BE-SAHF a.k.a. the art of reading fire

1 Introduction

Firefighters have been battling fires for over 200 years. During this long period, people have tried to refine to method used for fighting fires. One of the tools that has been thought up, is *reading* the fire.

After all, a fire is nothing more than an out of control chemical process in a certain environment. Fire is not a living creature that's aware of its surroundings. It doesn't choose between several different options. Fire is bound by the laws of physics and chemistry. The interaction with the surroundings is determined by many different factors, but each of those factors can be described in a scientific way. When everything is put together, the end result becomes incredibly complex.

Nowadays there are computer programs that can calculate fire behavior. Most of the time, a lot of simplifications are used in those calculations. This is the only way to limit the processing time. Also, numerous high end computers running for one or two weeks, are needed to determine what happens to the fire in a 10 minute time frame. It's therefor possible to look at fire in a scientific way, but it demands an enormous amount of computer power. In other words, fire is predictable.

People do not possess the large amount of calculative possibilities as opposed to computers. Still it's possible to observe a fire and draw certain conclusions from that which can be seen. Often it's possible to make predictions on the fire's behavior. Mind you: it says *often*, not *always.* Reading a fire is part science, and part art. This is because on the fire ground, a lot of information is not readily available that would otherwise be needed for a computer to make its prediction. Assessments made by reading the fire are always based on incomplete information. In other words: predictability of a fire on the fire ground, is limited.

Experienced firefighters will be better at reading the fire. Firemen which both train regularly at reading the fire and actively try to apply it on the fire ground, can become very proficient at it. This is where making decisions under time pressure comes into play. Scientists have long since known that decisions on the fire ground are made by comparing the assessment of the current fire to those of previous fires. This is called *recognition-primed decision making*.

1.1 History

Shan Raffel is an Australian fireman. He's been active in Brisbane, a city with 2,5 million inhabitants, since 1983. Currently he is a *station officer*, a rank which is similar to our captain. In the early 2000's, he was the first to come up with a model to read fire. He christened his model SAHF, an acronym which stands for Smoke, Air track, Heat and Flames. In the Netherlands, the model was introduced by Edward Huizer. Through the Dutch fire service, the model found its way into Belgium in the mid 2000's.

Figure 1 Shan Raffel during IFIW 2014 *(Photo: Karel Lambert)*

Shan Raffel is part of the international network of IFIW (International Fire Instructor's Workshop). Scientists and experts from all over the world use IFIW as a platform to share knowledge on fire behavior and firefighting. Here, the SAHF model received feedback from several international experts.

It quickly became clear that there was disagreement on certain signs described by Raffel. The blistering of paint, cracking of glass windows, … were subject of discussion. Stefan Svensson of Sweden indicated that he had never experienced these phenomena. Shan Raffel however, witnessed these signs at every fire in Australia that reached the growth/development stage.

American fire chief Ed Hartin offered the solution to this problem. He added the letter B (for Building) as a prefix to the acronym. Ed Hartin stated that SAHF indicators should not be assessed separately from the building in which the fire's raging. The building is the context in which the other indicators should be viewed. In 2008, Shan Raffel updated his model to B-SAHF. Under the influence of Karel Lambert, a Dutch acronym G-RSTV was created. The chapter written by Siemco Baaij in the book *Brandverloop* led to spread of this term in the fire service.

Figure 2 Ed Hartin proposed adding the B to the SAHF model. *(Photo: Karel Lambert)*

Around 2009, the phenomenon of *Wind Driven Fire* was discovered in North America. Research showed that a fire can behave radically different under the influence of a strong wind. It took some years before the gravity of this problem was adequately acknowledged. Many firefighters lost their lives at such a fire. Most of the time, these accidents occurred on the upper levels of tall buildings, which led to the belief that a wind driven fire was something that could only happen when fighting high rise fires. One particular fire which caused the death of a young fireman on the ground floor of a normal house, dispelled that illusion.

Peter McBride from Canada proposed to update the model a second time. Specifically, he suggested to add the letter E after the B in "B-SAHF". This letter stands for Environment. The idea is to isolate wind from the Air track and pay extra attention to it. After all, wind can have a disastrous effect on a fire. Shan Raffel decided to alter his model to BE-SAHF in 2014.

1.2 Goals

Firefighters that use the model have a specific goal: they want to get an idea of how the fire is going to progress in the next minutes. This can be achieved by combining the BE-SAHF model with an assessment of the burning regime and the ventilation profile of the fire. By looking at these three elements together, insight in both the current and potential future fire behavior can be obtained. It cannot be emphasized enough that this is only an estimation. It can always happen that important elements can't be perceived by firefighters and therefor, the wrong conclusions could be drawn.

Figure 3 Canadian Peter McBride has also influenced the development of the BE-SAHF model. *(Photo: Karel Lambert)*

Both the BE-SAHF model as well as the models of the *ventilated* and *under ventilated fire* are designed to help fight compartment fires. The model for reading fire is primarily suited for fires in buildings with smaller compartments. For larger compartments, like open office landscapes and industrial buildings, these models are less suited. It's important that an officer keeps that in mind when starting operations inside larger compartments.

When applying the BE-SAHF model, several questions will be asked:

1.2.1 What kind of fire development are we dealing with?

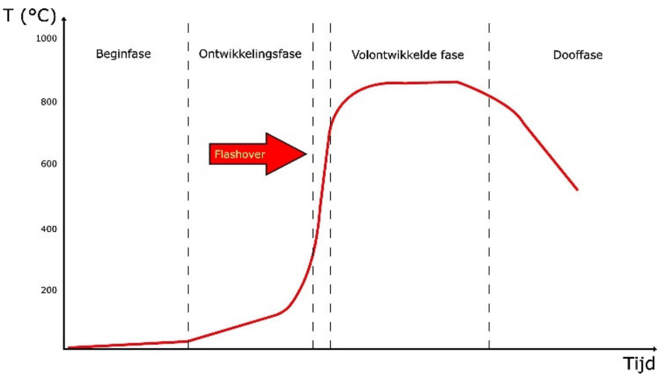

Figure 4 The ventilated fire progress. *(Figure: Karel Lambert)*

Books on fire behavior explain two kinds of fire behavior. When a fire has sufficient ventilation, then the fire will progress to flashover. After flashover has occurred, firefighters are faced with a fully developed fire. This is characterized by flames exiting through windows and other openings. This type of fire development is called the *ventilated fire*. The fire has access to enough ventilation to reach flashover.

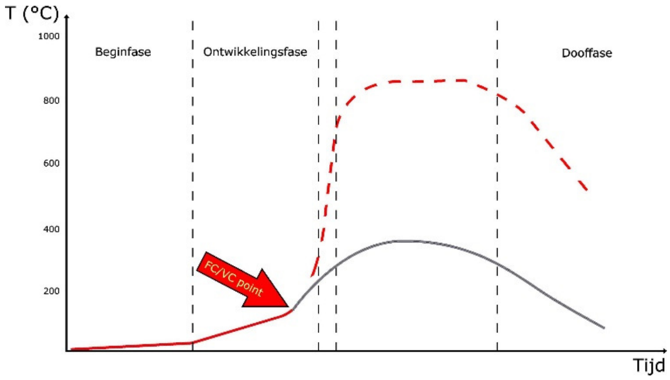

Figure 5 The under ventilated fire is formed by the red line followed by the grey line. *(Figure: Karel Lambert)*

The second kind of fire development typically will not have any open doors or windows. The fire only has access to the oxygen that is in the room. A room that remains closed, will cause the fire to burn with a shortage of oxygen. The fire will become ventilation controlled before flashover can occur. It will pass the FC/VC point (Fuel Controlled/Ventilation Controlled). Firefighters are faced with a building filled with smoke. Very few flames are visible and smoke is coming out through cracks. This type of fire development is called *under ventilated fire*. The fire does not have enough ventilation to progress into flashover.

Both kinds of fire development can be identified by certain visible signs. Both kinds are related to certain risks on the fire ground. And both kinds have different tactics to tackle the fire. The choice for a specific tactic will be determined by how far the fire has already progressed (see below).

All models are wrong but some are useful – Ed Hartin

It needs to be noted that the *ventilated fire* and the *under ventilated fire* are only models of reality. This means they're not 100% accurate. Still they are useful on the fire ground. This is what Ed Hartin means in the quote above. The two models cover most of the fires. It's important to realize though, that these models are less useful for describing fires in very large volumes. For instance, in industrial buildings.

Another kind of fire that differs significantly from those described above, is the so called *construction fire.* In this type of fire, the construction itself is burning. An example hereof is an insulation fire in a hidden space. The fire behavior of such fires is very different from the two classic models. This also means the tactical approach for these fires differs. It's important that officers recognize this and choose a correct approach.

1.2.2 What is the current burning regime of the fire?

The fire's development can be fuel controlled or ventilation controlled. This can often easily be determined just by looking at the fire. It needs to be said that a fire can develop in multiple rooms. It may happen that a fire started in the kitchen and has spread into the living room. This may then mean that the fire in the kitchen has become ventilation controlled while the fire in the living room is still fuel controlled. It could also happen that we're dealing with two fires in two separate rooms not connected to each other (e.g. arson). In that case the two fires can progress independently from one another.

When facing a fire in a fuel controlled burning regime, one must consider the possibility of flashover occurring (if the fire's not in final decay). When, on the other hand, the fire is ventilation controlled, one must look at the type of fire development and the ventilation profile. An assessment can only be made based on these two pieces of information.

1.2.3 Which stage is the fire currently in? (Where are we on the fire development curve?)

After the both the fire development (ventilated or under ventilated) and the burning regime (fuel controlled or ventilation controlled) have been identified, the stage of fire development can be determined. How far has the fire progressed? Which specific risks have come and gone and which risks are still present? What kind of risks can we expect in the near future?

By evaluating different indicators in relation to their context, a trained firefighter will be able to size up the kind of fire he or she is facing.

1.2.4 Where is the fire?

The next question that needs to be answered, is that pertaining the location of the fire. It's often possible, based on the indicators, to assess where the seat of the fire is or where it isn't.

1.2.5 What will happen next?

The following information has been gathered:

- The type of fire development
- The burning regime
- The current stage of fire development

The ventilation profile, and any possible changes to that profile, may also have a large impact on the fire.

Using the information described above, a well-trained (company) officer will be able to make a good assessment of how the fire is going to progress. The goal for him will be to use that assessment for:

1. Estimating risks
2. Determining tactical goals
3. If needed, request additional units and call for a higher alarm level

When firefighters do nothing, the fire will naturally progress. The development of the fire has been set from the beginning. In other words, fire doesn't "choose" to develop in a particular way.

However, the goal of the fire service is to take control of the fire, rescue any possible victims and save property. Fire crews can perform many different tasks and actions in order to achieve these goals. The BE-SAHF model can also be used to assess how the fire development will change as a result of actions undertaken by firefighters. These changes in fire development can be positive as well as negative. Again, in both cases, a well-trained (company) officer can use the BE-SAHF model to make an assessment of the situation.

1.2.6 An example

Firefighters arrive at a fully developed fire on the ground floor of normal house.

The lieutenant of the first engine on scene determines he's dealing with a ventilated fire (1). Next he realizes it's a ventilation controlled fire (2) and that the fire is in the fully developed stage. He sees that the windows of the room are completely open. He can't see the back of the room, but he can see that there is a risk for the fire spreading sideways. A second flashover in the hallway is very much a possibility.

The lieutenant knows he needs to act swiftly. The rooms to the left of the hallway will quickly become involved by the fire. As long as the fire can be kept inside the room in which it began, chances of survival for any possible victims upstairs are reasonably fair. This will depend on the type of floor that's separating the two levels.

He orders his crew to stretch two lines of Ø 45 mm. He realizes that the fire can be quickly knocked down using an indirect attack with full flowrate from both attack lines. After taking control of the fire, a crew can enter safely to perform a search & rescue operation. The officer sees there are several rooms to the left of the hallway. He will order these rooms searched first. Next, he will have a crew search the rooms on the upper floor.

Figure 6 Fully developed fire venting from the ground floor windows of a house. *(Photo: Nico Speleers)*

Deploying or stretching a supply line is not as high a priority as the tasks above. After all, by reading the fire properly, he can assess that the fire can be brought under control using the engine's own water supply.

1.3 Method of operation (MO)

1.3.1 The context

When applying the BE-SAHF model, a specific MO is used. First, the framework in which the fire takes place is established. The context, in relation to which all other parameters have to be viewed, is the building. Most of the time, a lot of information about the building can be perceived from the outside. It goes without saying that a fire in a hospital is vastly different from a fire in a single family home.

Along with the building, the environment is reviewed. The most important factor to take into account is wind. Other aspects of the weather could also play a part on the fire ground. An example hereof is freezing cold. Subzero temperatures will impact a fire intervention substantially on a logistical level.

The four fire indicators have to be evaluated in relation to the context. The sequential order of the indicators matters here. Smoke is an indicator that reveals a lot of information on the type of fire that is raging. The same goes for Air track. Heat and Flames both tell us less about the fire behavior.

1.3.2 Who uses BE-SAHF?

Reviewing the indicators can be done from the outside, as well as from the inside. The chief officer (or engine driver) on the outside will look at different things as opposed to crews or company officers working the inside of the building. All of them have to be aware of the fact that they may be seeing signs that someone else can't. If necessary, important information has to relayed by radio.

Consider the example in which an interior attack is taking place. The crew reports having located the seat of the fire and is starting extinguishment. On the outside however, smoke indicators are changing rapidly. The amount of smoke increases, the color is becoming darker and the speed at which it is exiting the building is rising. In such a case, the chief officer should probably order a tactical withdrawal of the interior crew, because there is a stark contrast between what is being observed on the inside as opposed to signs on the outside. As long as that contradiction in signs can't be explained, there's a heightened risk for fire crews.

1.3.3 Points of interest

The four fire indicators have to be viewed together. Any one indicator should never be analyzed on its own. This may produce an incorrect image of the fire ground. By looking at the four indicators at the same time, a lot of information can be gathered. This information will allow for a good assessment to be made of the situation.

The process of evaluating the indicators should be dynamic in nature. Looking at the indicators over a certain time period is more important than a "snapshot photo" made on arrival. Firefighters on the outside will have to watch different signs than those working the inside.

A fine example of this is a fire in a single family dwelling of which the front door is open. Upon arrival of the fire service, wispy grey smoke comes drifting out. The company officer quickly takes a look inside for his size up while his crew is preparing a coiled attack line. After the officer has returned and the crew has finished preparations, they take another look at the front of the house. The image has changed. More smoke is now coming out of the house. The smoke is darker and is flowing faster than before. The crew start their interior attack. The engine operator however, sees a continuing increase of exiting smoke. The smoke color keeps darkening and the smoke's becoming more and more turbulent.

The example above clearly illustrates that changes of the fire indicators over time are a much more valuable source of information than the single snapshot image seen by crews upon arrival. It's therefor important for firefighters to continuously check the different fire indicators for changes and also to take notice whether these changes are positive or negative.

Applying the BE-SAHF model on the fire ground demands some training. After all, a lot of things have to be taken into account all at once. Often there isn't time to go over each and every step. Fire is a dynamic situation in which things are changing almost constantly. Fortunately, it's possible to train for this. One good way of going about this, is watching videos of fires on YouTube. During the video, the BE-SAHF model can be applied and trained. Ed Hartin's website, www.cfbt-us.com, offers about 15 illustrated examples of such videos.

With sufficient practice, using the BE-SAHF model will become an automatic reflex. Upon arrival, all of the parameters will be processed almost subconsciously. Edward Huizer refers to this as the *SAHF-scan.* A lot of practice will lead to a faster analysis of the situation.

2 Bibliography

[1] *Reading the fire, Shan Raffel, 2001*

[2] *CFBT-instructor course Level 2 for the T-cell, John McDonough & Karel Lambert, 2012-2015*

[3] *www.cfbt-us.com, Ed Hartin*

[4] *www.cfbt-au.com, Shan Raffel*

[5] *Personal communication, Shan Raffel, 2009-2016*

[6] *Personal communication, Ed Hartin, 2010-2016*

[7] *Personal communication, John McDonough, 2009-2016*

[8] *Personal communication, Peter McBride, 2009-2016*

[9] *Fire dynamics: Technical approach, tactical application, Karel Lambert & Siemco Baaij, 2015*