Health Management of Compartment Fire Behaviour Instructors

CFOA
Chief Fire Officers Association

Contents

1. Introduction

It is generally accepted that the prolonged exposure to heat & smoke, as experienced by Compartment Fire Behaviour Instructors (CFBI), can have a detrimental effect on their health. However these adverse health effects, in terms of the specific nature and degree, differs from one academic paper to the next.

The purpose of this document isn't to clarify this position, but to recognise there are health implications from performing the role and more importantly, provide best practice guidance in an attempt to ensure a consistent approach across all UK Fire & Rescue Services (FRS). The document also includes what are generally no or low cost recommendations which will reduce these identified health risks.

2. Executive Summary

Despite a great deal of scientific investigation being conducted into the physiological hazards and risks associated with both operational firefighting and realistic fire training, there appears to have been very little specific research concerning the health and welfare of those live fire instructors who are, on a regular basis, subjected to such extreme thermal and toxic environments. With an increase in deaths and injuries to on duty firefighters causing concern to many UK FRSs there is an increasing call for more realistic compartment firefighting training (CFFT) of the kind that would best prepare operational staff for the dangers that they could potentially face.

"We are led to believe that due to a decrease in the occurrence of serious large fires that fire-fighters have less direct exposure to the risks they create; nevertheless, this remains the most common setting for fire-fighters deaths"

"The extent to which FRS's can create realistic and effective training opportunities to compensate for the comparative shortage of 'live' exposure is extremely important"

(The management of Health and Safety in the GB Fire and Rescue Service Consolidated Report Based on the 8 Inspections Completed by HSE in 2009/10. October 2010, p. 3-4)

Unfortunately, this increased demand for hot fire training will inevitably cause greater physiological and psychological stresses on CFFT training staff.

The existing body of scientific empirical evidence created by research conducted over the last few decades from around the world and, more recently, from within the UK South East Region, provide enough facts from which many generalisations, conclusions and recommendations can be safely made which relate directly and specifically to the health, safety and wellbeing of CFBIs.

The main purpose of the guidance contained within this report therefore is to inform a more proactive and holistic health management system specific to CFBIs. This will in effect represent the 'total package' approach endorsed in the document: "Fire Service Guidance on the Management of the Risk of Heat Stress During Training" (p. 2) as well as placing a greater emphasis on the type of leading performance indicators which are the hallmark of a more effective Health and Safety management system.

These recommendations are designed to be easily implemented with minimal attached cost and concern themselves with the following primary areas:

Hydration – with the strongest emphasis on pre-hydration along with the consideration for the use of electrolytes and carbohydrates mixtures.
Diet - with a combination of complex and simple carbohydrates to maintain constant energy levels throughout the day.
Active Cooling - before, during and after hot activities, not as a first aid measure but as a matter of course.
Frequency of Exposure - enabling rest and recovery time between hot exposures.
Regular Health and Wellbeing checks/monitoring - in order to ensure individuals are physically and psychologically capable of undertaking such training over prolonged periods of their careers.
Toxicity - both the minimising and decontamination of.

3. The Risks associated with Compartment Fire Behaviour Instruction

The Fire Service Manual Volume 4 Fire Service Training Guidance on the Management of the Risk of Heat Stress during Training deals specifically with what is described as "…less acute (but still short term risk) risk of physiological heat stress." (p. 1) to which those participating in realistic fire/breathing apparatus training may find themselves exposed to. This covers the students in receipt of the training as well as those instructors and any other support staff responsible for the delivery of such training.

However by its own admission the amount of evidence collated during the training scenarios which formed the basis for the advice was insufficient "…regarding exposures to differentiate them [instructors] from others exposed to the heat." (p. 5). It goes on to acknowledge that during any such fire training session instructors "…may be exposed to elevated temperatures for longer than the trainees." (p. 5)

It attempts to resolve the issues of differentiating instructors from students by claiming that instructors 'may' be able to keep to cooler areas of training environments, or that there is 'some' suggestion that they become more acclimatised to heat (p. 5). Graveling, who conducted the research which informed this particular document, is more forthright in his original report where he notes that: "…concerns have been expressed over the more general or chronic health effects, particularly on instructors experiencing regular or repeated exposures." (Graveling, Stewart, Cowie, Tesh and George 2001, section 3.2.5). Graveling also referred to previous research by Love et al, that originally identified that same point: "…regarding the possible heat exposures and potential consequential physiological strain of BA instructors and safety officers…" (Love, Johnstone, Crawford, Tesh, Graveling, Richie, Hutchinson and Wetherill 1996 as cited in the work by Gravelling et al 2001, section 1.1). The official guidance therefore, appears to be essentially concerned with the short term risk to students who experience infrequent exposure to compartment firefighting conditions, and less so with that of the instructors and this was felt to be unsatisfactory. With increasing demand for more realistic live fire training, as well as new legislative responsibilities and technical innovations, instructors are being asked to provide additional live fire development activities not only for the purposes of CFFT, but also for other essential training such as search and rescue exercises in heat and smoke, marine firefighting scenarios and offensive/defensive Positive Pressure Ventilation (PPV) training. This has in some cases resulted in extremely condensed training programmes with a small number of instructors being asked to undertake frequent live fire training sessions over many weeks.

4. Effects of Heat and Smoke on the Body

4.1 Heat

Firefighters often dismiss the physiological effects of heat, particularly when this is associated with humidity. These effects can have serious consequences if they are not addressed.

Components of Heat Stress

There are several factors that influence the effects of heat and humidity, namely:

a) Metabolic heat
b) Air temperature
c) Humidity
d) Air movement
e) Radiant temperature
f) Clothing
g) Individual level of fitness
h) Age/sex/race

The components of heat stress directly govern body core temperature, heart rate and the ability to lose heat via sweating. The human body maintains its temperature within about half a degree of 37c.

4.2 Heat Loss

There are four ways in which the body loses heat in differing proportions. These are:

a)	Convection (passage of air)	25%
b)	Radiation (surface temperatures)	50%
c)	Vaporisation (lungs)	15%
d)	Evaporation (sweating)	10%

4.2.1 Convection

Convection currents around the body account for 25% of its heat loss. The hot air rises from the body and is replaced by cooler air. Clothing, in particular that worn operationally by firefighters, can considerably reduce the amount of body heat lost by convection.

4.2.2 Radiation

Radiation accounts for 50% of heat lost whilst a person is at rest. This relies on the surrounding temperature being lower than that of the body. Although the body will continue to radiate heat under any condition, it must be remembered that where the environmental conditions are hotter than the body, then it will absorb heat from the surroundings.

Firefighters working in hot atmospheres must be protected from radiated heat. Fire kit provides some degree of protection, however it is important that firefighters understand that for more effective protection from the effects of radiated heat, clothing should be worn underneath the fire kit.

4.2.3 Vaporisation

Vaporisation accounts for 15% of body heat loss. The body temperature will rise whilst working in hot and humid atmospheres; therefore the blood temperature rises. The blood is cooled in the lungs by the inhalation of cool air and the excess heat is given off in exhaled air.

This presents a problem for a firefighters wearing BA, which can restrict the flow of heated breath. Positive pressure BA can reduce the loss of heat via vaporisation. The air pressure in the mask is above that of the surroundings; the wearer breathes air that has been briefly stagnant and heated by radiated heat through the visor.

4.2.4 Evaporation

Evaporation accounts for 10% of body heat loss. The rise in the body core temperature and also the skin provides some indication of the effects of heat stress on the temperature regulating mechanism of the body. An increase in heart rate is followed by the production of sweat.

The evaporation of sweat from the skin is the body's main defence against overheating. The presence of a humid atmosphere can reduce and even stop the evaporation process completely.

Sweating may be divided into two types:

a) Emotional – Related to nervous tension, anxiety etc. occurs on the palms, soles of the feet and armpits.
b) Thermal – Occurs when the body is becoming too hot occurs on the forehead, neck, backs of the hands.

The rate of sweating may or may not show physiological strain on a person in any given environment. Sweat is lost at a rate of between 0.5 and 2 litres per hour and varies between individuals. This underlines the fact that firefighters must ensure proper hydration if they are to minimise the effects of working in hot and humid atmospheres.

4.3 Humidity

The atmosphere is made up from a number of gasses, water vapour being one of the most important. There is an upper limit to the amount of water vapour that a space can contain, which is directly related to its temperature. At low temperatures the amount of water vapour is low, and at high temperatures it is high. When a space contains a maximum amount of water vapour it is said to be 'saturated'. The proportion of water vapour in air is small and can vary from 1% to 4%.

One of the factors governing heat related illness is the amount of water vapour in the air, called the 'relative humidity'. This determines the rate at which sweat can evaporate from the body and its resulting cooling effect. Generally speaking, the higher the 'relative humidity' the lower the evaporation rate of sweat.

4.4 Effects of Heat and Humidity

There are physiological effects on the body due to exposure to heat, particularly when this exposure is in conjunction with humidity.

When the body is subjected to heat, there is a general reddening of the skin caused by an increase in blood flow in the vessels of the skin. This brings more heat to the surface of the skin, causing heat loss by radiation. If the external temperature is higher than the body this can have a negative effect by allowing the body to absorb more heat from the environment via the increased blood flow near the surface of the skin.

Thermal sweating will increase, causing the torso, forehead, legs and the back of the hands to become moist. The pulse rate will raise 40 beats per minute for every one-degree rise in body temperature, which will be accompanied, by a rise in the rate of breathing.

This process will continue as the body's temperature regulatory mechanism is attempting to maintain the body core temperature within half a degree of 37c. If unsuccessful the body losses its thermal equilibrium and the symptoms of heat related illness will appear.

4.5 Symptoms of Heat Related Illness

The symptoms of heat related illness/distress can be classed under three separate categories:

a) Heat Exhaustion
b) Heat Syncope
c) Heat Stroke

4.5.1 Heat Exhaustion

Heat exhaustion is perhaps the most common reaction to heat exposure amongst firefighters. Heat exhaustion develops more quickly in high humidity conditions. Instructors involved in hot fire training are especially at risk due to the time of exposure to heat.

Cause - Heat exhaustion is due to excessive sweating which leads to a loss of body fluids and salts after being exposed to heat for a prolonged period of time, resulting in a decrease in blood pressure and volume.

Symptoms - Feeling unwell, tiredness, dizziness, nausea, vomiting, breathing difficulties - shallow/rapid respiration, rapid pulse, extreme thirst and dry mouth, muscle cramps - particularly in the stomach and legs, poor control over movements - stumbling and weakness, irritability, headaches, weakness, fainting/collapse.

Treatment - Remove to a cooler environment, rest in a reclined position with PPE relaxed, initiate cooling and administer water. In severe cases remove to hospital.

4.5.2 Heat Syncope

Cause - When a person is in an environment where the temperature is above that of the body, two effects occur.

Firstly, the exposed skin can be burned by radiated heat. Secondly, the blood vessels close to the surface dilate to increase the blood flow near the body surface in an attempt to get rid of excess heat. This allows heat to be absorbed by the increased blood flow near the skin's surface.

Symptoms - If this condition becomes extreme, the blood pressure falls due to the dilation of the blood vessels near the surface of the skin. This reduces the blood flow to the brain, which reduces the amount of oxygen reaching the brain, and fainting occurs.

Treatment - Remove from the source of the heat. For an imminent faint, sit down with the head and shoulders bent forward towards the knees. For a full faint, lie the casualty down with the legs and head slightly elevated. PPE should be relaxed and body cooling methods instigated along with rehydration. After recovery the casualty should not enter a hot environment for several hours. In severe cases remove to hospital.

4.5.3 Heatstroke

Cause - Heatstroke is the most serious disorder resulting from exposure to heat. The fundamental feature of the disorder is an uncontrolled rise in body temperature. This increase in temperature (as much as 41c to 44c) seriously affects the central nervous system and a person's mental functions are disturbed.

There is evidence to suggest that in its simplest form, heatstroke is due to the failure of sweating to reduce the heat produced in the body. Heatstroke is an acute and potentially fatal condition. It requires immediate medical attention with cooling of the body being essential.

Symptoms - When an insufficient sweat rate is achieved the body temperature rises, the following changes may occur:

- A further drop in the rate of sweating
- Cessation of sweating
- Rapid rise in body temperature
- Collapse, coma and death if prompt treatment by cooling is not initiated.

Treatment - Heatstroke is a very serious condition and must be treated urgently. The clothing must be removed and cooling initiated by the application of wet towels or water spray accompanied by a rapid fanning action. Conscious casualties should be encouraged to rehydrate. The treatment must be continued during transfer to hospital. All cases of heatstroke must be hospitalised.

4.6 Other effects

The following effects have also been recorded in elevated temperature environments.

- Burns.
- Heat oedema (swelling of the feet and ankles).

4.6.1 Prickly Heat

Prickly heat usually develops when a person sweats more than usual, such as during hot or humid weather. However, it is also possible to get prickly heat in the winter.

The condition is caused when the body's sweat glands become blocked. Excessive sweating can result in sweat becoming trapped beneath your skin. The trapped sweat causes skin irritation and the characteristic heat rash.

The symptoms of prickly heat are usually worse in areas that are covered by clothing. This is because clothing can make you sweat and sometimes causes friction (rubbing). (NHS)

4.6.2 Heat Cramps (muscle spasms)

Heat cramps are painful, involuntary muscle spasms that usually occur during heavy exercise in hot environments. Inadequate fluid intake often contributes to heat cramps.

4.6.3 Temporary infertility

In order to efficiently produce sperm the testes are located outside the body and an elaborate temperature regulatory system maintains them a few degrees cooler than the rest of the body. Exposure to elevated temperatures on a regular basis can inhibit the production of sperm and also their ability to swim.

In addition the following can be exacerbated by heat.

- Dermatitis.
- Fungal infections.

5 Smoke

Smoke is the un-burnt product of combustion and can contain numerous different toxic chemicals. Air sampling of compartment fire behaviour instructor's kit room in one FRS has shown that the atmosphere in this area contains traces of chemicals such as Styrene and Naphthalene, both of which are carcinogenic. The suggestion is that these chemicals are introduced into the area due to the storage of contaminated PPE.

A number of recent studies (National Institute of Occupational Safety & Health, Institute of Occupational Medicine) have suggested that firefighters may be at an increased risk to cancers which could be caused by exposure to carcinogens absorbed through the skin. After the lungs, the skin is the body's largest organ in surface area and is highly absorbent. Some areas of the skin are more permeable than others specifically the face, neck and throat. The skins permeability increases with temperature. Fire hoods are designed to protect the head and neck from heat but don't prevent contaminants coming into contact with the skin. Some cancer studies are noting that firefighters developing far more aggressive types of cancer, such as brain cancers, at a younger age than the general population, indicating that cancer could be as the result of exposure to contaminants during firefighting operations.

6. Control Measures

6.1 Acclimatisation

Studies (Fire Research Technical Report 1/2005 and M.H Stirling Loughborough University 2000 amongst others) have shown that a body's ability to withstand the effects of heat is increased by acclimatisation. Acclimatisation is achieved by exposure to high temperatures over time.

Practical Example
West Yorkshire FRS have incorporated a heat acclimatisation room into the training centre gym facilities to assist instructors in reacclimatising after returning from leave or other breaks in compartment fire behaviour training.

Acclimatisation helps to reduce sodium loss but increases the rate of fluid loss through sweating leading to the potential that dehydration may occur earlier.

At the onset of exercise, sweating commences earlier in the acclimatised as compared to the un-acclimatised individual, improving the ability to tolerate heat. The body will naturally try to maintain sodium at a base level by excreting excess and retaining any that is ingested if levels are low. The level of sodium excreted by the kidneys can be controlled and if necessary reduced to nil. However sodium loss through sweat cannot be fully prevented, acclimatisation encourages the secretion of aldosterone which promotes the maximum reabsorption of sodium by the kidneys and sweat glands helping to maintain the sodium balance.

Sodium is an electrolyte, which means it has an electrical charge. The body needs electrolytes to control blood pressure and blood volume. The kidneys remove excess fluid from the blood by osmosis, which is a process by which fluid is drawn across cell walls. A specific level of sodium, along with another dietary mineral potassium, is necessary so that excess fluid is drawn out of the bloodstream through the blood vessel walls and into collecting ducts in the kidneys. This excess fluid is removed as urine.

Sodium is essential for electrical impulses to travel along nerves and for muscle function. It's part of the sodium-potassium pump found in the membranes of cells. Sodium is pumped out of the cells, and potassium is pumped into the cells, creating an electrical charge that leads to the transmission of impulses along nerves. The sodium-potassium pump is also necessary for muscles to contract.

Acclimatisation occurs gradually through regular exposure to hot environments and, depending on conditions, can take around ten days or less. Once acclimatised, the thermal strain on the body is decreased by the reduction of the heart rate and body temperature. Conversely, sweat rate increases in order to provide more sweat for evaporation, and hence increase dissipation of heat from dilated peripheral blood vessels. Plasma volume also increases (M.H. Stirling 2000).

Therefore, an acclimatised person is able to work in a hot environment for longer periods and under less physiological strain, (Bass, 1955)

An un-acclimatised person may experience dizziness, headaches, nausea and eventually heat illness, coma and even death under conditions that are tolerable by an acclimatised person. Acclimation to work in the heat is also characterised by a marked improvement in performance and comfort (Robinson & Robinson, 1954).

The benefits obtained by acclimatisation are soon lost, within a week or two, by individuals who are no longer exposed to high temperatures. This should be borne in mind when instructors return from any prolonged breaks in training such as leave, with time allocated to reacclimatise before return to full instructional duties.

6.2 Hydration

A great many reports highlight the crucial role effective hydration plays in mitigating the effects of heat stress. Mclellan et al (1999) recognised the role of dehydration in reducing heat tolerance and along with others (Stirling, 200; Williams et al, 1996; Davies, 2000; Budd and Brotherhood, 1996) recommend that more consideration should be given to ensuring adequate fluid intake before, during (if possible) and after live fire training activities. But when one also takes into consideration the findings of Bilzon et al (2001) who proved that hydration only takes effect 4 hours after fluid intake then, logically speaking, a more effective process would emphasise hydration that occurs before the event.

The recent research conducted by Kent FRS in collaboration with Canterbury Christ Church University also highlighted the fact that if an individual CFBI were to begin the training day already dehydrated then bringing this up to an acceptable level during the actual live fire training would be acutely difficult (see appendix 2).

Adequate hydration plays a vital part in maintaining the wellbeing of personnel exposed to hot conditions. Becoming dehydrated by as little as 2% from a fully hydrated level can contribute to impaired performance in terms of aerobic work capacity, strength, power and cognitive decision making.

People who begin physical work with a previously incurred fluid deficit display an impaired ability to dissipate heat during subsequent exercise. They experience a faster rise in core temperature and heart rate; this effect is exaggerated when activity is performed in a hot environment (ACSM, 1996)

CFBIs should be made fully aware of the effects of alcohol with regards to its dehydrating effects and should be discouraged from drinking alcohol on the day before exposure to heat.

A good practical indicator of hydration is the colour and volume of urine that is produced. Fire behaviour instructors should monitor urine using a standard urine hydration colour chart. The sensation of thirst should not be relied upon to stimulate an individual into consuming liquids as it has been shown (Adolph 1947; Rothstein et al 1947) that by the time that thirst was initiated, 1% of body weight may have already been lost leading to what is known as “voluntary dehydration”.

Condition	% Body Mass Change from Normal value	Urine Colour
Well hydrated (optimal)	+1% to -1%	Clear/very light yellow tint
Minimal dehydration	-1% to -3%	Light yellow - yellow
Significant dehydration	-3% to -5%	Dark yellow - orange - tan
Serious dehydration	Greater than -5%	Dark orange - brown

A more accurate but perhaps less practicable method of determining fluid lost during fire behaviour training would be to nude weigh the individual pre and post training with the difference between the two weights equating to the fluid lost. In order to guarantee that this is replaced the individual should drink 1.5 times this amount. (ODPM paper 5/2003)

In order to ensure that compartment fire behaviour instructors maintain adequate hydration they should be encouraged to drink suitable fluids on a regular basis. Typical fluid intake could consist of the following:

- 500ml two hours before heat exposure
- 300ml 15 minutes before
- 200ml every 20 minutes during work periods in hot environments
- 1 litre within 30 minutes after heat exposure has finished
- Continue drinking as required until fully rehydrated

Some evidence suggests that fluids supplemented with carbohydrate may be beneficial to those undertaking physical exercise for more than 1 hour, helping to combat fatigue. FRSs should consider whether it would be beneficial to provide instructors with fluids containing a suitable carbohydrate additive.

The advantages of replacing essential salts in a dilute electrolyte solution with water is also emphasised by some researchers (McLellan and Selkirk 2005) while others argue that any electrolytic requirements can be satisfied by dietary means. There is also some evidence which suggests that drinking plain water after a major sweating event could potentially lead to dilutional hyponatremia where the lower level of sodium in the blood stream is further diluted by excessive consumption of plain water. East Sussex Fire and Rescue Service (ESFRS) have been trialling electrolyte drinks as part of a strictly managed hydration regime with favourable results being reported by instructors in terms of their ability to deal with the physiological and psychological effects of conducting live fire CFBT.

Practical Example

Kent FRS using existing evidence together with some additional research carried out in collaboration with Canterbury Christ Church University have developed a more sophisticated approach to hydration.

The following hydration guidance is based on CFFT which necessitates the wearing of breathing apparatus in live fire conditions involving both morning and afternoon sessions:

2-3 hours prior to morning session:	1 bottle of water (500ml)
10-20 mins prior to morning session:	0.5 bottle of water (250ml)
During morning session:	1-2 bottles of water (500-1000ml)
During lunch:	1 bottle of isotonic drink (500ml)
During afternoon session:	1-2 bottles of water (500-1000ml)
End of session:	1 bottle of isotonic drink (500ml)

6.3 Diet

Diet is also important in ensuring that personnel are fit to carry out “hot wear” exercises. Instructors should ensure that they consume sufficient calories during the day to maintain energy levels. Consuming food will also help to ensure that salts lost through sweating are replaced.

It has been shown by various researchers (Nose 1988, Lassiter 1990, Takamata et al 1994) that full rehydration cannot be achieved without electrolyte replacement (primarily sodium). This electrolyte will, in most cases, be available within the subjects gut from previous meals as long as regular balanced meals are consumed (Schedi et al, 1994). The average diet within the UK is high in sodium content which may negate the necessity to supplement (3.2g per day against the 2.4g as recommended by the NHS).

Practical Example

East Sussex Fire and Rescue Service decided to replace their electrolytic drinks with ones that also contained a carbohydrate mix. This has proved effective in helping maintain energy levels of CFBIs throughout the course of a day’s live fire training.

Trials conducted by Eddie Fletcher of Fletcher Sports Sciences on behalf of Kent Fire and Rescue Service Occupational Health Department at the Denton National Sea Training Centre (NSTC) in Gravesend, highlighted the intense physical exertion required for live fire training, especially those which require heavy manual handling of loads (i.e. casualties or larger types of fire hose). Again the physical demands of wearing cumbersome, thermally insulative personal protective equipment (PPE) as well as heavy and restrictive respiratory protective equipment (RPE) are well documented. However when combined with heavy manual work in a hot and humid environment it can be appreciated that such circumstances can represent the most extreme examples of thermal stress for participants. The results of Eddie Fletcher’s observations (see appendix 3) as well as highlighting the stresses placed upon the heart also showed the calorific needs of those taking part. Eddie Fletcher’s background as a coach for professional athletes led him to offer advice on what type of foods should be consumed and when, in relation to separate training sessions in one single day. This advice supported that which is given in the Guidance on the Management of Heat Stress during Training document (section 4.1.5 page 24). Correct diet, together with hydration, is obviously vital in ensuring that participants, especially instructors with their particular safety role, can better maintain their cognitive functions. This requirement lasts well after the training event especially for those who may yet have to drive vehicles some considerable distance home.

Parsons (1993) also drew attention to the importance of vitamin C and how it can enhance heat tolerance. The use of this dietary supplement is again mentioned in the Fire Research Technical Paper 1/2005 “Operational Physiological Capabilities of Firefighters: Literature Review and Research Recommendations”, completed by Optimal Performance Limited on behalf of the then Office of the Deputy Prime Minister.

6.4 Limiting the Number of Wears

It can be hypothesised that the frequency of actual physical exposure to the extremes of live fire training environment is important with regards to both acclimatisation, (psychological and physiological) and in recovery. Graveling points out that controlling the frequency and duration of exposure to extreme thermal conditions "…should restrict the risk of adverse effects at source, thereby adhering to one of the central tenets of occupational health and safety." (Graveling 2001, p.58). The Fire Research Technical Report 1/2005 also highlights the possible benefits of acclimatisation. This particular report recommended research into acclimatisation to establish what frequency of exposure would be required to develop and maintain acclimatisation, an especially important point for CFBIs. However the report failed to consider the effects of over exposure to hot environments because once again it was predominantly concerned with operational firefighters whose experience of such conditions is infrequent.

One possible side effect of repeated exposure to an extreme thermal environment is an unfavourable change in the immune system. Richardson, Maxwell, Watt, Smeeton and Wilmott in their research "Heat Exposure and the Immune Function in Fire and Rescue Service Personnel" (2013, see appendix 5) point to the fact that while previous studies (Barr et al. 2010; Reich, 1953; Scannel and Balmes 1995; Shepard et al, 1986;Shuster, 200;Smith et al, 2005) indicate short term changes in immune function, there is currently no research into longer term health risks associated with the severe repeated exposures particular to CFBIs.

The previously mentioned research carried out in Kent which used the services of Eddie Fletcher, monitored firefighters and instructors alike undertaking ship firefighting training at the NSTC and graphically highlighted the intense physiological stresses that participants were being subjected to. Mr Fletcher theorised from the evidence gathered that repeated exposure to similar conditions over time would denigrate the immune system of individuals in much the same way that excessive training combined with too little recovery time increases the susceptibility of modern day athletes to illness and infections.

This is supported by studies of personal health logs which suggest that CFBI's suffer recurring symptoms of fatigue, night time cramps/sweats, mood swings, chest infections, stress, headaches etc., after conducting regular live fire training sessions.

In order to safeguard the health and wellbeing of individuals a system of limiting the exposure to extreme temperature should be instigated. As no studies carried out have made definitive recommendations, individual FRS's (see below) have adopted their own procedures based around the Fire Service Manual Volume 4 guidance of: - a maximum of two hot wears per day with at least a 2 hour break between wears.

Number of Wears	Daily	Weekly	Monthly
FRS 1	2	4	8
FRS 2	1	4	16
FRS 3	2	4	9
FRS 4	2	4	10
FRS 5	1	3	9

None of these systems take into account the individuals perceived exertion level.

During the research the Fire Service College used a system that scored each hot wear.

In this system each wear is given a score of 3 however the instructors perceived exertion level during the exercise is then added using a scale of 1-4

Light	1
Moderate	2
Hard	3
Unable to perform a rescue	4

The use of this system takes into account the individuals daily physical state and their ability to take heat on any given occasion. It also allows for the unpredictability of fire compartment temperatures and the individuals task/location during the hot wear. The down side to this system is that it is hard to predict the number of wears that an individual may be able to make in a given time scale as a wear could score between 4 and 8 depending on the individuals perception, making course planning/staffing difficult without a large core of instructors.

Further research to determine the safe number of wears is required to enable a definitive guidance to be produced.

6.5 Pre and Post Exposure Cooling

The benefits of lowering the body core temperature as quickly as possible after a live fire event have been highlighted by several scientific articles with some of the earliest research being carried out by the Royal Navy, which identified forearm cooling as most effective in achieving this (House, Holmes and Allsop 1997). Mclellan and Selkirk (2005) then compared differing methods which included both passive cooling ('dressing down') and active cooling techniques (forearm immersion and fan/water mister). Once again it was found that forearm cooling (also known as 'radial cooling') was considerably more effective than the other methods tested. In the case of passive cooling it was also noted that core temperatures continued to rise even after subjects had dressed down. This is corroborated by evidence provided by trials held at Manston Defence Fire Training Development Centre and conducted by Coventry University in 2011 which monitored rectal, aural and surface skin temperatures of CFBIs in the course of their work (appendix 4).

Some reports (Fire Research Technical Report 1/2005) even consider the benefits to be gained from ‘pre cooling’ those individuals about to enter a hot environment, a technique which would be impracticable in an operational context but could form an effective measure for CFBIs in a training environment.
All the studies undertaken into the effects of high temperatures experienced during fire fighting highlight the fact that the wearing of the standard fire kit, even whilst carrying out normal activity, led to an increase in core temperature due to the insulating nature of the fabrics used. In order to keep the core temperature as low as possible before undertaking hot fire training, fire kit (if safe to do so), should be relaxed to allow heat to escape. Instructors who are expected to complete a hot wear should not be involved in building fires, placing dummies or raking out old fires immediately before carrying out a hot wear. Further it is suggested that instructors should be relieved of “making up” immediately after a wear to allow them to cool down by relaxing dress and using suitable body cooling measures to allow their core temperature to return to normal as soon as is possible.

The use of crushed ice drinks as an aid to pre cooling has been advocated by research published in the Journal of Military and Veterans’ Health (Brearly 2012). According to this research the ingestion of iced drinks has a number of benefits in that the cold ice acts as a ‘heat sink’ helping to absorb a greater amount of heat energy due to the fact that extra energy is required to convert the ice into a liquid state (latent heat of melting). This fluid will also help to maintain an individual’s state of hydration. Conversely however it has been shown that drink temperatures of between 10c and 15c encourages consumption (M.H. Stirling 2000) therefore suggesting that cold drinks may discourage individuals from consuming sufficient fluids.

The wearing of ‘ice vests’ during the lead up to exposure can help to maintain a lower core temperature which assists in the ability to prolong wear times before the body reaches an unacceptable core temperature.

Post wear cooling can be achieved using a number of methods. Radial cooling whereby the wrists are immersed in a container of cool water is a simple, cheap and extremely effective technique.

Positive pressure ventilation fans running at tick over have also proved effective and can be used in conjunction with a cool water mist.

Passive cooling using dressing down techniques is less effective with research showing that initially core temperatures continue to rise even when PPE has been relaxed. This is corroborated by evidence provided by trials held at Manston Defence Fire Training Development Centre and conducted by Coventry University in 2011.

Although post wear cooling is important there is a potential that the deep core body temperature can overshoot if the periphery (skin) is cooled too quickly, due to the brain becoming confused and closing down surface capillaries in order to maintain surface temperature.

6.6 Personal Protective Equipment (PPE)

PPE should only be worn when the situation requires and should be relaxed whenever safe to do so, in order to assist the body in dissipating excess heat thus helping to prevent elevated core temperatures. PPE should be kept clean to reduce the absorption through the skin of toxins. This is especially important for items that come into direct contact with the skin such as fire hoods and gloves. The placing of gloves inside fire helmets should be discouraged in order to decrease the likelihood of cross contamination.

CFBIs should be supplied with sufficient sets of PPE to allow them to change into clean kit whenever necessary. Ensuring that clean wood is used when setting live fires will assist in reducing the amount of contamination produced in live fire training.

Consideration should be given of where contaminated PPE is stored ensuring adequate ventilation and prevention of cross contamination of clean PPE and other clothing.

Along with the use of clean PPE, a high standard of personal hygiene should be maintained with CFBIs showering after exposure to live fires. In order to facilitate this, time during the training day should be built into the programme to release instructors. Shower facilities should be readily available and sufficient in number.

Practical Example

Northamptonshire FRS make use of additional personal protective equipment (PPE) in the form of cotton inner gloves which help to minimise the absorption into the hands of particles/substances from the one item of PPE that is not effectively decontaminated: fire gloves.

East Sussex FRS issue their CFBIs with 6 sets of fire-fighting PPE, 4 of which are solely for use instructing in CFFT.

Hampshire FRS have their own PPE laundry machines sourced from the PPE supplier for rapid turnaround of decontaminated items with a one use policy in place.

6.7 Health Monitoring

Due to the nature of the role, CFBIs are required to be physically fit. Individuals who are physically fit will experience lower levels of cardiovascular strain in hot conditions than those who are less fit and, as a result, are more likely to tolerate heat exposure. (Graveling 2001). Cheung et al. (2000) stated that individuals with higher proportions of body fat have a lower heat tolerance. Therefore, the fitter the CFBI (and with less body fat), the better they are able to handle the effects of heat stress.

In order to ensure that instructor's wellbeing is safeguarded, differing levels of health monitoring have been suggested:

1. Physical fitness assessments are undertaken prior to commencement of role and are repeated every six to twelve months. (Office of Deputy Prime Minister paper 5/2003). This monitoring should be carried out by Occupational Health Specialists.

3. CFBIs should carry out monitoring of core temperature pre and post exposure using tympanic temperature measurements. Pre exposure temperatures above 37.5oC should preclude the individual from taking part in hot fire training for that day. An abnormally high core temperature could point to underlying illness and could cause the individual to reach a dangerously high core temperature during live fire training.

Any instructor with a post exposure temperature above 39c should not wear within a hot fire compartment again during that day so as to assist the body to return to a normal temperature. Instructors who consistently reach this upper limit should seek further medical advice as to their suitability to continue in role, as some people's physiology is not suited to the role and removing such individuals from the role should be considered.

3. Instructors should maintain a health log noting pre and post exposure temperatures and any health issues that could be attributed to exposure to extreme temperature. An example of a log is shown in appendix 1. This log should be produced when undergoing the health screening mentioned above with the Occupational Health professional.

7. Recommendations

Based on the research undertaken in the production of this guidance document, the following recommendations are made to improve CFBI health & wellbeing:

1. Implement an acclimatisation protocol for CFBIs.

2. Implement a regime to ensure CFBIs maintain sufficient fluid intake to guarantee a high level of hydration.

3. Implement a working pattern to ensure CFBIs are given sufficient recovery time between wears within a hot fire compartment and limit number of wears per day/week/month.

4. Further research to be undertaken to establish a scientifically based safe exposure frequency which enables effective acclimatisation together with sufficient rest and recovery time to ensure the health and wellbeing of individuals. This is currently being considered by CFOA.

5. Implement systems to ensure that CFBIs are adequately cooled both pre and post exposure.

6. Ensure that adequate quantities of PPE are available to cater for a single days use before laundering, ensuring that cleanliness of equipment can be maintained especially items that are in direct contact with the skin. Provide cotton inner gloves that can be easily laundered, to minimise absorption through the hands.

7. Discourage the practice of placing contaminated fire gloves inside helmets.

8. Briefs/debriefs to be carried out in clean air away from contaminated areas.

9. Facilities for personal hygiene showers, wash basins etc., and the time within the working day for their use, should be readily available and sufficient in number for the expected size of training courses.

10. Temperature monitoring of CFBIs should be carried out pre & post wear and managed within recommended parameters. This along with other relevant factors should be recorded on a personal health log.

11. Professional health screening via Occupational Health provision should be conducted pre appointment and throughout the time that the individual performs the role. The frequency of this should be determined locally by risk assessment, but is recommended to be between 6 – 12 months.

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CFOA
Chief Fire Officers
Association

The Chief Fire Officers Association
9-11 Pebble Close | Amington
Tamworth | Staffordshire | B77 4RD

Telephone: +44 (0) 1827 302300
Facsimilie: +44 (0) 1827 302399
www.cfoa.org.uk

Photographs provided by West Yorkshire Fire and Rescue Service

This version published October 2016

Appendices available online at -
www.cfoa.org.uk/21622