RECONSTRUCTION OF THE FIRE IN “DE HEMEL” IN VOLENDAM, NEW YEARS EVE 2000/2001

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ABSTRACT

A tragic fire took place in the first hour of Jan 1st 2001, at a New Years Eve party in the café “de Hemel” in Volendam, The Netherlands. The fire started when dry fir branches which decorated the ceiling of the café were unintentionally ignited. The fire spread quickly over the entire room and 14 teenagers lost their lives. A further 200 suffered serious burns.

TNO Centre for Fire Research was commissioned by the Inspectorate of the Fire services and Disaster management (IBR), of the Ministry of Internal Affairs (BZK) to reconstruct the fire in the café.

The primary objective of the reconstruction was to present evidence on the question of the rate of growth of the fire. Witness statements spoke of very rapid fire growth, but available statements were inconsistent. In order to provide independent evidence, the essential features of the café and the conditions at the time of the fire were reproduced as faithfully as possible within strict time constraints.

Important issues addressed include:

- ensuring that the moisture content of the fir branches used in the reconstruction was similar to that of the fir branches that had decorated the ceiling of de Hemel;
- reproducing the ways by which the fir branches had been fixed to the ceiling;
- arranging similar ventilation conditions in the café, especially near the ceiling;

The floor dimensions of the original café are 10 m x 14 m. The horizontal dimensions were reduced to 7 m x 9 m in the full-scale test. The vertical dimensions (varying between 2.4m and 2.6m) were reproduced almost identically. The reducing of the dimensions was assumed to be acceptable because the study was concerned with the fire-spread characteristics of the ceiling.

After a first unsuccessful test, two large-scale tests took place at TNO Centre for Fire Research. The tests were observed and video taped from two directions through fire resistant windows. Limited measurements were taken in the mock-up to quantify the conditions the café visitors would have been subjected to, such as the temperature at different heights below the Christmas decorations, heat radiation and smoke density at head-level. Concentrations of O_2, CO and CO_2 were measured at one location in the room.

Both tests showed an extremely fast fire propagation, with full involvement of the room within 37 seconds and 50 seconds after ignition respectively. In both tests, close to the point of ignition the maximum temperature registered was over 900°C and the vertical heat flux was over 100 kW/m^2. The O_2 concentrations fell below 2% and CO concentration peaked at 4%. These concentrations showed that the fires self extinguished due to oxygen starvation.

The results of the reconstruction corroborate the witness reports speaking of a very short but intensive fire.

TNO Centre for Fire Research was also given the task, by the Inspectorate of the Fire services and Disaster management, of providing answers to the following questions in relation to the fire in de Hemel:

- have there been similar fires in the past;
- what lessons are to be learnt from previous similar fires;

These questions are briefly touched upon in this paper.

The paper discusses the set-up of the tests, and its main results. The paper also highlights the important role of coincidence in the actual development of the fire scenarios, as could be concluded from the test results.

INTRODUCTION

A fire at a New Years Eve party in the café de Hemel in Volendam, the Netherlands killed fourteen teenagers and wounded over 200.

The small café (125 m^2) was located on the second floor of a building that housed similar cafés at the two lower levels. It was accessible through a non-fire protected stairwell from the café on the first floor. Two emergency exits were available in de Hemel, although these did not fully comply with regulations. At the time of the fire, about 300 people, the vast majority youngsters below 20 years old, were celebrating New Year in the top café.

All three cafés in the building had had their ceilings decorated since the end of November with fir branches, held up by a web of nylon thread as used in a fisherman's net. The decorations were completed by Christmas lights, plastic lamettas and paper clocks.

In the part of the top café that had a low ceiling, a café customer ignited a few sparklers held together in a bundle. As the flame surprised him he brought the sparklers by reflex above his head to avoid hurting bystanders in the dense crowd. The sparklers came into contact with the fir branches at the ceiling and ignited these immediately. Efforts to extinguish the fire were fruitless, and the fire propagated quickly to the entire ceiling. Only a few of the customers were able to escape unharmed, most suffered burns and/or smoke inhalation. Two emergency exits were available but not very visible and the main stairs to the lower café rapidly became blocked as people threw themselves in the opening trying to escape from the flames. Approximately 200 customers were wounded and 14 died.

The Dutch government installed an independent commission with the task to investigate the circumstances around the fire and gather the results from a number of inspection teams. In accordance with their legal responsibility, six inspection teams studied the fire. The inspection (IBR BZK) requested TNO Centre for Fire Research to assist in the investigation by carrying out several research projects aimed at specific questions raised in the course of the investigation. Prominent is the large scale reconstruction of the fire. Witness reports spoke of a fast fire growth, but it was not possible to find out from the witness reports how much time was available for safe escape. An aim of the full-scale reconstruction was to bring out that information. The course of the fire as described below is taken from the investigation report issued by the Commission in June 2001.

Other questions studied by TNO include a literature study into similar fires in the past and to what extent these led to changes in building regulations or guidelines. In addition of presenting the results of the reconstruction, this article presents the main results of this research.

RECONSTRUCTION

The stated objective of the reconstruction was to simulate the events during the fire up to the moment the flaming stopped. The following elements were considered essential for a faithful reconstruction:

- the geometry of the café. This was to follow as closely as possible the actual dimensions;
- ventilation. This was identified by the police investigators as a possible factor making the fire more severe, as the air was introduced through gratings inside the layer of fir branches;
- the arrangement of fir branches: the quantity per square meter of ceiling, covered / uncovered areas, method of fixing the branches to the ceiling;
- the moisture content of the branches, as this obviously may have a substantial influence on fire growth rate.

Reconstructed room

De Hemel is on the second floor of a bar complex containing two other bars, “de Wirwar” and “de Blokhut”, both having exits on street level. In the attic there is a storage room and the bathrooms.

The original café, De Hemel, was scaled down from 10x14m^2 to 7x9m^2 in the reconstruction at TNO Centre for Fire Research. The reducing of the dimensions was assumed to be acceptable because the study was concerned with the fire-spread characteristics of the ceiling.

The height of the roof varied between 2.41m in the area where the fire started to 2.63m in the largest part of the café. The same scale of variation of the roof as seen in the bar was used in the reconstruction, the lowest area was 2.20m and the highest was 2.50m.

The main door leading down to de Wirwar was reproduced in the reconstruction. An air outlet was placed at the location of the spiral stairs that led up to the toilet area in the attic. Windows were placed at random spots around the room to be able to see the fire spread from outside the room.

In de Hemel a web of threads had been created to hold the branches to the ceiling. This web of threads was held up with screw-eyes. The screw-eyes were fastened in the ceiling and the opening (eye) was approximately 5cm under the ceiling. The threads were fastened by knots between the threads and to the screw-eyes.
In the reconstructed room, 3mm nylon fisherman’s thread was used in the ceiling. The system of putting up the threads was such that each thread was tied in one end in a screw-eye. It was then pulled through two screw-eyes, and fastened in a fourth screw-eye. The dried fir branches were then put up over the threads. Christmas lights, lamettas, paper clocks and plastic balls were then put onto the branches and on the threads. In the first test Christmas lights were not included as they were not believed to have played an important part in either the ignition, or the fire spread nor the total fire load. After the first test failed they were included in all subsequent tests.

Fir branches

The branch ceiling in de Hemel was constructed in the end of November and the café was only open on Saturdays between 18.00 - 02.00 during this season. The heating was kept at 20°C when the café was closed.

The fir trees used in the reconstruction (Abies Procera or Abies Nobilis) were of the same species that were used for the ceiling decoration in de Hemel. The species is widely used for Christmas decorations because their needles do not fall off when the branches dry out.

The surface density of fir branches was estimated on the basis of statements of police officers who had seen the identical decoration in the cafés situated below de Hemel.

Because of the short time frame imposed for the reconstruction tests, it was not possible to let the fir branches dry naturally as had been the case in de Hemel. A procedure was therefore devised to find out which accelerated drying process could lead to the same conditions as in de Hemel. The procedure followed involved three separate sets of conditions:

- one batch of fire branches was kept at 20°C and 50 % relative humidity, close to the conditions in de Hemel in the month preceding the fire. At regular intervals samples were taken out for determining moisture content. This gave the probable drying curve followed in de Hemel; it proved that completely dry conditions were reached in 15 days, which means that in de Hemel the fir branches were dry.
- one batch of fir branches was dried in a oven at 95°C. At regular intervals samples were taken out for determining the remaining moisture content and the reaction to fire behaviour; the purpose was to determine the relation between moisture content and fire behaviour. Samples taken out after 48 hours showed no further weight loss and were considered completely dry. The reaction to fire properties were measured using SBI equipment. The rate of heat release and the time to maximum heat release were determined as characteristic parameters. The results were that the rate of heat release is quite sensitive to moisture: fresh branches are difficult to ignite and give a low peak RHR after a long time, and at below 50% moisture in the branches (definition used: 50% of the moisture originally present is gone) the peak RHR rises sharply and arrives faster at the maximum. Since the sample with 0% moisture had a peak RHR significantly higher than the sample with 50% moisture, it was concluded that the moisture content of the branches to be used for the large scale tests should be below 10%.
- one batch was dried in a large drying chamber at 40°C and 10% relative humidity. By measuring samples taken out at different intervals, it was determined that the moisture content of the branches fell below 10% after three days.

The results of this study show that forced drying at 40°C and 10% r.h. for three days are sufficient to obtain the fully dry conditions that had been present in de Hemel for about 15 days.

Table 1: The different drying times in the oven (95°C) and the corresponding humidity loss.

Sample nr.	**Drying time (h)**	**Humidity loss (%)**	**Max heat release [kW]**	**Time to max heat release (s)**
1	0.5	12	40	1320
2	1	22	55	450
3	2	33	100	240
4	3	52	160	160
5	16	100	270	150

Ventilation

A separate series of small scale tests were carried out to determine the influence of the ventilation air blowing in the layer of fir branches at 2.5 to 3.5 m/s (velocity determined on the basis of an investigation of the design of the ventilation system by a building services consulting firm). The burning behaviour was only slightly sensitive to the velocity: without ventilation, a stably stratified smoke layer remained after the small test fire died out, whereas the ventilated fire lead to smoke logging of the reconstructed room. The results were sufficient to conclude that the ventilation system in de Hemel was to be simulated in the reconstruction.

The length and width of the ventilation system were scaled down to 70% of its original size and the height was kept the same as in de Hemel. The ventilation gratings came from the same manufacturer that had supplied the café, complemented by some taken from the actual café. Some of the opening surfaces were closed to get matching velocities to those in de Hemel.

Test plan
Three large-scale tests took place at TNO Centre for Fire Research.

Measurements were made to determine the fire propagation and the conditions that the café visitors were subjected to such as temperatures at different heights below the Christmas decorations, heat radiation and smoke density at head-level. Analysis of the O_2, CO and CO_2 contents in the room during the fire were performed.

Thermocouple trees were positioned at four places in the room. One heat flux metre was placed next to each thermocouple tree. The gas analyser was placed in the middle of the room at a height of 1. 60 m.

Test results
Test 1a
This part described the first test, which for the final goal of the reconstruction was considered as unsuccessful.

The fir branches ignited directly after sparklers were held to them. After 10 seconds the fire was visible in an area of less than 1 m^2. Very soon the nylon threads melted, causing the burning fir branches to fall to the ground. This happened so fast that the adjacent branches did not have the time to ignite. Not more than 1 to 2 m^2 of branches had been set on fire when no more burning branches were left in the ceiling. The fire was extinguished after all the burning branches had fallen to the floor.

It was concluded after this test that there were two possible causes for the test not leading to full involvement as in de Hemel:

- The surface density of the fir branches was considered to be too low by police staff familiar with the cafés below de Hemel. With a larger amount of fir branches per square metre, the fire spread between branches would likely increase;
- The Christmas lights in de Hemel probably allowed the fir branches to stay at the ceiling longer. Since the copper core of the Christmas lights was not expected to melt as quickly as the nylon threads, the branches that fell on the floor in the first test when the nylon threads melted would stay under the ceiling.

Test 1b
The test set-up was changed for tests 1b and 2. A larger amount of branches per square metre was applied and Christmas lights were attached to the branches.

The fir branches ignited immediately after coming in contact with the burning sparklers. After 15 seconds the branches were beginning to fall down. The following fifteen seconds the branches situated where the fire was started continued to fall down, however they were still partly held up by the Christmas lights. The flames from the half fallen branches reached the ceiling again to ignite nearby branches. After 30 seconds the flames reached the second area with the higher roof and from this moment it only took another five seconds for the flames to reach the entire ceiling. The entire room was in flames 37 seconds after ignition. 30 seconds later the flames were decreasing in intensity.

After the fire, branches that were only partly burnt could be found all over the floor. Only close to the door no burned branches were seen; there the branches had been fully consumed by the fire. This indicates that the fire stopped because of the lack of oxygen and only at the door enough oxygen was available to let the branches burn.

Measurements were taken and registered every ten seconds. All thermocouples measures temperatures in excess of 380°C when the entire room was in flames. The highest temperature was 972°C. The video of the reconstruction shows that the flames move towards the front side of the scale model towards the door that is opened, much more than they move sideways and thus the temperatures in the area beside the place of ignition are left lower. The heat flux gauge gave for a short moment a value of 109 kW/m^2 at the place of ignition. 10 seconds later the radiation value was at 26 kW/m^2. The gas analysing equipment for the measurements of O_2 and CO_2 levels broke down shortly after the start of the test when the levels were at 16%, respectively 6%. Therefore only limited information is available of the minimum O_2 concentration and the increased concentration of CO_2. The measurement of the smoke density at head-level proved irrelevant in view of the rapid fire spread.

The time (37s) between the ignition of the branches and the fully developed fire is very short.

Considering the normal variation of fires and their effects it is not surprising that the results obtained in this reconstruction differ from the ones observed in de Hemel. However this test confirms the statements in the witness reports talking about a short but intensive fire.

When comparing tests 1a and 1b it can be noticed that relatively small details have enormous consequences for the overall fire behaviour. The presence of Christmas lights in the branches, which before the tests were considered irrelevant, proved to make the difference between an unimportant fire causing perhaps a few burns and a national disaster. This is shocking since fire regulations prescribe that all ceiling decorations should be fixed using incombustible fixing materials to prevent burning materials from falling down on people.

Test 2

The test set-up was slightly changed from test 1b to test 2. In test 2 every light bulb in the Christmas lights was attached to a fir branch using a plastic loop, where this had been omitted in about half the bulbs in test 1b. Picture 1 shows the test room before the fire, picture 2 shows the room during the fire and picture 3 shows the room after the fire.

The fir branches ignited directly when the sparklers were put in contact with them. The fire stayed in the area where it had been ignited for about 40s and contrary to tests 1a and 1b, no branches fell down, due to the improved fixing of the Christmas lights. Instead, a “ball of fire” was visible between the branches and the roof. After 40s during a time period of 5s a number of branches started to fall down where the fire first was ignited. 5s afterwards the fire spread to the entire room. The time between the ignition of the branches and the fire spread to the entire room was 50s. The sight of the room after test 2 was very similar to the room after test 1b.

Picture 1: Room before ignition

Picture 2: Room during first 40 seconds of fire, a ball of fire is visible between branches and roof

Picture 3: Room after extinguishing

Measurements were taken and registered every five seconds. All thermocouples showed a temperature in excess of 400°C when the entire room was in flames. The highest temperature at this moment was measured to be 907°C. The radiation showed for a short moment higher values than those in test 1b: 104 kW/m^2 and 117 kW/m^2, the peaks also seem to be a little broader than in test 1b. The gas analysis shows that the O_2 concentration dropped below 2%, thus all available oxygen was used. The CO concentration reached 4%. The measurement of the CO_2 unfortunately stopped when showing a CO_2 concentration of 10%. The duration of 50 s between ignition and a fully developed fire is still very short. This confirms that test 1b was not an extreme test but probably fits well in the natural variation of the fire behaviour. The observations seem to come even closer to the witness observations, for example the witnesses explained that the fire build up was only seen under the branches in the beginning of the fire. After 40s the entire layer was hot, oxygen poor, and rich enough in flammable gases to enable a rapid fire spread to the rest of the room.

This differences seen in test 1b and 2 come from the improved attachment of all the Christmas lights to the branches. This confirms the extreme sensitivity of the final result to small changes in the test set-up.

DISCUSSION

The following discussion addresses only the physical and fire technical details of the fire.

An important question naturally was whether the fires in tests 1b and 2 are accurate copies of the fire in de Hemel. Direct and objective details such as plastic beer glasses that were put on a table in the middle of the room and beer mats on the bar indicate that the fire was more intensive in the reconstruction than in the in actual fire in de Hemel.

In test 2, the heat flux showed levels above 30 kW/m^2 for 15s to 30s and from these results it would be expected that the top of the table, on which the plastic beer glasses were put, would ignite in the reconstruction.

This becomes complicated, because the accelerating heat flux is accompanied by the oxygen concentration falling to zero. The best illustration of this fact comes from the fir branches themselves. As flammable as they proved to be, after both tests large amounts of branches were still hanging in the ceiling and lying on the floor. This effect could only be explained by a decreased oxygen level. These two factors combined makes it less straightforward to compare the actual damage seen in de Hemel with the damage levels seen from the reconstructions.

Assuming that the tests showed more severe conditions than actually experienced in de Hemel the following reasons for this can be suggested:

- The influence of the 300 people that were present in the café and what happened with the falling burning fir tree branches, it is difficult to make an assumption of this effect.

- Possible deviations between the design choices (mainly based on the description of de Hemel from the police reports) and the reality.

LITERATURE STUDY OF SIMILAR FIRES

The Inspectorate of the Fire services and Disaster management (IBR) asked TNO to search for information regarding for similar fires that had occurred with rapid fire spread or with many casualties or involving Christmas decorations in discotheques or similar public buildings and to look at the way in which the country concerned changed its fire safety rules or controls after the fire.

In total approximately 15 fires fulfilling these conditions were identified and a number of them were studied closer, based on usefulness and availability of information. Hotel fires where guests were asleep and fires caused by extreme violence were ruled out of the study.

Opemiska[1]
The first fire identified took place exactly 20 years prior to de Hemel in the town of Opemiska in Quebec, Canada. Fir branches hanging as a large bow (the branches were stapled to a board so that they would not fall down) over the hallway to the main entrance since Christmas, were put on fire as a practical joke and caused the ceiling ignite. 48 people were killed.

Switel[2,3,4]
The fire at the Switel hotel in Antwerp, Belgium took place exactly six years before the frie in de Hemel. This fire started because candles were placed by mistake under two large Christmas trees in the entrance area of a conference room where a party was held. The trees ignited, leading to the ignition of the combustible wall covering. 15 people were killed.

Joy /Tobako [5,6,7]
Other fires comparable to the de Hemel fire are fires that involve temporary decorations such as two “Styropor” Parties that took place in Austria October 23 1999. Two fires took place the same evening at two different discotheques. A Styropor party involves dancing knee deep in polystyrene pellets. A guest wanted to check if the polystyrene could burn and ignited it with a cigarette lighter. When he saw how well it burned he dropped it on the floor which caused the polystyrene on the floor to ignite. In the second discotheque it is believed that a falling cigarette caused the fire. No one was killed but in total 150 people were injured.
The fires in Austria did not lead to a specific technical research concerning the cause and spread of the fire. The regulations in Austria were not changed, as the regulations were considered to be sufficient to avoid disco disasters such as the fires in Joy and Tobako.

However no permission had been asked for the polystyrene parties and the locking of one escape route (in one of the cafés) was not in rule with current regulations. A letter from the authorities suggesting changes was rejected by the owner. After these fires a study was made to look at the fire safety in the Tyrol region. The result of this study showed that 45 of 48 bars did not comply with the safety regulations. The owners of the studied bars were accused of criminal charges, and the procedure for enforcing regulations became stricter.

Makedoniska Föreningen [8,9,10]
A fire took place on October 29 1998 in Göteborg, Sweden killing 63 teenagers and wounding nearly 200. The fire was intentionally started in an escape staircase, where it could grow un-noticed and the warm gases filled the stairwell. The disc jockey opened the door to the emergency exit to investigate because he smelled smoke and the door was left open. A chimney effect was created and in a matter of minutes the entire dance hall was filled with smoke. The floor covering ignited creating a pool fire. The Swedish research institute SP concluded afterwards that the catastrophe could have been avoided if the door would have been equipped with a door-closer. The commission responsible for the research of the fire, Svenska Haveri Kommisionen, SHK, issued recommendations to different Swedish government boards and agencies because of the Göteborg fire. These were directed to among other the Swedish National board of Housing, Building and Planning, the Swedish Rescue Service Agency and the Swedish National Board of Health and Welfare. They included directions such as reviewing the methods for the dimensioning of evacuation routes, introducing requirements for automatic alarms in adjacent unoccupied spaces and the routine for ambulances and at hospitals in case of large emergencies.

Happy Land [11]
A very similar fire to Göteborg was the fire in the nightclub "Happy Land" in New York. Petrol was spread over the main entrance and ignited. When a patron tried to escape through

the main entrance, where the fire was, a chimney effect was created by the opening of the door to the outside lobby and the fire and the smoke spread quickly to the dance floor. 89 people were killed. The nightclub was illegal and did not follow the safety regulations. An almost identical tragedy happened in a social club in New York in the Bronx in 1976. Petrol was ignited at the only entrance of a first storey illegal club. 25 people were killed.
Both the Göteborg and Happy Land fires were caused by arson but the rapid development of the fires and the large amount of victims make them suitable for discussion here.

Stardust [12,13]
In the Dublin discotheque Stardust, as in Göteborg, chairs were set on fire. The fire did not start in the main dance hall but in an adjacent room behind curtains. The beginning of the fire was seen from the dance hall when the curtains were opened. The fire spread from the chairs in the back of the room to the entire back wall, a process that took about 6 min. After that the fire spread quickly to the side walls and burst into the dance hall in approximately 10 seconds. Around 800 people were in the dance hall, 48 people died and 214 were injured. Following the fire changes were introduced to the fire regulations in Ireland.

- The building regulations existing at the time of the fire, were completed and finalised after the fire;
- User regulations for public buildings were introduced;
- Operational regulations on floor and wall finishes were introduced;
- Operational regulations were made on furniture in assembly premises;
- Rules for size and number of escape routes were re-adjusted;
- For high-risk situations warning and smoke detection systems became obligatory;
- Large financial sanctions were introduced for not following the rules;
- Exceptions from the rules were only allowed on the basis of a fire safety engineering approach.

Very critical remarks were made on the education level on fire safety. A proposition was made to integrate fire safety in the education of architects and designers.

Cinq-Sept [14,15,16]
In the discotheque "Cinq-Sept" in France a home-made heating system caused a fire. The fire started in an upstairs room and spread immediately to the entire ceiling that was covered with polypropylene and polyesters. Drops of burning plastic fell down on the people on the dance floor. People tried to get out but the revolving doors at the entry were blocked by the number of people trying to escape and 147 people died. Because of the role played by the ceiling in the rapidity of the fire and smoke spread the French regulations now include rules concerning toxicity of smoke products of materials.
These rules mainly consist of ways to limit the amount of nitrogen and chloride in products. Stricter rules were also developed concerning furniture in discotheques.
The most important consequences of the fire were at the level of control, more exactly for all public assembly buildings. Specific guidelines were made to allow competent fire help, preventive regulations for escape routes and heat installations and smoke control. While in the past the controls were made by safety commissions, a system of accredited private control offices was installed.

CONCLUSIONS

The reconstructions of the de Hemel fire at TNO Centre for Fire Research confirm the witness reports speaking of a very short but intense fire. In the two large tests 1b and 2 it took respectively 37s and 50s between the time of ignition to full involvement of the entire reconstructed room. In the real café, that was slightly larger than the reconstructed room, only a few seconds more would have been necessary.

Two out of the three tests showed probably even more severe conditions than those seen in de Hemel; however this is not certain. The tests give a good indication of the fact that the severity of the fire in de Hemel depended on details. A far less severe fire could have happened had the Christmas lights not been attached to the branches. In that case the first burning fir branches would have fallen down without doing much harm.

These tests also show the danger associated with a large amount of fir decorations. In this case the highly flammable decorations led to the deaths of fourteen teenagers and wounded around 200. Dry fir branches present a grave fire hazard due to their extremely fast flame propagation when used as Christmas decorations;

- the inherent hazard of the fir branches was aggravated in de Hemel by the ceiling configuration with a large portion of the ceiling covered;
- the resulting hazard posed by a highly combustible ceiling was so high that no combination of mitigating measures, passive or active, could have prevented the disastrous outcome.

Current building regulations in the Netherlands do not provide practical methods by which fire inspection authorities can check whether building products, furniture and decorations comply with reaction to fire requirements. The formal responsibility rests with the building owner, but in practice he cannot take this responsibility since suppliers do not provide reaction to fire declarations with their products.

The study of previous similar fires confirms that a small change can make a big difference. This was particularly true in de Hemel where the fire might not have developed beyond the area of ignition at all, had only nylon threads been used to fasten the fir branches; the same would probably be valid for the fire in Opemiska, Canada. These kinds of small details are difficult to know or to predict.

It is important to see that in many cases human behaviour is the cause of the fire, in most cases accidents or non-awareness. This suggests that people are not aware of the dangers fire can cause and the dangers related to “playing with matches”.

Big fires with a large amount of casualties in public places are generally caused by a combination of violations of safety regulations. A common factor in all of them is the large scale application of flammable surface finishings and furniture. These allow the rapid spread of fire over large surfaces, which generates the large rate of heat release that is directly responsible for casualties.

The capacities of the escape routes were insufficient in many of the studied cases and/or the number of occupants of the area was too large in proportion to the number of escape routes. It is this combination of negative factors that turned out to be fatal and to cause a large number of casualties.

In some of the cases studied one can speak of a real learning-effect in the aftermath of the tragedy. In most cases these concern adherence to the rules but in some cases also the regulations themselves were made more stringent. This “learning by mistakes” effect unfortunately often only exist on a national level. As an example the same Styropor parties that led to the fires in Austria were after the incidents also taking place in the Netherlands without anyone being aware of the risks. A reason for this can be that technical research of this kind is not often published internationally. Nor do concerned organisations of supervisors and consultants lead an active programme to learn from mistakes in the past.

Our opinion is that changes of regulations and application of these will not prevent fires such as those listed in this article. On one hand because the knowledge and expertise of controllers falls short in recognising all unsafe situations as such, and on the other hand because even though the controls can be made extremely strict the users or owners of establishments with insufficient knowledge of fire safety can always introduce unsafe situations between the controls. Therefore, together with making the controls stricter a programme of raising the conscience of the dangers of fire to the public and owners of establishments is needed to be able to diminish the risks of fire.

RECOMMENDATIONS

The following recommendations are made:

- Provide an organisation that can learn from mistakes already made, both nationally and internationally;
- Increase the awareness of the dangers of using flammable materials and of insufficient escape routes. This should be organised so that the awareness will rest constantly high.

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