A fire suffering from a lack of air...

In the last article we looked at the fire triangle and the ventilated fire development. This is the way a fire will develop if there is sufficient air (oxygen). But it is a reality that we are not constructing our buildings in the same way as let’s say fifty years ago. Double highly insulated glazing is a standard nowadays. Average thickness of insulation in roofs and walls has more than doubled. And the buildings are becoming more and more airtight. In so-called low energy and passive houses the walls and roofs even have an airtight layer on the inside. These houses will transmit a lot less energy to the outside, staying warmer during winter and cooler during summer. Therefore during a fire a lot more energy will stay available to the fire itself. And on top of that there is a lot less air present for the combustion. This is because double-glazing stays intact a lot longer than single glazing. It is logic that we will get a different fire behavior.

1 The underventilated fire development.

1.1 Limited temperature build up.

A fire that becomes ventilation controlled (VC) before flashover is called an underventilated fire. The so called FC/VC point will be before the flashover on the graph. On figure 4.1 we can see the red curve in the incipient stage and during the development phase. Within the development phase we can see the FC/VC point. This means that a lack of ventilation inhibits the fire of going through its normal development. This normal development is indicated on this graph by the red dotted line. The underventilated fire regime is indicated with the grey line.

Right after the FC/VC point the heat release rate (HRR) will decrease. If the transition from fuel controlled (FC) to ventilation controlled (VC) comes early in the development phase, there will be a very limited accumulation of temperature.

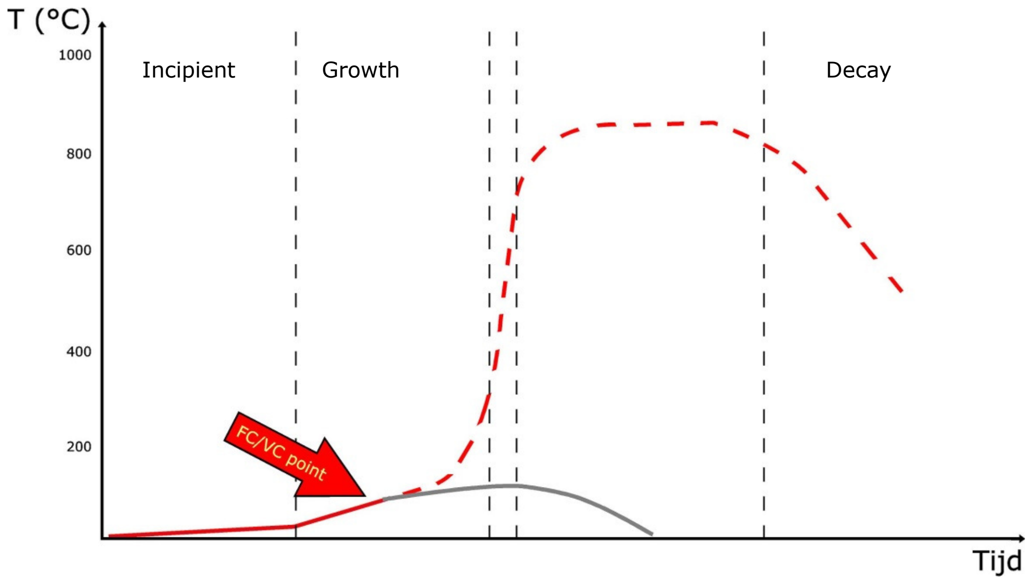

Fig 4.1 The fire becomes underventilated very early . As a consequence there is a very limited accumulation of temperature.

1.2 Important temperature build up

If a fire becomes ventilation controlled towards the end of the development phase, there has been an important release of energy and heat. The following evolution on a temperature level will depend of the physical properties of the room. The underventilated fire is here illustrated with the grey curve.

If the room is rather airtight, the HRR will continue to reduce. But due to the insulation the room or volume will retain its temperature for a longer time than normal. Eventually the temperature will also go down. If there is no change in the ventilation profile of the fire, it will auto-extuingish.

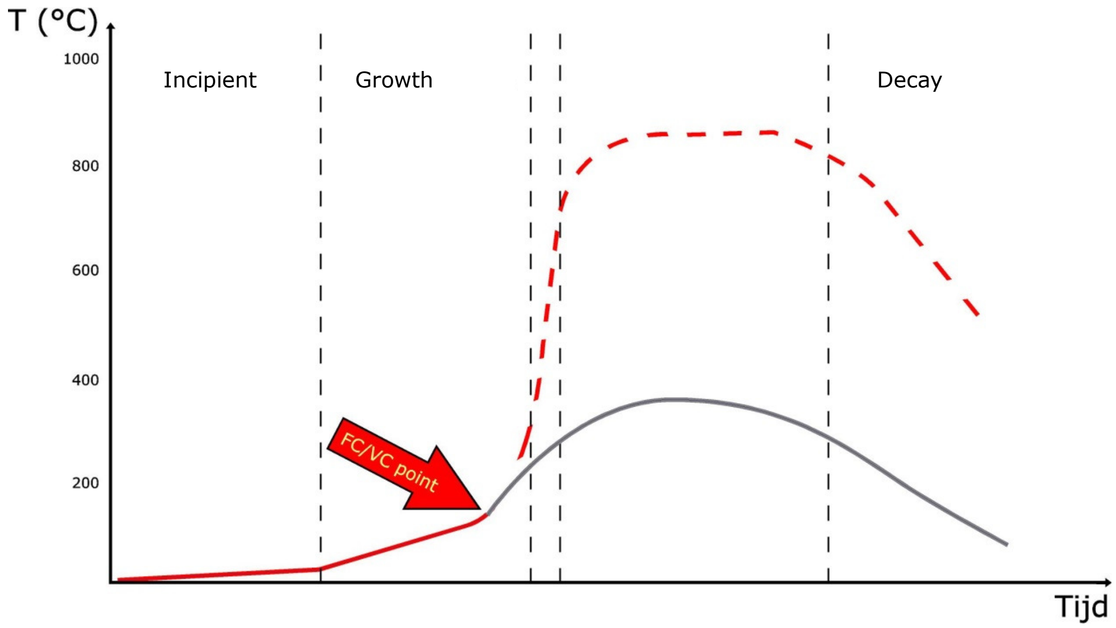

Fig 4.2 The underventilated fire development.

During the time that a fire is underventilated with sufficient energy (heat) left, a change in the ventilation profile can have disastrous consequences for the safety of the team involved.

1.3 The pulsating fire.

A last type of underventilated fire is a fire in a compartment with a limited inlet for the suply of fresh air. The fire will still become underventilated quite quickly. During the development phase it will produce a lot of smoke which will partially disappear through the opening. Because the production of smoke will increase, the part of the opening that has to be used as a smoke exit will become bigger. The neutral layer will drop lower. The supply of fresh air towards the fire will no longer be sufficient. The HRR will go down because of this. After a certain time the temperature in the compartment will go down too. As a consequence the smoke gasses will shrink, the overpressure will disappear and the evacuation of smoke will stop. A slight underpressure will occur and fresh air will enter again.

Once the fresh air and oxygen reaches the fire it will speed up again. If the fire speeds up, the HRR also increases. The smoke production becomes important again and the smoke will be evacuated through a part of the inlet. As a consequence the supply of fresh air will decrease at first and eventually even stop. The process of combustion will again slow down due to a lack of air. The HRR decreases again and so will the temperature. This again leads to the shrinking of the gasses with an underpressure as a consequence. The air supply will restart and so will this cycle.

This way a cyclic process emerges that is illustrated in figure 4.3. This type of fire is called the pulsating fire. In The Netherlands it is believed that the fire in De Punt was of this type. More info about this fire you can find in "Fire in a ships warehouse, De Punt" http://www.onderzoeksraad.nl/en/onderzoek/1575/fire-in-a-ships-warehouse-de-punt

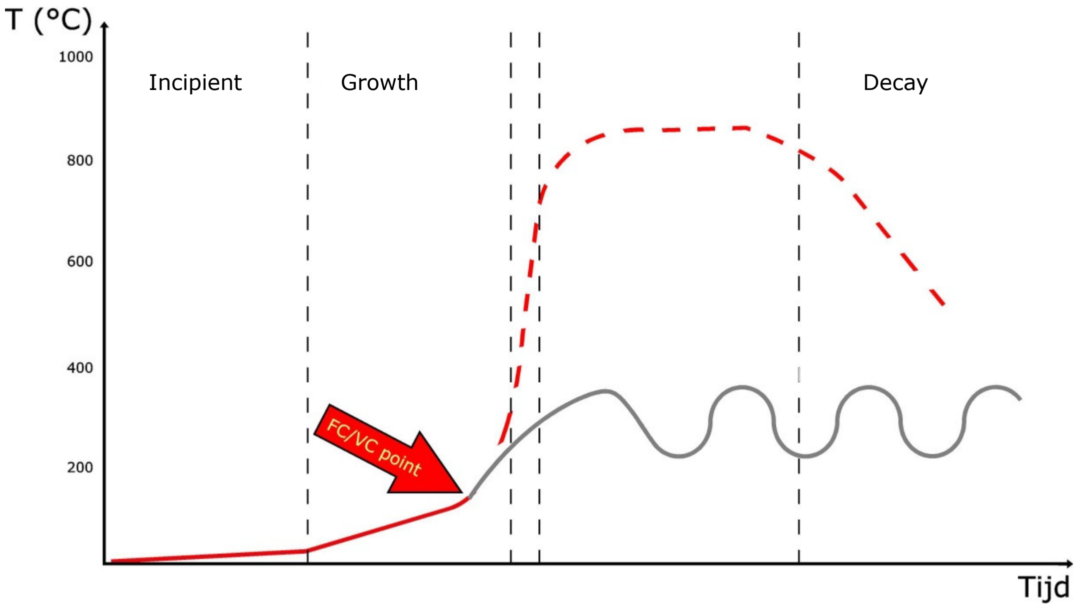

Fig 4.3 The pulsating fire.

2 The Super Sofa Store Fire, Charleston (US).

Underventilated fires have a high risk factor. If for any reason there is a change in the ventilation profile, the fire will get more air. Because of this the intensity of the fire (HRR) will increase. Sometimes this happens gradually and is there time to react. But it can also happen very fast with the occurrence of a backdraft or ventilation induced flash over. In recent history the Charleston Super Sofa fire is one of the most controversial cases with an underventilated fire.

2.1 The Super Sofa store.

The Super Sofa Store was located in Charleston, South Carolina. The building existed out of different parts. One part was the original store (1.625 m^2) with left and right an extension (each 650 m^2). At the back there was a storage building (1.500 m^2) constructed that connected with the original building via a covered loading dock. (see fig. 5.1).

The store sold furniture. This meant there was a high fire load present in the building. Because of the big surface (thus big volume) per definition the air supply ratio has be seen as rather limited. There were some exterior doors, but they were not sufficient to create a big enough air supply to allow the fire to become fully developed. In a building like this a fire will become quite quickly underventilated. The fire spread will be slowed down a lot and maybe even stop, keeping the fire contained at one location. But the smoke will disperse throughout the whole building. And when this smoke has travelled some distance it will cool down en start to drop down. This will reduce the visibility and hamper firefighting efforts.

Fig 5.1 Aerial picture of the Super Sofa Store *(picture: NIOSH)*

2.2 The fire

The fire started on June the 18th 2007 at the back of the store on the loading dock. The fire department dispatches 2 engines to the call. One is used for exterior firefighting while the other is performing an interior reconnaissance. During this first reconnaissance there is little smoke inside the store. The fire itself is burning away on the covered loading dock and it is expected it will expand into the store. The response scales up massively and quickly. Twenty minutes after the initial call there are seven engines and four chief officers on scene.

The fire is still attacked from two sides. The efforts to save the main store are seriously scaled up in the meantime. Inside the store five teams are working with several nozzles to try to stop the fire. During this effort the store itself slowly fills up with smoke. Some firefighters that went in with good visibility are now searching their way out in very bad conditions with heavy smoke. Multiple firefighters get in trouble and the first maydays are called.

The incident commander hopes to improve visibility through ventilation. He orders to break out all windows on the front side of the store (see figure 5.2). This way he hopes to give his men more changes to get out of the building alive. This tactic has quite some consequences. The fire inside the store is at that moment heavy underventilated. The moisture, visibly present on the inside of the front windows, is a known sign for an underventilated fire. Also, the front windows all together represent an important surface. By breaching all these windows a lot air (oxygen) becomes available to the fire. Because of this the fire will rapidly evolve. The flame front grows and the temperature increases drastically. The conditions inside the store become infernal (see figures 5.3 and 5.4) Nine firefighters won't make it out of the store alive.

Fig 5.2 A firefighter breaking the windows *(Picture: Bill Murton)*

Fig 5.3 Smoke starts to flow out through the broken windows while a massive flow of fresh air enters the building. *(Picture: Charleston post)*

Fig 5.4 Once the fire got sufficient oxygen, it quickly evolves to a fully developed fire. *(Picture: Charleston post)*

2.3 Some critical thoughts.

The fire in Charleston is tragic. Nine firefighters lost their life. But it is not so that the decision to ventilate the only reason is for this tragic outcome. The fact that there were several firefighters in trouble was the main reason to initiate ventilation. This decision only worsened a situation that was already going wrong.

An important element that caused this tragedy was the shortage of water. The crews had to cover quite some distance with hoses between the hydrant and the engines. Because of the intensity of the fire it was (with good reason) decided to scale up seriously. Most of the reinforcements were allocated at fighting the fire and not at securing the water supply. Some departments have specific procedures and resources for long distance water supplies. But what if a departments doesn't have these resources. Is there sufficient training on how to establish a water supply over a semi long distance (500m / 1500ft) with basic means. Can this be improved by looking at the use and allocation our resources?

An important item in Charleston was the incident command structure. When a fire is scaled up, multiple commanders come on scene. If the incident involves a big surface area, it becomes very hard to maintain a good overview and to coordinate a good cooperation between the multiple teams. The first and most important way to prevent a situation to go bad is training and practice before. How many hours does average Belgian chief officer train in large incident command. And in this perspective I am not talking about emergency planning, but over the actual job of a chief officer on the incident leading his men.

The fact that there was no PAR-system ("firefighter accountability) for the firefighters working with a SCBA meant that it was not possible to adequately react when these firefighters got into trouble. In Belgium there are some departments that have a PAR-system for their firefighters working with an SCBA. But how many will actually have a RIT team on stand-by? How many departments train for those specific situations when firefighters under SCBA get in trouble? How do we rescue our own? Within the New York Fire Department a Mayday system has been developed and implemented. New battalion chiefs get one week (!) of training on how to manage and cope with a mayday-call. To have a closer look at this would be very interesting. But this will be done in another article.

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