Responding to a chimney fire – Case Study

On March 28th 1994 around 19hrs36 the fire department of New York is responding to a chimney fire in Watts Street 62. At arrival heavy smoke is coming out of the chimney. The chimney fire runs out of control and three firefighters are killed. In this article we look at a unique case of backdraft. Unique because of the backdraft itself but also because it is so well documented.

1. The apartment building

The apartment building where the fire originated dates back to the 1800's. These kind of buildings are still found in most major cities. It are in reality buildings in the row with one apartment on each floor. This building had 4 floors. One, the basement, was half below ground level (see fig 1.2). In the building were four apartments: one on each floor. The apartment in the basement had its own access. The three other apartments were accessible via a common stairway.

Fig 1.1 Streetview of 62 Watts Street. An identical building is seen to the left of it. To the right there was a similar but not identical building.

The building had been renovated several times throughout its lifespan. With the last renovation the ceilings of old plaster on wooden laths was replaced with new ceilings. The result was that the ceiling height was lowered to 2,5m. Windows and doors were also replaced and thorough insulation was put into place. There also was an effort to make the building more airtight.

Each apartment covered about 80m^2. And in each apartment there was a living room, a kitchen, a bathroom, a toilet and a bedroom,… (see fig. 3.1) Actually this floor plan looks a lot like what we find in renovated apartments in Ghent, Brussels of Antwerp. There is no doubt, this can happen to us too.

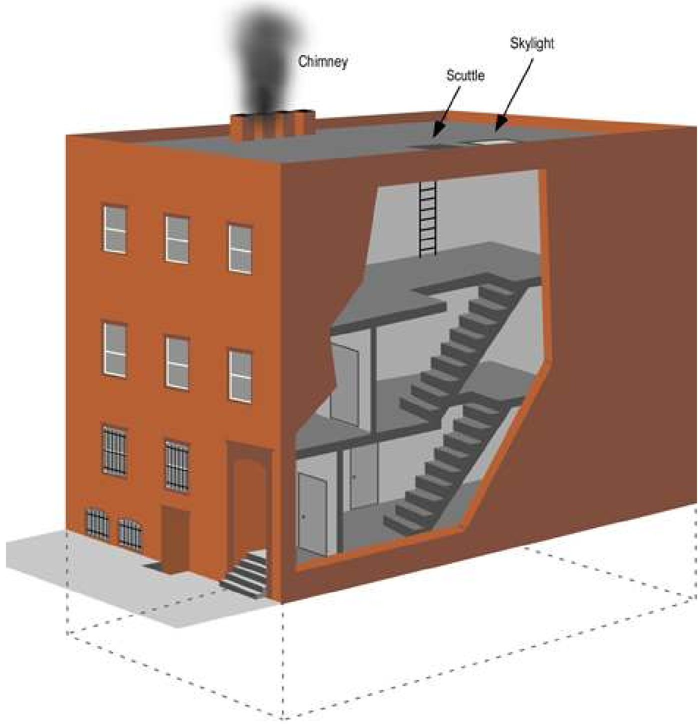

Fig 1.2 View on the staircase *(Figure: Ed Hartin & Richard Bubowski)*

2. The fire

The fire started on the first floor. It is known that the inhabitant left a plastic bag with garbage on the stove in the kitchen when he left the apartment around 18h25. It is believed that the pilot flame from the gas stove has put the plastic bag and its content on fire. The fire then grew quite quickly until the whole kitchen was on fire. Without doubt this happened with an important increase in temperature in the compartment. The only inlet of fresh air for the fire was the chimney from the open fireplace in the living room. In the beginning of the fire this was the way fresh air followed towards the fire. Because the doors to the bathroom and the bedroom were closed, the inflow of fresh air towards the fire in the kitchen was very limited. Afterwards the damage from the fire was limited to the living and kitchen.

At a certain moment the smoke layer came below the upper side of the open fireplace in the living room. From this moment on the chimney served as an exit for smoke. The fire used up all the available oxygen and became underventilated. (see also the second article in this series: "A fire suffering from a lack of air…"). Since this was an almost airtight construction, there was almost no more oxygen available and the fire started smoldering because of lack of oxygen. Because of a thorough insulation the high temperature in the compartment was maintained. This temperature stayed high enough to keep materials pyrolyzing. During an important time pyrolysis gasses filled the compartment. The compartment became a reservoir filled with flammable gasses.

The fire stayed unnoticed in the beginning. At a certain time a passing person noticed an abnormally amount of smoke coming out of the chimney. This was accompanied by flames. The person called the fire department for a chimney fire.

3. Actions of the fire department

The fire department responded with three engines, two ladder trucks and a chief officer.

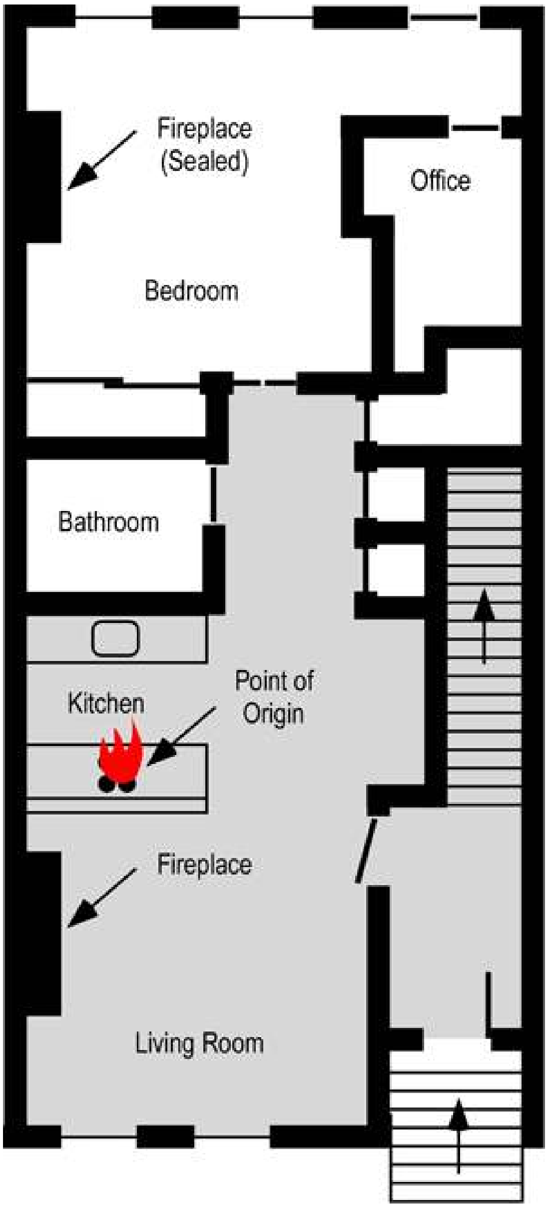

Fig 3.1 Floor plan first floor
(Figure: Ed hartin)

When the fire department arrives there are few or no elements that indicate any exceptional danger in this building. On arrival standard operating procedures are used as known in the fire department of New York (FDNY). An important task in most of the North American fire departments is the ventilation (venting). Therefore one ladder truck will directly be deployed to open up the hatch above the staircase so that any smoke is evacuated.

The chief officer takes thorough steps in dealing with this fire and sends in two crews with three firefighters each. Armed with a hoseline they have to check every apartment in the building. They start with the first floor and then the second floor.

Both crews start by putting in place their attack line. When the firefighters open the door on the first floor warm (not hot) smoke billows into the staircase. This is quite quickly followed by a strong airflow of fresh air going into the apartment. The firefighters in the door opening recognize this as the warning signs for a backdraft and try to dive away. Shortly after this a backdraft takes place and the staircase is filled with flames. The intensity of the flames is so high that they go up and through the smoke hatch at the top of the staircase. These flames are visible from the street. There, a civilian is filming the whole scene. Based on his footage researchers could conclude that the flames from the backdraft lasted for more than six minutes.

The firefighters on the first floor saw the backdraft coming and got out with only minor injuries. But the firefighters on the second floor were trapped with no way out. One died on scene. Both other firefighters were transported to the burn unit in the hospital. One will succumb to his injuries within 24 hours, the other after 40 days.

The fire department of New York city asked the NIST to investigate what could have caused such an intense backdraft. Especially the fact that fire torch lasted for more than six minutes was a dazzling factor.

4. The (scientific) analysis

4.1 Experiments on the behavior of a backdraft

In the early nineties three scientists conducted research into the condition that could cause a backdraft. The researchers mostly used methane (natural gas) as a substitute for the pyrolysis gasses that occur with a real fire. They used a compartment with the following dimensions: l x w x h= 2.4m x 1.2 m x 1.2 m (7.87ft x 3.93ft x 3.93ft). In the compartment measuring sensors where installed together with a computer commanded hatch that can be opened at a chosen moment to create an airflow into the compartment. In the room a burner was installed. For these experiments a 70 kW and a 200 kW burner where used. The conclusion was that at least 10% gaseous hydrocarbons had to be present to get a real backdraft. At lower concentrations a combustion of the gasses occurred but no explosion.

The last article already looked at the Chitty study which shows that a backdraft cannot be initiated by smoldering of the initial fire. He showed that this smoldering does not generate enough energy. It are the flames of the reigniting fire that that ignite the fire gasses. During the research into the backdraft at Watts Street 62 these conclusions are taken into account.

4.2 Analysis with CFAST

CFAST is software that makes it possible to simulate fires. Scientists attempted to modulate the Watts Street fire with this software. Therefore they assumed that the plastic bag on fire generated an energy of 25kW. That is a heat release rate that can be expected from a burning plastic bag. They simulated such a fire in a compartment with the same dimensions as the real apartment, being the living and the kitchen. The staircase and the chimney were also taken into account in the simulation. The expected peak was 1MW , but this was never reached due to a lack of fresh air.

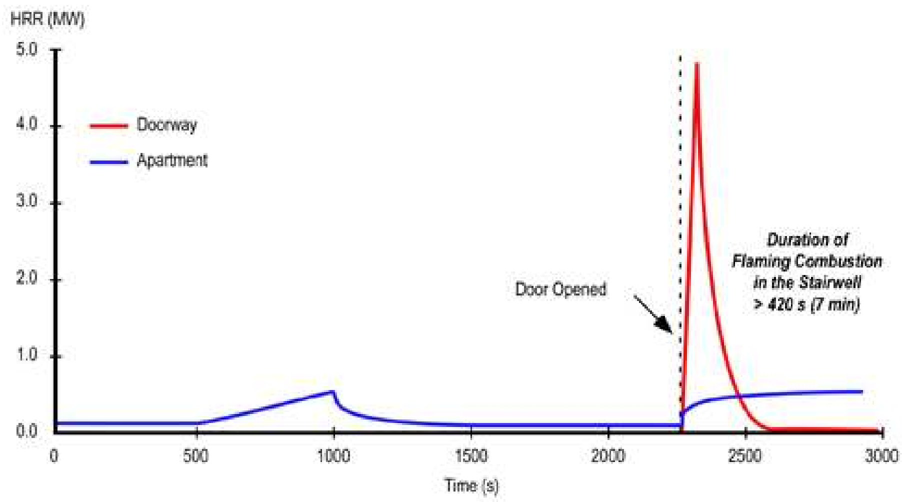

Fig 4.1 Energy build up. The blue line indicates the heat release rate in the apartment, while the red line shows the heat release rate in the staircase. *(Graphic: Ed Hartin & Richard Bubowski)*

At the opening of the door, the computer simulation showed a flow of fire gasses out of the apartment and an inward flow of air into the apartment. The simulation confirmed the observations of the firefighters at the scene. Figure 4.1 indicates the heat release rate over time. We notice that the heat release rate in the apartment was never more than 500 kW. The heat release rate developed in the staircase on the other hand is 5 MW.

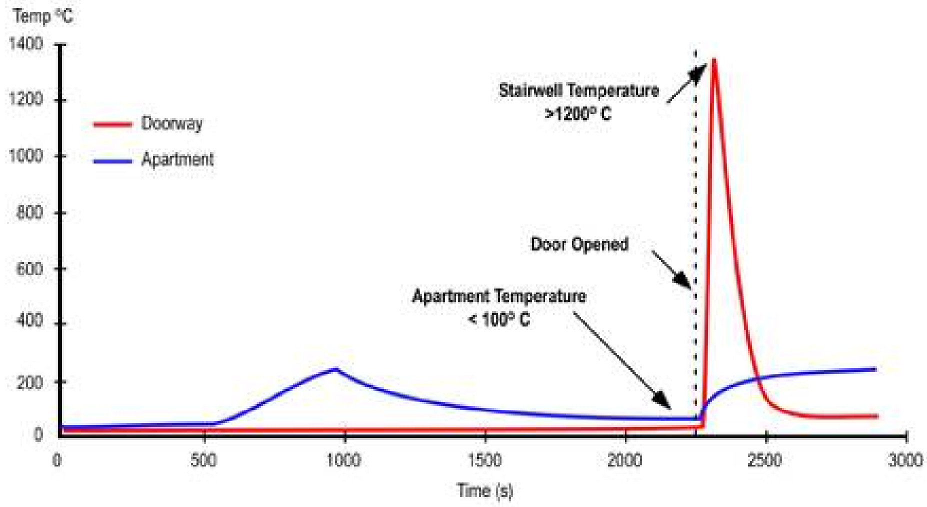

Fig 4.2 The temperature in the apartment (blue) and in the staircase (red).
(Graph: Ed Hartin & Richard Bubowski)

The temperatures in the apartment stayed rather low. In the simulation the combustion with flames starts (developing phase) after about 500 seconds. The temperature rises over 8 minutes till 300°C. After this moment the temperature gradually descends until the opening of the door. This means that that the temperature in the compartment stayed high enough for the production of pyrolysis gasses for a long time. The simulation showed that in the apartment enough pyrolysis gasses and CO were produced to keep the flame torch going for almost seven minutes.

Before the opening of the door the temperature in the apartment went below 100°C. After opening of the door the temperature in the staircase rises till 1200°C. It is obvious that survival in these conditions is impossible.

5. Lessons Learned

5.1 Renovated buildings.

Renovating buildings is a trend. Governments are motivating people with financial support to make houses more energy efficient. The apartment involved was constructed in late 19e century. In this case the different consecutive renovations changed the building drastically. As a consequence you can no longer link the expected fire behavior with the first impressions you get from a building. In the past on arrival it was possible to predict with high probability the fire behavior when looking at an obvious old building. As soon as the temperature inside goes up the windows would break and you would get a ventilated fully developed fire. There were less technical shafts or voids where smoke could build up being a hidden danger. These days one has to be on the lookout even in old buildings for the dangers of an underventilated fire and accumulated fire gasses in shafts, voids, false ceilings,….

5.2 Door procedure

With the start of the new training for firefighters in Belgium a standardized national door procedure is introduced. This new door procedure foresees in pulses of water to cool hot smoke that can come out of the compartment. Also the second team member is supposed to keep control over the door. So that he can close it if anything goes wrong. The first action would at least have slowed down the ignition of the hot fire gasses. The second makes sure that the team has the reflex to close the door when they are surprised by a lot of smoke billowing out of the compartment or if they notice a strong inward airflow.

5.3 Vertical ventilation.

Until recent is was accepted that vertical ventilation is the answer to a backdraft situation. Just as with any other ventilation scenario the path followed by the fire gasses is of extreme importance. If the fire gasses ignite in a volume on their way out, then that will almost always cause a secondary fire. If any civilians of firefighters are present in this flowpath then this will almost always cause severe injury. Ventilation techniques are a domain on which the knowledge in Belgium is rather limited. But one thing is sure: it is not as simple as " backdraft = vertical ventilation"

5.4 Gascooling

Gascooling (3D-technique) is at the moment worldwide accepted as the technique to neutralize the dangers of smoke. But it has always been stated that the application was limited to volumes of less than 70m2 (753sq ft) and with a limited height. This case teaches us that there are underventilated fires with fire gasses at temperatures so low that any cooling would have very little effect. Just before the opening of the door the temperatures in the apartment went below 100°C. This means that water won't evaporate anymore and that the temperatures of the fire gasses will hardly descent due to a lack of steam production. It is the steam that has to slow down or stop a possible flamefront. Gascooling techniques are great, but they have limitations.

5.5 Chimney fire.

The fire department was initially called for a chimney fire. In North America more, but smaller, units will be dispatched to a chimney fire then for example in Europe. Thanks to this system there were quite a bit of resources on scene when the backdraft occurred. This way it has been avoided that the situation deteriorated even more.

In Belgium fire departments sometimes respond with four firefighters and one or two trucks to tackle a chimney fire. What would happen when a backdraft knocked down one or two team members? On Februari 7th 2007 Eric Pero from the Rochefort fire department (Belgium) died on duty due to some kind of rapid fire progress. The call he and his team were responding to was … a chimney fire.

4. Resources

[1] *Bubowski, Richard, Modelling a Backdraft incident, Fire Engineers Journal November 1996*
[2] *Hartin Ed, 15 years ago: Backdraft at 62 Watts Street, March 2009*
[3] *Hartin Ed, 62 Watts Street: Modelling the backdraft, March 2009*
[4] *Bengtsson Lars-Göran, Enclosure Fires, 2001*
[5] *Fleischman, Pagni & Williamson, Quantative backdraft experiments, 1994*
[6] *Chitty R, A survey of backdraught, 1994*
[7] *Perez-Pena Richard, New York Times, Fireman dies in battling blaze in Soho, 1994*
[8] *Le Soir, mort dans un incendie à Rochefort, February 2007*

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