Simulation of the Switel Hotel Fire

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1998

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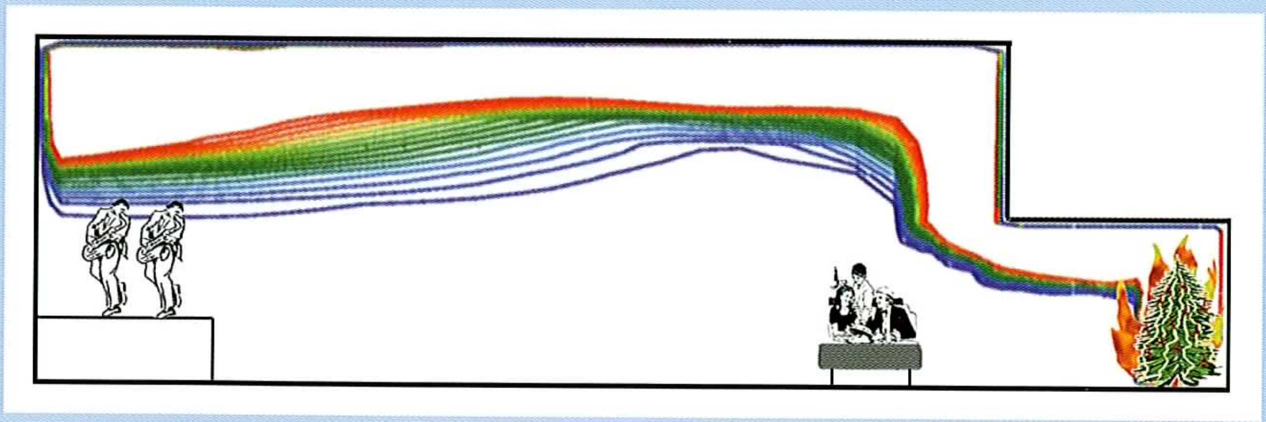

SP Swedish National Testing and Research Institute
Fire Technology
SP REPORT 1998:04

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Abstract

This report describes simulations of a fire which took place in the Switel hotel in Antwerp on New Year's eve 1994. In the fire a very particular plume development was observed. Simulations with both the zone model Hazard I and the CFD (Computational Fluid Dynamics) code SOFIE are reported. It is found that the zone model predictions only reveal limited information on the plume development that occurred. However the CFD simulation gives a very detailed picture of the fire. It is concluded that CFD can be used as a tool for the post fire investigations of such fires and for pre investigation of the fire hazard in buildings where more complex configurations are encountered.

Key words: CFD models, zone models, fire investigations, fire growth, fire plumes

SP Sveriges Provnings- och Forskningsinstitut
SP Rapport 1998:04
ISBN 91-7848-708-0
ISSN 0284-5172
Borås 1998

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Summary

On New Year's Eve 1994 a very short but intensive fire occurred in the banqueting room of the Switel hotel in Antwerp (Belgium). This report describes simulations of the fire by means of the zone model Hazard I and the CFD code SOFIE. The simulations are based on public available information. The fire started in a small entrance room where two Christmas trees were placed. Although the fire had a very short duration and self extinguished many people lost their lives or were severely injured. The simulations reveal that the zone model is only capable to predict a short vent fire inside the large banqueting room. Detailed smoke flows and smoke layer depths are not possible to predict with the zone model.

The CFD model SOFIE however predicts more accurately the smoke flow, temperature distribution and smoke layer. The CFD predictions also reveal that people nearby the fire might have apprehend the fire as a jet fire emanating from the entrance room to the large room due to the high velocity of the smoke gases escaping from the fire room. It is clear that CFD models in the future can be used for both post fire investigations and for evaluation of the fire hazard inside more complex buildings within the frame of fire performance based engineering.

Sammanfattning

Simuleringar har utförts av en brand som uppstod i festvåningen till ett hotell i Antwerpen på nyårsaftonen 1994 (Switel Hotel). Ett stort antal personer var samlade i festsalen när det började brinna i två julgranar som var placerade i ett mindre, angränsande rum. Branden fick ett mycket häftigt men kortvarigt förlopp. Ögonvittnen fick intrycket av en jetflamma som kom ut från brandrummet. Branden slocknade av sig själv inom några minuter. Då hade redan 12 personer fått sådana skador av brandröken att de avled inom kort tid, mer än 140 personer blev allvarligt skadade.

I simuleringarna har en zonmodell, Hazard I, och ett fältmodellprogram, SOFIE, använts. Resultaten visar entydigt på zonmodellernas svårigheter att ge detaljerad information om brandutvecklingen och rökspridningen i ett rumskomplex av den här typen där man också har inverkan av ventilation. Fältmodellprogrammet ger en betydligt bättre bild av brandförloppet. I stort sett stämmer förloppet överens med ögonvittnenas berättelser. Från beräkningarna noteras att brandgaserna får en mycket hög hastighet när de strömmar ut från det lilla brandrummet in i festvåningen. Personer placerade nära dörren till brandrummet kan mycket väl ha uppfattat brandröken som en jetstråle. Strålningsnivån vid de bord nära brandrummet där personer satt när branden bröt ut har beräknats ha sådana nivåer att brännskador kunde uppstå inom några tiotal sekunder.

Slutsatsen av simuleringarna är att fältmodeller är utmärkta verktyg för såväl brandundersökningar som vid utformning av förebyggande brandskydd, speciellt när man har komplexa rumsgeometrier.

1 Scope

On New Year's Eve 1994 a very short but intensive fire occurred at the Switel hotel in Antwerp (Belgium). Although the fire had a very short duration (apparently less than one minute) there was considerable personal and material losses: 12 people died within a couple of days and more than 140 people were injured. As the hotel seemed to be in complete compliance with the building and fire regulations in Belgium a number of questions arose. Together with the University of Leuven in Belgium, SP started a project with the following objectives:

1. To simulate the course of the fire starting from the open information. Due to the particular plume movement during the fire both a zone model as well as a field model were to be used for this purpose. The fire was to be simulated using only public available information of the fire.

2. To compare the results of the simulations of the zone model and the field model with the observations during and after the fire.

3. To investigate the utility of both types of models in simulating such fires.

4. To investigate the influence of the ventilation in the room on the fire.

5. To discuss the possibilities of modern fire engineering techniques for the post fire investigation.

2 Description of the fire

2.1 Fire development

This paragraph describes the fire as reported in the public domain [1]. On new years eve in 1994 about 450 people were having a party in the banqueting room of the Switel Hotel in Antwerp (Belgium). In a smaller entrance room two Christmas trees were located. A candle light nearby the Christmas trees ignited them and a short moment later the Christmas trees were burning. Almost immediately the smaller room went to flashover and a hot fire plume entered one of the banqueting rooms. Testimonies revealed that this plume progressed very fast into the room. Consequently the banqueting room was filled with hot, black smoke in a few seconds. Less than one minute later the fire self extinguished without spreading further into the hotel.

2.2 Information used for the simulations

The information used for all simulations was available from the public domain [1]. Detailed information was due to the confidential aspect not yet accessible at the moment of writing this report. A schematic plan view and cross section are given in Figure 1 and Figure 2, respectively .

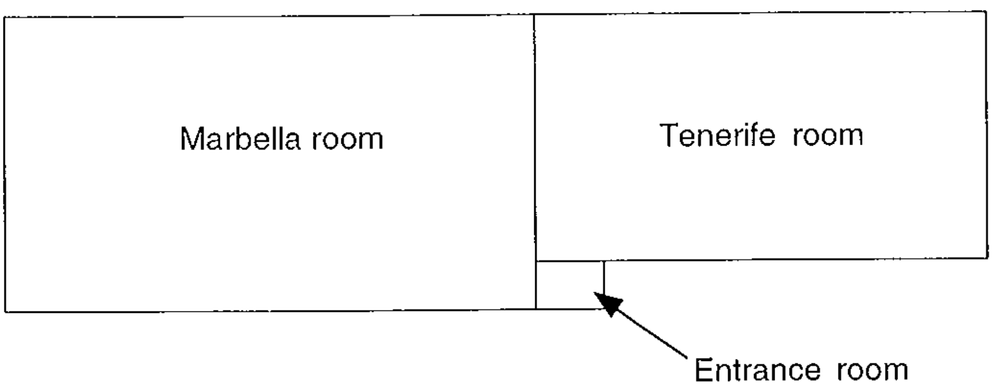

Figure 1 Schematic plan view.

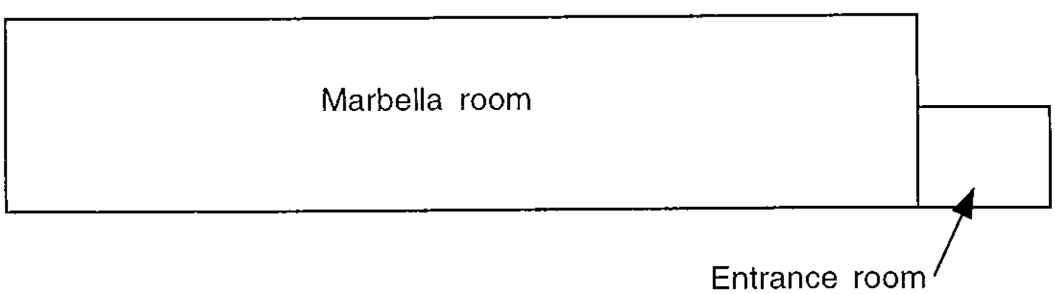

Figure 2 Cross section along the length of the entrance room and the Marbella room.

Summary of input data used in the simulations

1. Dimensions of the different rooms

• Marbella room	Length: 28.25 m Width : 15.54 m Height : 5.62 m
• Tenerife room	Length : 27.10 m Width : 14.00 m Height : 2.55 m
• Entrance room	Length : 3.70 m Width : 3.55 m Height : 2.62 m

2 Dimensions of openings used

Some of these dimensions are approximate because no details were available:

- Between the hotel and the entrance room: door opening with dimensions of 2x2 m (50% opened)
- Between Entrance room and Marbella room : Opening of 3.55x2.62 m
- Between Marbella and Tenerife rooms: Opening of 14x2.55 m
- Between the Marbella room and the outside: 2x2 m. This opening was only used in some of the simulations to investigate the influence of it.

3 Ventilation in the different rooms:

• Marbella room	Inlet ventilation via 11 different openings:	12000 m^3/h
	Outlet ventilation via one extraction point:	15000 m^3/h
• Tenerife room	Inlet ventilation via 8 different openings:	9600 m^3/h
	Outlet ventilation via one extraction point:	10200 m^3/h

- Net ventilation in different rooms:
  Marbella room 3000 m^3/h underpressure
  Tenerife room 600 m^3/h underpressure

4 Heat release rate from the fire.

It was assumed that the HRR inside a room such as the entrance room could easily go up towards 5-6 MW when a flashover is occuring [2][11]. This can easily be checked by using the flashover criteria developed by Thomas for the dimensions of the entrance room [2]. The time to reach this HRR must be less than 30 s according to the testimonies. Hence to simulate the fire an αt^2 or αt representation can be easily used [3]. The exact values are discussed in the following paragraphs.

3 Simulation of the fire by means of a zone model

3.1 The Hazard I code

The two zone model used in this project is CFAST, a model developed at Centre for Fire Research at NIST. The model is included in a commercially available software package, HAZARD 1.2. Detailed information about it can be found in the literature [4][5].

A two zone model is a simplified model of the environment in a compartment exposed to a fire. The prediction of the environment is based on the assumption of a discontinuous temperature profile in the compartment. This is approximated by two zones of gas: one upper hot and smoke filled and one cool, clear lower layer. The depth and temperatures of the two zones are predicted. The model requires a specified input of the time history of the fire growth. The HRR is the driving force that will generate the zone system. If other environmental parameters than temperature and layer depth is to be studied also production rates of smoke and toxic species have to be given as input. This has not been done in these simulations.

3.2 Overview of the different simulations

Three simulations have been performed to investigate how a zonemodel would predict the fire development. Table 1 gives an overview of these three simulations.

Table 1 Overview of different simulations with Hazard I

	Door opening Entrance room	Door opening Marbella room	Roof extraction
Simulation 1	open	closed	closed
Simulation 2	open	open	closed
Simulation 3	open	open	open

Simulation 1 is a simulation where there is only one opening to the exterior namely the door in the entrance room (room 1, R1). This gives an impression of the situation where no extraction is taking place inside the large room. Simulation 2 adds another opening to the exterior in the Marbella room (room 2, R2). This will learn us whether the opening of a door in the Marbella room considerably influences the fire development. Finally a third simulation has been done with a roof vent in the Marbella room to investigate the influence of roof extraction. The heat release used is a linear growing fire towards the level given in the previous chapter, namely 6 MW within approximately 30 s. After reaching 6 MW a linear decrease was used. The linear fire growth was mainly chosen to facilitate the input of the data in the code. In all simulations the Tenerife room is defined as room 3 (R3).

3.3 Results of the different simulations

The results from the simulations are displayed in the following figures.

3.3.1 Simulation 1

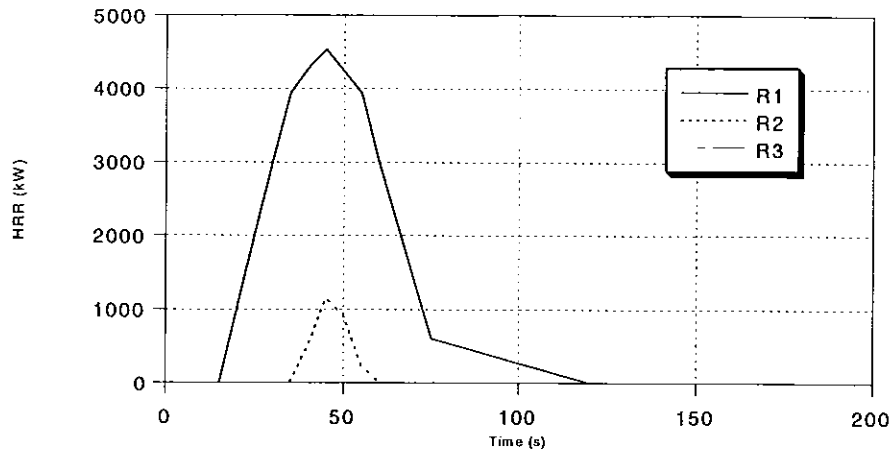

Figure 3 HRR as a function of time for simulation 1 in all three rooms.

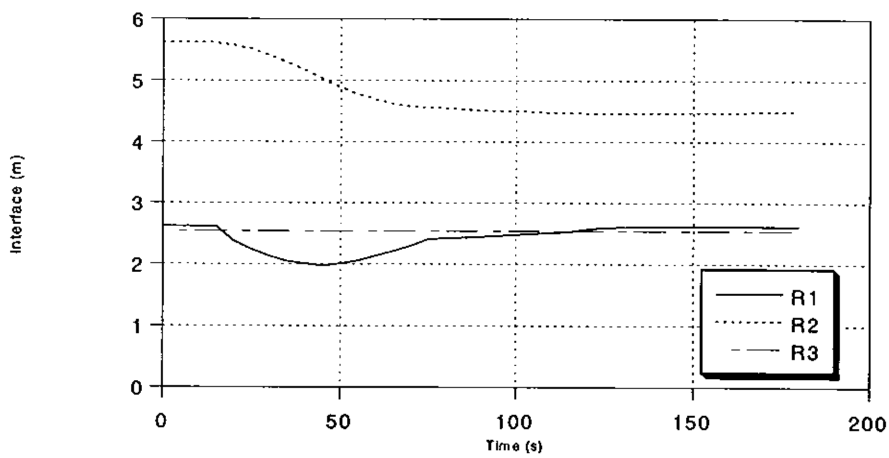

Figure 4 Interface height as a function of time for simulation 1 in all three rooms.

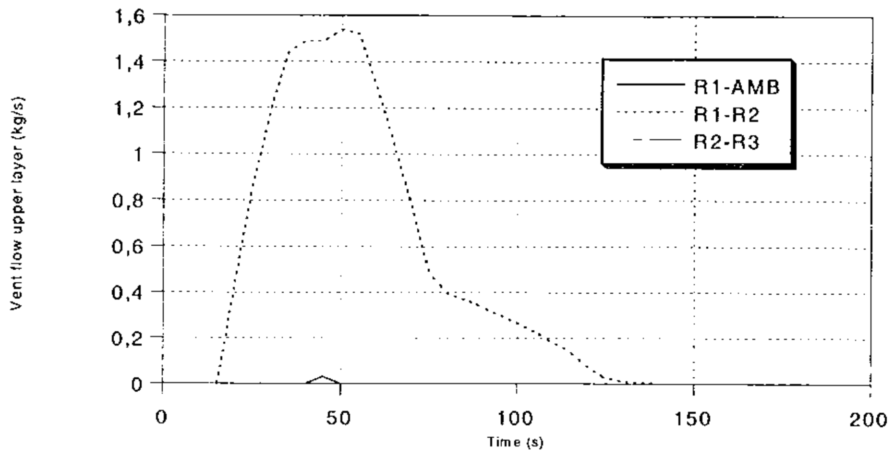

Figure 5 Vent flows as a function of time for simulation 1 in all three rooms.

3.3.2 Simulation 2

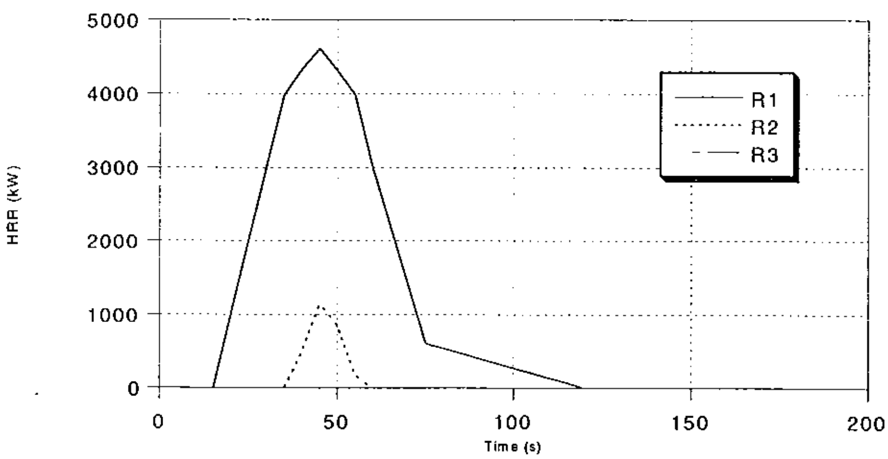

Figure 6 HRR as a function of time for simulation 2 in all three room.

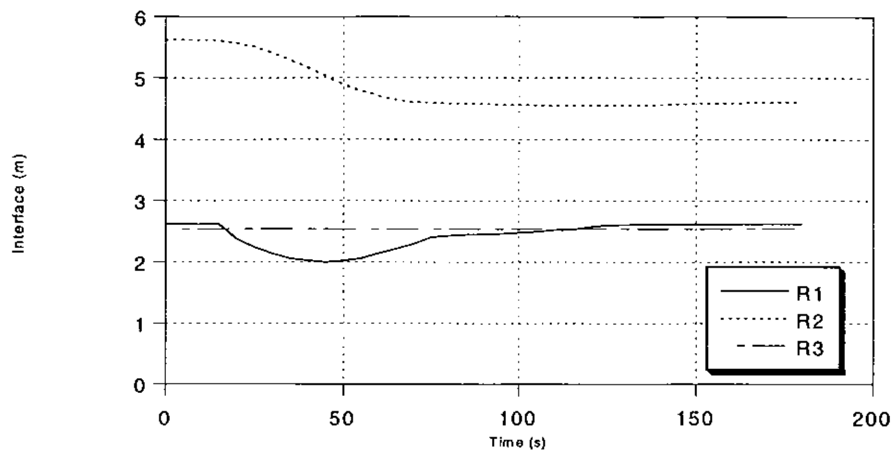

Figure 7 Interface height as a function of time for simulation 2 in all three rooms.

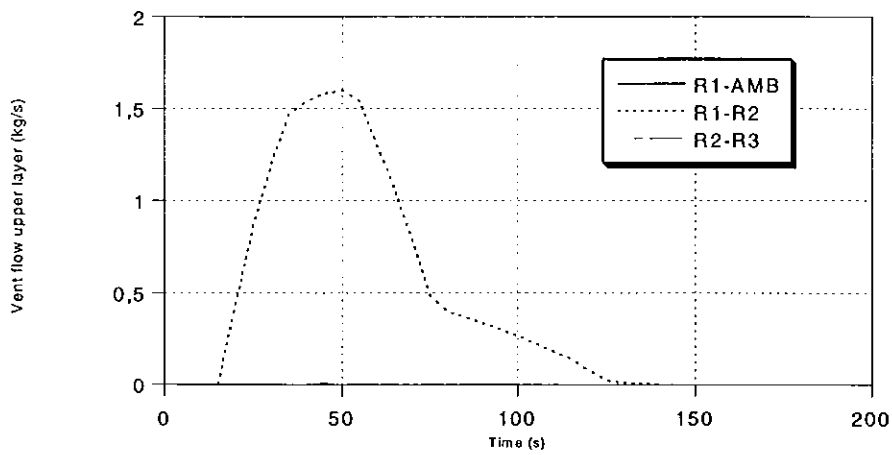

Figure 8 Vent flows as a function of time for simulation 2 in all three rooms.

3.3.3 Simulation 3

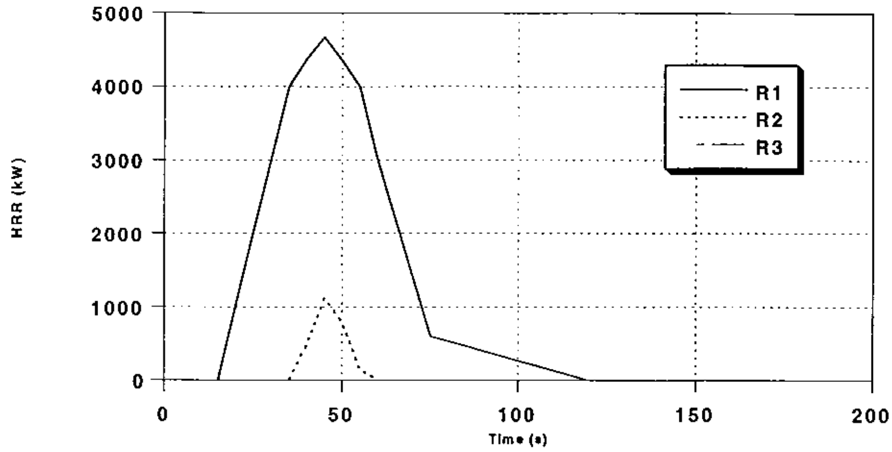

Figure 9 HRR as a function of time for simulation 3 in all three rooms.

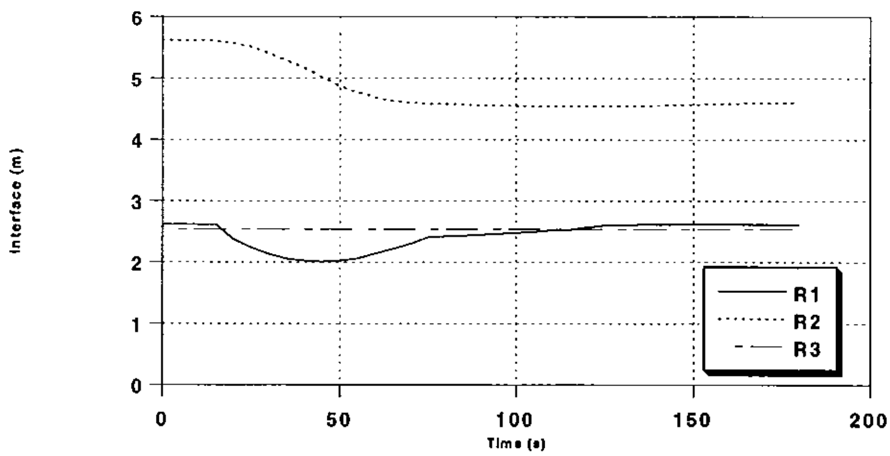

Figure 10 Interface height as a function of time for simulation 3 in all three rooms.

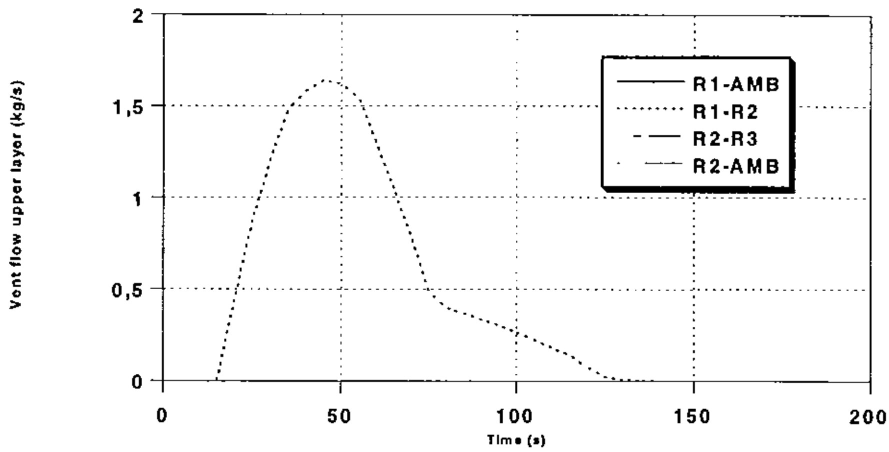

Figure 11 Vent flows as a function of time for simulation 3 in all three rooms.

3.4 Discussion of the different simulations

The following observations can be made from the simulations by means of the zone model:

- In all cases a fire of approximately 1 MW occurs in the vent flow toward the Marbella room (R2). This confirms that a considerable fire took place outside the entrance room (R1).
- In none of the cases the smoke enters into Tenerife room (R3). This can be seen both from the interface height calculations and from the vent flows.
- The interface heights are only slightly changed by changing the set up of the simulation. This means that the zone model does not detect changes in extraction via the roof. Only limited variation is observed. The smoke layer in the Marbella room is approximately one meter below the ceiling.
- Only a small amount of smoke escapes from the entrance room to the ambient air. This amount decreases from simulation 1 to 3. When extraction in the roof is connected to the Marbella room the smoke escape to the ambient is almost zero.
- Most of the smoke flows from the entrance room to the Marbella room for all three simulations.

A more extended discussion of the simulations by the zone model is given in chapter 5.

4 Simulation of the fire by means of a CFD model

4.1 The CFD code SOFIE

The field model simulations have been performed using the CFD code SOFIE [6], which is specially designed for simulation of fires. The SOFIE code is based on the full solution of the fundamental laws of conservation of mass, energy, momentum and chemical species.

The SOFIE code contains several sub-models. Two combustion models; the laminar flamelet model [7] and Magnussen's Eddy Dissipation Concept (ECD) [8] can be chosen to calculate the combustion. In this work the Magnussen model, in which the slowest of the turbulent dissipation rates of either fuel, oxygen or hot products determine the rate of reactions, is used. This is an extension of Spalding's Eddy Break Up model (EBU) [9], in which the rate of chemical reactions is related to turbulent dissipation rate of fuel alone. The SOFIE code has a standard k-ε turbulence model, modified by a buoyancy term. For the calculation of the radiation exchange between fluid and solid walls of the enclosure, a discrete transfer model (DTRM) [10] is available.

4.2 Description of the input to SOFIE

4.2.1 Computational mesh and calculation domain

The calculation domain was divided into 162 840 control volumes: 69, 40 and 59 in the x, y and z directions, respectively. The y co-ordinate was defined positive in the upward direction. To improve the accuracy a more dense grid was used in the fire room, compared to the other spaces, as strong gradients of temperature and velocity prevail in this room. A large outside region (5 m wide) was included in the calculation domain at the side of the building where fresh air flows into the fire room. Above the lower building of the hotel, Tenerife (see Fig. 1), the space between the roof and upper border of the calculation domain was defined as an inactive blockage.

4.2.2 Model of fire source

In most of the simulations a model of the burning Christmas trees was defined as a cubic box with side length 0.5 m, except in one scenario in which a 2 m high and 0.5 m wide box was used. The fuel (C3H6), approximating the pyrolysis gases, was uniformly ejected trough the top and all side faces of the box, giving the desired heat release rate for the particular scenario. In one scenario, a wall fire outside the fire room was also simulated. The wall fire was assumed to take place in the Marbella room, above the door opening to the fire room. The rate of heat release from the Christmas trees was modelled to follow the growth history of an ultra-fast t^2 fire

$$\dot{Q} = \alpha t^2$$

where α is a fire growth parameter. Two different values for α were used, 60.0 kW/s^2 and 4.67 kW/s^2. In scenarios using $\alpha = 60.0$ kW/s^2, the t^2 curve was applied from $t = 0$ to $t = 8$ s, and thereafter the RHR was increased linearly to 6.0 MW at $t = 20.0$ s. In the scenarios using $\alpha = 4.47$ kW/s^2, the t^2 curve was applied during the whole simulation, up to $t = 30$ s.

4.2.3 Simplifications and approximations

In the simulations radiation was not taken into account in order to save computer storage and calculation time. However, it is possible to calculate the radiation intensity with SOFIE by switching the radiation on and execute the program for just one iteration.

4.2.4 Boundary conditions

All solid walls, including the floor and the ceiling of the building were considered as inactive blockages, i. e. the gas flow is obstructed and no heat exchange takes place between the gas and the walls. The boundaries of the large outside region facing free air were defined as static pressure boundaries, which allow the mass flow to or from the calculation domain. A static pressure boundary is used when the pressure is assumed to be constant i.e. sufficiently far from the fire where the velocities are negligible. The opening in the back wall of the Tenerife room was treated as either an outflow boundary or an extract boundary. The former boundary type allows the mass to flow out through the opening at a rate calculated by SOFIE, the user does not need to specify the flow magnitude. In the latter type of boundary condition the flow through the boundary is prescribed, for example simulating forced ventilation with known flow velocity through the vent.

4.2.5 The pre-fire situation, vent flows

Before the fire was ignited the code was run to establish a steady state condition with only ventilation flow. Inflow through each inflow vent opening (12 vents) of size 60 cm x 60 cm was set to 1000 m^3/h giving a total air inflow of 12000 m^3/h. Outflow through the large vent opening in the middle of the Marbella Room ceiling was set to 15000 m^3/h. In some of the scenarios a vent outflow of either 600 or 2000 m^3/h through the Tenerife back wall was set in the pre-fire simulations. In reality there was no vent through the back wall of Tenerife. These simulations were carried out to investigate the sensitivity to different vent flows as the actual vent flows in the fire situation were uncertain.

4.3 Overview of different simulations

To investigate the influence of different parameters, seven different scenarios (labelled as #1 through #7) were simulated with various ventilation configuration, fire source location and size and heat release rate. Scenario #1 was mainly used for investigating the influence of control volumes sizes etc. on computing time and computer core requirements. This showed that by omitting the radiation the simulations with a fairly dense grid of the compartments could be performed with reasonably short computation times. Description of scenarios #2 through #7 are shown in Table 222 below (description of #1 is omitted).

Table 2 Overview of different scenarios

Scenario	RHR history	Fire sources	Forced ventilation	Natural ventilation
#2	F1	FS1	V1	O1
#3	F1	FS2	V2	O2
#4	F1 + WF	FS3 + WF	V2	O2
#5	F2	FS3	V2	O2
#6	F2	FS3	V3	O2
#7	F2	FS3	V2	O3

Explanation of notations used in Table 2:

Fire growth

F1: $Q = 60\ t^2$ kW to 8 s, thereafter linear increase to 6 MW at 20 s.
F2: $Q = 4.667\ t^2$ kW up to 30 s.
WF : Wall fire.

Fire sources

FS1: 2 m high, 0.5 m x 0.5 m cross section located in the middle of the fire room.
FS2: 0.5 m high, 0.5 m x 0.5 m cross section located in the middle of the fire room.
FS3: 0.5 m high, 0.5 x 0.5 m cross section located at the back part of the fire room.

Forced ventilation

V1: Marbella: 15000 m^3/h roof extract vent, twelve inflow vents of 1000 m^3/h each.
V2: Marbella: 15000 m^3/h roof extract vent, twelve inflow vents of 1000 m^3/h each.
Tenerife: Back wall extract vent 600 m^3/h.
V3: Marbella: 15000 m^3/h roof extract vent, twelve inflow vents of 1000 m^3/h each.
Tenerife: Back wall extract vent 2000 m^3/h.

Natural ventilation

O1: Open door and a small opening near floor level at Tenerife back wall.
O2: Open door only.
O3: Closed door in the fire room. No openings for natural ventilation.

4.4 Evaluation of the results

The results from the simulations give a detailed picture of the spread of the fire gases as a function of time. Unfortunately there is no simple definition of the smoke boundary in CFD as it is in zone models. Therefore the smoke spread in the following is exemplified by considering the isothermal where the gas temperature has increased 110 K above the ambient temperature.

The results show that the simulated fire creates a very strong smoke plume from the fire room into the Marbella room. The velocities at the ceiling when the gases exit the fire room is in the order 10 m/s. When the gases enter the larger Marbella room the velocities rapidly decreases due to the expansion and the plume is very soon bending upwards. There is no simulation showing the tendency of the formation of a true jet plume from the fire room at lower heights than at the ceiling of the fire room. However the thickness of the smoke layer entering the Marbella room rapidly increases and may for an observer close to the fire room be perceived as a jet.

A comparison between results from the different simulations is given below where the main features of the smoke spread is exemplified by showing temperature and velocity plots for a vertical plane through the middle of the fire room (extending into the Marbella room).

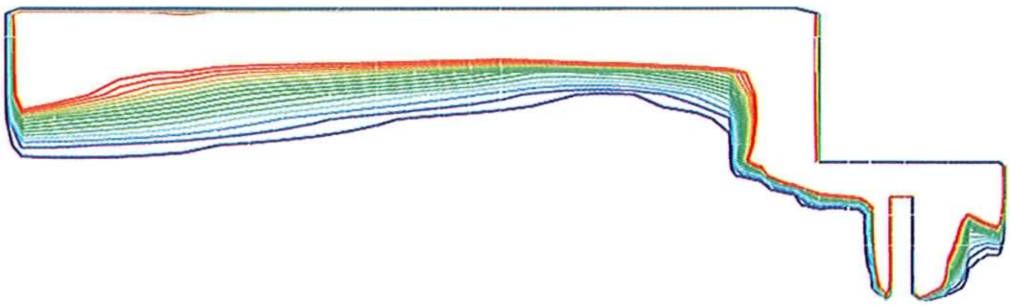

Figure 12 Plan view of temperature distribution in the fire room and in Marbella after 12 s for scenario #2. Plotting plane in the middle of the fire room. The simulated Christmas tree appears as a rectangular object in the fire room. The red line identifies the region where the temperature isotherm is 110 °C.

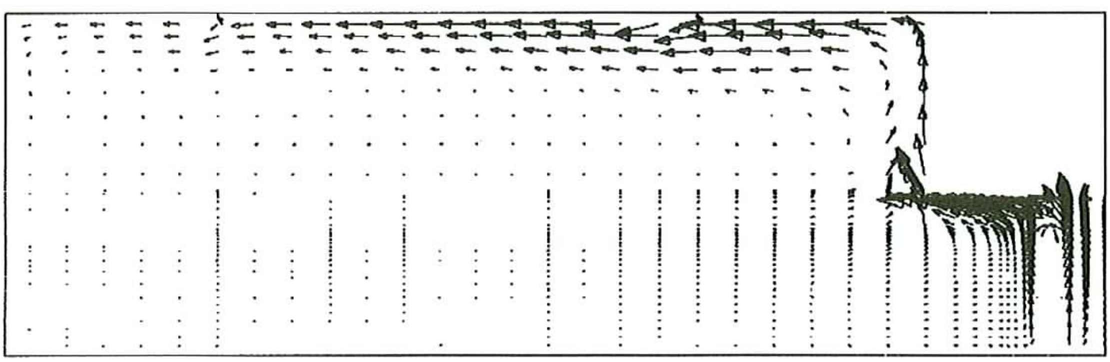

Figure 13 Plan view of velocity distribution in the fire room and in Marbella after 12 s for scenario #2. Plotting plane in the middle of the fire room. The simulated Christmas trees appear as a rectangular object in the fire room.

Figure 12 shows a plot from scenario #2 after 12 seconds. The heat release after this time lapse has reached 4.3 MW and the smoke has already hit the opposite wall of the Marbella room and is beginning to be pushed downwards towards the place where the orchestra was placed. In the figure the box simulating the Christmas trees can be noticed. Figure 13 shows the corresponding velocity field. The velocity at the entrance to the Marbella room from the fire room is about 9 m/s. The smoke plume rapidly turns its direction and moves upwards in the Marbella room. A ceiling jet in the Marbella room is formed and the smoke is rapidly spreading towards the opposite wall. The smoke (defined as the 110 K isotherm) hits the wall already after 9 s. From the figure it is also noticed that air is sucked into the fire room from the Marbella room.

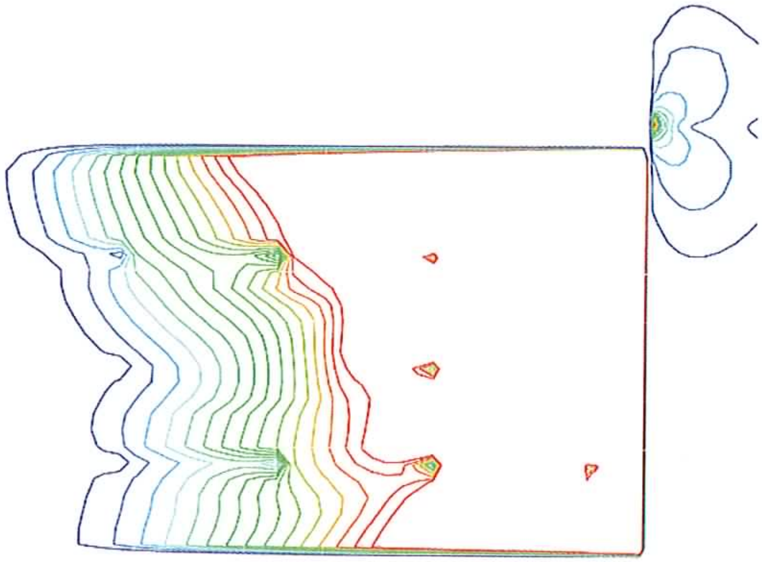

Figure 14 Horizontal view of temperature distribution in the fire room and in Marbella after 12 s for scenario #2. Plotting plan close to the ceiling in the Marbella room. The red line identifies the region where the temperature isotherm is 110 °C.

In Figure 14 the temperature distribution at the ceiling of the Marbella room is shown for scenario #2. There is a tendency that the hot smoke is spreading more rapidly sideways when it enters Marbella. As the side door of the fire room is open in this scenario one would expect the fire plume to be more leaning towards the Marbella room. This is not the case. In order to find out if this is due to the way the Christmas tree was modelled, the height of fire source was decreased in scenario #3. With a lower box simulating the fire source the fire plume should not be as much restrained by the box.

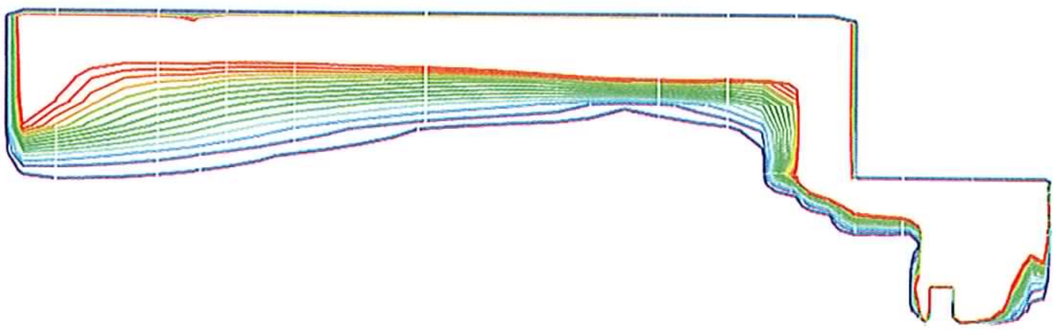

Figure 15 Plan view of temperature distribution in the fire room and in Marbella after 12 s for scenario #3. Plotting plane in the middle of the fire room. The simulated Christmas trees appear as a rectangular object in the fire room (decreased size of fire source). The red line identifies the region where the temperature isotherm is 110 °C.

Figure 15 displays the temperature field from scenario #3 at the same location as in Figure 12 - 14. The difference between the results are small indicating that there is very little influence of the size of the fire source. The results from the calculations with a reduced size of the fire source corresponding to the cases shown in Figures 13 and 14 are not displayed as the changes are very small. The only noticeable difference is that there appears to be a slightly increased tendency of the smoke plume to move sideways when entering the Marbella room.

In scenario #4 the fire source was moved towards the back wall of the fire room in order to investigate the influence of the location. In addition a small wall fire was simulated in Marbella above the door from the fire room. Figure 16 shows the temperature plot after 12 s. In this case the wall fire has reached 300 kW. Compared to the previous simulations the change is very small. The smoke plume in Marbella is a little bit thicker but otherwise the tendencies are the same.

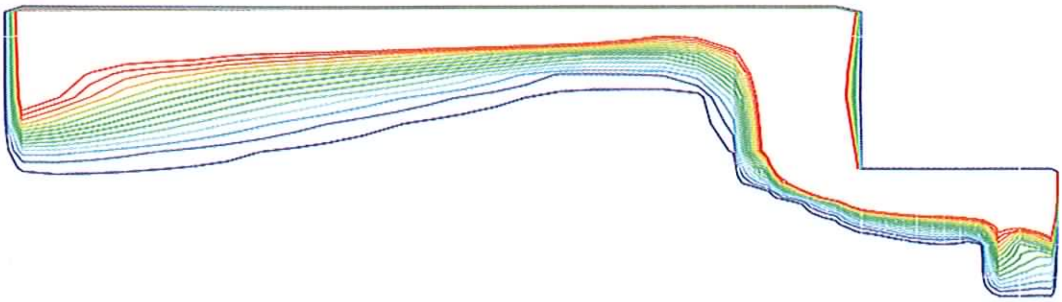

Figure 16 Plan view of temperature distribution in the fire room and in Marbella after 12 s for scenario #4. Plotting plane in the middle of the fire room. Fire source moved to the back wall in the fire room. Wall fire in the Marbella room included. The red line identifies the region where the temperature isotherm is 110 °C.

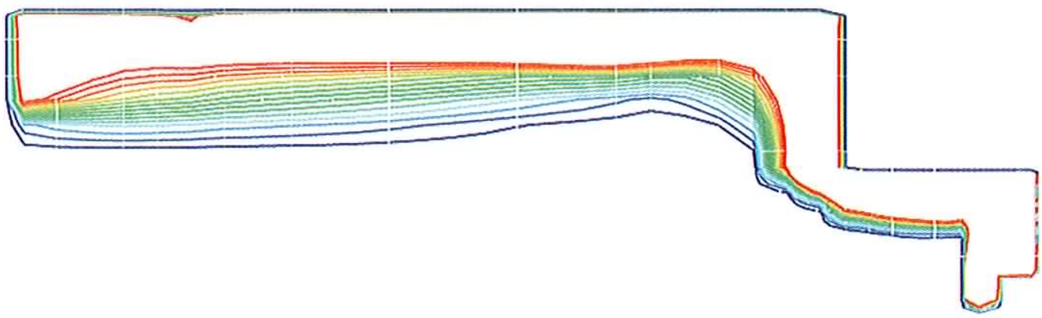

Figure 17 Plan view of temperature distribution in the fire room and in Marbella after 30 s for scenario #5. Plotting plane in the middle of the fire room. The simulated Christmas trees appear as a rectangular object in the fire room. Reduced RHR. The red line identifies the region where the temperature isotherm is 110 °C.

The previous simulations were performed based on a too rapid heat release rate. In scenario #5 the heat release was adapted to values resulting in a more slow process. However, it turns out that the main tendencies are the same although the time scale is shifted. Figure 17 shows the temperature distribution after 30 s when the heat release is 4.2 MW. This is comparable to the previous simulations after 12 seconds. It is also seen from the figure that the smoke spread is very similar.

In scenario #6 the venting flow from the Tenerife room was increased from 600 m^3/h to 2000 m^3/h to find out if this is an important effect. It turned out that this variation had almost negligible effect.

In the final simulation, scenario #7, the door to the outside of the fire room was closed. The temperature distribution after 30 s is shown in Figure 18. The tendency is almost the same as in the other simulations. There is a slightly increased thickness of the fire plume when entering the Marbella room and from a velocity plot it is clear that the smoke plume does not bend as rapidly as in the case when the door in the fire room is open.

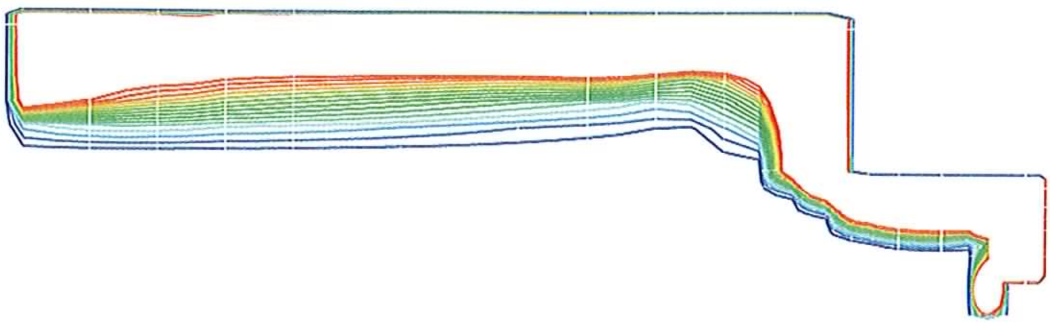

Figure 18 Plan view of temperature distribution in the fire room and in Marbella after 30 s for scenario #7. Plotting plane in the middle of the fire room. The simulated Christmas trees appear as a rectangular object in the fire room. The red line identifies the region where the temperature isotherm is 110 °C.

To get an indication about the heat radiation that people close to the fire room might have been exposed to, a separate calculation was performed by including the radiation model into the computer simulation for scenario #4 after 12 s. At a location 2 m from the opening to the fire room (in the Marbella room) and at a height of 1 - 1.5 m the radiation turned out to be approximately 5 kW/m^2. This level of thermal radiation exposure to human skin yields pain after about 13 s exposure [6].

5 Discussion

The zone model simulations learn us the following:

- the zone model predicts a large fire inside the Marbella room as a vent fire. This seems to be confirmed by the witnesses.

- the zone model however cannot predict a specific jet flame due to its two zone concept.

- the vent flow and the interface height confirms that most of the smoke went directly inside the Marbella room. No smoke flow to the Tenerife room is predicted. However in the real fire some smoke came inside the Tenerife room but this was very limited.

- No large differences are observed between the three simulations with respect to the interface height and the vent flows, mainly due to the large volume of the Marbella room.

Hence it can be concluded that only the vent fire in the Marbella room can be predicted from the zone model. Specific flows of smoke and change in smoke layers inside the Marbella room are not possible to simulate.

The CFD calculations indicate that the main reason for getting such a rapid development of the fire and such rapid smoke spread as occurred in the accident is that the fire took place in a small room with an abundant access to air. The small room serves as a blowtorch and creates a strong hot smoke layer that enters into Marbella at high speed. The speed of the smoke when entering Marbella is about 10 m/s. Due to the rapid expansion when the smoke leaves the fire room the smoke plume speed decreases and the smoke turns upwards. A ceiling jet in the Marbella room is formed and the smoke spread is rapid, after a few seconds the smoke hits the opposite wall and is turned downwards. This is apparently in agreement with eye witnesses noting that the smoke very soon set curtains in movement at the opposite wall.

Neither changing the size of the fire source, changing the ventilation conditions, or closing the door in the fire room affected this course of events to any perceivable degree. Due to the existing uncertainties in the heat release rate of the fire two different HRR curves were used in the calculations, one with a very rapid fire growth increasing to about 4 MW in 8 s and a more realistic one increasing to 4 MW in 30 s. The main tendencies in the simulations are the same although the time scale is shifted.

To get an indication of how an observer in the Marbella room might have experienced the transient effects of the fire growth and the smoke spread, an animation of the smoke spread has been carried out. There are indications from this animation that due to the strong speed of the smoke when it leaves the fire room, the smoke plume as seen by an observer close to the fire room, may very well have been identified as a fire jet entering the Marbella room. Furthermore, the smoke plume soon attains a considerable thickness when entering the Marbella thus amplifying the impression of jet. People located close to the fire room may have been exposed to a severe radiation just after a few seconds and furthermore been affected by the convective influence of the smoke plume. The radiant intensity just outside the fire room was estimated to 5 kW/m^2 after 20s.

6 Conclusions

From simulations with both a zone model and a CFD model the following conclusions can be made with respect to the prediction capabilities of both models:

- the zone model predicts a vent fire outside the entrance room but is not at all capable of predicting the local plume flows inside the Marbella room and gives only a very rough estimate of the smoke movement.

- the CFD model predicts more accurately the smoke flow, the temperature distribution and the smoke height as a function of time.

- with the results available from the CFD simulation it is clear that people close to the fire might have apprehended the fire as a jet fire due to the high speed of the fire plume coming from the entrance room.

- CFD models are versatile tools for use of pre fire investigation and can give more detailed solutions of the fire development and are furthermore capable of handling more complex and realistic geometry and boundary conditions.

- CFD models can also successfully be used in the evaluation of very specific fire hazards where a prescriptive code might be difficult to apply. CFD models are tools which are apt to be used in the future in fire performance based assessments of fire hazards.

For the present investigation more precise simulations could be performed provided more detailed information about the exact dimensions of the building and the ventilation conditions was available. Furthermore, it is envisaged that it will be possible with CFD models in the near future to also investigate the influence of sprinklers inside a fire room on the development of the fire. This will be done as soon as the information which is classified for the moment, will become available.

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8 Acknowledgment

The authors would like to thank the Swedish Board for Fire Research (Brandforsk), the Swedish National Testing and Research Institute and the Katholieke Universiteit Leuven Research and Development for their financial support in this project.

The authors would hereby also like to take the opportunity to express their deep regret for the human lives lost and damaged during this fire.

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SP REPORT 1998:04
ISBN 91-7848-708-0
ISSN 0284-5172