Firefighting: Command & Tactics

Suppose it's a beautiful summers day afternoon at the end of August and you're taking a stroll with your kids next to a corn field. One of the kids asks you to play hide and seek in the corn field with them. Together with your two other children you run off into the corn field and start to play. It seems like a picture perfect afternoon until the farmer arrives with his harvester and starts to harvest the corn. Terror grips you as you already imagine one of your kids being caught by the harvester. You call out to them, telling them to get out of the corn field, but they don't respond. After all they are still playing hide and seek. How can you save them from a terrible accident? By going into the field to try to find them or by going to the farmer, explaining the situation and stopping the harvester and thereby removing the danger? Everyone will agree that the correct answer is: removing the danger.

1 First rescue, then extinguishment

The current doctrine dictates that when dealing with an interior fire involving victims still inside the building, rescue takes precedence over extinguishment. This doctrine is a very old one. It has been applied by fire services for many centuries around the world.

1.1 Origins of the doctrine

The first organized fire services were formed in the early 19th century. Until then, fighting fires had been a community effort. Rows of people were formed to pass along buckets in order to get water onto the fire. Citizens were asked to help in order to achieve this. The moment genuine fire services were established, people were also appointed to lead the fire interventions. At several places, people started thinking about how they could be more effective. More equipment was made at the fire services disposal and their possibilities increased. Just as it is today, rescuing victims was the top priority.

The first fire services were organized inside major cities. Often they were confronted with buildings made of several stories. Upon arrival it would often happen that the residents of the buildings upper floors had fled onto the balcony or were standing in window openings. The fire services quickly realized that it was more efficient to save these people first using manual ladders and afterwards start extinguishment.

"First rescue, then extinguishment" has since been a doctrine and the standard operating procedure of the fire service. Actually what they really meant was "First rescue any people that can be rescued with ladders from the building fronts". This probably was too long for a punch line so it became "First rescue, then extinguishment".

1.2 Has anything changed?

At the time of the doctrine's introduction, firemen first performed rescues with ladders of people standing in windows or on balconies. Afterwards they entered the building to start the extinguishment. Most of the time they couldn't go in very far. When there was too much smoke or heat, they'd have to stop.

Fig 1.1 The equipment of fire services in the early 19th century
(Photo: www.mechelsepompiers.be)

In the course of the last century, the fire service has undergone a technical revolution. Protective clothing improved considerably. On top of that, the use of the breathing apparatus became common practice. This allowed firefighters to enter burning buildings. For the first time it became possible to enter rooms in which survivability odds had been slim due to the large amounts of smoke and heat inside. Firefighters started to perform rescue actions inside as well as outside. This evolution led to saving even more lives on fire grounds.

The oil crises in the '70s of the past century ushered in yet another change for fire crews. One that wasn't so easily noticed at first. Fuel prices started rising and have continued to do so until today. Where once, before the oil crisis, fuel was cheap, it now became a precious commodity. Housing became more and more insulated. The result of this was that fire behavior changed as well and the under ventilated fire made its appearance. Nowadays fires sometimes react differently to ventilation than before (see previous articles in this series).

At present we're seeing firefighters who are equipped and protected in order to enter burning buildings, while the fire itself has become a lot more dangerous. "First rescue, then extinguishment" now has a completely different meaning than 200 years ago. Back then it was possible to quickly find a victim that was hiding inside. After all there was a lot less smoke back then. The internet hosts videos in which a traditional room fire with furniture of the '50s is compared to one involving modern day furniture. The difference in smoke production is huge. Now a search for victims really is a search in the true sense of the word.

So now we've arrived back to the starting point of my case. Are we going in to search for victims or are we going to take the fire first? Are we going to run into the corn field after the kids or are we going to stop the harvester?

1.3 New doctrine: First, put the fire out!

More and more the fire service is being confronted with under ventilated fires. In these cases the power of the fire is limited by a lack of oxygen. A lot of smoke gas is present

though. Survival of victims inside the fire compartment is near impossible. Steve Kerber's study (see [2]) showed however that residents have very good survivability odds when located in another room that's separated from the fire room by a closed door. These rooms have less heat and lower concentration of toxic gases. It's possible to apply the same reasoning for fires in the growth stage.

Victims exposed to toxic gases like CO will gradually absorb these substances into their blood stream. The higher the concentration of toxic gas, the more quickly this will happen and the faster they will die. The toxic gases are being produced by the fire. As long as the fire is burning, the situation will worsen because of the continuing rise in smoke gas concentration. By putting out the fire, the production of toxic smoke gas is halted. Thus by extinguishing the fire, the concentration of smoke gas will stabilize and even lessen when vented. This in turn, improves survivability odds for victims.

Searching a victim in smoke logged house is very time consuming. It's a search comparable to trying to find kids in a corn field. Searching the fire is not that difficult. With the use of a Thermal Imaging Camera (TIC) you can observe the currents in the smoke. You can see the elevated temperatures. This will allow you to determine which direction to follow to find the fire.

A final and important argument to advocate a change in operating procedure is the following: when a fire crew enters a burning building for search and rescue, they often do so without a hose line. They want to make good progress and don't want any hindrances caused by the hose line getting stuck around corners or furniture. Even without a hose line, searching multiple rooms will take some time. During this time, the fire will reign free. The article "New insights into ventilation" showed that opening the front door is enough to allow the fire to rapidly progress into flashover. There are numerous case studies known in which firefighters perish while searching for victims inside a burning building. Often it turned out to be a small fire that grew quickly during the search. And more often than not, it would have been possible to first quickly extinguish the fire and then search for victims.

This leads to a new doctrine that's increasingly being applied around the world: "First, put the fire out!"

1.4 Network of stations

Lots of people will protest when reading the above. After all it contradicts all current doctrine. To avoid having to make a 180° turn in operating procedures, fire departments can organize multiple stations to work together. The engine to arrive first on scene can start the fire attack. As soon as the second engine arrives, it can start search and rescue. Another possibility for certain fires, is for the first engine crew to prepare the attack line. The team normally responsible for water supply can then start search and rescue. Naturally this can only be done when there's a six person team in the engine. There also needs to be assurance that a second engine is on the way. The six person engine team will then be divided into an attack team and search & rescue team of two firefighters each, an engine operator and a commanding officer. It's also extremely important for both teams to be properly trained and have at least one experienced person in them. Both tasks (fire attack and search & rescue) are very high risk without a backup team present. A final aspect that needs to be taken into account is that these tactics are being performed with use of the engines own limited water supply. The second engine needs to

arrive quickly on scene to provide an independent and lasting water supply and provide backup teams.

2 Case: Cherry Road

Even when it's certain there is no one inside the building, it's important to put out the fire as quickly as possible or at least, confine and control it. When multiple teams are being deployed, the team to make contact with the fire first needs to contain it. This will create an increase in safety for the other fire teams. The fire attack needs to be executed correctly of course.

A case in which firefighters didn't immediately tackle the fire out of fear of endangering the lives of other fire teams is the Cherry Road Fire. This fire was considered a routine job upon arrival. Firefighters did what they had been trained to do and went searching for the fire. During the search the fire escalated. Two firefighters died and three others got injured. What's tragic about the incident is that backup fire teams were standing by but were not allowed to attack the fire from outside because the IC was afraid the search teams would become injured by the steam. Let's now take a closer look at the case.

2.1 The building

The building is located in a residential housing area. It's a small row house made up of three floors: basement, ground floor and 1st floor. It's important to note that there's a difference in ground level between the front and the back end. At the back, the yard is at the same level as the basement making it seem as if there are 3 building layers all above ground: ground floor, 1st and 2nd floor (see fig 2.1). Such situations always create confusion amongst fire teams on both ends of the building.

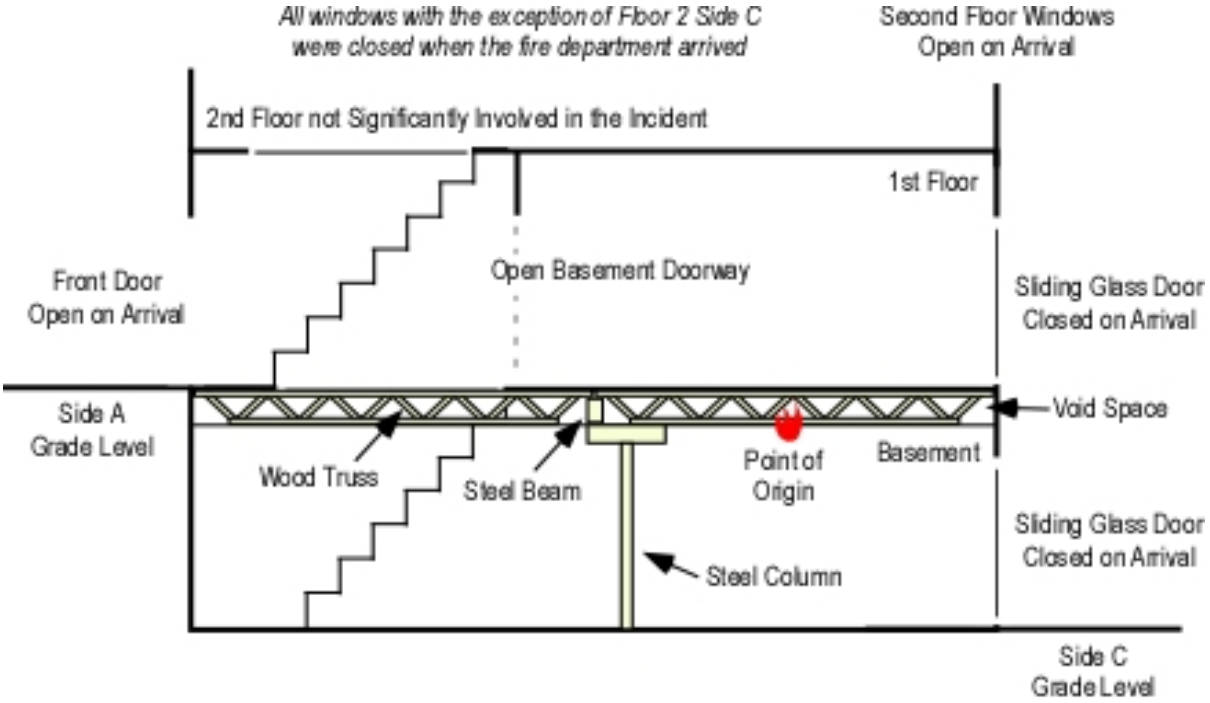

Fig 2.1 A cross section of the building. The front end is on the left hand side of the drawing. The back end with the yard at basement level is on the right hand side.
(Drawing: Ed Hartin, www.cfbt-us.com)

The building has a wooden frame. Steel beams and columns are built into the basement to transfer the weight of the ground level floor to the foundation. Both the front as well as the back are made up by brick walls. In Europe these construction methods are becoming more and more popular for passive and energy efficient housing.

The basement is being used as recreational den. There are some bookshelves, sofa's, a bar, … In other words, there a substantial fire load present in this room.

Upon arrival of the fire service, the front door is open. The moment a fire team arrives at the back end, they see that the sliding window on the 1st floor is also open. To them this looks like the 2nd floor. All other windows are closed.

2.2 The fire

On May 30th 1999 a fire starts at about a quarter past twelve at Cherry Road 3146. A smoke alarm alerts the residents who are able to flee the building before getting trapped in the smoke. Investigation afterwards will conclude that the fire started because of an electrical malfunction of a light in the basement. The light was built into the ground level floor. The fire spreads and an ever increasing part of the basement is being caught up in the blaze. At some point flashover occurs in the basement. Hot smoke is pouring out through the open staircase into the ground floor.

At that point two firemen are conducting a search for the seat of the fire on the ground floor. They get caught by surprise by the rapid fire progress and perish.

2.3 Fire departments tactics

Upon arrival on scene, a large volume of smoke can be seen. Because of this the IC decides to scale up the incident. A bi-directional flow can be seen at the front door. Thick, black smoke is flowing out the door. At the front end a low pressure 38mm attack line is deployed by the 1st engine. The attack team uses this hose line to enter the building. The 3rd engine is deploying a 38mm backup line. A lot of Belgian firefighters will be surprised to find out that three engines had been dispatched to the fire. In America it is custom to man the engines with fewer people. A lot of fire departments put four firefighters on a single engine and some services put three or five on a vehicle. This service uses four man engines. They send four engines and two trucks to the fire scene. The smaller engine crews are offset by sending more units to incidents.

Firefighters of other vehicles start to break the windows of the front. In the US there is a strong conviction that early venting will always improve conditions. Recent studies have shown that this is not the case (anymore).

Meanwhile the second engine has deployed a long hose line to the back of the building. To achieve this they have passed round the side of house 3142 (see fig. 2.2). Because of the sizeable distance covered, they haven't noticed that they've "gone down one level". They arrive at the sliding window of the basement. This is the level of the seat of the fire. They arrive at the growing fire inside the basement. At this point it's still a small fire. They actually describe it as several small fires. These turned out to be wooden ceiling tiles that had dropped down.

However, from their point of view it is a fire at ground level. Therefore they assume that their colleagues are on the far end of the fire. The window is covered with burglary bars. The 2nd engine crew removes these bars. They then proceed to break the windows to vent the fire. Quickly after they see an inward air track through the open window. At this point the fire crews have unwillingly created a chimney. At the front end the windows have been broken and thus an outlet has been created, while downstairs an inlet (sliding window) was made. The effect of the chimney will cause the fire progression to speed up. Crews at the back testify they could see the fire grow.

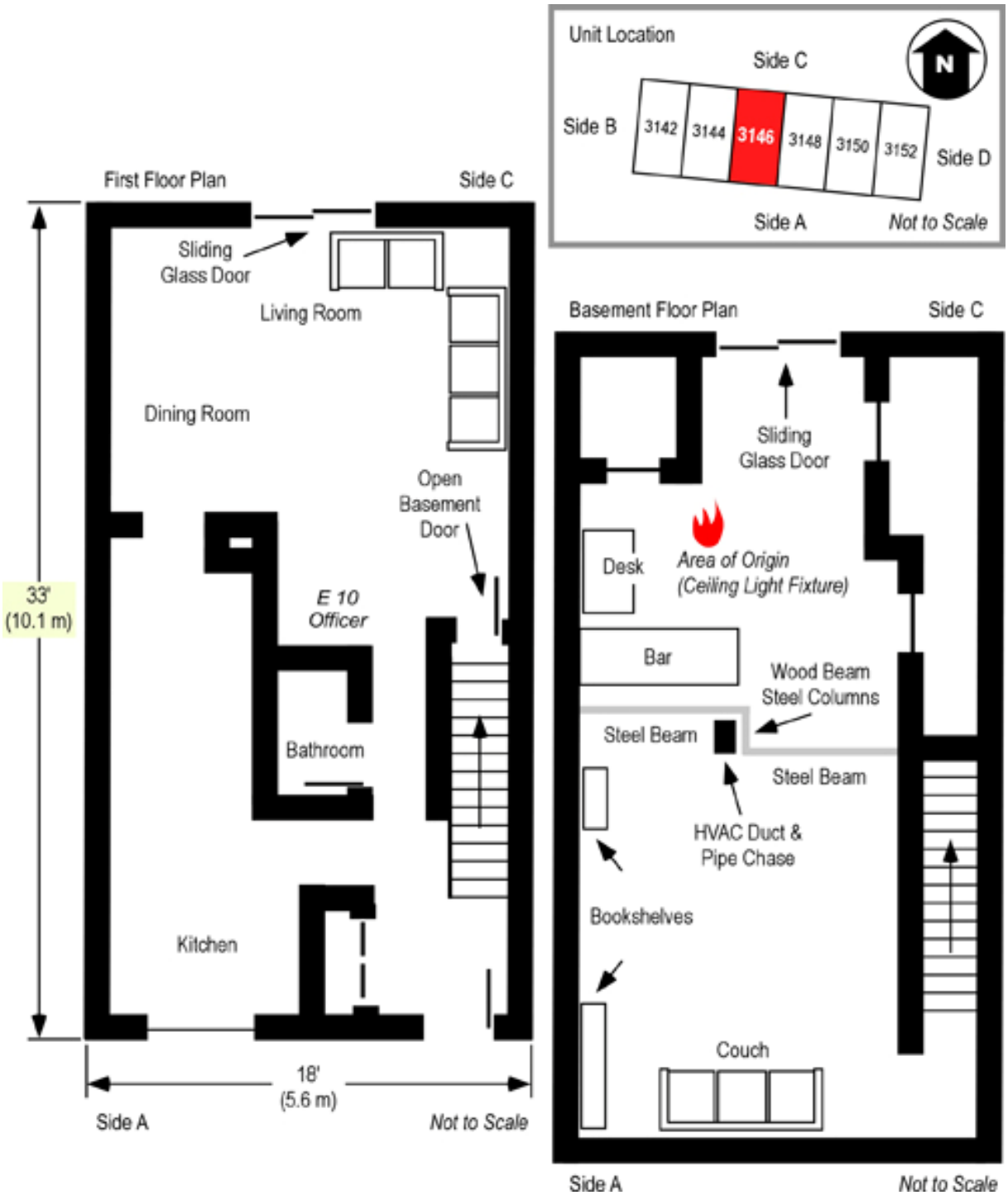

Fig 2.2 Floor layout of the ground level and basement.
(Drawing: Ed Hartin, www.cfbt-us.com)

At this point in time, firefighters without a hose line are advancing into the basement to search for victims. During the search, they find that the small fire is rapidly growing. Temperature is rising and flames are appearing in the smoke layer. Therefore they decide to retreat. During the retreat they describe a "tunnel of fresh air" entering the room. This allows them to quickly find their way back to the exit. The officer at the back end calls out to the IC and asks permission to attack the fire from his position. This request is denied because of the fear that the forming steam will cause too much trouble for the attack crew. It's important to note that everyone on scene is thinking that both crews are operating on the same level. Experienced firefighters know that the use of a solid jet implies any crews caught on the other side of the fire will get steamed.

Shortly after this, the attack crew makes contact with the fire and starts extinguishment. However they are not aware that the original seat of the fire is located beneath them in the basement. Even though flames are blackened down, the temperature keeps on rising and the smoke layer drops until there's zero visibility. Soon after, the attack and backup crews start to pull back from the ground floor because the heat is no longer bearable. In the confusion that follows, three firefighters get left behind inside the building.

Fig 2.3 Exiting flames from the sliding window into the back yard. *(Photo: District of Colombia Fire & EMS)*

Again the officer at the back asks the IC to allow exterior fire attack from his end. Again permission is not granted.

One of the three firefighters inside realizes something is seriously wrong and manages to find the exit. RIT teams are deployed to try to save the remaining two firefighters. Because of the high temperatures, the rescue attempts have to be aborted.

It isn't until the officer at the back asks, for a third time, to allow exterior fire attack, that permission is granted. The fire is fully developed at the basement level as well by now.

Soon after water was put on the seat of the fire, the situation is put under control. The fire isn't completely extinguished, but its power has been cut off and temperature has dropped substantially.

New rescue attempts are being made. This time the RIT crews do manage to evacuate the two missing firemen. One of them had already perished. The second died the next day at the hospital.

2.4 Simulating a fire

The Cherry Road fire is the first fire for which afterwards during the investigation a computer fire simulation was made. The US government institute NIST has software that allows them to simulate fires: Fire Development Simulator (FDS). Scientists of NIST have modeled the building and simulated the fire to ascertain the exact fire development. That way they could prove that the fire was lacking oxygen and had become under ventilated before the sliding window in the basement was broken down. After that the fire progressed to flashover in 60 seconds (see [12]). Such a result was confirmed ten years later by Steve Kerber's research at UL.

Figure 2.4 depicts a section of the staircase in which temperatures are shown. The front is at the right hand side and the back at the left hand side. The figure is a mirrored image of fig. 2.1. The section also cuts through the room behind the staircase. This room is separated from the fire compartment by a closed door. As mentioned before, people inside this room have a decent chance at survival. The image also shows hot smoke coming out of the basement and exiting the basement through the window (left on the image) and through the staircase. The flow and air track are clearly visible. Fire crews on the ground floor were operating in a reasonably stable environment. The moment the basement window is broken, an air track is formed. By adding air the fire progresses into flashover. Almost immediately temperatures rise at ground level.

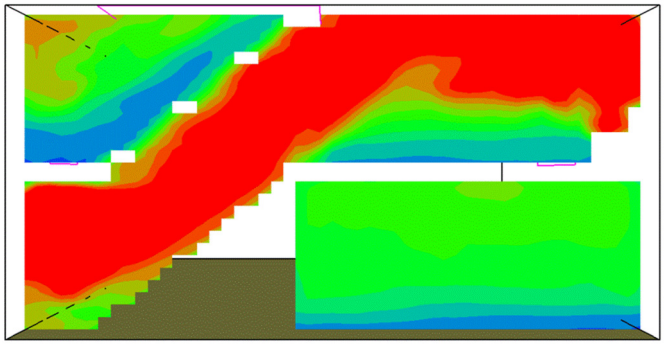

Fig 2.4 Image from FDS *(drawing: Dan Madrzykowski & Robert Vettori)*

3 What could have been done differently?

It's clear that at this fire scene a number of things went horribly wrong. We now take a closer look at some key learning points.

3.1 Extinguishing the fire

"First put the fire out!" is the new doctrine. When fighting fires there often is a lot of confusion. It often occurs that we're crawling inside a burning building and having a hard time to determine a proper visual image of the surrounding, only to be surprised (afterwards when the fire is put out) by the layout of the rooms. That's why it's important to confine and control the fire as soon as possible. **This isn't an excuse or plea for reckless cowboy behavior or improvisation!** It's important for the IC to know what's happening on the fire ground. The fire crew that wants to start an exterior fire attack needs to ask for permission or needs to at least inform the IC they'll start the attack.

Contrary to what firefighter are used to doing, such an exterior fire attack can't be performed with a straight solid jet. When a fire is being hit from the outside with a

straight stream, a large volume of steam will be produced and fire crews inside will get scolded. On top of that, the efficiency of a solid jet is very limited. It's better to start a "soft exterior attack".

Fig 3.1 Use of penciling in a container during CFBT *(Photo: Christophe Gardin)*

It's after all also possible to black down several small fires without creating a large amount of steam by using the technique of penciling. When the power of the fire is too high, a technique can be chosen that's in between penciling and painting. Of course it's difficult to explain this on paper. The need for live fire training remains. Only then can the efficient use of a nozzle be truly shown. If the fire crew at the back had been given permission to attack from the outside, the fire wouldn't have progressed to flashover. Probably it would have been possible to extinguish the several small fires with penciling after opening the basement window.

1.5 Effect of ventilation

One key element that certainly played a part in the lethal course of events is ventilation. In the US it's standard procedure to remove or break as many windows as possible. The FDS simulation showed that creating openings on the first floor hardly caused any change at all. It wasn't until the sliding window in the basement was opened up that conditions inside deteriorated rapidly.

In our parts of the world it's not common practice to vent everything. However we could still cause the same result by opening up the front door of a room. Windows can also break due to heat buildup. An under ventilated fire will give itself away by creating a "tunnel of air rushing in". If this occurs when a door is opened, a strong increase of the fires power will be the result. It's important to respond quickly and appropriately to this situation. In the case of Cherry Road, immediately attacking the fire with the right nozzle technique would have been a correct way to counter the changing fire behavior.

1.6 Gas cooling

A final element that merits attention is gas cooling or the 3D technique. These techniques are rarely used in the US. Even in Belgium there's still not enough awareness for the use of this technique. The moment hot smoke flows out of the staircase it enters the smoke layer of the ground floor. Soon after the smoke layer on the ground floor will ignite. The situation will deteriorate. Suppose the attack crew had been cooling smoke throughout the entire advance, the smoke layer would then contain a large amount of inert steam. This would not have stopped the problem, but it buys the attack crew some time. These precious seconds could be used to get out alive.

2 Final thoughts

Case studies like the Cherry Road fire are very interesting learning tools. There are numerous case studies available on the internet. Often they have been analyzed by

multiple organizations or persons. It is however very important to realize we're all human beings and that it's easy to comment in hindsight. Let us try to make (interior) fire attack safer and more efficient. And case studies are a (cheap) way to help achieve this.

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