Backdraft

In earlier articles published we had a closer look at fire behavior. We noticed that a fire will behave different if there is a shortage of air. The ventilation profile (open windows, doors, vents, etc…) will determine if a fire becomes under-ventilated or not. Some phenomena will appear because this ventilation profile has changed. This can be the fire department that opens a window. Or that same windows can fail (due to thermal stress) because of the difference in temperature between inside and outside. Even the simple opening of the front door to gain entry, is a change in the ventilation profile. Changing the ventilation profile of an under-ventilated fire will quite often worsen the conditions, on the contrary. A first scenario we will look at is backdraft.

12. Backdraft

12.1 Description of the phenomenon

Backdraft is a phenomenon that killed many firefighters over the years. Ventilation plays a crucial role in these incidents. The precondition for a backdraft is that you need an enclosed fire that filled up a compartment with sufficient fire gasses . Because of the characteristics of the compartment (airtightness, insulation,…) the fire became underventilated. The concentration of fire gasses in the compartment is above the upper flammability level. If in this situation the ventilation profile isn't changed the fire will extinguish by itself.

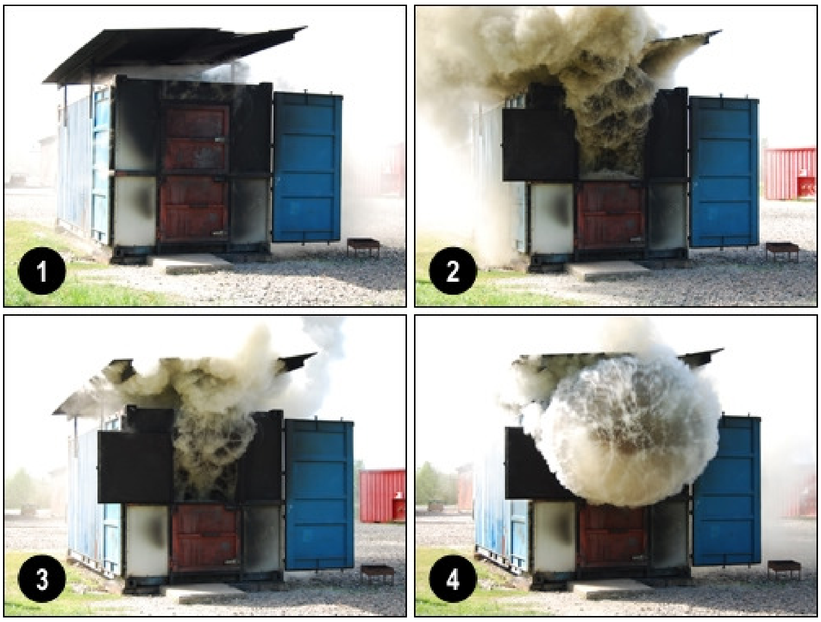

Fig 12.1 The different steps that an underventilated fire goes through until a backdraft. Step 1: The compartment is closed. Step 2 & 3: the door is opened and a bidirectional flow occurs. Step 4: a backdraft takes place. *(Pictures: Ed Hartin)*

But, if in such case the ventilation profile is changed, this will result in a very powerful phenomenon. The fresh air will rush into the volume. This addition of air will result in a mixture between warm fire gasses and cold fresh air. With the added air, the fire gasses will be diluted. The mixture will enter the explosive zone.

At this point there is a good mixture of fuel (the warm fire gasses) and the oxygen (the cold air). The only thing lacking is sufficient energy to trigger the backdraft. The mixture has to be ignited. In the 90's Chitty has done research about the onset of a backdraft and found that it was initiated by the resurging of the base of the fire. It became clear with his research that simple glowing the original base of the fire was insufficient to ignite the mixture of gasses in the compartment. It is only when flames show up that there is enough energy to cause a backdraft.

A backdraft will announce itself by fire gasses rolling out of the window(s). At times this is described as a "cauliflower-cloud". The ignition of these fire gasses happens from the inside. A flame-front runs from inside the structure towards the outside through the fire gasses. This is accompanied by a pressure wave and a very strong rise in temperature (see figure 12.2). The maximal temperature with a backdraft is higher than with a flashover.

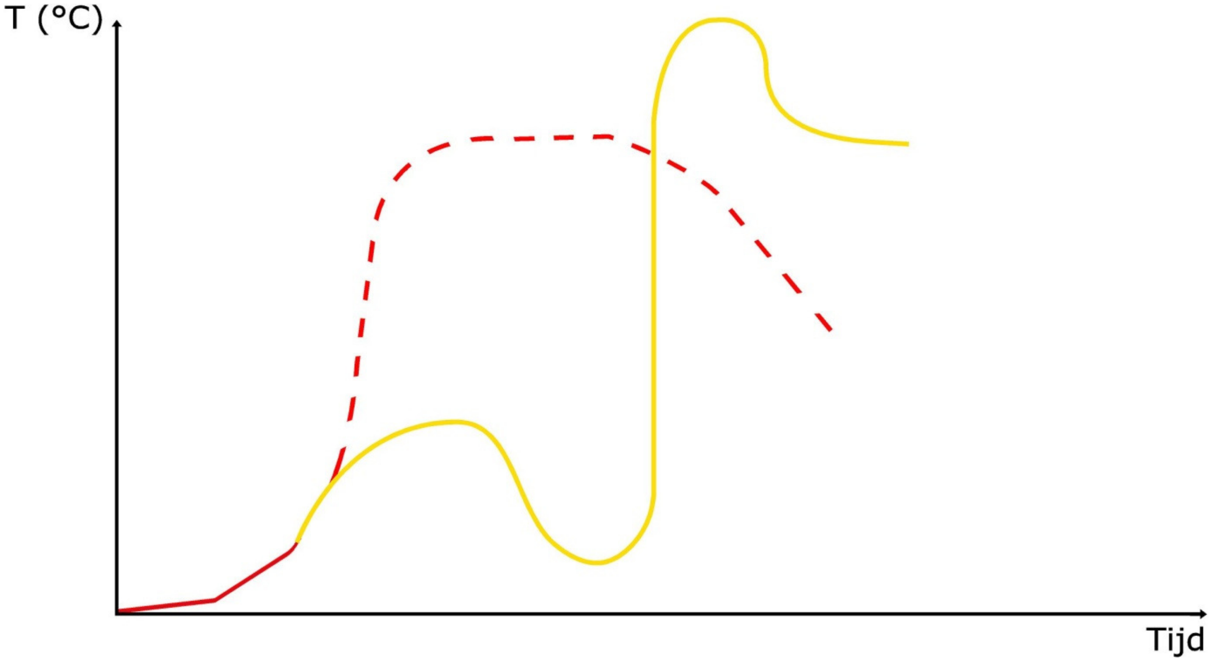

Fig 12.2 Backdraft *(Graphic: Karel Lambert)*

12.2 Warning signals for a backdraft

The challenge for officers on the fireground is to recognize the warning signals for a backdraft (see figure 12.3). There are a few parameters to evaluate the risk for a backdraft. It is the duty of the officers to observe these signs during reconnaissance. Discovering pre-backdraft signs in time can save many lives.

The phenomenon that is most described in the literature are the blackened windows. These are created by the hot fire gasses coming in contact with the cold windows. There, the fire gasses condensate. This mechanism is similar to water vapour that condenses against the cold kitchen window when you are cooking. In reality we can also see other colours of tarnish: brown and brown-yellow. We have to mention that the better insulated the windows are, the less this phenomenon will occur. There are cases described were the windows functioned as big black radiators. Anybody standing in front of this window could feel heat radiating through the glass.

Smoke being pushed through cracks is another warning sign for a backdraft. It is clear that in such case there is a serious overpressure in the compartment behind the crack. A distinction is made between smoke that flows out continuous and a pulsating flow. If the smokes comes from under a door then this means that the complete compartment is over pressurized.

The colour of the smoke can vary from black to brown-yellow. The black smoke indicates an important concentration of combustion gases. While the more brown smoke indicates a higher concentration of pyrolysis gases.

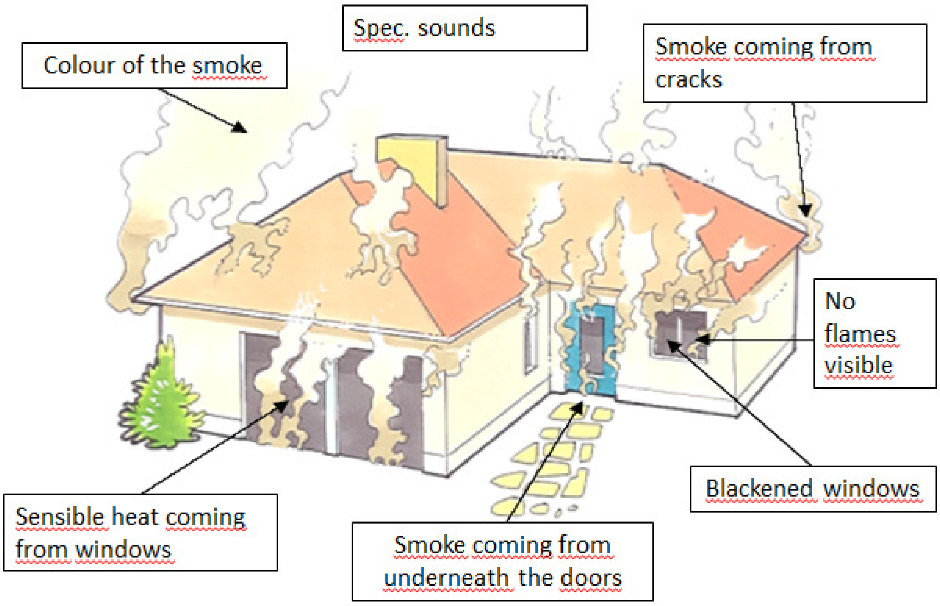

Fig 12.3 warning signals for a backdraft

The absence of flames is also mentioned as a warning sign for a backdraft. However, there is an important remark to make with this. The absence of flames should be interpreted in a cautious way. It is so that when there are no flames in a certain compartment that this is a warning sign for a backdraft. It is not so that the danger for a backdraft isn't there anymore when there are flames in a neighbouring compartment. Both compartments can be completely separated. In the first compartment you can have a pre-backdraft situation, while in the second compartment you have a fire in developing phase because of the window that was left open.

Another option is the ignition of the fire gases immediately when they exit the compartment. In both cases flames will be visible, but you should not conclude that the danger for backdraft is not present.

12.3 How can we avoid a backdraft?

Dealing with a pre-backdraft situation is a problem where fire departments don't have a uniform answer for. In the past several techniques have been applied that showed to be successful. The difficulty is to choose the right tactic at the right moment.

Until now the books said to ventilate a fire in case of a pre-backdraft situation. Meaning: create a ventilation hole as high as possible in the compartment. By doing this hot fire gases can escape. The overpressure will decrease and the smoke layer will rise so that down below in the compartment a layer of cooler air gets installed. Because we don't make a lower opening, hardly any fresh air can enter the compartment. In theory there will be no mixture because there is no constant airflow towards the ventilation hole high up. By ventilating away the fire gases we are decreasing the concentration of gaseous fuel needed for a backdraft. This tactic can result in fire gases igniting when they exit the construction. This ignition can create a second fire outside of the first compartment. Therefore the rule is to have a charged line ready at the ventilation hole. The firefighters handling this line should understand that under no circumstances they should aim water inside. Their task is to cool down the exiting fire gases if they are too hot.

A second problem that could be encountered with this tactic is creating the ventilation hole. With high complex buildings it is quite often impossible to create a high ventilation hole. For these buildings we need alternative techniques.

One alternative technique is to inject a water fog of small water droplets into the compartment. There are documented cases in the past where there was a pre-backdraft situation and a small opening into the compartment. That opening would be a window that was broken or a water drainage that had melted away. The opening was too small to provide sufficient fresh air for the smouldering fire. But it was big enough to have access with a nozzle. If this happens, it is possible to cool down the fire gases inside with 3-D pulsing technique to the level where a backdraft becomes impossible. With the 3D technique we will have a double effect: an inertisation of the atmosphere inside and controlling the base of the fire by smothered it with the steam.

In most cases there won't be an opening available to insert a nozzle. Then you need to create an opening. With a closed compartment this is not that easy. In Sweden a special tool has been developed as a solution for this problem: the Cobra Cold Cutting Extinguisher. The Cobra is a device that works with very high pressurer. A pump supplies the water at about 300 bar to a special nozzle-gun. In the pump small metal particles can be added to the water.

Fig 12.4 The Cobra in action on a training site. The fire gases are rendered completely inert and are cooled. *(Picture by: Willem Nater)*

The combination of water under high pressure and the metal particles gives this stream a high cutting ability. It is possible to puncture a burglar-proof door, a concrete wall or a steel beam with this stream. Once the water-metal mixture has punctured the construction element the supply of the metal particles is stopped. The water is not stopped and will result in an indirect extinguishing of the fire. Because of the limited flow (about 60 l/min) the extinguishing capability of one Cobra is limited. But in Sweden there are documented cases were up to six Cobra's were deployed on one fireground. Most of the times this is combined with the use of many PPV fans to put the connecting compartments in overpressure. By doing so, the leaking of hot fire gases is avoided and so is the propagation of the fire.

A last methode used to avoid a backdraft is a modified door entry procedure. With a normal door entry procedure the door is opened about 20 cm. Then 3 short pulses are given inside through the door opening. In case of a pre-backdraft situation the door will be opened a bit more so that it becomes possible to use a flow of 400 to 500 l/min. The spray angle is adjusted to about 30° en a circular movement is made. After this the door is closed. This way the door was opened for a short time. Off course air went inside. But with the diffused stream air is flowing less deep into the structure then with a full stream. There will be less turbulence and the chances on a backdraft are smaller than with a full stream. Besides air there are also several tens of liters of water are injected into the compartment. This amount of water has to secure the cooling of the fire gases. The higher flow rate also offers a better protection for the crew attacking the fire if needed. If there is no backdraft after the first cycle this can be repeated until all danger is avoided.

12.4 Sources

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