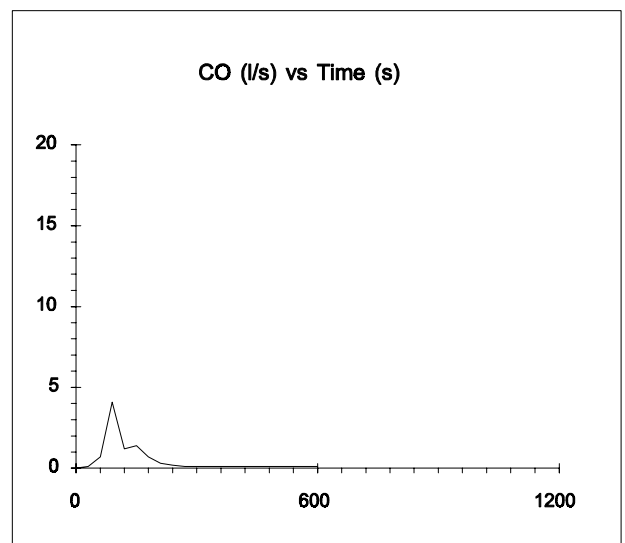
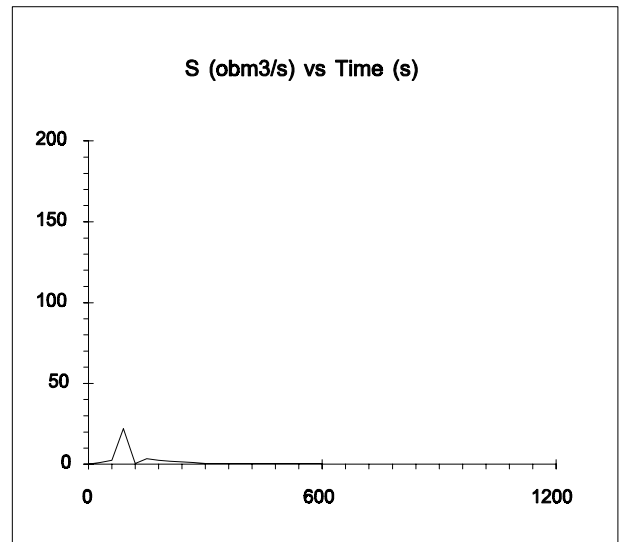
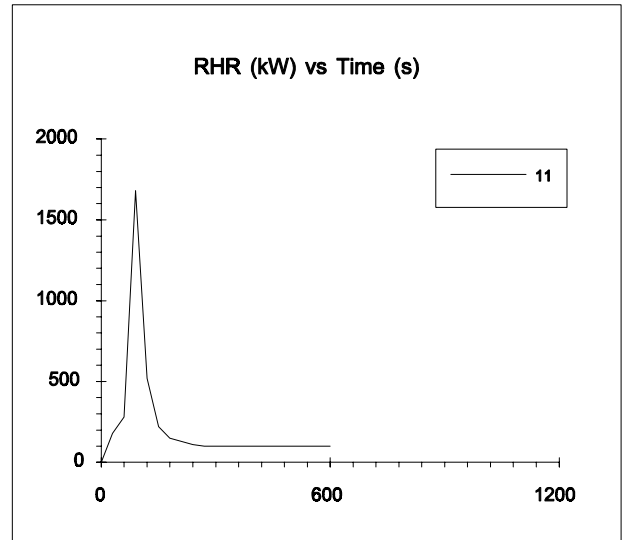
Method: Room/corner test. 3 walls and ceiling covered with material
Ignition source: Gas burner, 100 kW in 600 s.

Also available:

Heat flux, gas temp. and flame spread

Reference:

Söderbom, J
EURIFIC - Large Scale Tests according to ISO DIS 9705
Fire Technology
SP REPORT 1991:27, ISSN 0248-5127
Borås, Sweden 1991



10: Melamine faced particle board

Thickness: 13 mm (Laminate 1.2 mm)

Density: 810 g/m³

Moisture content: 6.7%

Application: Laminate glued on both sides of board

Test 9

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, burning area and production of CO₂ and hydrocarbons.

Reference:

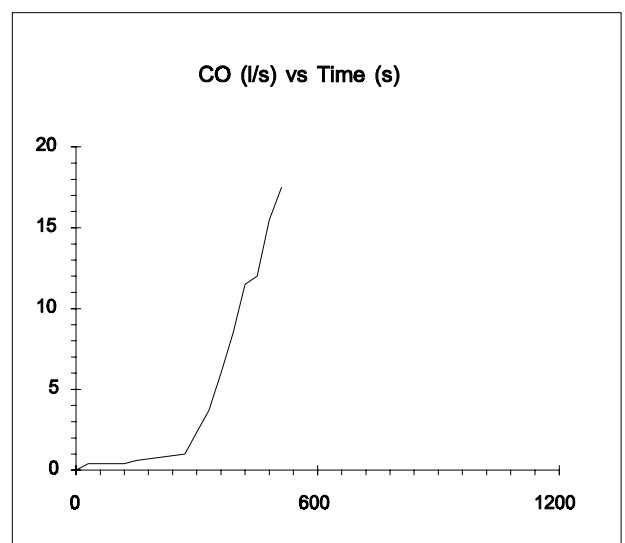
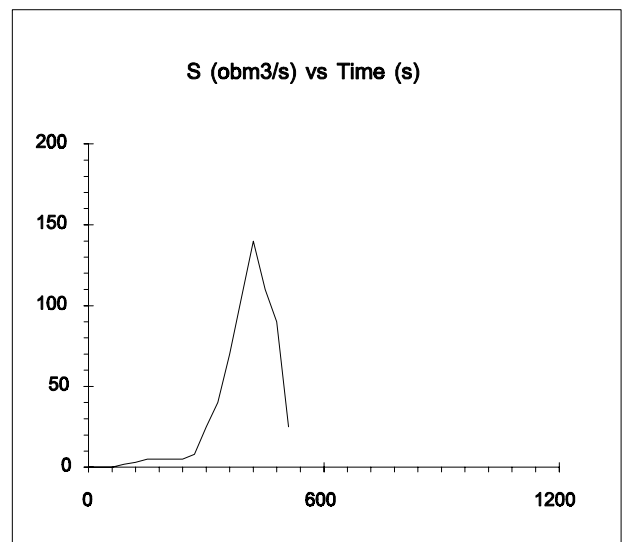
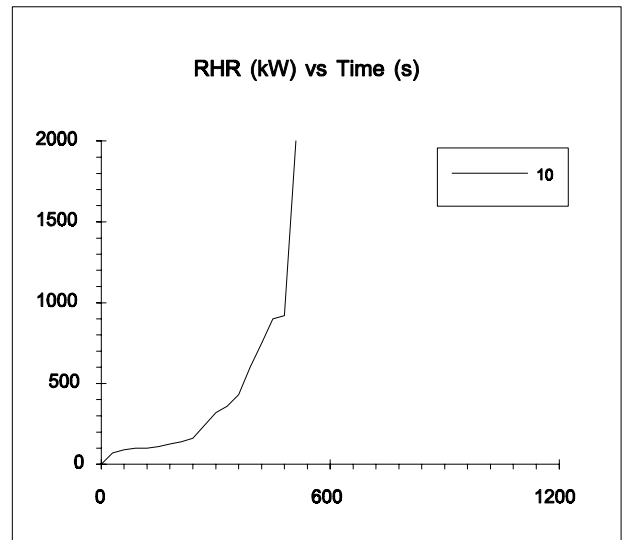
Sundström, B

Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986



Laminate faced panels

Laminate faced particle board
Front surface lined with decorative laminate and back of panel lined with protective laminate
Thickness: 11 mm
Density: 760 kg/m³ (particle board)

11:

Mounting: Horizontal furring strips making a 25 mm space between panel and wall gypsum board.
Test: Composite wall panel 210

12:

Mounting: Directly on wall gypsum board.
Test: Composite wall panel 310

Test procedure:

Method: Room/corner test. 3 walls covered with material
Ignition source: Gas burner, 40 kW, thereafter 160 kW.

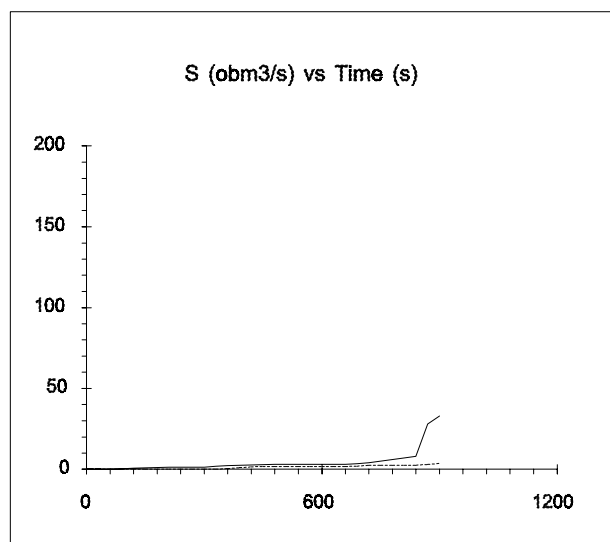
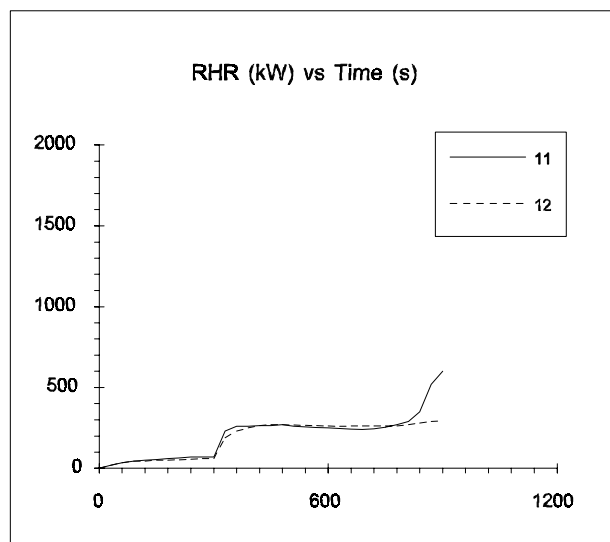
Also available:

Heat flux and gas temp.

Reference:

Söderbom, J
Swedish results from interlaboratory calibration tests according to ISO/ASTM room fire test method
Fire Technology
SP-AR 1991:27
Borås, Sweden 1991

O6/11-12



13: Melamine faced high density non comb. board

The boards were faced on both sides

Thickness: 1.5 + 12 mm

Density: 1055 kg/m³ (total)

Test: 4, MEL FAC

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW in 600 s, thereafter 300 kW in 600 s.

Also available:

Heat flux, gas temp. and flame spread

Reference:

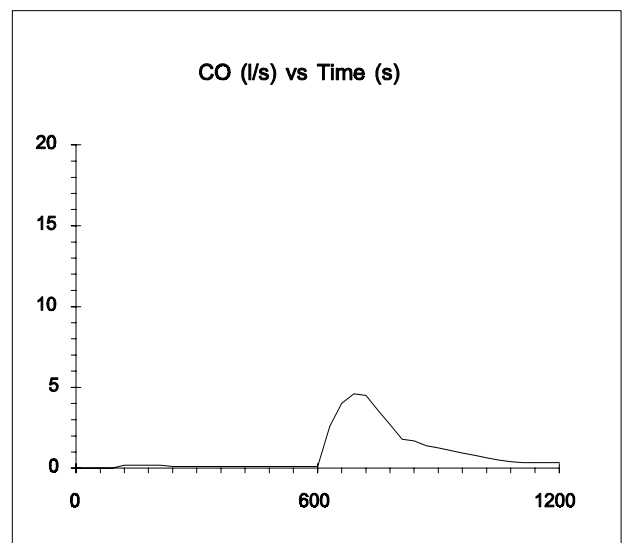
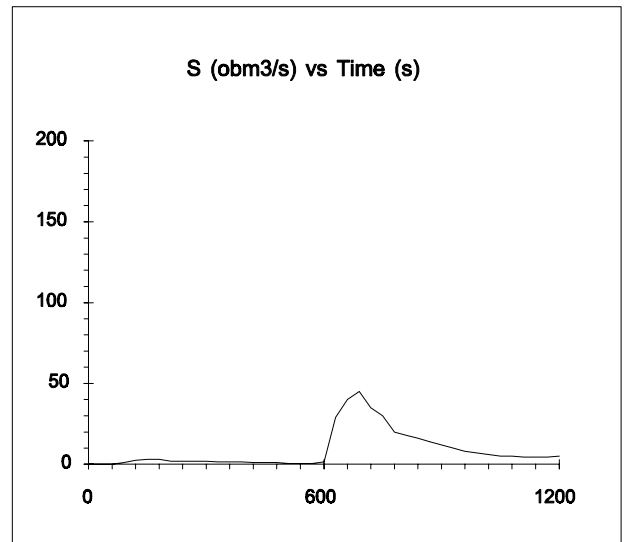
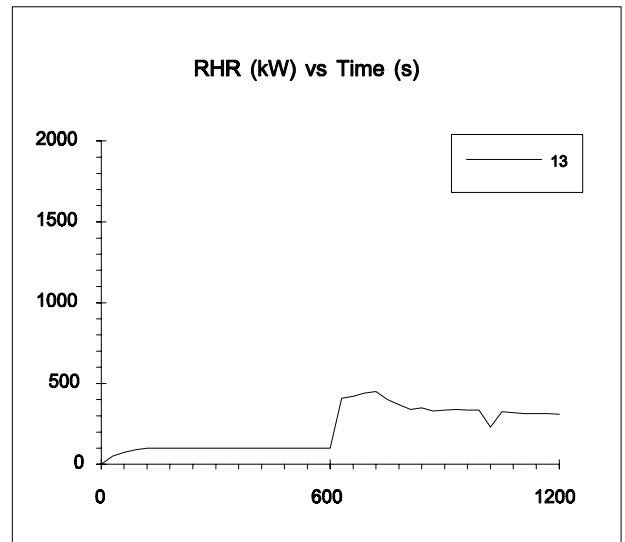
Söderbom, J

EURIFIC - Large Scale Tests according to ISO DIS 9705

Fire Technology

SP REPORT 1991:27, ISSN 0248-5127

Borås, Sweden 1991



20: Expanded PS

Thickness: 50 mm

Density: 20 g/m³

Application: Glued to non-combustible silicate board

Test 10

21: Rigid PU foam

Thickness: 30 mm

Density: 30 g/m³

Test 11

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Gas and surface temp., heat flux, mass flow, burning area and production of CO₂ and hydrocarbons.

Reference:

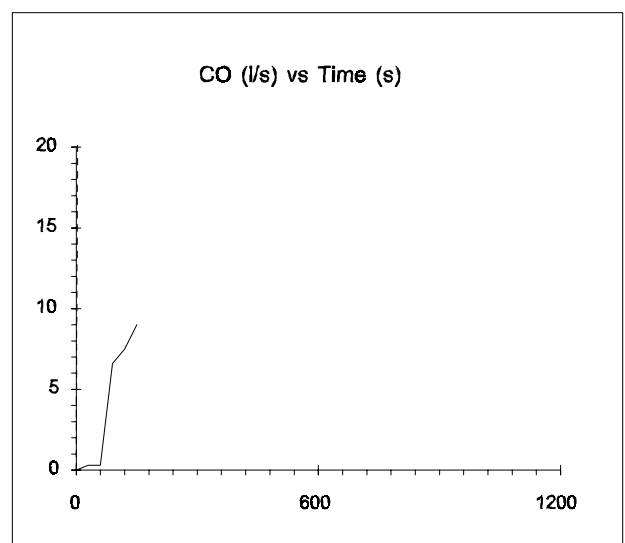
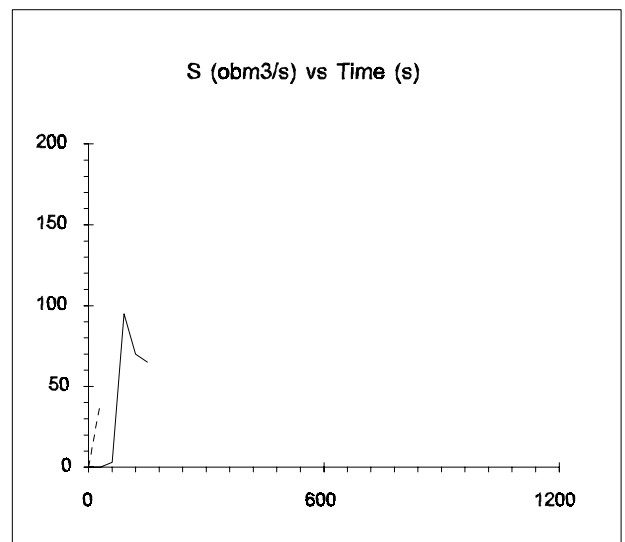
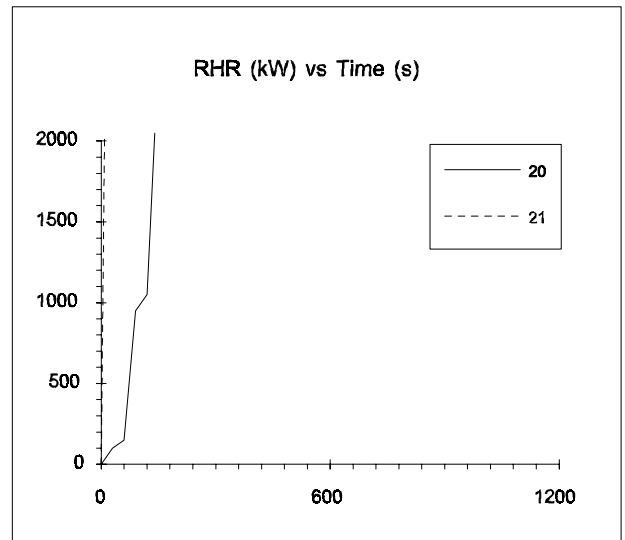
Sundström, B

Full Scale Fire Testing of Surface Materials

Fire Technology

Technical report 1986:45, ISSN 0280-2503

Borås, Sweden 1986



22: FR expanded PS

Thickness: 25 mm (foam)

Density: 37 g/m³

Glued to non combustible board

Test 11, EX.POLYS

Test procedure:

Method: Room/corner test. 3 walls and ceiling covered with material

Ignition source: Gas burner, 100 kW.

Also available:

Heat flux, gas temp. and flame spread

Reference:

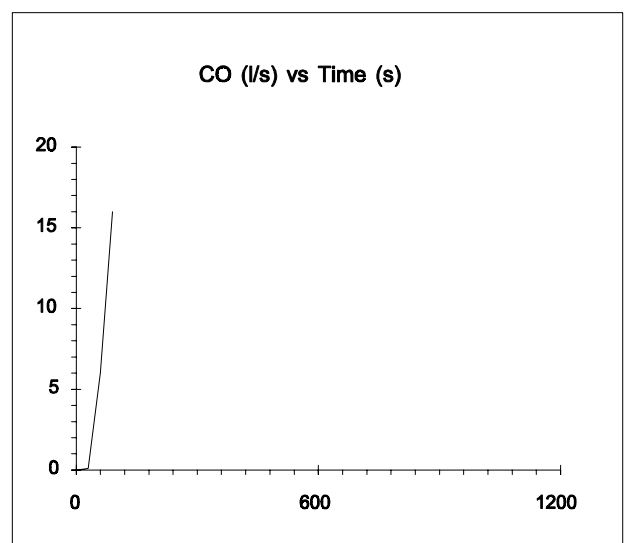
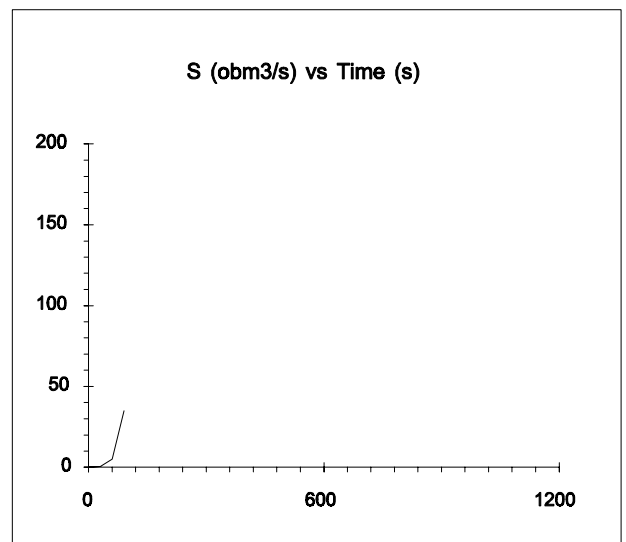
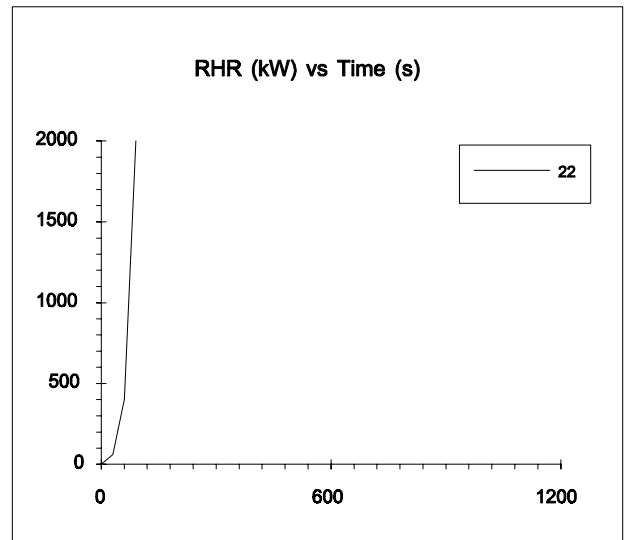
Söderbom, J

EURIFIC - Large Scale Tests according to ISO DIS 9705

Fire Technology

SP REPORT 1991:27, ISSN 0248-5127

Borås, Sweden 1991



10: Simulated navy cabin

Furnishing: Two two-storey beds.

Beds: 0.80 x 2.00 x 0.12 m³ PU foam mattress with a cotton cover, and one pillow. The bottom beds had an additional mattress as a back cushion.

(Total: 6 mattresses)

Walls and ceiling: Non combustible

Room size: 4 x 3 x 2.4 m³

Door opening: 0.8 x 2.1 m²

Room ventilation: 0.060 m³/s

The door was located in the middle of a 12 m corridor with the hood in the open end.

Test procedure:

Method: Room calorimeter

Ignition source: Fibre insulating board, 75 mm in diameter and 75 mm long, soaked in with 120 ml of heptane and wrapped in a polyethylene bag, placed on bottom bed next to the pillow.

Note:

The room was completely burned out after the test.

Reference:

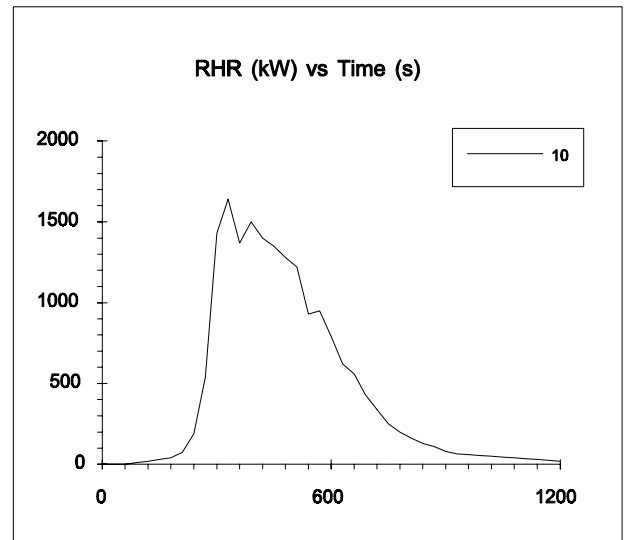
Dahlberg, M

Fartygshytt

Fire Technology

Borås, Sweden

Not published



Room furnished with an office module. The partitions were forming a U, with a desk on one side and a file cabinet on the other.

Partitions: Steel framed hardboard panel covered with
Width: 1.8 + 2.1 + 1.8 m
Height: 1.7 m
Thickness: 41 mm

Desk: Steel frame with plastic top
Size: 1.8 x 0.6 x 0.76 m³
Mass: 59 kg
Paper load: 14 kg

Shelve: Steel shelve 0.56 m above the desk
Size: 1.8 x 0.3 m²
Paper load: 32 kg (open top file boxes)

Drawers: Conventional two drawer steel file cabinet
Paper load: 6 + 6 kg

Chair: Molded plastic, lightly padded and covered with

File cabinet: 5 shelf steel construction
Paper load: 20 + 20 kg on the two top shelves.

20:
Test 320

21: Similar to sample 20, with a rearrangement of the papers on the desk
Test 321

Test procedure:

Method: Room calorimeter
Ignition source: Steel trash can with 1.7 kg paper, in the corner between the desk and the back partition.

Also available:

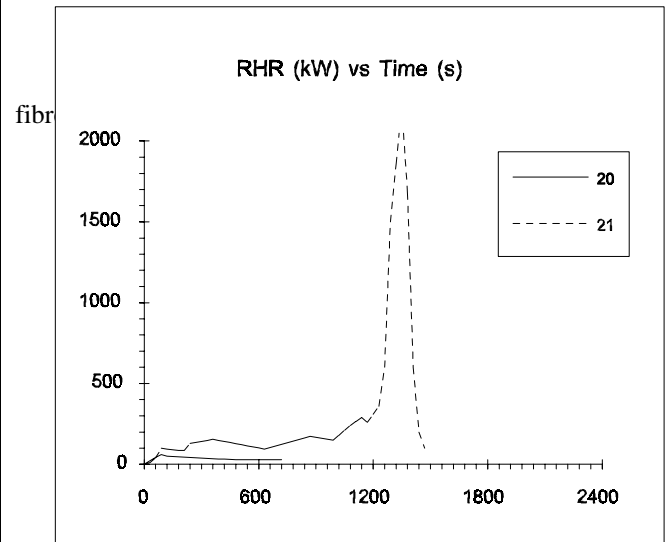
Total heat release, gas temp, and O₂, CO₂ and CO concentrations.

Note:

In sample 20, the fire did not spread from the trash can. Similar tests were performed using different types of water sprinkler.

Reference:

Walton, W. D. & Budnick, E. K.
Quick response Sprinkler in Office Configurations: Fire Test Results
NISTIR 88-3695
U.S.A 1988



synthetic fabric. Steel frame. Mass: 19.5 kg

Offices

Computer work station with a computer desk and a bookcase at right angles to each other.

Computer desk: The desk had a set of 4 shelves above
Plastic laminate covered 16 mm hardboard
Size: 0.60 / 0.24 x 1.24 x 1.52 m³
Mass: 58.1 kg
Paper load: 44.9 kg distributed on the 4 shelves

Book case: 5 shelf construction
Plastic laminate covered 16 mm hardboard
Size: 0.3 x 0.91 x 1.83 m²
Mass: 46.3 kg
Paper load: 72.6 kg distributed on the 5 shelves.

22:

Freeburning
Test 101

23:

In room
Test 102

Test procedure:

Methods:

Sample 22: Freeburning in calorimeter

Sample 23: Room calorimeter

Ignition sources: In the corner between the desk and the book case.

Sample 22: 50 kW gas burner.

Sample 23: Steel trash can with 1.7 kg paper,

Also available:

Total heat release, gas temp, O₂, CO₂ and CO concentrations.

Note:

Similar tests were performed using different types of water sprinkler.

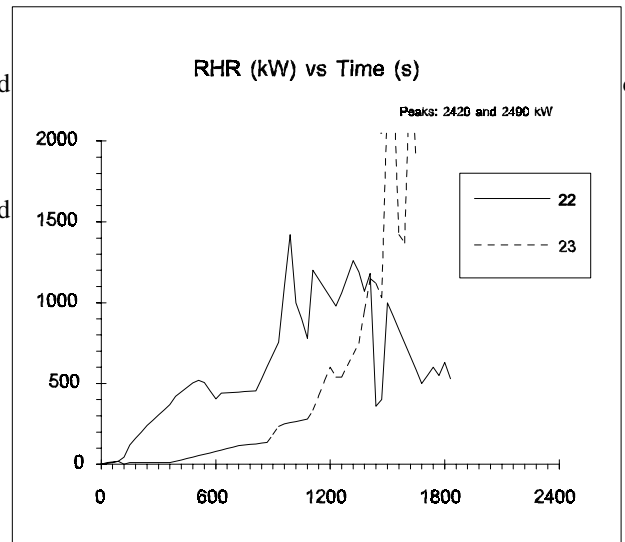
Reference:

Walton, W. D. & Budnick, E. K.

Quick response Sprinkler in Office Configurations: Fire Test Results NISTIR 88-3695

U.S.A 1988

and
and



covered

Y0/22-23

30: Acetone spill in laboratory

Steel laboratory bench with closed drawers and stone bench top. Above the bench there was an open wooden shelving unit.

Bench:

Size: 1.23 x 0.56 x 0.94 m³

Mass: 134 kg

Shelves:

Size: 0.94 x 0.30 x 0.99 m³

Mass: 24.0 kg

Load: Computer paper, folders, notebooks et c. distributed

Mass: 50.8 kg

In the floor pan there was placed a glass disposal

Acetone:

3 l of acetone in a 1.23 x 0.76 m² steel pan on the

1 l of acetone in a 0.61 x 0.46 m² steel pan on the

Test procedure:

Method: Freeburning in calorimeter

Ignition source: Acetone in floor pan ignited

Also available:

Total heat released

Note:

Tests using sprinklers were also performed.

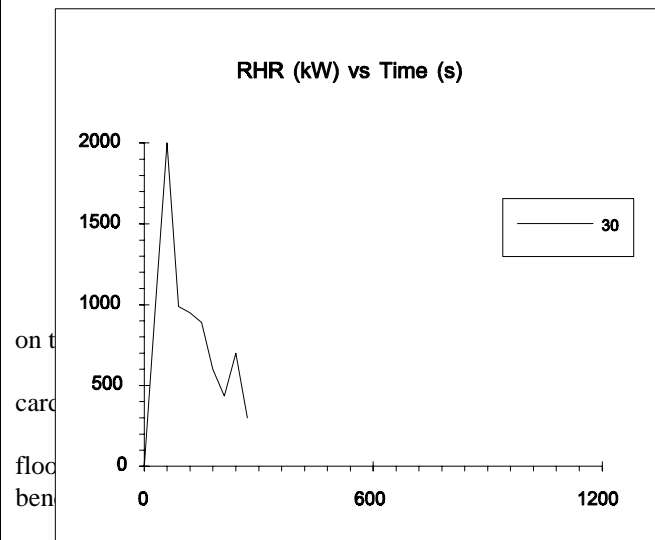
Reference:

Walton, W. D.

Quick Response Sprinkler in Chemical Laboratories: Fire Test Results

NISTIR 89-4200

U.S.A 1989



Coffee makers

10: Melitta

Mass: 1117 g

11: Philips

Mass: 820 g

12: Melitta

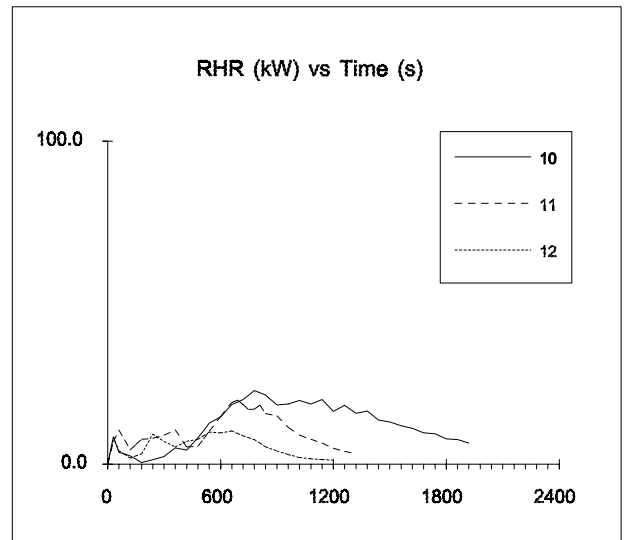
Mass: 1290 g

Test procedure:

Method: Freeburning in furniture calorimeter

Reference:

Andersson, Berit
Kaffebryggare
Departement of Fire Safety Engineering
Lund Institute of Technology, Lund University
Not published



Television sets

The receivers were manufactured in the early 1960's

Frame: Wood

Back cover and components: Plastics

The components were covered with dust from twenty years of use.

20: Luxor Carina, 24"

Mass: 32.7 kg

Expt.no. 1

21: Luxor Continental, 26"

Mass: 39.8 kg

Expt.no. 3

Test procedure:

Method: Room calorimeter, in the corner.

Ignition source: 100 ml isopropanol in tray, about 4 kW, inside the TV sets.

| | | |
|---------------------------|----|----|
| Sample: | 20 | 21 |
| H_{eff} (MJ/kg): | 14 | 15 |

Also available:

Radiation and gas temp.

Reference:

Ahonen, A, Kokkala, M & Weckman, H.

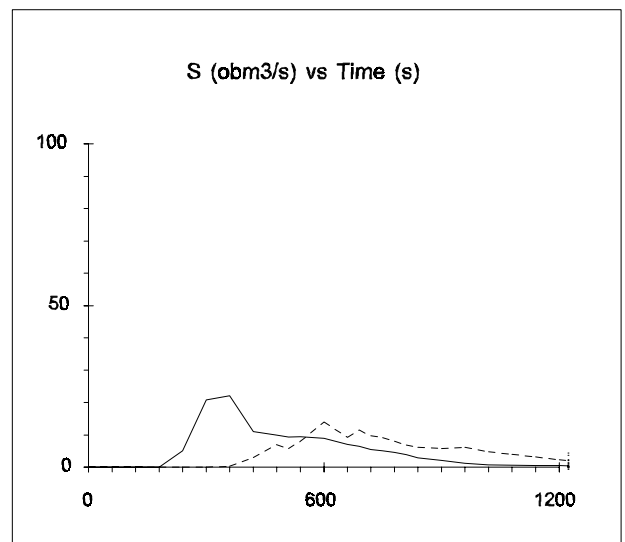
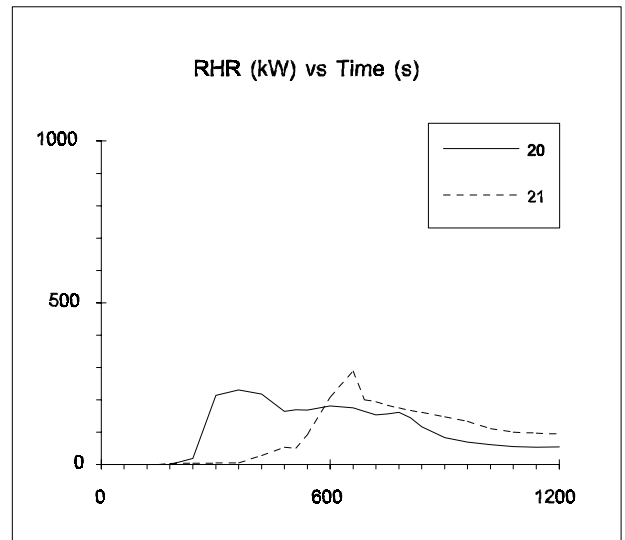
Burning Characteristics of potential ignition sources of room fires

Technical Research Center of Finland

Research reports 285, ISSN 0358-5077

Espoo, Finland 1985

Y1/20-21



Television sets

Two cabinets with the spacing 0.025 m.
The TV cabinets were moldings of an external cabinet only. The opening was closed with a steel cover. No internal working parts were used.
Size: 0.36 x 0.33 x 0.25 m³
Thickness: 3.0 mm

22:

High impact polystyrene base formulation.
Mass: 3.7 kg
Sample H.

23: FR

High impact polystyrene bas formulation with decabromodiphenyl oxide (12% by mass) and antimony oxide (4% by mass).
Mass: 3.7 kg
Sample G.

Test procedure:

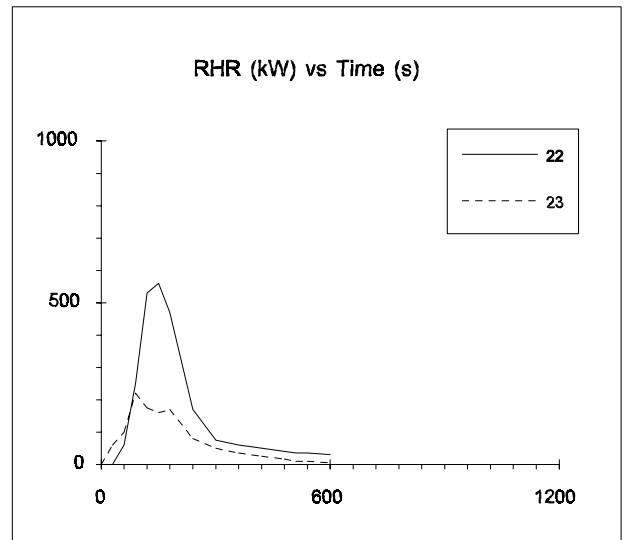
Method: Freeburning in furniture calorimeter
Ignition source: 50 kW gas burner in 200 s, positioned between the cabinets.

| | | |
|-------------------------------|-------|-------|
| Sample: | 22 | 23 |
| H _{eff} (MJ/kg): | 23 | 20 |
| Smoke (obm ³ /kg): | 13200 | 28000 |
| CO (kg/kg): | 0.12 | 0.37 |
| CO ₂ (kg/kg): | 1.39 | 0.74 |
| HBr (kg/kg): | NA | 0.08 |

Reference:

Babrauskas, V et al.
Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products
National Bureau of Standards
NBS Special Publication 749
U.S.A. 1988

Y1/22-23



Two Business machine cabinets with the spacing 0.025 m.
The cabinets were moldings of an external cabinet only.
No internal working parts were used.
Thickness: 3.0 mm.

25:

Poly(2,6-dimethyl 1,4-phenylene)oxid, also including polystyrene, polybutadiene, polyethylene, mineral oil and stabilizer additives.

Mass: 3.5 kg

Sample F

26: FR

The same base formulation as sample 25 with a triaryl phosphate ester based flame retardant (1% by mass).

Mass: 3.5 kg

Sample A.

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: 50 kW gas burner in 200 s, positioned between the cabinets.

| | | |
|-------------------------------------|-------|-------|
| Sample: | 25 | 26 |
| H_{eff} (MJ/kg): | 24 | 28 |
| Smoke (obm^3/kg): | 11500 | 12800 |
| CO (kg/kg): | 0.13 | 0.29 |
| CO ₂ (kg/kg): | 1.61 | 1.45 |

Reference:

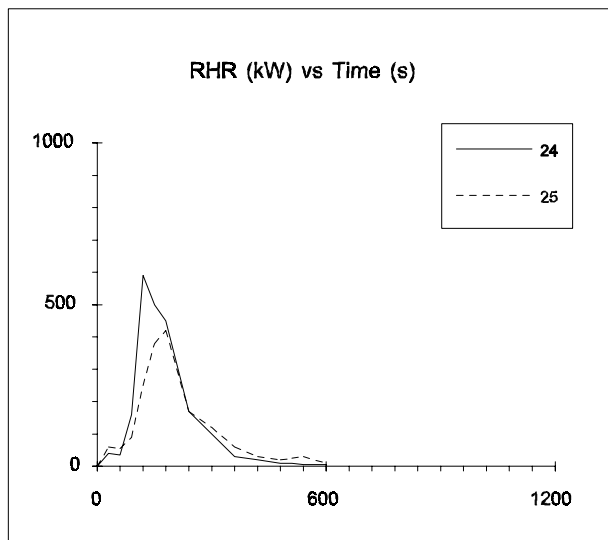
Babrauskas, V et al.

Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products

National Bureau of Standards

NBS Special Publication 749

U.S.A. 1988



Simulated clothing:

Four different fabrics placed into the wardrobes on 16 clothes hangers. 53% cotton, 47% polyester.

Mass: 0.87 kg,

10: Steel wardrobe

Size: 0.47 x 1.22 x 1.6 m³

Thickness: 0.69 mm

Painted

Test 21

11: Plywood wardrobe

Size: 0.61 x 1.22 x 1.78 m³

Thickness: 12.7 mm

Unfinished

Test 43

12: Particle board wardrobe with drawers and shelves

Back covered with 3.2 mm hardboard

Shelves covered with plastic laminate

Size: 0.4 x (0.42 wardrobe + 0.81 drawers and shelves) x 1.6 m³

Thickness: 19.1 mm

Test 61

Test procedure:

Method: Freeburning in furniture calorimeter. The wardrobe door next to the ignition box was closed and the other door was opened 178 mm.

Ignition source: Cardboard box filled with 10 sheets of crumpled newspaper placed in the corner of the wardrobe under the fabrics. Total mass 0.90 kg.

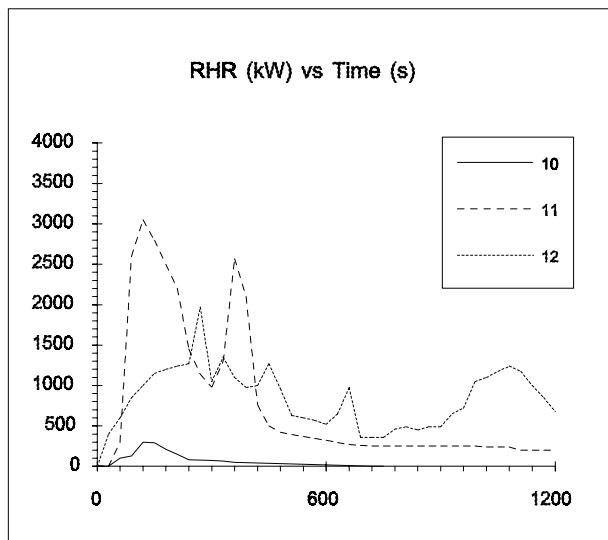
| Sample: | 10 | 11 | 12 |
|---------------------------|------|------|------|
| H _{eff} (MJ/kg): | 18.8 | 14.9 | 17.5 |
| CO (g/s), peak: | 0.3 | 2.3 | 1.2 |

Also available:

Mass loss, target irradiance and smoke particulate conversion

Reference:

Lawson, J.R et al
 Fire Performance of Furnishings As Measured in the NBS Furniture Calorimeter. Part I
 National Bureau of Standards
 NBSIR 83-2787
 U.S.A. 1983



Simulated clothing:

See page Y3.1/10

Plywood wardrobe

Size: 0.62 x 1.22 x 1.82 m³

Thickness: 3.2 mm

Rolling doors

13:

Unfinished

Test 41

14:

1 coat FR latex paint on the inside

Test 42

15:

2 coats FR latex paint inside and out

Test 44

Test procedure:

See page Y3.1/10

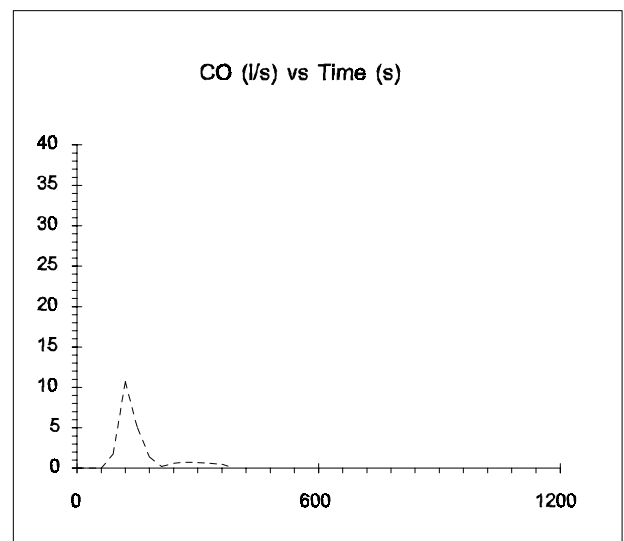
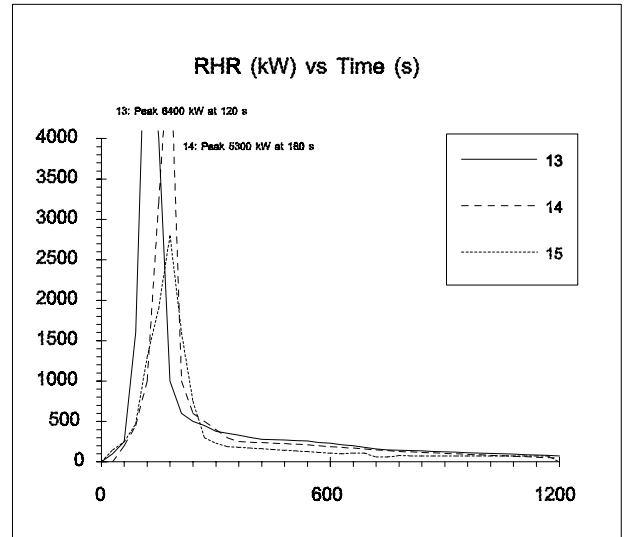
| | | | |
|---------------------------|------|------|------|
| Sample: | 13 | 14 | 15 |
| H _{eff} (MJ/kg): | 16.9 | 15.9 | 14.2 |
| CO (g/s), peak: 3.1 | 12.6 | 7.7 | |

Also available:

See page Y3.1/10

Reference:

See page Y3.1/10



Hospital records closely packed in a set of 3 metal shelves.

10: Hospital records

Paper envelopes containing paper. Not even a tray with 2 dl ethanole was sufficient to get a fast fire growth. No data available.

11: X-ray records

Paper envelopes containing paper and plastic X-ray plates. At 450 s one metal shelf collapsed and the journals fell inwards. Melted plastics dripped on the bottom shelf but did not ignite the journals.

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Match on journal at the middle shelf

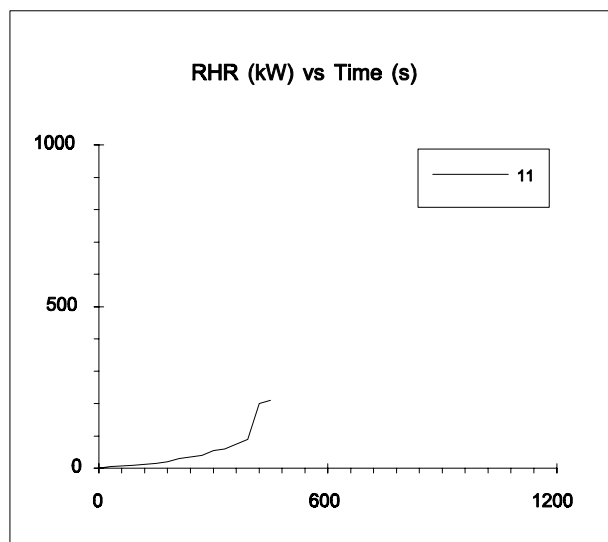
Reference:

Malmquist, P-O

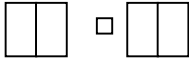
Riskanalys, Helsingborgs lasarett - arkivet

Helsingborgs brandförsvär

Helsingborg, Sweden 1988



Four open shelving units placed as in the figure:



Each unit consisted of:

5 steel shelves with vertical steel support at the corners.

Size: 0.91 x 0.46 x 1.80 m³

Shelf loads:

1(bottom) and 2: 37 kg horiz. stacked paper each.

3 and 4: 14 kg paper in open top vert. file holders each.

5 (top): 19 kg paper in closed cardboard boxes.

12: Open shelving unit with paper

Distance between the units: 0.7 m

Test 201

13: Open shelving unit with paper

Two boxes with paper products were placed in the aisle between the units. Total mass: 3 kg

Distance between the units: 0.61 m

Test 202

Test procedure:

Method: Freeburning in calorimeter

Ignition source: 50 kW gas burner located as shown in the figure, 0.37 m above the floor

Also available:

Total heat release

Note:

In sample 13 all the units were involved in the fire.

In sample 12 only the two units next to the burner were involved.

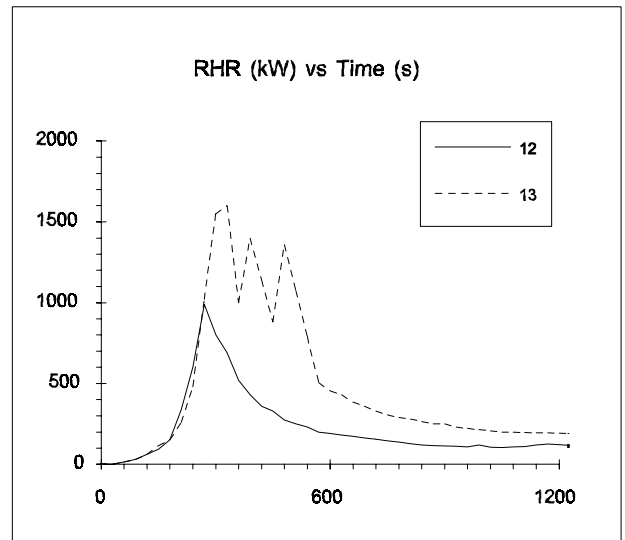
Reference:

Walton, W. D. & Budnick, E. K.

Quick response Sprinkler in Office Configurations: Fire Test Results

NISTIR 88-3695

U.S.A 1988



14: Book case with file holders

3 shelve book case

Frame: Fibre board and hard board (back)

Size: 0.64 x 0.38 x 1.22 m³

Mass: 19.1 kg

Load: Paper in 15 open top PS file holders

Mass: 3.8 kg (PS) + 7.0 kg (paper) distr. on 3 shelves

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Cigarette lighter

Note:

The plastic were melting, making a liquid pool fire on the floor under the book case

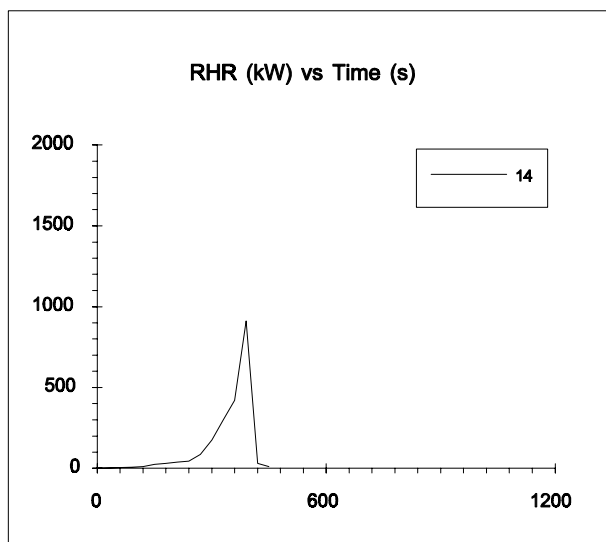
Reference:

Andersson, L et al.

Universitetsbiblioteket. Risker och brister vid utrymning

Brandingenjörslinjen, Lunds Tekniska Högskola

Lund, Sweden 1988



Single pallet freeburn tests

50: FMRC standard plastic commodity

125 PS cups packaged in compartmented, singlewall corrugated cartons on wood pallet.

Size 530 x 530 x 510 mm³

Weight: 6850 g (4125 g PS and 2725 g carton)

Pallet load: 8 cartons in a 2 x 2 x 2 array

51: CEA Standard commodity

PS chips packaged in singlewall corrugated cartons (completely filled) on wood pallet.

Size 450 x 550 x 370 mm³

Weight: 1145 g (340 g PS and 805 g carton)

Pallet load: 12 cartons in a 2 x 2 x 3 array

52: SCEA Swedish standard commodity

PS chips packaged in singlewall corrugated cartons (completely filled) on wood pallet. Not the same shape as the CEA-chips

Size 380 x 570 x 380 mm³

Weight: 1120 g (420 g PS and 700 g carton)

Pallet load: 12 cartons in a 2 x 2 x 3 array

53: Large SCEA Swedish standard commodity

PS chips packaged in cartons filled to 75-80% on wood pallet. Quality of chips and cartons identically to the SCEA goods.

Size 600 x 800 x 500 mm³

Weight: 2690 g (1220 g PS and 1470 g carton)

Pallet load: 4 cartons in a 1 x 2 x 2 array

Test procedure:

Method: Freeburning in industry calorimeter

Ignition source: Fibre insulating board, 75 mm in diameter and 75 mm long, soaked in with 120 ml of heptane and wrapped in a polyethylene bag

| | | | | |
|---------------------------|------|------|------|------|
| Sample: | 50 | 51 | 53 | 54 |
| H _{eff} (MJ/kg): | 21.0 | 13.7 | 12.6 | 10.9 |

Reference:

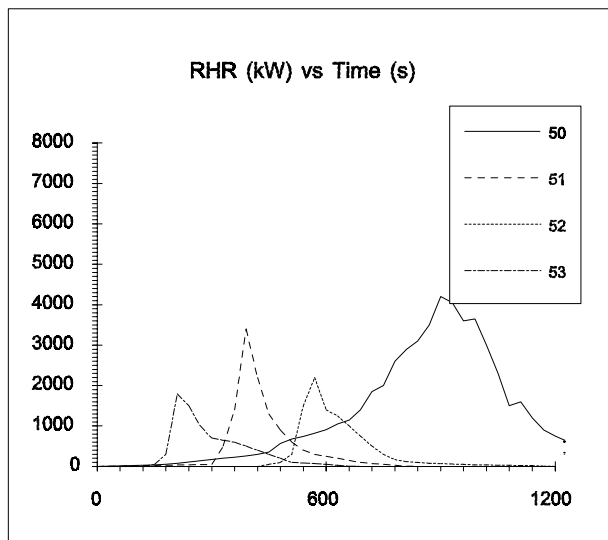
Persson, H

Evaluation of the RDD-measuring technique

Swedish National Testing and Research Institute

SP Report 1991:04, ISSN 0284-5172

Borås, Sweden 1991



Pallet systems

Pallet storage with water sprinkler

54: CEA Standard commodity

Same as sample Y3.3/51

Post pallet system

Fuel array: 12 pallets in a 2 x 2 x 3 array

Flue spaces: 450 mm (short side) and 150 mm (long side)

55:

Same as sample Y3.3/54

Fuel array: 8 pallets in a 2 x 2 x 2 array

56: SCEA Swedish standard commodity

Same as sample Y3.3/52

Post pallet system

Fuel array: 12 pallets in a 2 x 2 x 3 array

Flue spaces: 335 mm (short side) and 270 mm (long side)

57:

Same as sample Y3.3/56

Fuel array: 8 pallets in a 2 x 2 x 2 array

58: Large SCEA Swedish standard commodity

Same as sample Y3.3/53

Post pallet system

Fuel array: 8 pallets in a 2 x 2 x 2 array

Test procedure:

Method: Freeburning in industry calorimeter

Ignition source: Fibre insulating board, 75 mm in diameter and 75 mm long, soaked in with 120 ml of heptane and wrapped in a polyethylene bag, placed in the center of the flue space at the bottom of the pallet loads of the lowest tier.

Also available:

Required Delivered Density for the sprinkler system

Note:

In the tests, water sprinkler were used. The rate of heat release is given until the sprinkler was activated

Reference:

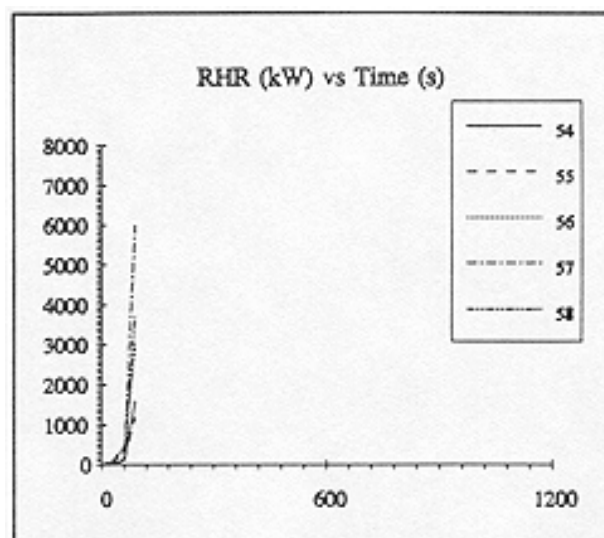
Persson, H

Evaluation of the RDD-measuring technique

Swedish National Testing and Research Institute

SP Report 1991:04, ISSN 0284-5172

Borås, Sweden 1991



Pallet systems

PET bottles in crates (Swedish standard bottle) on wood pallet

Bottles: Polyethene, volume 1.5 l, empty

Crates: Plastic, each containing 6 bottles

Crate size: 0.27 x 0.30 x 0.40 m³

Pallet load: 36 crates in a 3 x 4 x 3 array

Pallet size: 0.81 x 1.21 x 1.34 m³

Total mass: 83.2 kg

59:

Single pallet

60:

Double row steel rack

Fuel array: 8 pallets in a 2 x 2 x 2 array

Water sprinkler started at 330 s

Test procedure:

Method: Freeburning in industry calorimeter

Ignition source: Fibre insulating board, 75 mm in diameter and 75 mm long, soaked in with 120 ml of heptane and wrapped in a polyethylene bag, placed in the center of the flue space at the bottom of the pallet loads of the lowest tier.

Also available:

Required Delivered Density for the sprinkler system

Note:

In sample 60, water sprinkler were used. The rate of heat release is given until the sprinkler was activated.

A test was performed with bottles filled with sparkling water that showed to be almost self-extinguishing. No data available.

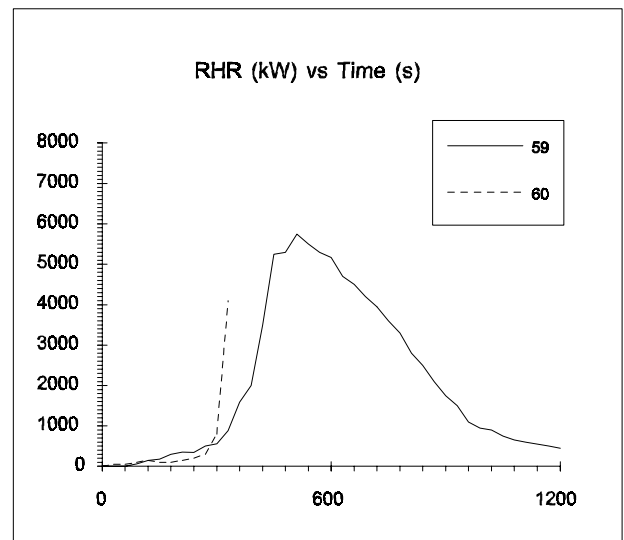
Reference:

Arvidson, M. & Persson, H

Sprinkling av PETflaskor

Brand & Raddning, 3/93, pp 26-27, ISSN 0283-1155

Katrineholm, Sweden 1993



Waste baskets

Polyethylene paper baskets

10:

14 l basket with tight walls

Mass: 0.63 kg

Filling: Shredded paper, 0.20 kg

Expt.no. 4

11:

14 l basket with net walls

Mass: 0.53 kg

Filling: Shredded paper, 0.20 kg

Expt.no. 6

12:

14 l basket with net walls

Mass: 0.53 kg

Filling: Milk cans (parafinized cardboard), 0.41 kg

Expt.no. 7

Test procedure:

Method: Room calorimeter, in the corner.

Ignition source: 20 cm cotton wire wetted in isopropanol.

Sample 13 was ignited with 10 ml isopropanol on a 20 cm² tray, appr. 1 kW.

Sample: 10-12

Smoke prod: Hardly visible

Also available:

Gas temp.

Note:

Sample 10 only melted. The filling burned.

Reference:

Ahonen, A, Kokkala, M & Weckman, H.

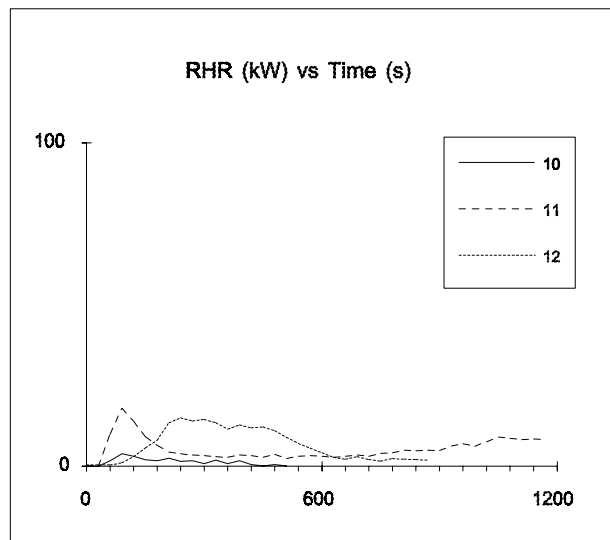
Burning Characteristics of potential ignition sources of room fires

Technical Research Center of Finland

Research reports 285

Espoo, 1985

Y3.4/10-12



Waste baskets

Polyethylene waste baskets

13:

6.6 l basket

Filling: 12 milk cartons

14:

Simplified representation from 5 samples similar to sample 13

Test procedure:

Method: Freeburning in furniture calorimeter.

Reference:

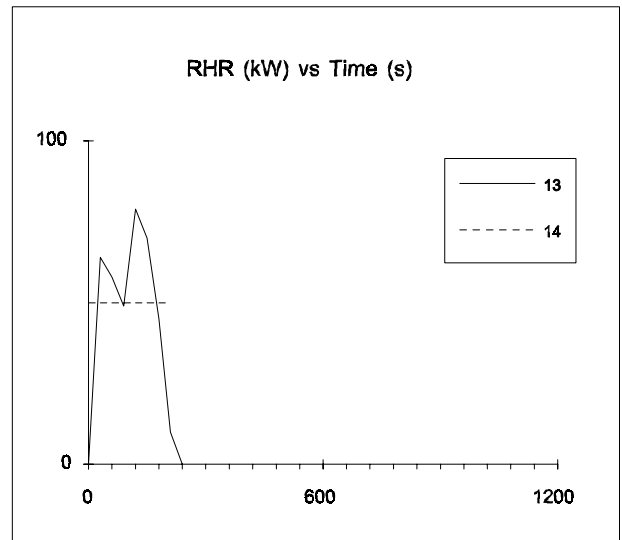
Babrauskas, V.

Burning Rates

The SFPE Handbook of Fire Protection engineering, pp 2-1 to 2-15

U.S.A., 1988

Y3.4/13-14



Rubbish sacks

20: One sack

Filling: straw, grass and duff

Mass: 4.1 kg

21: Three sacks

Filling: paper rubbish

Mass: 3.51 kg

22: Two sacks

Filling: paper rubbish

Mass: 2.34 kg

23: One sack

Filling: paper rubbish

Mass: 1.17 kg

Test procedure:

Method: Freeburning in furniture calorimeter

Reference:

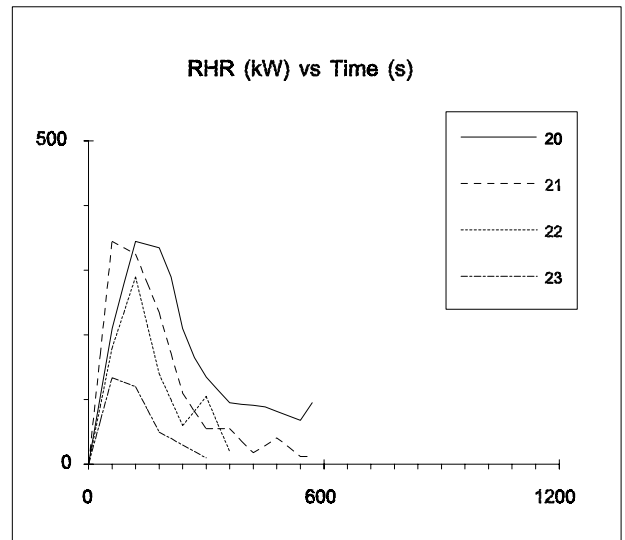
Babrauskas, V.

Burning Rates

The SFPE Handbook of Fire Protection engineering, pp 2-

1 to 2-15

U.S.A., 1988



Chairs, stackable

Stackable plastic chairs
Neither padding nor cushions
Seat and back: Polypropylene (one piece)
Legs: Metal
Size: 0.50 x 0.55 x 0.70 m³
Mass: 1.49 kg (combustible)

10: Single chair

11: 5 chairs in 1 row

Middle chair ignited

12: 8 chairs in 4 rows

Chair in second row ignited

13: 6 chairs in 1 stack

Top chair ignited

14: 12 chairs in 2 stacks

Top chair ignited

Test procedure:

Method: Freeburning in furniture calorimeter.

Ignition source: 17 g wooden cribs at the seat.

Also available:

Total mass loss, CO₂-production and heat flux

Note:

The chairs were melting, making a liquid pool fire on the floor under the chairs.

Reference:

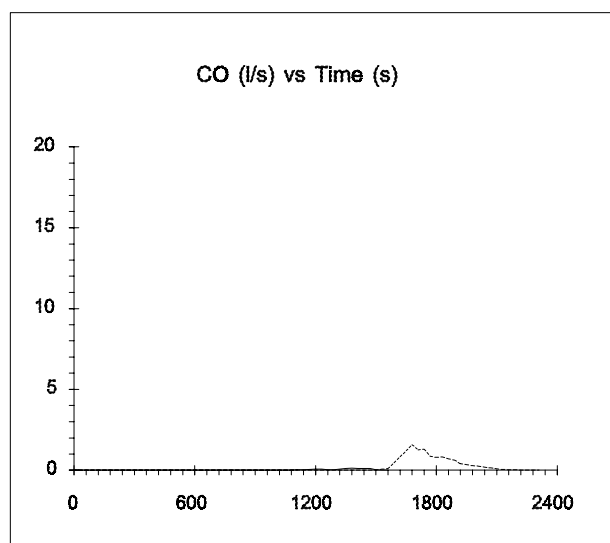
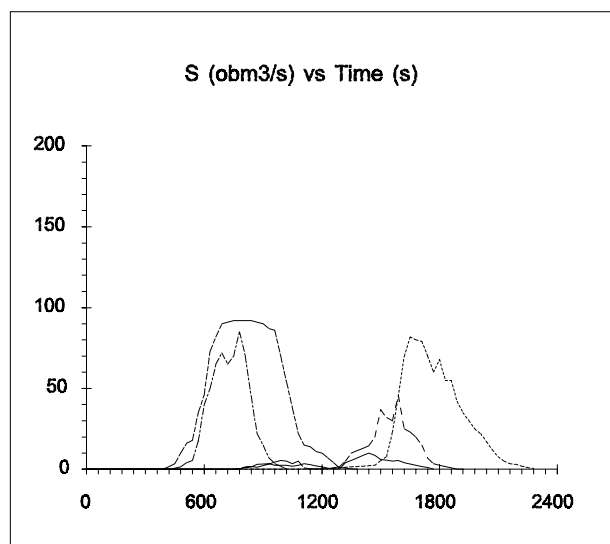
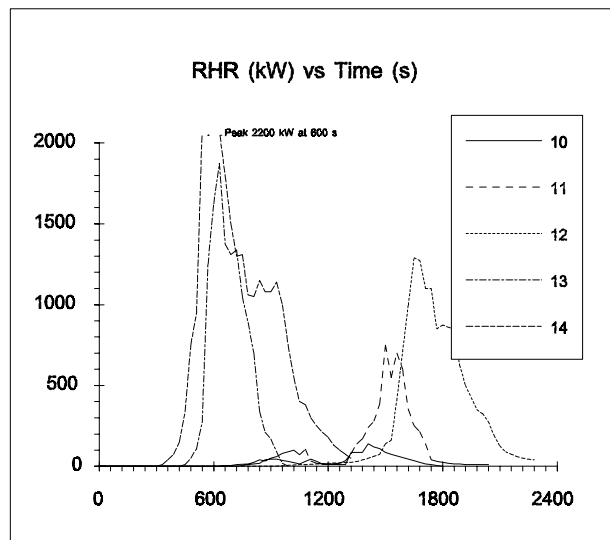
Irjala, B-L

Muovituolien palo-ominaisuuksien selvittäminen

VTT, 76/759/86

Espoo, Finland, 1986

Y5.0/10-14



Chairs, stackable

Metal framed chairs containing approx. 0.5 kg PU foam and 2 kg cellulosic materials

15: Single chair

16: 4 chairs in 1 stack

17: 8 chairs in 1 stack

18: 8 chairs in 1 stack

Burned in the corner of a standard room

Test procedure:

Method: Freeburning in furniture calorimeter.

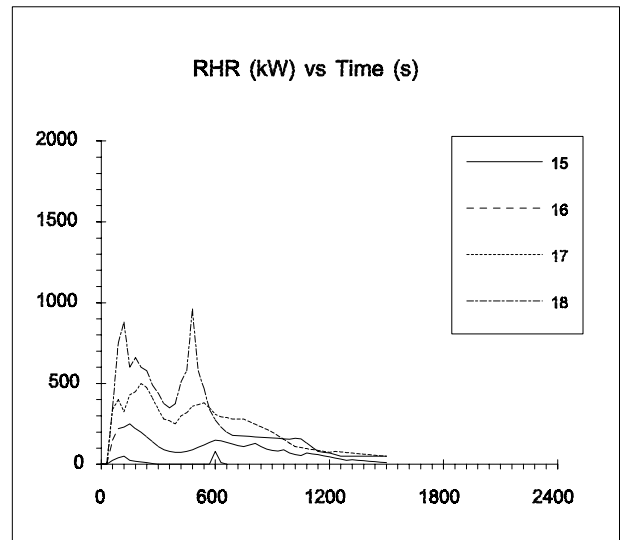
Ignition source: NA

| | | |
|---------------------------|----|----|
| Sample: | 17 | 18 |
| H_{eff} (MJ/kg): | 12 | 18 |

Reference:

Williamson, R. B., & Dembsey, N. A.
Advances in Assessment Methods for Fire Safety
Fire Safety Journal, Vol 20 No 1, pp 15-38
1993

Y5.0/15-18



Chairs, stackable

19: 4 chairs in 1 stack

Seat and back: Plywood with PU padding

Frame: Metal

Size: 0.56 x 0.44 x 0.81 m³

Mass: 29.94 kg

Test 75

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Gas burner at the side of the stack, 50 kW in 200 s (subtracted from the RHR).

| | |
|---------------------------|------|
| Sample: | 19 |
| H _{eff} (MJ/kg): | 18.7 |
| CO prod. (g/s), peak | 0.3 |

Also available:

Mass loss, target irradiance and smoke particulate conversion

Reference:

Lawson, J.R. et al.

Fire Performance of Furnishings As Measured in the NBS

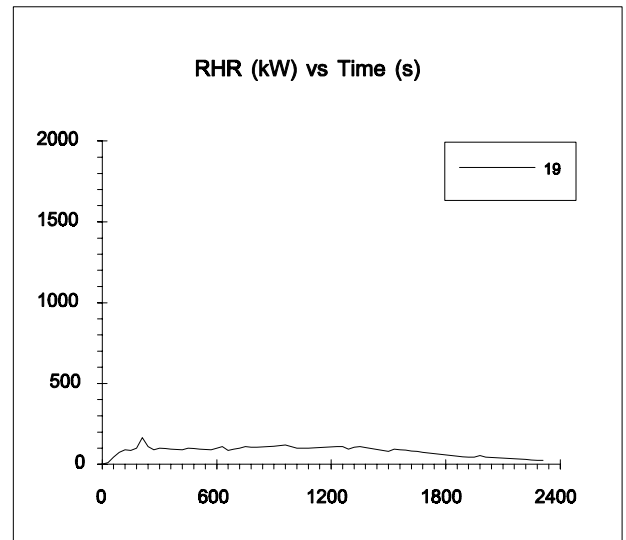
Furniture Calorimeter. Part I

National Bureau of Standards

NBSIR 83-2787

U.S.A. 1983

Y5.0/19



10: One piece molded glassfibre

Neither padding nor cushions

Legs: Metal

Size: 0.61 x 0.64 x 0.74 m³

Mass: 5.28 kg

Test 51

11: Group setting chair

Frame: Metal with plywood seat and back

Padding: Thin PU foam

Cover: Synthetic fibre fabric

Size: 0.46 x 0.51 x 0.76 m³

Mass: 6.08 kg

Test 55

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Gas burner at the side of the chair, 50 kW in 200 s (subtracted from the RHR).

| | | |
|---------------------------|------|------|
| Sample: | 10 | 11 |
| H _{eff} (MJ/kg): | 26.2 | 19.2 |
| CO (g/s), peak: | 0.3 | 0.0 |

Also available:

Mass loss, target irradiance and smoke particulate conversion

Reference:

Lawson, J.R. et al.

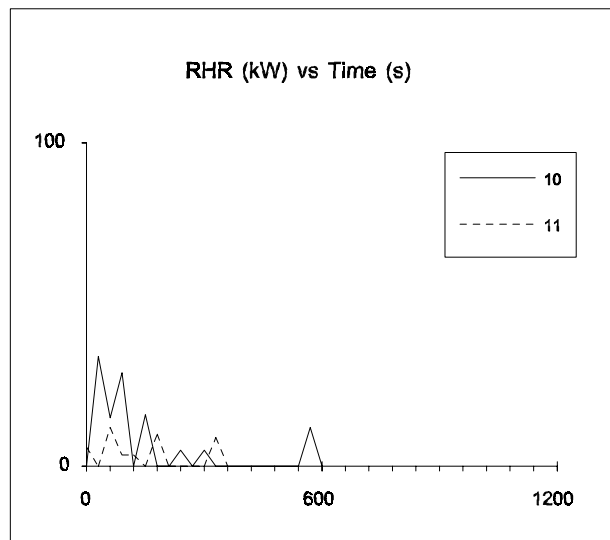
Fire Performance of Furnishings As Measured in the NBS

Furniture Calorimeter. Part I

National Bureau of Standards

NBSIR 83-2787

U.S.A. 1983



50:

Frame: Metal
 Padding: PU foam on 16 mm particle board
 Cover: Polyester fibre
 Size: 0.89 x 0.61 x 1.07 m³
 Mass: 20.82 kg
 Test 47

51:

Frame: Metal
 Padding: Vegetable fibre and cotton
 Cover: Plastic coated fabric
 Size: 0.76 x 0.56 x 0.86 m³
 Mass: 16.52 kg
 Test 50

52:

Frame: Metal
 Padding: PU foam on 12.7 mm plywood
 Cover: Plastic coated fabric
 Size: 0.81 x 0.66 x 0.79 m³
 Mass: 15.54 kg
 Test 53

53:

Frame: Wood
 Padding: Latex foam on 14 mm plywood. On the seat also 10% cotton felt
 Cover: Plastic coated fabric
 Size: 0.64 x 0.61 x 0.76 m³
 Mass: 11.20 kg
 Test 56

Test procedure:

Method: Freeburning in furniture calorimeter
 Ignition source: Gas burner at the side of the chair, 50 kW in 200 s (subtracted from the RHR).

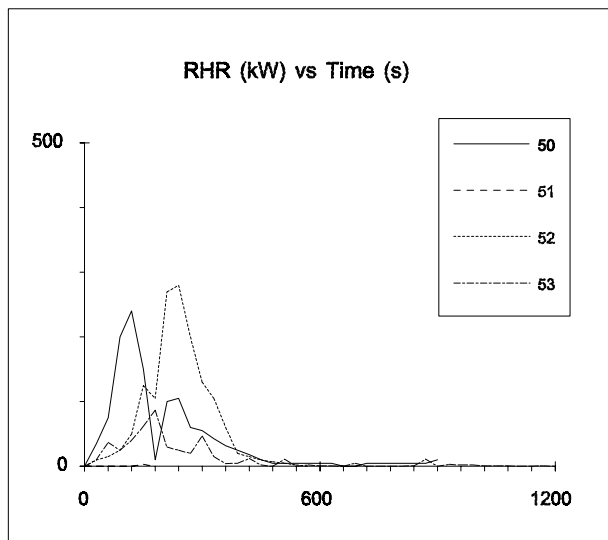
| Sample: | 50 | 51 | 52 | 53 |
|---------------------------|------|-----|------|------|
| H _{eff} (MJ/kg): | 21.8 | NA | 21.4 | 16.5 |
| CO (g/s), peak: | 0.4 | 0.0 | 1.1 | 0.3 |

Also available:

Mass loss, target irradiance and smoke particulate conversion

Reference:

Lawson, J.R. et al.
 Fire Performance of Furnishings As Measured in the NBS Furniture Calorimeter. Part I
 National Bureau of Standards
 NBSIR 83-2787
 U.S.A. 1983



2-cushion mock-up chairs

Built according to BS 5852

Pillow size (seat and back): 0.5 x 0.5 x 0.075 m³

Filling: PU foam, 0.95 kg

Cover: 52% linen / 48% cotton fabric, 0.43 kg

54: Single chair

Ignited with 2 meteneamine tablets

Expt.no.12

55: Single chair

Ignited with 1 meteneamine tablet

Expt.no.13

56: Doubled chair

Ignited with 2 meteneamine tablets

Expt.no.14

Test procedure:

Method: Room calorimeter, in the corner.

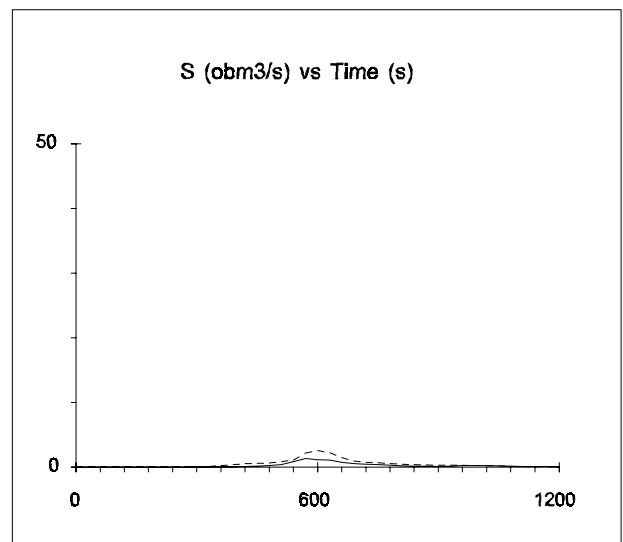
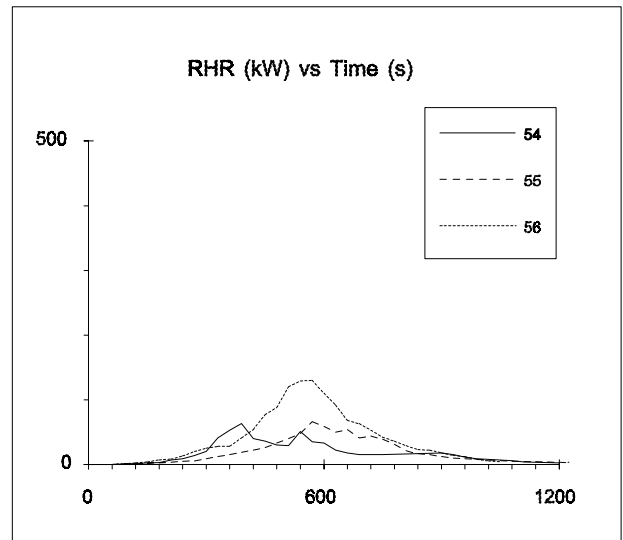
Ignition source: Metheneamine tablets located at the junction of the seat and the back at each pair of pillows.

| | | | |
|---------------------------|----|----|----|
| Sample: | 54 | 55 | 56 |
| H_{eff} (MJ/kg): | 15 | 16 | 17 |

Reference:

Ahonen, A, Kokkala, M & Weckman, H.
Burning Characteristics of Potential Ignition Sources of Room Fires
Technical Research Center of Finland
Research reports 285
Espoo, Finland 1985

Y5.2/54-56



2-cushion mock-up chairs

With plastic covers

Built according to BS 5852

Pillow size (seat and back): 0.5 x 0.5 x 0.075 m³

57:

Filling: FR PU foam, 35 kg/m³

Interliner: FR polyester wadding, 200 g/m²

Cover: Imitation suede, 1.3 mm, 420 g/m²

Test no II, 6A

58: Identical to 57 with

Filling: FR PU foam, 30 kg/m³

Test no II, 6B

59:

Filling: FR PU foam, 33 kg/m³

Cover: PVC furniture plastics, 670 g/m²

Test no I, 17

60: Identical to 59 with

Interliner: FR cotton fabric, 150 g/m²

Test no I, 10B

Heat release below 25 kW, no data available

61:

Filling: FR PU foam, 65 kg/m³

Cover: PVA PVC fabric, 475 g/m²

Test no I, 13

62: Identical to 62 with

Interliner: FR cotton fabric, 150 g/m²

Test no I, 13B

Heat release below 25 kW, no data available

Test procedure:

Method: Room calorimeter, near back wall.

Ignition source: Wooden cribs (BS-7) on the seat in contact with the back.

Also available:

Radiation, temp, CO₂ production and mass loss

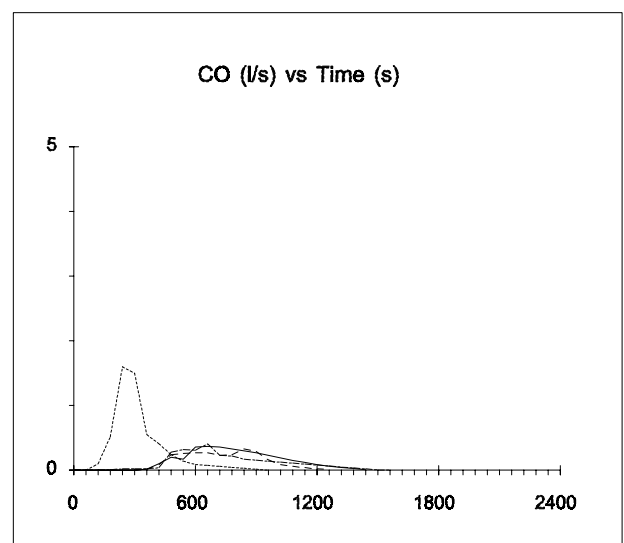
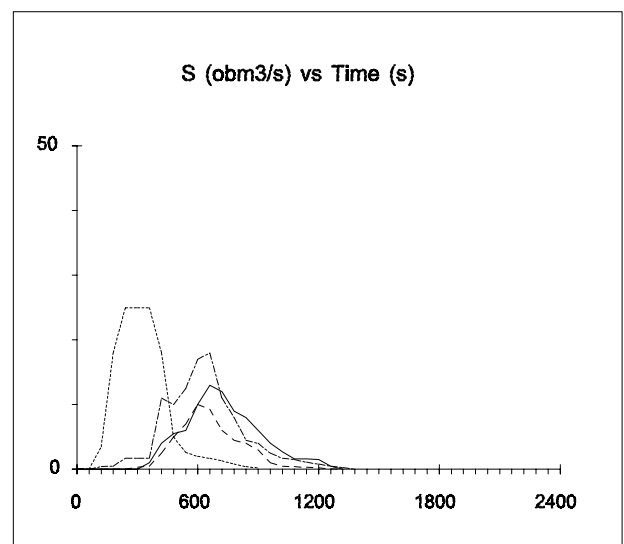
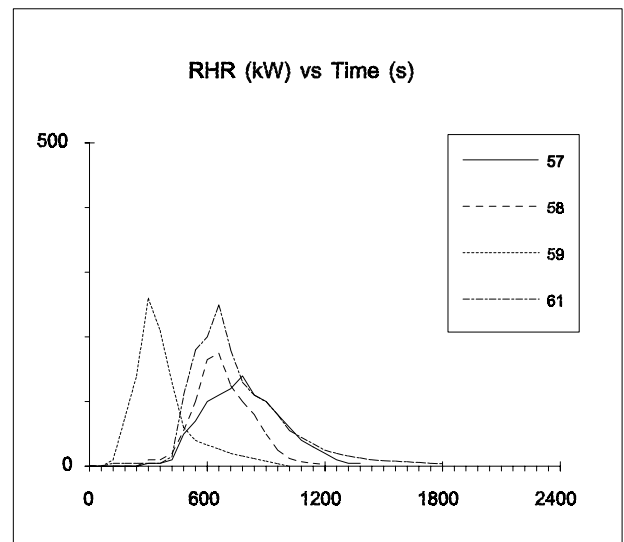
Note:

Sample 59 had a peak S above 25 obm³/s.

Reference:

See page Y5.2/63

Y5.2/57-62



2-cushion mock-up chairs

With cotton velvet covers

Construction, see page Y5.2/57

63:

Filling: FR PU foam, 33 kg/m³

Cover: FR cotton velvet, 380 g/m²

Test no I, 1

Heat release below 25 kW, no data available.

64: Identical to 63 with

Interliner: FR PU foam, 20 mm, 35 kg/m³

Ignition source: BS-5

Test no II, 1A

Heat release below 25 kW, no data available.

65: Identical to 64

Ignition source: BS-7

Test no II, 1AX

66: Identical to 64

Ignition source: Burning curtain

Test no II, 1B

67: Identical to 63 with

Filling: FR PU foam, 65 kg/m³

Test no I, 2

68: Identical to 63 with

Filling: FR PU foam, 50 kg/m³

Test no I, 14

70:

Filling: FR PU foam, 65 kg/m³

Interliner: FR PU foam, 1180 kg/m³

Cover: cotton velvet, 380 g/m²

Test no II, 9

Heat release below 25 kW, no data available

Test procedure:

See page Y5.2/57

References:

Pakkala, L. & Ryyänen

Täytteellisten huonekaljujen ja patjojen paloturvallisuuden parantaminen

VTT Research notes 750, ISSN 0358-5085

Espoo, Finland 1987

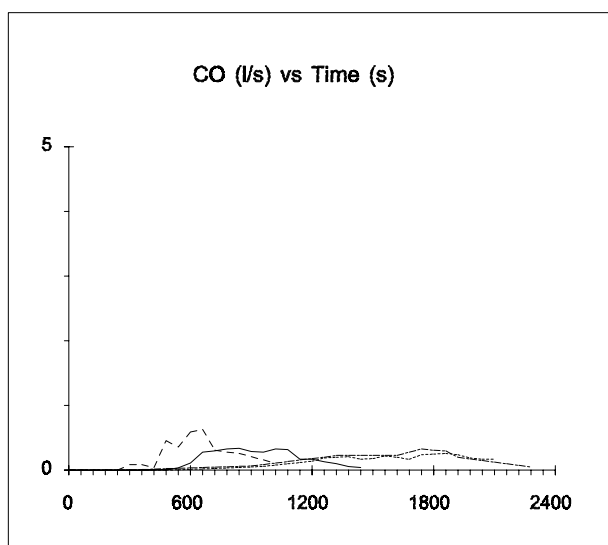
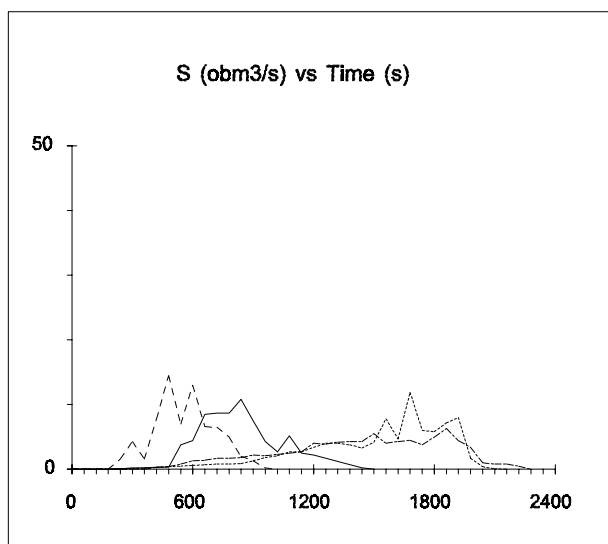
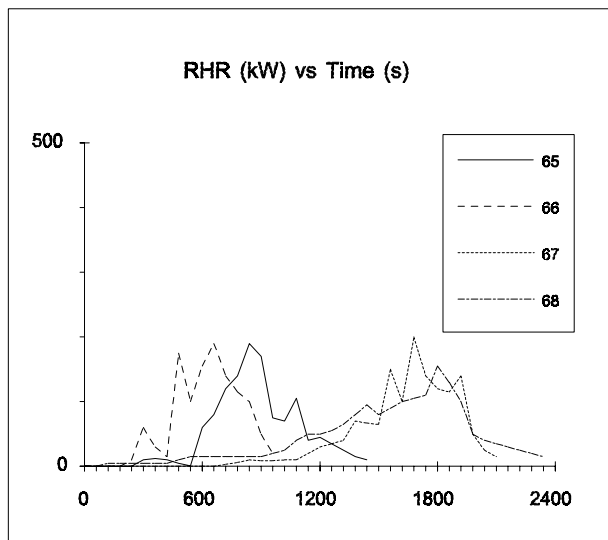
Pakkala, L. & Ryyänen

Improving the Fire Resistance Properties of Upholstered Furniture

VTT Research notes 1002, ISSN 0358-5085

Espoo, Finland 1989

Y5.2/63-70



2-cushion mock-up chairs

With polyester fabric covers

Construction, see page Y5.2/57

71:

Filling: FR PU foam, 33 kg/m³

Interliner: FR PU foam, 20 mm, 35 kg/m³

Cover: FR polyester fabric, 190 g/m²

Ignition source: BS-5

Test no II, 2A

Heat release below 25 kW, no data available.

72: Identical to 71

Ignition source: Burning curtain

Test no II, 2B

73:

Filling: FR PU foam, 35 kg/m³

Interliner: FR cotton fabric, 230 g/m²

Cover: FR polyester fabric, 340 g/m²

Test no II, 7

74:

Filling: FR PU foam, 35 kg/m³

Interliner: FR PU foam, 10 mm, 1180 g/m²

Cover: FR polyester fabric, 425 g/m²

Test no II, 8

Heat release below 25 kW, no data available.

75:

Filling: FR PU foam, 33 kg/m³

Interliner: FR PU foam, 10 mm, 1180 g/m²

Cover: FR polyester fabric, 340 g/m²

Ignition source: Burning curtain

Test no II, 11

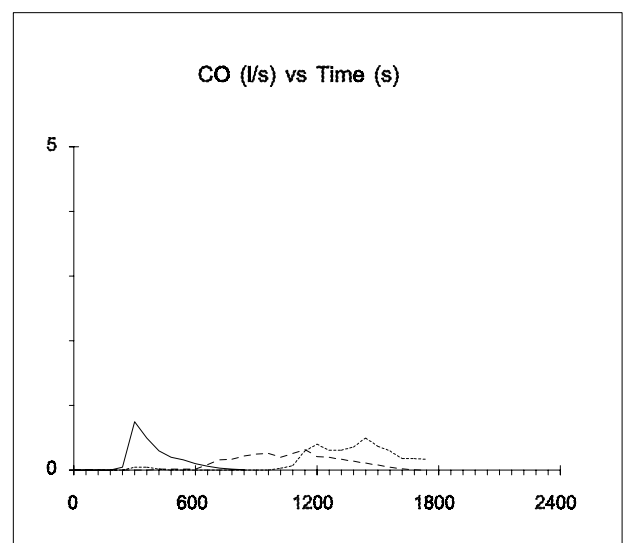
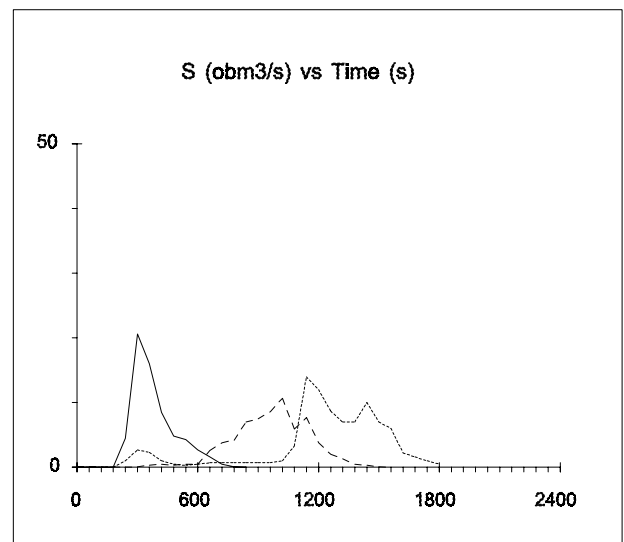
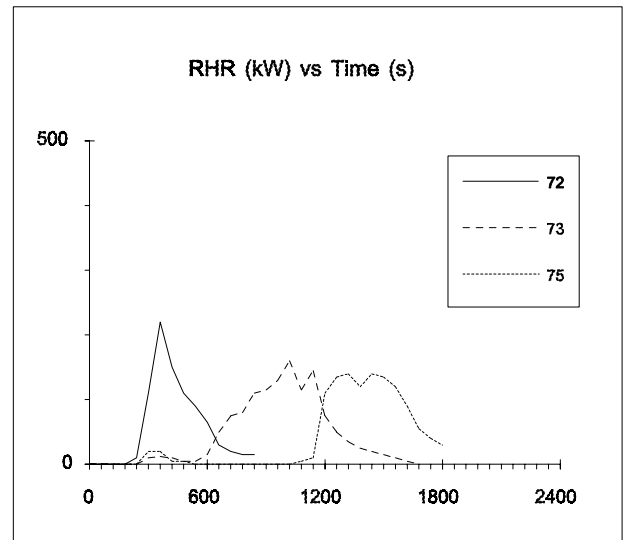
Test procedure:

See page Y5.2/57

Reference:

See page Y5.2/63

Y5.2/71-75



2-cushion mock-up chairs

With polyester/cotton fabric covers

Construction, see page Y5.2/57

76:

Filling: PU foam, 30kg/m³

Interliner: PU foam, 20 mm, 20 kg/m³

Cover: Polyester/cotton fabric, 340 g/m²

Ignition source: BS-5

Test no II, 3A

77: Identical to 76

Ignition source: Burning curtain

Test no II, 3B

78:

Filling: PU foam 30 kg/m³

Interliner: FR polyester wadding

Cover: Polyester/cotton fabric, 230 g/m²

Test no II, 10

79:

Filling: FR PU foam, 65 kg/m³

Cover: FR polyester fabric, 400 g/m²

Test no I, 5

80: Identical to 79 with

Interliner: FR cotton fabric, 150 g/m²

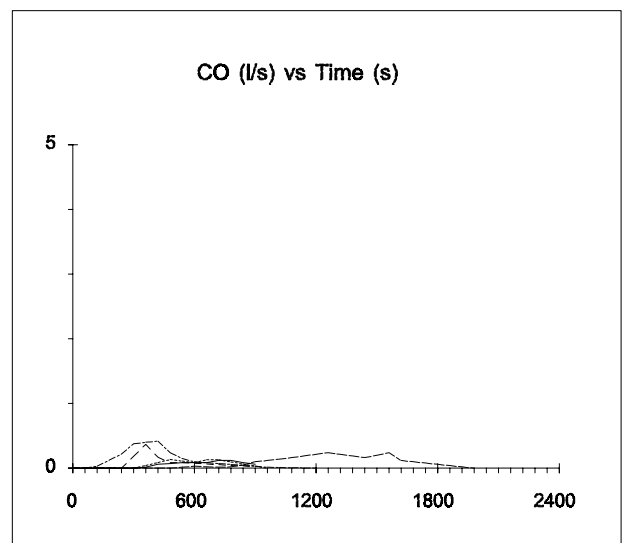
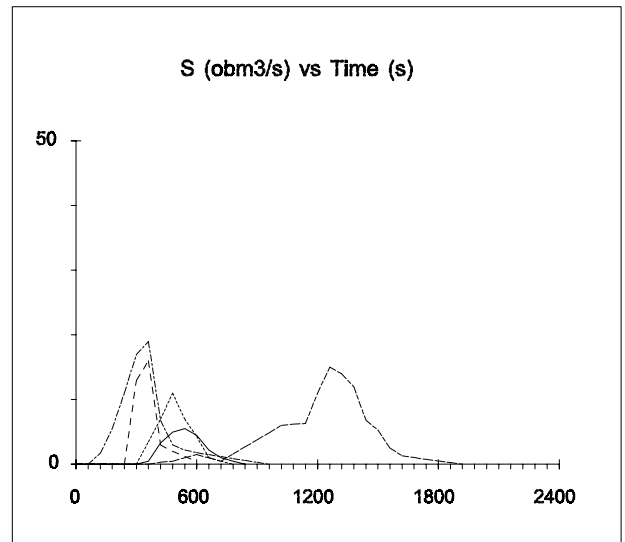
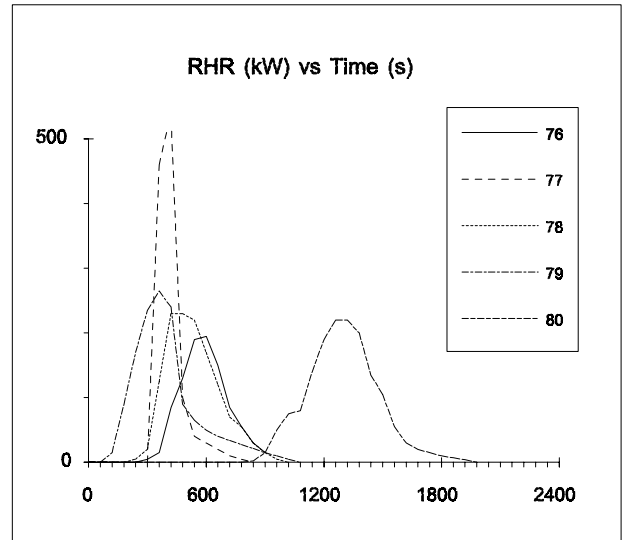
Test no I, 5B

Test procedure:

See page Y5.2/57

Reference:

See page Y5.2/63



2-cushion mock-up chairs

With polyester fabric covers

Construction, see page Y5.2/57

81:

Filling: FR PU foam, 33 kg/m³

Cover: FR polyester fabric, 400 g/m²

Test no I, 4

82: Identical to 81 with

Interliner: FR cotton fabric, 150 g/m²

Test no I, 4B

Heat release below 25 kW, no data available

83: Identical to 81 with

Interliner: FR cotton fabric, 230 g/m²

Test no II, 4B

84: Identical to 81 with

Interliner: FR wool wadding, 10 mm, 710 g/m²

Test no II, 4C

85: Identical to 81 with

Interliner: FR PU foam, 10 mm, 1180 g/m²

Test no II, 4D

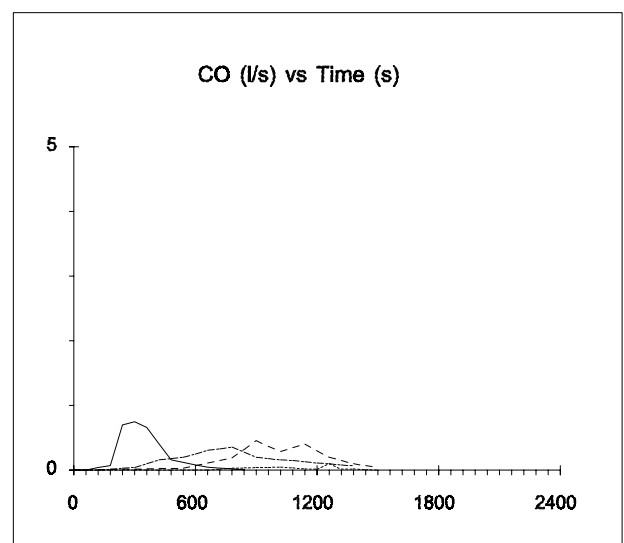
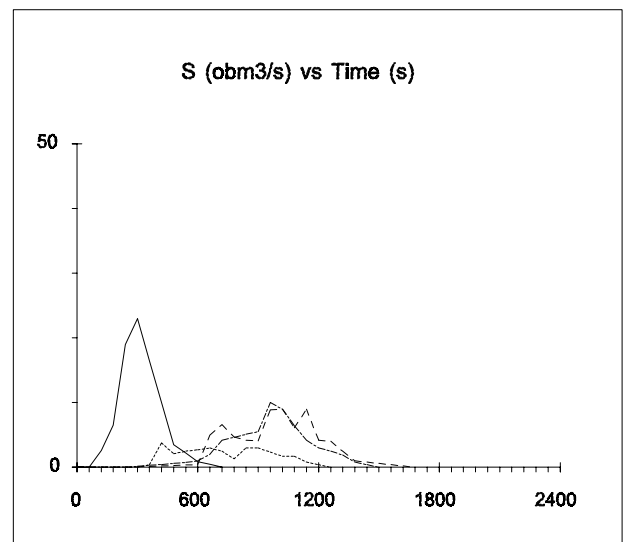
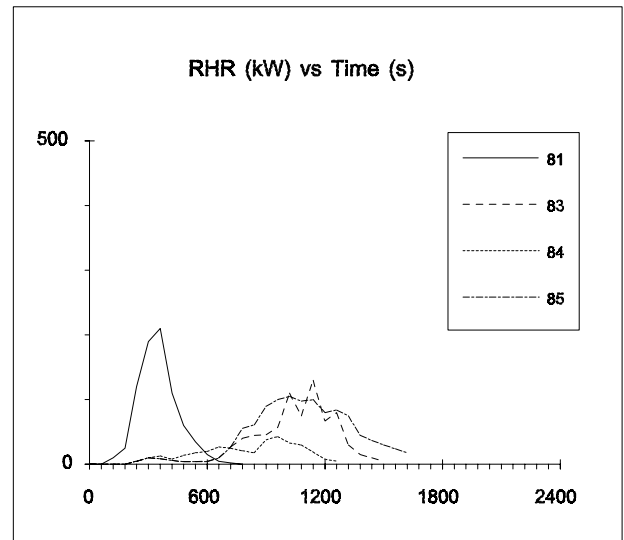
Test procedure:

See page Y5.2/57

Reference:

See page Y5.2/63

Y5.2/81-85



2-cushion mock-up chairs

With wool fabric covers

Construction, see page Y5.2/57

86:

Filling: FR PU foam, 33 kg/m³

Cover: 56% wool fabric, 480 g/m²

Test no I, 7

87: Identical to 86 with

Interliner: FR cotton fabric, 150 g/m²

Test no I, 7B

Heat release below 25 kW, no data available

88:

Filling: FR PU foam, 65 kg/m³

Interliner: FR PU foam, 20 mm, 25 kg/m³

Cover: wool fabric, 1.8 mm, 488 g/m²

Test no II, 5A

89: Identical to 88 with

Interliner: FR cotton fabric, 230 g/m²

Test no II, 5B

90: Identical to 88 with

Interliner: FR wool wadding, 10 mm, 710 g/m²

Test no II, 5C

91: Identical to 88 with

Interliner: Carbon fibre fabric, 330 g/m²

Test no II, 5D

Heat release below 25 kW, no data available

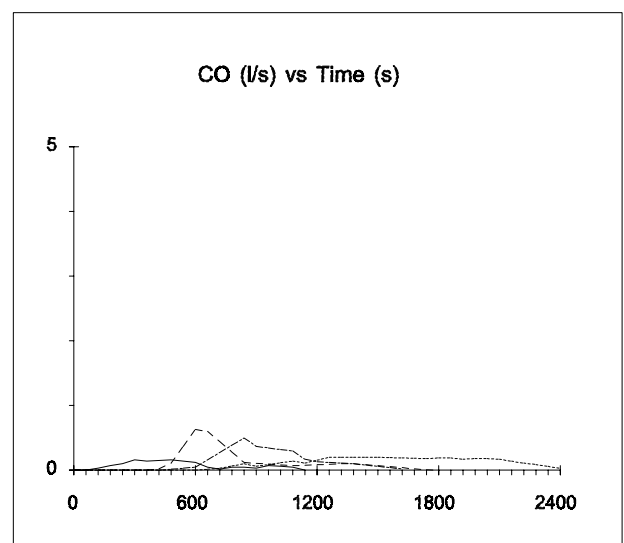
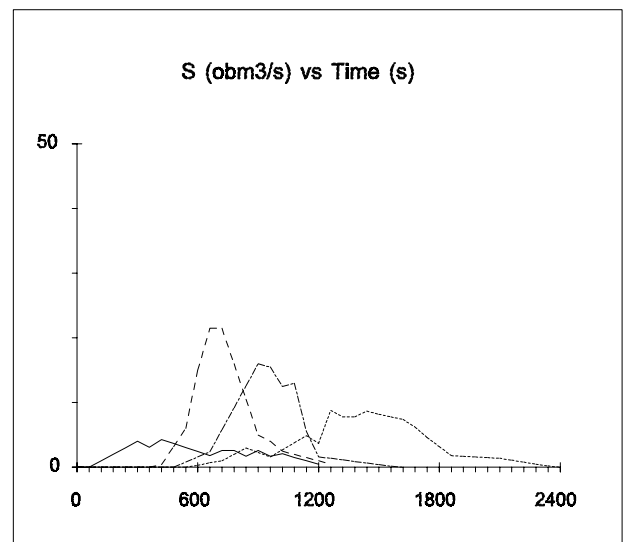
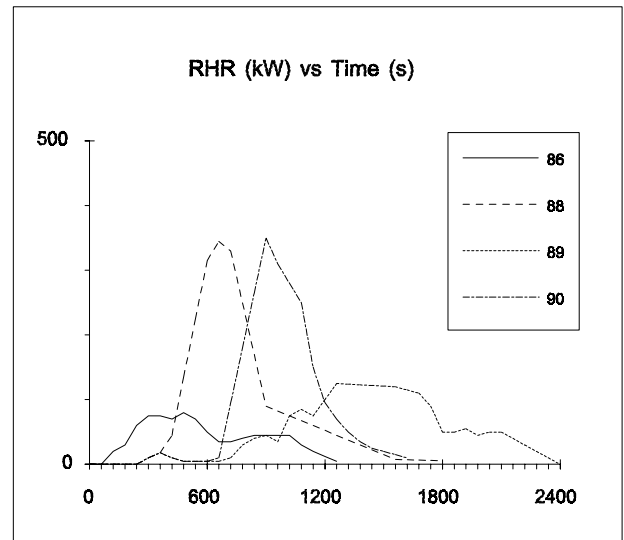
Test procedure:

See page Y5.2/57

Reference:

See page Y5.2/63

Y5.2/86-91



Easy chairs

10:

Frame: Wood

Padding: PU foam

Cover: Polyolefin fabric

Size and mass: 0.84 x 0.84 x 0.81 m³, 28.34 kg

The armchair is of the same model as the sofa Y5.4/21

Test 45

11:

Frame: One-piece molded PS with plywood inserts

Padding: PU foam

Cover: PU foam with polyolefin fabric backing

Size and mass: 0.84 x 0.84 x 0.81 m³, 11.52 kg

Test 48

12:

Frame: Wood

Padding: PU foam

Cover: Cotton fabric

Size and mass: 0.91 x 0.91 x 0.81 m³, 15.68 kg

Test 49

13:

Frame: Wood reinforced PU foam

Padding: Metal springs with 25-50 mm polyester batting

Cover: PU foam imitation leather

Size and mass: 0.84 x 0.84 x 0.76 m³, 15.98 kg

Test 64

14:

Frame: Wood

Padding: PU foam. Polyester filled cushions

Cover: Cotton fabric

Size and mass: 0.84 x 0.84 x 0.76 m³, 23.02 kg

Test 66

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Gas burner at the side of the chair, 50 kW in 200 s (subtracted from the RHR). Sample 14 was ignited with smoldering cigarette

| Sample: | 10 | 11 | 12 | 13 | 14 |
|---------------------------|------|------|------|------|------|
| H _{eff} (MJ/kg): | 18.1 | 33.3 | 23.0 | 21.0 | 22.7 |
| CO (g/s), peak: | 1.3 | 3.1 | 0.5 | 0.6 | 1.0 |

Also available:

Mass loss, Target irradiance and particulate conversion

Note:

The RHR curve of sample 14 starts 2500 s after ignition.

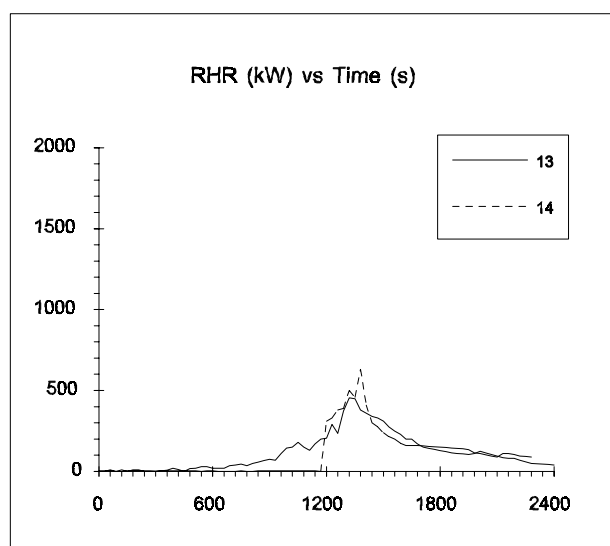
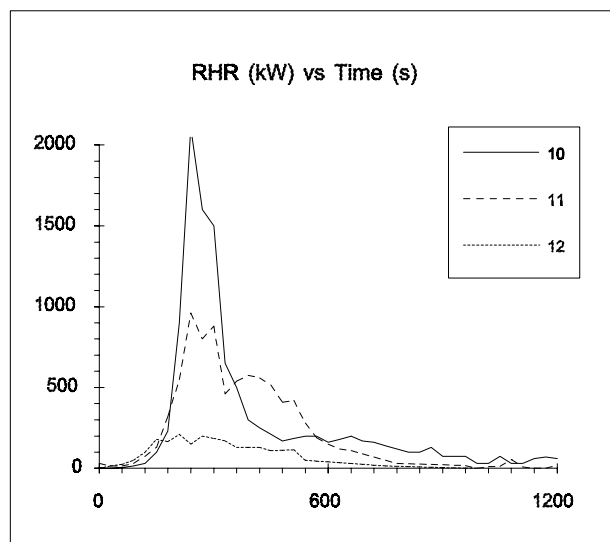
Reference:

Lawson, J.R. et al.

Fire Performance of Furnishings As Measured in the NBS Furniture Calorimeter. Part I

National Bureau of Standards

NBSIR 83-2787, U.S.A. 1983



4-cushion mock-up chairs

Y5.3/15-20

Size and mass: NA

15:

Padding: PU foam
Cover: Light olefin fabric
Test 12, A1

16:

Padding: FR PU foam
Cover: Light olefin fabric
Test 07, A2

17:

Padding: FR PU foam
Cover: Heavy olefin fabric
Test 14, A3

18:

Padding: FR PU foam
Cover: Light cotton fabric
Test 21, A4

19:

Padding: PU foam
Cover: Heavy cotton fabric
Test 20, A5

20:

Padding: FR PU foam
Cover: Heavy cotton fabric
Test 17, A6

Test procedure:

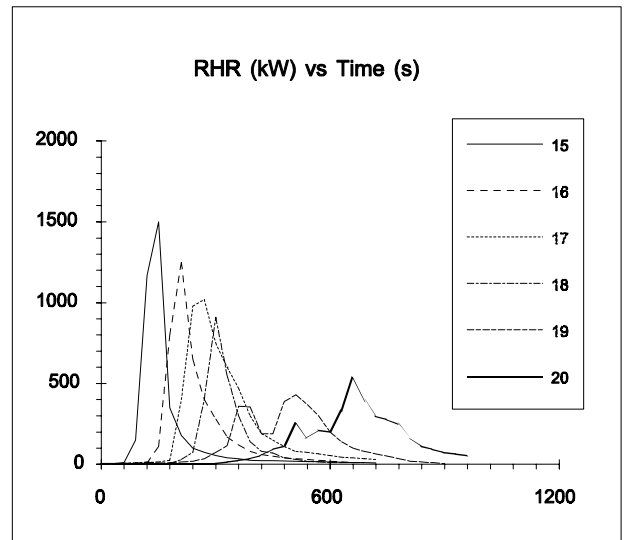
Method: Freeburning in furniture calorimeter
Ignition source: Wooden cribs, at the seat 0.10 m from the back.

Also available:

Mass loss

Reference:

Dietenberger, M. A.
Modifications to Furniture Fire Model for Hazard System
University of Dayton
NIST-GCR-92-601
U.S.A. 1992



4-cushion mock-up chairs

Mock-up chair with 4 cushions

Frame: Steel mock-up

Cover: Nylon fabric, , 250 kg/m²

Cushion size: 0.61 x 0.61 x 0.10 m³

21:

PU foam, 25 kg/m³

Mass: 5.5 kg

Chair T, test 16

22:

FR PU foam, 64 kg/m³

Foam containing organic chlorinated phosphate, organic brominated retardant and alumina trihydrate (Elemental content: 10% Al, 4.75% Br, 2.6% Cl and 0.32% P).

Mass: 11.9 kg

Chair S, test 17

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: 50 kW gas burner in 200 s at the side of the chair

| | |
|-----------------------------|--------------------------|
| Sample: | 36 |
| H _{eff} , (MJ/kg): | 27 |
| CO (kg/kg): | 0.01 |
| CO ₂ (kg/kg): | 1.89 |
| HCN (kg/kg): | 0.001 (Determined by ion |

Reference:

Babrauskas, B et al.

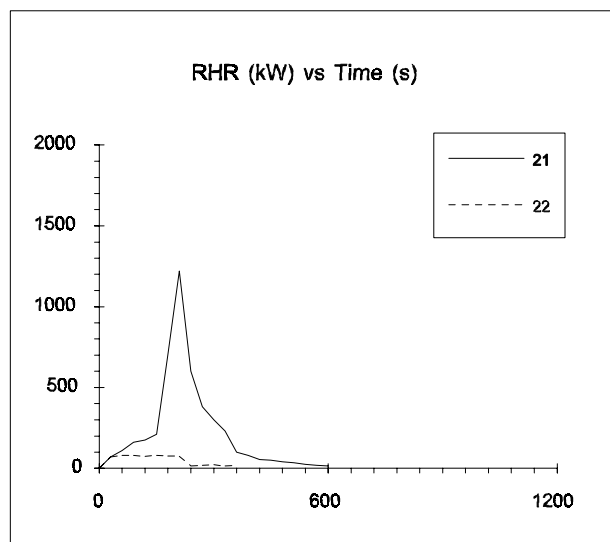
Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products

NBS Special Publication 749

National Bureau of Standards

U.S.A. 1988

Y5.3/21-22



chromathography)

Commercial 3-seat sofas

10: Sofa-bed

Frame: Wood

Filling: Ordinary PU foam

Cover: 100% viscose fabric, 665 g/m²

Mass: appr. 65 kg

Test 4

11: Old design sofa

Filling, seat cushions: Latex rubber foam

Filling, back cushions: Cotton felt

Cover: 100% wool fabric, 420 g/m²

Mass: appr. 40 kg

Test 5

Test procedure:

Method: Freeburning in furniture calorimeter.

Ignition source: 126 g wooden cribs, positioned in the corner where seat, back and arm rest cushion meet.

| Sample: | 10 | 11 |
|---------------------------|------|------|
| H _{eff} (MJ/kg): | 11.7 | 15.4 |

Also available:

CO/RHR, CO/mass loss, CO₂/RHR, CO₂/mass loss, S/RHR, S/mass loss and total energy, CO and smoke.

Reference:

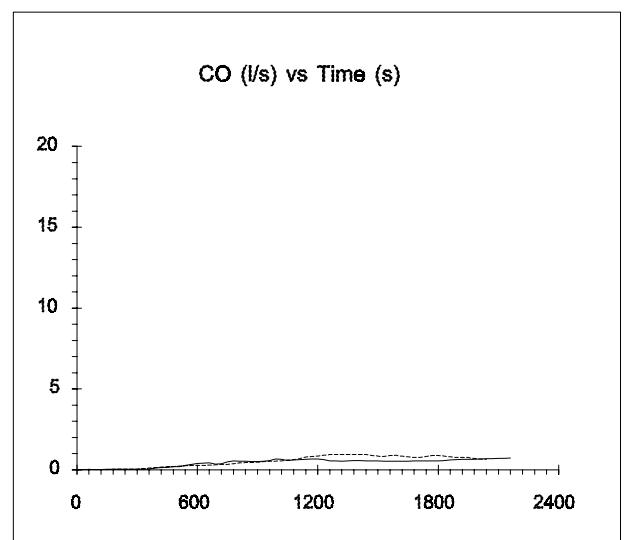
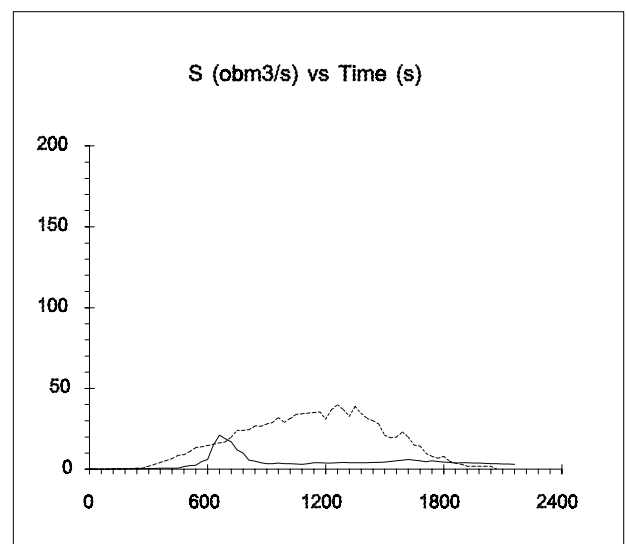
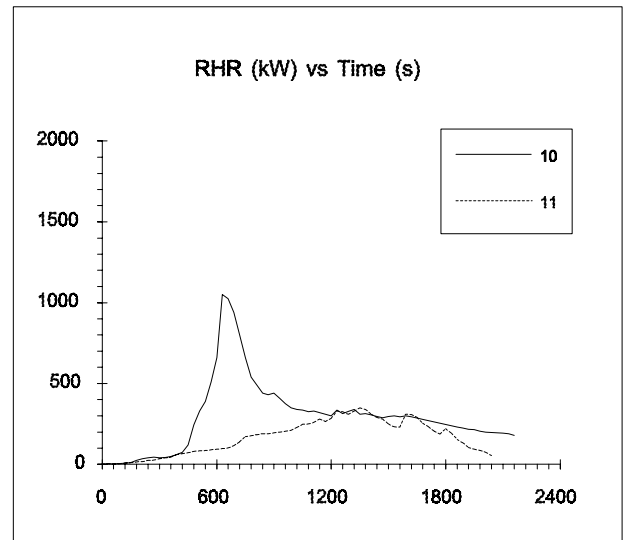
Sundström, B. & Kaiser, I.

Full Scale Fire Testing of Upholstered Furniture

Technical Report

SP RAPP 1986:01, ISSN 0280-2503

Borås, Sweden 1986



Mock-up sofa

Frame: Steel with wire net

Size: 0.65 x 1.8 x 0.76 m

Frame mass is not included below.

Cushions, filling material covered with fabric:

Number: 3 seat-, 3 back-, and 2 arm rest cushions

Thickness: 0.10-0.14 m

12:

Filling: Ordinary PU foam, 25 kg/m³

Cover: 100% acrylic velour fabric, 400 g/m²

Mass: 8.80 kg

Test 1

13:

Filling: Ordinary PU foam, 25 kg/m³

Cover: 100% cotton fabric, 480 g/m²

Mass: 8.91 kg

Test 2

14: FR

Filling: Highly resilient FR PU foam, 37 kg/m³

Cover: 100% PVA/PVC fabric, 500 g/m²

Mass: 10.90 kg

Test 7

15: FR

Filling: Highly resilient FR PU foam, 37 kg/m³

Cover: 65% wool / 35% viscose fabric, 500 g/m²

Mass: 11.13 kg

Test 8

Test procedure:

See page Y5.4/10

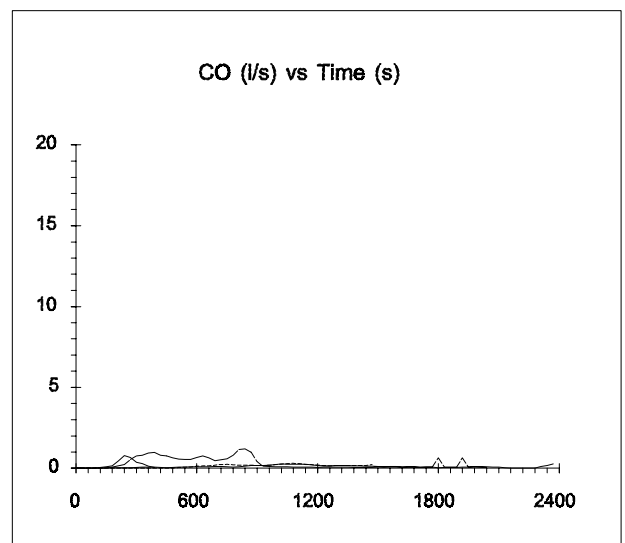
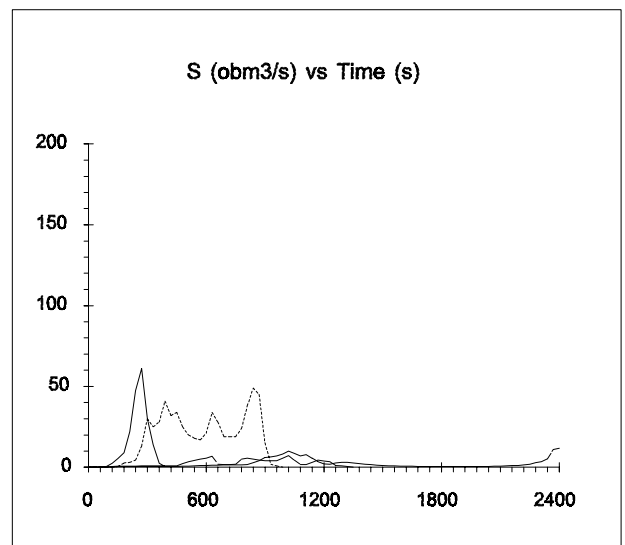
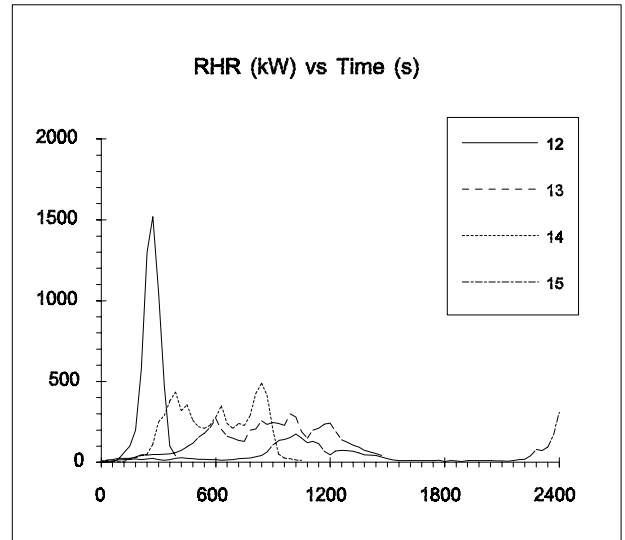
| Sample: | 12 | 13 | 14 | 15 |
|---------------------------|------|------|------|------|
| H _{eff} (MJ/kg): | 18.5 | 22.4 | 18.9 | 20.3 |

Also available:

See page Y5.4/10

Reference:

See page Y5.4/10



Mock-up sofa

Construction and size similar as to sample 12

16:

Filling: Standard PU foam, 30 kg/m³

Cover: 100% acrylic fabric, 300 g/m²

Mass: 8.2 kg

Test 5

17:

Filling: FR PU foam, 35 kg/m³

Cover: 100% acrylic fabric, 300 g/m²

Mass: 8.9 kg

Test 6

18:

Filling: Standard PU foam, 30 kg/m³

Cover: 61% wool / 39 % viscose fabric, 540 g/m²

Mass: 9.3 kg

Test 7

19:

Identical to sample 16.

Ventilation restricted (lower half of the door shutted off)

Test 10

20:

Identical to sample 16.

Freeburning

Test 12

Test procedure:

Method: Room calorimeter

Ignition source: Liquid fuel burner with 0.1 l heptane positioned in front of the sofa at the side. Burner output: 20 kW for 150-180 s.

Sample: 16-21

H_{eff} (MJ/kg): 24.6

Also available:

Gas temp., heat flux, RHR calculated from mass loss and total prod. of smoke, CO, CO₂ and NO_x.

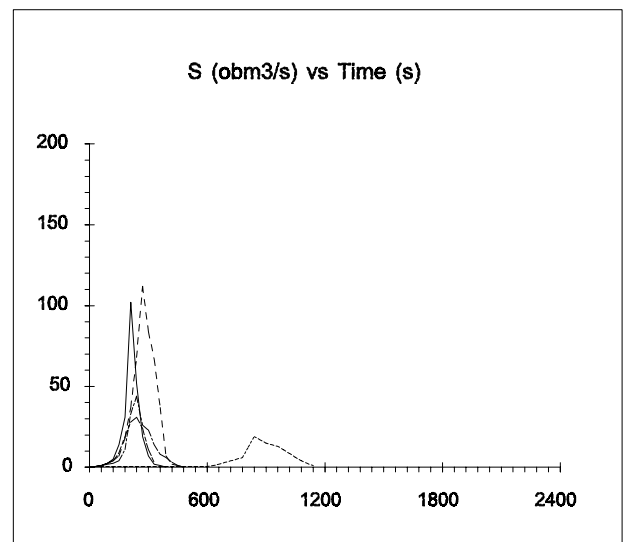
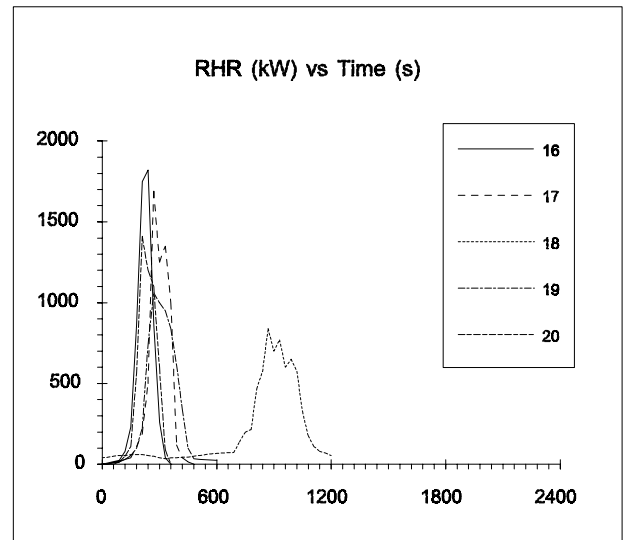
Reference:

Andersson, B

Fire Behaviour of Beds and Upholstered Furniture - an Experimental Study

REPORT LUTVDG/(TVBB-3023) ISSN 0282-3756

Lund, Sweden 1985



21: 3-seat sofa

Frame: Wood

Filling: PU foam

Cover: Polyolefin fabric

Size: 0.84 x 2.0 x 0.81 m³

Mass: 51.50 kg

The sofa is of the same model as the armchair Y5.3/10

Test 38

22: Loveseat

Frame: Metal

Filling: PU foam

Cover: Plastic coated fabric

Size: 0.84 x 1.32 x 0.72 m³

Mass: 27.26 kg

Test 54

23: Loveseat

Frame: Oak wood

Filling: PU foam covered with a layer of cotton

Cover: Plastic coated fabric

End panels: 9.5 mm plywood with PU padding and plastic coated fabric cover

Size: 0.81 x 1.37 x 0.76 m³

Mass: 54.60 kg

Test 57

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: Gas burner at the side of the sofa, 50 kW in 200 s (subtracted from the RHR).

| Sample: | 21 | 22 | 23 |
|---------------------------|------|------|------|
| H _{eff} (MJ/kg): | 18.9 | 18.6 | 15.1 |
| CO (g/s), peak: | 4.5 | 2.3 | 4.0 |

Also available:

Mass loss, target irradiance and particulate conversion

Reference:

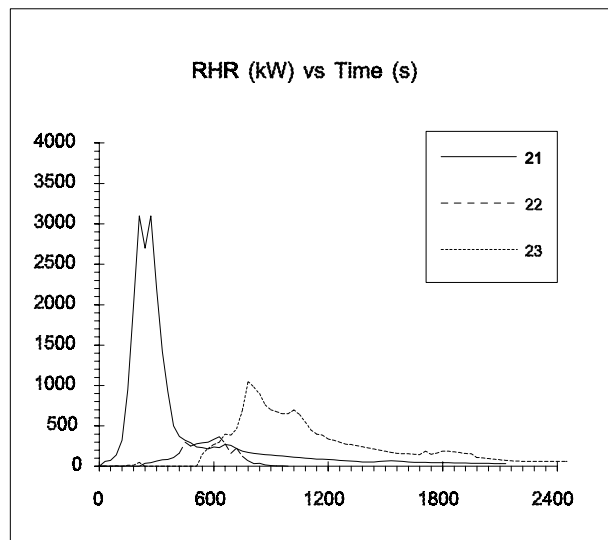
Lawson, J.R. et al.

Fire Performance of Furnishings As Measured in the NBS Furniture Calorimeter. Part I

National Bureau of Standards

NBSIR 83-2787

U.S.A. 1983



Beds

With foam mattresses. The beddings were all well laundered.

10: Hospital bed

Standard bed used in many Swedish hospitals

Mattress: polyether foam 27 kg/m^3 , 0.10 m

Sheets: 7 layers, polyester/cotton/PVC

Blanket: cotton

Pillow: feather/cotton/polyester/PVC

Säng 1A

11: Improved hospital bed

Mattress: PU foam 35 kg/m^3 , 0.10 m with polymeric surface

Sheets: 4 layers, 100% polyester, 140 g/m^2

Blanket: 100 % polyester

Pillow: 100% polyester

Säng 2A

12: Prison bed

Mattress: PU foam 35 kg/m^3 , 0.10 m. with interliner, 0.01 m polyester and polymeric surface

Sheets: 4 layers, polyester/viscose

Pillow: feather/cotton/polyester

Säng 3A

Test procedure:

Method: Room calorimeter

Ignition sources:

10: Meteneamine tablets (SIS 83 25 27), one in the center of the bed and one next to the pillow.

11: Wooden cribs in the center of the bed

12: Meteneamine tablet (SIS 83 25 27) next to the pillow

Also available:

Production of CO_2 and NO_x

Reference:

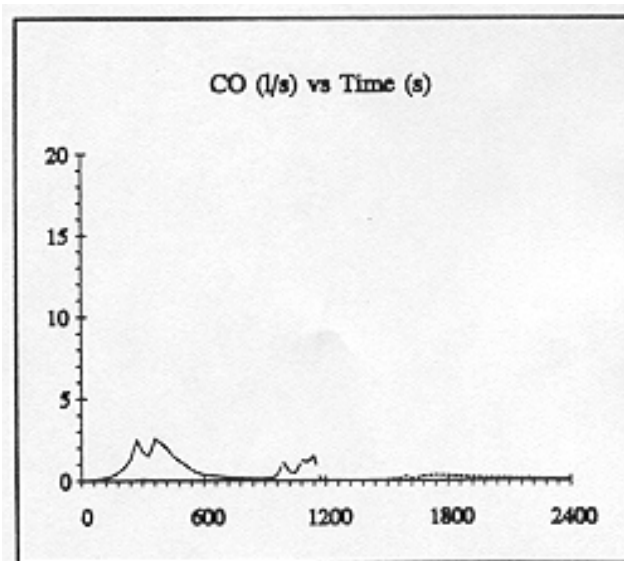
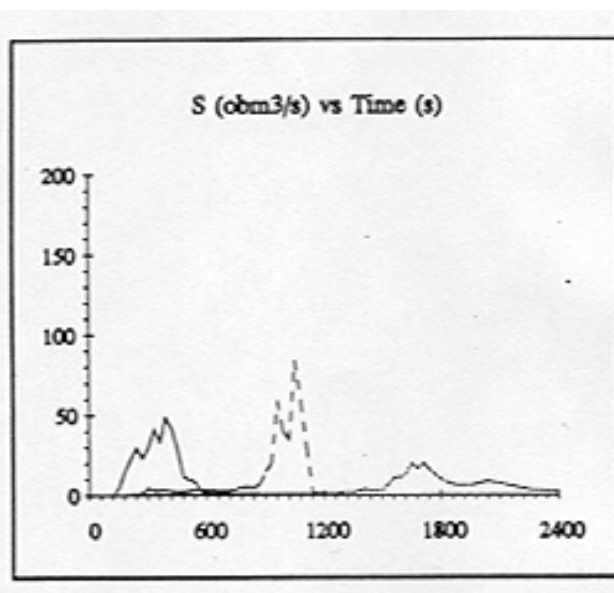
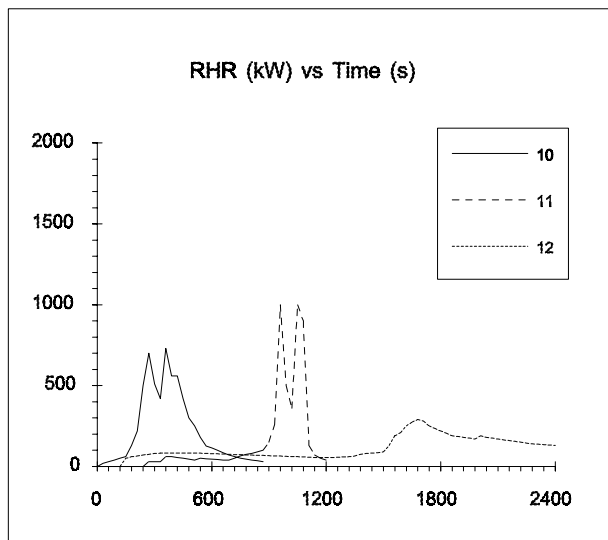
Holmstedt, G. & Kaiser, I.

Brand i vård bäddar

SP-Rapp 1983:04, ISSN 0280-2503

Borås, Sweden 1983

Y6/10-12



With polychloroprene foam mattresses

Bedding: Similar in bed 13-21

Drawsheet: 1 layer, cotton, 108 g/m²
Sheets: 2 layers, cotton/polyester, 125 g/m²
Bedspread: 1 layer, cotton/polyester, 200 g/m²
Pillow filling: shredded PU foam 670 g
Pillow cover: cotton, 230 g/m²
Pillow protector: PVC, 108 g/m²
Pillow case: cotton/polyester, 125 g/m²
Total mass: 3,6 kg
The bedding was not retardant treated and was not laundered

13: Navy mattress

Core: FR Polychloroprene foam, 152 mm, 67 kg/m³
Ticking: FR Cotton, 253 g/m²
Size: 0.88 x 1.93 x 0.15 m³
Mass: 18 kg
Test M08

14: Prison mattress

Core: FR Polychloroprene foam, 76.2 mm, 50 kg/m³
Ticking: FR PVC with nylon fabric, 354 g/m²
Size: 0.66 x 1.84 x 0.08 m³
Mass: 6 kg
Test M10

Test procedure:

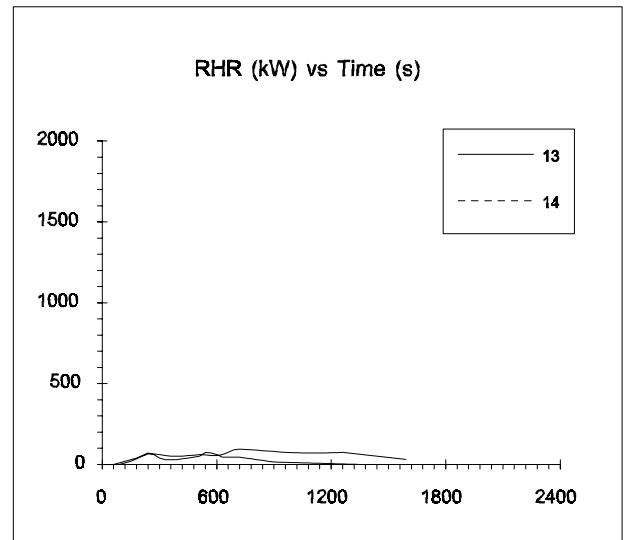
Method: Room calorimeter
Ignition source: Polyethylene wastebasket with mixed contents, located on the side of the bed. Mass: 725 g

Also available:

Mass outflow

Reference:

Babrauskas, V.
Combustion of Mattresses Exposed to flaming Ignition Sources part II. Bench-Scale tests and Recommended Standard Test
National Bureau of Standards
NBSIR 80-2186
U.S.A. 1980



With PU foam or latex mattresses

Bedding:

See page Y6/13

15: Hospital mattress

Core: FR PU foam, 86.9 mm, 64 kg/m³
Padding: PU foam, 36.8 mm, 25 kg/m³
Ticking: FR PVC, 378 g/m²
Size: 0.89 x 2.03 x 0.17 m³
Mass: 14 kg
Test M01

16: Hospital mattress

Core: Latex (butadiene-styrene), 101.6 mm, 81 kg/m³
Ticking: FR PVC with cotton backing, 410 g/m²
Size: 0.92 x 2.11 x 0.11 m³
Mass: 19 kg
Test M04

17: Commercial mattress

Core: PU foam, 127 mm, 20 kg/m³
Padding: Rayon fabric, 20 g/m²
Padding: PU, 78 g/m²
Ticking: Rayon fabric, 154 g/m²
Size: 0.95 x 1.88 x 0.13 m³
Mass: 6 kg
Test M05

18: Prison mattress

Core: PU foam, 76,2 mm, 22 kg/m³
Ticking: FR PVC with nylon fabric, 284 g/m²
Size: 0.66 x 1.84 x 0.08 m³
Mass: 3.2 kg
Test M09

Test procedure:

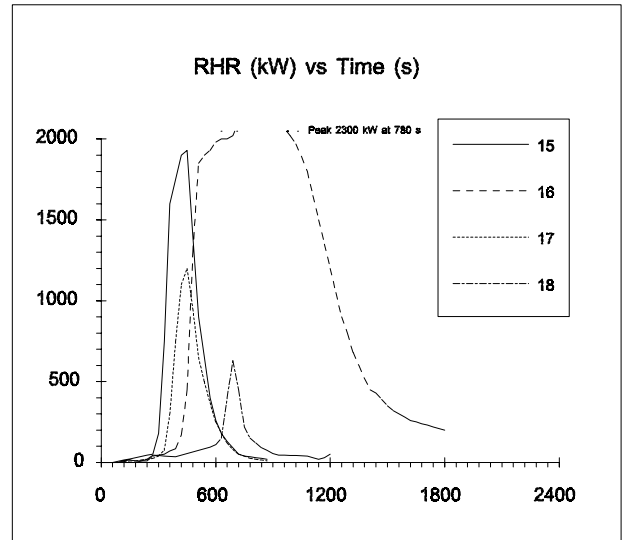
See page Y6/13

Also available:

See page Y6/13

Reference:

See page Y6/13



With innerspring mattresses

Bedding:

See page Y6/13

19: Hospital mattress with innersprings

Interfacing: PP fabric, 64 g/m²

Padding: PU foam, 37.5 mm, 19 kg/m³

Ticking: FR PVC, 385 g/m²

Size: 0.89 x 2.03 x 0.17 m³

Mass: 15 kg

Test M02

20: Hospital mattress with innersprings

Interfacing: PP fabric, 70 g/m²

Padding: FR Cotton felt, 49.6 mm, 38 kg/m³

Ticking: PVC, 379 g/m², FR

Size: 0.9 x 2.0 x 0.17 m³

Mass: 20 kg

Test M03

21: Mattress with innersprings

Insulator: FR Cotton/nylon/polyester pad, 7 mm, 90 kg/m³

Padding: Cotton/polyester felt, 38 mm, 43 kg/m³

Ticking: Polyester, 170 g/m²

Size: 0.99 x 1.91 x 0.18 m³

Mass: 12 kg

Test M06

Test procedure:

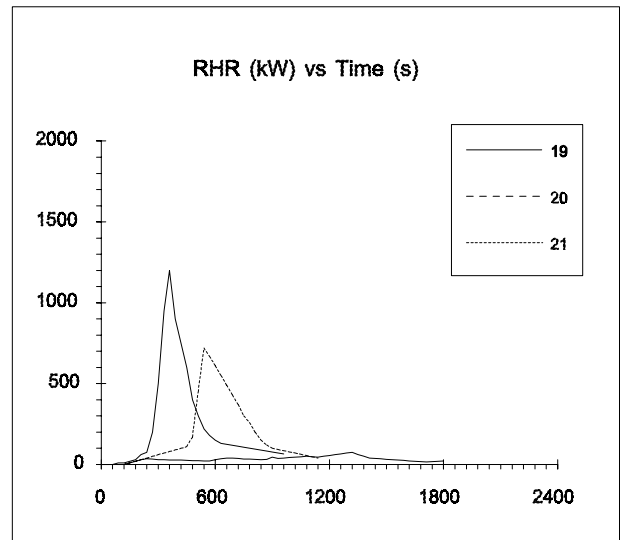
See page Y6/13

Also available:

See page Y6/13

Reference:

See page Y6/13



Beds

Mattress used in sample 22-24:

Filling: Standard PU foam, 35 kg/m³

Cover: Cotton, 135 g/m²

Size: 0.9 x 2.0 x 0.1 m³

Mass: 6.0 kg

22: Mattress

Test 1

23: Mattress

Freeburning

Test 11

24: Complete bed

Bedding:

Sheet: Cotton 180 g/m²

Quilt, filling: Polyester fibre, 200 g/m²

Quilt, cover: Viscose fabric, 110 g/m²

Bedding mass: 2.4 kg

Test 3

Test procedure:

Method: Room calorimeter

Ignition source: 40 g wooden cribs placed in center of bed
0.5 m from the head end.

| | | | |
|----------------|----|----|----|
| Sample: | 22 | 23 | 24 |
|----------------|----|----|----|

| | | | |
|---------------------------|----|----|----|
| H _{eff} (MJ/kg): | 22 | 22 | 20 |
|---------------------------|----|----|----|

Also available:

Flame spread rate, gas temp. and total prod. of smoke, CO,
CO₂ and NO_x

Reference:

Andersson, B

Fire Behaviour of Beds and Upholstered Furniture - an
Experimental Study

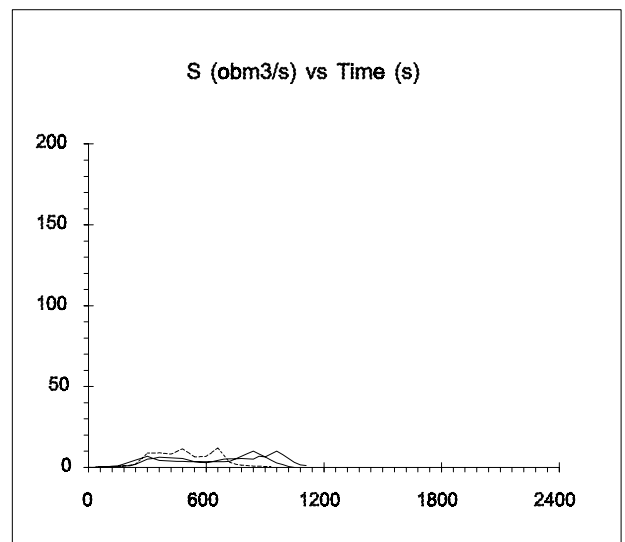
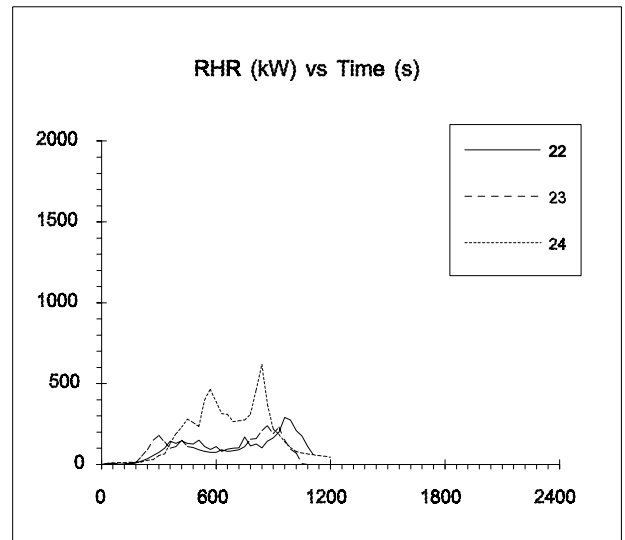
Division of building fire safety and technology

Lund Institute of Technology

Report LUTVDG / ISSN 0282 - 3756

Lund 1985

Y6/22-24



Pillows

50:

Filling: One piece latex foam
 Cover: 50% cotton / 50% polyester fabric
 Pillow mass: 1.003 kg
 Mass (including pillow case and ign. source): 1.238 kg

51:

Filling: Shredded PU foam
 Cover: Nonwoven fabric
 Pillow mass: 0.650 kg
 Mass (including pillow case and ign. source): 0.885 kg

52:

Filling: Shredded PU foam
 Cover: Nonwoven
 Pillow mass: 0.628 kg
 Mass (including pillow case and ign. source): 0.863 kg

53:

Filling: Polyester fibres
 Cover: 80% polyester / 20% cotton
 Pillow mass: 0.602 kg
 Mass (including pillow case and ign. source): 0.837 kg

54:

Filling: Feathers
 Cover: Cotton
 Pillow mass: 0.966 kg
 Mass (including pillow case and ign. source): 1.201 kg

55:

Filling: Polyester fibres
 Cover: Fibreglass
 Pillow mass: 0.687 kg
 Mass (including pillow case and ign. source): 0.922 kg

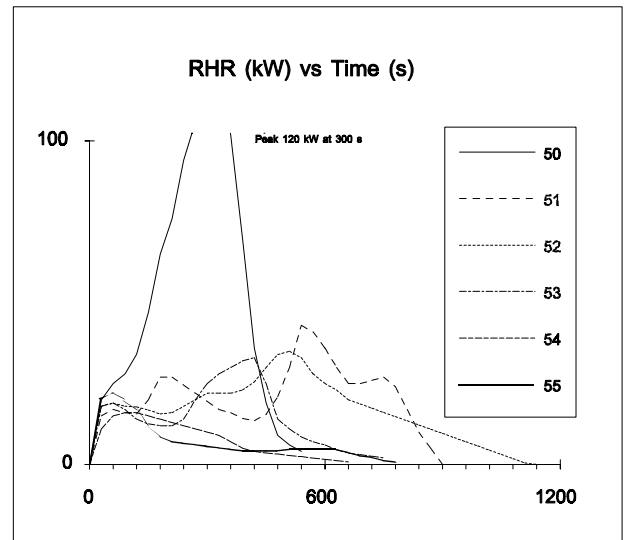
Test procedure:

Method: Freeburning in furniture calorimeter
 Ignition source: Balled up newspaper sheets

| Sample: | 50 | 51 | 52 | 53 | 54 | 55 |
|---------------------------|------|------|------|------|------|------|
| H_{eff} (MJ/kg): | 27.6 | 22.0 | 23.7 | 20.0 | 18.3 | 17.4 |

Reference:

Babrauskas, V.
 Burning Rates
 The SFPE Handbook of Fire Protection Engineering, pp 2-1 to 2-15
 U.S.A., 1988



10: Trevira CS

FR polyester, loosely woven fabric
 Surface weight: 150 g/m²
 Test 22L

11: FR Cotton

FR cotton, closely woven single cloth
 Surface weight: 220 g/m²
 Test 11R

12: Mod-Acrylic

Mod-acrylic, loosely woven fabric
 Surface weight: 190 g/m²
 Test 17R

13: Cotton

Cotton, closely woven single cloth
 Surface weight: 190 g/m²
 Test 20L

14: Acrylic

Acrylic, pile fabric
 Surface weight: 360 g/m²
 Test 8R

Test procedure:

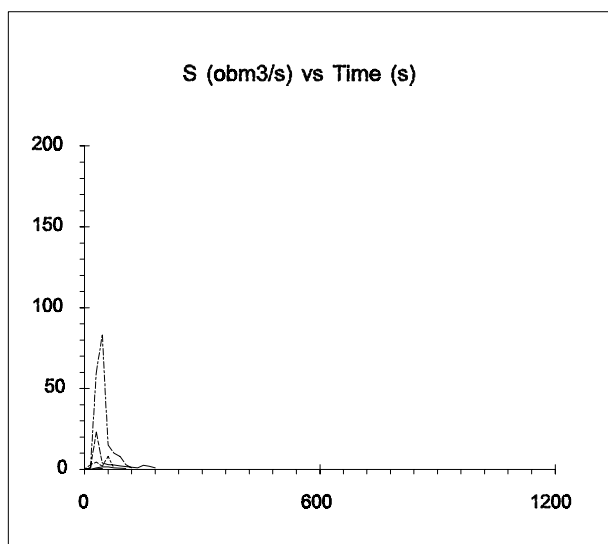
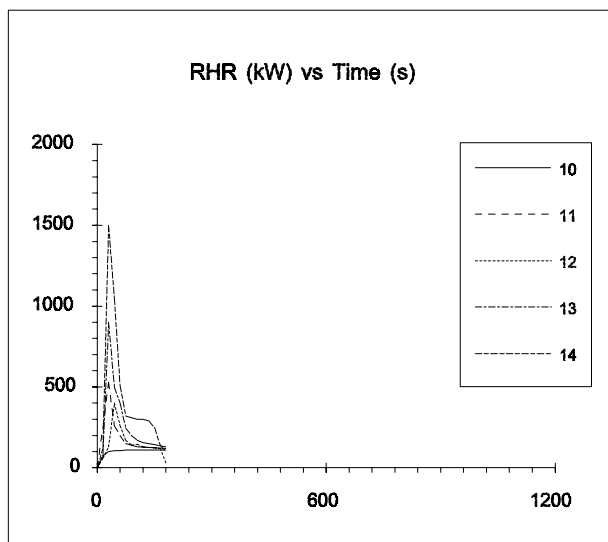
Method: Room calorimeter. The curtain is 3 (pleated to one third) by 3 m² and is hanging freely against a wall with an airgap of about 0.1 m.
 Ignition source: 100 kW gas burner under the curtain.

| Sample: | 10 | 11 | 12 | 13 | 14 |
|-------------|----|----|----|-----|-----|
| W. loss (%) | 29 | 49 | 80 | 100 | 100 |

Sample 10: 20-30 % melted and dripped away, is not included

Reference:

Wetterlund, I. & Göransson, U.
 A Full Scale Fire Test Method for Free-hanging Curtain and Drapery Textiles
 Fire Technology
 SP Report 1988:45, ISSN 0284-5172
 Borås, Sweden 1988



15:

Cotton velvet
 Surface weight: 310 g/m²,
 Mass: 1.87 kg
 Expt.no. 9

16:

45% acryl, 39% cotton, 16% polyester
 Surface weight: 230 g/m²
 Mass: 1.43 kg
 Expt.no. 10

Test procedure:

Method: Room calorimeter. 2 curtains were hanging in the corner of the room. The curtain size was 1.24 (folded to half the width) x 2.42 m². They were hanging freely against the wall with an airgap of 100 mm.
 Ignition source: Tray with 5 ml isopropanol located in the corner under the curtains

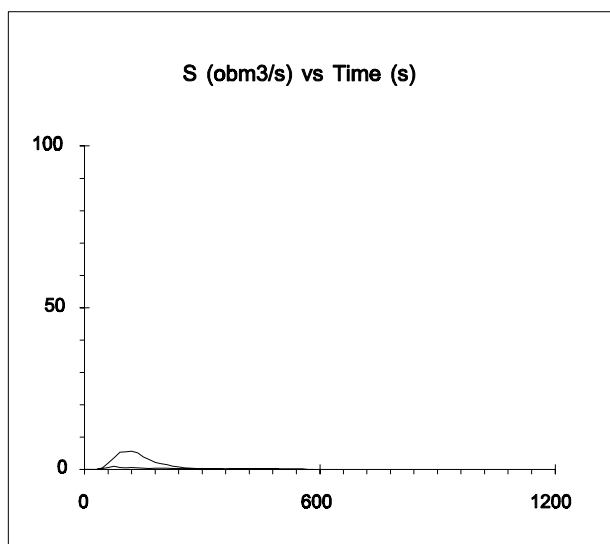
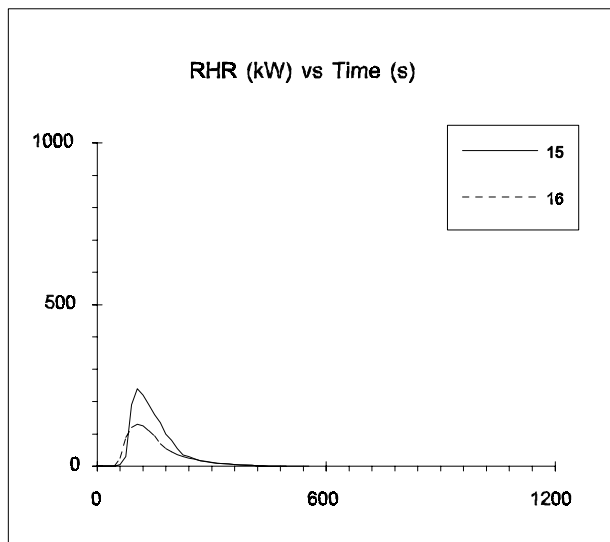
| | | |
|---------------------------|----|----|
| Sample: | 15 | 16 |
| H _{eff} (MJ/kg): | 14 | 13 |

Also available:

Radiation and gas temp.

Reference:

Ahonen, A, Kokkala, M & Weckman, H.
 Burning Characteristics of Potential Ignition Sources of Room Fires
 Technical Research Center of Finland
 Research reports 285
 Espoo, Finland 1985



All the plants were of the height about 1 m.

10: Palm, small and bushy

Palm leaves treated with glycerine mounted on an artificial stem.

11: Palm, tall and slim

Palm leaves treated with glycerine mounted on an artificial stem.

12: Ficus Benjamina

Polyester treated textile leaves mounted on a natural stem.

Test procedure:

Method: Freeburning in furniture calorimeter

Ignition source: 10 and 11: Match, 12: Gas burner

Note:

Sample 12 was hard to ignite and gave a low heat release.

Reference:

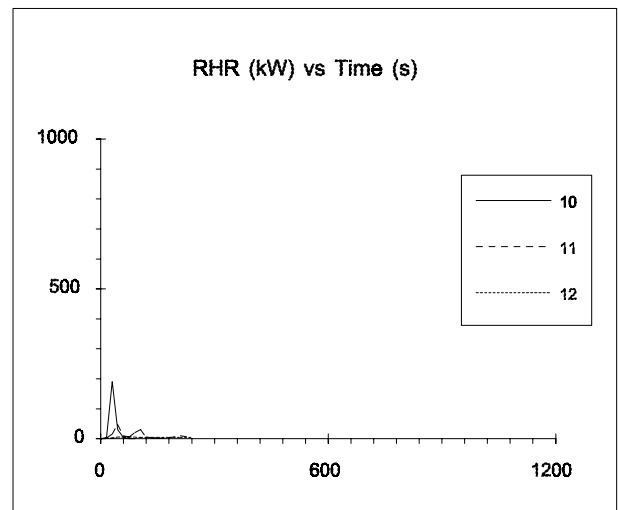
Ondrus, J

Brandförsök med prydnadsväxter

Departement of Fire Safety Engineering, Lund Institute of Technology, Lund University

Lund, Sweden 1991

Not published



Christmas trees

All trees were spruces (*Picea excelsa*) with the height of about 2.4 m

20:

Mass: 6.5 kg

Condition: Green

Expt.no. 16

21:

Mass: 7.0 kg

Condition: Dried (Needles beginning to fall off)

Expt.no. 17

22:

Mass: 7.4 kg

Condition: Dried (Needles beginning to fall off)

Expt.no. 18

Test procedure:

Method: Room calorimeter. The trees were located in the corner of the room

Ignition source: Isopropanol tray standing on the floor under the undermost branches.

Also available:

Radiation and gas temp.

Reference:

Ahonen, A, Kokkala, M & Weckman, H.

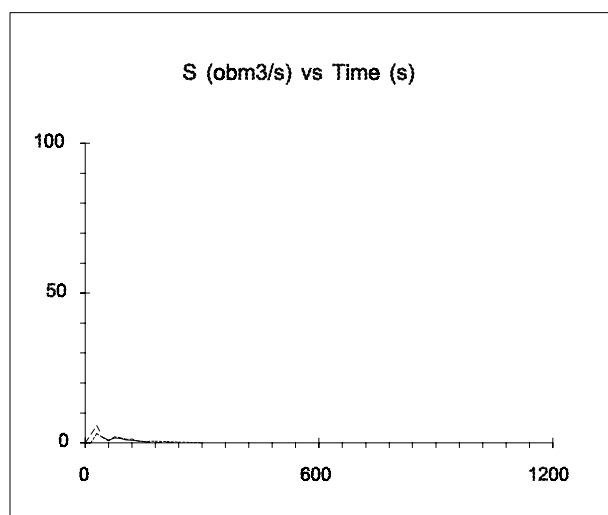
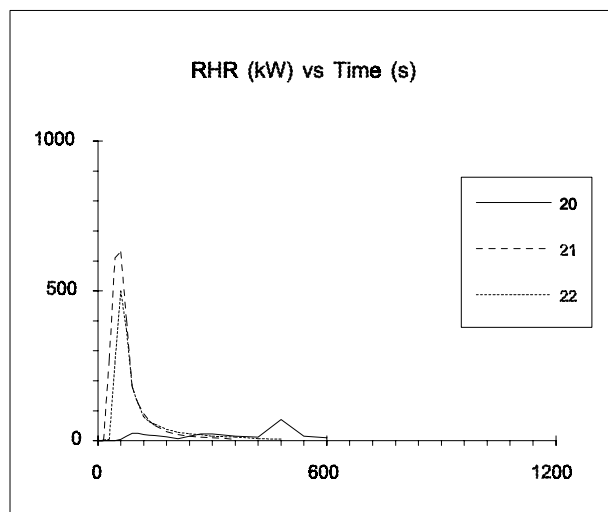
Burning Characteristics of Potential Ignition Sources of Room Fires

Technical Research Center of Finland

Research reports 285

Espoo, Finland 1985

Y8/20



30: Stuffed fox

DDT and Arsenic treated

Test procedure:

Method: Freeburning in furniture calorimeter.

Ignition source: Heptane tray (Ø 0.15 m) under the fox.

Note:

The fox gave a very low RHR, only the heptane burned.
No data available.

The smoke is presumably quite poisonous due to the DDT and arsenic.

Reference:

Eriksson, H. et al.

Malmö slott

Department of Fire Safety Engineering

Lund Institute of Technology, Lund University

Lund, Sweden 1990

Pools

Expression for freeburning pools of varying size

| Material | Density [kg/m ³] | H _C [MJ/kg] | m" _∞ [kg/m ² s] | kϑ [m ⁻¹] |
|----------|---------------------------------|---------------------------|--|--------------------------|
|----------|---------------------------------|---------------------------|--|--------------------------|

Cryogenics (for pools on dry land)

| | | | | |
|---|-----|------|-------|-----|
| Liquid H ₂ | 70 | 120 | 0.017 | 6.1 |
| LNG, mostly CH ₄ | 415 | 50.0 | 0.078 | 1.1 |
| LPG, mostly C ₃ H ₈ | 585 | 46.0 | 0.099 | 1.4 |

Alcohols

| | | | | |
|---|-----|------|-------|---|
| methanol, CH ₃ OH | 796 | 20.0 | 0.017 | * |
| ethanol, C ₂ H ₅ OH | 794 | 26.8 | 0.015 | * |

Simple organic fuels

| | | | | |
|---|------|------|---------|-------|
| butane, C ₄ H ₁₀ | 573 | 45.7 | 0.078 | 2.7 |
| hexane, C ₆ H ₁₄ | 650 | 44.7 | 0.074 | 1.9 |
| heptane, C ₇ H ₁₆ | 675 | 44.6 | 0.101 | 1.1 |
| benzene, C ₆ H ₆ | 874 | 40.1 | 0.085 | 2.7 |
| xylene, C ₈ H ₁₀ | 870 | 40.8 | 0.090 | 1.4 |
| acetone, C ₃ H ₆ O | 791 | 25.8 | 0.041 | 1.9 |
| dioxane, C ₄ H ₈ O ₂ | 1035 | 26.2 | 0.018** | 5.4** |
| diethyl ether, C ₄ H ₁₀ O | 714 | 34.2 | 0.085 | 0.7 |

Petroleum products

| | | | | |
|---------------------------------|-------|-------|---------|-------|
| benzine | 740 | 44.7 | 0.048 | 3.6 |
| gasoline | 740 | 43.7 | 0.055 | 2.1 |
| kerosine | 820 | 43.2 | 0.039 | 3.5 |
| JP-4 | 760 | 43.5 | 0.051 | 3.6 |
| JP-5 | 810 | 43.0 | 0.054 | 1.6 |
| transformer oil, hydrocarbon | 760 | 46.4 | 0.039** | 0.7** |
| fuel oil, heavy | 940 | 39.7 | 0.035 | 1.7 |
| | -1000 | | | |
| crude oil | 830 | 42.5 | 0.022 | 2.8 |
| | -880 | -42.7 | -0.045 | |

Solids

| | | | | |
|--------------------|------|------|-------|-----|
| Polymethylmethacr. | 1184 | 24.9 | 0.020 | 3.3 |
| Polypropylene | 905 | 43.2 | 0.018 | NA |
| Polystyrene | 1050 | 39.7 | 0.034 | NA |

* Independant of diameter

** Uncertain estimation

Note:

The pool fires are not available in the database.

Reference:

Babrauskas, V
Burning Rates
The SFPE Handbook of Fire Protection Engineering, pp 2-1 to 2-15
U.S.A., 1988

RHR calculation:

The RHR may be calculated by the formula:

$$\text{RHR} = H_C \times m'' \times A$$

where

$$m'' = m''_{\infty} (1 - e^{-k\vartheta D})$$

Alcohols are independant of the diameter, giving:

$$m'' = m''_{\infty}$$

Nomenclature:

| | | |
|------------------|-----------------------|---|
| A | [m ²] | Pool area |
| D | [m] | Pool diameter |
| H _C | [MJ/kg] | Heat of combustion |
| kϑ | [m ⁻¹] | Extinction-absorption coefficient of the |
| m'' | [kg/m ² s] | Mass loss rate |
| m'' _∞ | [kg/m ² s] | Mass loss rate for a pool with an infinite diameter |

Complicating effects

The expressions above represents an idealized pool burning. In some cases the error may be as much as a factor 2. Some of the complicating effects are:

Boil-over

This effect is rare, but can occur for certain grades of petroleum crude and petroleum products with moisture.

Transients

The burning rate is often increasing with the time, due to the heating of tank walls et.c. For a conservative estimation, the effect can be ignored.

Lip heights

The effect is uncertain, in lack of experimental data

Winds

This effects can change the burning rate up to a factor 2. The wind has been reported to both increase and decrease the burning rate, and at velocitys greater than about 5 m/s some fires may be blown out.

Very large pool diameters

For pool diameters larger than 5 to 10 m, a decrease in the order 20 % in the RHR is usually noted, attributed to poorer mixing, poorer combustion and a layer of cold smoke above the surface.

Expression for freeburning wood pallet stacks of varying size

Stacked standard wood pallets
Size: 1.22 x 1.22 x 0.14 m³

20:

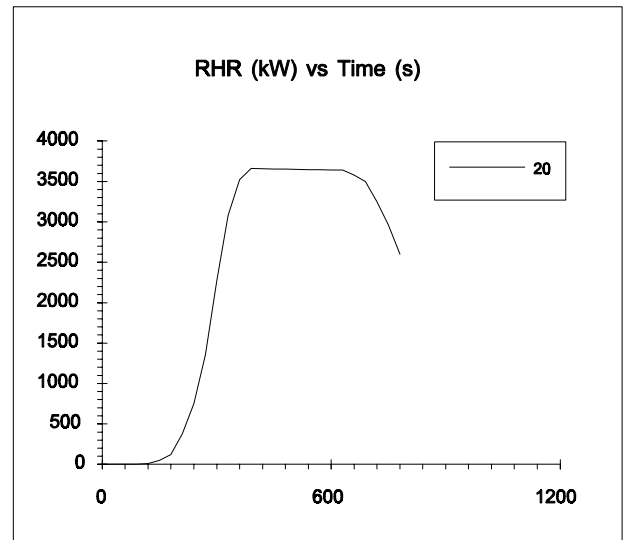
Height: 1.22 m

Note:

The pallet fires except sample 20 are not available in the database.

Reference:

Babrauskas, V
Burning Rates
The SFPE Handbook of Fire Protection Engineering, pp 2-1 to 2-15
U.S.A., 1988



RHR calculation:

The RHR may be calculated by the formulas:

$$\text{RHR} = 1450 (1 + 2.14h_c)(1 - 0.027M)$$

(expression for single stacks)

$$\text{RHR} = A \times 970 (1 + 2.14h_c)(1 - 0.027M)$$

(expression on a per-unit-pallet-floor-area basis)

Nomenclature:

| | | |
|-------|-------------------|--------------------|
| h_c | [m] | Stack height |
| M | [-] | Moisture content |
| A | [m ²] | Covered floor area |

The heat of combustion is assumed to be 12 MJ/kg

Complicating effects:

The expression overpredict the RHR if applied to stacks shorter than 0.5 m

Plastic stacks

30: Stacked PS boards

Stacked boards of expanded PS. The stack is lying directly on the floor.

Size: 1.20 x 0.60 x 0.10 m³

Mass: 1.4 kg

Stack: 12 x 2 boards

Total size: 1.20 x 1.20 x 1.20 m³

Total mass: 16.8 kg

Test procedure:

Method: Freeburning in industry calorimeter

Ignition source: 1000 kW gas burner at the side of the stack.

Note:

The first peak on the RHR is caused by the gas burner.

Reference:

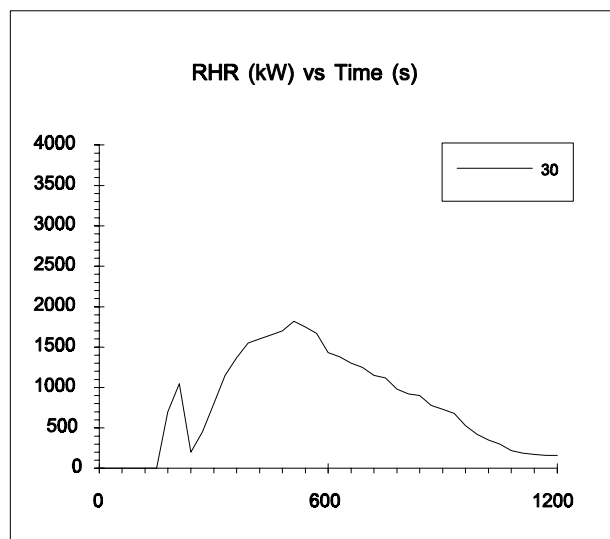
Dahlberg, M

Polystyren

Fire Technology

Borås, Sweden

Not published



10: A half tram car

Half a standard tram car from Gothenburg. The car was cut in two parts and the hole was closed.

Seats: Upholstered with plastic faced fabric

Floor: Rubber carpet

Walls: Plastic laminate

Ceiling: Masonite boards and aluminium sheets

Length: 6 m

Test procedure:

Method: Freeburning in industry calorimeter

Ignition source: 127 g wooden cribs at one seat.

Note:

Only about 80% of the smoke was exhausted by the hood. The real RHR would therefore be higher.

Due to the size, only half a car was burned. A whole car would presumably have a RHR of the double size and the same rate of rise. The time to flashover would be a little longer.

At 300 s the fire had spread from the ignition seat

At 390 s the first window broke.

At 530 s the other windows starts to broke.

At 720 s the extinction started

Reference:

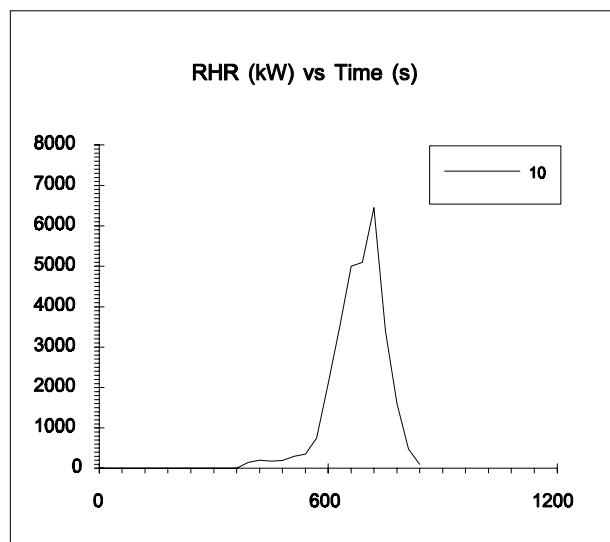
Dahlberg, M

Spårvagn

Fire Technology

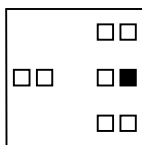
Borås, Sweden

Not published



Simulated bus/train

Four double bus seats in a 2.4 x 3.6 x 2.4 m³ room.
The room was furnished as in the figure.



Ceiling: Ordinary bus ceiling material.

11:

Chairs: City bus

Padding: High resilient PU foam

Cover: 40% viscose, 20% wool, 20% polyester, 20% polyamide fabric

12:

Chairs: Inter-city train

Padding: High resilient PU foam

Cover: 100% wool fabric

Walls and floor covered

Test procedure:

Method: Room calorimeter

Ignition source: Wooden cribs at one seat.

Also available:

Sample 12: CO₂ production

Note:

The fire produced a large amount of smoke, but did not ignite the wall or ceiling until two chairs were burning

The fires were extinguished after about 360, and 1200 s, respectively.

Reference:

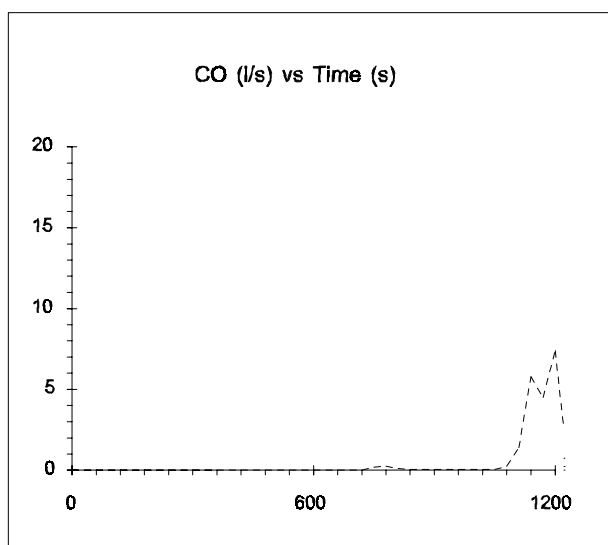
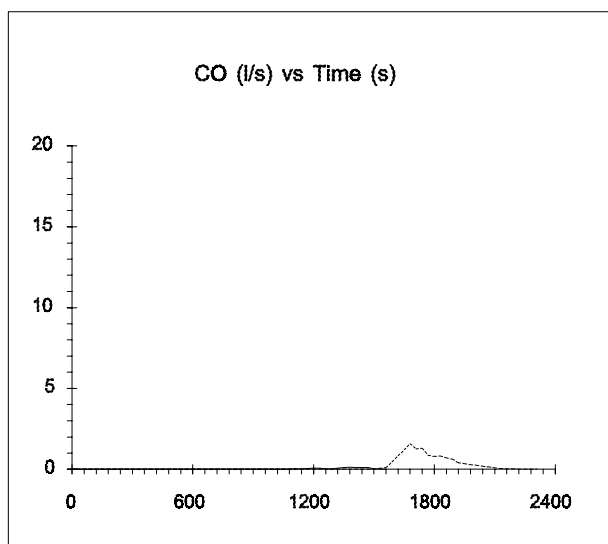
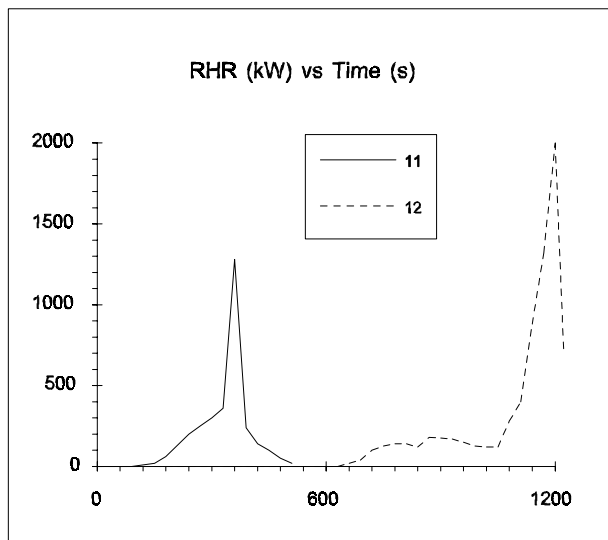
Göransson, U. & Lundqvist, A.

Fires in Buses and Trains, Fire Test Methods

Fire Technology

SP REPORT 1990:45, ISSN 0284-5172

Borås, Sweden 1990



Passenger cars

Ordinary sedan passenger cars manufactured in the late 1970's

The total energy release is estimated to be 4000 MJ.

20:
Test 1

21:
Test 2

22:
Test 3

Test procedure:

Method: Freeburning in calorimeter

Note:

The first RHR peak is due to the compartment fire and the second to the fuel fire.

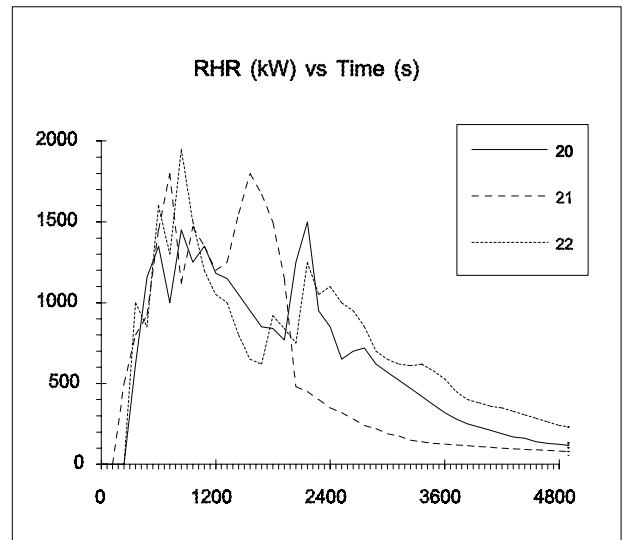
Sample 20: The fuel burned from the mouth of the filler pipe.

Sample 21: The fuel burned from the mouth of the fuel tank and from a pool under the car, when the filler pipe and the fuel hose had melted.

Sample 22: The fuel burned from the mouth of the fuel tank, when the filler pipe had melted.

Reference:

Mangs, J. & Keski-Rahkonen, O.
Fire Safety for Open Car Park Buildings
VTT
Espoo, Finland
To be published



REGISTER

The code shows only the first page where a sample appears. Many objects are also to be found in the following pages.

| | | | | | |
|------------------------------|--------------------|----|----------------------------|--------------|-------|
| Armchairs | Y5.3 | | Pallet storage | Y3.3/50 | |
| Artificial plants | Y8/10 | | Pallet systems | Y3.3/50 | |
| Animals, stuffed | Y8/30 | | Panels | O | |
| Bedding | Y6/50 | | Paper baskets | Y3.4/10 | |
| Beds | Y6/10 | | Particle boards | | O4/20 |
| Bedrooms | Y0/10 | | Passenger cars | Z3/20 | |
| Boards | O | | Pillows | Y6/50 | |
| Bookcases | Y3.3/10 | | Pipe insulation | | K4 |
| Bottles, plastic, in crates | Y3.3/59 | | Plants, artificial | Y8/10 | |
| Business machines | Y1/25 | | Plaster boards | O1 | |
| Buses | Z3/11 | | Plastic bottles, in crates | Y3.3/59 | |
| Cabins, navy | Y0/10 | | Plastic laminates | O6/10 | |
| Cables | J4 | | Plastic sheets | O6 | |
| Cable trays | J4 | | Plastics, stacked | Z1/30 | |
| Cars, passenger | Z3/20 | | Plastic, stored | Y3.3/50 | |
| Cars, tram | Z3/10 | | Plywood | O3/20 | |
| Chairs | Y5.2 | | Pools | Z1/10 | |
| Chemical laboratories | Y0/30 | | Prototype furniture | Y5 | |
| Chemicals | Z1/10 | | Rack storage | Y3.3/50 | |
| Christmas trees | Y8/20 | | Records, hospital | Y3.3/11 | |
| Coffee makers | Y1/10 | | Rooms, furnished | Y0 | |
| Computers | Y1/20 | | Rubbish sacks | Y3.4/20 | |
| Computer work stations | Y0/20 | | Seating units | Y5 | |
| Containers | Y3.4/10 | | Seats | Y5.2 | |
| Couches | Y5.4 | | Seats, upholstered | Y5.2/50 | |
| Crates, with plastic bottles | Y3.3/59 | | Sofas | Y5.4 | |
| Cribs, wood | Z1/20 | | Stacked chairs | Y5.0 | |
| Curtains | Y7 | | Stacked expanded plastics | Z1/30 | |
| Cushions | Y5, Y6 | | Stacked wood pallets | Z1/20 | |
| Desks, office | Y0/20 | | Standard commodities | Y3.3/50 | |
| Drapery textiles | Y7 | | Steel sheets | O2 | |
| Easy chairs | Y5.3 | | Storage units | Y3 | |
| Electric cables | | J4 | Storage units, closed | Y3.1 | |
| Expanded plastic boards | O6, Z1/30 | | Storage units, open | Y3.3 | |
| Expanded stone boards | O5 | | Stuffed animals | Y8/30 | |
| Fibre boards | O4 | | Surface lining materials | O | |
| Furnished rooms | Y0 | | Surface materials | O | |
| Furniture | Y | | Technical fittings | Y1 | |
| Gypsum plaster boards | O1 | | Television sets | | Y1/20 |
| Hospital records | Y3.3/11 | | Textiles | Y7 | |
| Insulating boards | O5, O6/20 | | Thermal insulation | K, O5, O6/20 | |
| Insulation | K, O5, O6/20 | | Trains | Z3/12 | |
| Laboratories | Y0/30 | | Tram cars | Z3/10 | |
| Laminates | O6 | | Trash bags | Y3.4/20 | |
| Liquids | Z1/10 | | Trees, artificial | Y8/10 | |
| Mattresses | Y6/10 | | Trees, christmas | Y8/20 | |
| Metal panels | O2 | | TV cabinets | Y1/20 | |
| Mineral wool | K4, O5 | | Upholstered chairs | Y5.2, Y5.3 | |
| Mock-up furniture | Y5 | | Upholstered furnitures | Y5 | |
| Navy cabins | Y0/10 | | Vehicles, large | | Z3/10 |
| Office furniture | Y0/20, Y3.3/10, Y5 | | Vehicles, small | Z3/20 | |
| Office modules | Y0/20 | | Wallcovering | O | |
| Office storage | Y3.3/10 | | Wardrobes | Y3.1 | |
| Pallets, stacked | Z1/20 | | Waste baskets | Y3.4/10 | |
| | | | Wiring | J4 | |
| | | | Wood laminates | O3/20 | |
| | | | Wood panels | O3/10 | |
| | | | Wood pallets | Z1 | |