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Selection and Use of Self Rescuers in Conjunction With Safe Havens in British Mines

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Introduction

The Escape and Rescue from Mines Regulations 1995 (1995 Regulations) differ fundamentally from The Coal and Other Mines (Fire and Rescue) Regulations 1956 in that for the first time, there is a clear legal requirement for effective "self rescue" from

mines in the event of an emergency. A fundamental step towards fulfilling this requirement is the selection and provision of suitable self-rescuers, and where necessary, safe havens.

Arrangements for Escape

When the 1995 Regulations were introduced, it was not expected that they would require significant changes to existing arrangements for escape at the majority of mines. It was, however, recognised that certain locations would present rescue and evacuation problems and would require particular attention, viz:

- Long length single entry headings and long length coal face districts
- Roadways having hot and humid conditions and/or steep gradients
- Roadways having a risk of hydrocarbon ingress
- Extensive room and pillar operations employing large diesel powered plant.

In all cases, a risk assessment is required which must cover all persons at work in the mine including contractors. Where there is more than one employer at the mine, there is a need for full co-operation between them to ensure that account is taken of each employers risk assessment.

The mine owner must also take into account activities external to, and in close proximity of, the mine; either on the surface (chemical plants producing heavier than air products) or neighbouring mines (mines in a complex) sharing common airways. Particular regard should be given to the possibility of fire and explosion. The risk assessment should also consider flammable materials introduced into the mine such as mineral oil, wood, chemicals (isocyanate material), belt conveyors and electrical equipment.

The risk assessment has to take account of an atmosphere polluted by toxic gases or unable to support life due to an oxygen deficiency. Such circumstances may arise following outbursts of gas; where ventilation in narrow drivages is impaired by the inadequacy of the auxiliary ventilation system; where the available oxygen is largely consumed in a conflagration; or from the outflow of blackdamp or firedamp from old workings at times of low barometric pressure.

Selection of Self Rescuer

It is the mine owners duty to provide suitable self rescuers and where necessary, safe havens or facilities for the exchange or re-charge of self rescu-

ers. The Approved Code of Practice (ACOP), which gives guidance on the 1995 Regulations, provides information on the types of self rescuers

presently available for use in British mines and the following sections of the paper summarises their essential features.

Filter Self Rescuer

The principal advantages of the Filter Self Rescuer (FSR) currently in use in the majority of British mines is that it is designed to provide protection for 90 minutes against carbon monoxide concentrations up to 1.5% and is of such a size as to make it readily carried on the person. In many instances, protection will continue for some considerable time beyond the 90 minute period. The latest 290 model has also benefited from re-design following experience at the Cardowan Colliery explosion in 1982 which makes it easier to remove from the case when men may have sustained burns to their fingers in an explosion.

Filter self rescuers have provided many years of reliable service to the mining industry and are well understood and trusted by the workforce. FSRs are suitable for general use in conditions where the oxygen level is likely to remain sufficient due to high ventilation quantities possible in modern mines. In the majority of cases it is therefore envisaged that, properly maintained, filter type self rescuers would continue to be considered as providing adequate protection. The importance of proper maintenance cannot be over emphasised and it should be noted that the effective wearing period of FSRs is reduced considerably where the hopcalite oxidising compound has degraded.

Operation of the FSR is totally dependant upon having an adequate oxygen level present in the atmosphere. Further, whilst it is acknowledged that the FSR can provide protection against a range of toxic gases generated as products of combustion, these are not normally specified and in certain circumstances inhalation resistance and inspired air temperature may rise to uncomfortable levels. However, a new generation of FSRs are now becoming available with claims to considerably extended wearing times, lower inspired air temperature and much reduced breathing resistance.

Oxygen Self Rescuer

Self-contained self-rescuers (SCSR) are of two essential types - compressed oxygen and chemical

oxygen sets. At present, only chemical oxygen self-rescuers have undergone suitability trials by the Health and Safety Executive (HSE) for use in mines [ACOP 46(b)(ii)].

There are a range of new, compact Chemical Oxygen Self Rescuers (COSR) considered appropriate for use in British mines. These are either approved under the Control of Substances Hazardous to Health Regulations 1994 (COSHH) and have been assessed in suitability trials carried out under HSE supervision or are 'CE' marked.

Chemical oxygen self rescuers benefit from being totally independent of the outside atmosphere. They are larger than a FSR rated for a similar period of wearer protection and may be more expensive. To off-set this, they should have relatively low maintenance costs and a long shelf life.

COSRs appear to have less overall restriction to breathing than a FSR but may actually have an exhalation resistance comparable with a FSR in the first instance. Generally, during trials in mines, wearers were impressed by the comfort of a COSR and in many instances gave the impression of out-performing the observers who were accompanying them.

COSR units may therefore prove more useful in hot and humid conditions where both the high inspired temperature (where CO is present) and relatively high inhalation resistance experienced with FSRs may conspire against the comfort of the wearer.

The major draw-back of a COSR is the relatively short wearing time available from those units small enough to be worn on the person. In some cases, ¹nominal 30 minute sets (often bearing the term "30" in their title) may actually only have only a 20 minute duration which can further reduce if the wearer is large or the work load heavy. Even at moderate workloads, persons wearing self rescuers will breathe at 40-45 litres/minute. This issue must be carefully assessed when considering selection. It is also advantageous for a COSR to be equipped with some form of starter which precludes the wearer taking several inhalations of the surrounding contaminated air before the oxygen production process is initiated.

Longer duration nominal 90 minute COSR sets are available. However, these are physically too large to be carried on the person and would need to be

¹ In this text, the term 'nominal' refers to a European standard which is based upon a chemical oxygen self-rescuer fitted to test equipment, 'breathing' at a fixed rate of 35 litres/minute. .

stored at suitable locations or carried by the person to his place of work and kept within his close proximity for use as a replacement unit.

Where a risk assessment identifies the likelihood of an oxygen deficient or toxic atmosphere and results in the selection of a COSR, it is envisaged that unless those wearers are very close to fresh air, it is highly likely that provision of a safe haven or change over facility would also be required to facilitate

changing the short duration personal COSR for a long duration set or wait to be rescued.

For a COSR, at low breathing rates, the (entrapment) duration would normally be at least three times the nominal duration.

Wearer training for the COSR is vital to ensure it is donned correctly and to make the user aware of how the unit performs, especially during the initial stages.

Safe Havens

Safe havens are a relatively new concept in British mines however there have been parallels of a sort. Air supply lines have previously been installed in coal seams where there was a history of methane outburst. These normally took the form of filtered compressed air supplies, placed at intervals in roadways and faces. They were accessed by pulling out a tube from a supply point. This automatically opened the supply valve and the miner then directing air into his helmet out of which he breathed.

Provision of safe havens is covered in ACOP 51 to 54 of the new 1995 Regulations and identifies such a place as having an independent air supply to maintain the atmosphere at a positive pressure (greater than the surrounding atmosphere), such that persons may wait in safety until rescue arrives. It should be noted that the term "independent" refers to the independence of the atmosphere of the safe haven in relation to the atmosphere in the roadway and does not necessarily mean "dedicated" in as much that it would not normally be considered necessary to install a dedicated air line back to the surface compressor if such a supply was already

installed in the roadway. It is recommended that the compressed air supply should however be filtered and monitored for carbon monoxide.

In certain locations around the world where shallow mining is carried out, surface boreholes provide a separate air supply, means of supplying fresh drinking water and communication. Whilst the Mines Rescue Services maintain the facility of a drill rig for such purposes, there are few remaining applications for this in the UK. However, modern oil well drilling techniques may eventually prove accurate enough to target specific areas in a deep mine.

Some mines may depend on underground compressors for their air supply and electrical power to these units would have to be guaranteed (dedicated) otherwise a separate surface supply may indeed be required. Most underground compressors are, for reasons of cooling, located in main intakes, therefore it may be possible to maintain power to these in an emergency.

Design of Safe Havens

The design of the safe haven depends on its proposed use. There are two main types with variations in detail:

1. Sealed unit with air locks and positive air supply providing communication and suitable environmental monitoring where persons can wait without wearing self-rescuers. Due to the physical size of an installation, such a facility would have to be located in a main roadway at some central location appropriate to the district. This type of safe haven would serve as a focal point for persons collecting from a wide area and would be appropriate for large miscellaneous
2. semi-sealed installations, pressurised canopies or refuges having an air supply inducing positive pressure where persons can change self-rescuers before continuing outbye or wait to be rescued whilst wearing filter or self-contained self-rescuers. These would be positioned at suitable locations in long headings where space was limited and would be especially relevant in conditions which

mines or the larger coal mines where excavation on a sufficient scale could be carried out and where mine workings were extensive and distant in relation to the surface shafts or drifts.

were warm and humid. A signalling or communication system would be vital to identify and locate person taking refuge.

It is recommended that safe havens be equipped with vital survival equipment and material such as:

- Environmental monitoring equipment
- Survival food and water supplies
- Means of communication
- Plans showing escape routes to fresh air or other safe havens
- exchange long duration self-contained escape apparatus
- basic first aid equipment.

Provision and Location of Safe Havens when considered in conjunction with limitations imposed on persons wearing Self-Rescuers in hot and humid conditions or travelling in smoke filled roadways:

It is desirable to equip persons working underground with self-rescuers having the maximum possible wearing life. This will provide a high factor of safety and extended "entrapment" performance (when physical effort is kept to a minimum). Longer duration filter self-rescuers having a life of up to 4 hours are already available, however this wearing time may exceed to a considerable degree, the physical capability of the wearer. To base an emergency plan on the assumption that a person can walk and wear a self-rescuer for such long periods in a hostile climate is unrealistic and fraught with risk. The principal limiting factor on wearing duration for any type of long duration breathing equipment will be the wearer himself. It would be unwise to evolve an escape strategy based upon persons walking long distances, possibly in smoke, or in hot and humid conditions. Research and trials have suggested that in relatively good mine walking conditions and in a comfortable environment, the following operational parameters may be used as a guide:

- Persons equipped with a nominal 90 minute COSR may achieve approximately 70 to 80 minutes wearing time during which they could walk between 3000m to 4000m. This does not take into account any initial fatigue or stress and assumes unrestricted vision.
- Wearers of nominal 60 minute COSR could display significant distress after 40 or 45 minutes due to oxygen depletion and

may travel up to 2000m, in clear vision conditions.

- Under relatively good conditions, a 30 minute nominal duration set may provide as little as 17 minutes wearing time and could limit travelling to between 500m and 1000m.

Due to the high likelihood of restricted visibility caused by the presence of smoke and aggravated environmental conditions due to heat and humidity, estimates of realistic self-rescuer operational limits, in terms of time and distance travelled, must be assumed to be significantly less than those stated above. In "saturated" warm and humid environmental conditions in excess of 30°C, safe wearing times should be considered to be less than 45 minutes reducing to under 30 minutes for fully saturated temperatures over 32°C, regardless of the type or duration of the self-rescuer.

In the event that a person is only required to take refuge and effectively employ what the Mines Rescue Service term the "entrapment" procedure it should be appreciated, that at rest, the duration of a chemical oxygen self-rescuer, because it functions on a "demand" basis, can significantly exceed the "nominal" stated duration.

It can therefore be asserted that in a very large and/or warm and humid mine, coal or non-coal, regardless of which type of self-rescuer is selected, safe havens may be required close to the place of work and strategically placed at intervals in the mine in order to permit men to rest whilst escaping and where appropriate, take refuge until rescue teams have assessed the situation or brought the hazardous environment under control.

When planning long distance single entry, auxiliary ventilated developments, there is a risk of an irrespirable atmosphere occurring due to destruction of the ventilation duct in a fire. The presence of Free Steered Vehicles (FSV) increases the risk. Selection of COSR for such locations would appear appropriate and would by implication require safe havens close to the place of work where short duration sets could be uprated.

In long life, warm and humid production longwall coal faces, whilst oxygen depletion may be unlikely, due consideration must be given to mines rescue implications, especially with regard to the limitations (Figure 1) placed on mines rescue apparatus wearing times in hot and humid conditions.

Figure 1. Fully saturated air.

Degrees		Minutes Wearing Time		
F°	C°	SEFA	PROTO	AEROLC
80	27		60	
82.5	28	63	52	
85	30	46	44	120
87.5	31		38	64
90	32	33	32	42
92.5	34	27	28	31
95	35		24	24
97.5	36	22	21	20
100	38	19	19	17

When, at Stillingfleetmine in the Yorkshire coalfield, on 6 April 1992, eight men were trapped in a heading for over 15 hours, temperatures of 32°Wet/35°Dry were experienced. Had breathing apparatus been required, the Selected Elevated Flow Apparatus (SEFA) used by the Mines Rescue Service, wearing times would have been limited to 31 minutes. It must be further appreciated that this translates to 10 minutes travelling time either way and only 10 minutes working. Relating 30 minutes wearing time to distance travelled by a mines rescue team recovering a casualty and carrying equipment, this could be as little as 200m either way. Climatic control may be available to moderate the most extreme conditions for day to day operations. This could not be guaranteed to function in an emergency where electrical power may be lost or isolated.

There is no evidence to suggest that men attempting to escape whilst wearing self-rescuers in

hot and humid conditions could be expected to fare any better than a rescue team attempting to reach them. At Thoresby Colliery, Nottingham, in 1995, during a rescue attempt when men were trapped by an irrespirable atmosphere at the face of a development heading, a rescue worker collapsed whilst wearing breathing apparatus as a result of the hot and humid conditions, graphically demonstrating some of the difficulties which could be experienced. Attempts to improve the performance of mines rescue teams in hot and humid conditions by equipping them with "cool gel vests" and open circuit breathing apparatus may provide a slight psychological boost, but appears to have little actual physiological benefit due to the fundamental difficulty in cooling the core body temperature. The biggest benefit is derived by providing frequent sips of cool water, unfortunately not an option normally available whilst wearing breathing apparatus or a self rescuer.

Conclusions

1. Careful consideration is necessary when selecting self rescuers. This cannot be done in isolation from other mine factors and must be integrated into an overall emergency plan. Tests carried out on various types of self rescuers in the United Kingdom suggest that their performance is not only site specific, but varies considerably in relation to each wearer, depending on their fitness and particularly physical mass. Mine wearer trials are therefore considered an essential part of any self rescuer selection process.

2. To provide immediate protection in an emergency (such as an explosion where visibility may be reduced to zero due to the pressure blast), the self rescuer should always be worn on the person. Whilst this limits the size of the unit which can be comfortably carried for long periods, it does guarantee that the self rescuer is where it is needed in an emergency—with the wearer. Self rescuer manufacturers should take this into consideration when designing their equipment to ensure the casing is not only ergonomically correct in terms of being

opened easily, even by burned hands, but is as comfortable as possible to wear continuously on the miners belt.

3. The use of safe havens in conjunction with self rescuers may not only enhance the viability of the self rescuer in terms of providing a safe place to up-rate a short duration SCSR for a longer duration unit, but play an essential part in establishing an effective emergency strategy whether the self rescuer be filter or self contained. In more stark terms it appears that there may be only two choices; either limit the extent of workings, particularly in hot and humid mines, or put in place an emergency plan which adequately deals with the situation, recognising the physical limits imposed on anyone required to wear breathing apparatus or self-rescuers in an emergency.

Author Information and Personal Note

Mr. Forster currently serves as one of her Majesty's Inspectors of Mines, Wales and West England District, within the Health and Safety Executive. He is secretary of the National Advisory Committee on Rescue Work and Rescue Apparatus and is a member of the Mines Rescue Technical Advisory Committee.

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References

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