Live fire training: benefits and risks

1 Introduction

July 30th of 2002 was to become a special day for the fire service of Osceola (Florida). A so called "acquired structure burn" was performed under great public interest. This basically means that a house is set on fire in order to conduct firefighter training inside. The training was started, a fire was lit and firefighters started to work towards different training goals. The day ended in tragedy however for two firemen who lost their lives during the exercise. From 2000 till 2007, at least seven firefighters died in the US in live fire training gone wrong. An even higher number has gotten severely injured. In Belgium, live fire training has also been introduced to fire services (inside as well as outside of the fire training schools). And in Belgium, something also goes wrong on occasion. Luckily there haven't been any serious injuries so far. This recent evolution is the reason for the following article: benefits and risks of live fire training.

2 History

Fire is evolving. This has been known by many people in the fire service for quite some time now. In the 90's several fire services ran exercises with steel baskets containing wood which simulated a fire. Most of the time old training buildings were used that were located on the station grounds of the fire service. In Belgium the fire school of Antwerp, called PIBA at that time, was the first to offer realistic training for firemen. By doing so, the academy now named VESTA, took a leading role in fire training. A lot of firefighters went to train for an entire day and had their eyes opened.

Partially because of the efforts of VESTA, the federal government of Belgium invested heavily into such training courses for the second half of the 2000's. This prompted other schools to take action as well. The fire school of Jurbise (Hainaut) started its own program. That school was then followed by Brussels, PIVO (Vlaams-Brabant), Liège, PLOT (Limburg), PBO (Oost-Vlaanderen) and WOBRA (West-Vlaanderen). This evolution made for a solid base to reform the basic firefighter training course in Belgium.

In 2009 everyone agreed that it was unacceptable for a firefighter trainee not to have realistic training involving live fire. More than once the analogy was made of a written instructional course on how to swim. As of 2010, three CFBT-exercises have become mandatory in the basic firefighter course. CFBT means "Compartment Fire Behavior Training". Because of this, our new firefighters have a better understanding of fire and interior firefighting.

3 Benefits of live fire training

3.1 Setups using one container.

Our fire schools usually run fire exercises in containers. There are different kinds of containers that are commonly used: the demo-cell, the attack-cell, the window-cell and the backdraft-cell. Aside from this, "warm" exercises are also conducted in training structures but here temperatures are a lot lower than in containers. Training structures often aren't equipped to handle the high temperatures produced by realistic fire conditions.

Trainees can study the fire progress in these containers. Most of the time, the fire is started with the trainees inside the container. The instructor can then comment the fire progress. This allows trainees to experience the fire behavior. For many trainees these experiences are richer and more tangible than the sometimes stale and difficult theory they get in a classroom. Some of the trainees get motivated to study harder. After all they want to understand what's happening. By closely watching the fire from inside a container, they become stimulated. They form links to the theory and build a frame of reference that they'll be able to use in real life firefighting.

Figure 1 Trainees working an attack cell. *(Photo: John McDonough)*

Another benefit of wood based fire exercises is that the produced smoke gas more or less behaves as it would in a real fire. Trainees can see for themselves whether or not their nozzle techniques are effective. Instructors are able to fully demonstrate the possibilities of a nozzle. One has to look at the motivational side of this as well. Young football players often have to practice endlessly with a football to develop ball control skills. Likewise firefighters should practice sufficiently to obtain an adequate control of the nozzle. The benefit of these smoke gases is that they offer the trainee both safe and realistic training conditions.

A final benefit of using a shipping container as a training environment is the possibility to create and study under ventilated fires. Both the backdraft- and window-cell are two examples of containers specifically set up to achieve this. In the backdraft-cell (of which the name is rather poorly chosen) it is possible to show fire gas ignitions (FGI) to the trainees. By experiencing a smoke explosion, trainees will truly understand why they need to cool smoke before opening up a door. This sort of exercise is very valuable for getting people to think about their own personal safety. It is extremely important because at a real life fire, there are no instructors to help and correct if things become difficult. The safety of interior firefighting is based upon an attack crew using their minds.

3.1.1 Multi-container setups

After having worked for several years with single containers, Vesta took the first step towards multi-container setups. An example that was followed by the colleagues of Liège and later other fire schools as well.

Such configurations allow training on a tactical level as well. The level of realism increases once again. It's clear that we, as an educational community, still need to grow and progress ourselves in the use of such training facilities. Now fire schools have the possibility to offer training exercises that come very close to a real life fire ground. Small teams can be deployed in exercises in which commanding officers can train their tactics while firefighters can hone their basic skills. Contrary to other forms of training, these exercises are now done in a dynamic environment in which there's interaction between the fire and the actions of the trainees.

Figure 2 Exercise in the T-Cell at PIVO. *(Photo: Karel Lambert)*

There's also the added benefit for commanding officers that they can now practice skills such as exterior size up and decision making under time pressure. The fact that the realism is increasing is a large plus.

3.1.2 Acquired structure burns?

In the US it is custom for housing that will demolished, to be offered to the fire service for training first. A training scenario is created for the house. One room is equipped with a fuel load. The fuel is set on fire and the exercise is run. It goes without saying that the level of realism is even greater in this case. It's possible to use a very realistic fuel load. At this point, there actually isn't a difference any more between training and real life interior firefighting.

Figure 3 Acquired structure burn in Oostkamp. *(Photo: Siemco Baaij)*

I personally feel we have to be very careful when using this kind of training. The "sorcerer's apprentice" scenario should not be underestimated. Leading such exercises is not for everyone. A few years ago I was a invited to attend an exercise in Wallonia that went wrong. Luckily the training was being conducted by several competent instructors who quickly realized they had misjudged the situation. The order to evacuate the building was given, the exercise was halted and an exterior fire attack was started. In the end, it was the group of instructors that had learned the most that day.

4 What went wrong in Osceola?

4.1 Summary of the burn

The training in Osceola had been thoroughly planned in advance. Many safety precautions were put in place. There were several safety officers. Four different people were assigned to watch the safety of the exercise in the building. The trainees had been inside the building prior to the exercise in order to familiarize themselves with the layout. There had been a safety briefing in which training goals and safety precautions were discussed. During the training, a Rapid Intervention Team (RIT) was standing by outside with a charged hose line supplied by a separate engine.

In order to provide fire and smoke a fuel load was constructed around a closet in the bedroom using five palettes and one bale of hay. When the exercise was started, the fire was considered to be progressing too slowly. The training was not enough of a challenge. Two instructors went and took a polyurethane foam mattress from another room and tossed it onto the fire. This produced a much bigger fire and severely ramped up the exercise. The training could now commence.

First a search & rescue (SAR) team was sent in. These two firemen were to search for any victims. The SAR team was followed by an attack crew made up of three people. A second attack line consisting of yet again three firemen was also deployed. In total there were eight firemen inside the building participating in the training while being supervised by instructors and safety officers.

About 3,5 minutes after the SAR team made entry, the window of the room containing the seat of the fire was broken from the outside. This was done by the "outside vent man" and was at the time a standard tactic in the US. The intensity of the fire increased and flashover occurred in the room. It became clear quickly thereafter that the SAR team was missing. The RIT team was then sent in to search for them. Extinguishment was started and soon after the two firemen were found. Unfortunately they had perished.

4.2 Which mistakes were made?

It is very easy in hindsight, with the knowledge we possess today, to look at a training burn of 2002 and condemn the people involved. This certainly is not the goal here. However it is very informative to analyze the elements leading up to the fatal outcome of the training exercise.

4.2.1 Fuel load

At the start of the burn, the two instructors decide that conditions aren't challenging enough. They walk into another room to fetch a mattress and add it to the fire. Two conclusions can be drawn from this event. Firstly there are no clear instructions regarding the fuel load. Apparently the instructors are allowed to add more fuel as they see fit. This may cause the exercise to turn out quite differently on the inside than what is expected by the crews standing outside. In Osceola, a double mattress was added. The heat release rate produced by this piece is many times higher than that of the original fuel load. Aside from that, it seems there was also still ample fuel left in other rooms. That would mean the fire can spread uncontrollably.

When organizing exercises in acquired structures, the building needs to be totally stripped down. The only fuel load allowed needs to have been brought in by the instructors. The entire training staff should be aware of the type and size of the fuel load at the start of the exercise and any changes that can or will be made. This way everyone will have a similar idea of the burn. The fuel load is hereby limited and clear communication is organized concerning the initial fire and any possible alterations that are implemented during the training.

An extra safety precaution is the deployment of one or two hose lines for the instructors so that they can correct the intensity of the fire should it grow too large. This also serves as a quality control measure. By adjusting or correcting the fire, all trainees are presented with a more or less identical exercise. If this isn't done, it's possible that the first trainees are confronted with a heavy fire while the following crews will face a fire in decay.

4.2.2 Strategy and tactics

During the training, the choice was made to first start a search. This means that people are going into a burning building without a hose line in search for victims. These people will not be able to defend themselves against fire spread and should they stumble onto the seat of the fire, they can't even put it out.

Figure 4 Evacuation of a victim during a tactical fire training. *(Photo: Lars Ågerstrand)*

Now in 2013 we know that a fire attack crew always needs to be deployed first and that any search crews are also best equipped with hose lines. If the SAR team had been carrying a nozzle, it would have been possible to decrease the intensity of the fire or even put it out.

4.2.3 Ventilation

During the exercise the order was issued to break fire room window. This allowed for extra oxygen to become available to the fire. A ventilation induced flashover was triggered. It's clear that our colleagues in 2002 had no idea that this was going to happen. In the investigation following the incident, the question was asked what had caused the "uncontrolled flashover".

Organizations that would like to conduct acquired structure burns need possess very extensive knowledge on fire behavior. Otherwise the risk for serious injury will remain because the training staff inadequately understands fire dynamics.

The breaking of windows will forever remain problematic. Each time a window is broken in a ventilation controlled situation, the intensity of the fire will increase. To solve this problem, all windows could be boarded up. This is best done on both the inside as well as on the outside. That way, should a glass pane burst due to thermal tension buildup, the glass shards won't cause any injuries. On top of that, control is kept on the ventilation profile of the building. After every exercise the boards need to be checked. If necessary, any damaged boards need to be replaced.

4.2.4 A lot of participants

During the exercise in Osceola three teams were sent inside. At one point eight trainees were inside. On top of that there were several safety officers and instructors inside as well. It's difficult just to keep track of everyone inside. Therefore it's necessary for one instructor to keep tabs on everyone wearing a breathing apparatus. He needs to make sure that everyone going in is also coming out at a predetermined moment in time. That way it's immediately clear when someone is left behind inside.

4.2.5 Gas cooling

A problem that perpetually arises in American case studies is the lack of gas cooling. A lot of the time crews do take a hose line in to search for the fire. However they will not use the nozzle until they have reached the seat of the fire. Gas cooling might not be enough to prevent flashover from happening. It will cause flashover to take longer to occur. That way, more time is "bought" for finding the seat of the fire or for a safe retreat.

4.2.6 Floor layout

A final element that undoubtedly played a part is the layout of the building. The fire was started in a bedroom on the right hand side of the structure (see Figure 5). Crews had to enter the building through the front door. Next they had to pass through a hallway. Inside that hallway was a narrowing. At its narrowest the hallway was only 66cm wide. Such a narrowing severely hinders any swift evacuation by crews wearing BA's. Knowing there were four safety officers in the same building, it will have been rather tight in the hallway. The report by NIOSH mentions a collision in the hallway between a victim and a safety officer the moment the SAR team is advancing towards the fire room.

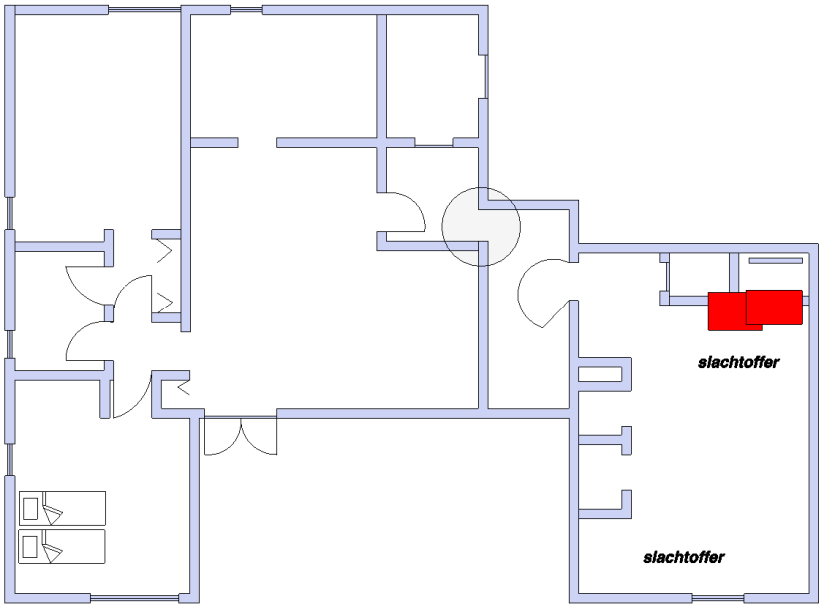

Figure 5 The Floor layout of the building used in Osceola. The narrow passage is indicated with a circle. The seat of the fire is depicted by two red blocks. *(Figure: Pieter Maes based on a NIST report)*

5 Closing arguments

In 1982 two firefighters died in a training exercise. As a result of this the NFPA started drafting a standard for live fire training. The NFPA 1403 standard on live fire evolutions was altered several times during the following years. After every serious injury, the standard was adapted and the lessons learned were incorporated into the new version. The goal of the standard is to allow live fire training to be conducted in a safe way. After all, our US colleagues are aware of the fact that live fire training is an absolute necessity in both the educating (new skills) and the training (maintaining of skills) of firefighters. Even though the standard is written from an American point of view on fire ground operations, it still offers a decent guideline for European organizations that want to conduct live fire training.

NFPA 1403 distinguishes between live fire training in an infrastructure built specifically for training purposes and "acquired structure burns". For the latter, many additional parameters are defined and need to be checked. The standard assumes that instructors are sufficiently knowledgeable on fire behavior. Aside from this it also implies that the instructors are guided by people that are proficient in fire dynamics in order to determine things such as the fuel load.

In New South Wales in Australia acquired structure burns are used solely for fire research and for refresher courses for fire instructors. They are very aware of the possible "sorcerer's apprentice effect". Sometimes people think too quickly that they have everything under control and nothing can go wrong.

This article isn't a plea against acquired structure burns. There are certainly many important benefits to such training exercises. However it is a warning that "playing with fire" holds many risks. In fire schools, containers or training buildings are used that produce far less surprises than acquired structures. Usually such a training building is made up out of inflammable materials. Fire schools also invest heavily in the education of their instructors. Risk analyses are made and training routines are constantly improved upon to guarantee both safety and quality. One has to be of the very best level of firefighter instructor to be able to apply all these things in an acquired structure burn. It would be disastrous for the Belgian fire service in general and for the officers responsible in particular, should anyone die or become seriously injured during such an exercise because of poor preparation or underestimated risks. A warned man counts for two…

6 Bibliography

[1] *NIOSH, Firefighter fatality investigation and prevention program, www.cdc.gov/niosh/fire, 1984-2013*

[2] *NIOSH, Career lieutenant and fire fighter die in a flashover during a Live-Fire Training evolution, F2002-34, 2003*

[3] *NFPA 1403, Standard on Live Fire Training Evolutions, National Fire Protection Association, Quincy, MA, 2007*

[4] *Madrzykowski Daniel, Fatal training fires: fire analysis for the fire service, NIST, Gaithersburg, MA,*