Reducing fire fighter fatalities – the knowledge based approach

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Introduction

Being a fire fighter is a profession. And as in any profession, fire fighters are expected to act professionally, with adequate and sufficient knowledge, training and equipment. The fire fighter is expected to enter any environment others flee, without hesitation and with the sole objective to save, protect and to put things back as they should be. Fire fighters around the world do so, with all the effort and courage it requires.

There are countless examples of fire fighters giving their lives for the sake of the public, examples ranging from house fires to Chernobyl, some fatalities being practically unavoidable. But when a large number of fire fighters are killed each year just by doing their job, there is surely a problem. Has the altruistic approach in fire fighting gone too far? Are we putting the life of fire fighters at risk when there is nothing to gain, due to lack of knowledge in favor of the glory of being heroes?

Fire fighter fatalities; statistics and causes

Compared to other countries with seemingly similar technology, training, command system, etc., the fatality ratio in the United States is large, table 1. The reason for this is probably very complex although there might be some common and very fundamental reasons.

Table 1; Fire fighter fatalities, based on data from 1977 – 2006.

	per 1,000,000 population	per 100,000 fires	per 1,000 fire fighters
US	0.459	5.856	0.108
Sweden	0.057	1.318	0.030
UK	0.010	0.565	0.015
New Zealand	0.137	2.160	0.066
Ratio US/Sweden	**8**	**4.4**	**3.6**
Ratio US/UK	**44**	**10**	**7.3**
Ratio US/New Zealand	**3.4**	**2.7**	**1.6**

The causes of fire fighter fatalities differ between countries. An example of this is shown in figure 1, below. Please note that figure 1 is based on 3 years of data in the US case and more than 60 years of data in the Swedish case. Consequently, it is hard to make any extensive conclusions in the Swedish case but it gives a hint of the problem in the United States.

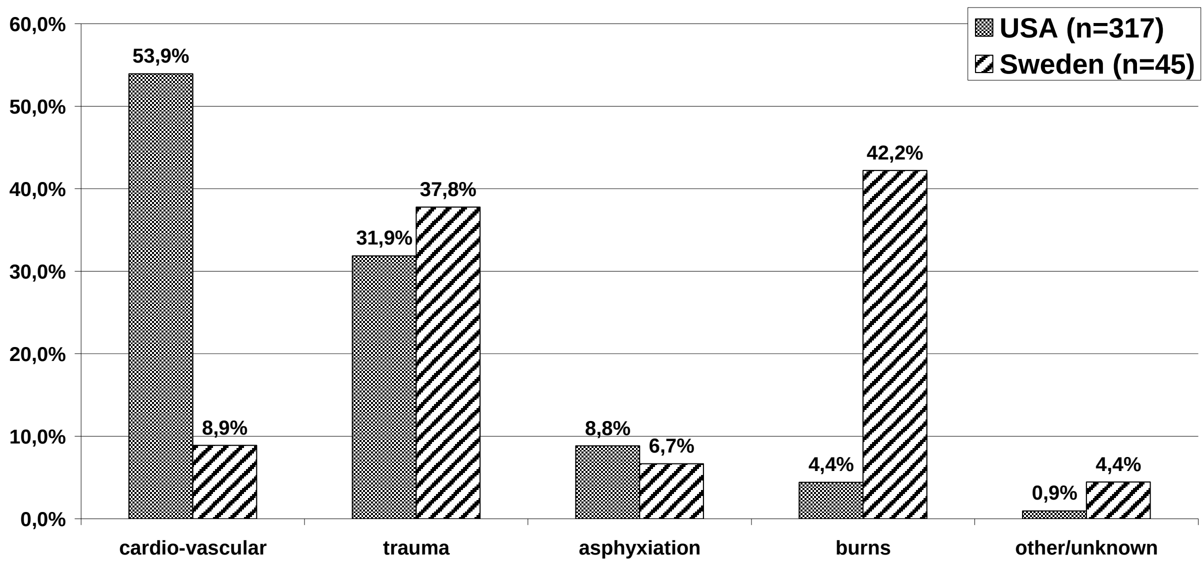

Figure 1; Causes of fire fighter fatalities.

The reasons for the differences are complex and they include, amongst others,

- building constructions,
- physical demands,
- expectations by the public, and
- attitude.

The way buildings are constructed affects fire behavior and it affects the way operations can be carried through. Fire fighters must be able to assess a situation and to take appropriate countermeasures, depending on the type of construction, etc. Physical demand on fire fighters affects how operations can be carried through. Fire fighters that are in a good physical condition can accomplish other tasks than fire fighters in poor physical condition although they do not necessarily have to be stronger.

Public expectations play an important role when carrying through fire and rescue operations. In many cases, high expectations lead to a more aggressive approach during operations and fire fighters tend to take on a more risk-prone approach when the public is watching. Then, it also affects the attitude and image of the fire fighter as a hero, thus sacrificing life and limb when accomplishing tasks on the fire ground. How often do fire fighters and fire officers ask why and for what reason?

However, no matter the cause it all relates back to knowledge and understanding of various aspects of being a fire fighter. Cardiovascular related fatalities may be due to the lack of knowledge of the importance of physical fitness and healthy living or the danger of heat stress and its causes. Trauma related fatalities may be due to the lack of knowledge of the impact of reckless driving or safety related problems when working on roofs above a working fire. Asphyxiation related fatalities may be due to lack of knowledge on how to manage the air-supply or due to lethal myths about airmanagement. Burn related fatalities may of course result from the lack of knowledge of fire behavior.

Lack of knowledge leads to safety related problems

There are numerous stories in the United States about the bravery of fire fighters, stories such as

> *"…without aid of bunker gear, self-contained breathing apparatus or a charged line, he continued into the blinding smoke until he felt a life-less body under his hands…dragged the victim to safety …within seconds of their exit, the room flashed over behind them."*

Eventually, for such a brave and heroic deed, the fire fighter is presented an award and is saluted with all the respect that comes with it. Of course this encourages others to do the same and to act with the same kind of "bravery".

In Sweden, the UK or New Zealand, a "heroic deed" such as in the above fictive example would probably had led to inquiries, changes in training manuals, the dismissal of the fire fighter and probably even prosecution of the fire fighter for causing immediate danger to others. Even the officer in charge of the operation and the fire chief of that organization might get a conviction. A purpose of this is of course to discourage others from acting foolishly and unprofessionally. Yet, the fire fighter can still act with bravery and be looked upon as a hero. However, bravery must rest upon the correct basis.

Behavior like in the above example cannot be accepted as being professional and fatalities due to such behavior can be prevented. Let us take a more in-depth look at the above example, its statements and their relation to accessible knowledge.

"Without aid of bunker gear…"

Levels of radiation and its impact on human skin, turnout gear and other materials are well known, see table 2. Without a basic understanding of terminology and concepts such as radiation, pyrolysis and spontaneous ignition, it is very hard for the fire fighter to translate and relate such knowledge into the real world of fires and other accidents.

Table 2; Effect of radiation.

Radiation level [kW/m^2]	Observed effect
0.67	Summer day in Great Britain
1	Threshold value of pain for unprotected skin
6.4	Pain on skin after 8 seconds of exposure
7	Threshold level for fire fighters in turn-out gear after 3 – 7 minutes of exposure
10	Pain on skin after 3 seconds of exposure
12	Pyrolysis of wood
16	Blisters on unprotected skin after 5 seconds of exposure
20	Threshold level for fire fighters in turn-out gear after 2 minutes of exposure
29	Spontaneous ignition of wood
52	Spontaneous ignition of fiberboard after 5 seconds of exposure

It should be noted that everything with an elevated level of temperature, exceeding a normal body temperature (appr. 37°C), generates radiation that affects the fire fighter. This includes objects and smoke as well as flames.

Temperatures exceeding a normal body temperature affect the body negatively. Effects such as cramps, exhaustion and stroke have been reported. The higher the temperature or the longer the exposure time, the faster or worse the body will be affected. Here, it should be noted that the turnout gear itself can raise the body temperature to levels dangerously affecting the body.

The numbers in table 2 are based on thorough investigations; theory, experiments, simulations, etc. Every fire fighter should know and understand this, without exceptions. The turnout gear is no superman costume and the human inside it certainly is no superman.

Doesn't it seem like a foolish idea to expose oneself to heat and radiation, without the protection of the turnout gear?

"Without… self-contained breathing apparatus (SCBA)…"

Smoke contains a number of toxic and highly lethal substances such as carbon dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, soot, volatile hydrocarbons, nitrogen monoxide, sulfur dioxide, iso-cyanide and dioxin. In many cases, one breath of smoke is sufficient to receive a lethal dose of any of these substances.

The discharge of these substances is harder to quantify than temperature or radiation because it depends on the burning material as well as under which conditions the material is burned. Examples of typical values for a fully involved bedroom (or similar) are 6 µg dioxin, 500 g polycyclic aromatic hydrocarbons and 800 g volatile hydrocarbons. The typical amount of carbon monoxide released during a room fire is approximately 100 kg. Carbon monoxide is immediately lethal at a concentration of 400 ppm, which is exceeded very early in a fire.

Doesn't it seem like a foolish idea to expose oneself to smoke, without the protection of a breathing apparatus?

"Without… a charged line…"

Despite extensive research on various extinguishing agents, water is still a superb extinguishing agent. It's cheap, it's available everywhere and, especially, its thermal properties are perfect for cooling smoke, flames and burning materials, i.e. putting out fires.

In most building fires, besides being toxic, smoke reduces visibility. Consequently, a hand-line gives the fire fighter at least two options: to put out fires or to cool down flames, smoke or hot surfaces and; it shows the fire fighter the way out of a building. If the situation for some reason changes and becomes immediately dangerous, which the fire fighter should be able to identify beforehand thus making a retreat, it gives some level of protection and it shows a potential rescuer a way in to a fire fighter in distress.

Doesn't it seem like a foolish idea to run into a building on fire without a charged line?

"…he continued into the blinding smoke …he felt a life-less body under his hands…dragged the victim to safety …"

In recent years, technology has given us a wonderful tool that actually increases visibility in smoke – infrared cameras (also known as thermal imagers). By using them, we will be able to get to the fire faster, we can easily find our way out and, which is important to address based on the example, it gives us the possibility of accessing a victim much faster and at lower risk.

Science and technology from other fields, provide us with tools that can be used in the fire service as well. However, the fire service is well known to be a very conservative business and change does not come for free. It requires the ability, knowledge and courage to introduce new technology in the fire service. It requires an open mind to knowledge and to new technology.

Doesn't it seem like a foolish idea to run into a building filled with smoke without a thermal imager?

"…within seconds of their exit, the room flashed over behind them."

In the last decades rapid developments in modern building technology have resulted in unconventional structures and design solutions. But there have also been great strides in the understanding of fire processes and their interrelationship with humans and buildings. Although there is still a lot to discover, we have gained a tremendous amount of knowledge on how fire behaves in various materials and configurations.

This is a crucial point – fire behavior should be first priority when it comes to fire fighter knowledge. There should not be a fire fighter or a fire officer that does not fully understand how fire develops under various conditions on the fire ground. Figure 2 shows an example of typical temperatures in a training fire. The knowledge of phenomena such as ventilation controlled fires and fuel controlled fires, how various objects and materials behave under fire conditions and the influence of vents on the spread of fire becomes very important to have. In addition, this knowledge includes the understanding of basic physical properties and relations such as temperature, energy, heat and pressure, things that are taught in elementary school.

By attacking a fire, conditions in the burning building change, sometimes to our favor and sometimes not. A door is opened or a vent is made in the roof, air is introduced thus making the fire to increase and spread, more smoke is generated and more energy is released. Eventually, the smoke will ignite making conditions untenable and unable to support life.

In many cases it is a very thin line to walk and the fire fighter must be able to assess the situation and must understand how conditions change and why they change.

Without knowledge and understanding of fire behavior, doesn't it seem like a foolish idea to enter a building on fire?

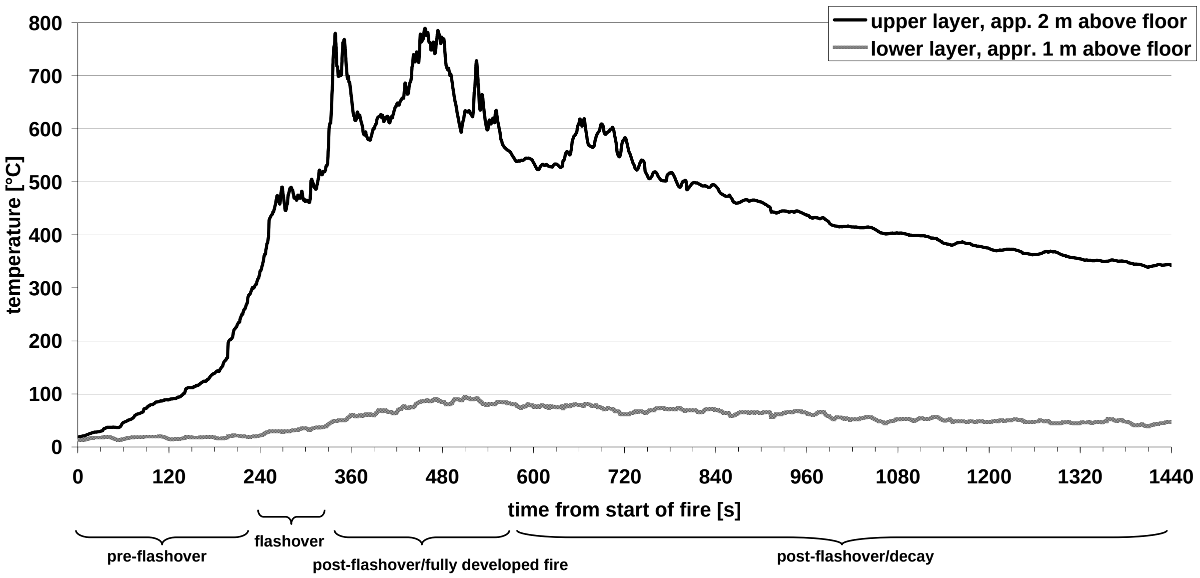

Figure 2; Example of typical temperatures in a training fire.

Importance of knowledge and training

Much knowledge has been gained from and by the fire service, through experience and experimental work. In addition, there is a growing interest in looking at the fire service from a more scientific standpoint, and the development of technology to be used by the fire service has been tremendous over the last fifteen years. It should be noted that problems faced by the fire service are similar all over the world. However, there is still a huge amount of knowledge to be discovered, which eventually has to be transferred to the fire service community.

However, it should be noted that the knowledge referred to here does not include amateurishness such as the fire triangle (it is far more complicated than that), wrong ideas such as believing fog nozzles are dangerous (even a toothpick can be dangerous in the wrong hands), or stupid and lethal myths such as nozzle breathing (which has nothing to do with reality).

Sound knowledge is the foundation for all activities, not at least in the fire service. This is a matter of professionalism as well as a safety issue and requires a close relation between scientists and practitioners. However, scientists must be able to identify the needs in real life, to investigate these needs and to transform scientific results into useful knowledge. Practitioners must be able to understand what scientists deliver and help scientists to get on track. Nothing comes for free and the development and exchange of knowledge is in many cases a long process that requires humbleness and understanding.

We need to get more science into the fire service. Technology, methods and tactics for dealing with fires and other emergencies should be thoroughly investigated. We need to develop and extend the training of fire fighters and fire officers. We need a more academic approach on actions taken on the fire ground. We need academics and scientists to work more closely together with experienced fire fighters and fire officers. The bottom-line is that this is a safety issue.

Together, we must push the fire service forward into the future, based on sound science and approved experience in concord.

In conclusion

There is nothing wrong in acting with bravery or having peoples trust of being heroes. Fire fighters are expected to enter environments others flee, without hesitation and with the sole objective to save, protect and to put things back as they should be. There are of course risks connected with fire fighting activities and fire fighters must understand these risks and they must be able to manage them – with knowledge.

Bravery and heroic deeds must result from knowledge, not from illusions.

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About the Author

Stefan Svensson started his career as a fire fighter in the Swedish Air Force in 1986. In 2002 he earned his Ph.D. at Lund University in Sweden, on fire fighting tactics. During the last thirteen years he has been involved in experimental and theoretical investigations on fire fighting tactics, including high and low pressure fire fighting and positive pressure ventilation. Also, Dr. Svensson is a well-known and highly respected instructor for the Swedish fire service, in tactics and in command and control. The safe and effective use of fire fighting resources is a particularly important feature of his work. He is also involved at the local fire brigade, as a fire fighter/officer.

About the Symposium

Reducing Firefighter Deaths and Injuries: Changes in Concept, Policy, and Practice is presented as a public service of the Public Entity Risk Institute (PERI), 11350 Random Hills Rd., Suite 210, Fairfax, VA 22030. Web: www.riskinstitute.org.

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