

## What to do in case of a fire?

In the past 10 years, many changes were made in how we fight fires. A very large amount of both knowledge and insight in fire behavior has been gained. The fire service is better aware of the problems it may face during firefighting. And there are much more problems now than in the past. New ways of construction have led to under ventilated fires. Firefighting has become more versatile. Fire behavior has changed immensely.

The upside is that a lot of solutions have been thought up which can be used to tackle these new problems. However, many firefighters nowadays will not see the wood for the trees. This article aims to outline several different situations along with possible solutions.

### 1 Critical task analysis

The reform of the Belgian fire service has instigated the debate on how many firefighters should man an engine. A crew of six was to become the standard. However, more and more people are advocating 4 man crews in rural areas. In those areas, there sometimes aren't 6 firefighters available on call. Implementing career firefighters is not an option due to small number of fire calls.



**Figure 1** An engine with a six man crew consists of a company officer, a driver and 2 firefighter duos. This allows for two tasks to be performed simultaneously. (Photo: Patrick Verhaeghe)

estimated time of arrival of backup crews, ...

An engine with a six man crew will be able to do more than an engine manned by four. This does not mean however that a crew of four can't do anything at all. And likewise, this doesn't mean that a six man crew will be able to do everything.

In both cases the company officer will need to assess the situation. This is called a critical task analysis. Which tasks need to be performed first? He will need to take into account the size of the fire, the type of building in which the fire's burning, the number of people he has available to him, the training and experience of his crew, his own knowledge and abilities, the

While taking into account all these elements, he will have to prioritize the tasks at hand. Next he will assign these tasks to his crew members. If an engine is manned by four, only one task will be done at a time. The city center of Madrid has eight firefighters on an engine. This crew will be able to perform three tasks at the same time. It's assumed here that there are both an engine driver-pump operator and a company officer. Subsequently, duos or pairs can be formed. Each pair can perform a task.

Numerous countries are currently testing different vehicle crews. In the Netherlands this is called "variable vehicle staffing". Vehicles can be staffed with 2, 4 or 6 firefighters. In Sweden as well, there are certain areas where there are 2 man crews on an appliance. It

goes without saying that a two man crew will operate differently from a six man crew. Especially the engine's company officer has an important role to fulfill. He needs to choose carefully and judiciously which task can be performed and which others have to wait until backup arrives. Quality training and education are therefore indispensable. As long as there's only one crew on scene, the engine's lieutenant will be the one making choices. When a battalion chief arrives, then this officer will start calling the plays. He'll be the one assigning tasks. This is preferably done in consultation with the company officers on the engines.

When fighting fires in residential buildings, fire attack will almost always be the most critical task at hand. After the fire's been tackled (or right after crews have been deployed that will perform a fire attack), efforts will be directed to search and rescue.

Depending on the situation, water supply lines will have to be put in place. It's up to the commanding officer to judge whether setting up water supply is more urgent than rescuing possible victims. The same goes for ventilation. This is also one of the tasks that will have to be performed at some point. During firefighting operations, the IC needs to check for fire spread into any exposures. The "cube idea" can help visualize the possible fire spread. Sometimes, checking for fire spread will take a lot of time. It is therefore possible that one or more crews are assigned to that task.

In the sections above a sequence is listed that will yield the best result most of the time. However, "most of the time" is not the same as "always". Again, it is up to the commanding officers to make choices.

The remainder of this article describes three different fire ground scenarios, the different tasks at hand and the ideal order in which to perform them. The reader of the article needs to keep in mind that these are fires in relatively small compartments: houses, offices, hospital rooms, retirement homes, hotel rooms, ... Larger buildings such as malls and factory halls require a different approach.

## **2 The ventilated fire behavior**

### **2.1 The fully developed fire with flames exiting out of the compartment (with rescue)**

A fully developed fire is characterized by flames exiting from the compartment. It's a specific type of fire which the fire service has been facing for decades. In the past, this fire was usually handled by deploying numerous hose streams. The water was directed in solid jet streams through openings. Most of the time, thousands and thousands of liters of water were being used to extinguish the fire. Because of this there often was more water damage than there was fire damage. Thanks to the implementation of breathing apparatuses in the 80's, firefighters were able to attack fires from the interior. This method was a lot more successful. After all, a fire can only be extinguished by putting water on the seat of the fire. This isn't so easily achieved when aiming a solid stream from 20 meters outside through a window.



**Figure 2** Fully developed fire in Ghent.

The interior attack proved to be a better way. In the beginning, solid jets were primarily being used. In the early 2000's, gas cooling started being used to advance towards the fire. Ten years later, techniques such as the "massive attack" came into play. These led to a faster knockdown of the fire.

During the past 60 years however, a significant change has occurred in fire behavior. Fire development has become a lot faster. In the 50's, fire development up to flashover took 30

minutes (providing there were enough ventilation openings). In the 70's that time frame shrunk to 17 minutes. Nowadays the time until flashover is only 2 to 4 minutes. This severely impacts the way the fire service operates on the fire ground. The interior attack has become a lot more dangerous because of the faster fire progress. An interior attack that was considered safe in the 90's, is not safe any longer in the present.

In the US, a tactic called "transitional attack" was thought up to counter the quickly developing fires of today. A transitional attack is made up of an exterior attack combined with an interior attack. First the fire is knocked down by a brief exterior attack. On the ground level this can be done by using a fog pattern. Up on higher floors, a solid jet will have to be used. That jet is typically aimed up against the ceiling. Ideally a high flow rate ( $>400 \text{ lpm}$ ) is used. One quick way to perform an exterior attack is by using a Ø 45 or Ø 70 mm line hooked up directly to the engine.

Such an exterior attack lasts 10 to 15 seconds. It's therefore completely different from the exterior attacks of back in the days where water was being flowed in from the outside for 30 to 60 minutes. The goal is to quickly knock the fire down. The fire is being brought back to the growth stage and will need time to regain its power. During this time, the fire will be unable to spread. Fire crews can utilize that time to execute an offensive interior attack in safer conditions.

After the fire's been knocked down, the tactic transitions to a classic interior attack. The goal is then to extinguish the fire. As soon as the fire's been completely taken care of, a search and rescue can be started. Because the fire's been brought under control, the risks for both victims and firefighters are drastically reduced.

### 2.1.1 *Ideal sequence*

The ideal sequence to approach such a fire scenario is summed up below:

- 1) Size up
- 2) Exterior attack: 10 to 15 seconds
- 3) Interior attack

- 4) Search & Rescue: primary and secondary
- 5) Water supply  
Ventilation  
Check for fire spread
- 6) Overhaul

The battalion chief commanding the incident will choose to have certain tasks carried out by one or more crews. He can also opt to have several tasks handled at the same time. Whether or not a ladder truck is on scene can influence his decision. A ladder crew can save possible victims at windows or balconies very quickly. They can also do a preliminary check for fire spread by inspecting the windows. This specific remark on ladder trucks also applies for the other type of fires listed below.

## 2.2 Fire in the growth stage

The size of a fire in growth stage is limited. Typically the seat of the fire is one single location. This fire is producing hot smoke. The radiant heat coming from both the flames and the smoke will eventually cause fire spread.

In the past it was taught: "Rescue first, then extinguish!" In the context of the 50's this was a logical choice. After all there was more than enough time to perform search and rescue. On arrival, fire crews typically faced a lot less smoke than nowadays. It was easier to find victims. Because fire progress has changed, it's now no longer possible to – safely – search for victims first. That's why the creed is now : "Put the fire out first!"

The goal of our actions is still the same: saving human lives is of the highest priority. The way we achieve that goal has changed however. Before, doing a search and rescue first offered the biggest chance of success. Now, putting the fire out first offers the highest success rate.

After one -or more- fire attack crews have been sent in, it's best to assign the next crews to perform search and rescue. Ideally both a primary and a secondary search are performed. This means that each and every room will be searched twice and by different crews as well. People make mistakes and it's not impossible for a victim to be overlooked by a search crew. Searching the room for a second time reduces the odds of not finding the victim.

A fire in growth stage will need only a small amount of water to extinguish. Most likely this can be done using the engine's own water tank. Laying out water supply lines therefore has a lower priority. At such a fire it's wise to set up ventilation as soon as the fire's been put out. This will help remove smoke, which in turn helps crews doing overhaul. Aside from that, it increases survivability of any potential victims that haven't been found yet.

Belgian fire crews will usually assign search and rescue a second highest priority. Often the search for victims will commence while extinguishment is still being performed. But because the fire is not yet fully under control, ventilation will be held off. Positive

pressure ventilation may fan the fire. Ventilation can only be started after the fire's been brought completely under control.

### 2.2.1 Ideal sequence

The ideal sequence to approach such a fire is listed below:

- 1) Size up
- 2) Interior attack
- 3) Search & Rescue: primary and secondary
- 4) Water supply  
Ventilation  
Check for fire spread
- 5) Overhaul

The risk for fire spread is likely less for a fire in growth stage. A lot depends on the type of building though. In buildings that have fire resistant compartments, a fire in growth stage will only rarely cause fire spread. Checking for fire extension can thus be put lower on the priority list.

## 3 The under ventilated fire behavior

At an under ventilated fire, fire crews are facing the effects of new building methods on the fire behavior. The introduction of double pane windows led to fires becoming ventilation limited during the growth stage. The fire is being paused due to lack of ventilation. The room in which the fire's burning is filling up with smoke. This will also happen in any other room that has an open connection to the fire room. Smoke buildup will kill any victims still in these rooms. It is highly likely that the fire service won't be able to save anyone from rooms that have been completely filled up with smoke. The only way victims will be able to leave these rooms is by having active smoke alarms.



**Figure 3** Under ventilated fire. (© Photo: Zbigniew Wozniak)

Studies performed by UL and IFV prove that occupants can survive (for a long time) if they are behind a closed door. In case of a kitchen or living room fire, occupants will be able to survive for 20 to 30 minutes in their bedroom if the bedroom door is closed. So even though there's a large amount of smoke, the fire service will still be able to perform rescues.

The nature of the fire requires that these rescues are done in a sensible way. The above sections explained already that fires develop much faster these days. It takes 2 to 4 minutes for a fire to progress into flashover. At an under ventilated fire, that progress is halted by a lack of oxygen. As soon as the door leading into the room is opened, fresh air will rush in. The fire will resume its development. If no counter measures are taken, ventilation induced flashover might occur two minutes after the door has been opened. To prevent this from happening, fire crews can implement door control or set up a smoke stopper. Currently there's a research project ongoing at UL on the use of positive pressure ventilation at under ventilated fires. The end report of this project is expected early 2016. Undoubtedly, this will lead to more insight in the use of fans at under ventilated fires.

An alternate way of dealing with these fires is the use of piercing nozzles or cobra cutting extinguishers. These appliances can flow water into a compartment without entraining air inwards. That way the environment inside is both made inert and being cooled, before an opening is created. This will cause the fire to react less quickly when the door is opened.

### 3.1 Ideal sequence

At under ventilated fires there are two possible ways to approach the fire which both yield a reasonable chance of success: The classic approach where an interior attack is combined with anti-ventilation and the modern approach in which an exterior attack is done first to improve the inside environment from the outside. The latter approach is called an "offensive exterior attack" in the Netherlands.

#### Classic approach

- 1) Size up
- 2) Anti-ventilation
- 3) Interior attack
- 4) Search & Rescue
- 5) Ventilation  
Water suply  
Check for fire extension
- 6) Overhaul

#### Modern approach

- 1) Size up
- 2) Exterior attack with piercing nozzle/cobra
- 3) Interior attack
- 4) Search & Rescue
- 5) Ventilation  
Water suply  
Check for fire extension
- 6) Overhaul

Experience on the fire scene is limited when it comes to dealing with under ventilated fires. It's therefore advisable to act prudently at such fires. In the coming years, the fire service will face these type of fires more and more. This will lead to increased knowledge on successful tactics for these kind of fires.

To be continued ...

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