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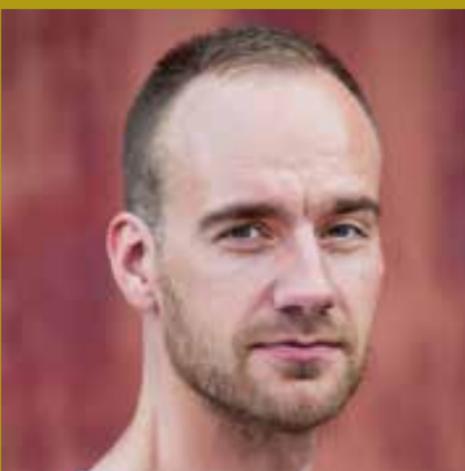
Healthy firefighters

– the Skellefteå Model improves the work environment





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Foreword

"It's dangerous being alive – you can die!"

(David Eberhard, Chief Psychiatric Doctor, 2005)

For a long time, we have had the joy and the privilege to work together in the emergency services with professions that we are very proud of. The firefighting profession is a vital and indispensable part of civil protection in most countries. The profession is carried by people with the will and goal of saving and securing the lives, health and property of others. But as is discussed in this book, research clearly shows that firefighters unfortunately run a greater risk of being affected by a number of diseases which in the worst cases are fatal.

It is difficult to find a firefighter who does not have colleagues that have affected by suspected occupational illnesses. The unfortunate situation is deemed difficult to change and there are many reasons for this. It is well known that the firefighters' work environment can be extreme at times and that this can be a considerable strain on the individual. The firefighters' vulnerability is also a result of such trivial factors such as professional culture, lack of basic routines and illnesses that develop deceptively slowly. For us, this situation is impossible to accept.

This book has come about for the purpose of describing how to break the pattern and with a desire to have a positive impact on the firefighters' work environment. The book is based on research, in-depth knowledge of the duties and everyday life of a firefighter and on personal experience. It has been compiled into a publication about how to prevent and counteract hidden sources of illness in firefighters' everyday lives. The book can be seen as guidelines for how to achieve great changes in the fight for firefighters' health and well-being with small means.

Special thanks to all of the friends, colleagues and others who were committed to driving the process forward. Thanks also to our families who patiently accepted our absence to allow us the freedom to write.

Stefan Magnusson and David Hultman

Summary

Research shows that firefighters run a higher risk of suffering from serious illnesses than the rest of the population (LeMasters et al. 2006). This despite the fact that firefighters as a group often have a healthy lifestyle and thereby good health.

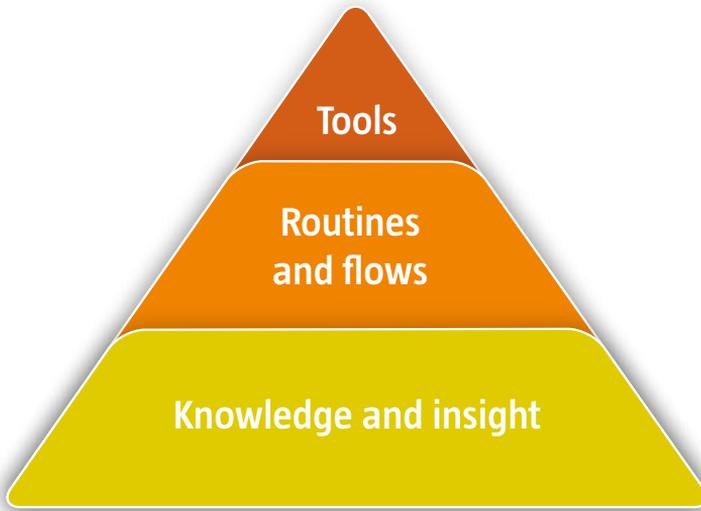
One condition that separates firefighters from many other groups is that firefighters are often exposed to situations in which foreign and unknown chemical pollutants are present. The contamination of firefighters is both evident and hidden. It should however be a given that the firefighters themselves are able to act on the extent of their exposure.

Firefighters should be able to start their shift in full, clean protective clothing and be able to protect their airways and skin in all situations. There should also be the facility of the cleaning of protective clothing and other equipment by machine every time they have been contaminated. Routines that separate contaminated from clean when transporting and when handling at the fire station are also essential.

Three important factors which in combination reduce the quantity of harmful substances that firefighters are exposed to and then keep the quantities at a minimal level are:

- all personnel in the organisation receive the knowledge and insight they require in order to reduce the incidence of contamination.
- simple, clear routines and flows are used to minimise the number of instances in which firefighters are subjected to foreign substances.
- the organisation provides the necessary material and opportunities for personnel to carry out the operational routines.

These factors lead to an improvement of firefighters' health over time. The Skellefteå Model is a tried and tested way of creating a good and sustainable work environment in accordance with these points and with very basic means.



The Skellefteå model consists of three factors which, combined, improve firefighters' work environment.



A book about improving the working environment of firefighters

It has long been established that there is a connection between the firefighting profession and the risk of suffering from serious illness. In 2007, WHO (the World Health Organisation) established the connection between the firefighting profession and various forms of cancer (testicular cancer, prostate cancer and cancer of the lymphatic system). The result was reached by a work group consisting of 24 researchers from ten different countries (Straif et al. 2007). Many questions remain unanswered and ambiguity surrounds the issue of how firefighters are affected by their work environment over time. The context is complex, as so many different factors work in combination to affect firefighters' health.

According to research, the health risks entailed by firefighters' work situation not only lead to cancer, but other health problems such as fertility disorders, cardiovascular diseases, asthma and allergies (LeMasters et al. 2006). If we summarise firefighters' conditions, we can distinguish a number of health factors that are known and well documented.

- The firefighting profession involves both evident and hidden exposure to hazardous substances in various forms.
- Firefighters often work in shifts with irregular hours and thereby irregular stress patterns.

- Firefighters expose themselves to extremely hard physical strain and thermal stresses for short periods.
- Being a firefighter is associated with an identity rather than a profession, which leads to long employment. This in turn lays the foundation for occupational illness.

No-one can know exactly which substances or combination of substances individual firefighters are exposed to, nor the extent to which this happens. For unknown substances, there are no hygienic threshold values. It is not possible to establish what dose or how long an individual must be exposed to unknown combustible gas particles in order for it to be harmful. It is therefore difficult to introduce health checks that provide an early warning of imminent illness. Some of the diagnostic methods available today for these types of illness are still not perfected and not entirely reliable. One example is the PSA test for prostate cancer (Cooper et al. 2004). Attempts to diagnose illness at an early stage may therefore lead to unnecessary medical treatment and anxiety in the individual. The types of cancer concerned here are difficult to anticipate and detect in their preliminary stages. At the same time, the connection between a heightened risk of illness and the firefighting profession has been proven. (LeMasters et al. 2006). A reasonable conclusion from this must therefore be that it is important to minimise the occasions on which firefighters come into contact with unknown matter and substances.

Theoretically, it should be possible to completely protect firefighters from exposure to harmful substances. In practice, however, firefighters attending the scene of an accident/fire are sometimes forced to enter an extremely unhealthy work environment if they are to be able to carry out their work. Such situations not only arise in the event of large, spectacular fires but also smaller and more everyday incidents. These everyday incidents are so frequent that they likely constitute the major portion of the total exposure to harmful substances. Even if the employer were to use all available means to improve the firefighters' situation, the work environment could not be completely sterile and free from harmful situations and particles. With common sense and simple tools, however, clear improvements can be achieved for firefighters.

Thus far, there has been a lack of a compilation of effective measures for reducing the quantity of foreign substances in firefighters' work environment. This book contains examples and solid advice on how firefighters and organisations can achieve an improved work environment with very simple means and thereby also better health for the firefighters.

The “Healthy Firefighters” project and the Skellefteå Model

Sweden is no exception when it comes to problems facing firefighters across the world. Firefighters’ work environment is a global problem and several types of cancer are classed as an occupational illness for firefighters in Canada, Australia and parts of the USA (Forrest, A.2012). Strong measures are required in order to quickly and adequately effect changes to the current situation. Back in 2006, Swedish employee and employer organisations came together over the issue in a collaborative project which took the name “Friska brandmän” (Healthy Firefighters).

At a fire station of average size in the northern part of the country, a model was created within the scope of the project with which to address the health risks. This work method came to be known as the Skellefteå Model, after the location of the emergency services where the method was developed. The Skellefteå Model received the prestigious “Good practice award” from the European Agency for Safety and Health at Work in 2011 and thus became internationally acclaimed and recognised. Together with the European Trade Union Institute (ETUI), the European Federation of Public Service Unions (EPSU) has had the Skellefteå Model in its action programme since 2012. The programme names the model the Skellefteå Model. The Skellefteå Model is also referred to as The Swedish Way in international contexts.

Focus on being exposed to unknown substances

This book looks at the link between the firefighting profession and the risk of suffering from serious illness as a result of being repeatedly subjected to unknown harmful substances. It also discusses proposed measures for handling this.

There are many other examples of occupational illnesses that can affect firefighters. Several studies have investigated how night shifts and disruptions to the circadian rhythm affect the human body. It has been proven that there is a connection between disruptions to the circadian rhythm and metabolic disorders and changes in hormone level. Circadian rhythm disorders also increase the risk of cardiovascular diseases (David and Mirick 2006). Many firefighters regularly work in shifts, with frequent night shifts. The consequence is that normal sleep and circadian rhythm are at risk of disruption, in addition to the added stress of emergency call-outs. Such matters are discussed sparingly in this book, however.

The Skellefteå model has become internationally acclaimed and is also known as The Swedish Way.



Furthermore, repetitive strain injuries, musculoskeletal disorders, exposure to liquid foam, fire-extinguishing powder, inert gases and other chemical extinguishing agents are not discussed here. The same applies to burns, blood infections, fertility disorders and injuries caused by trauma such as falls, explosions, being crushed, landslides and training-related injuries.

The term “firefighters” is used here as a collective term for what in certain cases may also include other members of the emergency services.

At the end of the book is a glossary of terms and expressions used in the text.



Combustion gases

Content of combustion gases

The exact substances and combustion products created in a fire depend on the type and quantity of fuel, the size and nature of the surface, access to oxygen, the temperature and other conditions (Karlsson & Quintiere, 2000). All the variables make it difficult to know what type and quantity of waste products are formed during a fire. The point of departure, however, is that harmful substances are always produced at the scene of a fire.

As there are so many artificial materials in our surroundings, most fires create combustion products derived from synthetic material. In a pyrolysis test of seven common plastics, over 400 different substances have been identified. It is likely that additional substances which could not be identified were also created (Bengtsson & Antonsson, 1993). In a normal house fire, for example, there is of course a much greater number of substances.

Common substances found in combustion gases, and which have been established as carcinogenic, include: benzene, dioxin, formaldehyde, polyaromatic hydrocarbons (PAH) and vinyl chloride. Some of these substances are easily absorbed through the skin. Certain substances, such as common components of flame retardants, can numb and dampen cough reflexes. This means even more substances are taken up. Some substances are produced in the largest quantities when the combustion is incomplete; when the fire is very “sooty” and does not have enough oxygen. Other substances continue to be produced once the flame is out but the



In a fire, many harmful substances are created, and certain substances are more easily taken up via airways and the skin than others.

fuel is still glowing. This is often the case with the final extinction of a fire (Bengtsson and Antonsson, 1993).

New mixtures and compounds of materials are constantly being developed. In our lives we come across more and more new materials with to some extent unknown properties which can constitute a hazard to health in the long and short term. One example is nanoparticles, where the extremely small size means that a substance can have entirely different properties when in nanomaterial to those they possess in their normal form. Nanoparticles, which have a small diameter compared to other particles, are able to penetrate the protective barriers of living organisms. The nanoparticles are easily taken up via the skin and airways, transported into the body via the blood, and spread throughout and accumulated in various organs. Whilst research has shown that certain nanomaterials are very toxic, it is necessary to conduct further studies which more extensively document the impact of these particles on health over a longer period. (Ostiguy et al. 2006). Despite continuous research in the area, it is almost impossible to document the long-term effects of substances on people at the same pace as new nano-substances appear on the market. More documentation on the substances' properties when they are combusted is also required.

In fire exercises with well-known fuels such as wood, chipboard,

gas, ethanol, diesel and lighter fluid, products such as PAH (polyaromatic hydrocarbons), VOC (volatile organic compounds), oxides, isocyanates, dioxins and particles which have a negative impact on the body are formed in different sizes. At the fireground, firefighters are exposed to more unknown substances from the fire than during training as there are many types of fuel present at the same time. Instructors and firefighters that train a lot can, however, be exposed to harmful substances more often during training. (Svensson and Månsson 2009).

Spread of combustion gases

Combustion gases and combustion gas particles are able to spread and contaminate the surrounding environment. An indication of this is how even a small, limited fire in a household causes extensive damage to adjacent areas and surfaces. According to Insurance Sweden (2010), payments to policyholders that have incurred fire damage in Sweden cost around SEK 5 billion every year. This only covers property damage. In addition to this, there are costs for healthcare, rehabilitation, absence from work, etc. Even small apartment fires cost hundreds of thousands of Swedish Kronor in decontamination and restoration costs. It is thus very costly to clean up rooms after a fire so as to be rid of pollutants and odours. In more complex and extensive fires, in industrial areas for example,

Combustion gases spread and contaminate the surrounding environment, it is dangerous to enter such environments and costly to clean up.



there is an even greater spread of harmful substances and toxic particles. In such situations, it is not uncommon for emergency services to inform and warn the public of instances of toxic smoke. The warning may concern people in areas situated relatively far from the scene of the fire. Despite this, unprotected firefighters often find themselves in a considerably worse environment directly adjacent to the scene of the fire.



REFLECT

Do you as a firefighter know if the house you are extinguishing contains asbestos or how many glass particles from a cut up car window are in the air at incident site?

The body's uptake of harmful substances

In this context, there are three primary ways in which airborne harmful substances can make their way into our bodies (Rodricks 1992):

- via inhalation
- via skin absorption
- via the mouth (orally).

Uptake via inhalation

All people must breathe to survive. Normal breathing frequency at rest is 12-20 breaths per minute (approx. 7-14 litres of air). Under extreme stress, firefighters with normal lung capacity can metabolise up to 100 litres of air per minute (Malmsten & Rosander 2006). If the air inhaled contains foreign substances, the body's metabolism of these substances will increase if the individual is subjected to hard work.

It is not uncommon for firefighters to believe they are protecting their airways via simple solutions which in reality do not provide proper protection. Examples of this are breathing through the nose instead of the mouth in the hope that nose hairs and mucous membranes filter and protect them against harmful substances in the smoke. Another example is the "skip breathing method" based on the theory that a lower frequency of breaths in a poor air



environment reduces the intake of harmful substances. It is also common to breathe into the elbow crease or the collar as a means of protection. Unfortunately, none of these methods is especially effective. These methods can be thought to be irrational, but are a real problem and have logical explanations. This behaviour occurs in situations which are not planned or pre-meditated. Such situations occur for example when the wind suddenly changes, the fire quickly changes character, or when the firefighters need to change position and circumnavigate the scene of the fire. There is often no immediate access to protection for the airways or any possibility of breaking off the task at hand and moving to a better environment.

A common type of emergency callout and task is “smoke smell investigation”. In order to locate a suspected source of fire, it is common for firefighters to use their sense of smell as a tool. For logical reasons, protective equipment for the airways is used in such situations, and at these times firefighters often find themselves in spaces where people normally do not enter. These may be attics, storage, crawlspaces, fan chambers and ventilation spaces. In such spaces, the presence of mould, spores, dust and other harmful airborne particles cannot be ruled out. Firefighters normally give no importance to the situation, but in other contexts these environments would be considered hazardous for people to enter.

Harmful substances in connection with fires are taken up by the body via inhalation, absorption through the skin and orally.

Situations which at first glance are not perceived as hazardous can easily be overlooked or mistaken as harmless. Respiratory protection is almost always used when the environment is so unsuitable and unpleasant that the firefighters can establish with their natural senses that the environment is toxic or hazardous. But in situations when the normal defence mechanisms such as smell, taste, tear ducts and coughing reflex do not react in a natural way, it is normal for the firefighters not to use breathing apparatus. Some of the harmful substances that form during fires can be seen and smelt but others are completely invisible or odourless. An environment without an irritating odour or visible soot is thus not necessarily harmless, despite there being no perceived threat. The reason for wearing respiratory protection is not that combustion gases are always toxic; rather, because it is impossible for firefighters to determine whether or not the air they will inhale is harmful (Bengtsson & Antonsson, 1993).

It is important to protect both the skin and airways in all situations potentially involving harmful substances.



REFLECT

Are there any present or past contexts and situations that you can relate to in which you have unwillingly been forced to inhale bad air as a result of being unable to protect your airways.





When firefighters touch their own skin with contaminated hands, the surface of the skin comes into contact with combustion gas particles.

Uptake via skin absorption

There are many situations in which firefighters' skin comes into contact with harmful substances. This happens every time the firefighters touch their own skin with contaminated hands or with gloves that have been in contact with fire debris, for example when scratching or urinating. Another example is when the firefighters are situated in a smoky environment and an area of skin is exposed. Here, particles from combustion gases come into contact with the surface of the skin.

How much of a substance is absorbed by the body via the skin is determined by the quantity and type of substance, the size of the molecules and the skin condition. The substance penetrates warm and sweaty skin quicker than dry or cool skin (Thors et al. 2013). Firefighters often have warm and sweaty skin when they are in environments in which there are foreign substances. Moreover, it is not only in physically demanding tasks such as smoke diving, hose routing, venting or other demanding operations that firefighters' skin is warm and moist. The construction and functional requirements of the turnout gear mean that even simpler tasks constitute a higher temperature.

Many medicines are designed to be absorbed by the skin, e.g., analgesic creams, heart disease medication and nicotine patches. As these medicines contain molecules that pass through the skin barrier, they can be absorbed into the blood stream and thereby take effect. In the same way, undesirable and harmful molecules can make their way into the firefighter's body when they come into contact with the skin.

Today, knowledge about how firefighters' protective clothing prevents the surrounding environment from reaching the skin during e.g., indoor firefighting.



REFLECT

Think about how your skin has been subjected to visible soot and how long after a fire you can still smell smoke on your body. Is it a matter of minutes, hours or even days? Can you possibly know what substances remain on your skin?



Uptake via swallowing

Not all harmful chemical agents and substances from the scene of a fire can be perceived or detected with our natural senses. This makes the situation even more treacherous and is one of the reasons why firefighters tend to swallow unknown substances (oral uptake). This can happen in different situations:

- Gases and particles that have entered via the upper respiratory tract are carried via mucous and saliva into the digestive system and are thereby absorbed into the body.
- After or during long operations, sustenance is required.
- Food is often consumed at or directly adjacent to the fireground, with no opportunity for the firefighters to change clothing, wash themselves or even put the food in a clean place.
- Firefighters that use snuff and carry out work that contaminates their hands are at risk of placing foreign substances in their mouth via their fingers, with the snuff as a carrier.

Eating close to the scene of a fire entails a risk of harmful substances entering the body via the mouth.

The hazardous effects of combustion gases

Several research studies have shown that firefighters run a heightened risk of certain forms of cancer (LeMasters et al. 2006). To ensure the quality and reliability of studies of illnesses that take a long time to manifest, it is necessary to perform measurements over a long period. In parallel with these studies, firefighters' personal protective equipment and work methods have been developed and improved, which has had a positive impact on their work environment.

In recent decades, the presence of new materials and chemical substances in our surroundings has increased drastically. For many new substances, there is insufficient or no documentation about how they affect health in the long term (Ostiguy et al. 2006). Professional culture and local work methods are additional factors which affect how firefighters are subjected to combustion gases and their harmful effects.

The correct equipment and a good working method are important for protecting firefighters against harmful substances.

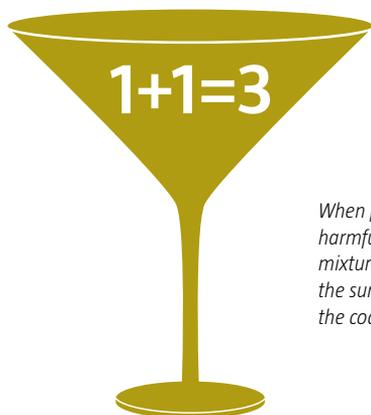


Combination effects

When a person is exposed to a number of different substances at the same time, one of the following occurs:

- The substances have no effect whatsoever on one another.
- The substances are aggregated (additive).
- The substances counteract one another's effects (antagonism).
- The substances enhance one another's effects (synergy).

Normally, the more hazardous the substances people are subjected to, the more harmful the effect (Mayer 1977). When firefighters are subjected to combustion gases and particles, they are exposed to several harmful substances at once. The effects of this are difficult to assess, but there is a risk of synergistic effects. Substances which at a determined quantity affect (or do not affect) the body can have an entirely different impact if the body is subjected to another substance before, after or at the same time (Lidman 2008). There is a risk that the mixture of different substances absorbed by the firefighter's body will become even more harmful than the sum of the various components; there can be a synergistic or "cocktail" effect.



When people are subjected to several harmful substances at once, the mixture can be more hazardous than the sum of its parts. This is known as the cocktail effect.

How harmful substances affect the body

Apart from the effects that harmful substances have on health previously mentioned, these substances can also impact on everything from the heart to the immune system, the muscles, the nerves, the internal organs and the body's system for hormone regulation, including the reproductive organs (Lidman, 2008). Children of firefighters run a three to six times higher risk of



Some substances that fire-fighters can be exposed to are suspected to be, or have been established as, toxic to reproduction

suffering from congenital heart defects compared with children of parents in other professional groups (Olshan et al. 1989). It has also been established that during their normal duties in connection with callouts, firefighters are subjected to substances that are suspected to be, or have been established as, toxic to reproduction (McDiarmid et al. 1991).

Some substances that are formed in fires (e.g., acetaldehyde and formaldehyde) react with one another or with e.g., water (saliva or mucous in the airways). These substances can either remain in the upper respiratory tract or be transported down to the stomach and lungs and have harmful effects. Some substances (such as isocyanates from glue, plastic and paint) can evoke asthma, allergies and other hypersensitivity, even for those exposed to low quantities if this occurs repeatedly. Free radicals are formed in fires involving normal construction materials. Free radicals are very reactive; i.e., they easily react with other substances, and they have a harmful effect on DNA, among other things.

At the scene of a fire, firefighters are at risk of being subjected to mixtures of harmful substances from particles, gases and waste products that come from fire and pyrolysis. These can include heavy metals (lead, cadmium, uranium), various chemical agents

(benzene, polyaromatic hydrocarbons, toluene, formaldehyde) and minerals (asbestos, silicon dioxide, silicates).

Even the fire station, where the firefighters spend a great deal of time, contains complex mixtures of substances in particle form. (LeMasters et al. 2006).

Serious illness can be the result of having been exposed to many different harmful substances. It has also been proven that combinations of different chemicals which are not particularly harmful individually can give rise to entirely new and very hazardous effects (Mayer 1977). Firefighters are at risk of exposure to quantities of foreign chemicals at the scene of a fire and when handling material that has been in contact with pollutants from the fire. As a rule, both the type and concentration of substances that are formed or released in the event of a fire and pyrolysis are unknown to the firefighters.

People have varying degrees of sensitivity for exposure to different chemicals and mixtures of chemicals. This means that the risk of different individuals developing illnesses due to exposure to foreign substances varies.

It is known that harmful substances are formed in fires. Different substances can become even more hazardous in combination,

Some substances formed in fires only lead to harmful effects when they react with water from saliva or mucous in the airways.





People have varying degrees of sensitivity and the risk of developing illnesses varies.

and firefighters at risk of exposure to these mixtures do not know what substances they are exposed to or how this affects them as individuals. It is known that firefighters as a professional group are affected by certain illnesses, but it is not known which firefighters are affected. It has been established through previously mentioned meta studies (LeMasters et al. 2006) that firefighters run a higher risk of certain types of cancer. What is less researched is what other illnesses can arise as a result of firefighters being subjected to foreign substances. More studies are required to investigate the connection between the firefighting profession and serious chronic or sub-chronic diseases other than cancer.

Difficult to make early and reliable diagnoses

The only reasonable way to determine how people are affected by combinations of unknown substances suspected to be included in complex mixtures in different concentrations is via tests or taking samples. The problem with some of the illnesses that affect firefighters is that they can remain latent for a long time before any symptoms arise or are even measurable (Barry 2001).

Measuring and controlling illnesses is therefore difficult. Aside the fact that detailed health examinations can be resource-intensive

and lengthy, it is difficult to decide what should be measured and how. As the substances and consequences can be unknown, this can also mean there is a false sense of security in measuring certain substances as the most relevant tests could be those not carried out. Health examinations are necessary, but before we begin measuring health markers, the measurements must be so reliable that they do not cause more concern in the person being examined.

Even if it is possible to measure and prove the presence of certain substances in firefighters' bodies, it is at present difficult to predict the consequences of the combination of substances that a particular individual has been exposed to and how this affects him or her in the long term.

When discussing firefighters' heightened risk of serious illness as a result of their work, this must always take into account the fact that everyone can contract cancer and other diseases. Cancer is found among all professional groups, and it is very difficult in each individual case to ensure that an illness which takes a long time to manifest is work-related. At the same time, the connection between the professional role of a firefighter and a heightened risk of cancer has been evidenced, so it is therefore important to ensure that firefighters are not exposed to harmful substances more than absolutely necessary.

It is difficult to predict the consequences of harmful substances in the body, even if it is possible to check whether the substances exist in the body.





Risk factors in firefighters' work

Most people probably believe that a firefighters' working day takes place at the chaotic scene of a fire or accident. In reality, this working day is filled with completely different duties. Some of firefighters' work involves direct operative work, i.e., fighting fires and attending the scene of an accident. The rest of the work consists of various operations such as exercises, training, maintenance, recovery of used materials, physical training, prevention work and preparations for operative work. The fact that the work has such a shifting nature and involves such varied operations means that it is complex and difficult to predict. This also means that firefighters are subjected to a number of unnoticed, constantly recurring operations and situations, which in the long term can have a serious impact on health if such operations are not carefully executed.

Many fire stations can increase the safety of their operations

Foreign substances are handled in an unstructured manner at many fire stations. This is due to factors such as carelessness, culture, logistical conditions, lack of knowledge and behavioural psychology.

It is normal for contaminated turnout gear to be hung back in its place without first being cleaned. There are examples where turnout gear has been highly contaminated when hung up, leading to the spread of such large quantities of gaseous substances via the building's ventilation that people in entirely different parts of the



The working day consists of various operations such as exercises, training, preventive work and preparations for operative work.



All contaminated equipment must be handled so that people are not exposed to harmful substances.

building felt acute discomfort and had irritation symptoms. The majority of fire stations have been in operation for many years and ventilation systems are not constructed to prevent or limit the spread of undesirable substances between different parts of the building.

All pollutants from fire treated the same

All fires release harmful and toxic substances that affect people's health. Some common examples of substances from fires are benzene, chloroform, styrene, formaldehyde, brominated flame retardants, asbestos, isocyanates and carbon fibres.

Firefighters can never predict which harmful substances are formed or in which pollutants and concentrations these can occur in the event of a fire. It is difficult to protect against something unknown, which means that there is a tendency not to respect the danger. Moreover, damaging effects on health often do not manifest until much later (latency period). The fact that a long time can pass (10–40 years) before illness breaks out is perhaps the single biggest reason that firefighters tend to handle all pollutants from fire the same (“smoke as smoke and soot as soot”).

Different points of contamination

Obvious situations in which firefighters risk exposure to unknown substances include fires and accidents involving the release of harmful substances. Other less obvious situations include exercises, training, final extinction of a fire, decontamination, and

salvage work and fire investigations. The risk of contamination is also present when restoring equipment such as turnout gear, respiratory protection, hoses, vehicles and other turnout material. Simply staying in and working at a fire station with inadequate or non-existent procedures for handling contaminated material can have a negative impact on health in the long term.

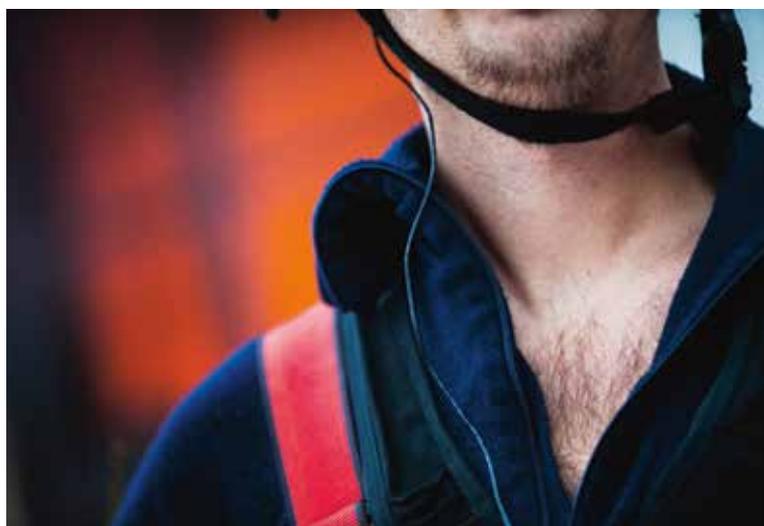


REFLECT

Why do we sometimes act as though combustion gases and soot particles released from a burning car during an exercise are less harmful than in a real callout?

Involuntary risk-taking

It is common for firefighters to enter the site of an accident without protection for both airways and skin. This is especially true for firefighters who have duties other than direct smoke diving, e.g., commander, pump operator or engineer. Research (Hertzberg et al. 2003) shows that harmful substances from a normal fire spread quickly and are found in high concentrations, even far from the area of the fire. This spread can be difficult or almost impossible to detect with our natural senses.



Even firefighters who do not subject themselves to direct smoke can be exposed to harmful substances.

Combustion gases from a normal fire also contain substances that have a numbing and desensitising effect on the airways' natural protective reflexes, by e.g., inhibiting the cough reflex. This means that firefighters risk involuntary exposure to even more harmful substances and particles due to the fact that their biological defence mechanisms are weakened and put out of action. Even firefighters who enter a fireground but do not pass through dense areas of smoke are exposed to substances and particles. As they are less exposed than colleagues in the immediate proximity of the source of the fire, the work environment is not perceived to be harmful, despite it being in reality a hazard to health. This experience is treacherous as the firefighters instinctively relate their situation to a visually healthier environment at the same accident scene. Firefighters often have a high acceptance for poor work environments, as it is always possible to relate to nearby situations with even worse working conditions. Furthermore, the situation of a person in the proximity of the site of the damage is normally considered temporary and quickly changeable.

IMPORTANT



The reason for wearing respiratory protection is not that the smoke is always hazardous; rather, because the firefighters are unable to know whether or not the smoke is harmful.

Many firefighters have long careers

The firefighting profession is not to be considered a transitional profession. Historically, firefighters begin work at a young age and then remain in the profession their entire working lives, until retirement. There is a low staff turnover in the firefighting services, something which indicates a high level of satisfaction. This means that there is plenty of opportunity and time for firefighters to be exposed to large quantities of harmful and unknown substances overall. Individual occasions on which firefighters take in harmful substances do not need to be particularly noteworthy, but the risk of suffering from a serious illness increases with the number of occasions. It is a matter of recurring situations and time spent in hazardous environments for an entire career. The saying “many small streams make one big river” is entirely appropriate here.



Firefighters often have a long career and run the risk of being subjected to large quantities of harmful and unknown substances overall.

There are a large number of occasions over a long career in which firefighters are exposed to unknown and harmful substances. Assuming that a firefighter in some way comes into contact with foreign substances in some form around once per week on average via callouts, exercises, training or handling contaminated equipment. This would mean over 50 occasions each year, which over an entire career would be around 2,000 occasions. Just one occasion per week for firefighters to be exposed to harmful substances should be considered a conservative estimate. The actual number of occasions is normally many times more.

Common points of discussion

Reflect on the following hypothetical situation. A fire station is alerted to a fire in a waste disposal room. A normal team for this kind of callout is one commander and four firefighters (AFS crew requirements for smoke-diving, AFS 2007:7) In order to effectively tackle the fire, the fire engine is placed as close to the waste disposal room as possible. The commander gains an overview of the situation at the fireground and prepares orders. Three firefighters prepare for firefighting indoors¹.

¹ Provisions and general advice on smoke diving and chemical diving can be found in the Swedish Work Environment Authority's directives, AFS 2007:7.

The driver (who is also a pump operator) is responsible for ensuring the firefighters' supply of safe water. Where possible, try to relate to first-hand experience and real events

1. Can someone determine with any certainty what the combustion gases from such a fire contain?
2. Is it possible to know with any certainty what effect repeated exposure to such combustion gases has on health?
3. In what way is vehicle placement important in this context?
4. Is the municipal Chief of Emergency Operations' capacity to assess the situation at the fireground and give orders affected by what protective equipment he/she is wearing?
5. Is full gear a given in simpler firefighting operations?
6. Do firefighters ever remove their respiratory protection equipment in too early a stage of the operation?
7. What protective equipment is worn by firefighters not fighting the fire internally at the scene?

When large quantities of mixed materials burn, it is impossible to assess the contents of the combustion gases.



After the operation, the firefighters return to the fire station to restore the vehicle and replenish supplies and equipment. Upon return, contaminated material arrives at the station from the site of an incident. The function and serviceability of the equipment is checked. The vehicle is resupplied and prepared for the next emergency operation.

8. Is it likely that tools and materials that have been at the fireground are contaminated?
9. How is the equipment used at the fireground transported back to the station?
10. Are the personnel's personal protective equipment and the vehicle always supplemented with clean and decontaminated equipment?

Waste is a simple, everyday example of a mixture of several unknown materials in different quantities. When this kind of mixture of materials burns, such large quantities of various chemical pollutants are released that it is impossible for the firefighters to assess the properties of the combustion gases and how toxic and harmful they are.

The air inside the vehicle cabin is the same as that of the surrounding environment, though heavily filtered via the vehicle's fresh air inlet. Standardised cabin filters in vehicles provide no

All equipment that is contaminated is potentially harmful before it is decontaminated.



protection against foreign, harmful substances and particles from a fire. An unfavourable placement of the vehicle leads to contamination inside the cabin and on the vehicle's other surfaces. Opening doors and shutters increases the level of contamination.

When the firefighters are to gain an overview of the scene of an incident and the commander is preparing orders, they are focused on their task. This situation entails that certain natural protective reflexes are not noticed. Few firefighters reflect on the fact that they have tears in their eyes and are coughing at the scene of a fire, for example, despite these being reflexes which in other situations act as warning signals.

Ensuring firefighters are wearing full gear even for simple firefighting operations would have a major impact on the way in which the skin is exposed to harmful substances in the surrounding environment. When firefighters remove their respiratory protection equipment too early (e.g., in the final extinction of a fire), the firefighters are exposed to harmful substances from their surroundings in situations where the toxicity is also high due to incomplete combustion.

The driver/pump operator/engineer is often in the proximity of the vehicle in order to extend the hose, secure the water supply and provide tools at the fireground. The placement of the vehicle is therefore of the highest importance for the driver's working environment.

All material that has been exposed to particles and dense combustion gases is to be considered contaminated. This may include firefighters' personal protective equipment: helmet, turnout gear, gloves, boots and respiratory protection. But it also includes other equipment such as hoses, hand tools, ventilation fans, thermal imaging cameras and radios.

All contaminated material gives off harmful substances via skin contact, at least initially. The material also emits harmful substances via particle dispersion (soot, etc.) at the location where they are stored and handled.

Material and equipment which is contaminated is potentially harmful before being decontaminated.

Personal Protective Equipment and contamination

Turnout gear

Modern turnout gear is designed to withstand stress from both the surrounding environment and the user's physique. There is also a strong symbolic value in clothes that have connotations of trust,



The performance of turnout gear is continuously developed and improved. The images show the development of turnout gear from the 70s and onwards.

group affiliation and personal identity. The functional requirements are thus also numerous. For example, the turnout gear must:

- protect the user from sharp objects
- withstand extremely high (and low) temperatures and the effects of steam
- repel moisture and water
- serve as high-visibility clothing so that firefighters are seen
- denote the professional role each individual firefighter has
- be well adapted ergonomically, as well as flexible and comfortable
- facilitate fall protection equipment (harness or belt)
- have space for communication devices, hand tools, etc.

There are many ergonomic challenges for firefighters at the scene of a fire or accident. The work involves a number of situations in which the firefighters must be able to move freely, such as when carrying equipment, climbing ladders, working on the roof or crawling.

Firefighters must be able to feel safe and trust in the function of their turnout gear as protective clothing in all imaginable con-

Throughout its life, turnout gear has been subjected to many stresses and instances of contamination; some difficult to remove with a normal wash.





Firefighters work in their turnout gear in many different environments.

ditions and situations, regardless of the surrounding environment with heat, cold, moisture, external force, etc. Functioning turnout gear is therefore expensive to produce and acquire.

The replacement cycle for turnout gear is relatively long, which means that the clothing is subjected to repeated and regular contamination during its service life. Soot and particles from dense combustion gas and aerosols have a tendency to become stored in textiles. Furthermore, some particles are difficult to remove in a normal wash. These include carbon fibres and asbestos, which are heavy, sharp and fibrous by nature and are able to cling to the fabric.



The helmet is another part of the equipment that becomes contaminated and it should be decontaminated as often as other equipment.

Helmet and Gloves

Helmets, gloves and boots are also surface layers which are contaminated to the same extent as turnout gear. The difference between these and turnout gear is that helmets, gloves and boots are, in general, decontaminated even more seldom.

Due to its function and design, the helmet can become contaminated inside and out. Furthermore, it is worn on the head, where it has close contact with both fine skin and airways. The helmet can thereby expose the user to harmful substances in a number of ways.

Firefighters' protective gloves are probably the protective clothing most subjected to contamination. The glove is the item which traditionally is the most difficult to wash and dry simply and effectively whilst retaining function. Firefighters' gloves are often made in leather or leather-like material, meaning they are sensitive to machine-washing. They also have a tendency to lose their shape if they are cleaned and dried carelessly. It is entirely inappropriate to touch a used protective glove with bare hands if it is not decontaminated as it may be contaminated by substances that can be absorbed via contact with the skin.

Boots

Firefighters’ boots often have a sole with a deep tread so as to provide good traction on different surfaces. This means that dirt and waste from the fireground is gathered under the boots and is easily transported back to the fire station unnoticed. A boot which is not decontaminated therefore functions as an effective spreader of uncontrolled and undefined chemical compositions.

Other textiles

Firefighters use uniforms and training clothes during almost every working shift. If these clothes come into contact with a contaminated environment, they also become contaminated, e.g., via storage, washing or drying together with turnout gear which is not correctly decontaminated. Handling clothes in this way therefore entails a risk of subjecting firefighters to foreign substances via contact with the skin. In the same way, towels and bed linen can transfer foreign substances to the skin if handled incorrectly.

Careless handling of contaminated equipment can lead to the transfer of harmful substances to textiles such as towels and training clothes.



Even when the worst of the fires has been put out, the compressed air breathing apparatus must be kept on.



Breathing apparatus and contamination

Respiratory protection with overpressure is personal protective equipment for firefighters and life assurance in the truest sense. When firefighters use the breathing apparatus, they often find themselves in environments which can be directly harmful to health and deadly. This means that the stress on the outer layer of the breathing apparatus is often extreme.

The construction of the breathing apparatus has a number of design considerations other than its main function. It is both heavy and bulky, and there is plenty of surface area for airborne soot and particles to attach to.

When the need of breathing apparatus is no longer deemed urgent, its weight quickly becomes a burden. To move more effectively, firefighters are therefore tempted to remove the apparatus at too early a stage. Unfortunately, it is not always the case that the apparatus is replaced at this point with another form of respiratory protection. As final extinction and similar tasks take a long time, firefighters are exposed to a large total dose of foreign substances. The need for protection for the airways remains even after the worst of the fire is extinguished.

The properties of the breathing apparatus also affect how it is washed and restored. Qualitative manual decontamination of breathing apparatus is time-consuming, tough and laborious. The perception that the equipment will soon be used again and thus dirtied once more can mean that it is tempting not to clean it. Foreign substances remain on breathing apparatus that is inadequately or carelessly cleaned.



A normal fire often results in large quantities of contaminated equipment.

There are many occasions on which firefighters come into direct physical contact with breathing apparatus. Examples of this are:

- functional (when switching watch)
- alarm
- exercise
- training
- post-fire care
- all other use of the fire engine
- transport to and from callouts
- service and maintenance.



The fire engine becomes contaminated like other equipment and can have harmful substances inside and out.

Vehicles and contamination

Vehicles used at the fireground are at risk of contamination both externally and internally. They are also contaminated when used material and personnel with dirty clothing are handled carelessly when they are to be transported back to the fire station. Firefighters often come into contact with the vehicle's exterior, e.g., during:

- alarm
- exercise
- training
- service and maintenance
- maintenance and replenishment of the vehicle's equipment
- functional check when switching fire watch
- transport to and from study visits, physical activity, lunch visits, etc.

Other material and contamination

Firefighters often come into contact with e.g., hand tools, thermal imaging cameras, power tools, piercing nozzles, branch pipes, crowbars, Halligan tools, lines and spades. Sporadic contact with poorly contaminated hand tools and machines are also occasions on which firefighters are exposed to harmful substances.

Shared radios and mobile phones are used by different people. It is impossible for the individual user to know in which situations they have been used previously. Radios and telephones are generally sensitive and therefore difficult to decontaminate, which means that they are seldom decontaminated. The apparatus is used in contact with and close to the skin and airways, thereby exposing the firefighters to unknown substances.

Great lengths of fire hose are often used in fires. The hose has a coarse, durable surface which functions as an undesirable gatherer of substances from the surrounding environment. When a fire hose full of water is dragged across the ground at the scene of a fire, it collects soot, ash and other waste from the fire. After use, the hose is rolled up, transported back, decontaminated, pressure tested and, where necessary, repaired in order to be used again in service. Firefighters' work to restore fire hoses is another occasion on which they involuntarily come into contact with foreign substances.



The coarse surface of the fire hose means that soot, ash and other waste from a fire are easily gathered.

Contamination during callouts and training

All incomplete combustion leads to the emission of toxic and harmful substances in various forms and quantities. There is no doubt that any fires encountered during a callout release harmful substances. But a car which is set on fire during an exercise, for example, is not always met with the same respect and protective action as a burning car in a real accident. Harmful substances are of course the same regardless of whether they are released in a real accident or a training situation.

REFLECTION



What is your experience of the use of personal protective equipment in the post handling of dirty material from exercises, compared with the same handling after a real callout situation, e.g., when processing hoses, turnout gear and respiratory protection equipment?

Psychological aspects: Ignoring risks

It is obvious that the environments that firefighters periodically find themselves in are directly harmful and that this affects the individual's health in the long term (see the chapter on Combustion gases). This is public knowledge, but most fire stations have taken few or no measures to address the situation.



How an individual perceives and interprets risks affects how he or she goes on to handle the risk.

The individual's own view of risks

There must be at least as many reasons to apply to become a firefighter as there are firefighters. An important part of the professional role of a firefighter is to provide assistance and to resolve various situations for those who are vulnerable and in distress. The willingness to help others sometimes means that firefighters' own protection is neglected. In a group consisting of many people with such duties, this behaviour can be reinforced.

For the psychological aspects of risks, it is important to understand that it is not only the real risks that are significant. It is important how individuals perceive and interpret risks, as this has a major impact on how individuals handle these risks (Glassner, 1999). The factors that cause concern among people differ from one community to the next, and have varied historically. From time immemorial, hazards and risks have been associated with traditions and cultural beliefs (Odén, 1998). How individuals evaluate risks is affected by their perception of how the risks occur and what capacity they have to protect themselves. People therefore react strongly to certain risks and ignore others, even if the reaction does not reflect the actual severity of the threat (Enander, 2005).

People generally have the ability to disregard risks as most people believe that others are more vulnerable or run a higher risk of injury than themselves (Pidgeon et al. 2003). Risk perception differs significantly between women and men as groups. Women tend to perceive risks more clearly than men (Savage 1993). Men have greater difficulty than women in immediately seeing the positive side of safety and safety measures (Gustafson 1998). Men also feel in general that they have sufficient information and knowledge of risk and safety issues. They are also less concerned than women, especially when it comes to assessing risks to the individual (Enander 2002). A study in 1993 also showed that safety awareness is generally better among women than men (Crowe, 1995). As the firefighting profession has a heavy over-representation of men, it is likely that firefighters find themselves in a work environment where the risk to individual health is underestimated more than in professional groups where there is a more even gender distribution.

A hero's role, but no supermen

Firefighters are often perceived as heroes to some extent; constantly prepared to save and protect. This hero's role can contribute to

a feeling of invulnerability and a willingness to deny the actual risks. There can to some extent be a point in firefighters not having an exaggerated sense of their own fragility, so as to function socially in their group and professional role. At the same time, it is important to understand that no human being is invulnerable or immune to serious illnesses. Firefighters are not supermen.

An individual with their own experiences of undesirable events generally assesses the likelihood of similar events occurring in the future higher than others. Such individuals are more careful. But the more time that passes after such an event, the more this carefulness subsides. (Reason 1997). The person's own experience of an undesirable event is also interpreted individually. Two people with experience of the same ordeal can have entirely different perceptions of the risks and have entirely different standpoints afterwards (Weinstein, 1989). If a firefighter suffers a serious illness which is expected to be work-related, the colleagues' risk awareness will likely increase immediately, but only in the short term. Due to difficulties in breaking old patterns, the firefighters are at risk of gradually resuming the habits and routines that were in place prior to their colleague's illness.

Firefighters that put aside their own health to save others can in the worst cases become ill and cause losses for themselves and their families.





Voluntary and involuntary risks

There is a difference in how the individual reacts to voluntary and involuntary risks. People accept to a greater extent risks that are perceived as voluntary (Starr 1969). Some acute risks trigger emotions in the individual and automatically release natural warning signals. Other risks that take a slower course or are associated with well thought-out decisions based on an assessment of likelihood, etc., do not result in the same intense emotional response (Slovic 2002). It is thus important to understand how people evaluate, perceive and reflect on risk (Slovic 1987). Many of the risks in firefighters' work environment are evident, e.g., in an indoor firefighting situation, working at height or working on a road at the scene of a traffic accident. But the risk of suffering from ill health in the long time is not nearly as tangible, even though it may be just as serious. In addition, firefighters see advanced firefighting and the handling of equipment in connection with a fire as a natural part of the job and associate this with a sense of volunteerism.

Protective measures are often taken in face of immediate risks in firefighters' work, unlike in the case of risks whose consequences are delayed.



Like smoking, the risks in firefighters' everyday lives affect health in the long term and tend not to be treated with the same respect as an evident risk of injury.

Habitual blindness

When people routinely and repeatedly find themselves in contexts and environments, such as at their workplace, they tend to develop habitual blindness. Habitual blindness means that a person subject to repeated experience of the same situation or phenomenon becomes numb to it and stops reacting to or even noticing the circumstances in question (Miller 2001). Tobacco smoking is a common example of this phenomenon. It can be said that almost all smokers at least partly know the risks to health associated with tobacco. Smokers do not change their behaviour despite knowledge, insight and clear marking in capital letters on the product packaging itself, declaring that “SMOKING KILLS”. Conscious choices and dependency factors aside, habitual behaviour is interesting.

Simply put, it can be argued that firefighters function in a similar way to smokers in the sense that acts which can affect health in the long term are so common, and so evident and frequent in their context, that the individual is not concerned in carrying them out. So that firefighters can carry out their everyday tasks, contact with materials or environments that contain unknown substances is difficult to avoid. Though it is known that the situation at hand

can entail the risk of contact with unknown substances, it will likely go ahead even if adequate protective equipment is not available.

The difficulty with assessing risks

Situations which entail delayed effects are not perceived as serious or dangerous as situations with immediate effects. The same applies to invisible, new or unknown risks (Fischhoff et al. 1978). The risk is thus perceived as lower if the effects of being exposed to the risk are delayed, unknown or hidden. Unfortunately, these criteria correspond well with several of the risks that can cause firefighters to develop serious illnesses. This means that the risks can be perceived as less serious, despite the fact that in the worst cases the consequences can be fatal. The reality is that the majority of the factors that affect risk perception are to the firefighters' disadvantage:

- Risk-taking is voluntary in the sense that the tasks are largely self-elected.
- The risks are common.
- Similar operations are part of the work of all firefighters across the world and are repeated on a daily basis.
- The consequences are delayed due to the fact that it takes a long time for the illnesses to develop.
- The consequences vary as the mixture of particles and chemicals cannot be assessed or checked.
- The work sometimes entails extreme time constraints and a heavy workload, and this likely affects the inclination to not follow self-protection and decontamination routines.

These factors mean that attentiveness to, awareness of and insight into firefighters' situation - as well as functioning routines - are important in reducing the risks.

Tools

**Routines
and flows**

Knowledge and insight

The Skellefteå Model

– Better health for firefighters

“Self-maintaining works best”. This is the starting point of the Skellefteå Model (The Swedish Way). The Skellefteå Model is a points system which exemplifies and describes how firefighters can avoid hidden dangers in their working day with the use of simple routines and logical flows. The goal of the model is for the firefighters to avoid serious illness as a result of long-term and repeated contact with foreign substances. The model is based on the thesis “from one alarm to the next”, which also summarises the cyclic activities of firefighters called into duty.

Firefighters’ perception of their own situation does not always correspond with the actual circumstances. The reason for this can be found in historical professional culture, attitudes and the fact that the threats or dangers in this case have relatively unclear and obscure contours. The basic knowledge that leads to insight is therefore the foundation of the model.

The Skellefteå Model is a collaboration

The Skellefteå Model consists of a number of operations which each have a special function. The model is based on a team approach: “one for all, and all for one”. The work with the model requires individual responsibility in a way that and individual that deviates from the new routines will expose themselves and their colleagues to what everyone is working together to avoid. A person who shows respect for themselves quickly wins that of others. When the

An individual that deviates from work routines exposes themselves and their colleagues to what they are fighting to avoid.



Skellefteå Model is applied, the positive changes in the general environment are so immediately noticeable that even small deviations stand out via smell and visible dirt and are therefore easier to address; this may include forgotten or neglected materials.

Unknown particles to be considered harmful

One of firefighters' regular duties is to restore vehicles, materials and protective clothing that have been in contact with foreign substances in connection with fires, accidents and exercises. It is very common for such material to be restored and handled by a firefighter that does not know what the material has been subjected to or in which situations it has been used.

As firefighters have irregular working hours, varied workloads and a large number of shifting operations, jobs can sometimes be interrupted and then completed by a different person. It is also quite common for a firefighter to take over a colleague's task in the event of e.g., interruptions in the form of an alarm, shift changes or abnormally long and large-scale operations that require relief or extra personnel. This means that the firefighters lose a sense of context and thereby also lose control over what the materials and equipment have been subjected to and in contact with. The result can be that all particles and pollutants are handled routinely.

As the firefighters are unable to check which substances they risk coming into contact with, the conclusion is to use the precautionary principle. All unknown particles and remains from dense combustion gas shall be considered harmful as there is no evidence to the contrary.

Clear and simple routines that work

In order to distinguish contaminated clothes, materials and vehicles from what is clean, clear and simple flows and routines are required. These flows and routines should however neither delay nor complicate the everyday work. Experience clearly shows that everything which is time and energy-consuming or includes a greater number of operations tends to be avoided (Halbesleben et al. 2008).

Without a frame of reference, it is difficult to compare a thoroughly decontaminated work environment with one which is imperceptibly contaminated. The absence of serious illnesses is not necessarily down to the work environment being controlled. If the firefighters of the future are not as often affected by serious illnesses, it is still never possible to prove that individuals have become healthy as a result of improved routines and flow.

The vast majority of firefighters do not suffer from a serious occupational illness. For those affected, it often takes a very long time before the illness develops; in some cases as long as 40 years (Mustacchi 1996). The fact that it takes a long time for firefighters' occupational illnesses to manifest is one of the biggest reasons for the situation not having changed appreciably. When it takes a long time for illness to manifest, firefighters are often able to retire before they fall ill. The illness is thus not always associated with professional life. This means that knowledge and insight must be quickly disseminated so that the situation changes for the better. However, it is not enough simply to change behaviours and routines. There must be a certain level of equipment to ensure the right conditions for a sound and health-conscious work environment.



Equipment and material must be handled as if it were contaminated if it is unsure as to what it has been in contact with.



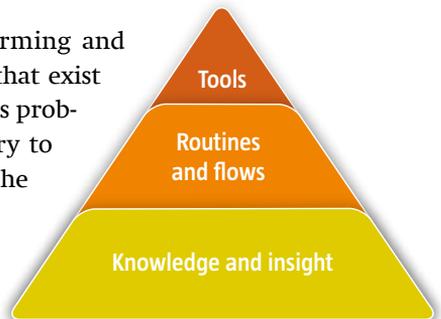
Introducing and using the Skellefteå Model

The Skellefteå Model is a tried and tested approach to creating a good and sustainable work environment with simple means. The model ties together a number of points into one. It deals with normal operations found in all fire departments and emergency services in varying degrees and frequency. Naturally, local opportunities and conditions must be taken into account for the station in question. Emergency services that fully introduce the Skellefteå Model in all its parts will quickly see surprising and tangible results in the work environment. Clear improvements are soon so noticeable that those affected tend to be surprised. It is only afterwards that people notice what the situation was like before.

Training, knowledge and insight

A suitable start for this process of change is informing and educating about the hidden risks of contamination that exist in firefighters' work and what can be done about this problem. To create motivation for change, it is necessary to provide information about the risks that exist and the harmful effects of poor or non-existent routines.

When firefighters gain knowledge of and insight into their own situation, it is obvious to them



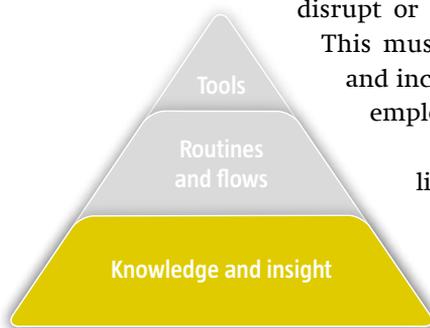


Simple solutions produce tangible improvements; it comes down to reviewing common operations in daily working life.

what changes and improvements are necessary, which thus makes them easier to implement. It has proven to be crucial to the results that as many individuals as possible have knowledge about how firefighters are exposed to harmful substances. All personnel in all personnel categories on all levels of the organisation must receive this knowledge. In order to facilitate changes to ingrained routines and behaviours, everyone must help one another. The importance of smart, obvious and simple solutions that do not disrupt or complicate operations cannot be overemphasised.

This must apply to all personnel affected in the workplace and include the entire organisation, full-time and part-time employees alike.

Sound health is a fundamental condition for a good life and is therefore a precious gift. It is also an area which affects everyone. When the everyday behaviour and routines of a given group are set to change, regardless of which areas are concerned, there are individuals who deny or belittle new

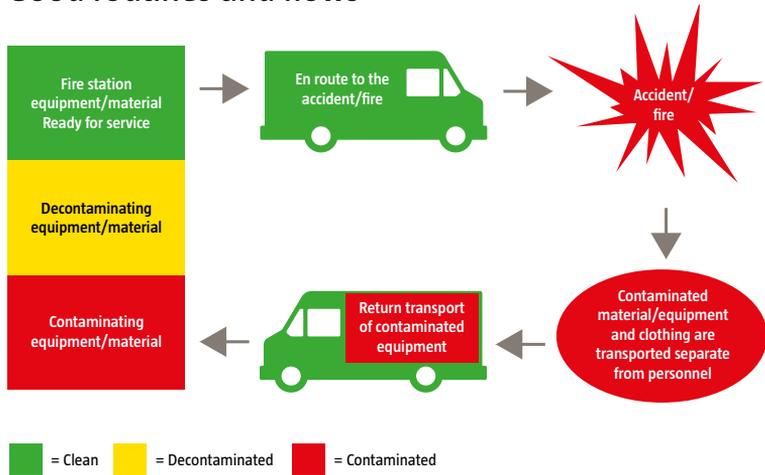


findings, changes or reforms. This may be due to ignorance, fear or how they are as a person. It is not entirely uncommon for these individuals to be influential and command a lot of space (Mårtensson 2002). Fortunately, it has proven to be the case that even these individuals become interested and are influenced by clear decisions concerning the vulnerability of their own health. This is one of the reasons why it is so important that a well-composed and clear message about working with health issues is firmly established and communicated to everyone in the concerned organisation. As the process takes into account everyone's health, even those opposed to changes tend to stop hindering the development. It is then easier for those driving the process to garner attention for the necessary adaptations and improvements.

Knowledge and insight are important to understanding what changes and improvements are needed.



Good routines and flows



The Skellefteå Model is based on simple routines and flows which, combined, create a good work environment.

Transporting clean equipment to the scene of the accident

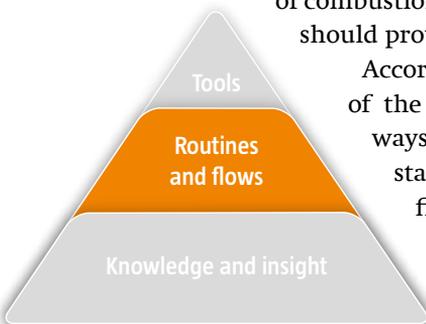
When the alarm sounds and the firefighters head to the scene of the incident, the starting point is that all equipment is clean and free of harmful substances. This includes the firefighters' personal protective equipment and the vehicle cabin in which they are transported. Upon arrival at the scene of an accident, the vehicle should be positioned so that the fire engine and associated equipment are not contaminated unnecessarily.

Routines at the fireground

It is common knowledge that when firefighters are at a callout or in an exercise situation in which foreign chemicals are present (known as a chemical alert), there are well-established safety routines and a high level of protection. Routines for the decontamination of individuals and material are also self-evident. But in the most common situations, where the poor environment is a result of combustion products, it is for many not as self-evident that they should protect themselves.

According to the Skellefteå Model, the routines at the site of the accident are therefore based around avoiding the ways in which firefighters can be exposed to harmful substances: via breathing, skin contact or oral intake. Firefighters should not unnecessarily expose their skin in a poor environment, take in poisons via the airways or unintentionally consume harmful substances.

When the context no longer requires the use of



the breathing apparatus, each firefighter should have a filter mask on hand with which to protect the airways. The filter mask must be immediately available, stored in a pocket in the turnout gear. This helps avoid “I’m just going to ...” situations, whereby the firefighter does not use any form of protection for their airways during temporary tasks or conditions in a poor environment. When a firefighter is to pass through a contaminated zone or provide a colleague with equipment, or when the wind suddenly changes, for example. All experience shows that even the smallest detour required to fetch protection for the airways is too long if the reason for doing so is a task which is considered temporary or quick.

It is tempting for firefighters to remove their protection during prolonged tasks and thereby expose the skin, especially in hot environments. Firefighters must strive to retain the protection of their full body covering and protect the skin as far as possible. If firefighters eat at the site of a fire, they must do so in a suitable environment so that what enters the mouth has not come into contact with unknown substances. Naturally, the facility to wash hands should also be available. It is also worth considering that some of the airborne particles that reach the mouth and throat, when firefighters do not use protection for the airways, will reach the stomach and be absorbed into the body this way, just as when we eat.

Changing routines and storage of contaminated protective clothing

When the intervention is complete and the firefighters’ equipment has become contaminated, they must remove their protective clothing and pack this into an airtight case. After hard work, firefighters are often sweaty and moist on the surface of their skin. To remove a protective layer of clothing at this point can lead to a rapid decrease in temperature with severe discomfort as a consequence. It is therefore important to have a dry, suitable change of clothing close at hand. One appropriate solution is to have a change of clothing for all passengers available in the fire engine. In this way, no-one is at risk of being without a change of clothes. An alternative is for each individual to have a personal change of clothes that they take with them on every callout or other situations.

Switching to clean, dry clothes after completing an intervention in a callout or an exercise is a task in itself. The circumstances cannot be predetermined and the change must take place even if it is the middle of the night, if there are poor weather conditions, or in other inconvenient situations. Firefighters are often exhausted



Switching to clear, dry clothes after completing an intervention should be done regardless of the weather and time of day.

after a callout and their focus is on recovery. In this situation, it is stressful to have to prepare the turnout gear for washing. If the equipment on the turnout gear is first removed at the station, this facilitates the change of clothing at the site of the incident. When the task of changing clothes is simplified, it is more likely to be carried out.

Storing contaminated breathing apparatus in an airtight case

The design of the breathing apparatus, with different composite materials and many components, means that it easily becomes dirty. The breathing apparatus' primary area of use is in the most hazardous of environments. Naturally, the breathing apparatus is therefore greatly exposed to the harmful substances and particles released in fires. The soot and particles stick to its surface and are thus carried on to the post-fire handling process. When contaminated breathing apparatus is to be transported to the station to be decontaminated and restored, it should therefore be stored in an airtight case. The case facilitates handling of the apparatus and is used to prevent the spread of harmful substances to firefighters and the surroundings.

Storing dirty hoses in an airtight case

As fire hoses have a coarse surface which easily attracts dirt, substances in the surroundings such as soot, ash and other contaminants from the fireground readily cling to them. A hose full of water is heavy, and at the fireground it is often wet or moist. When



Rolling a clean hose involves no health risks. If the hose is dirty, gloves should be used.



A hose full of water is heavy, and when it is dragged across the dirty ground, large quantities of particles cling to the coarse surface.

the hose is to be moved, the firefighters pull or drag it along the ground. The weight means that friction with the ground increases, and thus the surrounding jumbled waste from the fire easily clings to the hose's coarse exterior. If in addition the waste from the fire is wet and sticky (which it often is), large quantities of various particles stick to the hose.

When the hose is to be gathered up at the fireground after an operation, the firefighters should use gloves so as not to come into

contact with foreign substances. If the environment is dry and the hose kicks up dust, for example, it is appropriate to use a filter mask when handling. Ideally, the hose should be placed in an airtight storage device in the same way as turnout gear and respiratory protection in order to reduce the amount of particles spread during transportation and handling.



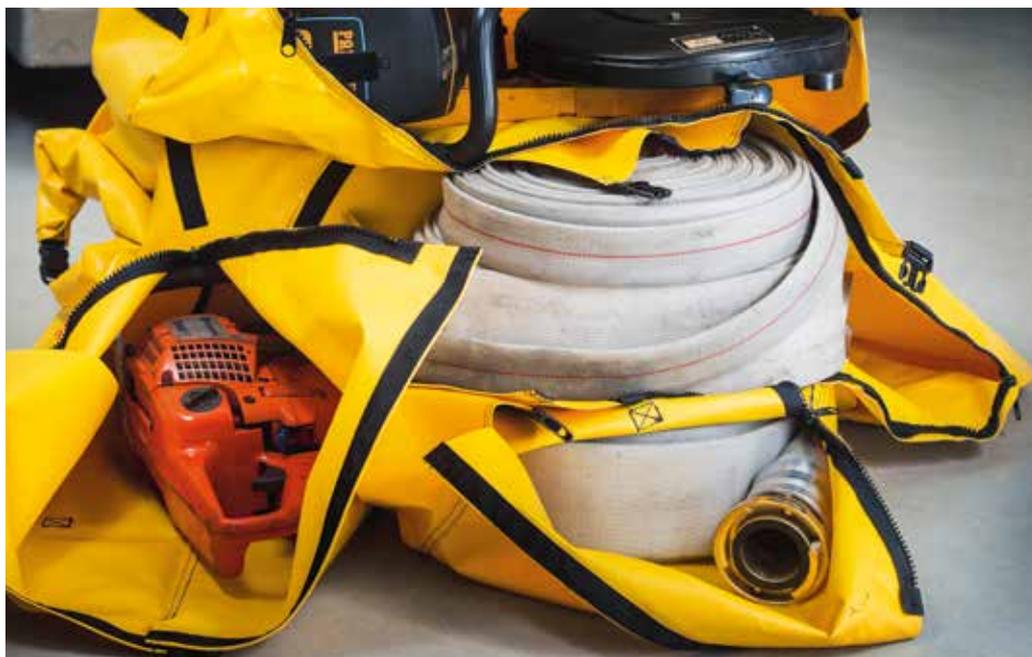
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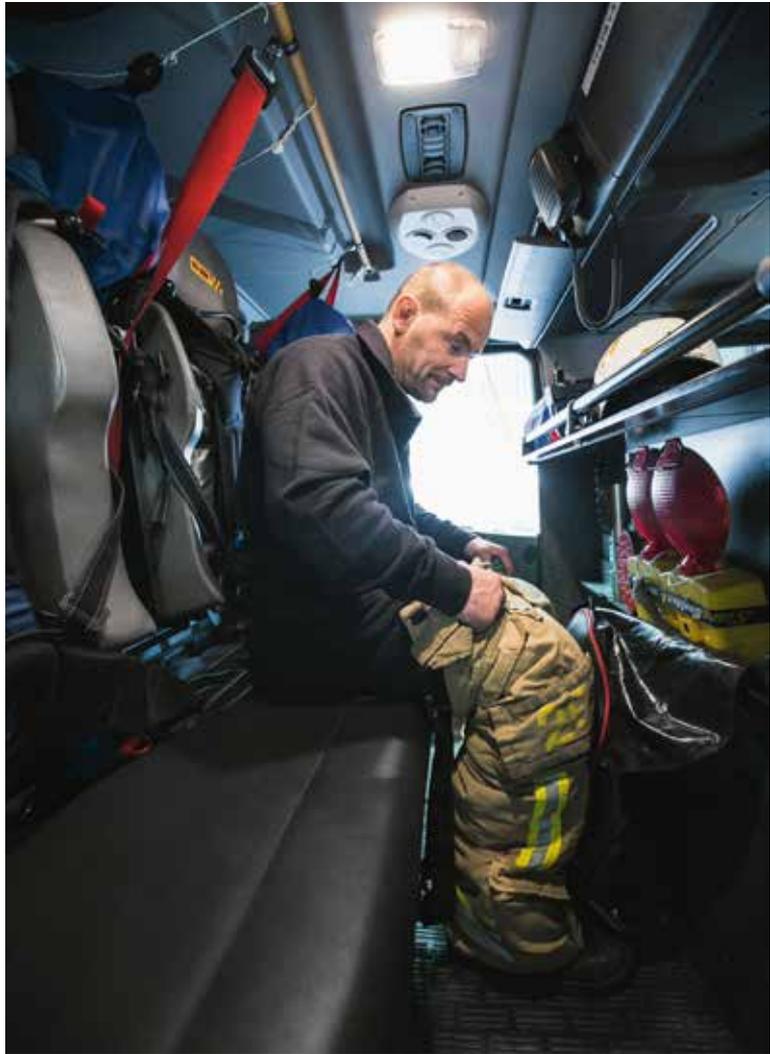
Do you as a firefighter use gloves when rolling up the hose?

Storing other equipment in an airtight case

All other materials which are used in firefighting operations and which thus become contaminated are potential spreaders of foreign substances. These include power cutters, chainsaws, thermal imaging cameras, power tools, steel rods and steel pipes. If other material is encased and stored securely during transport and handling prior to decontamination, additional sources of risk to the firefighters' health are removed.

After an operation, the hose should be placed in an airtight storage device so that particles are not spread.





The bags containing the contaminated equipment can be kept easily accessible so that if necessary in the event of a subsequent callout, the firefighters can suit up whilst retaining acceptable turnout times.

Return transportation must be conducted in a clean environment

When the above routines are followed, the environment during return transport will automatically be clean and healthy for the firefighters. The contaminated protective clothing (turnout gear, helmet, gloves, boots and, where applicable, base layers) have been packed into a storage device and are perhaps stored in controlled conditions in the cabin beside the firefighters. Other equipment is also well packed in another place in the fire engine.

It is of course desirable for the firefighters to return to the fire station at this point in order to decontaminate and restore the

equipment in an orderly manner. Normally, there are no further alarms on the return journey to the fire station, but unfortunately it is occasionally necessary for the firefighters to carry out one more mission. If an event of an acute nature occurs and the contaminated team are the most appropriate resource at the time, the firefighters can suit up once more, preferably without having to leave the vehicle, and carry out the new assignment. With the above routine, the turnout time (the time from the alarm to arrival at the scene) will be the same as if the firefighters had never removed their contaminated clothing. The advantage of this habit is that it is possible to retain the discipline of removing contaminated turnout gear even those times when the firefighters feel they have been subject to very little contamination or are in a good state to conduct further operations. It does not need to be particularly hazardous to health to work in dirty turnout gear on isolated occasions; it is the combination of frequency and time that has an impact.

All contaminated material has only one way into the fire station

It is important to have well thought-out flows so that firefighters can control the spread of harmful substances prior to decontamination and restoration. It is therefore good for the used equipment to be brought into the fire station via a predetermined route where possible. If this is not possible, e.g., due to the state of the premises, it is even more important for the contaminated equipment to be contained so as not to needlessly spread harmful substances throughout the fire station.

Protect skin and airways when washing turnout gear

Preparing turnout gear for washing is an additional task which can entail the risk of contact with foreign substances. Before the turnout gear is placed in a washing machine, all zips and Velcro must be fastened, pockets emptied and filters, note-taking materials, radios, telephones and hand tools removed, along with any fall protection equipment. It is therefore important to protect the skin and airways when carrying out this task. This is preferably achieved with full gear (long arms), gloves and some form of particle filter for the airways. Turnout gear must be washed and dried separate from other items of clothing.

It is important that the turnout gear can be washed quickly and easily. As a rule of thumb, the washing, impregnating and drying process following an everyday alarm should not need to take more than three to four hours in total. If the washing process



A smart solution for the thorough decontamination and cleaning of compressed air breathing apparatus is to machine wash.

When preparing turnout gear for washing, the airways and skin should be protected.

The process of washing, impregnating and drying should be effective and not take more than three to four hours.

is kept effective, double sets of turnout gear for each individual are not required in most cases. One solution if a subsequent alarm is received whilst gear is being washed is that each firefighter designates a colleague in another team with similar body measurements and temporarily borrows his or her turnout gear. Another solution may be to have a number of sets of turnout gear in different sizes on standby which can be used as a replacement whilst others are being washed. The reason for not investing in double sets of turnout gear for each firefighter is that the performance of turnout gear is constantly being developed and improved. Solutions with double sets of turnout gear risk doubling the service life, which can eventually result in outdated protective equipment. There are also economic reasons for keeping the capacity to a size which is reasonable in relation to the station's everyday events.

Thorough decontamination of respiratory protection equipment by machine

One smart solution for thorough decontamination and cleaning of compressed air breathing apparatus after each use is to machine wash. Thorough decontamination in a purpose-built machine pro-



In the absence of a washer, manual washing is an alternative for decontaminating the breathing apparatus.

duces quicker and better results and is one of the cornerstones of the Skellefteå Model. Just as with all other handling of contaminated material, the washing process is carried out for full gear and simpler forms of protection for the airways.

Manual cleaning is an alternative in the absence of a machine.

Soak fire hoses when storing prior to washing

Traditional washing and hydrostatic testing of fire hoses involves many different stages and actions which can expose firefighters to harmful substances. A dirty fire hose handled dry will release large quantities of the waste from the fire which remains on the outer layer in the form of dust and soot, particles which then become partially airborne. If in such a situation the firefighters do not have respiratory protection when handling the fire hose, they will inhale some of the dust. If in addition the hose is handled without gloves and full gear, the skin will come into contact with the foreign substances found on the fire hose's outer layer. It is therefore appropriate to always handle a fire hose used in unfamiliar environments with full gear, gloves and respiratory protection.

In order to drastically reduce the quantity of airborne particles spread from the fire hose, it is appropriate to keep the hose in water until it is washed. Soaked hoses release considerably less airborne contaminants and are also much easier to wash and clean effectively.

All other material must also be cleaned

All other equipment used at the fireground must also as far as possible be decontaminated before being used again, for example hand tools, thermal imaging cameras, power tools, piercing nozzles, branch pipes, crowbars, Halligan tools, lines, spades, radios and telephones. Even the simplest drying process for materials, using detergent and a cloth, are a winning concept in the long term. Suitable protective equipment should also be used when handling such material.

Bodily decontamination

Alongside decontaminating equipment and material, it is important that firefighters have the possibility to wash themselves. A thorough shower with soap and shampoo is appropriate for removing particles and waste from the fire from the body's exterior. This should be done as soon as possible after entering a contaminated environment.

The change of clothing used during transportation to the station must be washed before being used again.

Conditions and equipment

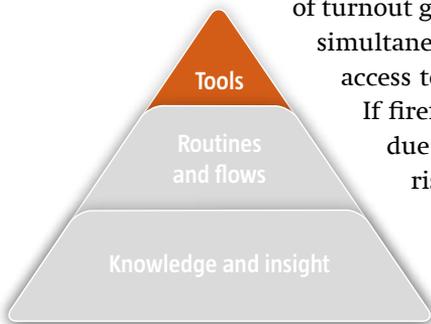
Alongside knowledge, insight, flows and routines, certain purpose-built equipment is required to achieve a good and healthy environment.

Washing machine with sufficient capacity

It is important to create opportunities for handling, washing and drying turnout gear separate from other clothing. Washing machines for turnout gear must be of the right quality and have sufficient capacity in order to avoid inadequate cleaning or queueing of loads.

A common "everyday alarm" (such as a fire in an apartment, waste disposal room, car or storage) normally results in two to five contaminated sets of turnout gear. It should be possible for all sets of turnout gear contaminated in this everyday task to be washed simultaneously and without delay so that each firefighter has access to their personal turnout gear as quickly as possible.

If firefighters risk not having access to their turnout gear due to queued loads in the washing process, there is a risk that the turnout gear will not be left for washing unless absolutely necessary (see the chapter Personal protective equipment and contamination, concerning turnout gear, function and identity).



Washer with sufficient capacity for thorough decontamination of compressed air breathing apparatus and other equipment

A machine used for thorough decontamination of compressed air breathing devices should have high capacity, as many respiratory protection devices are required even in everyday fires. Naturally, training exercises and events of a larger scale than the everyday also use up many respiratory protection devices. To facilitate thorough decontamination of compressed air breathing apparatus quickly and easily, it is therefore good if the machine has a certain capacity above the everyday. Wash programmes must of course be quick and effectively clean the equipment without affecting its function or shortening its service life.

The machine should be located so as to facilitate the flow when the equipment is restored following callouts and exercises. It should thus be placed close to the part of the station where the used equipment enters the building, if possible. If this is not possible, it is even more important for contaminated equipment to be well packed when handled and moved inside. This is to avoid the needless spread of harmful substances in the workplace.

The washer should have a high capacity as it is common for a large number of respiratory protection devices to be used in everyday fires.





As much as possible of the material used in an intervention should be kept in a sealed container pending decontamination.

Storing and transporting equipment in an airtight case

Dirt does not need to be removed if it is not brought into a vehicle or room in the first place. To facilitate simple control over all contamination, as much of the material as possible must be contained or stored by other means and transported in a sealed container pending decontamination.

Adapted ventilation is important

The ventilation must be approved in the areas of the fire station where contaminated material is handled and stored. Air that passes through these rooms must not be able to spread to adjacent spaces.

Simple donning and removal of equipment

Every fire station has a different layout, and thereby also different conditions for donning and removing equipment. The challenge is to design as simple a flow as possible with consideration for the local conditions. The goal is to avoid touching or moving contaminated material unnecessarily. A simple flow is important in order to have control over what material is dirty and what is clean.

Different filter masks

Respiratory protection in the form of filter masks is found in many different forms. The filter mask kept in the turnout gear is used for sudden and unforeseen events. The filter should be as compact and convenient that it does not disturb or get in the way when not in use. A larger and more cumbersome filter mask suitable for use over longer periods can be kept in the vehicle. Note that a filter mask must never be used in place of a compressed air breathing device.

Experiences



IMPORTANT

Not everything that smells is harmful and what doesn't smell is not necessarily harmless.

In an organisation that is to introduce routines similar to those of the Skellefteå Model, it can be problematic to immediately find the right level for which measures are to be taken.

Assessing who has been contaminated

Excessive fear of being exposed to harmful substances can be counterproductive and result in the inability to act. The perception of



It can be difficult for the individual to assess how contaminated their equipment is; let a team leader assess the need for decontamination.

contamination is subjective and is of course determined by what the individual firefighter has been exposed to. Nor is it necessarily the case that all individuals that have attended the scene of a fire have contaminated their equipment to the same extent. It can therefore be difficult for the individual firefighters to determine for themselves whether or not their equipment is contaminated. This is partly because it is often impossible to know what the individual has been exposed to and partly because not all harmful substances can be smelled or seen, and because different people experience the same situation in different ways. One solution to avoid arbitrariness and the inability to act is for a team leader or similar to take responsibility for assessing the need for decontamination. An individual that does not follow the routines will put their colleagues in danger (compare with passive smoking).

Handling other contaminated material

Not only turnout gear, breathing apparatus and hoses are contaminated by fire waste. Routines must be in place so as to facilitate simple handling and transportation of what can be summarised as “other material” back to the station. Other material includes power cutters, chainsaws, thermal imaging cameras, power tools, piercing nozzles, branch pipes, crowbars, Halligan tools, safety lines and spades. One good fix is to have storage solutions (bags, cases, etc.) ready so that diverse material can be stored away before being transported home. In this way, the spread of fire waste is reduced and the vehicle does not need to be cleaned to the same extent. For large-scale events involving a large turnaround of equipment, a separate means of transporting equipment back to the station is preferable; e.g., a truck or trailer.

Establishing work methods throughout the organisation

It is not unusual for a change in the working environment to take some time if the directive for change does not come with well-founded explanations. When it comes to new elements that change habitual behaviour, the person that is to carry out the new element must be told why. Otherwise, there is a risk of interrupting the decontamination process, which would eliminate the use of the new work method. The emergency services constitute a utilitarian organisation, and it is preferable if the benefits of a certain change can be shown in advance. In other words, it is a question of credibility, and of establishing support for the method throughout the organisation, so that the change is promoted by the firefighters themselves.

Simplifying

New routines that lead to a higher frequency of cleaning and decontaminating materials will take up more time and resources when done incorrectly. It is therefore important to keep the new elements simple, so that they are not deprioritised. For an organisation that has implemented the Skellefteå Model in a thought-out, well-prepared manner, and with the right resources, everyday operations will not be noticeably more complicated than before.



It's all about getting started – and solving any possible problems as they arise on the road towards new and improved working methods.

Making a habit of good handling practices

The firefighters may feel that they rarely work on fires of a magnitude that would expose them to large amounts of foreign substances. However, it is easy to forget that they are most likely exposed to a larger amount of contaminants from the total number of small fires they are involved in putting out, than from the lesser number of large fires.

Firefighters may be exposed to hazardous substances during their own callouts and training exercises, but also when they come in contact with the contaminated equipment of their colleagues, if this has not been properly handled. It may be tempting to skip the decontamination routines under poor conditions. If there are no established procedures in place, a situation may arise where those affected come to accept a hazardous environment under the premise “it was just this one time”. (Read more in the chapter Psychological aspects: ignoring risks).

It's simple – just do it

There must be a thousand excuses to query, delay or complicate the introduction of the Skellefteå Model in an organisation. One of the apprehensions is usually that it takes a lot of work to get started. Fortunately, the actual solution is very simple, and in many cases, the concerns have proven to be unfounded. A risk during the introduction is that focus is placed on the problems rather than the solutions. But it's all about getting started. After that, the fine-tuning and the local adaptations will follow naturally. Each day that passes without the model being introduced is a day wasted.

Conclusion: The Skellefteå Model improves the working environment of firefighters using very small means

The firefighter working environment is a global and widely recognised issue. Despite the known risks, there are few documented concrete action programmes. The Skellefteå Model (the Swedish Way) is an example of how it is possible to significantly improve the firefighter working environment with very small means, without complicating the work process. It is highly unlikely that firefighters will ever work in an environment completely free from hazardous substances; nor would it be practically possible. But on the other hand, no firefighter should have to risk unnecessary ill-health or suffering in their attempts to save human lives, property and the environment due to a neglected working environment.

There are few or no benefits from being afraid of soot or particles on isolated occasions. Aside from the incidents that are obviously harmful to human health, there is a long chain of repeated and often unnoticed occasions when the firefighters are exposed to hazardous substances. This chain is harmful and therefore needs to be disrupted. And doing so is perfectly possible without complicating the work of the firefighters. But it is difficult for a single individual to break a harmful pattern, since the firefighters' situation is so highly affected by the behaviour of their colleagues. Team work is required, and the knowledge and awareness must therefore be disseminated and accepted throughout the workplace if it is to have the intended effect. The current general situation is not satisfactory, and it must be taken seriously. At the same time, a healthy balance of common sense and deeper understanding is also necessary in this context.

Recommended further research and investigation

The fertility of firefighters

There are many aspects of firefighter health. One area that touches upon it, but which lacks extensive and reliable empirical data, is problems relating to the fertility of firefighters. It is known that firefighters are exposed to conditions that may impede reproduction, but it has not been proven whether this difference is significant in comparison to other parts of the population.

Fertility problems appear directly or in close connection to the firefighters being exposed to hazardous substances; fertility issues, unlike cancer, thus have a short latency period, or none at all. The effects of a reproductive disorder are thus clear and immediately discernible (Wischmann 2005). Certain professional activities have proven to be more common in men who seek medical help for infertility. These include activities where they have been exposed to solvents, metals, heat or cold and psychological stress. These factors are assumed to have a great impact on male reproductive abilities (Mendiola 2008). Even if there is limited knowledge regarding the effects of physical, chemical and emotional factors on male



Fertility may be affected when the body is exposed to hazardous substances, and the effect is not necessarily delayed as it is in other illnesses.



fertility, some connections have been found. Despite the proven connection between infertility and certain professions, it is difficult to distinguish specific causes and exposure to certain substances. The theory is that this is because there are often several concurrent factors which cause infertility (Sheiner 2003).

There is currently only very limited research available on pregnant firefighters, and how the work of a firefighter affects pregnancy. Smoke diving is currently prohibited for pregnant firefighters, in accordance with AFS 2007:7 BA (*Breathing Apparatus*) and *Full Suit Rescue*. What remains more or less unknown is whether the general working environment of the firefighters (aside from smoke diving and the actual firefighting) has any effect on fertility, and what that effect would be. However, we do know that many firefighters are exposed to several of the external factors that have been proven to affect reproductive ability. The question of whether firefighters are over-represented in cases of miscarriages and involuntary childlessness (for both women and men) is highly interesting. The same goes for the question of whether the firefighter work environment could even be detrimental to foetal development. This question is relevant not least because the correlation between children whose fathers are firefighters and congenital heart failure has already been proven (Olshan et al. 1989).

More knowledge is required on the effect of the working environment on firefighter fertility and foetal development.

As new work procedures are introduced, the demand for products to help improve the working environment increases.



Products adapted to the working environment of a firefighter

As the Skellefteå Model is becoming the norm, the demand for products to improve the firefighter working environment has begun to increase. Since the model is based on protecting firefighters from unnecessary contact with foreign substances, there are of course opportunities to develop products to help them in this respect. The innovative approach of the Skellefteå Model shows

that knowledge on the subject is still limited, and the product range is relatively undeveloped. Firefighters being a relatively small professional group, they have had to make do with material and standard equipment intended for other purposes than fire-fighting. This means that the development of specific products with adapted protective properties has long been neglected.

There are great possibilities for developing protective products directly aimed at firefighters: products that have the inherent capability of preventing or hindering the absorption of hazardous substances. The same is true for equipment that can be repeatedly but effectively decontaminated while maintaining function. There is currently no good selection of such products for those who feel that the aforementioned requirements are reasonable. New and creative innovations and solutions to improve firefighter health will hopefully be developed as knowledge and awareness of the problems grow.

What does turnout gear protect against?

The only thing that is more dangerous than being unprotected is taking risks thinking that you are protected. It is unclear how resilient the firefighters' turnout gear is to foreign substances in the gases, particles and aerosols in their working environment. The Swedish method of extinguishing fires through indoor fire-fighting may very well impact on the amount of foreign substances that the firefighters are exposed to. Turnout gear is designed primarily to shut out the heat of the combustion gases, but we now know that these gases also contain a high amount of toxic and hazardous substances. The firefighter turnout gear is in other words not primarily designed to prevent combustion gas particles from coming into contact with the body.

Indicating instruments

There are a number of products to detect the presence and levels of various hazardous gases in the environment. These products are effective when the user already knows what gases and substances they want to protect themselves from or discover. When a firefighter uses this type of product, one problem is that combustion gases contain so many different substances. It is therefore difficult to determine which of those substances the indicating instrument should be set to detect. Using warning equipment that does not indicate all hazardous substances entails a risk that the firefighter is given a false sense of security.

Glossary

Accumulation	Storage of substances absorbed from the surroundings.
Active operations	The parts of the firefighters' work that takes place in direct connection to an emergency operation.
AFS 2007:7	The Swedish Work Environment Authority's directives, publication Rök- och kemdykning (Breathing Apparatus and Full Suit Rescue).
Breathing Apparatus	Compressed air or various filter masks to protect the airways.
Cancer	Collective name for illnesses involving uncontrolled cell growth that destroys cell tissue.
Chemsuit	Protective clothing intended for measures with particular chemical risks.
Cocktail effects	Interaction of various chemicals, which can be detrimental to health. See Synergies.
Combustion gases	Energy-rich residues from incomplete combustion, in gas and particle form, which are expelled from fire.
Contaminated	Something that has been polluted or exposed to a foreign substance.
Contamination frequency	The number of times a person or object must be cleaned after contamination.
Engineer	Firefighter responsible for the provision of tools during an operation, for example after a traffic accident.
Exposure	When someone is exposed to something hazardous, such as skin being exposed to dangerous chemicals.
Fertility disorder	Disruption in the ability to have children (fertility).
Free radicals	Atom or molecule that is highly reactive, i.e., which easily reacts with other substances.
Full gear	The firefighter's personal protective clothing, when worn correctly, which minimises the thermal effects on their body.
Genetic material	Information coded in DNA.
Good practice award	European award to highlight the best examples of solutions to prevent work environment risks.
Hidden health risks	Risks to health that we do not notice.
Immune defence	The body's defence against pathogens.
Impregnation	Treatment of materials to give them particular properties, such as water-resistant fabrics.

Incident commander	The commanding officer (legal person) of a rescue operation in accordance with the Swedish Civil Protection Act (2003:778).
Incomplete combustion	Combustion without sufficient oxygen input, which means that residual products from the fuel remain or spread. This is always applicable to some extent in accidental fires.
Initial fire	The early part in the course of a fire, when the fire is only set in the initial source and does not yet have uncontrolled access to fuel.
Latency period	The time between initial exposure and symptoms, during which the illness remains undiscovered.
Mixed waste	Regular waste along with other types of waste.
PAH	Polyaromatic hydrocarbons.
Particle	A small portion of matter, such as soot, and small parts of residual substances from combustion.
Precautionary principle	Considering all that is potentially hazardous as risks until proven otherwise.
Pregnancy	Gestation period.
Proliferation	Reproduction (see Pregnancy and Fertility disorder).
PSA test	A medical test to check levels of prostate specific antigens, in order to discover an increased risk of prostate cancer.
Pump operator	The firefighter handling the engine during an accident, and who is responsible for the provision of water for the extinguishing operation.
Pyrolysis	Thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. The heated material expels volatiles in gas form.
Ready time	The time it takes from the firefighters receiving a call until they are on their way.
Replacement period	The period after which a product, such as turnout gear, is recommended to be discarded.
Routine alarm	A regularly occurring alarm that does not entail any significant deviations in terms of type or scope.
Skellefteå Model	A procedure for firefighters to follow in order to avoid exposure to foreign substances.
Smoke diving	Entering dense smoke (usually to save lives or to extinguish a fire).

Synergy	When the interaction of two or more substances produce a combined effect greater than the sum of their separate effects, i.e., 1+1 is not 2 but 3 or even 4.
Thermal stress	Strain caused by the temperature.
The Swedish Way	See Skellefteå Model.
Turnout gear	The firefighter's regular operative protective clothing.
Toxicity	The degree to which something is toxic.
VOC	Volatile organic compounds. Compounds that cause damage to organs and the nervous system.
Water supply	The firefighters' access to pressurised water at an (indoor) extinguishing operation.

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Appendix

Examples of risk identification at the fire station

- What routines are in place for handling turnout gear which has been decontaminated/dirtied during a callout/exercise/training?
- Is contaminated/dirty turnout gear transported separate from the personnel?
- Is turnout gear washed and dried systematically, and with the correct equipment?
- Is there a possibility to wash and dry turnout gear separate from textiles that sit close to the body (uniform, underwear, training clothes, linen, towels, etc.)?
- What routines are in place for handling dirty/contaminated breathing apparatus?
- Is contaminated breathing apparatus transported separate from the personnel?
- Is the breathing apparatus washed thoroughly by machine/manually prior to delicate wash/testing/restoring?
- What routines are in place for handling other material and equipment contaminated/dirtied during a callout/exercise/training?



A firefighter on an emergency response will often be in an environment where hazardous substances are present; and will be handling equipment and material contaminated by contaminants from the combustion gases. Repeated exposure to harmful substances may pose a greater risk of contracting a serious illness.

To avoid exposure a firefighter should have the option in all situations protect their skin and their respiratory tracts.

In Skellefteå, the fire & rescue service has now for many years developed procedures and working methods for a better work environment both at incident sites and at the fire station. The Skellefteå Model is now a proven way to work. A central part of the model is the procedures for the handling and cleaning of protective clothing and equipment.

This book provides examples and practical tips on how a fire & rescue service with simple means can reduce the amount of contaminants that personnel are exposed to, and thereby achieve a better work environment and improved health for firefighters and other fire & rescue service personnel.