MAUK
The Mining Association of the United Kingdom

Guidance and Information on the Role and Design of Safe Havens in Arrangements for Escape from Mines

Updating of Existing Guidance

February 2023

Index

Part 1 - Introduction

General Information

1. The use of a safe haven should be considered secondary to that of self-escape.

2. Safe havens and other types of refuges shall be considered as part of the arrangements for self-escape and mines rescue.

3. The purpose of a safe haven is to provide a safe area, in the event that it is not possible to self-escape.

Who should read this guidance?

4. This document is aimed primarily at mine operators with a statutory responsibility under the Mines Regulations 2014 for ensuring effective arrangements for escape and rescue, and the other elements of effective emergency planning. Others in the mine management structure, safety representatives and members of mines rescue service may also find this information useful.

Legal provisions

5. The Mines Regulations 2014 (L149) place duties on the mine operator to ensure that they can reach a place of safety promptly in the event of an emergency. The relevant regulations are included within **Appendix 1**.

6. The Mines Regulations 2014 (Reg 7, Guidance Points 19-22 and 25-27) require that the mine operator make an assessment of the major hazards using a suitable system of risk assessment (for example bow tie, failure mode analysis etc.) As part of any such assessment the mine operator should consider major hazard controls and mitigation measures, including the use of Safety Performance Indicators (SPI's). Those mitigation measures must include a provision for self-escape and mines rescue.

7. The Mines Regulations 2014 (Reg 7, Guidance point 23), requires that a mine operator has an effective Safety Management System (SMS) and as such the operators should produce rules, standards and procedures for their emergency arrangements which would include the use of safe

havens, these procedures where applicable would include the role of the safe haven as part of the escape and rescue provision. Where applicable the guidance should consider, how a safe is designed, constructed, maintained, operated, and how the safe haven is positioned and located.

The role of safe havens

8. Safe havens should be provided as a refuge if the nature of the emergency prevents a person travelling to the surface.

9. Safe havens that are close to the workplace will provide escaping persons with a safe place to congregate in the event of an emergency (this is different to 'muster point or other meeting points that may also be provided), it is important to have an informed emergency response strategy. It may be possible to continue towards the surface and fresh air – this should always be the priority.

10. However, it may be safer to remain in the safe haven and wait for assistance while rescue teams tackle the source of the incident. Commitment of mines rescue teams in hot and humid roadways or complicated mine layouts searching for unknown numbers of escaping persons is fraught with risk. National and International experience suggests that there are circumstances where the opportunity to self-escape may be limited or inappropriate, in these types of scenarios the use of a safe haven has increased the likelihood that people survive.

11. Where it is anticipated that persons may have to spend significant periods waiting to be rescued, the mine operator will need to consider several factors in designing and installing a safe haven.

What is a safe haven?

12. A safe haven is a place with facilities including an independent air supply to maintain an atmosphere at positive pressure (e.g., greater than the surrounding atmosphere), so people can wait in safety until rescue arrives. There are two types of safe haven:

a. a sealed installation **(see Appendix 4)**, with airlocks and suitable environmental monitoring etc. where people can wait without wearing self-rescuers; or
b. a semi-sealed installation where people can change self-rescuers or wait while wearing self-rescuers.

13. There are new developments in safe havens, which include sealed units that may be transportable (e.g. rail mounted and moved by locomotives) to allow the transport of people from the site of the incident to a known place of safety, which is often the surface. Use of these types of arrangements can usually be seen in long single-entry tunnels.

14. Safe havens need to have suitable systems so that people inside can communicate their presence and messages can be sent to and from the surface.

15. Any equipment kept in the safe haven should be maintained and regularly tested in accordance with the requirements of Regulation 15 of the Mines Regulations 2014 (Maintenance and Inspection of Equipment) or such to retain its effectiveness or usability.

16. The concept of redundancy should be considered when provisioning and installing communication and other critical systems. There should be at least two means of communication which have been installed in different roadways where this possibility exists. For installations in a single-entry roadway, the communication system should be routed in different places within that roadway.

When should a safe haven be provided?

17. Where the risk assessment indicates escape to a place of safety is not likely to be reached by use of self-rescuers alone, after taking account of the factors outlined above.

18. The requirement and positioning of a safe haven should be determined through the completion of a suitable and sufficient risk assessment taking account of all influencing factors including those defined within the regulations.

Arrangements for Escape

19. It is essential to have effective arrangements in place for the safe and prompt evacuation of people from mines, as well as taking measures to control the risk from fires, outbursts (gas) and explosions.

20. The primary focus of any emergency plan put in place by the mine operator is to discharge their responsibilities in relation to the requirements of Regulation 53 of the Mines Regulations 2014, any such plan should place

the emphasis on the requirements of self-escape.

21. Arrangements for evacuation usually require provision of self-rescuers for all people going below ground in mines. Mine operators that are considering and planning escape strategies should not rely solely on self-rescuer manufacturers' nominal duration information for calculating the distance people can safely travel. Physiological and tolerability issues also need to be considered.

22. Effects of heat and humidity, as well as reduced visibility following an underground fire (or in certain circumstances explosion) will limit the evacuation distance miners can attempt, before being under significant physical, thermal, and mental stress. Properly designed safe havens at strategic locations will enhance the likelihood of survival.

23. The mine operator will need to review the plan prepared under Regulation 54 of the Mines Regulations 2014 (Escape and Rescue Plan), it will need to be periodically reviewed and updated, any review should include / consider the number, location, and type of safe havens required.

24. Wearing a self-rescuer makes verbal communication and rehydration impossible. Self-rescuers can dehydrate the wearer's mouth and render them speechless due to the use of 'gag' type mouthpieces and nose-clips (as opposed to facemasks). In addition to self-rescuer duration, when assessing whether safe havens or facilities for the exchange and recharge of self-rescuers should be provided, it is important to think about:

a. likely composition of the inhaled air (particularly for filter self-rescuers).
b. maximum distance to travel to reach a place of safety.
c. travelling conditions and visibility.
d. physical and mental effort required to escape; and
e. temperature and humidity (the key considerations relating temperature have been included in Appendix 2.)

Part 2 - Considerations When Determining the Requirement and Siting of Safe Havens

Availability of Rescue Teams

25. An operator must make suitable arrangements for mines rescue, and these arrangements should not only be reliant on a response from the fire and rescue services.

26. The mine operator should realistically evaluate the time it would take to respond given their rescue arrangements, and the fact that these may rely on assistance from other mine operators, specialist rescue provider or a combination of the two. Often these types of arrangements mean that there will be time taken to mobilise, organise, travel to, and deploy at the affected operation.

27. The mine operator should consider the response times of mines rescue, and the impact of that response, should the means of egress, and any transport system be compromised by the events giving rise to the emergency.

Location of the Safe Haven

28. There are several factors relating to the layout and underground environment that the mine operator should consider when determining the location of a safe haven, these include:

a. availability or otherwise of dual intake roadways.
b. travel distances to fresh air from any place of work.
c. normal levels of heat and humidity.
d. escape route gradients; and
e. distances of the in-bye workings relative to the surface portal or shaft bottom.

29. The mine operator should also consider, how the physical limitations of an individual or the characteristics of an incident may influence the speed at which people can travel. In assessing the location of any safe haven consideration should be given to the following:

a. the nature of the ground underfoot (typical maximum values based on the Naismith's rule would be 5km in 1 hour, however these conditions are optimal and assume smooth paths).
b. any gradients (typical maximum values based on Naismith's rule would be to allow 60 minutes for every 600m of assent).

c. the impact of reduced visibility on travel times.
d. the impact of stress induced by the incident.
e. the potential impact of wearing of a self-rescuer.
f. restrictive spaces, ladderways etc.

30. In circumstances that require the movement of casualties to a safe location, the management and transport of those casualties will further reduce the speed of travel.

31. The mine must always determine / verify the maximum distance between safe havens by conducting a physical simulation.

32. The type of equipment provided for self-escape shall be of adequate duration to allow the individual to reach the safe haven, having considered the impacts of points ***29-31*** of this guidance.

Occupancy levels

33. Identifying the number of people likely to access the safe haven and estimating the duration of use is essential, up to the most extreme scenario.

34. Looking at shift patterns and distribution of workforce throughout the mine should help, when determining potential levels of occupancy. Cognisance should also be given to peak times such as shift changeover patterns.

35. The duration of how long the safe haven would remain viable should be calculated and considered (see note 37 for guidance on the quantities required per person), as a guide, safe havens should extend the period of protection beyond the life of self-rescuers, keeping people safe until mines rescue teams can reach them, or toxic / noxious gasses within the mine environment have returned to levels where it is safe to travel. The factors that affect the duration of the air supply available would include:

a. The nature of the air supply, whether it is a continuous compressed air supply or fixed volume cylinders.
b. The number of people that the safe haven is planned to accommodate.
c. The temperature within the safe haven.

Air supply

36. Safe havens work by separating the people inside from the toxic / noxious

atmosphere outside. Examples include:

a. A sealed portable enclosure providing a storage battery back-up air-conditioned life-support mechanism with bottled O_2 supply and CO_2 scrubbers. These are suitable for large mines where transportation is convenient. (See Appendix 4a)
b. A compressed air fed cement-block enclosure, shipping container or prefabricated structure. These tend to be more static. arrangements. A secondary compressed air supply from cylinders may also be installed to provide redundancy in the event of a failure of the primary supply. (See Appendix 4b)
c. A borehole supplying fresh air via a compressor direct from the surface. This arrangement is particularly suited to relatively shallow mines.
d. A large 'residual air' sealed void with emergency bottled O_2 supply to expand the duration to that identified through risk assessment. (See Appendix 4c)

37. Studies suggest that when considering the quantities of breathable air required to support an individual within a safe haven, the equivalent allowance of 12.5litres per minute of fresh air should be considered or (0.5litres per minute oxygen) (Brake and Bates 1999):

a. Using the above as an example, a safe haven designed for a maximum occupancy of 12 persons would require 9000 liters of breathable air (360 liters of oxygen) per hour.

38. An air / oxygen supply must achieve two primary functions:

a. maintain a respirable environment; and
b. maintain tolerable conditions in terms of heat and humidity.

39. In a addition to the two primary functions identified in note 38 above, the air / oxygen supply will also serve to positively pressurise the internal space of the safe haven stopping the ingress of any toxic / noxious gasses.

Breathable compressed air supply

40. To determine the minimum safe haven compressed air supply, breathable air is defined as constituting a minimum O_2 content of 19% and CO_2 content not exceeding 0.5% (5000ppm).

41. During entrapment, it is assessed that individual O_2 consumption will be 0.5 l/min with a breathing rate of 12.5 l/min of fresh air. To maintain CO_2 levels

below 0.5%, an airflow no less than **85 l/min per occupant** is required (for a safe haven housing 12 people, this would increase the required airflow to 61,200l liters per hour) (Brake & Bates, 1999).

Safe haven thermal environment

42. The challenge facing safe haven designers, in addition to providing adequate means of respiration, is maintaining thermal tolerability. To establish the criteria for maintaining a tolerable thermal environment within a safe haven, assumptions must be made for the physiological heat exchange mechanism:

a. metabolic heat production of 120 W per person.
b. target maximum core body temperature of 38°C.
c. people inside safe haven will strip down to minimum clothing.
d. assume sufficient water to restore hydration; and
e. assume occupants sit down and maintain 'low-level' activity.

43. Taking these assumptions into account, numerous other variables remain including, compressed air inlet temperature and humidity, virgin rock temperature, geothermal gradient, mine air temperature, dehydration levels induced by the use of self-rescuers, incident induced "stress" and numbers and rates of people entering the safe haven.

44. Based on compressed air input conditions of 26.5°C @ 64% relative humidity (RH), the minimum airflow estimated to maintain 'comfortable' conditions is **255 l/min per occupant** (e.g. three times that required to maintain a 'breathable' atmosphere).

Table 1 Analysis of safe haven air supply cooling potential

(Target air condition of air delivered to safe haven 26.5 C @ 64% RH)

	'Comfort' case 28°C, 100% RH	***'Survival' case 35°C, 100% RH***
Heat absorption by air, J / m^3	1,663	9,425
Heat absorption, evaporation, J / m^3	28,228	60,978
Total heat absorption, J / m^3	29,891	70,403
Minimum airflow per occupant, litres / min	250	100

45. Whilst considering the thermal environment, the mine operator should also consider the impact that thermal environment has on decision making. Studies indicate that cognitive performance may reduce by between 10% and 15% at a wet bulb global temperature of 32°C (and

above.)

46. The cognitive performance of those in the safe haven may be further impacted by dehydration, with dehydration of only 2% sufficient to start impairment.

47. Consideration must be given to cooling, studies have shown that the temperature within the haven will increase over time. *Venter et al* (1998) showed that temperatures that started at a modest 25°C increased to 29°C dry bulb, 29°C wet bulb (i.e. fully saturated) within 60 minutes.

48. A failure of breathable air systems may lead to a further increase in temperature *Keilblock et al* (1988) showed that temperatures climbed from 20.9°C WB to 35°C WB in a period of 90 minutes after the failure of the compressed air system.

49. Excessive heart stress and the development of heat illness for those within the safe haven is a potential outcome, even if the toxic gas concentration is maintained at safe levels.

50. Additional cooling will extend the capacity and tolerability for safe haven occupants and could be achieved by a combination of:

a. Battery (or mains) supplied air conditioning units (where an explosive atmosphere has been identified as unlikely to occur and therefore have not been classified as hazardous under regulation 7(1) of DESAR) and therefore regulations 22 and 23 of the Mines Regulations 2014 do not apply.
b. The use of ice from freezers, (where the freezers can be installed in a location where regulation 22 and 23 of the Mines Regulations 2014 do not apply.) Studies have shown that using blocks of stored ice, which are allowed to slowly melt 'soak up' the external heat according to the sensible latent heat of melting.
c. multiple compressed air inlet jets aimed at occupants.
d. internal air movers (compressed air venturi or blade type); or
e. restricted safe haven ceiling heights (maximising air velocity).

Standby breathable air arrangements

51. In addition to compressed air, mine operators should consider what would happen if the compressed air supply became contaminated or interrupted and how this condition may be detected.

52. Providing a secondary means of breathable air can extend survival

chances. However, without compressed air or cooling, the thermal environment inside the safe haven could become intolerable.

53. Once secondary airline fed hoods or masks are used, the safe haven doors may need to be opened to reduce humidity. People wearing fresh self-rescuers should consider getting out of the safe haven entirely and into the main air current where it may be cooler (but contaminated). Examples of standby air-delivery arrangements can include:

a. banks of large, compressed air cylinders fitted with facemasks, hoods, or outlet nozzles; and
b. spare sets of long duration self-contained self-rescuers.

54. If the compressed air supply fails and people are committed to wearing airline hoods or masks, these facilities should be close to means of communication inside the safe haven.

55. Where hoods / masks are provided, then the mine operator must consider the type of hood or mask used. If a constant flow mask or hood is provided, then this may cause rapid depletion of the compressed gas if left open to the environment.

Wayfinding

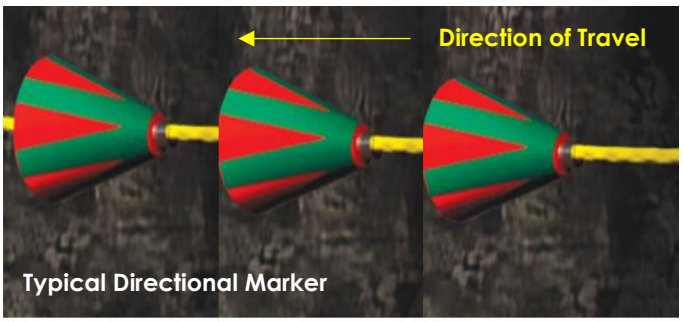
56. Access to safe havens should be clear and free from obstructions. They should be easy to locate, and special 'sensory' measures taken to identify them when visibility is limited. There are several systems available to allow an individual to locate the safe haven, these include:

a. The use of signs indicating the direction of travel.
b. The use of reflective route markings.
c. Passive lifeline technologies.
d. Active electronic audio and visual guidance systems.

57. ***Signs and Reflective Route Markers***, these have shown to be of limited use, where visibility is an issue. In order to remain effective, there must be a regime in place to ensure that they are periodically inspected and cleaned.

58. ***Illuminated Signs,*** may provide a useful indication of the location, however consideration needs to be given to a failure of the power supply and there must be a regime in place to ensure that they are periodically cleaned.

59. ***Passive Guidance Systems***, these systems are typically provided by:
    a. experienced persons relying on structures such as cables, conveyors and other such arrangements to form a lifeline in conditions of reduced visibility.
    b. The installation of dedicated lifelines which indicate the direction of escape. The lifeline should have the features that provide for an unambiguous direction (a typical example is the use of shaped cones that can be used to indicate the correct direction) when it comes to escape.



Studies completed by *Kriel et al (1995)* showed that the use of lifelines increased the walking rate to 75% of normal when using a self-rescuer. The number reduced to 40% of walking rate when other fixed structures were used.

60. ***Active Guidance Systems,*** these systems tend to employ a combination of visible and audible signals to guide personnel. The spacing of the devices needs to be such that they can be seen / heard in reduced visibility. The spacing can be maximised using systems that give audible directional cues, using a synchronized stepped tone output. Consideration should be given to how the system is to be triggered in the event of an emergency considerations may include:
    a. Triggered automatically in the event of loss of power.
    b. Triggered automatically via the environmental monitoring systems.
    c. Triggered manually.
    d. Combination of the above.

61. Where an active guidance system is employed, consideration will need to be given to the effective examination, maintenance, and testing of the system, including the methodology for triggering activation.

62. Whichever system is selected, it should as part of the assessment for use achieve the following:
    a. Significantly increase the speed of egress.
    b. Be useful in conditions of extremely low visibility.
    c. Not present ambiguous directional information.
    d. Provide visual, audible, and tactile cues.

e. Offer high integrity and preferably fail-safe operation.
f. Not rely on background or other ambient lighting being present.

Food and drink

63. A supply of drinking water should be available. People entering a safe haven after wearing self-rescuers are likely to be dehydrated. Water can be supplied in sealed and sterilised containers (to prevent bacteria growth) or by application of the reverse osmosis technique.

64. To maintain an individual's ability to regulate their body temperature (thermoregulate), they need to drink at least one liter per hour.

65. Water would normally be sufficient for hydration, however in certain circumstances sweating may case electrolyte imbalances. Sports drinks have been shown to provide an effective source for electrolyte replacement.

66. Nutritional emergency ration packs can be provided to replenish lost energy in order, where possible, to continue a staged escape or cooperate with rescue teams during a planned evacuation from the safe haven.

67. Where it is expected that persons may be required to use the safe haven for long periods, considerations should be given to providing 2000-cal/ person/ day. *(based on the NIOSH Report. Underground Mine Refuge Alternatives 2015)*

Environmental monitoring

68. Internal and external environmental monitoring will confirm the atmosphere inside the haven is safe without wearing self-rescuers and provide information on environmental conditions surrounding the safe haven.

69. Instruments sited in the region of safe havens should be of a suitable range to allow indication well above the normal CO readings. This may require multiple instruments to be installed at that location or in common return roadways.

70. Consideration should be given to the siting of remote displays within the safe haven.

71. Considerations should also be given to how any environmental monitoring instruments are connected into the wider mine network, this may provide useful information to those managing an evacuation or rescue response.

72. A portable multi-gas instrument is desirable, monitoring not only carbon monoxide (CO), but oxygen levels (O_2) and if possible, carbon dioxide (CO_2).

It should be noted that O_2 reduction alone is not a reliable measure of CO_2 levels since there is a 5:1 displacement ratio. i.e. O_2 only makes up 1/5 of breathable air. The other 4/5 is nitrogen. Therefore, with a 1% reduction in O_2 levels, if fully displaced by CO_2, would have a significant impact on breathing difficulty.

First aid equipment

73. First aid equipment should be provided, there should be an emphasis placed on being able to deal with and manage trauma events including burns.

74. Consideration should also be given to the inclusion of:

d. Eyewash, it is possible that people arriving may suffer smoke exposure to their eyes.
e. Cooling ice packs to assist where required in reducing body temperature.

Toilet

75. People may need to stay in the safe haven for several hours. Sealed portable chemical toilets with modesty screens should be provided. Basic urinals with 'U' tube outlets could be fabricated into the safe haven wall.

Lighting

76. Consideration should be given to providing mains powered emergency lighting as the primary lighting system within the safe haven. Battery backup, or emergency lighting should also be considered to reduce the impact of mains failure.

77. Consideration should be given to the provision of chemical 'glow sticks' which could provide a source of emergency lighting.

78. Once inside the safe haven, people should be trained to use their personal cap lamps sparingly to enhance their capability when resuming evacuation from the mine.

Windows

79. Human factor studies suggest that providing a window in the safe haven so that people can see what is happening outside will reduce feelings of entrapment and lower the temptation to leave the safe haven until it is safe to do so.

Mine plans and writing

80. An up-to-date mine layout / ventilation / rescue plan should be visible in the safe haven next to the means of communication. A suitable writing surface with spare pens / pencils will assist in recording the names of those within the safe haven, or any information from the incident controller should they be instructed to leave the safe haven.

Training

81. A key part of the workforce's competence as required by regulation 11 of the Mines Regulations 2014, should include the following provisions:

a. Understanding the emergency arrangements at the site.
b. How to trigger an emergency.
c. The use of communication equipment.
d. The use of equipment provided for self-escape.
e. The use of safe havens.

82. The key competencies must be periodically tested, refreshed, and evaluated as part of the mines safety management system and emergency planning arrangements.

83. The competency and training requirements should be:

a. Reviewed periodically as the mine layout changes.
b. Following the introduction of new equipment.
c. Following the outcome of an emergency or simulated emergency.
d. At any point when it is considered that the training and competencies no longer remain valid.

84. Any training scheme may wish to consider those with responsibility for taking control of the emergency or incident within the underground environment.

Having a person that displays confidence, takes control is useful in maintaining morale, discipline and communicating with the surface and those in the haven.

85. It has been shown that training which develops objective skills proficiency are able to maintain cognitive performance for longer in a hot thermal environment.

Commissioning

86. The mine operator must have a system in place to ensure that all systems provided for self-escape or in support of mines rescue activities, including safe havens are suitably commissioned.

87. As required by the Mines Regulations 2014, a record of the commissioning tests must be maintained whilst ever the plant or equipment is in operation.

Maintenance

88. Safe havens, communication devices and other emergency equipment should be maintained as required by regulation 15 of the Mine Regulations 2014. When developing the maintenance requirements, the mine operator should take account of:

a. Potential failure modes.
b. Potential consequences to health and safety in the event of a failure.
c. The failure rates.
d. Manufactures recommendations.
e. Working environments.
f. Industry standards / guidance.

89. The results of any maintenance completed should be recorded and retained.

Other

90. To reduce physical stress, backrests could be provided in addition to benches. Means of distraction, e.g. playing cards, dominoes etc. could be provided. This not only provides light relief but has also been shown to reduce stress levels and therefore minimise individual oxygen demand and physical heat output.

Part 3 - Semi-sealed Installations

Changeover facilities

91. Guidance on the provision of this type of emergency equipment was developed by the Deep Mines Coal Industry Advisory Body in 2001 and is published in the HSE document *Guidance and information on escape from mines* ISBN 0-7176-2006-9.

Design

92. These semi-sealed safe havens can be pressurised canopies, compressed air / auxiliary ventilation outlets, or flexible enclosures maintained at positive pressure. They should be robust and compact and sited in main roadways or single entries as close as possible to the workplace and at appropriately spaced intervals throughout the escape route. Their position along the escape route should be prominently marked to assist in escape where visibility is limited.

Purpose

93. Intended primarily as a rendezvous for people escaping, they should also facilitate the exchange of self-rescuers and rehydration as people carry out a staged escape from the inbye mine workings to a place of safety.

Air supply

94. The independent air supply should be capable of maintaining the atmosphere inside a changeover facility below the Control of Substances Hazardous to Health Regulations (COSHH) 15-minute Workplace Exposure Limit (WEL) (defined in EH40) for carbon monoxide (CO).

The independent air supply will allow people to change their self-rescuers safely or extend the effective life of a filter self-rescuer for those choosing to remain at the changeover facility until rescued.

Provision of changeover facilities will also give people the opportunity to rest for a few minutes and in certain cases, where the design incorporates a 'cool-haven' structure, provide some relief in hot and humid conditions before proceeding outbye.

Communication

95. Changeover facilities should be located close to a means of communication. If a telephone or tannoy cannot be fitted permanently inside the changeover enclosure, it should be practicable to fit a tannoy on a flexible cable which can be moved inside the 'clean air' environment to facilitate communication.

Replacement self-rescuers

96. One of the primary functions of a change over station (sometimes referred to as a type 'b' safe haven) is to facilitate the safe exchange of self-rescuers. In carrying out the risk assessment required by regulation, the mine operator should consider what arrangements are suitable in terms of the provision of self-rescuers and where necessary, replacement self-rescuers.

97. Where people depend on self-contained self-rescuers (SCSR) in long single-entry roadways and production districts, changeover will be almost inevitable and will need to be completed safely. In many cases, change from a relatively short life SCSR to a long duration device will be appropriate.

Other equipment

98. As with the larger fixed (or mobile) safe havens, the chance of successful self-escape or rescue in an emergency can be improved by giving careful consideration to the equipment provided. To assist people to survive while awaiting rescue or to escape, the following items may be considered:

a. environmental monitoring equipment to test the air outside the changeover station:
b. drinking water:
c. plans showing escape routes to fresh air or to other safe havens; and
d. basic first aid equipment.

Safe haven performance evaluation

99. There are a large number of variables in any design or location of a safe haven, and therefore it is only by thorough evaluation and review that the

individual performance of a safe haven can be determined, and the design refined accordingly. The safe haven design should be verified by appropriate testing and measurement to confirm that air delivery and other safety critical equipment are fit-for-purpose.

100. If the use of safe havens form part of the emergency plan, they should be tested and evaluated regularly during mines rescue practices and annual mock evacuation drills.

Conclusion

101. Most underground workers in UK mines will go through their working life without experiencing a major emergency situation. However, statutory requirements place duties on employers and managers to ensure that in the event of an underground emergency, suitable contingency arrangements are in place. The extensive layout of modern mines combined with long roadways and the potential for hot and humid conditions will limit rescue potential when breathing apparatus is required. Where this occurs, enhanced escape arrangements should be in place. Only by carrying out assessments that adequately address all foreseeable risks will 'effective arrangements' be maintained, and statutory obligations satisfied.

Part 4 – Appendices

Appendix 1 – Extract from the Mines Regulations 2014

Exits from the Mine 48.

1. The mine operator must ensure that there are at least two shafts or outlets providing at least two separate exits to the surface.

2. The shafts or outlets required by paragraph (1) must be:
    a. of sound construction;
    b. readily accessible to persons below ground at the mine; and
    c. sufficiently separated so that, so far as is reasonably practicable, anything that happens in one of them will not affect the safety of the other or others.

3. The mine operator must ensure that, so far as is reasonably practicable, two exits from the mine are available for use at any time by persons below ground at the mine.

4. The mine operator must prepare a suitable written plan of the action to be taken to secure the safety of persons when, due to an unforeseen event or planned maintenance, only one exit is available for use.

5. If only one exit is available for use, the mine operator must ensure that:
    a. the plan required by paragraph (4) is implemented; and
    b. the persons below ground are restricted, so far as is reasonably practicable, to those who will not be exposed to danger by reason that only one exit is available for use and who:
        i. are needed to carry out work essential for securing the safety of the mine;
        ii. are involved in work relating to the unforeseen event or planned maintenance;
        iii. at the time the exit became unavailable, were already working below ground, provided they do not remain below ground after their normal period of work has ended; or
        iv. are needed to secure the health or safety of any person.

Ways Out from Places of Work 49.

1. Subject to paragraph (3), the mine operator must ensure that every place where a person works has at least two ways out.

2. At least two of the ways out required by paragraph (1) must:
    a. be clearly identified;
    b. be passable with reasonable convenience;
    c. be separate from each other; and

d. lead to a different exit from the mine.

3. The requirements in paragraphs (1) and (2) do not apply in relation to a heading or other place from which it is not reasonably practicable to provide at least two ways out that comply with paragraph (2), provided that the mine operator ensures that the following conditions are met:
    a. there are in place suitable procedures to ensure that all persons can leave the place safely;
    b. the activities carried out in the place are limited to those that are required to be carried out there; and
    c. the persons present at the place at any time are limited to those necessary for the activity or activities being carried out there.

Emergency routes and emergency doors 50.

1. Emergency routes and exits must remain clear at all times and lead by the most direct and safe route to the open air or a safe area.

2. Doors that may form part of an emergency route or exit must be capable of being opened easily at all times.

Auxiliary equipment 51.

The mine operator must ensure that suitable auxiliary equipment is available for use when any equipment that is required to be used by persons to leave the mine becomes unavailable or breaks down.

Intake airways 52.

The mine operator must ensure, so far as is reasonably practicable, that the intake airways for the mine are constructed of suitable fire-resistant materials.

Duties of the mine operator with regard to escape and rescue 53.

1. The mine operator must:
    a. ensure that suitable arrangements are in place so that persons below ground at the mine can reach a safe place promptly in the event of an emergency; and
    b. provide and operate the necessary warning and other communication systems to enable assistance, escape and rescue operations to be launched immediately if the need arises.

2. A mine may not be worked unless the mine operator has made suitable arrangements:
    a. for the rescue of persons from the mine; and
    b. for the carrying out of work necessary to secure the health and safety of persons below ground at the mine in the event of an emergency.

Escape and rescue plan 54.

1. The mine operator must prepare and maintain a written plan (in these Regulations referred to as the "escape and rescue plan") which sets out the action to be taken to effect safely and promptly the evacuation and rescue of persons to a safe place in the event of an emergency.

2. In preparing the escape and rescue plan, the mine operator must have regard to every relevant risk assessment carried out in accordance with these Regulations and regulation 3 of the Management Regulations.

3. The mine operator must review the escape and rescue plan regularly at suitable intervals and whenever
    a. there has been a significant change in the matters to which the plan relates; or
    b. the plan has been put into use.

4. The mine operator must keep an up-to-date copy of the escape and rescue plan in a suitable place and make it available to appropriate persons promptly in the event of an emergency.

Emergency equipment and communication systems 55.

1. The mine operator must ensure that suitable equipment is available for use at all times where it is necessary in any operation involving escape or rescue.

2. The mine operator must ensure that the emergency equipment is
    a. maintained in good condition; and
    b. stored in easily accessible places.

3. The mine operator must ensure that in the event of an emergency the warning and other communication systems referred to in regulation 53(1)(b) are put into operation immediately.

Training and information 56.

1. The mine operator must ensure that
    a. all persons who work at the mine are trained in the appropriate actions to be taken in the event of an emergency at the mine; and
    b. appropriate persons are trained in the use of emergency equipment.

2. The mine operator must ensure that written instructions are prepared on
    a. the appropriate actions to be taken in the event of an emergency at the mine; and
    b. the use, handling, and operation of emergency equipment.

3. The mine operator must ensure that safety drills are held at regular intervals for the purpose of ensuring that persons who work at the mine are familiar with the matters specified in paragraph (2).

Self-rescuers 57.

1. In any mine in which the risk assessment carried out in accordance with regulation 3 of the Management Regulations has identified the likelihood of an irrespirable atmosphere, the mine operator must provide:
    a. suitable self-rescuers for all persons going below ground at the mine; and
    b. where necessary, safe havens or facilities below ground for the exchange and recharge of self-rescuers.

2. The mine operator must ensure that every person who has been issued with a self-rescuer:
    a. has been instructed how to use it; and
    b. does not go below ground without it.

3. The mine operator must ensure that, so far as is reasonably practicable, every person who has been issued with a self-rescuer keeps it within the person's reach at all times when below ground.

4. The mine operator must ensure that all self-rescuers are checked regularly and stored in a suitable place at the mine. (5) In this regulation, "safe haven" means a place below ground at a mine which is provided

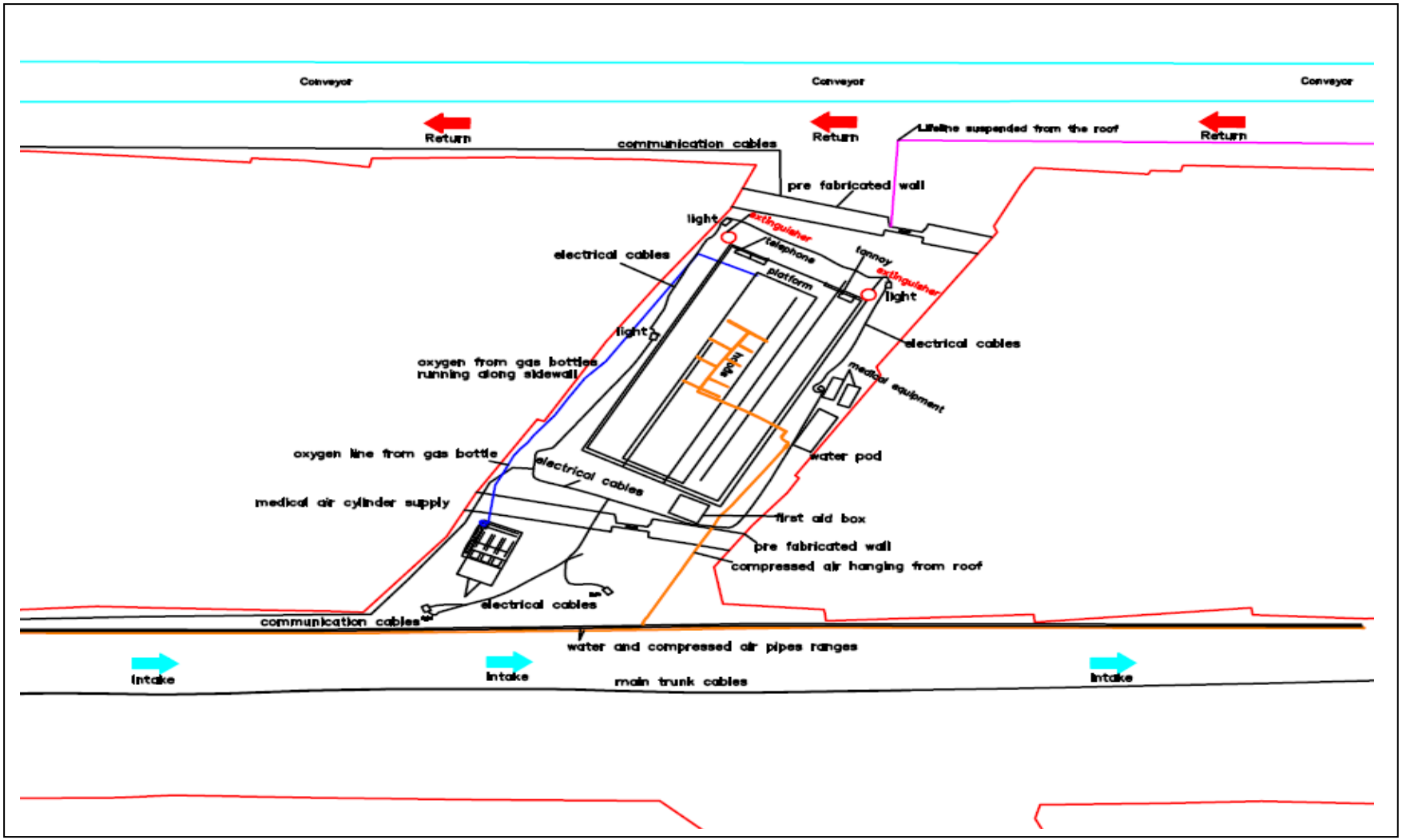
Appendix 2 – Research Report

In 2003, the Health and Safety Executive produced 'Research Report 180 – Use of self-rescuers in hot and humid mines'- ISBN 0-7176-2788-8, prepared for HSE by Mines Rescue Services Ltd.

This report dealt with climatic chamber testing of fit mines rescue workers wearing a variety of filter self-rescuers (FSR) and self-contained self-rescuers (SCSR) in a series of medically supervised tests under hot and humid conditions. In an executive summary, the key results showed:

- In a range of fully saturated atmospheres between 27°C and 37°C all test subjects were withdrawn inside one hour of entering the chamber;
- In some subjects, an increase in core body temperature of 2°C was observed after 30 minutes of exercise;
- During the tests, exceeding a core body temperature limit (38.5°C) was the predominant reason for withdrawal;
- Subjects self-paced themselves at between 2 to 4 km/h but in all cases, core body temperature continued to rise during periods of exercise;
- Only limited cooling took place during rest periods;
- The average total distance covered during the test runs was 1448m;
- The maximum distance covered was 2350m;
- The minimum distance covered was 590m;
- Total distance covered was influenced strongly by chamber temperature;
- Observed run-out times for SCSR varied (MSA SSR 30/100) from 10 to 25 minutes with equivalent distance covered of between 560m and 1400m; and
- The mean travel speed for the subject group was 3.3 km/h.

Appendix 3 - Typical "Sealed" Safe Haven Installation Diagram



Appendix 4 – Typical underground installations

4(a) – Sealed Portable Enclosure System

4(b) – Cement Block (Compressed Air Fed) Enclosure

4(c) – A Residual Air Sealed Void with Emergency Bottled Oxygen Supply

4(d) – An Inflatable Unit

Appendix 5 - References

1. *Criteria for the design of emergency refuge stations for an underground metal mine*, Brake DJ and Bates GP (1999), Aus. IMM Proceedings, No.2, 1999, pp 1-7

2. *Enhancing Mine Emergency Response, Brenkley, Bennett, Jones (1999), 28th International Conference on Safety in Mines Research Institutes, Sinaia, Romania*

3. *Research Report 180 – Use of self-rescuers in hot and humid mines'* Health and Safety Executive (2003)- ISBN 0-7176-2788-8, or online at http://www.hse.gov.uk/RESEARCH/rrhtm/rr180.htm

4. Note on Respiratory and Thermal Environmental Design Criteria within a Type 'a' Haven (Mines Rescue Service Limited – May 2006)

5. Guidance and Information on Escape from Mines (HSE – 2001) (ISBN 0-7176-2006-09)

6. Guidance and Information on the Role of Safe Havens in the Arrangement for Escape from Mines (HSE) (web-only at: www.hse.gov.uk/pubns/mines08.pdf)

7. A reference from Australia http://www.dmp.wa.gov.au/Documents/Safety/MSH_G_RefugeChambersUGmines.pdf