

Guidance and information on escape from mines



This illustrated booklet is aimed mainly at mine owners and managers. It includes guidance to help them determine escape arrangements for their mine and to draw up an emergency plan, bearing in mind that there is no escape definitive procedure to follow, and that there can be a huge difference between mines. The booklet covers legislation relevant to escape; the different types of self-rescuers (and details of wearer trials) and safe havens and changeover facilities. Appendix 2 looks at escape practice in mines abroad.

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Introduction

What is this booklet about?

1 This booklet contains guidance on *escape* from mines in an emergency. Appendices at the end of the booklet contain information about:

- Appendix 1 – emergency planning procedures;
- Appendix 2 – mines escape practice in other countries;
- Appendix 3 – emergencies involving escape from mines;
- Appendix 4 – self-rescuer wearer trials;
- Appendix 5 – current *mines rescue* provision in the United Kingdom; and
- Appendix 6 – legislation on self-employed staff.

Who should read this booklet?

2 The guidance and information in this document is primarily for mine managers and mine owners. However, others in mine management structures, such as under managers, overmen and command supervisors, will also find much of the information useful, as will safety representatives and members of the Mines Rescue Service and part-time rescue brigadesmen at mines. The practical examples within the guidance could also be incorporated into instruction and training for the workforce; for example, during self-rescuer refresher training.

3 A principal aim of this booklet is to provide sufficient information and guidance to help mine managers determine escape arrangements appropriate to their mines and so help them to draw up an emergency plan. It will also help owners to see what they should do to provide managers with the assistance and resources necessary to prepare the plan and to put it into effect.

Background

4 There is no definitive procedure to follow to determine the best means of escape. Circumstances can vary enormously between mines and even between different parts of the same mine. The Health and Safety Executive (HSE) and the National Technical Advisory Group on Rescue Work and Rescue Apparatus identified a need for guidance and other information relevant to escape from mines. HSE has published this booklet to meet that need.

What law applies?

Legislation relevant to escape

5 Some of the legal provisions relevant to escape from mines are listed below. The Escape and Rescue from Mines Regulations 1995¹ contain a number of provisions which relate specifically to escape. However, several other mining-specific and across-the-board requirements also have a bearing. The Approved Code of Practice and guidance² support the Regulations.

The Escape and Rescue from Mines Regulations 1995

6 The Escape and Rescue from Mines Regulations 1995 differ fundamentally from the escape and rescue provisions of the Coal and Other Mines (Fire and Rescue) Regulations 1956, which they replaced. Key provisions of the Regulations:

- require managers to plan for the escape and rescue of people from the mine in the event of an emergency;
- require the owners of most mines to provide self-rescuers and, where necessary, safe havens; and
- provide for the establishment and maintenance of an independent mines rescue service.

7 The Regulations recognise there are three separate stages for escape and rescue in an emergency. These are:

Primary The owner provides each person working below ground with a suitable self-rescuer to enable them to escape in an irrespirable atmosphere;

Secondary Where people might not reach fresh air before their self-rescuers expire, the owner provides extra escape facilities, such as safe havens or changeover facilities. Safe havens are places where people can wait in safety until rescued. Changeover facilities are places where people can exchange their used self-rescuers for fresh ones before continuing out of the mine; and

Tertiary The availability of a mines rescue service to rescue those who are unable to escape.

The emergency plan

8 Regulation 4 requires managers to prepare and maintain a written plan which includes arrangements for evacuation (escape) and rescue of people from mines in an emergency. Regulation 2 defines an emergency as a situation which renders necessary either or both the evacuation and rescue of people from a mine. Among other things, the plan should therefore identify the measures necessary to enable people to escape from the mine.

Mine plans for emergency use

9 Regulation 7 requires mine owners to make sure that there are readily available plans of the mine workings which are suitable for use in an emergency. The Approved Code of Practice, paragraphs 37-41, gives guidance on complying with this requirement.

Self-rescuers

10 Regulation 10(1) requires owners of all mines, other than those where there is a minimal fire risk, to provide suitable self-rescuers. You will find practical guidance on the selection of suitable self-rescuers on pages 15-20 of this booklet.

Safe havens

11 Where the time to escape to a place of safety is greater than the duration of the self-rescuers in normal use at the mine, regulation 10(1)(b) requires owners to consider providing safe havens. You will find guidance on the provision and types of safe haven on pages 20-24 of this booklet.

Training and information

12 Regulation 11 requires managers to ensure that everyone below ground at a mine knows what to do in an emergency; for example, how to use emergency equipment and which route(s) to use to escape to safety.

The Management of Health and Safety at Work Regulations 1999

13 Regulation 3(1) of the Management of Health and Safety at Work Regulations³ 1999 requires employers to make a suitable and sufficient assessment of risks to the health and safety of both employees and others who may be affected by the employer's activity, for example contractors. At mines, therefore, one of the things owners (as employers) need to do is to assess the risks arising in an emergency. These assessments should cover all those who work at the mine, including contractors and visitors, who might be at risk. Managers will need to take account of these assessments when preparing their emergency plans.

The Management and Administration of Safety and Health at Mines Regulations 1993 (MASHAM)

14 Where there is more than one employer at the mine (ie when contractors work there), regulation 4 of the Management and Administration of Safety and Health at Mines Regulations 1993⁴ requires them to co-operate. For escape and rescue, this is necessary to ensure that any relevant risk assessment made by employers, other than the mine owner, is taken into account during the development of the emergency plan. You will find further information in the Approved Code of Practice to MASHAM⁵ regulation 4.

15 Regulation 6(2) requires owners to take steps to ensure that their mines are managed and worked in accordance with the law. In relation to escape, owners should therefore ensure that they give their managers the necessary assistance and resources to prepare an emergency plan and to put it into effect. Paragraphs 26 and 27 of the ACOP give owners practical guidance on what they should do to meet these requirements.

16 Regulation 23 requires managers to ensure that people at the mine, including contractors, are properly trained. This training requirement extends to training in the use of self-rescuers and escape procedures, including regular familiarisation with the means of exit from the mine and the routes to any safe havens or changeover facilities.

17 Regulation 29 relates to the form and content of mine plans, including emergency plans.

The Mines (Safety of Exit) Regulations 1988⁶

18 These Regulations set out the aims to be achieved in order to prevent danger from operations in workings below ground. They apply to the means of leaving the underground parts of all mines.

19 Regulation 3 requires that all mines have at least two shafts or outlets to the surface.

20 Regulation 7, with certain exceptions, requires there to be at least two ways out of the mine from every place where people work; that those ways out are clearly marked; and that the manager draws up a scheme so that everyone is familiar with the ways out of their places of work, including in an emergency.

Emergency planning

Assessing the hazards and risks associated with an emergency

21 In order to meet the requirements of the Escape and Rescue from Mines Regulations 1995, managers need to assess who is at risk in various types of emergency. Managers can then decide who would need to be evacuated in such situations and how best that might be achieved. These escape and rescue procedures should then be included in the emergency plan.

What should the assessment cover?

22 The assessment must cover everyone at work in the mine, including contractors. If there is more than one employer at the mine, they will need to fully co-operate with each other to ensure that each employer's risk assessments are taken into account. For example, where a development roadway is being driven by a team of contractor's employees, the contractor (as an employer) has a legal duty to identify hazards and assess risk to his employees.

23 When selecting escape routes, managers will need to consider the types of emergency that could occur at the mine. The level of risk will depend to some extent on what escape routes are available from places of work and how easy it is to travel along them.

24 Where there is a possibility that not everyone might be evacuated, the assessment will help managers to decide what is needed to help those who are trapped to survive until they can be rescued.

25 For example, a fire outburst in a main intake may require the evacuation of nearly the whole of the mine. In this case, the main escape route might be along the main return. If there was a risk of dangerous concentrations of products of combustion reaching people travelling out along the main return, because the speed of the ventilating current was faster than walking pace, managers would need to consider whether or not the use of self-rescuers alone would allow them to escape. If not, they should advise owners that they may need to provide safe havens where those people could wait in safety until rescued, or changeover facilities where they could exchange their self-rescuers for fresh ones.

Places where risks may be enhanced

26 Certain places present escape and rescue problems which may increase the risks to people in an emergency. These include:

- single-entry headings;
- longwall coal faces with gate roadways over 1000 m long;
- hot and humid roadways;
- steep roadways;
- roadways driven in strata which may emit high-pressure hydrocarbon gases;
- workings where large diesel-powered plant is used;
- mines where there are large amounts of flammable materials, for example storage mines; and
- mines using halon or carbon dioxide flood arrangements designed to suppress any outbreak of fire.

Risks from nearby work activity

27 Managers need to take into account activities in the vicinity of the mine. Surface hazards might include neighbouring factories or plants producing or storing heavier-than-air products which, if they escaped, might be drawn into the mine by its ventilation system.

Mine complexes

28 Where a mine is part of a complex and shares common airways with a neighbouring mine or mines, managers need to take into account the likely effects of emergencies at other mines in the complex.

Flammable materials

29 When identifying hazards and assessing risks, managers will need to take into account the presence not only of firedamp and coal dust, but also of any flammable materials in the mine such as:

- mineral oil;
- diesel fuel;
- wood;
- chemicals;
- belt conveyors;
- electrical equipment; and
- ammonium nitrate.

30 Managers need to take account of these hazards when assessing the risks associated with the production of toxic gases in a fire, and of oxygen deficiency.

Oxygen deficiency

31 Oxygen deficiency can occur due to:

- a sudden inrush of firedamp;
- depletion due to fire or explosion;
- loss of ventilation through the destruction of air doors, or of ventilation ducting within a single-entry heading;
- the migration of blackdamp from old workings during a period of falling barometric air pressure; and
- the operation of halon or carbon dioxide flood-type fire suppression systems.

Toxic gases

32 Fires, explosions, spontaneous heatings, outbursts, mining explosives and diesel engines all produce toxic gases. Above certain levels, these can give rise to a series of symptoms ranging from headaches and disorientation to unconsciousness and even death. Toxic gases include:

Carbon monoxide – produced by the oxidation of coal (spontaneous heating), fires and explosions, and present in shot-firing fume and diesel engine exhausts.

Oxides of nitrogen – present in shot-firing fume and diesel/engine exhausts.

Hydrocarbon and n-hydrocarbon series gases – present in strata close to oil-bearing measures. They can be released in significant quantities in outbursts.

Other gases – chlorine, hydrogen chloride, hydrogen cyanide and phosgene may be produced when many synthetic materials used underground are decomposed by heat.

Inrush of water

33 Water will flow and will collect at depressions (low points) within roadways. If a depression within a single-entry heading is deeper than the roadway height and the water level reaches the roof, it will cut off ventilation and the escape route.

Entrapment by a fall of ground

34 People working in single-entry headings may be trapped by a fall of ground. The auxiliary ventilation system would be disrupted, although pipe ranges may remain intact which could be used to provide compressed air emergency ventilation. There may be leakage paths along the edges of the fall, enough to allow air to diffuse, delaying the onset of an irrespirable atmosphere.

Developing an emergency plan

35 The emergency plan, required by regulation 4 of the Escape and Rescue from Mines Regulations 1995, should set out the action to be taken to effect, safely and promptly, the evacuation and rescue of people from the mine in an emergency. Paragraphs 8-24 of the Approved Code of Practice give practical guidance on complying with regulation 4.

36 Managers should base their emergency plans on assessments of the risks that might occur in an emergency.

37 As employers, mine owners are responsible for assessing risks. However, mine managers will often be better placed than mine owners to assess the risks that might arise in an emergency. Whether mine owners assess risks themselves, or appoint their mine managers to do it on their behalf, in preparing an emergency plan managers have a duty to take account of any relevant risk assessment made in accordance with regulation 3 of The Management of Health and Safety at Work Regulations 1999.

38 To provide a systematic approach to risk assessment and subsequently the emergency plan, two sets of pro formas have been developed to suit either a large mine with a complicated ventilation system or a smaller mine with a straightforward ventilation system. You will find these pro formas in Appendix 1 of this guidance, together with examples of completed pro formas from one mine in South Wales.

39 This assessment approach should help identify;

- the risks associated with each hazard;
- the number of people at risk;
- the measures already in place to control risks; and
- any further measures that should be taken to minimise or eliminate the risk.

40 For example, on a longwall face district, the following factors may have a bearing on the ease of escape. Managers may therefore need to consider them when making an assessment for drawing up an emergency plan:

- length of roadways (distance to travel to escape to safety);
- length of face (distance);
- seam thickness (ease of travel);
- gradients (ease of travel);
- roadway support (possibility of collapse);
- ventilation (hot and humid conditions – ease of travel);
- machinery (trapping, catching fire);
- haulage systems (assistance for rescue/escape);
- size of workforce (number of people likely to be exposed); and
- communications (system flexibility).

41 The major factors influencing the assessment will be the:

- distance and ease of travel;
- temperature/humidity of the workings; and
- ability of a rescue team to effect a proper rescue.

42 The measures already in place to control the risk need to be identified and these may include:

- self-rescuers (filter or self-contained type);
- safe havens or changeover facilities;
- tried and tested evacuation procedures; and
- environmental monitoring and alarm systems.

43 For a large mine, the pro formas in Appendix 1 can help managers to assess the worst potential outcome in relation to a particular hazard. For example, an explosion in a drivage may fatally injure a number of people, but it may also result in a shortage of oxygen, thereby threatening the lives of others in the drivage and outbye who initially escaped injury.

44 Managers of small mines can use the pro forma to make a whole-mine assessment for each hazard, the risks it gives rise to, and potential numbers of people likely to be affected.

45 After completing the relevant risk assessment pro forma, the manager can judge the likely effectiveness of procedures already in place and make any necessary changes to the emergency plan.

46 Managers need to keep their emergency plans under review and amend them to reflect changes at their mines (see regulations 4(3) and 4(4) of the Escape and Rescue from Mines Regulations 1995).

Arrangements for escape

Key principles of escape

47 There are four key principles for people to follow when escaping from a potentially irrespirable atmosphere:

- where possible, alert others without delay;
- never knowingly travel towards danger;
- if in any doubt, wear a self-rescuer; and
- it is better to call out the mines rescue service in genuine error than not to call it out at all.

What managers should consider

48 Managers should ensure that everyone working below ground is familiar with:

- warning arrangements in place;
- escape routes from working places;
- the use and limitations of self-rescuers; and
- the siting and type of any safe havens and/or changeover facilities.

Warning arrangements

49 Managers should ensure that appropriate arrangements are in place for warning people in an emergency. These include ensuring that there are sufficient telephones or intercoms for people to contact each other and the mine surface without undue delay. The complexity of the communications system at a mine will be proportional to its size and the number of working places in it. HSE recommends the use of communications systems which incorporate an 'emergency button' which overrides normal means of communication.

50 People who detect an incident giving rise to an emergency need to know who to contact and in what order. The priority for anyone raising the alarm in an emergency where people may need to wear self-rescuers to escape, is to warn others in the vicinity. Where no means of communications is close by, the person raising the alarm should proceed to the nearest telephone or intercom travelling away from the source of the danger along an escape route, wearing their self-rescuer if necessary.

51 Owners and managers need to ensure that at the mine surface arrangements are in place to alert people below ground, and the mines rescue service, in an emergency that may cause an irrespirable atmosphere. At mines with an intercom system, the whole mine could be alerted simultaneously from the surface by opening all channels. At mines relying only on telephones, it may be necessary for a person, or people, on the mine surface to make a number of calls to different working places.

52 If someone at the mine surface receives only an emergency signal (generated when an emergency button is depressed) and cannot establish verbal contact, they should assume that the atmosphere is irrespirable. They should then alert other working places and call out the mines rescue service. Managers may wish to consider putting in place a signalling system using the emergency button as a signal key. A series of short simple questions from the surface may be sufficient to establish that there is an emergency, where it is, and that the atmosphere might be irrespirable – for example, one beep for ‘yes’, two beeps for ‘no’.

53 At mines where people are below ground and there is no-one at the surface, managers should make arrangements to contact someone away from the mine at predetermined times. Should a call be missed, the contact can, if necessary, alert the emergency services that there may be a problem.

Escape routes

54 When drawing up their emergency plans, managers should consider the types of emergency that could occur at the mine, to enable them to define escape routes. These will vary, depending on the location and type of incident leading to the emergency.

55 Where intake roadways, or parts of them, are expected to remain unpolluted, managers should define escape routes which enable people to reach those roadways in the quickest possible time and continue along them. However, there may be circumstances where the whole of the main intake is likely to be polluted. In this case, smoke, gas or fumes from the incident would take longer to reach return airways and the escape route might be along the main return.

56 The ways out of the mine should already be clearly marked to meet the requirements of regulation 3 of The Mines (Safety of Exit) Regulations 1988. Normally, this will be by green reflective signs. However, emergency wayfinder beacons (flasher units) are now available to help people trying to escape in low visibility (see Figure 1). These are spaced at intervals along a roadway and, when activated, produce an audible signal, together with a green, high-intensity, flashing light on one side and a red one on the other. The green lights indicate the route to follow and the red lights warn disorientated people against going in the wrong direction, away from safety.



Figure 1 Emergency wayfinder beacon

Escape arrangements in other countries

57 For further information on escape philosophy and practices in Germany, France, the USA and South Africa, see Appendix 2.

58 For details of actual escape incidents, see Appendix 3.

The relationship between self-rescuers and safe havens or changeover facilities

59 Regulation 10 of the Escape and Rescue from Mines Regulations 1995 deals with the owner's duty to provide suitable self-rescuers and, where necessary, safe havens or facilities for the exchange or recharge of self-rescuers.

60 Paragraphs 46-50 of the Approved Code of Practice give practical guidance on the suitability of self-rescuers, and paragraphs 51-54 give practical guidance on safe havens and changeover facilities.

61 In some cases the only escape equipment that the owner will need to provide is appropriate self-rescuers. However, in deciding what type of self-rescuer is appropriate to the circumstances at the mine, managers should consider:

- how far people might have to travel wearing them;
- what the underground conditions are likely to be;
- how long it will take those wearing self-rescuers to reach a place of safety (remembering that people attempting to escape in a smoke or dust-laden atmosphere only travel very slowly); and
- the standard of ventilation.

62 Managers should then determine:

- whether self-rescuers alone are sufficient to allow people to escape to safety; or
- if any other escape facilities are needed.

63 If self-rescuers alone are unlikely to give protection for long enough to guarantee that wearers can escape, safe havens or changeover facilities will need to be considered. Mine owners may have to provide these to comply with their duties under both regulation 10 of The Escape and Rescue from Mines Regulations and regulation 6 of the MASHAM Regulations.

64 The likelihood of people being trapped by an inrush of water or by a fall of ground will also have a bearing on escape arrangements. For example, in an undulating single-entry heading working within an inrush precautionary zone, a safe haven provided and maintained within 100 m of the face of the heading will enable anyone trapped within the heading to be provided with sufficient oxygen, through a compressed air supply, to survive until rescued.

65 On the other hand, a fall of ground in a single-entry heading may trap the people working there, and also damage or destroy any compressed air range leading to a safe haven. Although the auxiliary ventilation system and emergency compressed air range may be disrupted, there will still be some diffusion of air through the fall area and it may take much longer for the oxygen to deplete. The rate of depletion will depend on local circumstances such as the firedamp emission rate, the volume of air available inbye of the fall, and the number of people trapped. In this case it may be better to provide chemical oxygen self-rescuers and maintain atmospheric sampling tubes close to the face of the heading to maximise the chances of people surviving until a temporary system of ventilation could be established.

Self-rescuers

Some limiting factors

66 Equipping people working underground with long-duration self-rescuers will increase their chances of being able to escape to safety or lengthen their survival time while awaiting rescue.

67 The length of time that someone can wear any type of long-duration breathing equipment will depend, in part, on the wearer's physical condition and reaction to stress. People attempting to escape in an emergency will be under considerable stress. Therefore, managers should not base their emergency plans on the assumption that people can walk and wear a self-rescuer for long periods; particularly in hot and humid conditions or where smoke may reduce visibility.

68 In good walking conditions with unrestricted visibility and in a relatively comfortable environment, and with no significant initial fatigue or stress, wearer trials (see Figure 2 and details in Appendix 4) suggest that:

- people equipped with a nominal 90-minute chemical oxygen self-rescuer may have approximately 70 minutes wearing time during which they could walk about 2000 m;
- those wearing nominal 60-minute chemical oxygen self-rescuers may have approximately 45 minutes wearing time and could walk up to 1350 m;
- a nominal 30-minute chemical oxygen self-rescuer may provide as little as 17 minutes wearing time and could limit walking distance to between 500 m and 1000 m.

69 However, in an emergency involving a fire or explosion, smoke or dust is likely to restrict visibility and wearers are likely to suffer confusion, stress and fatigue. These factors, together with the hot and humid conditions which prevail in many deep mines, are likely to increase the wearer's breathing rate and breath depth. This places an increased demand on the self-rescuer and will significantly reduce both its duration and the distance that the wearer can walk.

70 As a guide, for chemical oxygen self-rescuers, where the effective temperature exceeds:

30°C: allow no more than three-quarters of the nominal duration (for example, 45 minutes for a nominal 60-minute set);

32°C: allow no more than half the normal duration (for example, 30 minutes for a nominal 60-minute set).

Similar reductions should also be allowed for people wearing filter self-rescuers.



Figure 2 Chemical oxygen self-rescuer wearer trials in smoke in a Bathstone mine in Wiltshire

71 Conversely, where self-rescuer wearers do not physically exert themselves - for example because they are trapped and are using an entrapment procedure - and their breathing is slow and controlled, there is a reduced demand on their self-rescuers. In such circumstances, self-rescuer life can be up to three times its nominal duration.

72 In large and/or warm and humid mines, regardless of the type of self-rescuer selected, safe havens or changeover facilities may be required because of the reduced distances people wearing self-rescuers can walk in such conditions. Safe havens or changeover facilities should be close to the places of work and strategically placed at intervals in the mine in order to allow people to rest while escaping or, where appropriate, take refuge.

73 In single-entry development roadways there is the potential for the auxiliary ventilation duct to be destroyed in a fire. This might lead to an atmosphere made irrespirable by oxygen depletion. Chemical oxygen self-rescuers should therefore be considered. In long single-entry development roadways there may be a need to provide changeover facilities, where short-duration chemical oxygen self-rescuers could be replenished or exchanged for long-duration models.

Filter self-rescuers

74 Filter self-rescuers (see Figure 3) have reliably served the mining industry for many years. Workers are familiar with them and trust them.

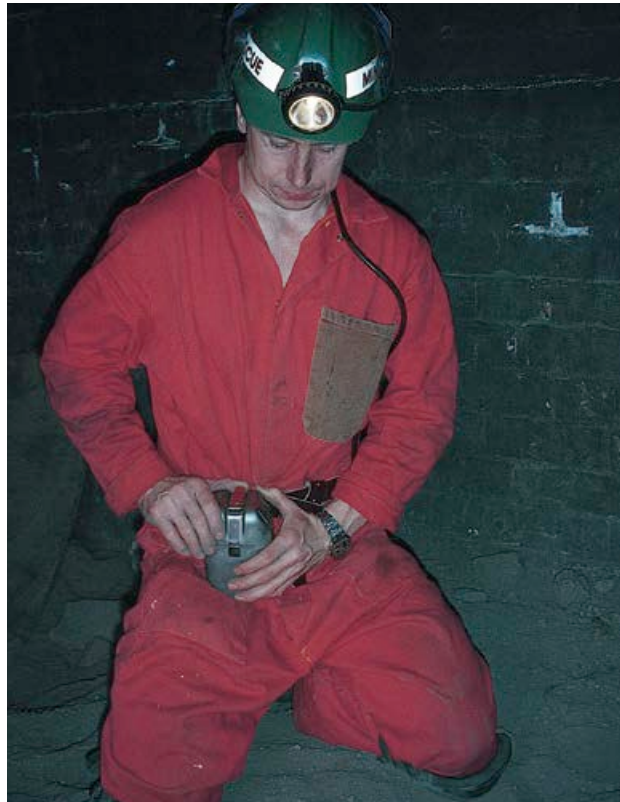


Figure 3 Putting on a filter self-rescuer

75 The filter self-rescuer is designed to protect the wearer from the effects of breathing carbon monoxide. As the wearer inhales, the polluted air is drawn into the self-rescuer through a dust filter and passes through a cartridge containing a granular chemical called Hopcalite in combination with either a drying agent or a noble metal catalyst. These convert the toxic carbon monoxide to carbon dioxide, which is safer to breathe.

76 The filter self-rescuer's relatively small size and light weight mean it can be easily be carried for a whole shift and longer.

77 For their size and weight, filter self-rescuers provide protection against carbon monoxide for a relatively long time. However, they do not protect the wearer in oxygen-deficient atmospheres as they do not provide an independent supply of oxygen, which may be depleted to a level low enough to render the wearer unconscious.

78 While filter self-rescuers provide protection against carbon monoxide, its presence will cause a significant increase in the temperature of the inhaled air and in breathing resistance.

79 In the majority of underground fires, properly maintained filter self-rescuers will provide their wearers with adequate protection. Oxygen is only likely to be depleted to a level likely to cause unconsciousness following an explosion, or a sizeable fire in a poorly ventilated part of the mine.

80 To ensure that filter self-rescuers work effectively when required, they must be adequately maintained. If the Hopcalite in filter self-rescuers is allowed to degrade or take up moisture, thus reducing its effectiveness, wearer protection may be reduced by up to two-thirds and the wearing time may be as low as 30 minutes, depending on the type of self-rescuer in use.

The MSA 290 filter self-rescuer

81 The 290 model was a redesign of the earlier 275 model following the Cardowan explosion. It has a longer opening clip and pressure relief device, and is therefore easier to open, even when the user has burned fingers.

82 This model is designed to protect the wearer from carbon monoxide atmospheres up to 15 000 ppm (1.5%) for up to 90 minutes.

83 The last model 290 filter self-rescuers were distributed within the UK mining industry early in 1991, and by the year 2001 many of them will be coming to the end of their designed life. Mine owners will need to carefully monitor the condition of the remaining model 290 filter self-rescuers, particularly degradation of the Hopcalite, and replace them before their wearing duration drops to a point where it might prejudice the safe escape of a wearer.

The AUER/MSA W95 filter self-rescuer

84 The W95 filter self-rescuer is a relatively new design which complies with European Standard EN404 and carries a CE mark. It gives protection against carbon monoxide and other hazardous gases produced by fire or explosion. It will protect the wearer for at least two hours in 1.5% carbon monoxide. It does not provide the wearer with oxygen.

85 When the wearer inhales, air is drawn in through a thin layer of Hopcalite which converts some of the carbon monoxide to carbon dioxide. It also filters out some other products of combustion, such as hydrogen cyanide and hydrogen chloride, which would otherwise contaminate the noble metal catalyst and reduce its efficiency.

86 After passing through the Hopcalite, the air passes through a noble metal catalyst embedded in a ceramic honeycomb which has a low resistance to breathing. It converts nearly all of the remaining carbon monoxide to carbon dioxide.

87 The W95 filter self-rescuer also differs from the 290 model in the following ways. It has:

- longer duration;
- lighter weight;
- improved head harness design;
- no inhalation valve;
- lower breathing resistance;
- lower wearer temperature;
- a short opening clip, similar to that on the model 275;
- no 'pressure relief' air hole for ease of opening; and
- a CE mark.

Self-contained oxygen self-rescuers

88 Self-contained oxygen self-rescuers are also known as self-contained escape breathing apparatus. There are two types – *chemical oxygen* and *compressed oxygen*. Both types function independently of the outside environment and therefore protect wearers in an oxygen-deficient and toxic atmosphere by providing them with oxygen.

89 There are a number of different compact oxygen self-rescuers – mainly chemical oxygen types – suitable for use in mines. These will either have been approved under the Control of Substances Hazardous to Health Regulations 1988 and assessed in suitability trials carried out under HSE supervision, or they will be CE-marked.

90 Both types of oxygen self-rescuers have a lower breathing resistance than the 275 and 290 filter self-rescuers, but are comparable with the W95 filter self-rescuer.

91 Because both types of oxygen self-rescuers have an independent breathing circuit, inhaled air temperature does not increase as quickly when carbon monoxide is present. Oxygen self-rescuers should therefore be considered in those parts of mines where, although the air might not be oxygen-deficient, people would have to escape in hot and humid conditions.

92 Appendix 4 gives details of wearer trials (see Figures 4 and 5) carried out to assess oxygen self-rescuer duration.



Figure 4 Chemical oxygen self-rescuer wearer trials in South Wales (MSA SSR 30/100)



Figure 5 Chemical oxygen self-rescuer wearer trials in South Wales (Fenzy Biocell 1 Start 30/100)

93 The longer duration sets (for example nominal 90-minute) are too large to be carried on the person for a full shift. Where these are provided, they need to be kept in a place where they are readily available in an emergency, such as a changeover facility.

94 Where short-duration oxygen self-rescuers are provided, the mine owner will probably need to provide safe havens or changeover facilities, unless the wearers are very close to fresh air. The changeover facility will allow wearers of short-duration oxygen self-rescuers to fit a fresh canister or cylinder, or to exchange a short-duration set for a long-duration one. Safe havens will allow wearers of short-duration oxygen self-rescuers to fit a fresh canister or cylinder, or to exchange a short-duration set for a long-duration one. Safe havens will allow them to remain there waiting to be rescued.

Chemical oxygen self-rescuers

95 Where the wearer of a chemical oxygen self-rescuer is breathing at a low rate, for example when trapped, the self-rescuer will normally provide protection for at least three times the nominal duration. A nominal 20-minute set could therefore be expected to provide protection for at least an hour.

96 Some chemical oxygen self-rescuers have a starter unit which, on opening, gives the wearer an immediate supply of oxygen until the chemical oxygen generator is fully activated. Others rely solely on the wearer's exhaled breath to progressively activate the oxygen-generating chemicals.

97 Training for those wearing the chemical oxygen self-rescuer is vital to ensure it is worn correctly and to make the user aware of how the unit performs, especially during the initial stage of use while the oxygen-generating chemical is progressively activated.

Compressed oxygen self-rescuers

98 Compressed oxygen self-rescuers give the wearer an immediate supply of oxygen. However, for their size and weight, they have a shorter duration than a chemical oxygen self-rescuer.

Safe havens

99 The provision of safe havens and changeover facilities (see Figures 6, 7 and 8) is a new concept for UK coal mines. However, in the past, the then National Coal Board provided equipment at some mines prone to large firedamp emissions, mainly in South Wales and South Yorkshire, to help people survive in atmospheres which were potentially oxygen-deficient. Dedicated compressed-air pipes were installed from the surface to those parts of the mine where people were at risk from this potential hazard. Below ground, special valves were located at intervals in the air ranges in roadways and in the air hoses which ran along coal faces. Workers could access the air supply by pulling out a plastic tube attached to a valve. This had the effect of turning the top of the valve through 90° and releasing a regulated stream of air through the plastic tube. Workers were trained to direct air into their upturned helmets so that two or three persons could breathe at the same time from one helmet.

100 Safe havens are places where people can wait in safety without wearing self-rescuers. Changeover facilities are semi-sealed installations where they can safely change their self-rescuers for new ones before proceeding outbye, or wait in safety while wearing self-rescuers.

101 Paragraphs 51-53 of the Approved Code of Practice to the Escape and Rescue from Mines Regulations 1995 give mine owners practical guidance on how they might comply with their duty to provide safe havens under regulation 10(1)(b).

102 Both safe havens and changeover facilities should have an independent air supply with sufficient capacity to maintain the atmosphere at a pressure greater than that of the surrounding atmosphere, so that any leakage is outwards.



Figure 6 Safe haven/changeover facility at Daw Mill Mine in Warwickshire



Figure 7 Safe haven at Tower Mine in South Wales

Safe havens

103 Safe havens are appropriate for all mines with extensive workings where the working places are far from the downcast shaft(s) or outlet(s). Safe havens should be positioned near the part of the mine they serve, so that people can meet there and wait to be rescued without needing to wear their self-rescuers. Such safe havens will be physically quite large and should therefore be sited in large main roadways or in intake cross-cut roadways.

104 The independent air supply should be capable of maintaining the atmosphere within the sealed type safe haven below the COSHH eight-hour occupational exposure standard (OES) for carbon monoxide, currently 30 ppm.

105 The air pressure within the safe haven should be higher than that outside. The design will need to include a simple air lock to allow people to enter the safe haven without contaminating the air inside.

106 The minimum recommended monitoring inside a sealed safe haven is for continuous monitoring of carbon monoxide.



Figure 8 Changeover facility at Silverdale Mine in Staffordshire

Changeover facilities

107 Changeover facilities are semi-sealed installations, which can take the form of pressurised canopies or refuges maintained at positive pressure. They take up little space and can be sited in gate roadways or headings.

108 The independent air supply to a changeover facility should be capable of maintaining the atmosphere inside it below the COSHH 15-minute OES for carbon monoxide, currently 200 ppm. This will allow people to change their self-rescuers safely or extend the self-rescuers' effective life for those choosing to wait there to be rescued. They may also help people to escape in conditions which are warm and humid, by giving wearers the opportunity to rest for a few minutes in a cooler atmosphere before proceeding outbye.

Independent air supply to safe havens and changeover facilities

109 An independent air supply is one that is not dependent on the general body of mine air in the roadway where a safe haven or changeover facility is situated. The air supply does not necessarily have to be dedicated to safe havens.

If there is already a compressed air supply from the surface, it will not normally be necessary to install a dedicated air line from the surface to the safe haven; a branch can be taken from the main air range. However, in such circumstances, it is recommended that the compressed air supply is filtered and monitored for the presence of carbon monoxide.

110 Where mines intend to use underground compressors to supply air to safe havens, managers will need to consider:

- the potential of an upstream fire, heating or explosion to pollute the compressor inlet air; and
- the security of the electrical power supply to the compressor(s) in an emergency.

111 If a fire upstream of underground compressors might give rise to significant risks to people sheltering within a safe haven, managers will need to take further steps to eliminate the hazard of compressor inlet pollution. This might involve:

- re-siting the compressor(s);
- extending the air inlet pipes further outbye; or
- bringing in a compressed air line from the surface.

112 If underground compressors are used to supply air to at least one safe haven, the compressors should be regarded as safety-critical electrical equipment.

113 Tests confirm that when the compressed air supply to the safe haven or changeover facility is activated, any contamination inside quickly clears. So long as the air supply remains constant, the atmosphere inside will remain tolerable.

114 With the compressed air supply removed, conditions can quickly deteriorate. In safe havens, which are relatively well sealed, carbon dioxide concentration can increase, oxygen concentration can reduce, and both temperature and humidity can significantly increase. In changeover facilities, pollutants in the mine air will enter, increasing the risk to anyone exchanging their self-rescuers.

115 In certain locations around the world, where shallow mining is carried out, surface boreholes provide an independent air supply, a means of supplying fresh drinking water and communication. Managers of shallow mines where safe havens are provided should consider using boreholes to provide fresh air, water and communications.

Equipment in safe havens

116 In addition to communications equipment (and in changeover facilities, replacement self-rescuers) safe havens need a basic level of equipment (see Figure 9) to help people survive while awaiting rescue or to escape. They will need, for example:

- environmental monitoring pipes, such as Dräger tubes, to test the atmosphere outside the safe haven;
- drinking water;
- plans showing escape routes to fresh air or other safe havens; and
- basic first-aid equipment.



Figure 9 Equipment in the safe haven at Daw Mill Mine, Warwickshire

Appendix 1 – Emergency planning pro formas *(completed example for fire)*

Emergency plan - risk assessment

Hazard: Fire underground

Last revised: 03 April 1997

Location	No of men affected	Measures already in place	Effect	Probability	Risk	Further action required
Main drift	70 Days 45 Afts 25 Nights	Owner's rules on mine fires. Method of reversing airflow on drift + buoyancy effect. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	Face and development men at the limit of their self-rescuers.	Major – low Minor - medium	HIGH LOW	Evacuation training required. Travelling times to surface while wearing rescuer to be established.
M2 Roadway	60 Days 40 Afts 25 Nights	Owner's rules on mine fires. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	No effect – men can reach fresh air via loading bay.	Major – low Minor - medium	LOW LOW	Evacuation training required. Travelling times to loading bay to be established.
West lateral intake	50 Days 35 Afts 20 Nights	Owner's rules on mine fires. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	No effect – men can reach fresh air via V27 face line.	Major – low Minor - medium	LOW LOW	Evacuation training required.
Face gate road	45 Days 30 Afts 15 Nights	Owner's rules on mine fires. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	No effect – men can reach fresh air via west lateral X-cut.	Major – low Minor - medium	LOW LOW	Evacuation training required.
Development heading	25 Days 15 Afts 15 Nights	Owner's rules on mine fires. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	No effect – men can reach fresh air via west lateral X-cut.	Major – low Minor - low	LOW LOW	Evacuation training required.
Main returns	10 Days 5 Afts 5 Nights	Owner's rules on mine fires. 75-minute CO self-rescuers. Evacuation alarm. Environmental monitoring.	No effect – men can reach fresh air via X-cuts.	Major – low Minor - medium	LOW LOW	None

Notes: Risk of poisonous fumes given off during a fire is very low due to high dilution effect on high ventilation quantities and the use of approved materials only underground. Risk of inadequate oxygen levels available during a fire is very low due to high ventilation quantities.

Emergency plan - evacuation procedures

Hazard: Fire underground

Last revised: 03 April 1997

Location	No of men affected	Action to be taken by the control room operator	Further action required
Main drift	70 Days 45 Afts 25 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the returns and M1 roadway to pit bottom. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at top of drift.
M2 Roadway	60 Days 40 Afts 25 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the returns and M1 roadway to the loading bay and intake drift. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at top of M2 and bottom of the 10' heading.
West lateral intake	50 Days 35 Afts 20 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the WLR – V27 face line – Strata bunker – M2 and intake drift. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at top of V27 faceline and bottom of M2.
Face gate Road	45 Days 30 Afts 15 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the face return – WL1 – M2 and intake drift. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at top of V43 supply and gate road.
Development heading	25 Days 15 Afts 15 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the WL1 – M2 and intake drift. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at west lateral X-Cuts outbye of fire and mouth of heading.
Main returns	10 Days 5 Afts 5 Nights	Sound the evacuation alarm. Open all channels and tell people to evacuate the mine via the WL1 – M2 and intake drift. Repeat the instructions at 60-second intervals.	Keep a log of action taken and inform incident control when established. Liaise with underground officials to establish sentries at west lateral X-Cuts, west Bute doors and loading bay.

Emergency plan - risk assessment

Hazard:

Last revised:

[illegible]

Notes: Risk of poisonous fumes given off during a fire is very low due to high dilution effect on high ventilation quantities and the use of approved materials only underground. Risk of inadequate oxygen levels available during a fire is very low due to high ventilation quantities.

Emergency plan - evacuation procedures

Hazard:

Last revised:

[illegible]

Appendix 2 – Mines escape practice in other countries

Germany

1 For many years, German mining engineers designed and laid out their mines so that following any fire or explosion, people could reach uncontaminated air in not more than 90 minutes without using any means of transport. The escape times, calculated at the planning stage, were based on escape exercises with filter self-rescuers, taking into account gradients and height of travelling roads.

2 However, further research work, carried out to review the performance of both filter and oxygen self-rescuers in hot and humid conditions, led to a strategic change in German escape philosophy and practice. Surface trials, with people wearing different self-rescuers in controlled climatic conditions, including walking upright, walking in a stooped position and crawling. They also carried out some research work below ground. They found that:

- for mines with effective temperatures above 29°C, the heat stress experienced by people during escape could be reduced if they lowered their escape speed by 33%; and
- for people wearing an SSR 120 chemical oxygen escape set (nominal 120-minute wearing time) escape speed should be reduced by 15% due to the size and weight of the escape set.

3 Both of these factors reduced the calculated distance people could travel while wearing self-rescuers. Mine planners and managers now have to take this into account when planning mine layouts and the number and position of safe havens.

4 German practice now is that all underground workers carry filter self-rescuers throughout their shift; these have a nominal wearing life of 90 minutes. Everyone receives basic training in escape procedures with filter self-rescuers, and they receive refresher training at two-yearly intervals.

5 Additionally, mines provide workers with oxygen self-rescuers in areas with a high risk of fire or explosion which would deplete the oxygen in the mine air, such as:

- auxiliary ventilated headings;
- where mobile plant operates; and
- where drilling operations are carried out in potential gas outburst areas of a mine.

6 In German mines, safe havens are usually small metal cabins (for five to ten people) supplied with mains compressed air and equipped with additional self-rescuers and a telephone link.

France

French eastern collieries – escape strategy

7 French eastern coal mines provide safe havens which can also be used as changeover facilities. These are places where workers can muster to receive further instructions, either from the district foreman or from a surface controller.

8 The Mines Rescue organisation and mine management generally agree the most appropriate locations of safe havens.

9 Rules governing escape from coal mines in eastern France include the following requirements :

- anyone entering a mine must carry a nominal 30-minute duration self-contained oxygen self-rescuer;
- a district foreman or the surface controller (whichever of them is best placed to make the decision) is responsible for issuing an alert in the event of an incident that may require people to escape;
- when the 'Go and Gather' escape procedure is implemented, people put on their self-rescuers and go to a safe haven;
- each safe haven is provided with self-rescuer refills, mine plans, first-aid kit, telephone and provisions for sampling the atmosphere outside the safe haven; and
- a district foreman or a surface controller decides whether people should continue with escape or remain in a safe haven.

Escape and evacuation arrangements – Forbach Simon Mine, Lorraine

10 Visual and audible alarm systems are provided in working districts as part of the surface computer control arrangements for environmental monitoring. The mine provides everybody with a Fenzy, nominal 30-minute, chemical oxygen self-contained self-rescuer, which they carry for the whole shift. There are established procedures for people to put on their self-rescuers in an emergency and proceed immediately to the nearest safe haven. Escape routes are marked by visual indicators and warning signals are broadcast over the underground intercom system to help people escape in low visibility.

11 There are three types of safe haven in use:

- steel modular;
- a permanent brick-built structure in the main intake; and
- wood with plastic liner.

All are provided with chemical relay cartridge self-rescuer refills, and a compressed air supply from the surface.

12 There are safe havens in the intake gates of the longwall retreat districts at the mine. These are the steel modular-type units which district personnel strip, move and reassemble as the face retreats. In an emergency, the compressed air maintains the pressure within the safe haven above that of the outside atmosphere and double doors form an air lock entry. People can stay in these safe havens and wait for rescue, or they can refill their self-rescuers using one of the chemical relay cartridges stored there and then proceed further outbye.

13 Training concentrates on people putting on their self-rescuers immediately and then proceeding directly to a safe haven, following a marked escape route. Refresher training is carried out every month and comprises watching a video and reviewing mine plans and escape routes.

United States of America

14 Researchers in the USA have, during the last ten years, carried out a considerable amount of work to understand the physiological responses of miners wearing escape apparatus in stress conditions. Understanding the response of individuals (who may react differently) in an emergency is essential in order to maximise their chances of survival.

15 They have found that:

- a concentration of up to 3% carbon dioxide in one hour does not impair escape;
- hot air breathing affects the function of a filter self-rescuer; attention must be paid to tissue temperature (mouth), heart rate and core temperature;
- the respiratory tract can dissipate heat effectively when breathing hot dry air, but with wet bulb temperatures above 35.2°C the respiratory tract gains heat.

16 In an emergency, the time people have to reach an oxygen self-rescuer is affected by the levels of toxic products and the oxygen concentration in the mine atmosphere. Levels of up to 11% CO₂ have been measured following an explosion, together with oxygen levels as low as 6%. Such an atmosphere will not support life and a filter self-rescuer offers no protection in this situation.

17 By studying fires and explosions in the USA, where people have immediately put on a filter self-rescuer and then changed over to a compressed or chemical oxygen self-rescuer, researchers concluded that people need to change over within five minutes to minimise the chance of their being overcome by a surfeit of carbon dioxide or by oxygen deficiency.

18 Researchers carried out further work at four different coal mines to look at the effects of:

- training in the use of an oxygen self-rescuer;
- self-rescuer integrity; and
- the oxygen demand placed on the apparatus by the wearer while escaping.

19 The results showed:

- the speed and efficiency with which workers could put on self-rescuers in an emergency was related to the general skill level of workers at a particular mine. The trials confirmed that survival odds increased as self-rescuer training improved.
- a 10% use-failure rate. This was due to either the apparatus failing to provide life support due to defect or damage, or the miner being unfamiliar with the function of the chemical oxygen self-rescuer, with its slow start-up profile.
- oxygen consumption depends on three factors:
 - body weight;
 - escape distance; and
 - oxygen demand rate.

South Africa

20 In carrying out work to determine escape criteria for mines, South African researchers have concluded that where people work in hot, humid and arduous conditions, they should use self-contained oxygen self-rescuers in preference to any type of filter self-rescuer. Such self-rescuers should:

- have a duration of 30 minutes at 35 l/min breathing rate;
- be approved by the State with regard to their design and construction;
- be carried on the person at all times; and
- be maintained in good condition, ready for immediate use.

21 A study of the wearing of escape devices concluded that each mine should:

- formulate an escape strategy for its own particular conditions and circumstances; and
- look at its escape routes with particular reference to travelling conditions with reduced visibility.

22 A monitoring programme has been set up which:

- identifies adverse performance trends and functional problems (samples withdrawn from service and tested on a breathing rig); and
- analyses each incident where rescuers have been worn to identify any problems or potential problems, and to review their life-saving potential.

Appendix 3 – Escape Incidents

The Endeavour Mine Explosion 1995

1 Following the explosion, survivors, due to the thick dust and smoke, quickly became disorientated and, together with problems in putting on their self-rescuers, wasted valuable time before trying to escape.

2 Such an incident confirms that:

- with disorientation a major factor, a mine emergency plan cannot assume that people can walk the potential maximum distance while wearing a self-rescuer;
- how long a person lives after an incident, when carbon monoxide levels are high and oxygen levels cannot sustain life, depends on the life and type of self-rescuer; and
- although some workers had difficulties in putting on their self-rescuers, they also delayed doing this because of the need to talk to one another to agree an escape route.

3 The lessons from this incident are to:

- take account of how people can behave in an incident, to establish an appropriate and workable escape strategy;
- provide appropriate self-rescuers where there is a risk that fire or explosion might lead to oxygen deficiency in the mine air;
- ensure that people are properly trained about when to put on their self-rescuers;
- regularly familiarise people with escape routes; and
- ensure that escape routes are properly signposted.

The Stolzenbach Mine Explosion 1988

4 Fifty-four miners died in this brown coal mine explosion and six miners survived. The injuries sustained by some miners, as a result of the explosion, were so severe that they were unable to put on their filter self-rescuer and were killed within minutes by a combination of carbon monoxide poisoning and oxygen deficiency. Not all miners carried self-rescuers; some either abandoned them in the rush to escape, and others put them on too late while fleeing toward the shaft.

5 There was no evidence to suggest that anyone died as a result of a faulty filter self-rescuer. However, some defects were found in unused self-rescuers, such as misshapen mouthpieces and difficulty in removing them from their containers.

6 Two lessons were learned from this incident:

- Someone carrying a self-rescuer has a much greater chance of putting it on quickly and increasing their chances of survival. Following this incident, it was made compulsory for miners to carry a self-rescuer on their person all the time.
- Underground workers must be properly trained in escape procedures, including having the opportunity to practise breathing through filter self-rescuers with raised inhalation temperatures.

Appendix 4 – Summary of underground wearer trials of oxygen self-rescuers carried out at UK mines

1 For each trial, the procedure for putting on the self-rescuer was clearly explained to all wearers. However, some minor problems still occurred and some people needed help to put on their self-rescuer correctly. This confirms the need for proper and regular training in the use of self-rescuers.

2 In most of the trials, wearers at first experienced a lack of oxygen during breathing immediately after they had put on the chemical oxygen self-rescuers. This was expected, due to the start-up characteristics of this type of self-rescuer. At mines where chemical oxygen self-rescuers are introduced, training and instruction given to wearers in their use should emphasise that chemical oxygen self-rescuers do not immediately give a full flow of oxygen, and therefore do not operate at full capacity, for the first few minutes of operation.

3 Running or other physical exertion causes the breathing rate to raise and oxygen demand to exceed that which can be provided by the self-rescuer, particularly in the first few minutes after it has been put on.

4 Walking at a constant rate and without undue physical exertion, can extend the effective life of a self-rescuer. Training schemes should therefore focus on this aspect.

5 The age of the wearer did not appear to be a significant factor. However, there is a suggestion – although the evidence is not conclusive – that the larger the body frame of the individual, the more oxygen they need from the self-rescuer. This therefore reduces wearing time and the distance they can walk.

6 Although the stress experienced by wearers escaping in an actual incident could not be replicated in the trials, it may be that increased stress leads to increased oxygen uptake. Therefore the life of chemical oxygen self-rescuers worn in a real situation may be shorter than those in the wearer trials. The amount of reduction cannot be predicted as it depends on an individual's reaction to stress.

Trial 1 – Anthracite mine, South Wales

Model: MSA SSR – 30/100 chemical oxygen self-rescuer
Route: Outbye through a main intake drift with an average rising gradient of 1 in 9
 Floor conditions poor – wet and slippery
Temperature: Cool – low humidity

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	44	5' 9"	11 st 0 lb	20 min 00 s	Reached surface
B	32	6' 2"	13 st 0 lb	11 min 40 s	
C	45	5' 6"	12 st 7 lb	12 min 20 s	
D	54	5' 7"	11 st 7 lb	14 min 30 s	Oxygen ran out 60 m from the surface

Trial 2 – Anthracite mine, South Wales

Model: MSA SSR – 30/100 chemical oxygen self-rescuer
Route: Crawling for 150 m at 1.2m maximum height, then walking outbye 1250 m against a gradient of 1 in 13 maximum to surface
Temperature: Cool – low humidity

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	44	5' 9"	11 st 0 lb	29 min 22 s	Reached surface and continued walking
B	32	6' 2"	13 st 0 lb	16 min 30 s	
C	54	5' 7"	11 st 7 lb	23 min 00 s	Reached surface
D	34	6' 0"	11 st 7 lb	19 min 00 s	Reached surface

Trial 3 – Anthracite mine, South Wales

Model: Fenzy biocell 1 start – 30/100 chemical oxygen rescuer
Route: 330 m through intake drift against a gradient of between 1 in 2 and 1 in 3. Floor uneven and slippery
Temperature: Cool – low humidity

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	32	6' 2"	13 st 0 lb	9 min 50 s	Reached surface
B	45	5' 6"	12 st 7 lb	8 min 15 s	Reached surface
C	48	5' 10"	13 st 7 lb	12 min 30 s	Got to within 20 m of surface – see note below

Note: A and B had an ample supply of oxygen when they reached the surface. Subject C tried to keep up with A and B instead of regulating his walking speed to something more comfortable to himself. The rescuer produced 'too much oxygen', overloading the relief valve and causing subject C to feel 'very sick'. The rescuer was still producing oxygen when removed from the wearer's mouth.

Trial 4 – Anthracite mine, South Wales

Model: Fenzy biocell 1 start 30/100 chemical oxygen self-rescuer
Route: Crawling for 150 m at 1.2 m maximum height, then walking outbye 1250 m, against a gradient of 1 in 13 maximum to surface through an intake roadway
Temperature: Cool – low humidity

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	32	6' 2"	13 st 0 lb	27 min 30 s	All three reached surface and continued walking
B	48	5' 10"	13 st 7 lb	28 min 25 s	
C	34	6' 0"	11 st 7 lb	36 min 45 s	

Trial 5 – Coal mine, North Yorkshire

Model: Fenzy biocell 90 start
Route: Outbye through a return airway at an initial gradient of 1 in 12 reducing to a gradient of 1 in 40 for a distance of 5400 m
Temperature: Varying from 31°C - 24°C dry bulb, 26 °C – 20.5°C wet bulb with air quantity rising from an initial 38 m³/s to 52 m³/s

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	43	5' 11"	12 st 7 lb	103 min	Both noted a slight increase in breathing restriction about 20 min before the oxygen ran out
B	44	5' 10"	12 st 7 lb	101 min	

Trial 6 – Salt mine, Cheshire

Model: Fenzy biocell 90 start
Route: 5600 m along level and gently undulating roadways
Temperature: Constant at 12°C with humidity at 60-70%

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	39	6' 1"	16 st 0 lb	80 min 0 s	Trained mines rescue worker. Commented on slow start-up (10-12 min before rescuer really 'got going'). Also commented on slow start-up as above – 5 min before rescuer working satisfactorily
B	47	6' 0"	17 st 0 lb	88 min 0 s	

Trial 7 – Coal mine, Staffordshire

Model: MSA SSR – 30/100 chemical oxygen self-rescuer
Route: From the inbye end of a 660 m long development heading, average gradient level of 1 in 20 maximum rising. Into main return, then main intake. About 1500 m total
Temperature: Hot in the development heading 6 m³/s forcing @ 34.5°C dry bulb, 30.5°C wet bulb

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	41	6' 1"	18 st	22 min	No problems

Trial 8 – Coal mine, Staffordshire

Model: MSA SSR – 30/100 chemical oxygen self-rescuer
Route: From inbye end of a 657 m long development heading with gradient of between 1 in 5 and 1 in 20 rising then into main intake roadway with gradually increasing gradient from 1 in 25 to 1 in 5
Temperature: 26.0°C wet bulb, 30.5°C dry bulb. Air quantity 10 m³/s in the development heading increasing to 50 m³/s in the main intake

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	41	6' 0"	15 st 0 lb	21 min	Travelled 1151 m
B	37	5' 8"	11 st 7 lb	27 min	Travelled 1426 m

Trial 9 – Coal mine, Staffordshire

Model: Fenzy biocell 1 start chemical oxygen self-rescuer
Route: From inbye end of a 657 m long development heading with gradient of between 1 in 5 and 1 in 20 rising then into main intake roadway with gradually increasing gradient from 1 in 25 to 1 in 5
Temperature: 26.0°C wet bulb, 30.5°C dry bulb. Air quantity 10 m³/s in the development heading increasing to 50 m³/s in the main intake

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	41	6' 1"	18 st	15 min	Walked for 773 m

Trial 10 – Coal mine, South Wales

Model: MSA SSR – 30/100 chemical oxygen self-rescuer
Route: Through a 300 m long, 1.7 m high longwall coalface line then outbye, travelling with the ventilation current along a 1 in 12 dipping tailgate
Temperature: 24°C wet bulb, 25°C dry bulb. Ventilation quantity 52 m³/s

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	37	6' 0"	14 st 0 lb	19 min 30 s	Walked for 1023 m before oxygen ran out
B	36	5' 11"	13 st 7 lb	19 min 30 s	Walked for 1023 m before oxygen ran out
C	34	6' 1"	15 st 7 lb	21 min 15 s	Walked for 1233 m before oxygen ran out

Note: All subjects in this test were trained mines rescue workers. Subjects A and B were full-time and subject C was part-time.

Trial 11 – Salt mine, Cheshire

Models: Dräger OxyK30 and OxyK50 chemical oxygen self-rescuers
Route: 3-4 km along level and slightly undulating roadways.
Temperature: 14°C humidity, 60-70%

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	50	-	17 st 0 lb	-	K30. Failed on opening
B	42	-	16 st 0 lb	59 min 0 s	K50. General underground worker, non-smoker
C	37	-	17 st 0 lb	57 min 0 s	K50. Mine manager, non-smoker
D	52	-	12 st 0 lb	49 min 0 s	K30. Shift manager, non-smoker
E	43	-	15 st 0 lb	43 min 0 s	K30. Mines inspector, non-smoker

Note: Chlorate candle starter unit produced 6.5 litres of oxygen on start-up

Trial 12 – Bathstone mine, Wiltshire

Models: MSA SSR – 30/100 chemical oxygen self-rescuers and Fenzy biocell start
Route: 200 m level circuit in pillar and stall workings. The circuit was fitted with safety lines as the trial was conducted in smoke
Temperature: 13°C, fully saturated

Trial results

Subject	Age	Height	Weight	Wearing Time	Comments
A	29	5'11"	12 st 0 lb	33 min 0 s	MSA. Rugby player, smoker. Walked 1950 m before oxygen ran out
B	38	5'10"	11 st 4 lb	33 min 0 s	MSA. Non-smoker, fit. Walked for 1950 m before oxygen ran out
C	36	5' 8"	12 st 7 lb	33 min 0 s	MSA. Non-smoker, fit. Walked for 1950 m before oxygen ran out
D	34	6' 1"	12 st 0 lb	38 min 0 s	Fenzy. Manager, smoker, fit. Walked for 2350 m before oxygen ran out

Appendix 5 – Effective arrangements for rescue

Rescue work

1 Rescue work in mines includes all operations carried out by rescue teams working in irrespirable atmospheres to meet any or all of the objectives set out below.

Objectives of rescue work

2 The objectives of mine rescue work are (in priority order) to:

- save life;
- prevent further loss of life;
- recover bodies;
- control risks by carrying out any necessary remedial work in atmospheres that are, or may become, irrespirable; and
- save property.

3 However, of equal importance to these objectives is the safety of the rescue teams who carry out this work.

4 Irrespirable atmospheres may occur following:

- an explosion; and
- an inrush of material.

5 They may also occur following or during:

- a fire;
- a spontaneous combustion; and
- an emission of firedamp, blackdamp or other noxious or suffocating gases.

The legal framework for mines rescue

6 Regulation 12(1) of the Escape and Rescue from Mines Regulations 1995 prohibits owners from working a mine unless they have made effective arrangements both for rescuing people from the mine, and for carrying out work necessary to secure the health and safety of people below ground in an emergency.

7 Furthermore, regulation 13 prohibits the working of a coal mine unless the owner of the mine is a participant in a mine rescue scheme approved by the Secretary of State. The National Mines Rescue Scheme was approved in December 1995 and is currently the only scheme approved. The scheme is operated by Mines Rescue Service Ltd.

8 The scheme provides the basis for Mines Rescue Service Ltd to work together with coal mine owners to enable them to comply with the requirements of regulations 12 and 13, in particular to secure:

- that two rescue teams, each comprising five trained and fully equipped rescue team members, are capable of reaching the mine within 60 minutes of notification;
- the provision of continuous 24-hour rescue cover during an emergency; and
- the availability of suitable rescue equipment.

9 Rescue teams may be full-time rescue personnel ('the permanent corps'), or people who normally work at mines but who are trained to act as rescue team members ('rescue brigadesmen'), or a combination of the two. Generally, Mines Rescue Service Ltd aims to provide the first team to respond to an incident, with the mine providing the second team.

10 Nationally, there is a need to ensure the maintenance of a sufficient number of officers, permanent corps and rescue brigadesmen to provide continuous rescue capability in a protracted emergency. The minimum number of officers and permanent corps members employed by Mines Rescue Service Ltd is set out in the scheme approved by the Secretary of State.

11 There is no legal minimum number of rescue brigadesmen. However, in order to maintain enough trained rescue brigadesmen within Great Britain, the Approved Code of Practice suggests that 5% of the underground workforce should be trained to act as rescue team members.

12 Maintaining this number of rescue brigadesmen may be beyond the resources of a single mine. A number of small mines may elect to jointly maintain a large enough pool of rescue workers to respond to an emergency at any of their mines. As a minimum, it is recommended that all mines should have at least one person fully trained in rescue work, who is available to act as a guide.

13 Regulations 3(2) and 12 also require owners of those non-coal mines where firedamp or an irrespirable atmosphere might occur, to have effective rescue arrangements to deal with the hazards identified in the emergency plan. These mines may make arrangements with the Mines Rescue Service to suit their own particular circumstances.

14 Regulation 16 requires that each rescue team comprises five members, one of whom is the captain. Regulation 21 requires each rescue team to be under the control of a rescue team captain who is required to use his 'best endeavours' to secure the team's safety. The rescue team captain may be a part-time rescue brigadesman from a mine.

15 Regulation 22 requires managers to ensure that any rescue operation that may require breathing apparatus to be worn is '...undertaken under the direction of a rescue officer acting under the overall control of the manager'.

16 Regulation 23 requires rescue officers to work to secure the safety of rescue team members.

17 Regulation 24 places duties on managers to consult with and to '...give due consideration to any recommendation received from any of the rescue officers'. Rescue team members should receive their instructions only from a rescue officer, or in the presence of such an officer.

Basic team equipment

18 Items taken to a mine by a rescue team include:

- breathing apparatus;
- oxygen reviver;
- stretcher;
- small first-aid box;
- flame safety lamp (left at fresh air base (FAB));
- multi-gas detector;
- cap lamps;
- self-rescuers;
- hygrometer;
- escape apparatus (type will depend on circumstances);
- lifeline;
- communications equipment;
- plan(s) of mine workings (rescue plan(s)); and
- tallies and authorisations.

Other equipment available

19 As well as the equipment carried by the rescue team, extra equipment may be required at the FAB. This could include:

- air sampling equipment (tubes and pump);
- communications equipment;
- additional oxygen revivers;
- additional escape apparatus;
- first-aid kit;
- analgesic equipment (Entonox and pethidine);
- lifelines;
- hydraulic lifting and cutting equipment;
- lifting bags and associated air cylinders; and
- chilled drinking water (depending on environmental conditions at the mine).

The SEFA regenerative breathing apparatus

20 The Mines Rescue Service uses regenerative breathing apparatus when operating in irrespirable atmospheres underground. The SEFA (Selected Elevated Flow Apparatus) is a self-contained, closed-circuit, compressed-oxygen breathing apparatus (see Figure 10). The wearer partially re-breathes exhaled air after the carbon dioxide concentration has been reduced and the oxygen concentration enriched. The set incorporates a 750 litre capacity oxygen cylinder.

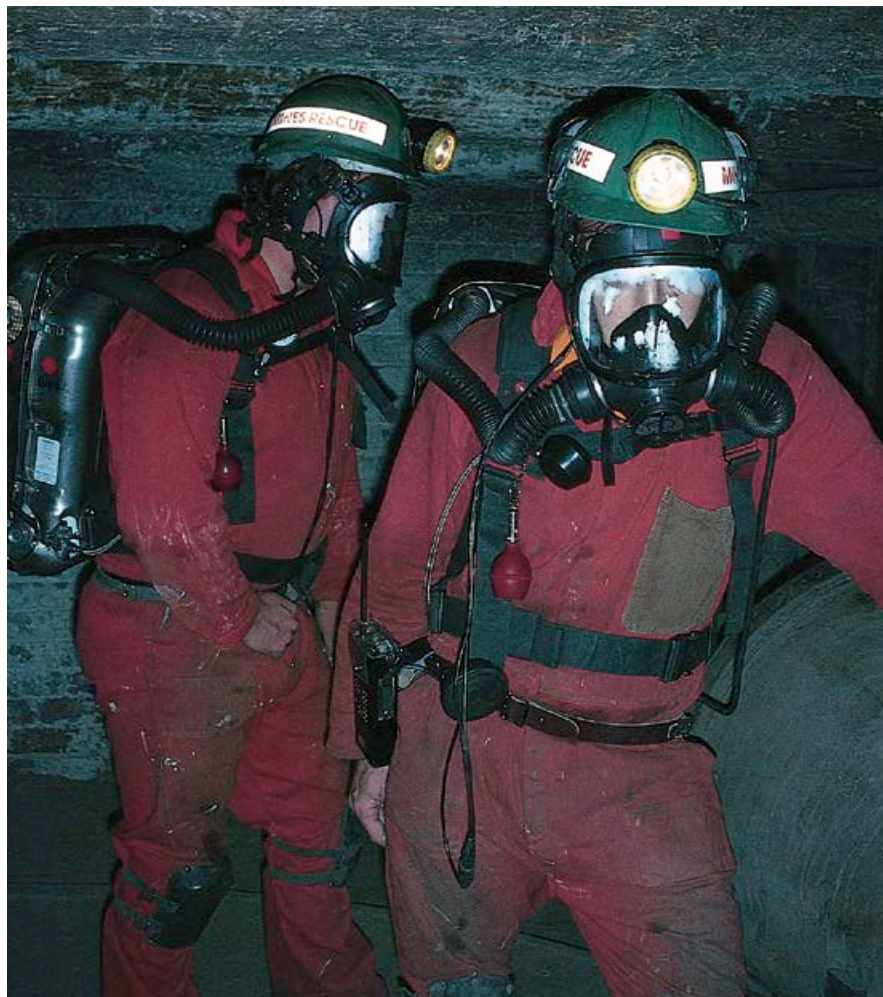


Figure 10 Two rescue team members wearing SEFA

21 SEFA can operate in two modes:

High mode – 60 minutes working time and 20% reserve.

Low mode – 120 minutes working time and 20% reserve.

22 Mines Rescue Service Ltd trains rescue team members to work in low mode, unless otherwise instructed.

23 Rescue team members receive frequent SEFA wearer training. This includes practice in hot and humid conditions, as the temperature and moisture content of mine air, and its effect on individuals, is critical.

Precautions for rescue in hot and humid conditions

24 Rescue teams need to have information relating to environmental conditions before they are deployed. The temperature and moisture content of mine air have a considerable effect on an individual's ability to perform hard work, and this may be exaggerated when wearing self-contained breathing apparatus.

25 When rescue personnel are required to operate in an irrespirable atmosphere, the wearing time of breathing apparatus is limited by temperature and humidity rather than the oxygen-carrying capacity of the apparatus.

26 The effective wearing time of 120 minutes when SEFA is used applies to atmospheres with wet bulb temperatures below 24°C. Temperatures above 24°C increase the difficulty both for people trying to escape and those required to wear self-contained breathing apparatus; extremes cause the body temperature to rise. When this happens, the wearer may start to show the signs of heatstroke and could even collapse.

27 Rescue teams are trained to frequently measure temperature and humidity when carrying out rescue work. Each rescue team member carries a chart which shows wearing times for fully or partly saturated atmospheres at different temperatures. Rescue workers strictly observe these guidelines to guard against the risk of collapse due to heat exhaustion. You will find examples of these charts in Tables 1 and 2 at the end of this appendix.

28 Fluid lost from a rescue worker's body during the journey from the surface to the FAB can have a significant physiological effect unless they replace the fluid by drinking.

29 Core body temperature can also increase during travel along an arduous route. To ensure that rescue teams arrive at a FAB in the best possible condition, mine managers should make arrangements to:

- provide assistance to rescue teams in carrying equipment from the surface to the FAB; and
- ensure any transport is available.

30 There are a number of general precautions followed by the Mines Rescue Service so that teams are more prepared to cope with hot and humid conditions.

- The selection of rescue workers takes into account their physical fitness and temperament for work in such conditions. Team members who normally work in hot and humid places in mines should be more acclimatised to such conditions.
- In addition to operational and physical training, rescue team members are instructed in dietary awareness, including alcohol intake, and on how to recognise signs that they might be temporarily unfit (colds etc).
- Rescue team members have periodic medical examinations. Further medical examination, immediately before rescue work, is carried out where practicable, but is not always possible for the initial teams.
- Clothing design enables the rescue officer to vary what is worn to provide the appropriate level for cooling and protection.
- Arrangements are made to try and ensure that a knowledgeable individual is available to communicate any significant matters to the initial rescue team before rescue work begins.
- Captains of teams who may have to operate in such conditions are trained to recognise the signs of heat stress in their team. If any team member indicates or shows signs that they are suffering abnormally from heat stress, the whole team will need to be withdrawn. Individual team members are trained to communicate any distress so that remedial action can be taken.
- Team captains will read and record both wet and dry bulb temperatures at regular intervals, and refer to the relevant SEFA tables. They communicate this information directly to the FAB to enable subsequent teams to be made aware of further precautions.
- The Mines Rescue Service issues guidelines on the further deployment of rescue workers after any period of duty in hot and humid atmospheres.

31 The Mines Rescue Service continually seeks to improve its equipment and the ability of the rescue teams to operate more efficiently in hot and humid conditions underground. In some instances, this means replacing equipment with that which is lighter and perhaps more adaptable.

32 The introduction of full-face masks means that rescue workers can now speak to each other and to the FAB, using a portable radio communication system.

Operational distances for rescue teams wearing breathing apparatus

33 The actual penetration distance of the team beyond the designated FAB will then depend upon a number of factors, including: roadway conditions underfoot, gradients, visibility and heat and humidity.

34 As a general indicator, 60 m/minute is an acceptable rate of travel for a rescue team in reasonable conditions.

35 The factors outlined are just some of the conditions that affect team travel rates. Further account may need to be taken of workload, tasks to be carried out by the team, temperature and oxygen readings. The above is only a guide to enable the colliery to appreciate the limiting factors that can affect a rescue team.

36 The initial team can gather and communicate vital information to the second team at the FAB. This might enable the second team to progress further beyond the FAB.

Table 1
SEFA wearing times in partly saturated atmospheres

Dry bulb °C

Wet bulb °C		24	26	28	30	32	34	36	38	40	42	44	46	48	50
		Safe wearing period in minutes													
	23	*	*	*	118	113	108	103	98	93	89	85	81	77	73
	24	119	114	108	103	99	94	90	85	81	78	74	71	67	64
	25		99	95	90	86	82	78	75	71	68	65	62	59	56
	26		87	83	79	75	72	68	65	62	59	56	54	51	49
	27			72	69	66	63	60	57	54	52	49	47	45	43
	28			63	60	57	55	52	50	47	45	43	41	39	37
	29				53	50	48	45	43	41	39	38	36	34	32
	30				46	44	42	40	38	36	34	33	32	30	30
	31					38	36	35	33	32	31	30	29	28	27
	32					33	32	31	30	29	28	27	26	26	25
	33						29	28	27	27	26	25	24	23	23
	34						27	26	25	24	23	23	22	22	22
	35							24	23	22	22	22	21	20	20
	36							22	22	21	20	20	19	19	19
	37							20	19	19	19	19	19	19	-
	38							19	19	19	19	-	-	-	-

Note: *120 minutes or more

Table 2
SEFA wearing times in fully saturated atmospheres

<i>Wet bulb °C</i>	<i>Safe period (minutes)</i>
28	63
30	46
32	33
34	27
36	22
38	19

Note: Flow rate is determined by permitted time; ie low flow when time exceeds 60 minutes

Appendix 6 – Other relevant legislation

The Health and Safety at Work etc Act 1974

The Health and Safety at Work etc Act 1974 applies to all employers, employees and self-employed people. The Act protects not only people at work but also members of the public who may be affected by a work activity.

Self-employed staff

Although only the courts can give an authoritative interpretation of the law, in considering the application of this guidance to the people working under another's direction the following should be considered:

If people working under the control and direction of others are treated as self-employed for tax and national insurance purposes they are nevertheless treated as their employees for health and safety purposes. It may therefore be necessary to take appropriate action to protect them. If any doubt exists about who is responsible for the health and safety of a worker this could be clarified and included in the terms of a contract. However, remember, a legal duty under section 3 of the Health and Safety at Work act (HSW Act) cannot be passed on by means of a contract and there will be duties towards others under section 3 of the HSW Act. If such workers are employed on the basis that they are responsible for their own health and safety legal advice should be sought before doing so.

References

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- 4 *The Management and Administration of Safety and Health at Mines Regulations 1993* (MASHAM) SI 1993/1987 HMSO ISBN 0 11 034897 4
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- 6 *The Mines (Safety of Exit) Regulations 1988* SI 1988/1729 HMSO ISBN 0 11 087729 2

While every effort has been made to ensure the accuracy of the references in this publication, their future availability cannot be guaranteed.

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

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