Magnus Arvidson

A Small Scale Comparison between the FMRC and the EUR Standard Plastic Commodities

Brandforsk Project 735-941

SP Swedish National Testing and Research Institute
Fire Technology
SP REPORT 1999:29

Magnus Arvidson

A Small Scale Comparison between the FMRC and the EUR Standard Plastic Commodities

Brandforsk Project 735-941

SP Swedish National Testing and Research Institute
Fire Technology
SP REPORT 1999:29

Abstract

A small scale comparison between the FMRC and the EUR Standard Plastic commodities

This report describes small scale comparison tests between the FMRC and the EUR Standard Plastic commodity cartons. Both commodities consists of polystyrene plastic cups without lids, placed upside down in compartmented cartons.

Two series of tests were conducted under as equal conditions as the outside geometrical differences of the cardboard cartons allowed. After the first series of suppressibility tests it can be concluded that the EUR commodity is more difficult to suppress compared to the FMRC commodity. However, the second series of heat radiation measurements shows that this difference can not be attributed to any difference in heat radiated from the fires.

Key words: Plastics, small scale fire tests, sprinkler systems.

SP Sveriges Provnings- och Forskningsinstitut
SP Rapport 1999:29
ISBN 91-7848-787-0
ISSN 0284-5172
Borås 1999

SP Swedish National Testing and Research Institute
SP Report 1999:29
Postal address:
Box 857, SE-501 15 BORÅS, Sweden
Telephone: +46 33 16 50 00
Telefax: +46 33 13 55 02
E-mail: info@sp.se
Internet: www.sp.se

Contents

Preface

These tests were financed by Brandforsk (project 735-941) and by SP and is a continuation of previous projects using the commodity classification technique.

The reference group for the project consisted of the following persons:

Gunnar Annelind	Sveriges Försäkringsförbund (Trygg-Hansa)
Leif Beisland	Sveriges Försäkringsförbund (Folksam)
Catarina Henriksson	Svenska Brandförsvarsföreningen
Susanne Hessler	Brandforsk
Lars Holmberg	Bengt Dahlgren AB
Göran Holmstedt	LTH-Brandteknik
Sven Jönsson	IKEA AB
Geir Magnusson	Scania
Claes Malmqvist	Statens Räddningsverk
Conny Nabrink	Projektrör AB - Brandteknik (represented VVS-installatörerna)
Per Sjölander	AssiDomän Försäkrings AB
Lars-Erik Willberg	Sampo Industriförsäkring AB
Haukur Ingason	SP-Brandteknik
Henry Persson	SP-Brandteknik

Sammanfattning

Factory Mutual's standardplastgods, det s k "Factory Mutual Standard Plastic Commodity" används sedan länge som referensgods i fullskaliga sprinklerförsök. Godset användes till exempel när ESFR konceptet utvecklades i mitten av 1980-talet. Som namnet anger innehåller godset en stor mängd plast, förpackad i wellpappkartong. Plasten finns i form av plastmuggar. Totalt lagras åtta stycken wellpappkartonger på varje lastpall. De enskilda wellpappkartongerna har en fackindelning om 125 fack där vardera en plastmugg (polystyren) lagras. Totalt lagras alltså 1000 stycken plastmuggar på varje lastpall.

Eftersom de enskilda wellpappkartongerna har sådana yttermått att de inte passar på Europapallar har SP-Brandteknik tagit fram en egentillverkad polystyrenmugg och en wellpappkartong som både passar lastpallar med måtten 1200 mm x 800 mm och 1200 mm x 1000 mm. Detta gods har givits namnet "EUR Standard Plastic Commodity". Avsikten har inte i första hand varit att godset skall användas vid sprinklerförsök. Istället har avsikten varit att godset skall användas för att ta fram referensvärden i den s k godsklassificeringsmetodiken. Godset skall alltså utgöra en slags länk mellan det amerikanska klassificeringssystemet och det europeiska klassificeringssystemet. Det är därför viktigt att den två godsen har relativt jämförbara brand- och släckengenskaper.

I de försök som beskrivs i denna rapport jämfördes brandegenskaper och släckbarhet för de kartonger som används i FMRC Standard Plastic och EUR Standard Plastic godsen. Försöken genomfördes i mindre skala. Med hjälp av en kalorimeter jämfördes utvecklad brandeffekt vid olika påförda vattentäther.

Resultaten visar att brandeffektutvecklingen är snarlik för de två olika godsen. Däremot krävs högre vattentäthet för att kontrollera branden i EUR Standard Plastic godset.

För att undersöka om dessa skillnader beror på skillnader i värmestrålning från godsen genomfördes fribrinnande försök där detta mättes. Försöken gjordes med, såväl som utan plastmuggar i kartongerna. Resultaten visar inte på några större skillnader i värmestrålning, varför detta inte kan sägas vara någon förklaring.

Sökord: Sprinkler, plast, småskaleförsök.

1 Introduction

The Factory Mutual Research Corporation (FMRC) Standard Plastic commodity has been widely used in large scale sprinkler testing to produce data which formed basis of several protection standards [1]. The sizes of the cartons used for the commodity makes them, however, impossible to use on European pallets. For that reason, a EUR Standard Plastic commodity has been developed by the Swedish National Testing and Research Institute (SP). The intention is to use this commodity as a benchmark commodity for the commodity classification tests, a technique developed by FMRC but previously evaluated by SP [2] and adopted as a Nordtest test method [3].

The EUR Standard Plastic commodity cardboard cartons are sized 600 mm by 400 mm by 500 mm (L x W x H). This allows the cartons to be arranged on both 1200 mm by 800 mm as well as on 1200 mm by 1000 mm European pallets.

Another reason for the development of a EUR Standard Plastic commodity is the need for a test commodity for the Shopping & Storage tests as described in IMO Res. A.800(19) [4]. The test method specifies the use of the FMRC Standard Plastic commodity as the fire source. However, similar commodities are permitted to be used if they are designed in a similar way and are proven to have the same burning characteristics and suppressibility.

A great deal of work has been spent to design a similar plastic cup, find similar polystyrene resin and similar corrugated cardboard. The individual weight of the polystyrene cup used with the EUR Standard Plastic commodity is less compared to the cup for the FMRC commodity. However, the primary aim during the development has been to get a similar commodity on a pallet load basis.

The objective of this project was to compare the fire and suppressibility characteristics of the FMRC and the EUR Standard Plastic commodity cartons. The commodity cartons were tested using as equal conditions as the outside geometrical differences of the cardboard cartons allowed. The test arrangement was reasonably inexpensive, as a limited amount of material was needed for a test, with associated fast test turn around times.

2 Part I - Suppressibility tests

2.1 General description

The FMRC Standard Plastic commodity consists of empty polystyrene cups without lids, placed upside down, in compartmented cartons, 125 cups per carton. The cartons are cubic, measures 530 mm by 530 mm by 530 mm and are made from single-wall, corrugated cardboard. When compartmented, the cartons are divided into five layers by corrugated sheets, with each layer divided into 25 compartments by overlocking corrugated cardboard partitions, forming a total of 125 compartments where the plastic cups are placed.

The individual cups have a measured average weight of 33,8 g. The total weight of the plastic is therefore 4,2 kg per carton, the overall weight of one carton including the cups is approximately 6,9 kg. For the tests described within this report, cardboard cartons made by Avon Corrugated Corporation, USA were used.

Eight cartons were placed on each pallet. The overall dimension of one pallet load was therefore 1070 mm by 1070 mm by 1070 mm plus the height of the pallet. The total weight of one pallet load of the commodity was approximately 55,2 kg of which approximately 61 % by weight was plastic, excluding the pallet.

The EUR Standard Plastic commodity consists of empty polystyrene cups without lids, placed upside down, in compartmented cartons, 120 cups per carton. The cartons measures 600 mm by 400 mm by 500 mm (L x W x H) and are made from single-wall, corrugated cardboard. When compartmented, the cartons are divided into five layers by corrugated sheets, with each layer divided into 24 compartments by overlocking corrugated cardboard partitions, forming a total of 120 compartments where the plastic cups are placed.

The individual cups have a measured average weight of 28,2 g. The total weight of the plastic is therefore 3,4 kg per carton, the overall weight of one carton including the cups is approximately 5,4 kg. For the tests described within this report, the cardboard cartons were made by Maxbox Emballage AB, Sweden in quality E 300 C.

Ten cartons were placed on each pallet. The overall dimension of one pallet load was therefore 1200 mm by 1000 mm by 1000 mm (L x W x H) plus the height of the pallet. The total weight of one pallet load of the commodity was approximately 54 kg of which approximately 63 % by weight was plastic, excluding the pallet. The resin for the polystyrene was made by Hüls, in quality Vestyron 114.

2.2 The test set-up

Two piles of cartons were arranged spaced 150 mm. The piles were two cartons high. To prevent the top cartons from falling over at an early stage of the fire they were supported by a steel stand. The overall height of the FMRC commodity cartons was therefore 1060 mm as compared to the EUR cartons being 1000 mm high. The arrangement is shown in enclosure 1.

The total area of the parallel surfaces facing each other was 2 x (530 mm x 1060 mm) = 1,12 m^2 for the FMRC cartons and 2 x (600 mm x 1000 mm) = 1,20 m^2 for the EUR cartons.

2.3 Instrumentation

All tests were conducted using the Room-Corner test calorimeter. The equipment is capable of measuring the convective and total heat release rate of a fire. A more detailed description of the equipment is given in [5, 6].

2.4 Water application system

To be able to distribute water evenly over the top of the piles of the commodities, a water applicator was built. The water applicator consisted of four parallel 12,7 mm (1/2") steel pipes fitted with four spray nozzles along each pipe to form a uniform 4 x 4 matrix of nozzles. The nozzles were 450 mm apart. The water applicator was installed above the piles of commodities such that the distance between the tips of the nozzles and the top surface of the cartons was 250 mm. This particular distance was used irrespective if the FMRC or the EUR Standard Plastic commodity was tested.

The nozzles used were of the full-cone type, manufactured by Lechler GmbH, and denoted 460.368.30.CA.

The water applicator was fed from two directions through solenoid valves via hoses. The filling time of the water applicator was therefore very short, approximately one second. The hoses were connected to two interconnected pressure tanks. Each tank had a nominal volume of 150 L and was fitted with an inlet for compressed air. A constant water flow rate could therefore be set by adjusting the air pressure.

Prior to each test the desired water density was adjusted by placing a 700 mm by 700 mm tray 250 mm centric below the sixteen nozzles. Water was applied for three minutes, after which the tray was weighed, and the average water density was calculated.

2.5 Ignition

Ignition was achieved by two igniters positioned on the floor, at the center of the flue formed by the piles of commodities. Each of the igniters was 60 mm by 60 mm by 20 mm and made of pieces of insulating fibre board. The igniter was soaked with 40 mL of Heptane and wrapped in a polyethylene bag.

2.6 Test procedure

Prior to each test, cartons enough for the test were taken from the conditioning room as the calorimeter and the water applicator were calibrated. The cartons were piled centric under the water applicator. The height of the water applicator was adjusted. Igniters were prepared and placed in their positions. The measurements were started and the igniters were lit with a torch after two minutes.

The fire was allowed to develop and the water applicator was activated as the convective heat release rate reached 350 kW. Water was applied for 30 minutes or until the majority of the combustibles were consumed, after which the test was terminated.

2.7 Observations and test results

Eleven tests were conducted, five tests using the FMRC Standard Plastic commodity and six tests using the EUR Standard Plastic commodity. The average water densities ranged from 2,1 to 4,2 mm/min. In addition two free burn tests were conducted. The conducted tests and the associated test numbers is shown in the table below.

Table 1 Test number identification

Water density	Test number identification	
	FMRC Standard Plastic	EUR Standard Plastic
4,2 mm/min	-	25
4,0 mm/min	23	24
3,1 mm/min	17	18
2,7 mm/min	27	20
2,1 mm/min	21	22
Free burn	14	13

Figure 1 illustrates a typical (total) heat release rate history of the tests. For reference purposes, the graph has been divided into four different phases, A - D.

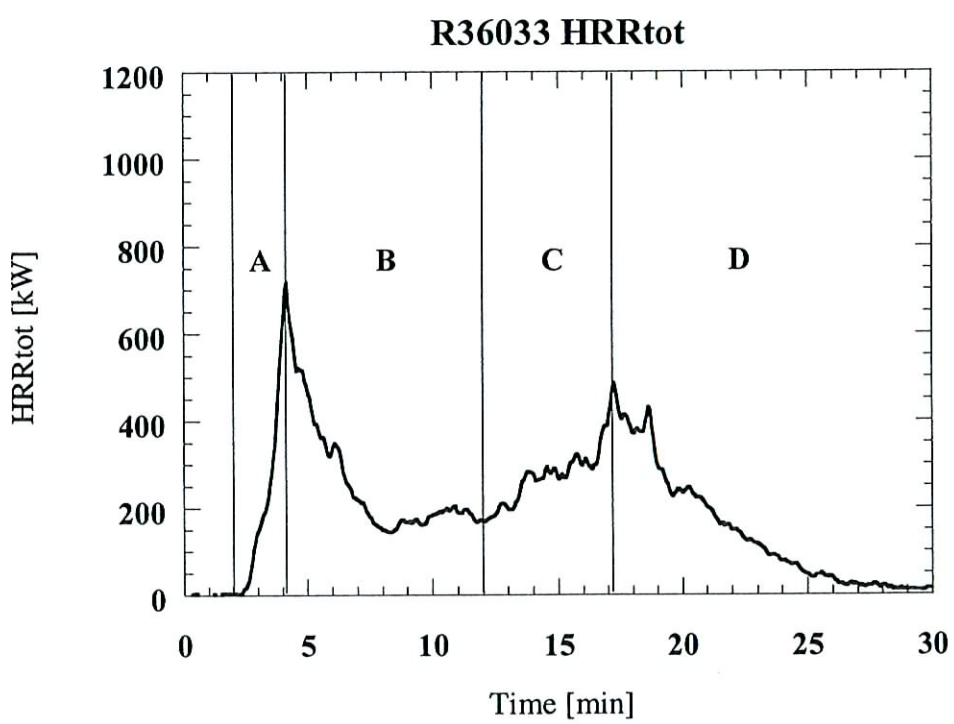


Figure 1 A typical (total) heat release rate history of the tests, illustrated by test 27.

The following observations were made during the different stages:

A Free burning development stage, before the water application was initiated. The moment when the cardboard cartons burnt through can be seen from the graphs, indicated by a short reduction in the rate of rise. For the FMRC commodity cartons this occurred approximately at 170 - 180 kW and approximately at 160 - 170 kW for the EUR Standard Plastic commodity cartons. After this moment the plastic becomes involved in the fire.

B The water was activated and the fire either suppressed or controlled. During this stage the fire primarily remained in the flue between the two piles.

C During this phase the fire consumed the combustibles of the lower parts of the cartons. As the fire became more and more shielded from the water the fire intensity increases. Eventually the fire spread to the sides of the cartons, leading to the second peak. The second peak was reached after about 15 minutes from the start of the test for the EUR Standard Plastic commodity cartons and after between 15 and 20 minutes for the FMRC Standard Plastic commodity cartons.

D The fire intensity decays as the combustibles are consumed.

Table 2 shows the energy generated during the first 10 minutes of the fire (phase A + B). The reason for making the comparison between the commodity cartons at this particular period of time is due to the fact that the geometrical differences between the cartons were not as influential, as the fire remained primarily in the flue between the piles. Later the fire spread to the outside of the cartons.

Table 2 Energy generated during the first 10 minutes of the fires.

Water density	Integrated Energy 2 - 12 min			
	FMRC Standard Plastic		EUR Standard Plastic	
	Conv Energy [MJ]	Total Energy [MJ]	Conv Energy [MJ]	Total Energy [MJ]
4,2 mm/min	-	-	50,9	139,2
4,0 mm/min	33,5	78,5	70,8	168,3
3,1 mm/min	62,2	167,2	111,6	221,8
2,7 mm/min	67,4	147,9	101,5	200,5
2,1 mm/min	83,1	181,5	154,1	260,5
Free burn	292,8	450,9	245,0	391,4
Ratio total / conv	1,54		1,60	
Free burn*	396,0	541,0	296,0	457,0
Ratio total / conv	1,37		1,54	

*) Values calculated based on whole fire duration time.

The data is plotted in figure 2.

Table 3 Maximum one minute total and convective HRR

Water density	Maximum one minute HRR			
	FMRC Standard Plastic		EUR Standard Plastic	
	HRRconv [kW]	HRRtotal [kW]	HRRconv [kW]	HRRtotal [kW]
4,2 mm/min	-	-	329	591
4,0 mm/min	318	524	357	616
3,1 mm/min	315	599	407	742
2,7 mm/min	325	586	400	714
2,1 mm/min	371	603	420	728
Free burn	719	1156	601	990

The data is plotted in figure 3.

Figures 4 through 7 shows the total and convective heat release rate histories of the FMRC and the EUR Standard Plastic commodity, respectively.

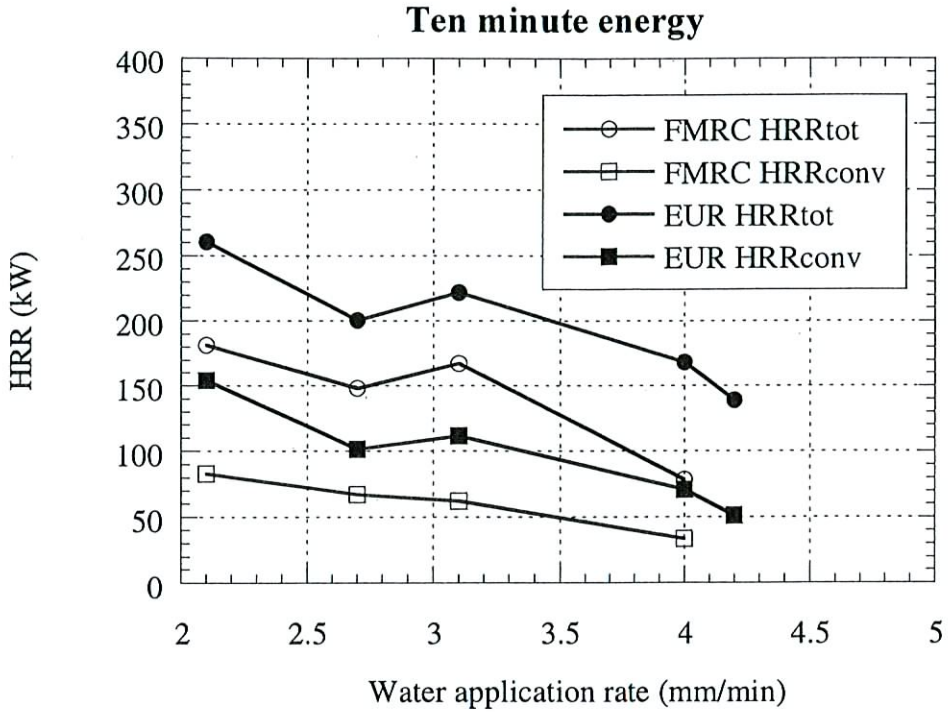


Figure 2 *The integrated total and convective energy during the first ten minutes as a function of the water application rate.*

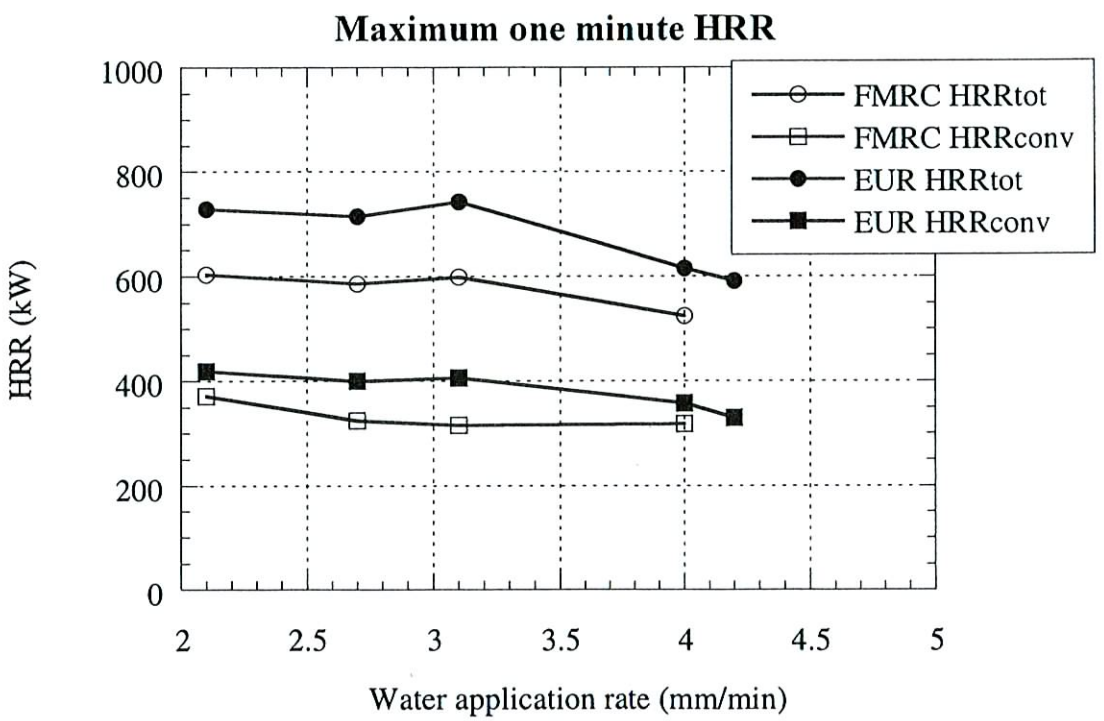


Figure 3 *The maximum one minute average total and convective heat release rate of the fires, as a function of the water application rate.*

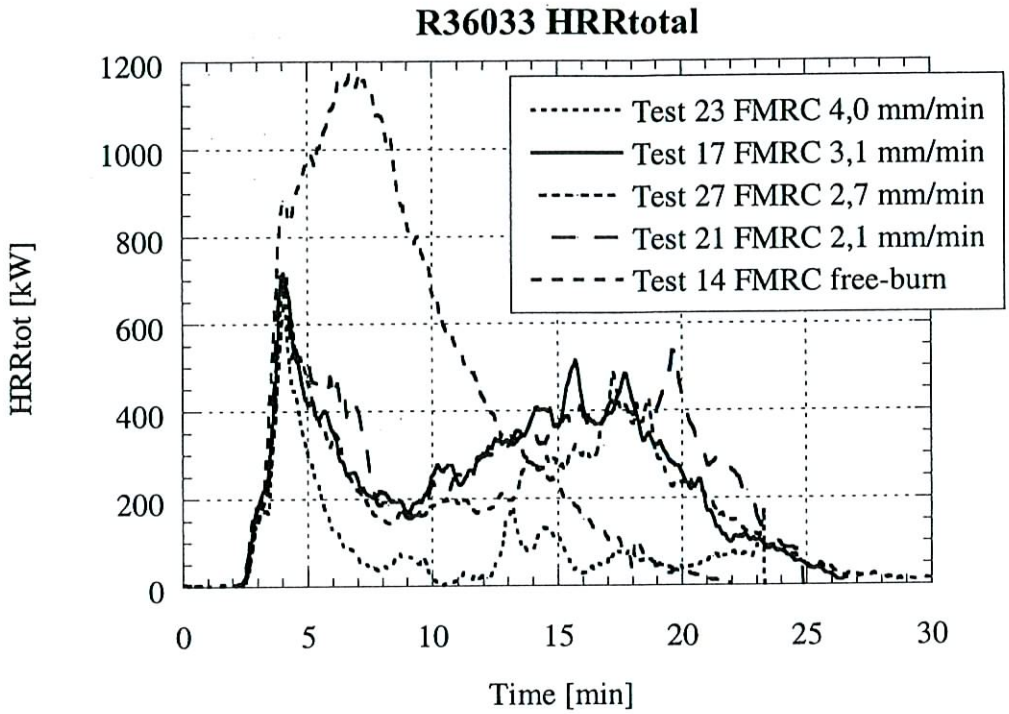


Figure 4 *Total HRR for the tests with the FMRC Standard Plastic commodity cartons.*

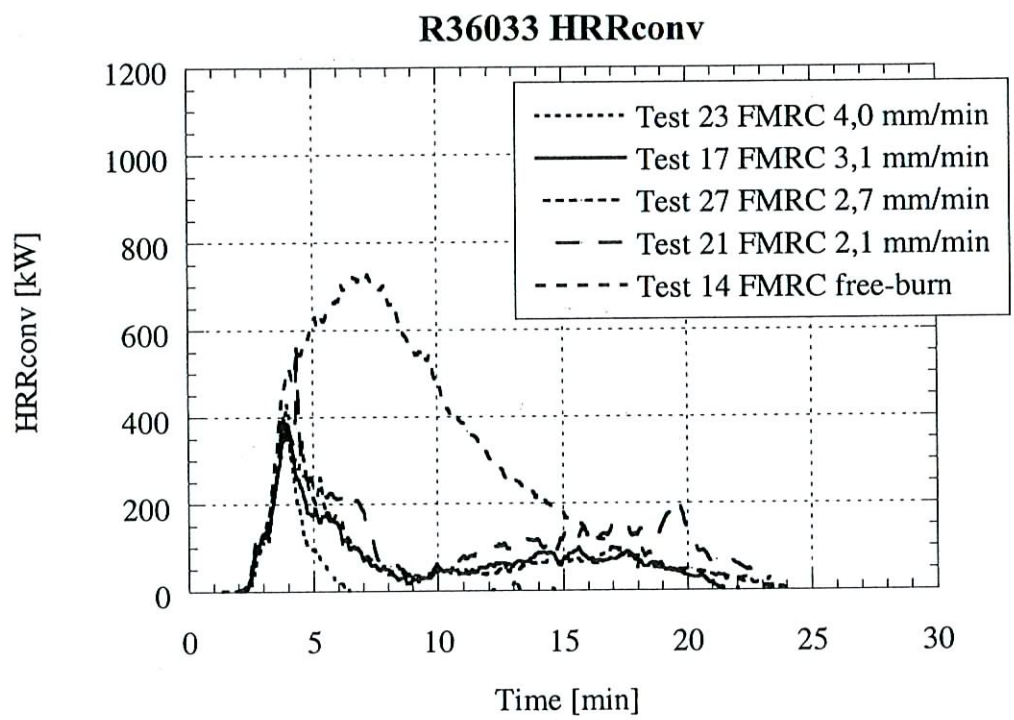


Figure 5 *Convective HRR for the tests with the FMRC Standard Plastic commodity cartons.*

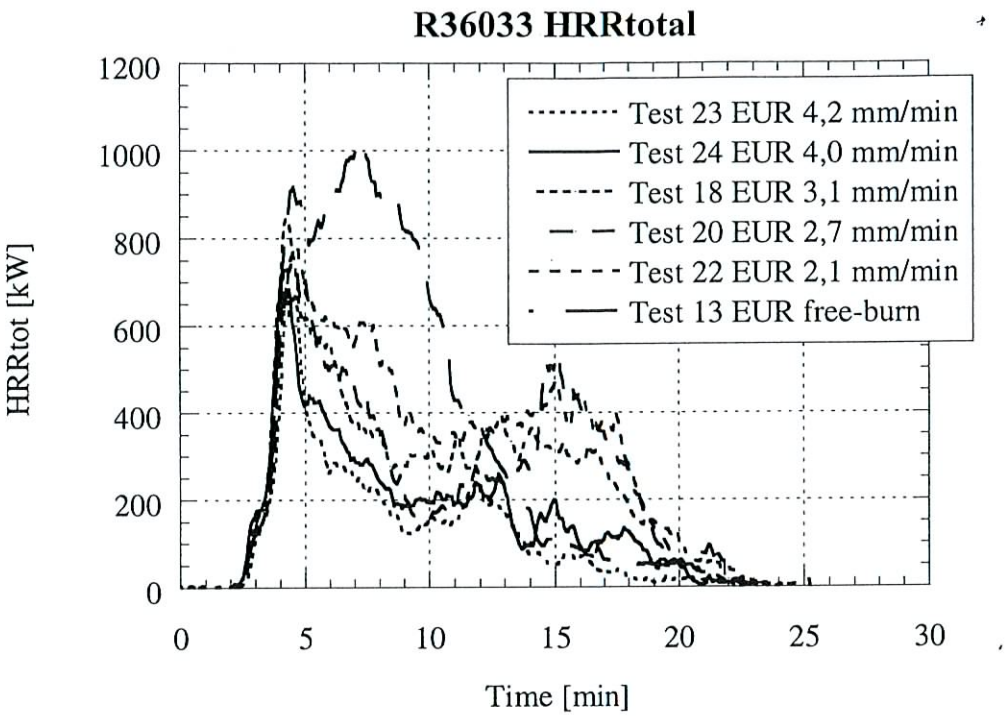


Figure 6 *Total HRR for the tests with the EUR Standard Plastic commodity cartons.*

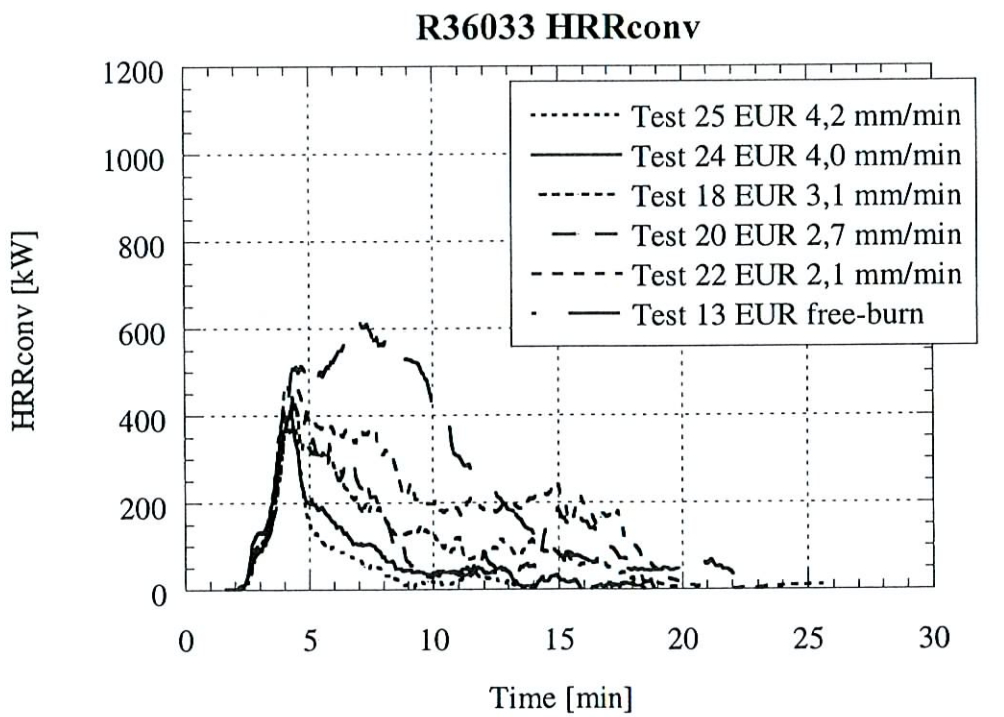


Figure 7 *Convective HRR for the tests with the EUR Standard Plastic commodity cartons.*

3 Part II - Heat radiation measurements

The intention of the test series was to compare the heat radiation from a pile of two burning cartons towards a parallel surface at a 150 mm distance. This is the heat radiation the adjacent pile of cartons would be exposed to in the previous suppressibility tests. The intention was to investigate whether the reason for the difference in suppressibility could be related to a difference in combustion behaviour.

The tests were conducted wit, as well as without plastic cups in the cartons.

3.1 The commodities

The commodities were similar to the ones described in Chapter 2.1.

3.2 The test set-up

One pile of cartons was arranged such that it faced an instrumentation panel at a 150 mm distance. The instrumentation panel is described in chapter 3.3. The pile was two cartons high. To prevent the top cartons from falling over at an early stage of the fire they were supported by a steel stand. The overall height of the FMRC commodity cartons was 1060 mm as compared to the EUR cartons being 1000 mm high. The arrangement is shown in enclosure 2.

3.3 Instrumentation

An instrumentation panel was fabricated using a 1000 mm high by 600 mm wide, nominally 12 mm thick, non-combustible board. Two Plate Thermometers, one heat flux gauge and three 0,5 mm type K thermocouples were attached to the panel. Two of the thermocouples were positioned at the position of the Plate Thermometers, at half the horizontal distance between the panel and the pile of cartons. The third thermocouple was positioned above the top of the pile.

It should be noted that the Plate Thermometer also responds to heat radiation.

The heat release rate from the fires was measured using the Room-Corner test calorimeter.

3.4 Ignition

The fires were ignited using one igniter as described in chapter 2.5

3.5 Test procedure

Cartons enough for the test were taken from the conditioning room prior to the test. An igniter was prepared and placed on the floor, at the centreline of the pile facing the instrumentation panel. The measurements were started and the igniter was lit with a torch after two minutes.

The fire was allowed to develop naturally and burn until the majority of the combustibles were consumed, after which the test was terminated.

3.6 Observations and test results

Altogether, four tests were conducted. Two tests where either the FMRC Standard Plastic or the EUR Standard Plastic commodity cartons were used and two additional tests using these commodity cartons without any plastic cups inside. The tests and the associated test identity is shown in the table below.

Table 4 Test number identification.

Test commodity	Test identification
FMRC Standard Plastic	1.1 FMRC
EUR Standard Plastic	1.2 EUR
FMRC Standard Plastic w/o plastic cups	2.1 FMRC
EUR Standard Plastic w/o plastic cups	2.2 EUR

The results from the tests are summarised in tables 5 and 6. Both peak values as well as the maximum one minute average values are given.

Table 5 Summary of the results for the two tests with FMRC and EUR Standard Plastic commodity cartons. The second value given is the maximum one minute average.

	FMRC	EUR
Peak HRRtotal [kW]	516	593
Peak HRRconv [kW]	350	390
Max one minute avg. HRRtotal [kW]	494	574
Max one minute avg. HRRconv [kW]	331	365
Max five minutes avg. HRRtotal [kW]	460	493
Max five minutes avg. HRRtotal [kW]	304	313
Total energy [MJ]	338,8	261,6
Total conv. energy [MJ]	224,2	174,7
Ratio total energy / conv. energy	1,51	1,49
Heat radiation [kW/m^2] (peak/max. one minute)	193 / 158	200 / 167
Temp. Ch21 [°C]	961 / 951	994 / 952
Temp. Ch22 [°C]	842 / 838	852 / 840
Temp. Ch23 [°C]	977 / 908	954 / 896
Temp. Ch24 [°C]	1095 / 1006	1069 / 982
Temp. Ch25 [°C]	783 / 660	1111 / 918

Table 6 *Summary of the results for the tests with commodity cartons without plastic cups. Second value given is maximum one minute average.*

	FMRC w/o plastic cups	EUR w/o plastic cups
HRRtotal [kW]	237	335
HRRconv [kW]	174	255
Max one minute avg. HRRtotal [kW]	221	263
Max one minute avg. HRRconv [kW]	159	193
Max five minutes avg. HRRtotal [kW]	191	171
Max five minutes avg. HRRtotal [kW]	140	126
Total energy [MJ]	78,5	59,2
Total conv. energy [MJ]	56,6	42,8
Ratio total/conv. energy	1,39	1,38
Heat radiation [kW/m^2] (peak/max. one minute)	73 / 63	124 / 77
Temp. Ch21 [°C]	609 / 597	588 / 582
Temp. Ch22 [°C]	595 / 588	544 / 541
Temp. Ch23 [°C]	938 / 890	886 / 712
Temp. Ch24 [°C]	870 / 774	668 / 569
Temp. Ch25 [°C]	692 / 574	405 / 338

Figures 8 through 13 provides measurement graphs of the tests. The results for the FMRC Standard Plastic commodity cartons are given in the top graphs, the results of the EUR Standard Plastic in the bottom graphs.

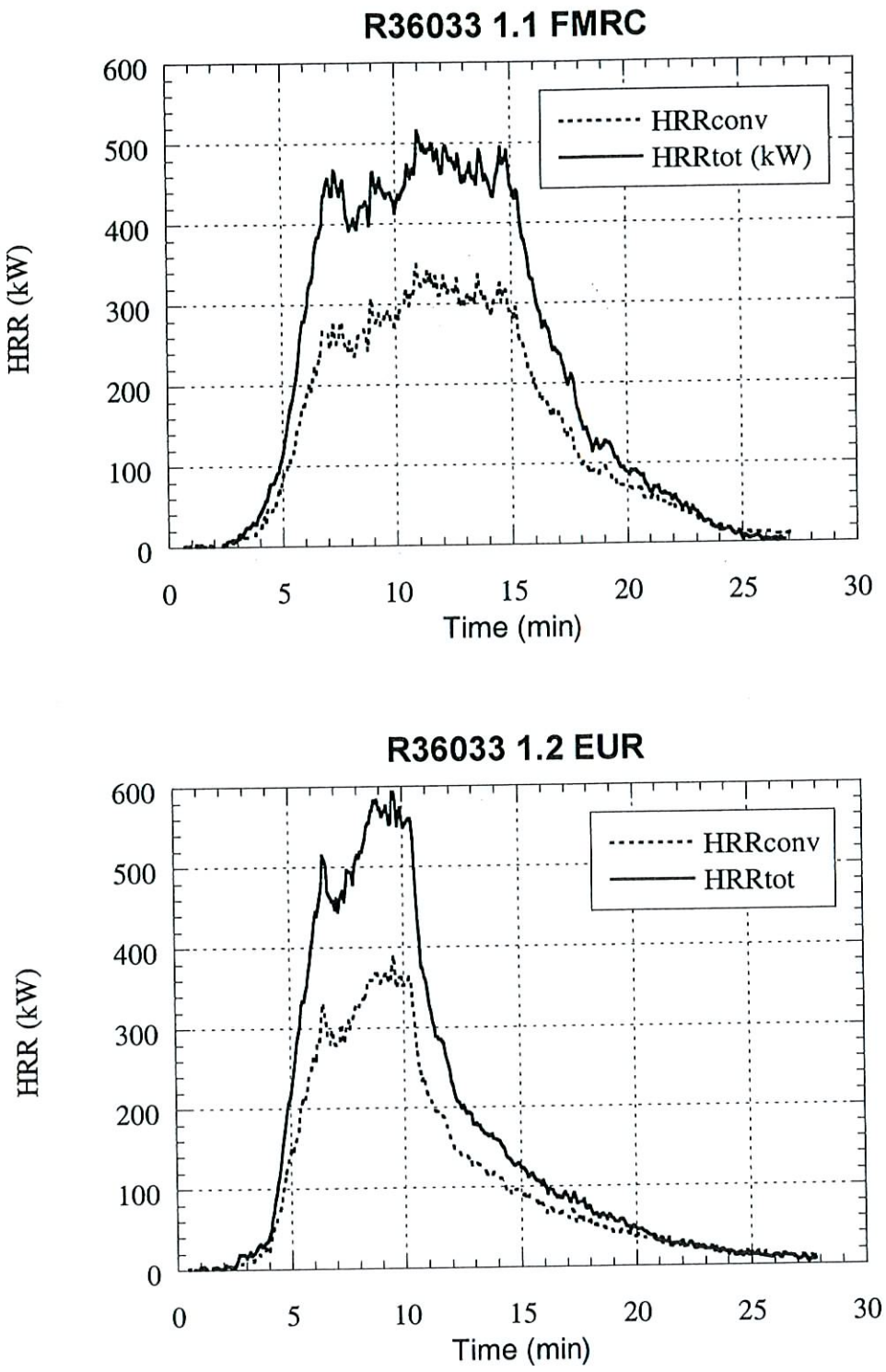


Figure 8 *Total and convective heat release rate histories of the pile of FMRC (top graph) and the EUR Standard Plastic commodity cartons.*

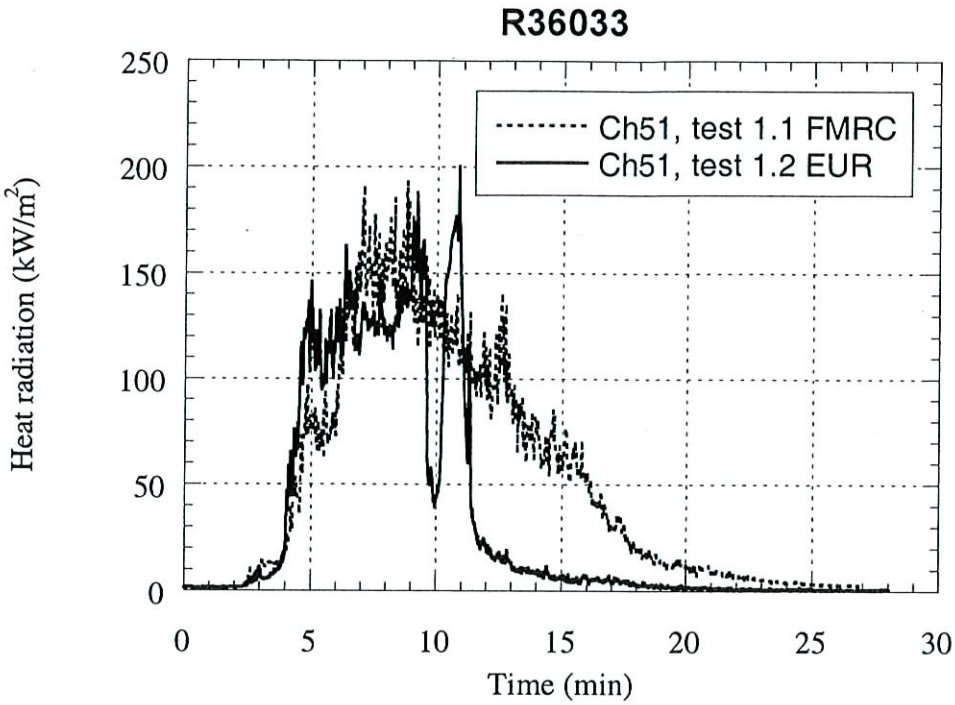


Figure 9 *Comparison of heat flux from the FMRC and the EUR Standard Plastic commodity cartons.*

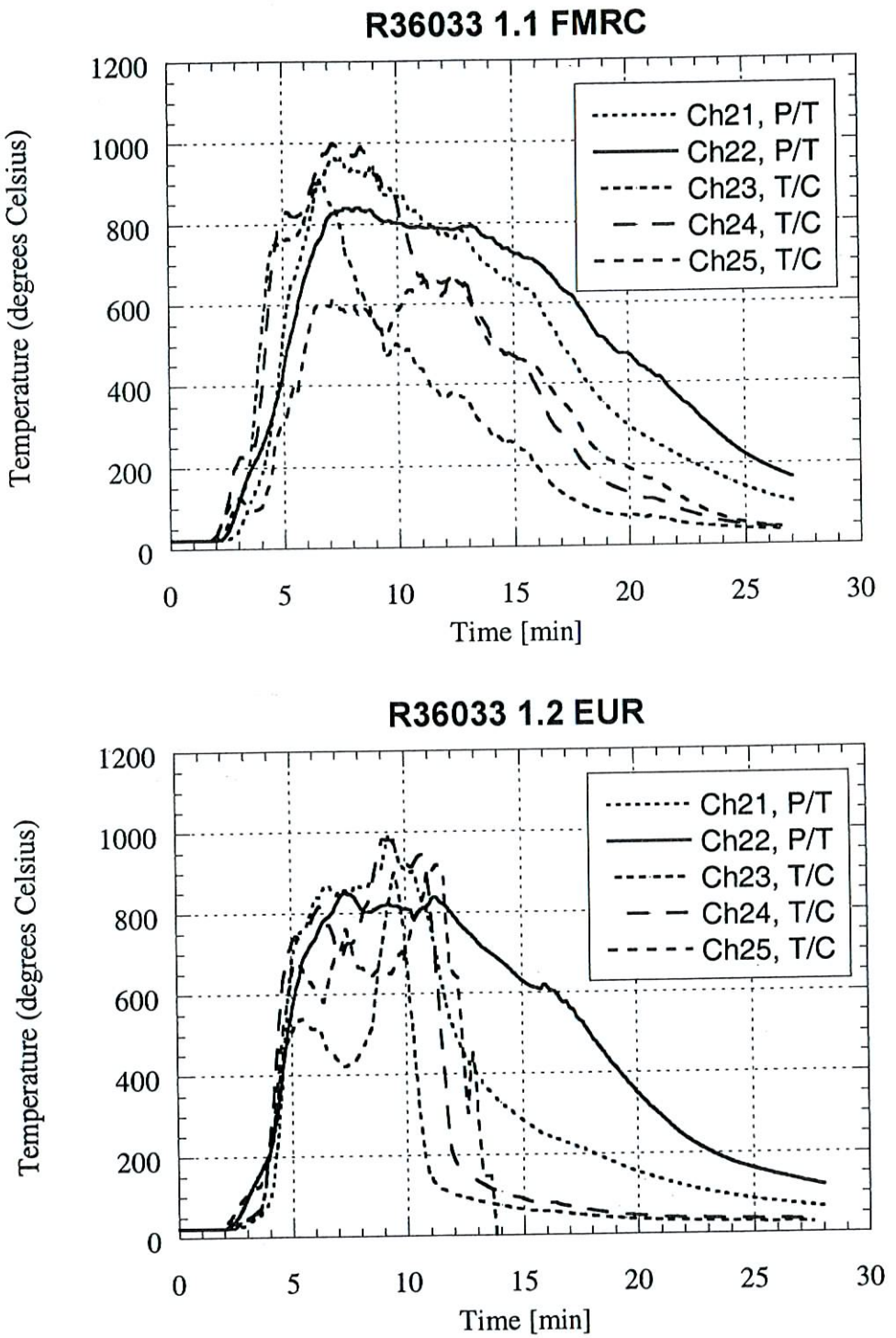


Figure 10 *Temperatures measured with the Plate Thermometers, Ch21 and Ch22, and thermocouples, Ch23, Ch24 and Ch25. FMRC Std Plastic commodity cartons (top graph) and EUR Std Plastic commodity cartons (bottom graph).*

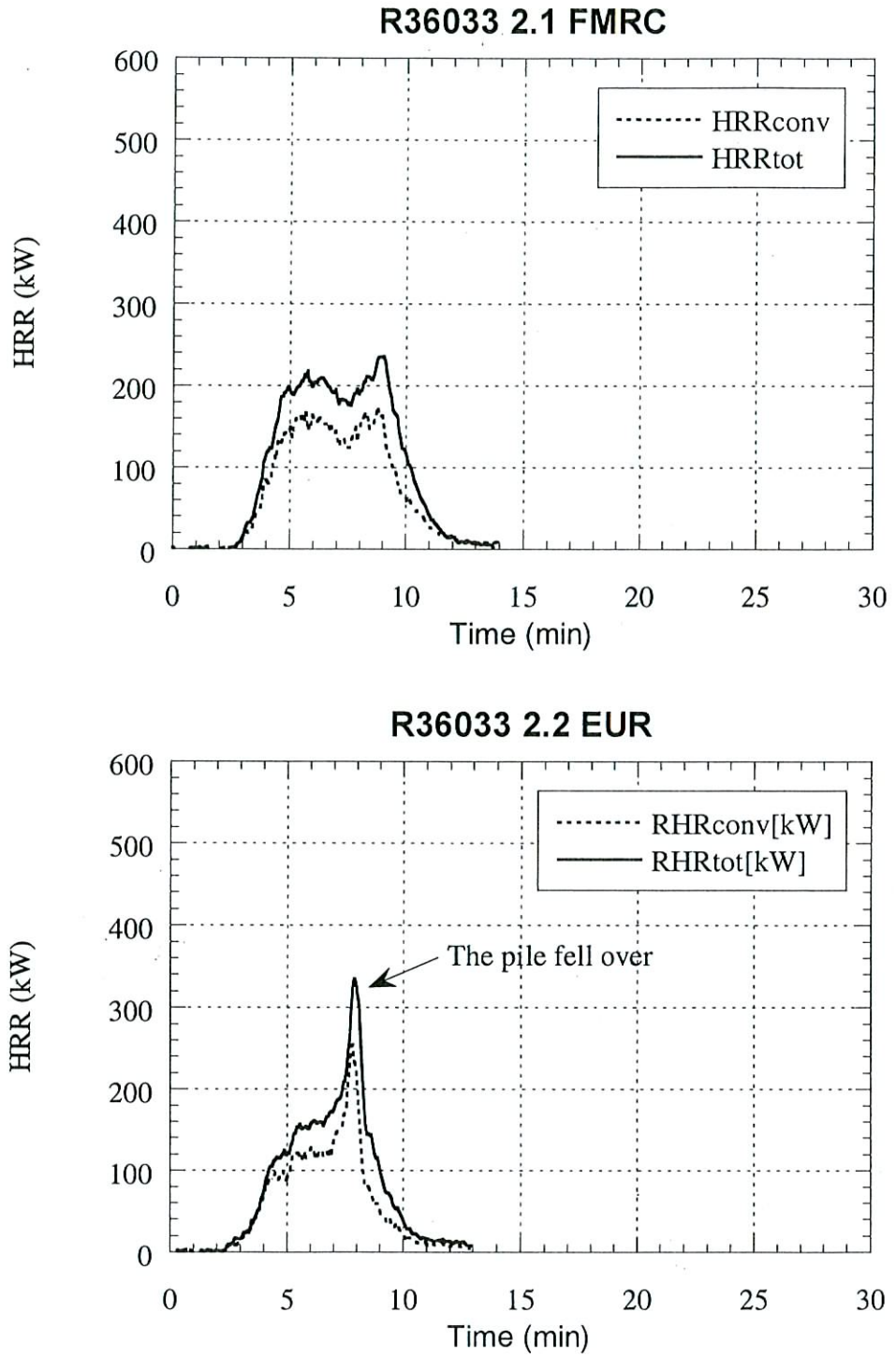


Figure 11 *Total and convective heat release rate histories of the pile of FMRC (top) and the EUR Standard Plastic (bottom) commodity cartons without any plastic cups. The fall of the pile of EUR cartons made the fire flash up and then decrease.*

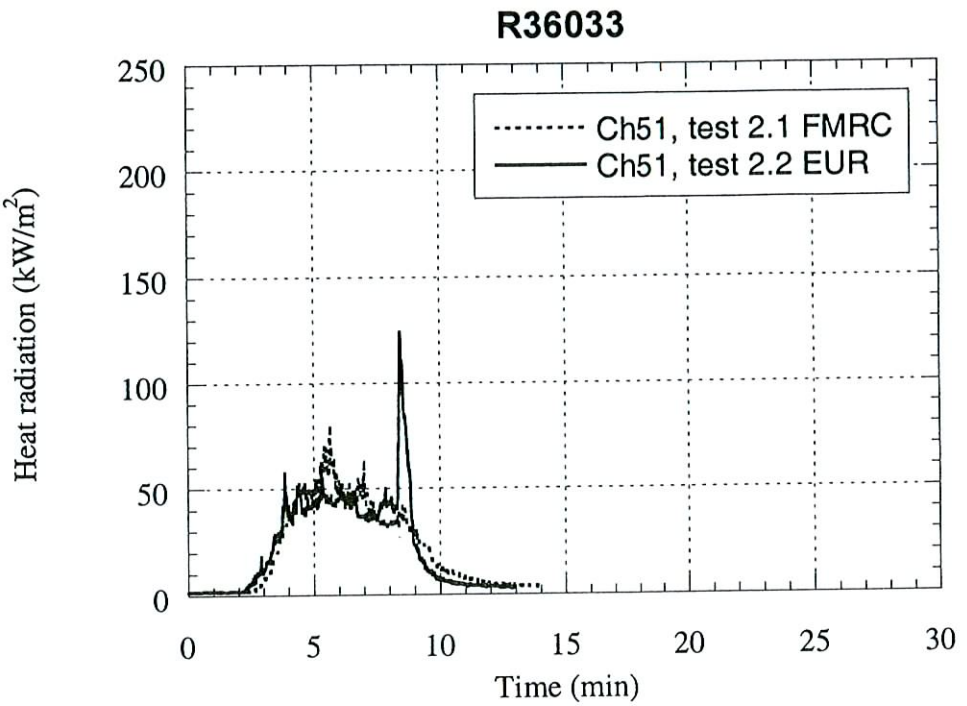


Figure 12 *Comparison of heat flux from the FMRC and the EUR Standard Plastic commodity cartons.*

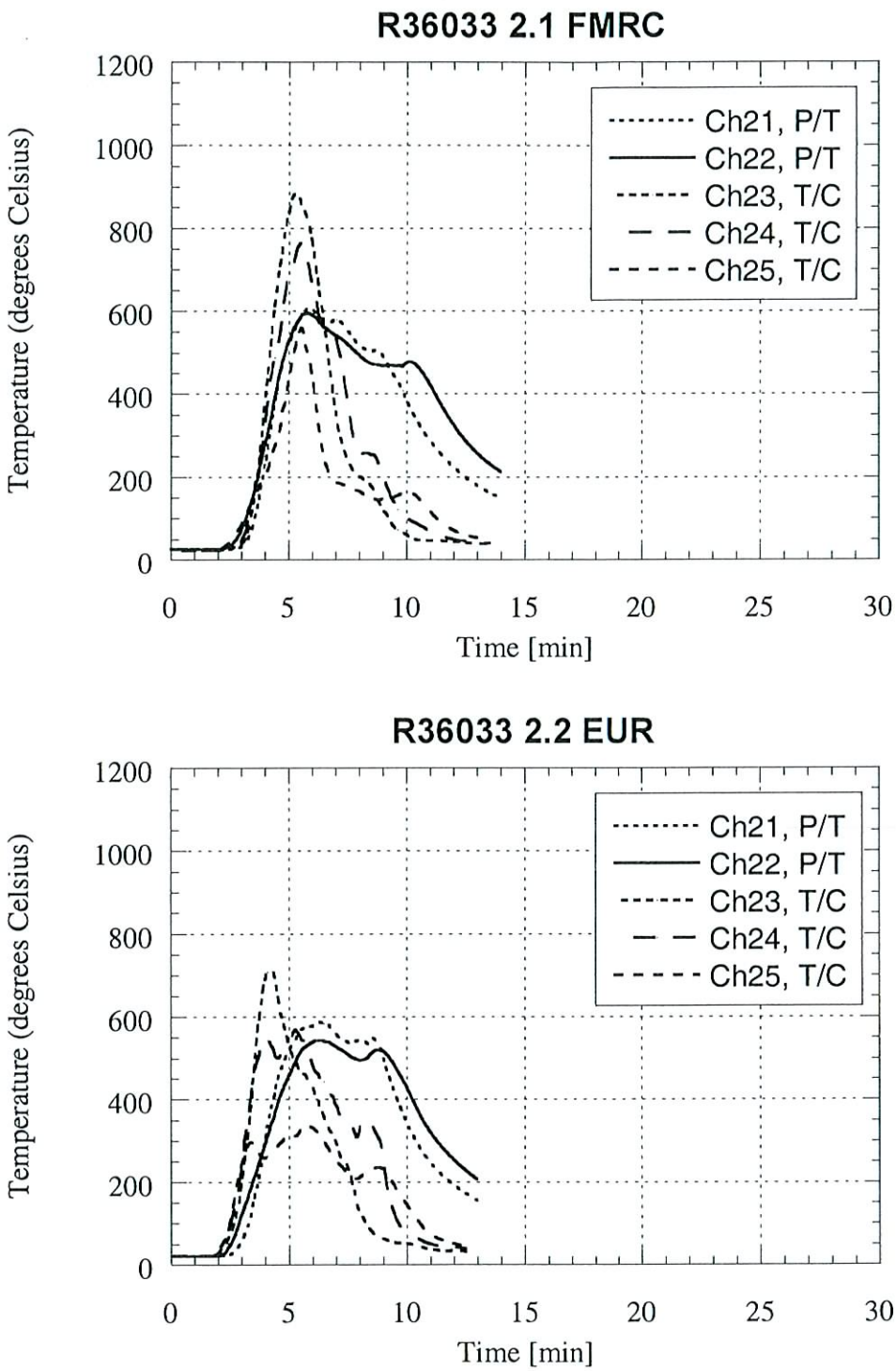


Figure 13 *Temperatures measured with the Plate Thermometers, Ch21 and Ch22, and thermocouples, Ch23, Ch24 and Ch25. No plastic cups were used inside the commodity cartons. FMRC (top graph) EUR (bottom graph).*

4 Discussion and conclusions

This report presents the results from two small scale comparison tests between the FMRC and the EUR Standard Plastic commodity cartons. The commodity cartons were tested using as equal conditions as the outside geometrical differences of the cardboard cartons allowed. The test arrangement was reasonably inexpensive, as a limited amount of material was needed for a test, with associated fast test turn around times.

4.1 Suppressibility tests

The test result comparison of the commodity cartons was based on the initial ten minutes of the fire. At later stages the difference between the amount of combustibles and the geometrical differences between the cardboard cartons becomes too influential.

The following observations and conclusions can be made:

- The fire development of the two different commodity cartons were very similar, although the burn through of the cardboard carton slightly differed.

- The ratio between the total energy released during the free burn tests corresponds well with the weight ratio between the total amount of combustibles for the different commodity cartons.

- The water application rate was varied from between 2,1 - 4,2 mm/min. The highest water application rate was only used for the EUR commodity cartons. For both commodities, this range of water application rates provided for controlled as well as suppressed fires.

- The energy released during the first ten minutes of the fires, as a function of the water application rate was calculated. Generally, both the total and the convective ten minute energy were higher for the EUR commodity. However, for the convective ten minute energy, the difference is decreasing with increased water application rate. On average, approximately 60 % more water was needed to reduce the total ten minute energy from the EUR commodity to the levels of the FMRC commodity. For the convective ten minute energy, approximately 30 % more water was needed.

- The maximum one minute average heat release rate was generally higher for the EUR commodity, however, the difference is decreasing with increased water application rate. At 4,0 mm/min water density, the convective maximum one minute value was similar for the two different commodity cartons.

The results show that the EUR Standard Plastic commodity cartons requires higher water application rates for fire control and fire suppression in this scale.

To determine whether or not the differences in suppressibility between the two different types of cartons could be explained by a difference in heat radiated from the fire, a second series of tests were conducted.

4.2 Heat radiation measurements

The intention of the second test series was to compare the heat radiation from a pile of two burning cartons towards a parallel surface at a 150 mm distance. Altogether, four tests were conducted. Two tests, one with the FMRC Standard Plastic cartons and one with the EUR Standard Plastic commodity cartons and two additional tests using these commodity cartons without any plastic cups inside.

The following observations and conclusions can be made:

- The fire development of the two different commodities were very similar, but not identical. The differences are likely due to the geometrical differences and how fast the fire spreads around the corners of the cartons. The maximum five minute average heat release rates are, however, similar which indicates that the average burning rate of the two different commodity cartons are similar. The ratio between the total and convective energy are very similar for the cartons, with as well as without plastic cups inside. This indicates that an equal ratio of energy radiated from the fires. The ratio between the total energy released for the different commodity cartons also corresponds well with the weight ratio between the total amount of combustibles.

- The heat radiation level measured with the heat flux gauge was reasonably similar comparing the FMRC commodity cartons with the EUR cartons. Without plastic cups inside the cartons, the measured heat radiated from the fires were very similar.

- The temperatures measured with the Plate Thermometers (also responds to heat radiation) were very similar for the commodity cartons. Without the plastic cups inside, slightly higher temperatures were measured using the FMRC cartons.

- The temperatures measured with thermocouples were similar, except for one of the three measurement points, when comparing the commodity cartons. Differences occurred at the lowest positioned thermocouple, where higher temperatures were recorded using the EUR cartons. When the cartons without plastic cups inside were burnt, higher temperatures were recorded for the FMRC cartons.

The general conclusion from these tests is that the difference in suppressibility that occurred in the first series of tests is not possible to explain by a difference in heat radiation from the commodity cartons. It seems therefore necessary to conduct suppressibility tests in a larger scale, to determine if the differences increases or decreases with scale.

5 References

[1] Chicarello, Peter, J., and Troup, Joan, M. A., "Fire Products Collector Test Procedure for Determining the Commodity Classification of Ordinary Combustible Products", Factory Mutual Research Corporation, August, 1990

[2] Persson, Henry, "Commodity classification - A more objective and applicable methodology", SP-REPORT 1993:70, Swedish National Testing and Research Institute, Borås, Sweden, 1993

[3] NT FIRE 049, "Combustible products: Commodity classification- Fire test procedure", Approved 1995-05, 15 pages

[4] RESOLUTION A.800(19), "Revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS Regulation II-2/12", International Maritime Organisation, 23 November, 1995

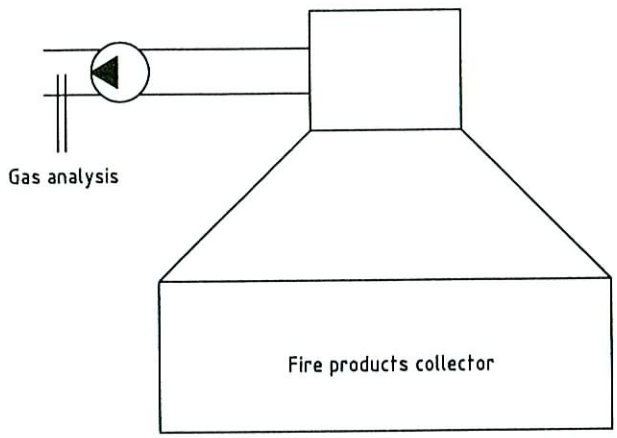
[5] Dahlberg, Martin, "The SP Industry Calorimeter", SP-REPORT 1992:43, Swedish National Testing and Research Institute, Borås, 1992

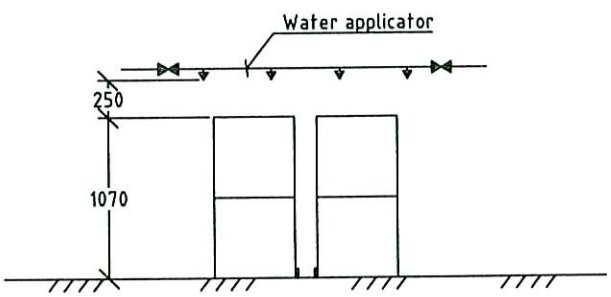
[6] Dahlberg, Martin, "Error Analysis for Heat Release Rate Measurements with the SP Industry Calorimeter", SP-REPORT 1994:29, Swedish National Testing and Research Institute, Borås, 1994

Test arrangement

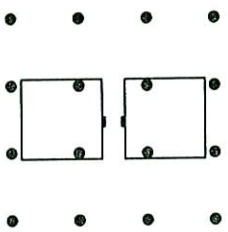
Suppressibility tests

Bilaga nr: 1	
Rapport nr: 1999:29	
Datum: 1999-11-22	Rev. Datum:
Skala: 1:50	Sign: MA

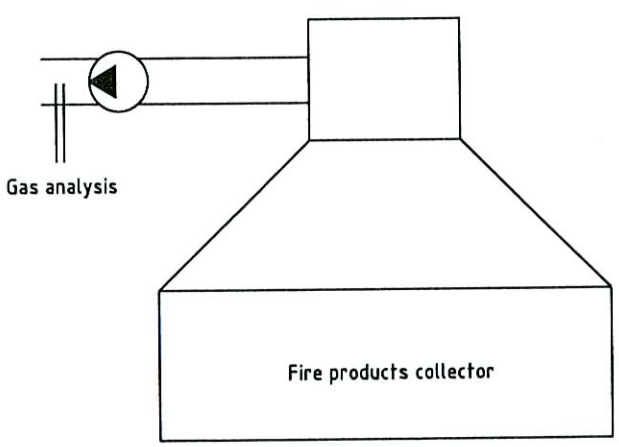


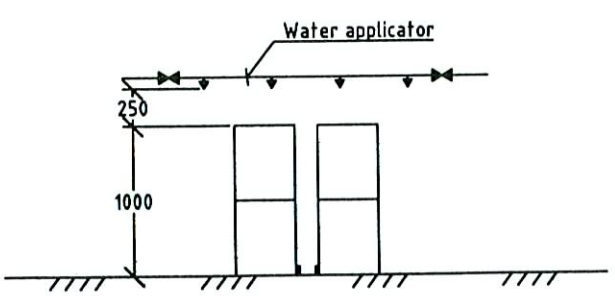


FMRC Std Plastic commodity

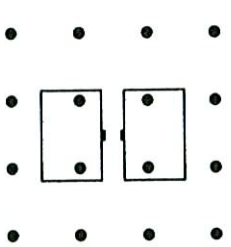


Top view with position of nozzles relative to cartons





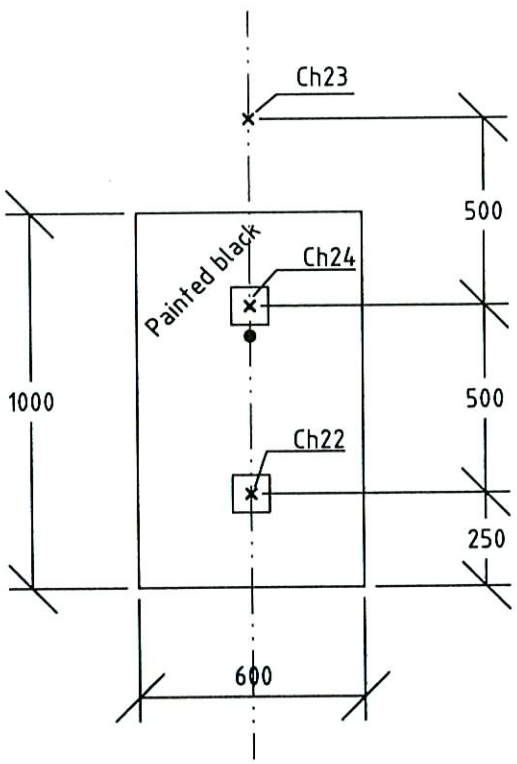
EUR Std Plastic commodity



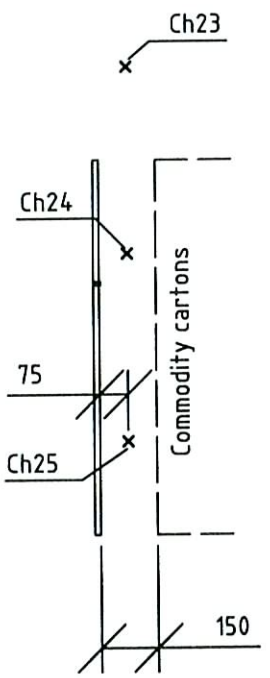
Top view with position of nozzles relative to cartons

Instrumentation panel

Bilaga nr: 2	
Rapport nr: 1999:29	
Datum: 1999-11-22	Rev. Datum:
Skala: 1:20	Sign: MA



Front view



Side view

Plate Thermometer

× Thermocouple

● Heat flux meter

SP Swedish National Testing and Research Institute
Box 857, SE-501 15 BORÅS, Sweden
Telephone: +46 33 16 50 00, Telefax: +46 33 13 55 02
E-mail: info@sp.se, Internet: www.sp.se

SP REPORT 1999:29
ISBN 91-7848-787-0
ISSN 0284-5172