Fire Service Manual

Volume 4

Fire Service Training

Guidance on the
Management of the
Risk of Heat Stress
during Training

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Preface

The guidance provided in this Manual is based on extensive research commissioned from the Institute of Occupational Medicine, and published by the Office of the Deputy Prime Minister (OPDM) as Fire Research Report Number 1/2001: ‘Firefighter Training: Physiological and Environmental Factors’. This has also been made available on the ODPM website.

The research, together with the development of this guidance, was overseen by a steering group with representatives from the Health & Safety Directorate, Her Majesty’s Fire Service Inspectorate, the Fire Brigade’s Union, the Chief and Assistant Chief Officer’s Association and the Fire Service College.
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Chapter 1 – Introduction

Health and safety legislation requires employers to reduce risks to health for their employees, so far as is reasonably practicable. The Fire Service is no exception to this and indeed health and safety is recognised as an essential part of all Fire Service activities. Members of the Fire Service deal with potentially hazardous situations; it is essential therefore that firefighters are trained to cope with the dangers that they might encounter at an incident. This creates a potential conflict in the training environment where the need to experience potentially hazardous situations must be balanced against the requirement to minimise possible exposure to risk. Training must therefore be planned in such a way that firefighters can experience reasonably realistic situations, in which they encounter the hazards likely to be met in operational incidents, whilst the risk of resultant injury is controlled and all unnecessary risks avoided.

General guidance on the planning and delivery of realistic operational training was produced by the Realistic Training Working Group and discussed and endorsed by the Joint Training Committee of the Central Fire Brigades Advisory Council. This document 'The Principles of Operational Training' (Fire Service Circular 5/1996 and corresponding DFM) outlined the importance of the training risk assessment, required under the provisions of the Management of Health and Safety at Work Regulations 1992. The guidance referred to conducting risk assessments of a specific activity or of a broad range of similar risks associated with specific training themes. Reference was also made to the importance of recognising that, in a training situation, staff and others participating in the training event may themselves be working in a hazardous environment. Any training risk assessment must also therefore consider the risks to which instructors and other staff are exposed during a particular training situation as well as the firefighters themselves.

One hazard which firefighters are likely to encounter in operational situations is that of elevated environmental temperatures. Such conditions present an acute risk of burn injury, for example, through contact with hot debris, and a less acute (but still short-term) risk of physiological heat stress. It is that latter risk which this document addresses. It provides provisional guidance on the management of the risk of heat stress experienced during training in elevated environmental temperatures, to assist Brigades in designing and planning training which meets operational needs whilst controlling the risk of heat stress at an acceptable level: it is not intended to be prescriptive. The guidance indicates the degree of physiological strain likely to be experienced in different environmental conditions for a number of different basic types of training scenarios. This should assist Brigades in
establishing acceptable environmental temperatures during training and to identify actions to reduce the risk of heat stress.

The guidance given is based upon a study of environmental temperatures during training sessions, together with the resultant body temperatures of those taking part. Many different factors affect heat exposure and its effects. Due to the limited number of establishments from where it was possible to obtain such data it has not been possible to derive comprehensive guidelines to cover every training establishment and scenario. Further studies are planned which will allow these guidelines to be refined and expanded. Further guidance will therefore be issued in due course.

The guidance outlines a staged process of assessing and managing the risk of heat stress either by reducing the risk of heat stress or by controlling the possible effects. This process may include procedures prior to any exposure; monitoring and control procedures during any training exercise; and procedures following any exposure. Many of the measures may already have been implemented by some Brigades. It is unlikely that any one measure will effectively control the risks associated with heat exposure and it is expected that a package of controls will be required.

Appendix I presents background information on the effects of heat on the body and outlines various disorders that can be caused or exacerbated by heat exposure. The research that was conducted in preparing this guidance has been published as Graveling RA, Stewart A, Cowie HA, Tesh KM and George JPK 'Firefighter Training: Physiological and Environmental Factors' [Office of the Deputy Prime Minister (FRD) Fire Research Report Number 1/2001].

Chapter 2 – Management of the Risks of Heat Exposure

2.1 Introduction

In common with all other employers in the UK, Brigades have an absolute duty to assess risks to health and safety to which their employees might be exposed. The Management of Health and Safety at Work Regulations 1992 require employers to make a suitable and sufficient assessment of risks to health and safety (and to record any significant findings). Regulation 3 of the accompanying Approved Code of Practice lays down a hierarchy of preventative and protective measures to be taken following the risk assessment:

(a) if possible, avoid a risk altogether
(b) combat risks at source
(c) wherever possible, adapt work to the individual
(d) take advantage of technological and technical progress
(e) take measures as part of a coherent policy and approach
(f) give priority to measures which protect the whole workplace and all those who work there
(g) ensure workers understand what they need to do
(h) promote the existence of an active health and safety culture.

A methodology to record the findings of risk assessments is provided in A Guide to Operational Risk Assessment – Volume 3 of the Fire Service Health and Safety Guidance for generic risk assessments.

As stated in (a) above, the first risk control measure is to avoid the risk altogether. Previous Home Office guidance (DCO letter 11/1999 and corresponding DFM) was quite clear on this issue. It specified for example that individuals engaged in real or simulated practical compartment fire training events must not be exposed to the effects of a flashover, backdraught or rapid fire development. This guidance has been revised and updated as Fire Service Manual, Volume 4 Fire Service Training – Guidance and Compliance Framework for Compartment Fire Behaviour Training. This identifies a clear requirement to establish the training needs and to determine whether or not there is any alternative to practical training. Assuming that there is not then, to be realistic, compartment fire training must involve fires within compartments and a degree of risk is therefore unavoidable. Table 2.1 shows a checklist for the design of compartment fire training reflecting this guidance.

Attention must therefore be paid to managing that risk. The second stage in the
2.2 Guidelines on Risk Assessment

2.2.1 Introduction

Where the risks of heat stress cannot be controlled at source, for example by removing the need for training involving live fire exposure or other sources of elevated temperatures, it is necessary to assess the risk of injury or ill-health arising from the work (training) situation. This section provides guidance on assessing the risk of heat stress from firefighter training. It is based upon studies at a number of training establishments in the UK where heat exposures during training were recorded along with measurements of body temperature. It therefore provides numerical guidelines that can be used to assess or limit heat exposures during similar training exercises.

Three generic forms of training were examined: search and rescue; heat and humidity; and fire behaviour (flashover). Guidance is given on suitable durations and temperatures for these activities in Sections 2.2.2–2.2.4 below. Appendix 2 gives details of the training scenarios used for collecting the data on which the guidelines are based. Clearly, the details of training vary between different training centres and the first step in using this guidance will be to determine the comparability of the training on which this guidance is based with that planned. The guidance provides an indication of exposure temperature and exercise duration that is unlikely to cause a significant risk of heat stress to most trainees or instructors. On the basis of extensive studies conducted within the UK Fire Service, these have been developed on the basis of restricting any increase in core temperature to 39°C, measured using an infra-red tympanic temperature instrument, for at least 95% of firefighters and instructors. Those responsible for training, should, however, be aware that individual susceptibility to heat stress varies, both between individuals and for the same individual on a day-to-day basis. For example, incipient illness may make a trainee less heat tolerant. Risk management procedures (see Section 3) should therefore be maintained even where training is designed in accordance with these guidelines.

The guidelines should also be used to assess the risk of injury to instructors and ground staff (where employed). Although, in developing the guidelines, measures were obtained from instructors, it was not possible to collect sufficient detail regarding exposures to differentiate them from others exposed to the heat. Especially where separate ground staff are not available, instructors are often responsible for setting and lighting fires etc. As a result they may be exposed to elevated temperatures for longer than the trainees. (See Table 2.1.)

However, when providing safety cover or monitoring the progress of a team through a building, they are often able to avoid exposure to the more excessive environments. They may be able to keep back from fires or stay close to exits where temperatures may be somewhat lower. Few, if any, training installations will have monitoring systems sufficiently detailed to determine different exposure levels on this scale. There is some suggestion that instructors are more acclimatised to the heat and consequently at less risk of injury or ill-health for a given set of conditions. Although they may be more accustomed to the heat, the exposure durations are insufficient for true physiological acclimatisation to occur.

It is therefore recommended that instructors are subject to the same guidelines as detailed below for firefighters and that their work schedules are designed accordingly.

Calculation of mean exposure temperature, known as a time-weighted average (TWA), will provide a more accurate estimate of the risk of heat stress than...
Table 2.1 Compartment fire training design checklist

<table>
<thead>
<tr>
<th>Identification of training needs</th>
<th>Managing safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What must the training achieve</td>
<td>• Who will conduct the training risk assessment</td>
</tr>
<tr>
<td>• What are the priorities</td>
<td>• Who will be responsible for the safety control measures</td>
</tr>
<tr>
<td>• What are the constraints</td>
<td>• Who will prepare the practical venue</td>
</tr>
<tr>
<td>• Who requires training</td>
<td>• The health and safety of those who will prepare/clean up practical venues</td>
</tr>
<tr>
<td>• What are their needs</td>
<td>before and after each training event</td>
</tr>
<tr>
<td>Planning considerations</td>
<td>Who else will be involved</td>
</tr>
<tr>
<td>• What training methods will be used</td>
<td>• Evaluating the training</td>
</tr>
<tr>
<td>• What, if any, are the alternatives to practical training</td>
<td>• How will the training be internally and externally validated</td>
</tr>
<tr>
<td>• Who will decide the lesson content</td>
<td>• What form will the assessments take</td>
</tr>
<tr>
<td>• Who will write the lesson plan</td>
<td>• Who will be assessed</td>
</tr>
<tr>
<td>• Who will be involved in delivering and supporting the training</td>
<td>• What are the arrangements for post event training de-brief</td>
</tr>
<tr>
<td>• How much time is needed, what time is available</td>
<td>• How the subsequent information is fed back into brigade systems</td>
</tr>
<tr>
<td>• What resources are needed, human, physical and financial</td>
<td></td>
</tr>
<tr>
<td>• What simulation will be required to achieve the objectives</td>
<td></td>
</tr>
<tr>
<td>• What procedures are in place to record changes in the training that may take place over time</td>
<td></td>
</tr>
<tr>
<td>• What skills and expertise are needed and available</td>
<td></td>
</tr>
<tr>
<td>• Are they in-house, or must they be bought in</td>
<td></td>
</tr>
</tbody>
</table>

one-off or peak temperatures. Guidance is given below on recording adequate information and calculating a TWA of temperature exposure. Modern computer-based environmental monitoring systems should be capable of providing a continuous calculation of this.

To calculate such a mean it is necessary to integrate environmental temperatures with information on the location of the team within the multicompartment firehouse in order to establish the most appropriate temperature to use. Section 2.2.4 (Search and Rescue) includes guidelines based on mean exposure for use where such a calculation is available. However, recognising (at least in the short term) that not all establishments will be able to derive TWA values, tentative guidelines based upon maximum temperatures have been provided. Although calculated in a manner that ensures a conservative estimate of risk these should be used with caution.

Numerous firefighters have observed that, even away from live fires or other elevated temperature training, physical effort when ‘dressed up’ can result in heat storage, particularly in warm summer weather. Instructors and others should be alert to the implications of trainees (or instructors) becoming heated prior to any training exercise and should pay particular attention to ‘dressing down’, pre-exercise fluid intake, etc. to avoid this preliminary heat stress making exercises more hazardous.

2.2.2 Heat and humidity training

2.2.2.1 Summary of scenario on which guidance is based:
Training activities were those widely employed in heat and humidity chambers (i.e. walking round; carrying containers; negotiating obstacles [under and over], generally heavy physical work).

2.2.2.2 Temperature range on which guidelines are based:
30–40°C, steamy saturated conditions (close to 100% relative humidity). Firefighters were ‘pre-heated’ by exposure to a small live fire in a firehouse prior to entry. This entailed walking slowly round a small crib for approximately 10 minutes. Values for environmental temperatures from this location were not supplied by the training establishment.

2.2.2.3 Clothing and equipment worn:
Full firefighters gear with self-contained breathing apparatus (BA).

2.2.2.4 Duration of training sessions monitored:
Sessions lasted from 25–50 minutes until whistle went on BA set or, more usually, when firefighters withdrew voluntarily.

2.2.2.5 Notes for Guidance
Heat and humidity training is mainly provided with the intention of enabling participating firefighters to experience the impact of heat and humidity in order to recognise the feelings and symptoms.

Excessive body temperatures (over 39°C) were recorded at all of the combinations of temperature and exposure durations observed and great care should be exercised in conducting training of this nature.

Many firefighters questioned the value of this exercise suggesting that, although it might be of value to new recruits, they had opportunities to experience similar feelings in other exercises.

In view of the questionable benefits of this form of training exercise and the undoubtedly high risk of core temperatures being elevated to hazardous levels, training establishments should give careful consideration to the need to continue with such training. It is recommended that no such training be undertaken unless a detailed reappraisal of the aims and objectives of such training indicates that the training needs are genuine and cannot be fulfilled by other means.

As the purpose of this training is to overheat those undergoing the training so that they can experience the symptoms, it is difficult to set a temperature limit as this will presumably result in trainees remaining in the environment for longer.
2.2.3 Fire behaviour

2.2.3.1 Summary of scenarios on which guidance is based:
Practical fire behaviour training was generally provided in dedicated, purpose-built units. The firefighters observed the build-up of smoke and gases from a safe distance, until a flashover occurred. Training was normally in two stages: observation; and real fire training delivery. Both live fire and LPG fire behaviour units were observed. Because of the nature of fire behaviour training, the temperatures to which firefighters were exposed varied widely in time and with specific location during different training exercises. In developing these guidelines, temperature recordings were obtained from exercises in 'container-based' fire behaviour units and in similarly sized non-container units. In each case, trainees were positioned no closer than approximately 3-4 metres from the fire source. Temperature sensors were situated at a height of about 1-1.5 metres, the same horizontal distance from the fire as the firefighters.

2.2.3.2 Temperature range in which guidelines are based:
240–250°C wood fire, container unit.
100–170°C LPG fire, solid unit (fire house).

2.2.3.3 Clothing and equipment worn:
Full firefighters gear with self-contained breathing apparatus (BA).

2.2.3.4 Duration of training sessions monitored:
Sessions lasting from 6 minutes to in excess of 40 minutes were documented. The latter entailed repeat exposures in small groups. Some instructors were exposed for most of this time.

2.2.3.5 Notes for Guidance
- Where training consists only of observation with trainees sitting observing fire behaviour demonstrations then longer periods of exposure can be tolerated without body temperature reaching hazardous levels than where active firefighting is involved.
- When the training is extended to cover observing (and practising) the effects of using water on the fire (real fire training delivery) this increases the heat exposure of the trainees (and instructors).
- Although temperature sensors may show similar readings, probably due to the radiant heat component, fully enclosed rooms create more potential heat load because, with open units, the fire appears to create an inwards flow of fresh air past the firefighters.
- Posture (e.g. kneeling up rather than sitting slumped) is likely to have a significant effect on heat exposure and consequent strain since more of the body surface is exposed to the radiant heat. Firefighters should be instructed to sit as low as possible during the exercise.
- The purpose of training should be clarified. If the purpose is to observe the build-up of gases followed by a flashover there is little additional value in 'feeling' heat by moving trainees closer.
- Where instructors are likely to be exposed to longer or multiple exposures then they should avoid positioning themselves closer to the fire source than the trainees if at all possible.
- Rotation of instructors should be practised to reduce individual exposure.
- The risk of heat stress depends to some extent on the starting temperature of the unit, rather than the final temperature.

Insufficient data are available for guidelines. The following values (Table 2.2), derived from physiological and environmental measurements taken during actual training sessions, are indicative of possible risk. However, they do not have the same statistical basis as those obtained for search and rescue training using average exposures and should be used with caution as indications only of the likely level of heat stress. As stated elsewhere, physiological monitoring is strongly recommended.

2.2.4 Search and rescue training

2.2.4.1 Summary of scenarios on which guidance is based:
A multi-compartment training facility was routinely used with a live fire in one room. A variety of ‘storyboards’ were used (warehouse, guesthouse, factory) with ‘persons reported’. Firefighter teams (of 2 to 4 firefighters) conducted searches and rescued between one and four casualties. In general, some firefighting took place with some of the team instructed to extinguish the fire. This usually occurred at the end of the exercise once the casualties had been removed.

2.2.4.2 Temperature range on which guidelines are based:
Recorded temperature during exercises ranged from 16–215°C.

2.2.4.3 Clothing and equipment worn:
Full firefighters gear with self-contained breathing apparatus.

2.2.4.4 Duration of training sessions monitored:
Sessions monitored lasted from 4 to 30 minutes although 10 to 20 minutes was the normal length of time spent in the unit. (See Table 2.2.)
Table 2.2  Indicative temperatures for limiting Fire Behaviour training

<table>
<thead>
<tr>
<th>Duration</th>
<th>Conditions</th>
<th>Environmental Temperature</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 to 8 minutes</td>
<td>see below *</td>
<td>see below *</td>
<td>low #</td>
</tr>
<tr>
<td>20 minutes</td>
<td>Container-based exercise, closed unit, some use of water, carbonaceous fire.</td>
<td>mean temperature 225–235°C, peak temperature 240–250°C</td>
<td>Excessive #</td>
</tr>
<tr>
<td>25 minutes</td>
<td>Container-based exercise, open back, observation only, carbonaceous fire.</td>
<td>mean temperature 225–235°C, peak temperature 240–250°C</td>
<td>low #</td>
</tr>
<tr>
<td>30-35 minutes</td>
<td>‘Permanent’ unit, closed room, observation only, LPG fire.</td>
<td>mean temperature 140–150°C, peak temperature 170–180°C</td>
<td>Moderate #</td>
</tr>
<tr>
<td>30-35 minutes</td>
<td>‘Permanent’ unit, closed room, observation only, LPG fire.</td>
<td>mean temperature 160–170°C, peak temperature 170–180°C</td>
<td>Excessive #</td>
</tr>
</tbody>
</table>

**Note:** These indications are based on an examination of the database of physiological and environmental measurements obtained during actual training sessions rather than any statistical projection and should be used with caution. The times indicated are measured from the start of the exercise. An individual trainee was not necessarily exposed to the heat for this duration although at least one instructor usually was.

### 2.2.4.4 Notes for guidance

- Search and rescue exercise routines vary considerably, both between different training establishments and at the same establishment where the training is being provided to different groups of trainees and/or for different purposes. In addition, even at the same establishment, the air temperatures obtained during different repetitions of the same exercise can vary significantly. This reinforces the need for establishing systems for monitoring temperatures during each exercise and not assuming that a ‘standard’ fire for a ‘standard’ exercise is safe.

- The fire source does not appear to be important (LPG or carbonaceous) although LPG systems can be ‘fired up’ more quickly and may give lower starting temperatures.

- Activity is an important source of heat. The guidance is based upon multi-compartment search and rescue. If the planned scenario is likely to entail a large rescue element or to exclude physical rescue activities then conditions/duration may be extended or reduced accordingly.

- In a multi-compartment training facility, temperatures in the different compartments can vary considerably, particularly with only one fire. Exposure to the more extreme temperatures close to the fire may be very brief. Nevertheless, in most cases temperatures close to the fire provide a reasonable guide to the temperatures likely to be encountered elsewhere in the training facility (as the fire heats the rest of the building) and therefore the heat exposure of the team.

- Not surprisingly, environmental temperature varies considerably with vertical height. The temperatures below are based upon readings obtained at 1–1.5 metres from the ground. Extensive measures have shown that the relationship between temperatures at these levels and ceiling temperatures is not consistent and cannot therefore be predicted with any reliability.

- Because the impact of training conditions on firefighters can vary widely it is strongly suggested that, even where guideline temperatures are adhered to, physiological monitoring is employed on a regular basis to verify the adequacy of risk control measures (See Section 4.2).

- An average exposure temperature provides a more accurate indication than peak temperature of the likely extent of any risk of heat stress. However, as discussed in Section 2.2.4, this requires training centres to have systems in place to monitor the temperatures in different parts of the training facility and to relate these to the location of the team undergoing training. Few centres have this capability at present. Consequently, guideline temperatures are provided based both on maximum temperatures recorded during exercises and on a time-weighted average (mean). In applying the maximum temperatures it is assumed that most of the training session will be spent in lower temperatures away from the direct heat source.

- Where the location of the team cannot be regularly established (either by radio or by automatic sensors) then, assuming that the team enters the fire compartment at some stage in the exercise, the duration of the exercise should be based solely on temperatures obtained from a sensor placed in this area at a similar distance from the fire to the firefighters. If the fire compartment is not entered during the exercise then the temperatures in the hottest compartment visited should be used to establish the guideline maximum temperature.
- Where team locations can be monitored then additional sensors can be used to provide more detailed information.

- Should temperatures in other compartments be considerably lower than in the fire compartment, longer durations than those indicated below may be acceptable. As a guide, examination of the data base on which the guidelines are based suggests that, if temperatures in other working compartments are more than 40°C lower than the fire compartment (maximum) temperature then the guideline used can be moved up one band. If (exceptionally) a temperature difference of more than 80°C is obtained then the guideline can be moved up two bands (see example below).

- Example of adjustment:
  
  Peak temperature: 149°C, other compartment: 104°C.

  - Criterion based on maximum temperature: less than 10 minutes
  - Difference from maximum temperature: 45°
  - Revised criterion: acceptable duration 10-12 minutes.

- The guideline temperatures below (Tables 2.3 and 2.4) assume that reasonable risk management procedures are in place (pre-training checks; fluid replacement; dressing down, etc).

Table 2.3  Guideline temperatures for limiting Search and Rescue training based on maximum temperature recorded

<table>
<thead>
<tr>
<th>Duration</th>
<th>Environmental Temperature</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 mins</td>
<td>see below *</td>
<td>Low #</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(core temperatures less than 38.5°C)</td>
</tr>
<tr>
<td>10-12 mins</td>
<td>maximum 130°C</td>
<td>moderate #</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(core temperatures above 38.5°C)</td>
</tr>
<tr>
<td>13-15 mins</td>
<td>maximum 120°C</td>
<td>moderate #</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(core temperatures above 38.5°C)</td>
</tr>
<tr>
<td>16-20 mins</td>
<td>maximum 100°C</td>
<td>moderate #</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(core temperatures above 38.5°C)</td>
</tr>
<tr>
<td>21+ minutes</td>
<td>insufficient data</td>
<td>moderate #</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(core temperatures above 38.5°C)</td>
</tr>
</tbody>
</table>

* For exercises less than about eight to ten minutes, unless exposure to fire is continuous, the fire kit appears to delay heat penetration such that only a low risk arises. Where fire exposure is continuous then fire behaviour guidelines (less than 8 minutes) should be followed.

# Low risk: core temperatures unlikely to exceed 38°C; moderate risk: some core temperatures may exceed 38°C but are unlikely to exceed 38.5°C; excessive risk: some individuals may experience core temperatures greater than 39°C

Table 2.4  Guideline temperatures for limiting Search and Rescue training based on time-weighted average (TWA) temperatures

<table>
<thead>
<tr>
<th>Exposure Time (mins)</th>
<th>TWA Environmental Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10</td>
<td>no more than 80°C</td>
</tr>
<tr>
<td>11-15</td>
<td>no more than 60°C</td>
</tr>
<tr>
<td>16-20</td>
<td>no more than 40°C</td>
</tr>
</tbody>
</table>

These guidelines are based upon predictions of no more than 5% of firefighters having a core temperature of 39°C (infrared, tympanic) in a given mean environmental temperature. They provide a more accurate estimate of the level of risk likely to be experienced during training than those based on maximum temperatures and should be used wherever possible.

Appendix 4 contains blank forms for use in determining a TWA, together with a recording checklist. Figure A5.1 presents a record sheet for use in the firehouse control room for recording temperatures and team locations during an exercise. Figure A5.2 presents a sheet to be used in calculating the TWA temperature from these data. Figure A5.3 presents a checklist to be used during exercises.

At many training establishments, crews enter the firehouse together and remain together throughout the exercise. In such cases, such monitoring is relatively straightforward. In other instances, such as some of the more complex exercises conducted at the Fire Service College, crews may be spread throughout a large structure and recording their location and exposures may not be so easily achieved. Consideration should be given to alternative approaches for determining exposure in such situations. Nevertheless, the principle of needing to know the temperatures to which firefighters and trainers are exposed remains true.

When a team enters the firehouse, the time should be recorded, and the temperature for the room or zone entered recorded:
Clearly, the more often a temperature is recorded, the more accurate an estimate of temperature exposure will be provided. It is suggested that recording the temperature on changing location within the firehouse will provide a reasonable degree of accuracy. However, if the team remains within the same location for more than 5 minutes it is recommended that a further time and temperature is recorded.

When the team then move on into the next zone or room, the time and temperature are recorded as before.

Figure 2.1 shows a completed record sheet for this session.

To calculate the TWA, a second sheet is provided. The temperature from the first row (column C) gives the initial exposure temperature. In the example, this is 63°C. The duration to which this temperature applies is calculated by subtracting the entry time from the time of the next reading (T2- T1). These two values are entered into column D and the result written in column E as shown.

At this point, the cumulative total time and the time since entry are the same and the TWA temperature is also that of the first location.

The temperature for the second reading is inserted in the second row. The time to which this temperature applies is determined by subtracting the entry time from the time this reading is taken at. The cumulative time; time since entry; and cumulative TWA can then be calculated using the entries as shown.

Figure 2.2 shows a completed calculation sheet for this session.

The recommended exposure was therefore exceeded for this training session. Future sessions should either be shorter (the temperature was acceptable for a session lasting no more than 10 minutes) or temperatures should be reduced by lighting a smaller fire, committing the team sooner after the fire is lit, etc.

Note that after 10 minutes of the exercise (third chamber) the average temperature was 69°C. Calculating an average during the exercise would have alerted the safety officer to the fact that the guideline temperature was likely to be exceeded and the exercise could have been shortened to safeguard trainees and instructors.
**Figure 2.1 Completed Record Sheet for Temperature Exposures**

| Brigade Name: | Wessex |
| Training Facility: | firehouse |
| Exercise Name: | search and rescue |
| Date: | 29th February, 2003 |

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Team Location</td>
<td>Location Temperature (°C)</td>
</tr>
<tr>
<td>T1 (entry)</td>
<td>10:20</td>
<td>Room 1</td>
</tr>
<tr>
<td>T2</td>
<td>10:25</td>
<td>Room 1</td>
</tr>
<tr>
<td>T3</td>
<td>10:28</td>
<td>Room 2A</td>
</tr>
<tr>
<td>T4</td>
<td>10:30</td>
<td>Room 2B</td>
</tr>
<tr>
<td>T5</td>
<td>10:33</td>
<td>Room 3</td>
</tr>
<tr>
<td>T6</td>
<td>10:35</td>
<td>Room 2B</td>
</tr>
<tr>
<td>T7</td>
<td>10:36</td>
<td>Room 2A</td>
</tr>
<tr>
<td>T8</td>
<td>10:37</td>
<td>Room 1</td>
</tr>
<tr>
<td>T9</td>
<td>10:38</td>
<td>Exit</td>
</tr>
</tbody>
</table>

**Figure 2.2 Completed calculation of Time-Weighted Average (TWA) temperature**

| Brigade Name: | Wessex |
| Training Facility: | firehouse |
| Exercise Name: | search and rescue |
| Date: | 29th February, 2003 |

<table>
<thead>
<tr>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<td>Temp x Duration</td>
<td>Total (Temp x Time)</td>
<td>Cumulative Total</td>
<td>Time Since Entry</td>
<td>Cumulative TWA (F x G)</td>
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<td>63 x 6</td>
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<td>(T2-T1)</td>
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<td>63</td>
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<td>(T3-T1)</td>
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<td>(T4-T3)</td>
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<td>(E3 + E4)</td>
<td>(T4-T1)</td>
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<tr>
<td>687</td>
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<td></td>
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<td>85 x 3</td>
<td>255</td>
<td>(E3 + E4)</td>
<td>(T5-T1)</td>
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<tr>
<td>942</td>
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<td>(T6-T5)</td>
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<td>(T8-T1)</td>
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<td>(T9-T8)</td>
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<td>(E7 + E8)</td>
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<td>1368</td>
<td>18</td>
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</tbody>
</table>

Exercise Duration: 18 minutes
Guideline TWA Temperature (from chart): 40°C
TWA exceeded / acceptable (delete as applicable)

Fire Service Manual
Chapter 3 – Risk reduction

As with any health and safety hazard, reduction of risk at source is the most effective control measure. Exposure to the hazard of elevated temperatures is an essential part of firefighter training. Nevertheless, Brigades should pay careful attention to the necessity for such training, questioning whether the training objectives can be achieved by alternative approaches. Section 2.1 included some elements, drawn from DCOL 11/1999, ‘Practical Training for Compartment Fires’ to facilitate this. As stated in this document, well-defined training objectives help to ensure that exposure to risks is justified by the training benefits.

Developing an awareness of the experience of exposure to hot fire conditions and learning how to recognise the negative effects of such exposures is clearly an important aspect of fire training. A survey of UK Brigades indicated that the majority included experiencing heat as one of their training objectives. However, ‘exit interviews’ with a number of firefighters following heat and humidity training suggest that experiencing heat on its own was not considered to be an appropriate training objective, at least in refresher training for experienced firefighters. Firefighters undergoing live fire training usually experience the effects of heat as a component of such training and this combining of training objectives was seen as a more appropriate use of training resources. The benefit of such training could be extended, for example, by considering incorporating elements requiring decision making or other mental processes into fire training activities so that firefighters can develop an appreciation of the psychological as well as the physical impact of hot work. This merging of training objectives will help to ensure that the training benefits justify the exposure to risk and will reduce comparatively ‘unnecessary’ risk exposure where training objectives could be met by other means or during other forms of training.

Assuming that the aims and objectives of the training are well thought out and that exposure to elevated environmental temperatures is a justifiable element of that training then application of the guidelines above should help to reduce the associated risk to an acceptable level. However, the use of any live fire system (carbonaceous or LPG) implies a potential lack of control over environmental temperatures. The temperature monitoring advocated in Section 2.2.1 provides an element of ‘control’ although reliance on this represents a ‘reactive’ rather than a ‘proactive’ system. As Brigades are well aware, carbonaceous fires can behave unpredictably at times, even in the ‘controlled’ environment of a crib, and temperatures can increase rapidly as a consequence. Although LPG systems provide a greater degree of flexibility and control, the possibility of system failure should not be
overlooked. The risk of sudden exposure to markedly elevated temperatures can be controlled by careful consideration of the risks of such increases occurring and ways of reducing that likelihood (HAZOP study) and the provision of well-thought out practicable procedures to deal with such eventualities.

The implementation of the measures advocated to reduce risk to acceptable levels; to reduce the likelihood of unexpected (uncontrolled) increases in risk; and to minimise the impact of any unexpected increases are an essential element of managing the risk of heat stress. However, because of the necessity for the degree of controlled realism in live fire training the emphasis of these measures is on reducing risk to a level justified by the training objectives. It must be emphasised that application of the guidelines above will not remove the risk.

4.1 Pre-exposure control measures

4.1.1 Pre-exposure screening

Pre-employment assessments should identify those individuals with permanent or long-standing medical conditions that might render them unsuited for physical work in hot conditions. These would be likely to include disorders:

- that might cause an individual to be particularly susceptible to heat stress (e.g. renal problems adversely affecting fluid control);
- that might cause an individual to be more likely to suffer as a result of such exposure (e.g. cardiac conditions which diminish the capacity to withstand the heightened cardiovascular strain of heat exposure).

Prior to any period of training involving exposure to hot conditions, firefighters should be subjected to some form of health check. This should take the form of some kind of self-completed checklist or questionnaire, agreed with the Brigade Medical Advisor, that would list symptoms, ailments or medications that might give rise to a temporarily increased susceptibility to the heat. A gastro-intestinal upset for example can temporarily disrupt fluid balance impairing thermal tolerance. Many drugs administered therapeutically have the potential to impair normal thermoregulation. Individuals should be asked about their use of prescribed medication, 'over-the-counter' medicines such as antihistamines, or any other remedies for self-treatment which have been purchased. Table 4.1 shows some predisposing factors to heat intolerance. This presents conditions most likely to be identified during a pre-employment medical. As such, it is intended as a prompt for a responsible clinician who will require to exercise clinical judgement as to whether or not the condition was sufficiently severe to jeopardise heat tolerance. However, other problems may create a short-term susceptibility and these are listed in Table 4.2.

4.1.2 Health monitoring and self-assessment

Prior to any period of training involving exposure to hot conditions, firefighters should be subjected to some form of health check. This should take the form of some kind of self-completed checklist or questionnaire, agreed with the Brigade Medical Advisor, that would list symptoms, ailments or medications that might give rise to a temporarily increased susceptibility to the heat. A gastro-intestinal upset for example can temporarily disrupt fluid balance impairing thermal tolerance. Many drugs administered therapeutically have the potential to impair normal thermoregulation. Individuals should be asked about their use of prescribed medication, 'over-the-counter' medicines such as antihistamines, or any other remedies for self-treatment which have been purchased. Table 4.1 shows some predisposing factors to heat intolerance. This presents conditions most likely to be identified during a pre-employment medical. As such, it is intended as a prompt for a responsible clinician who will require to exercise clinical judgement as to whether or not the condition was sufficiently severe to jeopardise heat tolerance. However, other problems may create a short-term susceptibility and these are listed in Table 4.2.

For assistance in training, this table, together with recommended actions, is presented in Appendix 5 in the form of a checklist. Firefighters should be instructed to specifically ask physicians or pharmacists whether drug preparations could
adversely affect thermoregulation or heat tolerance. Antihistamines for example can suppress sweating.

Where training is extended over more than one day, a brief follow-up check should be included in pre-exposure briefings. It may be advisable for this to also be a written self-administered questionnaire. Instructions should be issued to instructors as to the course of action to be followed if any problem is reported. It must be recognised that a firefighter or trainee might be reluctant to report any problem that excludes them from training. The importance for their own safety, as well as that of their colleagues and the instructors, must be emphasised and a culture of openness encouraged.

4.1.3 Information and training

Any system of self-assessment relies on accurate and honest reporting, unless the firefighter is visibly unwell. It is important therefore that firefighters are given adequate information and training, not just in recognising the symptoms of heat-related illness but also in understanding how their susceptibility might vary and the factors that can contribute to that variation. It is not sufficient, for example, to ask a firefighter ‘Are you taking any form of medication that might increase your risk of heat-related illness?’ unless the firefighter has an understanding of which forms of medication could have such effects. Brigades should compile lists of common medications for reference and medical advice should be sought on less common prescriptions. Leaflets such as ‘The heat is on’ used by a number of brigades provide a useful reminder to supplement such training. Instruction should cover:

- the risks of working in the heat (covering both the physical (health) effects and the physiological effects on reasoning and decision making);
- personal factors contributing to such risks (medical factors, lifestyle factors, etc.);
- risk control measures prior to an exercise (reporting illness, etc; water intake; avoiding unnecessary physical activity or heat exposure; etc.);
- control measures during an exercise (avoiding unnecessarily macho culture; avoiding unnecessary exposure; safety systems, etc.);
- control measures after an exercise (fluid replacement; cooling-off procedures, etc.);
- avoiding other hazards (e.g. driving) if affected.

4.1.4 Pre-cooling measures

The insulative properties of a firefighter's turnout gear are such that some elevation of body temperature can occur before exposure to hot environments. Physical activity or warm climatic conditions may both play a part. It is important that firefighters are encouraged to stay cool prior to a training session and they should be encouraged to loosen clothing and remove firehoods and other insulative clothing whenever it is safe to do so. Some scientists have advocated artificially pre-cooling firefighters prior to entry. Although the benefits of this have yet to be
demonstrated, a degree of water 'pre-loading' is considered desirable and firefighters should be encouraged to drink a modest amount (about 250ml) before training (see post-exposure control for more detail).

4.1.5 Dietary advice

Lack of food can lead to low blood sugar levels that can increase the likelihood of heat strain. Firefighters should be encouraged not to skip breakfast on training days. High carbohydrate foods are preferable. High protein foods place additional demands on water reserves as some water has to be lost in excreting the nitrogenous waste; and high fat foods take longer to digest, placing a heavier burden on the digestive tract. This places a competing demand on the cardiovascular system as more blood is required for heat transfer to the skin on exposure to hot conditions.

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4.1.5.2 Guidelines on dietary advice

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4.2 Monitoring and control during training

4.2.1 Environmental monitoring and recording

Monitoring and controlling environmental heat exposure should be regarded as an essential feature of any training session. All facilities used for hot training should be fitted with temperature sensors. It is unacceptable for trainees to be exposed to elevated temperatures creating a risk of injury if those responsible for the training have no knowledge of the temperature involved and consequent extent of the risk.

Exposure temperature levels should be monitored at all times during training. Appendix 1 provides basic guidance on measurement. It is essential that those responsible for monitoring have a clear understanding of the limits imposed on measurements obtained and of the procedures to be adopted should criteria levels be exceeded (e.g. shutting down fuel supplies; venting compartments; withdrawing teams).

Records of exposures should be maintained and correlated with physiological monitoring (see Section 4.2.2 below) to confirm the effectiveness of measures taken to control risk and to allow training environments to be modified or criteria refined as appropriate.

4.2.2 Physiological monitoring

Monitoring of the body temperature during training would provide individualised protection against allowing body temperature to rise to unacceptable levels. However, current technology does not provide reliable continuous monitoring at a reasonable price. Measurement of core temperature immediately after a training session provides reassurance that risk control measures are operating effectively (or indicates what they are not). Measurement of tympanic temperature using infrared thermometry (such as that manufactured by Braun) appears to provide reasonable indication of core temperature, subject to certain measurement constraints.

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4.2.3 Supervisor, buddy and self-monitoring

All those involved in work at elevated temperatures should be aware of the signs and symptoms of the effects of heat so that they can recognise the signs in themselves, or detect symptoms in others. Although limiting environmental temperatures and durations of exposure, together with other control measures, should provide adequate control, it should be emphasised to all that voluntary withdrawal from a training session is an option and that no stigma attaches to such an action. Team members should also be encouraged to observe colleagues and to alert instructors to any apparent problems. Many Brigades have informal procedures amongst instructors to identify those trainees with symptoms of heat illness. One difficulty with such approaches is that the instructor is also likely to be exposed to similar temperatures and their own judgement may be impaired. Such systems on their own are not an adequate risk control measure, although they do provide a useful additional measure. Care should be taken to ensure that the procedures are applied and interpreted in a reliable and consistent manner. In many industries, repeated exposures to environmental hazards can create a tendency to become over familiar with the hazard and cease to regard it as presenting a risk. Although instructors will...
become accustomed to heat exposure they will not become significantly acclimatised to it and should be counselled against becoming blasé. Such an attitude can endanger the safety of themselves and those in their charge. Instructors can, of course, reduce their personal exposure during safety officer duties by standing away from heat sources and minimising unnecessary physical activity.

4.3 Post-exposure control measures

4.3.1 Accelerated cooling

After a period of heat exposure a significant amount of heat will be trapped in the body and clothing of the firefighter. Their highly insulative clothing will now act to retain that heat, preventing its dissipation into the environment. The simple expediency of unfastening tunics can help to speed the cooling process. In some circumstances without this, body temperature can continue to rise as heat in working muscles continues to be distributed around the body.

Unfastening or removing tunics and removing helmets and gloves all provide passive assistance in losing heat. Where natural air movement is low, fans may assist in the evaporation of sweat and dissipation of heat, although care should be taken to avoid the firefighter becoming chilled. Alternatively, some studies have shown that immersing hands and wrists in cool water can assist in reducing body temperature.

4.3.2 Rehydration

Much of the adverse effect of heat exposure stems from the resultant dehydration as the body loses copious quantities of sweat in an attempt to regulate its temperature. Fluid replacement is, therefore, an important aspect of restoring the thermal and physiological equilibrium of the trainee and instructor. Studies have shown that, by the time a firefighter feels thirsty, they are already dehydrated. Similarly, although a few mouthfuls may be enough to remove the immediate sensation of thirst, this is not sufficient to restore thermal balance. Adequate fluid replacement is particularly important for instructors who may be exposed to elevated temperatures for longer periods.

Cool (10–15°C) rather than cold drinks are preferable, and there is some argument for tepid (30°C) drinks. The direct cooling effect of any fluid is minimal and, if a drink is too cold, it may cause local vasoconstriction of the blood vessels in the stomach resulting in a slower rate of absorption. Flavoured drinks are acceptable, if preferred, but carbonated and alcoholic drinks should be avoided (carbonated drinks cause misleading sensations of fullness). Despite the importance of fluid replacement, firefighters should be discouraged from drinking copious quantities too rapidly. Rapid absorption of large volumes of water can result in excessive dilution of blood ions (salts), with adverse effects.

It is not necessary to provide saline drinks or salt tablets. The salt concentration of sweat is less than that of blood and, although the salts lost through sweating ultimately require to be replaced, dietary salt is normally adequate for this purpose.

4.3.3 Emergency procedures

The measures described above should significantly reduce the risk of serious injury from heat exposure. Nevertheless, it is important that Brigades have clear emergency procedures to deal with such events. Clinical studies have reported individuals ‘driving’ themselves (e.g. in an athletics event) and then collapsing, and all staff should be aware of this possibility. In serious cases, if temperature control has failed, core temperature will continue to rise despite withdrawal from the high temperature environment, removal of clothing, etc.

Remedial measures should be in place, both for those experiencing minor symptoms (concentrating on rehydration and cooling) and those in a state of collapse, for whom the usual first aid priorities of airways, breathing and circulation should be adopted. In such circumstances, cooling the casualty is important as clinical experience has shown that complications do not occur if casualties are treated within fifteen minutes of collapse and if their temperature is below 38°C within one hour of starting treatment. A prompt response is clearly vital.

For the conscious casualty who can be cooled by removing protective clothing then wetting and fanning the body, and who is able to take water, hospitalisation is not considered necessary provided: there is no impairment of consciousness; no evidence of complications; and the core temperature has fallen back below 38°C within one hour after the prompt commencement of treatment. It should be noted that evaporation is a much more efficient means of removing heat. Wetting and fanning is likely, therefore, to be a more effective approach than immersion in water or ice packs. Hospitalisation will be required for more serious cases.

4.3.4 Information and training

Correct post-exposure behaviour should be included in any information and training. Firefighters and instructors should be aware of the importance of cooling and rehydration. Particularly at the end of a training day they should be cautioned against rushing away ("I’ll have a drink when I get home" is not acceptable). Those experiencing symptoms such as dizziness should be counselled against travelling (particularly if driving) until symptoms have subsided and adequate cooling and rehydration has taken place. Monitoring the core temperature of such individuals provides further reassurance. Urine colour (small quantities of dark urine suggest continuing dehydration) can also provide an informal check.
Appendix 1 – The effects of heat on the body and heat-related disorders

A1 The control of body temperature and the thermal environment

A1.1 Introduction

The human body is capable of maintaining an essentially stable core temperature of approximately 37°C over a wide range of environmental conditions. This is achieved using a number of involuntary thermo-regulatory mechanisms and by voluntary (behavioural) factors such as the choice of appropriate clothing or positioning the body in relation to the heat (shielding). If, however, the environmental factors are such that the core temperature cannot be maintained within a safe range, ill health may arise. Core temperature is the mean temperature of the thermal core of the body. The term ‘core’ refers to all the tissues located at a sufficient depth not to be affected by a temperature gradient through surface tissue.

In hot conditions, if the body’s various thermo-regulatory mechanisms cannot balance the heat input and output so as to achieve an equilibrium, there will be a steady rise in core temperature. Core temperature must be controlled within a relatively narrow band (±3°C) if potentially serious harm to health is to be avoided. In the context of work at high temperatures, the body’s thermal equilibrium is affected by the following factors:

A1.2 Metabolic heat generation

The body creates heat by internal chemical reactions. The rate of heat generation increases when physical work or exercise is carried out. Surplus heat must be dissipated within the body and lost to the environment.

A1.3 Evaporative heat loss

At high ambient temperatures, the main mechanism for heat loss from the body is the evaporation of sweat from the body’s surface. The factors which affect the rate of evaporation are:

- The relative humidity of the surrounding air. High humidity inhibits evaporation, thus restricting heat loss.
Heat exhaustion

Heat fainting results from a combination of thermal and cardiovascular strain. Symptoms include:

- A feeling of being unwell, including tiredness, headaches, dizziness, nausea and vomiting;
- Breathing difficulties/shallow rapid respiration;
- Rapid pulse which may be bounding or weak;
- Extreme thirst and mouth dryness;
- Muscle cramps, particularly effecting the stomach and legs;
- Poor control over movements/stumbling/weakness;
- Irritability.

This leads to two forms of heat exhaustion; salt depletion and, more likely in firefighting situations, water depletion. Table A2.1 tabulates the differences between the two forms.

A2 Health effects of working in the heat

A2.1 Introduction

There have been many examples of heat illness and death caused by heat stress in different industrial and leisure settings. A key factor in many of these cases is how accustomed those exposed are to hot conditions, both behaviourally and physiologically. In addition to effects on health, working in hot conditions can detrimentally affect task performance, co-ordination and judgement. This has been shown, in some industries, to have an effect on unsafe behaviour and accidents.
A2.4 Heat stroke

If the total heat load (environmental conditions and metabolic heat generation) is such that sufficient body heat cannot be lost to the environment then core temperature will rise. If this continues then body temperature may exceed its controllable limits. In wet humid conditions a reduction in sweating may occur due to swelling and blocking of the sweat glands. Although normally associated with humid external environments, the humid microclimate inside a firefighter’s clothing could also create such conditions. Alternatively, sweating may cease because of depletion of body water. The decrease in sweating promotes a further, often rapid, rise in core temperature to beyond 38–39°C where collapse may occur, to above 41°C (rectal temperature) where heat stroke may occur.

With heat stroke there is a major disruption of the central nervous function. At body temperatures above about 40°C the person’s mental functions are disturbed and sweating often stops. Normal temperature control mechanisms are lost and a further rapid temperature rise occurs. The symptoms include unconsciousness, convulsions, or mental confusion; failure of the central nervous thermoregulation and sweating; the casualty will be hot, dry and flushed with a high pulse and a core temperature probably in excess of 41°C. Heat stroke is an acute and potentially fatal condition. It requires immediate medical attention with cooling of the body essential.

The condition can be of sudden onset with no warning or may be preceded by headache, dizziness, confusion, faintness, restlessness or vomiting (symptoms of heat exhaustion). The change from normal aches or tiredness to serious symptoms may not be obvious to the casual observer. Therefore exposed individuals and their supervisors must be trained to recognise their onset. The transition from moderately elevated body temperature to heat stroke can be very rapid. For this reason, no person should work alone or unsupervised in potential heat stress conditions. If work performance deteriorates this is usually a reliable indication that significant physiological strain has already occurred.

A2.5 Other effects

A2.5.1 Burns

Apart from extreme exposures, the firefighter’s clothing provides excellent protection against burns. Previous studies have shown that most reported burns to firefighters occurred to unprotected areas such as the neck and wrists and should be prevented by the use of firehoods and suitably designed gloves. There have been a number of reports of burn or scald injuries inside standard issue firefighters’ protective clothing. One possible mechanism for this has been suggested, involving compression of the clothing by BA straps.

A2.5.2 Heat Oedema

This is swelling of the feet and ankles, and it usually occurs among those unacclimatised to the heat in the first week of exposure. It is usually alleviated by rest or on returning to a cooler environment. It is unlikely to be encountered in the sporadic exposure conditions of firefighting training.

A2.5.3 Prickly Heat (heat rash)

Prickly heat appears in red papules on the skin usually in areas where the clothing is restrictive. It gives rise to a prickling sensation, particularly as sweating increases. It occurs in skin that is persistently wetted by unevaporated sweat, apparently because the sweat ducts become blocked. The papules may become infected unless they are treated.

Heat rash is not dangerous, although it may result in patchy areas of skin that are temporarily unable to produce sweat. This may adversely affect evaporative heat loss and thermoregulation; prickly heat has been shown to decrease tolerance to heat and to reduce work capacity. Sweating capacity has been shown to recover within 3–4 weeks of prickly heat. A cool shower after exposure to hot conditions can help to reduce the risk of this problem occurring. If heat rash is suspected, the individual should be referred for a medical opinion.

In most cases the rashes disappear when the individual is returned to cool environments. It is also thought likely that none of the rashes occur when a substantial part of the day is spent in cool and/or dry areas so the skin surface can dry. Providing reasonable attention is paid to personal hygiene rashes should not therefore be a problem in firefighter training although those subjected to repeated heat exposures (e.g. instructors) may be at risk and problems may also be encountered during the summer months.

### Table A2.1 Distinction between predominant salt depletion and predominant water-depletion heat exhaustion

<table>
<thead>
<tr>
<th>Selected Features</th>
<th>Salt depletion Heat exhaustion</th>
<th>Water depletion Heat exhaustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of symptoms</td>
<td>3 to 5 days</td>
<td>Often much shorter</td>
</tr>
<tr>
<td>Thirst</td>
<td>Not prominent</td>
<td>Prominent</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Prominent</td>
<td>Less prominent</td>
</tr>
<tr>
<td>Giddiness</td>
<td>Prominent</td>
<td>Less prominent</td>
</tr>
<tr>
<td>Muscle cramps</td>
<td>In most cases</td>
<td>Absent</td>
</tr>
<tr>
<td>Vomiting</td>
<td>In most cases</td>
<td>Usually absent</td>
</tr>
<tr>
<td>(Thermal) sweating</td>
<td>Probably unchanged</td>
<td>Diminished</td>
</tr>
<tr>
<td>Urine concentration</td>
<td>Moderate</td>
<td>Pronounced</td>
</tr>
</tbody>
</table>

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It is known that prickly heat is related to surface ambient temperature and sometimes to having hot showers.

A2.5.4 Heat Cramps

Heat cramps (painful muscle spasm) may occur in individuals working in the heat. They are caused by salt deficiency when salt is lost during severe sweating and large amounts of water are taken without replacing the salt. The condition may have delayed onset and is most likely in people who are unacclimatised to hot work or have a low dietary salt intake. Cramps usually occur in the muscles principally used during work (limbs) or stomach. They can be alleviated by rest, the ingestion of water and the correction of any body fluid electrolyte imbalance, or by putting the affected muscle 'on the stretch' and applying gentle massage to the area. Adequate salt intake with food should prevent this occurring.

A2.5.5 Temporary Infertility

Heat exposure has been associated with temporary infertility in both male and females, with the effects being more pronounced in males. Heat related infertility is usually temporary, reduction in heat exposure or job transfer should result in complete recovery. Again, the relatively brief exposures of firefighter training should not create a problem.

A2.6 Illnesses exacerbated by heat

Because work in the heat increases the load on the body, in particular the circulatory system, illnesses affecting this system may well be exacerbated by work in the heat. The main ones are detailed in Section 4.1.1 (screening), and these may affect the individual’s ability to work in the heat. Some other illnesses may be exacerbated by hot conditions, while not rendering the individual unsuitable for the work. Two examples of this are dermatitis and fungal infections.

A2.6.1 Dermatitis

This is a very common skin condition resulting from irritation and inflammation of the skin by external causes (e.g. abrasive dusts). Sweating softens the outer layer of skin and reduces its effectiveness as a barrier to irritants. PPE and clothing may add to the problems by occluding chemical agents against the skin and therefore increasing uptake, or by mechanical abrasion. Avoiding tight clothing, regular replacement of badly soiled clothing, and good personal hygiene can all help to reduce the risk of dermatitic conditions developing. Prevention of skin problems requires a focused management programme; refer to HSE guidance MS 24 and IND (G) 233 (L).

A2.6.2 Fungal infections

Such infections are promoted by heat and humidity and tend therefore to occur in areas of the body where such conditions are most pronounced, such as between the toes (athletes foot) or in the groin or armpits (arm pits). Good personal hygiene, possibly enhanced by the use of an anti-fungal powder is usually effective in preventing or treating such conditions.

A3 MEASURING AND ASSESSING THE RISK

A3.1 Risk factors

There are a number of factors that increase the risk of individuals experiencing heat strain. These include the climate, workload, clothing and the individual themselves. Each of these factors normally has to be measured or estimated in order to determine the extent of the risk in any conditions.

A3.1.1 Climate

The main ways that the climate affects the heat strain experienced are via evaporation of sweat, convection, radiation and conduction of heat to or from the body (see Section A1). These factors will affect how much heat can be lost to any particular environment. A detailed analysis of the climate normally requires measurement of the following four basic parameters: air temperature, mean radiant temperature, air speed, and absolute humidity.

Air temperature is usually taken as dry bulb temperature, and absolute humidity is calculated from a combination of dry bulb and wet bulb temperatures. In firefighter training establishments, air temperature is registered using some form of electronic sensor such as a thermocouple. Technically wet bulb temperature is difficult to measure because the high air temperatures frequently encountered make the traditional approach with some form of wetted sensor ineffective. In addition, the extensive coverage of the body provided by a firefighter's turn-out gear renders humidity measurement of little practical significance since, despite the inclusion of a vapour-permeable layer, only a small proportion of sweat can be evaporated through the clothing to the environment.

Any instrument for measuring air velocity (e.g. a rotating vane anemometer) is likely to be acceptable provided that it is sufficiently sensitive to measure the low air velocities likely to be encountered (e.g. <1.0 ms^-1). One example is the Kata thermometer that has the added advantage of being effectively omni-directional. However, as with relative humidity, the comprehensive coverage of the body means that any effect of airflow is considerably attenuated and, as airflow within firehouses is frequently minimal, this factor can usually be disregarded.
At present, radiant temperature is rarely measured in Fire Brigade training establish­ments, despite the obvious relevance of radiant heating where exposure to live fires is involved. However, many training search and rescue scenarios involve a live fire primarily as a source of heat with actual firefighting a secondary or subsidiary activity. In such conditions, only a limited proportion of exercise time is spent in view of the fire. Where temperature sensors are located in 'line of sight' of a fire then radiated heat will influence the temperature reading obtained and a true air temperature will not be recorded. If radiant heating is considered to be of potential significance then globe temperature (measured using a six inch matt black copper sphere) should be recorded as well as the dry bulb temperature. If dry bulb sensors are located close to a radiant source they should be physically shielded from the radiant heating effect of the fire if a true dry bulb temperature is required. Otherwise the temperature obtained will be a composite value affected both by the air temperature and the radiant heat load. Although not providing an accurate globe temperature value this measure will probably be sufficient for most monitoring purposes.

Particularly with live fires, environmental conditions can vary quite considerably between adjacent locations and at different heights at the same location. Temperatures may also vary rapidly depending upon the stage of development of any fire (or of the LPG source). Experience has also shown that fires set to the same specification in the same location can have radically different effects depending upon the external climatic conditions (wind direction and speed etc). To provide an accurate estimate of heat load it is important that any temperature measurements are obtained with sufficient frequency to reflect these variations and at locations appropriate to the actual exposure patterns of those being trained. To take an extreme example, there is little benefit in obtaining temperature readings from a sensor on the ceiling above a fire if the firefighter’s activities are confined to the opposite end of the fire compartment.

In assessing the degree of risk (see Section 2.2), it is usually desirable to calculate a time-weighted average of environmental conditions. This is simply determined by measuring the temperature at intervals during the training session and calculating the average, taking account of any variations in time intervals between measurements. Readings of temperature at any one point in time are of limited value without some knowledge of the prior exposure of the individual (unless conditions are likely to be very stable). Individuals will normally move around within the training facility and it will be necessary to allow for differences in temperature around the installation to accommodate this.

A3.1.2 Workload

The body generates heat as a result of physical work, and this is known as metabolic heat. This internally generated heat makes an important contribution to the overall heat balance of the body and, consequently, the heat strain a body will experience in a given environment. A detailed assessment of risk normally requires an evaluation of the workload of those involved in the training scenario. The heat stress experienced will increase in going from sitting observing fire behaviour; through moving through a firehouse executing a search pattern; and up to the possibly heavy physical work associated with rescuing a casualty or handling a heavy charged hose. The guidance provided below is based on standard scenarios which therefore accommodate the general influence of the work being performed. However, if markedly differing training procedures are used then the metabolic heat load of activities can be measured directly (see BS EN 28996 Ergonomics – Determination of metabolic heat production) or values obtained from comparable activities can be used.

A3.1.3 Clothing

Firefighters’ clothing is highly insulative and of only limited vapour-permeability. Whilst being very effective in its primary role of protecting the wearer from the possibility of severe environments, such clothing can make a significant contribution to the risk of heat stress, causing considerable disruption to heat loss mechanisms. In assessing the extent of risk from heat stress this factor would normally have to be accounted for. However, the standardisation of firefighters clothing in recent years means that the guidance in Section 2.2, based on firefighters wearing such clothing, already accommodates this effect and does not need to be modified for different makes of clothing. Previous Fire Service research has shown that there is little measurable difference between different makes of clothing when worn in severe training conditions.

A3.1.4 The Individual

There is a wide variation in individual susceptibility to the heat. The main variations are:

1. Innate variations (some people just do not get on well in the heat);
2. Day to day variations in an individual’s ability to cope with the heat;
3. Acclimatization of the individual to the heat.

The selection and assessment of individual’s suitability for working in the heat are discussed in Section 4.1. This details some of the individual factors which may render any individual more susceptible to heat illness, consequently placing them at a greater risk of injury.

The guidance provided is based upon serving firefighters and reflects the variation in fitness and heat tolerance normally encountered. It is assumed that they are reasonably healthy and are not subject to any of the known risk factors. With new recruit training, where the trainees have not had a chance to become accustomed to the effects of the heat, the guidance temperatures may need to be reduced.
Appendix 2 – Details of scenarios studied in developing guidelines

A.1 Fire Behaviour

Two types of Fire Behaviour unit were involved in collecting physiological data for the development of exposure guidelines. These were a shipping container-based facility (Moreton in Marsh) and two units integrated into fire buildings.

The Fire Training School at Moreton in Marsh was the only premises visited where wooden pallets were burned to create flashover conditions. School staff attached wooden boards to the walls of one end of the unit and these were then ignited. The other two units (Fife and Northumberland) were both fuelled by LPG.

Trainees took part in two training scenarios. In the first, trainees watched the build up of smoke and gases until flashover and did not participate in the management of the blaze. Instructional staff then applied water and the trainees were asked to crouch or sit on the floor. Instructional staff often rotated the positioning of the trainees during this simulation to allow all trainees to observe the flashover. In training at The Fire Service College, this training took place with the end of the training unit open to the outside.

In the second scenario, held within a closed unit, trainees were paired and asked to tackle a flashover simulation using the technique employed by the instructional staff in the initial training session. Both trainees are given the opportunity to be “lead” firefighter, tackling the fire to prevent a flashover while the other trainee provides back-up should anything go wrong.

At the Fire Service College, an instructor would monitor the session from a doorway approximately midway along the long wall of the container. At the other two training establishments one member of staff was always located within the control room and monitored the temperature within the unit. Automatic venting occurred when a certain temperature was reached (in general, 250°C). Again, trainees were rotated to allow them to observe the flashover at close quarters.

A.2 Heat & Humidity

All heat and humidity exercises were recorded at The Scottish Fire Training School, Gullane. Trainees were briefed prior to the exercise on the training...
objectives and health implications of working in a hot and humid environment.

The exercise always began with the trainees walking round a crib fire within the firehouse. This would last approximately 10 minutes. Trainees would then walk approximately 100 metres across the exercise yard to the heat and humidity room. Once inside, trainees were expected to perform a variety of physical and mental processing tasks (for example: lifting barrels from one end of the room to the barrier to the other end of the room; answering simple arithmetic questions; or crawling through a tunnel at floor level).

A.3 Search & Rescue

At most training centres at which physiological monitoring was undertaken, training on search & rescue involved the use of water to extinguish the fire during the exercise. Only the Scottish Fire Training School at Gullane performed training exercises where no water was utilised during some search and rescue exercises. Prior to the exercise, trainees were briefed in the classroom as to the aims and objectives of the exercise. In general, two team members were employed to extinguish the blaze while the other members of the team performed a systematic search of the rest of the building. Any casualty discovered during this search was then removed from the building and placed in the recovery position at a safe distance from the unit.

At training centres where carbonaceous material was burnt, the fire was lit approximately 10–20 minutes prior to the exercise to allow the temperature to rise within the building. Brigades that utilised LPG systems could produce instant flames by the press of a button. Through the use of this system, the starting temperature where LPG was used tended therefore to generally be lower than where a carbonaceous system was used unless there had been a previous fire in the same installation.

Appendix 3 – Guidelines on obtaining measurements of tympanic (ear) temperature using an infra-red scanner

These guidelines are based upon the use of the Braun Thermoscan IR 3520 thermometer. Similar units are available from other manufacturers although these have not been evaluated in preparing these guidelines. The procedure given below may need to be modified if an alternative device is used.

Please follow the instructions provided carefully.

1. Identify an area/room where the ear temperatures will be recorded. If possible, this should be adjacent to where the training exercise is to be performed. The operating ambient temperature range should be within 10–40°C and below 95% relative humidity.

2. The Braun device should be kept inside this area/room throughout the exercise and should be placed in the room 20 minutes before the first measurement. Do not keep the thermometer in a pocket as this will cause it to be warmed. A chair should be provided for the firefighters to sit on when the measurements are recorded.

3. In addition to the measuring unit and an adequate supply of the disposable lens filters a supply of small plastic bags can be useful as this allows the filter to be retained hygienically and reused for the same firefighter after the exercise.

4. Once the firefighters have donned their kit in preparation for training, record initial temperature by inserting the ear probe into the ear canal. Follow the steps below:

   (a) Attach a new clean lens filter to the device.
   (b) Determine which ear is to be measured (ask firefighter which ear they prefer)
   (c) Press 0 / memory button to activate device.
   (d) Pull ear to perform an “ear tug” as shown in the manufacturer’s instructions (hold the ear at about 4-o-clock and pull backwards at an angle of approximately 45°). This will straighten the ear canal and provide a more accurate result.
While tugging the ear, insert the probe into the ear canal as shown in diagram 2 of the instructions. Hold the device in a vertical position as shown.

Ask the individual to lean against the device to ensure that it is firmly in place then press the green button on the top of the device. Once a beep is heard, remove the probe and record the temperature in the record sheet.

Repeat this procedure until three temperature readings have been obtained. Remove plastic lens and place in plastic bag (if used). This can then be given to the firefighter to carry in his/her tunic pocket during training.

Repeat procedure for all firefighters involved in the training session.

This procedure can be performed before dressing if required (e.g. following the initial safety briefing if this is conducted in the classroom). Particular care should be taken of any firefighters who have an elevated body temperature at this stage. Those with a temperature above 37.5°C should be excluded in case this indicates incipient illness (unless any such increase can reasonably be explained by previous heat exposure or heavy activity in firekit).

On exiting the training session, all those involved should go immediately to the room/area in which the ear temperatures are to be recorded. Breathing apparatus should be removed and the person asked to sit. Their lens filter should then be attached to the Braun device and the temperature recorded following the same procedure as before. It is recommended that the highest temperature recorded is used in evaluating whether or not the training temperatures have been excessive.
**Figure A4.1 Record Sheet for Temperature Exposures**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Team Location</td>
<td>Location Temperature (°C)</td>
</tr>
<tr>
<td>T1 (entry)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
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<tr>
<td>T4</td>
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<td>T5</td>
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<td>T6</td>
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<td>T7</td>
<td></td>
<td></td>
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<tr>
<td>T8</td>
<td></td>
<td></td>
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<tr>
<td>T9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure A4.2 Calculation of Time-Weighted Average (TWA)**

<table>
<thead>
<tr>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp x Duration</td>
<td>Total (Temp x Time)</td>
<td>Cumulative Total</td>
<td>Time Since Entry</td>
<td>Cumulative TWA (F+G)</td>
</tr>
<tr>
<td>(T2-T1)</td>
<td>(E1)</td>
<td>(T2-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T3-T2)</td>
<td>(E1 + E2)</td>
<td>(T3-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T4-T3)</td>
<td>(E3 + E4)</td>
<td>(T4-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T5-T4)</td>
<td>(E3 + E4)</td>
<td>(T5-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T6-T5)</td>
<td>(E4 + E5)</td>
<td>(T6-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T7-T6)</td>
<td>(E5 + E6)</td>
<td>(T7-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T8-T7)</td>
<td>(E6 + E7)</td>
<td>(T8-T1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(T9-T8)</td>
<td>(E7 + E8)</td>
<td>(T9-T1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exercise Duration:

Guideline TWA Temperature (from chart).

TWA exceeded / acceptable  
(delete as applicable)
Monitoring risk of heat stress

- Record time of entry into firehouse
- Record name or number of first room entered
- Record temperature in that room from sensor
- Remind Safety Officers to notify room change (i.e. moving into ‘kitchen’ now)
- At each notification record time, location and temperature as before
- If duration in any room exceeds 5 minutes record further set of time, location and temperature details
- Continue until exit
- Record time of exit

Guidance on the Management of the Risk of Heat Stress during Training

Appendix 5 – Factors adversely affecting heat tolerance

A number of factors can cause someone to be temporarily less tolerant of heat exposure than normal.

If any of the following apply to you then you may be at more risk of injury due to heat stress and you should inform your training officer. Factors such as significant alcohol consumption or illnesses causing sickness and diarrhoea can result in you becoming temporarily dehydrated. If there is any doubt as to your fitness then further advice will be sought from an occupational health nurse or physician.

Do any of the following apply to you? Indicate any that apply

<table>
<thead>
<tr>
<th>Factor</th>
<th>Indicate any that apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current upper respiratory infection or fever</td>
<td></td>
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<tr>
<td>Recent significant alcohol consumption (more than the driving limit)</td>
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<tr>
<td>Significant sleep deprivation (lasting for two or more nights)</td>
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<tr>
<td>Dehydrating illness, e.g. diarrhoea, vomiting</td>
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<tr>
<td>Skin diseases, e.g. anhidrosis, psoriasis, miliaria</td>
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<tr>
<td>Use of selected prescription, ‘over the counter’ or ‘recreational’ drugs including:</td>
<td></td>
</tr>
<tr>
<td>Anticholinergics, e.g. atropine, ‘Lomotil’</td>
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<tr>
<td>Diuretics</td>
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<tr>
<td>Phenothiazines</td>
<td></td>
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<tr>
<td>Tricyclic antidepressants</td>
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<tr>
<td>Antihistamines, cold remedies</td>
<td></td>
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<tr>
<td>Anti-Parkinsonian drugs</td>
<td></td>
</tr>
<tr>
<td>Beta-blockers</td>
<td></td>
</tr>
<tr>
<td>Amphetamines, ‘ecstasy’</td>
<td></td>
</tr>
</tbody>
</table>

Whenever you are given drugs, either on prescription or over the counter, you should make your doctor or pharmacist aware of your profession and check whether the drugs in question could adversely affect heat tolerance.
Guidance on the Management of the Risk of Heat Stress during Training

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