

“The Role of Communications in Confined Space Working”

by

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ACKNOWLEDGEMENT

The following article is an extended draft of an article published in the journal “The Safety and Health Practitioner”, the official journal of the UK Institution of Occupational Safety and Health (Vol. 18, No. 1, January 2000 issue). Full acknowledgement and thanks are extended to IOSH and the publisher:

Miller Freeman UK Limited,
Paramount House,
17-21 Shenley Road,
Borehamwood,
Hertfordshire,
United Kingdom,
WD6 1RT.

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Introduction

Communications equipment has traditionally been the Cinderella of confined space support equipment, with personal protective equipment, breathing apparatus, gas detection, retrieval and ventilation equipment having higher operational priority. However, the joint impacts of legislative prescription together with a recognition that communications can improve confined space working effectiveness and safety is leading to a number of operators asking where they can obtain equipment and what is the most suitable type of equipment.

The statistics for confined space accidents indicate that accident rates in confined space working and rescue are relatively high compared with other industrial activities. Historically, there has been several deaths each year in the UK involved with confined space working and probably a further hundred people involved in narrow escape situations. Fatality figures indicate that 1 - 2 rescuers die for each worker's life lost in a confined space accident.

The range of confined space working situations is large and includes the following; storage tanks, silos, process vessels, pipelines, tunnels, holding tanks, ship holds, boilers, reactors, sewers, ducts and trenches. Whilst figures are not collated for the UK, there are around 5 million permit-required confined spaces in the US, covering quarter of a million establishments in 40 industry sectors.

Compliance with Confined Space Regulations

In current regulations and guidance notes the aim is not to be prescriptive in the use or type of communications. In many cases the selection and use of equipment, if any, is left entirely to the discretion of the operator. The general statement of regulations is that any communication procedures should be appropriate to the workplace and level of risk. The legislation which prevails in the UK, the US and Australia is considered here.

In the UK, the Confined Space Regulations 1997 came into force on the 28 January 1998. These regulations extended the scope of previous legislation which effectively addressed specific industries, such as factories and shipbuilding. The regulations have expanded the definition of a confined space and specified risks. Up to this time the law did not consistently cover all sectors of industry and 40 per cent of deaths through working in confined spaces were not subject to law specifically concerned with confined space working.

Effectively the confined space may present the following risks:

- Being overcome by gas, fumes, vapour or the lack of oxygen.
- Injury due to fire or explosion.
- Being drowned or buried under free-flowing solids.
- Being overcome due to high temperatures.

The Confined Space Regulations require a safe system of work that renders the work safe and without risks to health, and all persons who may enter a confined space are considered at risk. This has wide ranging implications for competency, training, supervision, risk assessment and risk communication. The regulations also declared explicitly the need to consider the adequacy of communications systems and the measures to summon help and initiate rescue procedures. Essentially these requirements are as follows:

(Regulation 4 - Work in confined spaces)

Communications

An adequate communication system will be needed and should enable communication:

- Between those inside the confined space;
- Between those inside the confined space and those outside;
- To summon help the case of emergency.

(Regulation 5 - Emergency arrangements)

Raising the alarm

States there should be measures to enable those in the confined space to communicate to others outside the space who can initiate rescue procedures or summon help in an emergency.

The requirements to raise the alarm confirm in equal measure the need to provide an effective means a communication. The assessment of suitability of the means of communication is left to the user. However there is an expectation that the user is able to confirm the adequacy of the communication means, including whether intrinsically safe equipment needs to be used. This is clearly stated in the guidance note:

“Whatever system is used, and it can be based on speech, tugs on a rope, the telephone, radio etc., it is important that all messages can be communicated easily, rapidly and unambiguously.....Equipment such as telephones and radios may need to be intrinsically safe if the work is being carried out in a confined space where there is a risk of flammable atmospheres occurring”.

In the US, compliance with the Occupational Safety and Health Administration’s permit-required confined space entry rules (29 CFR 1910.0146) began on 15 April 1993. The definition of a ‘permit-required confined space’ substantially agrees with that used in current UK legislation. OSHA’s rule making requires that entry permits must, inter alia, include information on communication procedures and equipment required to maintain contact during entry. The duties of authorised entrants include, as necessary, the need to maintain communication i.e. telephone, radio, visual observation with attendants to enable the attendant to monitor the entrant’s status as well as to alert the entrant to evacuate. The attendant’s duties include maintaining communication with and keeping an accurate account of those workers entering the permit-required confined space.

In Australian legislation, specifically Section 13.11 ‘Communication’ of Australian Standard AS 2865-1995: ‘Safe Working in a Confined Space’, there is some guidance offered on the type of equipment that might be considered:

“Employers should ensure that communication and, where practicable, observation between those in the confined space and the stand-by person(s) are capable of being constantly maintained. Communication can be achieved, dependent on the conditions existing in the confined space, in a number of ways, including voice, radio, hand signals and other appropriate means. For example, where visual or oral communication is not possible, then a system of ropes signals could be devised. Microwave, long wave or low frequency radio equipment can be used in some confined spaces when normal radio is unsuitable.”

With reference to these sets of legislation, depending on the conditions, legislative compliance can be satisfied by using visual, oral or physical ropes signals. However whilst technically it is possible in a number of circumstances for shouting, tapping, rope tugging and visual messages to provide the primary means of communication, there are many circumstances when these methods would not be judged adequate. It remains to be seen whether there will be further legal clarification on compliance. Irrespective of this, it is widely accepted that a continuous voice communications system has a number of benefits in a confined space entry operation, which include:

1. The availability of communications permits jobs to be accomplished faster and with less manpower. This in turn reduces the overall level of risk associated with the operation. In some applications, for example sewer surveys, inspection times can be reduced by 30-50% by having continuous voice communications available. Payback on equipment can be very short, possibly over one to two major jobs.
2. The ability to monitor the well-being and any difficulties being experienced by the entrants, including the detection of onset of exhaustion or possibly above-threshold chemical exposure effects (slurring of speech, disorientation etc.). Communications helps reduce stress, anxiety and human error potential.
3. The attendant can offer valuable support to the entrants and assess their condition and the circumstances prior to rescuers entering the confined space.
4. Actual rescue operations can be substantially improved, with calls for additional equipment or support, medical information and co-ordination of hauling operations taking place more effectively.

Requirements of a Confined Space Communications System

Given the variation in circumstances which must be faced in confined space working and the relative lack of prescription in prevailing legislation, users have to weigh up themselves a number of technical, cost and operational factors when they are considering the purchase of communications equipment. The table below summarises a number of key requirements which any system should aim to satisfy:



Ideal requirements of a confined space entry communications system
<ul style="list-style-type: none"> • Reliable communications, site independent, matching a wide range of tasks. • Two-way continuous speech communications capability. • Compact, rugged, environmentally protected from water ingress. • Rapid deployment capability with simple, intuitive operation and minimum training requirements. • IS certification covering all anticipated gases, vapours and dusts. • Shift plus battery life, employing standard consumer battery types or rechargeable batteries. • Compatible with hard hats, gloves and breathing apparatus. • Operation possible with hazardous materials (Hazmat) isolation suits. • Lightweight, robust and low cost communications cable offering straightforward line management and line retrieval. • Cable reels taken into the entry to be compact and lightweight. • Inbuilt system integrity check, covering attendant's and entrants' equipment and any interconnecting cables. • Roving capability for attendant to permit local mobility whilst monitoring transmissions. • Single, open channel philosophy to enable attendant to monitor all calls between parties. • Emergency alarm button on the entrants' equipment. • Hands-off voice operated operation (where appropriate). • Ability to operate in a high noise environment, with either headset, earpiece or telephone handset as necessary. • Rapid response user support, repair and maintenance from within the UK. • Training and training needs analysis support available from the manufacturer/distributor. • DTI Radio Communications Agency licence exempt.

Types of Equipment

Portable powered communications equipment for confined space operation falls essentially into two categories; “wireless” and “wired”. These two categories essentially comprise radio systems and hard-wired intercom systems. However this needs to be broken down further, since recently, hybrid systems have become available, using inductively-guided propagation, where signals are induced into and carried by a dedicated communications cable or wire. For confined space and tunnel working, there are four principal candidate technologies:

1. Mobile radio using free space propagation, possibly with repeaters.
2. Mobile radio using leaky feeder guided propagation.
3. Hard-wired point to point intercom systems.
4. Low frequency wire-guided inductive communication systems.

The key features may be contrasted as follows:

Method	Key Features
<p>Mobile radio (free propagation)</p> 	<ul style="list-style-type: none"> • Lightweight, flexible, convenient. • Open space or line-of-sight communications reliable but unpredictable range, coverage and dead-spots in confined space entries (due to multi-path propagation, shielding and attenuation). • Active repeaters can increase coverage but deployment not straightforward. • Useful for surface attendant to rescue service communications link. • Typically push-to-talk simplex operation. • Gloved hand operation can be difficult. • Generally limited environmental protection. • Relatively high maintenance/replacement costs in harsh environments. • IS units have limited range (ERP must be strictly limited to prevent ignitions).
<p>Mobile radio (leaky feeder propagation)</p>	<ul style="list-style-type: none"> • May use conventional/IS mobile radios. • Not suitable for rapid deployment. Better suited to fixed tunnel communications. • Heavy, cumbersome, high cost feeder cable, which is liable to damage unless suspended. • Repeaters required every 300 - 500 metres. • Operation possible within several metres of the leaky feeder cable. • System costs high.
<p>Point-to-point hard-wired intercom systems</p> 	<ul style="list-style-type: none"> • Point-to-point communications only. Break-in points difficult to establish. • Integrated communications-retrieval equipment suitable for short range, fixed cable lengths only. • Line can be heavy and cumbersome to deploy, limiting comfortable handling range to around 100 metres. • Cable reels require slip-rings for on-the-move continuous communications. • Good quality speech, interference free, secure. • Full duplex and VOX operation options (but can cause channel lock-out). • System cost high for long cable runs. • Available intrinsically safe to highest standards. • Best suited to short range, hands free operation situations.

Wire-guided low frequency inductive communications



- New to confined space working but proven in underground mining environment.
- Inductively couples signal into communications wire - no direct connection required.
- Communications between any points along entire length of wire possible.
- Communications wire not critical - can be low cost, disposed of if necessary.
- Operation from 20 metres up to 10 kilometres or more with twin conductor wire.
- Some sensitivity to electrical interference, may require twisted pair wire in electrically noisy environments.
- Rapid deployment capability, lightweight cable and reels.
- Push-to-talk, simplex, open channel operation.
- Available intrinsically safe to highest standards.
- Ideal for rescue and rapid deployment tunnel communications.

On balance, in the authors' view, only point to point intercom and inductive communication systems offer practical, reliable, general purpose communication solutions. The supply side for this equipment is broadly split into three segments:

- a. Short range point to point systems where the intercom wire is woven into as an integral component of the safety lanyard.
- b. Point to point intercom systems where a separate, shielded multi-core communications cable is used. In some systems this may also be used to transmit gas reading data.
- c. Inductive communications systems, with systems having been initially developed for mining applications.

Other than for short range or line of sight applications, mobile radio systems cannot be recommended. Many users will already have experience of the highly variable reception which occurs when mobile radios or telephones are taken into a tunnel or similar structure, particularly after one or two bends have been negotiated. Leaky feeders provide a solution to the reception problems but would only be considered for long term, high usage tunnel communications. For the large majority of confined space entry situations, the communications system is taken in with the entrant and there is no scope for any prior installation of radio communication or telephone cables.

Operational and Human Factors

Whilst the technical aspects of communication system performance are, not unreasonably, acknowledged to be important, users may not be fully aware of human factor impacts on communications until an incident has occurred. For successful application in many confined space situations, equipment must be both durable and be designed to have good ergonomics. This final section examines a number of important issues including the use of communications whilst wearing breathing apparatus and personal protective equipment, working in a noisy environment, the impact of communications channel discipline, battery maintenance impacts and intrinsic safety issues.

Breathing apparatus and personal protective equipment

There will be situations where full working breathing apparatus must be worn. This apparatus comprises:

Self-contained breathing apparatus (SCBA) - Generally open circuit apparatus with a cylinder of compressed air supplying air to the user via a full face mask. Various sizes are available giving working times up to 45 minutes. These times are shorter where there is high heat stress. In fully saturated air temperatures of 36°C, for example, safe wearing time may be no more than 20 minutes. Under these circumstances the tasks must be accomplished quickly and effectively. Communications can become essential.

Airline breathing apparatus - Used where working times beyond 45 minutes are required. Airline breathing apparatus broadly comprises fresh air, constant flow and demand flow systems, possibly used in conjunction with back-up cylinders. Demand flow airline systems can probably at best provide 100 metres range, with simple fresh air lines limited to less than 10 metres. A further alternative is closed circuit SCBA offering 2 hours or more duration. However this requires specialist breathing apparatus training and is used almost exclusively by mines rescue services.

Any airline system brings with it problems of line management. In addition to the airline, entry into the confined working space may require the use of a safety lanyard for fall protection and to provide retrieval. There may also be a separate communications cable. Under these circumstances it can be appreciated that the management of the lines, particularly during paying out, can be time consuming and physically demanding. Any means which allows line management problems to be simplified in confined space working is of value. To simplify line management, the communications cable may be an integral part of the lanyard, whilst other systems may rely on lightweight, high tensile communication cables.

A predominant communications-related concern is the difficulty in communicating whilst using breathing apparatus. The problem is most acute for high stress environments such as firefighting and rescue, where the importance of effective communications for decision-making and relaying of safety related messages is critical. In high noise environments even face to face conversation through breathing apparatus is difficult. Breathing apparatus and communications system manufacturers are aware of these problems and have developed various products. These include integral speech ports and diaphragms, facepiece integrated microphones, throat microphones and bone microphones worn in the ear or on the forehead. Specialist microphones are increasingly being adapted to interface with intercom and portable radio systems.

There are also methods of working which can enhance the effectiveness of a breathing apparatus voice port. The speech diaphragm within the face mask inherently does not transmit high-pitched sounds. Therefore users need to be trained to speak calmly at normal to moderate volume with clear enunciation. It also helps greatly if the microphone of the communications device can be held directly in front of the voice port. This can reduce one of the major sources of variability in speech intelligibility between users. Some users also report success if the microphone is held directly against the neck, operating in an analogous fashion to a dedicated throat microphone. Difficulties are also noted where hazardous materials (Hazmat) personal protective suits must be worn. In this case it may be necessary to press the microphone directly against the suit visor. However, there are mixed views on the effectiveness of these approaches.

A criticism of many modern portable radios is that the drive towards increasingly smaller units has resulted in poor ergonomics. This makes for considerable difficulties whilst wearing personal protective equipment, with the switches and dials often being too small to operate with a gloved hand. Displays can also be difficult to read in a low light environment and can be subject to glare when directly illuminated by a cap lamp or hand lamp.

Working in a noisy environment

Background noise and signal interference can also greatly impact on the effectiveness of the communications channel. Equipment designed specifically for confined space working is however relatively immune to the effect on signals of atmospheric irregularities, topographic factors or characteristics of the enclosed space and any associated electrical infrastructure. However, high levels of background noise, for example from road traffic, engine, pump or fans, running water and miscellaneous tools can often impair communications. If high noise levels are expected in use and it is not practicable to resite the communications point away from high noise areas, then consideration should be given at the equipment selection stage as to whether the equipment provides a headset, earpiece or telephone handset output. A further factor is the use of voice operated transmission switching (VOX). In many noisy environments this may either require continuous adjustment or, worse still, may cause channel lock-out in a single channel system. Often, the most reliable solution under these circumstances is to adopt press-to-talk only operation.

A further problem with parties working in relatively close proximity in a reverberant structure is that acoustic feedback can be a problem. This can be reduced by turning away from the other party when speaking, or by shielding the microphone. However, again, the equipment should be assessed for its fitness for purpose in this regard if a number of communicating parties may be expected to come into relatively close proximity.

Communications discipline

To maximise the effectiveness of a communications system there is a need for appropriate human communication skills which may need to be provided by training and exercise. In particular, transmission discipline must be effective. The aim is to communicate the message in a logical format with good enunciation and then to smoothly hand over the communications channel. This is essential in simplex, press to talk systems. Recordings made of the multi-party communications during operational trials and training sessions can help users improve the clarity and accuracy of their communications. Message confirmation should also be practised to confirm that instructions or information have been fully understood.

Where there are multiple parties present in a working area, then communications discipline may be required to minimise simultaneous communications and overload of the attendant or incident commander. If the communications system offers a multi-channel capability then it must be possible to alert the attendant immediately that a call has been received on an alternative channel. It is difficult to monitor transmissions from a number of channels simultaneously and a single open channel with tight communications discipline is often the safest approach to ensure critical messages are received.

Battery maintenance

The battery charging and changing regime is also an important consideration. For intrinsically safe equipment this must be undertaken in fresh air or a designated safe area, unless a replaceable intrinsically safe self-contained battery or charging arrangement is provided as part of the certified system design. Operational requirements dictate that the battery life should be adequate to meet the full working time in the confined space and that communications should be available at all times. If equipment is used on an infrequent basis it is important that an effective pre-entry battery charging and changing procedure is implemented and the process recorded if necessary. It is advised that batteries be changed or checked prior to every entry task that is to be undertaken.

Intrinsic safety requirements

A further complication arises in the assessment of need for intrinsically safe (IS) approved communications equipment. In general, IS equipment is required for any portable device that is electrically powered, from any source including batteries, and which is going to be used in an explosive or potentially explosive atmosphere. In a confined space working environment this equipment typically includes gas monitors, lights, communications and paging equipment etc. Users need to be aware of Codes of Practice associated with the selection and installation of electrical equipment intended for use in flammable atmospheres. These include by example:

Part 4 of British Standard BS 5345

Parts 10 and 14 of British Standard BS EN 60079

Section 500 of US National Electrical Code ANSI/NFPA 70-1987

International users may also need to work with equipment holding a number of intrinsically safe certification approvals. Given the range of flammable gas, vapour and dust materials that can be encountered across industry, confined space entry electrical equipment must be certified to the highest standards. Rescuers, in particular, do not have the luxury of knowing exactly where they may need to go, or the composition of the atmosphere at various points within the entry.

Conclusions

It can be seen that there is a duty on employers to ensure that a safe system of work is in place for entry and working within confined spaces. The range of circumstances and hence related risks will inevitably be varied. Communications needs to be considered as one element of the support equipment which may be required to ensure that the residual risks from entering the confined space are as low as can be reasonably and practicably engineered. There are now communications systems available which are intrinsically safe and which have been specifically designed to address the difficulties of providing communications between entrants and those monitoring the operation. Increasingly the justification for this type of equipment is not solely on the grounds of safety. There is an emerging recognition that communications can also materially reduce the time and costs associated with the operation.

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