Hygiene at fires

This article is the 25th in the series on interior firefighting. The title of the first article back in 2010 was "Evolution in the knowledge on interior firefighting". The title is a hot topic in the fire service, now more than ever. Over the last five years, a large amount of knowledge has been acquired. In Belgium the firefighter training program has evolved at a slow and steady pace. Abroad there were numerous studies being done. A well-known example of this is the research performed by UL, who invest over one million dollar on a yearly basis into studying fire behavior and firefighting.

One particular topic that's been researched during the last few years is hygiene during and after firefighting. More and more it has become clear that fires produce a wide array of carcinogens. In the '80s the fire service took a big step towards better protecting lungs and airways of firemen. Making the use of breathing apparatuses (BA) a standard operating procedure, caused a major improvement in protecting firefighter health. Recently there has also been more attention given to the hazard of dirty clothing and turnout gear. Measures are being put in place to prevent dangerous substances from entering the bodies of firefighters.

Substances can enter the human body in three different ways:

- Inhalation
- Absorption through the skin
- Ingestion

The protective measures against the intake of substances through inhalation during interior firefighting are decent. However, the other intake mechanisms are not so well protected.

1 What does fire produce?

Let's take a look at the substances produced by a fire. The smoke is made up of several components. Fire produces a range of gas, liquid and solid particles (soot).

1.1 Gases

An ideal combustion in a laboratory environment produces only two gases: water vapor and CO_2. Water vapor is a harmless gas. CO_2 is the same gas that is in the air we exhale. An excess of CO_2 however will still cause health issues. After all, fire consumes oxygen and produces CO_2. This means that less and less oxygen is available for people.

The combustion process at real fires is far from ideal. Therefore a large number of other gases is being produced. Some more dangerous than others. The best known gases are CO and HCN.

When we are wearing a breathing apparatus, we are protecting our airways against these gases. However, during firefighting these gases penetrate our turnout gear. This will cause that gear to start degassing after the incident. When these gases rise, we will inhale them.

1.2 Liquid particles

Aside from a complex mixture of gases, fire also produces liquid particles. Similar to the gases, water will be formed. Also droplets of pyrolyzates and combustion products will be produced.

These drops will get mixed with the water used for extinguishment. If puddles form during firefighting, they will be made up of both water and hazardous particles. So when this liquid mixture comes into contact with turnout gear, it will be absorbed by the gear. Firefighters often come back out of buildings with very dirty turnout gear. Aside from the gases absorbed, there will also be a large amount of liquid that has infiltrated the gear.

Sometimes the liquid even gets through to the skin. Then it's the skin that acts as a barrier to counteract or limit the absorption of liquid particles.

1.3 Solid particles

Fires also produce a very large amount of soot. Soot is made up of several different chemical components originating from combustible products. It is highly carcinogenic. The solid particles are very small. This allows them to float in the air around us. These particles will also attach themselves to the firefighter's gear. After firefighting (and especially after the overhaul) a fireman's turnout gear will be covered in a layer of dust.

Figure 1 The helmet and vest clearly show a large number of solid particles. *(Photo: Pieter Maes)*

After the fire incident, these dust particles will be lifted from the gear into the air again by the wind or a breeze. Again this poses a threat to our airways and lungs. On top of that, the dust particles will also remain in the direct environment in which firefighters are situated. For instance the truck or engine. Most of the time fire crews just sit in the back of the appliance in their dirty turnout gear. The crew's compartment is then filled with lightweight and carcinogenic particles. These particles will again get circulated into the air and hover there.

2 How are we to protect ourselves against this?

Research has been done in different countries (Australia, US, Canada, …) into the intake of carcinogens by firefighters. Both blood and urine samples were taken from the firemen after they had been involved in interior firefighting operations. Several possible solutions were tested and evaluated.

2.1 Which solutions do *not* work?

One particular solution which was advocated in Sweden in the early 2000's, was standing in front of a fan. The idea behind this method was that the air flow would blow away all of the dust particles and gases.

A decade later however, this method was found to cause an increase of carcinogens in the firefighters' urine. Values were measured that were up to six times higher than those of a control group fireman. Apparently the air flow allowed for the particles to more easily penetrate the turnout gear. That way they reached the skin where they were absorbed into the body.

2.2 Fire academies

The fire academies have taken a leading role in improving the protection of firefighters during live fire training. In these schools it is possible to implement protective measures on a structural level.

2.2.1 Zones

The analogy of the decontamination area of a hazmat incident is used here. Fire training schools use hot, warm and cold zones. The hot zone is the building or structure in which the fire is located. Everyone in the hot zone needs to be in full turnout gear and wearing BA. The cold zone is the area in which trainees are recovering and where the debriefing is being held. No one can enter this zone while wearing dirty gear.

In between these two areas is the warm zone. In here, both the BA and the turnout gear are taken off. If multiple fire exercises need to be done, this is also the place where protective gear is put on.

2.2.2 PPE's

As soon as a firefighter takes off his BA, his airways are no longer protected. Especially the dust particles on his turnout gear are a major threat. When such a dust particle is inhaled, it enters very deep into the lungs. Many fire academies counter that risk by issuing dust masks to trainees for when they have to handle dirty gear. The dust mask is taken off to put on a BA. And the mask is put on again as soon as the BA is taken off. That way a continuous protection is created against dust particles.

Dirty turnout gear is removed at the earliest possible time in order to limit the inhalation of gases coming from the gear. By leaving this gear in the warm zone, all of the gases are released without any firefighters nearby.

Figure 2 Preparations are made for an exercise in the T-cell. Since there's dirty turnout gear being worn, participants are wearing a dust mask and latex gloves. This is particularly recommended because "dirty" nozzles and dividing pieces are used.

When firemen have to handle dirty gear and BA's, their hands get dirty. Both dust and liquid particles commonly get stuck on the skin or under finger nails. Sometimes these particles are very hard to remove. The numerous nail brushes used by firefighters in the shower to get rid of the dirt under their nails are a silent testimony to this.

For this problem fire academies have opted to use EMS gloves. The moment anyone needs to handle dirty gear, they first put on EMS gloves. All of the dirt that would normally get onto the skin is now caught by the gloves. This creates an important protection against absorption through the skin.

Finally trainees are advised to shower within one hour after their exposure. The shower will wash away the majority of any particles stuck on the skin. Only then is the exposure of the skin over.

2.3 Fire services

The measures put in place by the fire academies to improve hygiene aren't being adopted by fire services for the time being. Even though at fires a larger amount of often more hazardous substances is produced than at live fire training in schools. An example of this is asbestos. Asbestos is a carcinogenic substance that was once often used in construction. Companies occupied with clearing and removing asbestos are subject to very strict rules in regards to the protection of their employees and working environment. In some cases entire building are put in an under pressure state to prevent asbestos particles from exiting and polluting the surrounding area. In December 2014 the Dutch city of Roermond was completely locked down after a fire involving asbestos. Before the city was released again, the entire area needed to be cleared of asbestos. This incident paints an accurate picture of the level of hazard this substance poses.

When a fire occurs in a building that has asbestos in it, the particles could be released. They are then caught by the smoke and are carried off. Next they could get stuck on the turnout gear of fire crews. In the fire service of Brussels, any BA's used in a fire involving asbestos are rinsed with water at the fire ground. Afterwards technical personnel charged with BA maintenance will equip the proper PPE to then thoroughly clean and service the gear.

A good way to get an indication on dust particles present in the air, is to look at a ray of light during overhaul. The number of particles that becomes visible is enormous. And more often than not, firefighters are performing overhaul without any form of airway protection.

Consistent use of either BA's or dust masks could considerably increase health safety. Use of a BA will offer protection from both gases and dust particles. A dust mask will naturally only counter the dust particles. Switching from BA to dust mask should therefor only be done after sufficient ventilation has been performed.

The use of latex or nitrile gloves could also be introduced into fire services. This would limit exposure of the hands. Dirty gear and material is now often handled with bare hands. For instance offloading used hoses and dirty BA in the fire station. This will cause carcinogens to get onto the hands. Consistent use of latex or nitrile gloves can offer a solution to this problem. If this measure is not possible to implement, hands need to be washed immediately after the chores to stop absorption through the skin.

Fire services could also use some kind of zoning system to avoid contaminating the appliances and fire station. In some (foreign) fire services (dirty) turnout gear is put into bags at the fire ground. The gear is then transported to an industrial cleaning company. Firemen then sit in their engines or trucks in regular outfits. Once in the station they take out spare turnout gear. It goes without saying that this method of operating has the highest impact on the fire service's workings. The cost of both regularly washing and providing a second set of turnout gear is many times higher than providing dust masks and EMS gloves.

Figure 3 In some fire services in the Netherlands, turnout gear is wrapped in bags and brought to a laundry after the fire operation. (*Photo: DigiDamco Fotografie)*

Still the fire service as an employer needs to take action in this. Just as companies using asbestos back in the '70s became aware of its risks, fire services need to become aware of the dangers of smoke and substances related to firefighting. The companies using asbestos minimized the health issues back then. This led to numerous law suits of former employees and clients decades later. Will the fire service go down the same road?

3 Bibliography

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