# DOMESTIC PREPAREDNESS PROGRAM IN DEFENSE OF WEAPONS OF MASS DESTRUCTION

# REPORT ON COMMUNICATION EQUIPMENT

**SECTIONS:**

1. **PORTABLE RADIO ACCESSORIES**
2. **PORTABLE HARDLINE COMMUNICATION**

**Date: October 26, 1999**

## Purpose

The information presented here is for the consideration of personnel tasked with the selection of multi-purpose personal communication equipment for the Domestic Preparedness Program (D.P.) in Defense Against Weapons Of Mass Destruction (WMD). This report looks at issues that should be considered when applying communication equipment to various areas within a D.P. Response. During Operations of this nature, the equipment that is designed to protect life can by its very nature become a barrier to communication. For example, breathing apparatus, face mask respirators, encapsulated suits are all necessary in a Nuclear, Biological or Chemical Environment, however they all present barriers to Communication that must be overcome through the correct selection of equipment in order for responders to function efficiently and effectively.

## Scope

The Scope of this report is limited to Multi-Purpose Personal Radio Interface Accessories and Portable Hardline Communication Systems. For reasons of brevity, this report assumes that common simplex portable hand-held radios and any accompanying radio system have been selected and are in use.

Printed in Canada

# Section 1. Portable Radio Accessories

**Portable Radios**

Probably the most common piece of communication equipment used during any kind of response situation is a hand-held portable two-way radio. These radios are typically Simplex devices and do not allow simultaneous or full duplex communication. When one person transmits everyone else on the same frequency must wait until they are finished and the channel is open to respond. The obvious benefit of any radio is that it can be deployed virtually anywhere with an almost unlimited number of users. Radio equipment functions best when it is out in the open, in line of sight or in close proximity to a radio antenna or repeater or up-link. It can also perform well in areas that have openings allowing signals to "bounce" to or from another radio or repeater, etc. Operations requiring users to have freedom of movement or those that are carried out in the open are best suited to radio equipment.

Some of the negative aspects of radio equipment may not be readily apparent. For instance, radio equipment does not typically function reliably in enclosed spaces constructed of metal or concrete, etc. for example; voids inside collapsed structures, underground pipes, tunnels and confined space applications. In these environments, radio communication can be unreliable, subject to dead spots, fading and weak signals, similar to what happens to car radios when driving through an underground parking lot or tunnel. In addition, radios and cellular phones transmitting radio signals can be extremely hazardous in and around fuel tanks and live explosive ordinance (bombs) due primarily to Effective Isotropic Radiated Power (EIRP) that could cause and explosion. For example: Boeing recommends that its customers observe a minimum separation distance from open aircraft fuel tanks of 50 feet for radios transmitting less than 100 watts. (i.e. portable radios, radar, cellular phones, etc.) (Reference Boeing Service Letter Dated 30 April, 1996-Item 19). Explosive Ordinance Disposal procedures also forbid radio transmissions in the immediate area of an unknown device.

Another aspect of portable radio equipment commonly overlooked is the fact that radio transmissions are subject to potential unwanted or outside monitoring and/or interruption. During operations of a sensitive nature such as Triage and Decontamination of victims arriving at Hospitals or during victim rescue operations it is important to be cognizant that transmissions

can be monitored thereby releasing potentially sensitive information to the Media or to a potential adversary.

**Portable Radio Accessories**

This section looks at various types of commercially available multi-purpose radio accessories that attach to portable radios through the remote Speaker/Mic jack[1]. Probably the most common problem for radio users in a WMD environment is how to effectively communicate over a portable radio when wearing facemask respirators, breathing apparatus, or encapsulated suits. The Human voice to radio interface is limited as there are only so many places on the body to take a voice signal from. That said, many different accessories are available and include; Throat Microphones, Bone Conduction Microphones, and Ear Microphones which work in conjunction with a variety of speaker or earphone options for listening. All of these accessories take signals from the microphone send it through an amplifier to the radio via the remote speaker microphone cable. Electronics, housings, switches and accessories vary greatly from manufacturer to manufacturer. However, the following is a brief look at each major microphone type and a list of questions that need to be addressed when selecting equipment of this type.

**Boom Microphones** - Many accessories exist that utilize standard boom mounted microphone elements in both Dynamic and Electret configurations. These units function best in applications where the user's voice is NOT obstructed. These microphones are not suited for use with breathing apparatus or respirators. In an encapsulated suit or high noise areas, these microphones tend to pick up a lot of background noise.

**Ear Microphones** - These units are worn in the ear canal and pick up voice vibrations from the ear canal and/or surrounding bone. The signal is sent from an ear transducer to the radio as a microphone signal. Ear Microphones function best when each user has a custom fitted earmold to seal out ambient noise from the ear canal. The additional costs and logistics of custom mold fitting need to be considered. Ear Microphones are prone to fall out which causes problems

[1] It must be noted that this section has purposely omitted communication accessories that are built into facemasks or designed for a specific type of facemask. Suffice to say many of these products exist and information regarding them can be obtained from the respective breathing apparatus manufacturers. The reasoning for this omission is simple, dedicated systems do not give users the ability to communicate effectively under a wide variety of conditions. For example, when a rescuer moves to a safe area or removes his or her facemask radio communication capability is lost. Or a member of incident command needing to go from one to another donning or doffing a respirator as necessary would need to plug and unplug a dedicated communication accessory.

when wearing encapsulated suits. Also, users with earmolds in one or both ears are limited in what they can hear around them and prolonged usage can irritate the ear canal.

**Bone Microphones -** These units are contact microphones typically worn on the top of the Skull or behind the ear (mastoid). These microphones pick up voice vibrations from the skull and turn them into a microphone signal for the radio. These types of microphone come in a variety of shapes and sizes. They are commonly attached to webbing in helmets or the straps of facemasks, etc. For these units to function properly they must make good contact with the skull. If good contact is not possible due to other equipment such as flash hoods, respirator equipment straps or a thick layer of hair, the signal level is affected dramatically.

**Throat Microphones -** There are essentially two different types of Throat Microphones; Single Element and Dual Element designs. Both function by picking up vibrations and converting them into microphone signals. Throat Microphones are worn around the neck and held in place by an elasticized strap or steel neckband. They perform best when the element(s) are positioned at either side of the users "Adam's Apple" over the user's Voice Box. Positioning and Comfort are the primary areas of concern regarding Throat Microphones. Older dual element designs tend to be heavy and uncomfortable to wear for long periods of time. Some Throat Microphones use a sprung steel neckband that tends to slide around when the user sweats and in turn adversely affects positioning and degrades the signal. Some recent developments in single element Throat Microphone design have greatly improved Throat Microphone performance and comfort.

**"VOX" Activation -** Portable radios typically operate on "Push-To-Talk" (PTT) activation, requiring users to activate a switch on the side of the radio to communicate. To address the PTT issue, some radio users have turned to "Voice Activated"(VOX) radio accessories. It should be noted that while some of these units function well they are not a cure all for communication problems. Following are some issues that may not be apparent upon first glance; VOX accessories are best suited to work in Low to Medium noise environments. In High noise areas, VOX accessories can be plagued by accidental/false triggering of the radio due to ambient noise being picked up by the microphone. Sound triggers the *electronic* PTT and can lock a radio into transmit mode cutting off communication on a particular radio channel. Unwanted activation can also be caused by breathing apparatus noise, excessive suit noise or a user crying out in pain, all of which can result in locked up radio communication when it is needed most. To address this problem VOX units typically have some kind of microphone sensitivity or attack time

adjustment to accommodate different ambient noise levels. Difficulties arise when users move from low to high noise locations (or visa versa) and cannot re-adjust the microphone sensitivity because the unit is positioned inside protective clothing or encapsulated suit making adjustment difficult if not impossible. If it is determined that a VOX accessory is acceptable for a specific application make sure that the unit has the ability to switch to a "PTT Only" Mode.

**Assessment & Selection of Radio Accessories**

When assessing any radio accessory equipment, look for a design that offers the greatest flexibility and adaptability to get the best value for your dollar. In fluid situations like large-scale response/rescue operations, roles and responsibilities can change, as need dictates and equipment should be able to adapt. A good starting point in any assessment of this type would be to create a list of tasks in which a particular communication accessory could be used and then break them into primary and secondary applications. Then make a list of equipment of any Personal Protective Equipment (PPE) and any task related equipment with which the user will be working. It would also be helpful to try and take into account the work environment i.e. noisy, quiet, machinery, etc. To be most effective this process would be best done in conjunction with Task Force / Team Leader input, as many potential equipment/task conflicts may not be readily apparent.

You can then look at selecting equipment, which is best suited to the overall needs of the operation and provides the widest variety of deployment options. This may or may not include a variety of different types, styles of accessories and equipment configurations. However, an attempt should be made to consolidate the number of different accessory types to a minimum so that training time and communication budget allocations can be maximized.

Follows are some questions that may assist you during the selection process:

Q. Can I use the accessory with or without a facemask?
Q. Can I use the accessory with an encapsulated suit?
Q. What radios are compatible with the unit?
Q. How does the equipment function in a High Noise environment?
Q. Does the equipment require batteries? How many? What type? Battery life?
Q. Is the equipment Waterproof?
Q. Is the equipment Spark Proof, Intrinsically Safe or Explosion Proof? (See Appendix A)

Q. Is the product Voice Activated? Push-To-Talk? Both? How big is the PTT Switch?

Q. Can the PTT be activated through a suit? How tactile is the switch?

Q. What receiver options are available?

Q. Can the unit be decontaminated?

Q. Is the clarity of communication affected by other protective equipment?

Q. Will communication capability be affected by the removal or addition of any PPE?

Q. Is the product ruggedly constructed? What is the warranty period?

Q. Who uses the product now? Where? For what applications?

Q. How much does a complete unit with radio interface cable cost?

Q. What is the cost of ownership over time? i.e. batteries, additional components, etc.

**Examples of Equipment Applications**

- 1st Responders / EMS
- HAZMAT Response
- Disease Control Investigation Teams
- Incident Command & Control
- Swift Water Rescue
- Structural Fire Fighting
- Law Enforcement
- Water Patrol
- Bicycle/Foot Patrols
- SWAT/ ERT
- Clandestine Drug Lab Takedowns
- Traffic Control
- Riot / Crowd Control
- NBC and CB Response Operations
- Medical Personnel
- High Noise Applications

# Section 2. Portable Hardline Communication Systems

Hardline communication systems though not as common as two-way radios are standard equipment for work in Confined Space, Structural Collapse, Explosive Ordinance disposal as well as a variety of Rescue and Industry related operations. At first glance, the biggest drawback to this method of communication is the cable itself. That said, the cable is also one of this equipment's greatest assets as Hardline systems excels in areas where radios fail. Collapsed structure void spaces, shielded enclosures, bunkers, confined spaces and underground locations are good examples of areas where radio communication becomes unreliable due to the shielding effect of surrounding metal or concrete/rebar, etc. Users in these environments have benefited greatly using portable Hardline communication equipment in these operations.

Recent Studies[2] have shown that during prolonged large scale responses, mutual aid and task force interoperability is affected due in part to insufficient radio equipment and lack of radio channel allocations. Portable Hardline equipment and accompanying accessories have operational characteristics that offer some practical communication solutions and offer some relief regarding interoperability concerns

A great deal of attention is being paid to Portable Hardline equipment and how it is put to use in a D.P. / WMD context. Examples of successful Hardline communication system integration are Gross Decontamination stations positioned outside of Hospitals or long term HAZMAT operations that can benefit greatly from the continuous, open, hands-free, dedicated and private communication a properly configured and deployed Hardline system can offer. Additionally, rescue operations involving collapse search, confined space, deep shaft, cave, and some high angle rescue applications.

**Sound Powered Systems**

It is important to differentiate between portable "powered" equipment and *"sound powered"* equipment. This is a common mistake, but the differences make comparison in this context impossible. Rather than going into detail the following quote sums up this equipment, well. "The sound powered phone system is temperamental, cumbersome, and the volume and clarity is

[2] Reference - Public Service Wireless Network Program (PSWNP)Information Brief - Fire and EMS Communications Interoperability - Sponsored By the Dept of Justice & Dept of the Treasury

inadequate for confined space entry/gas free operations. Current sound powered phone headsets do not couple with standard breathing equipment and require one hand to operate and provide no means of emergency alarm notification."[3]

**Assessment & Selection of Hardline Systems**

Rescue grade Hardline communication systems typically provide *full duplex* communication meaning there is no push-to-talk, voice activation or switching required to communicate. These systems are completely hands-free and provide fully open simultaneous two-way voice communication. During jobs where supplied air breathing apparatus is used, the communication cable can be "piggybacked" onto a breathing air line, making a single umbilical, that is virtually invisible to the user. Accessories for portable Hardline systems can include pass-thru connectors for chemical suits, facemask communication accessories, high noise headsets, alarm options, victim location probes to name but a few. Portable units are typically battery powered and able to deploy anywhere they are needed. Due to the probability of entry into confined/enclosed areas and the possibility of explosive atmospheres due to gas leaks, etc., equipment should be approved for use in explosive environments (Per OSHA, NEC and NFPA requirements) scenarios. The negative aspects of portable Hardline communication systems include a limited number of users, physical attachment by cable, possible tripping hazards and distance limitations. However, as with any equipment evaluation the negative aspects must be placed in the context of the user application.

It goes without saying that any equipment considered for WMD operations must be designed and built to survive in the environment(s) that it must operate. Unfortunately in emergency response situations, we do not have the luxury of knowing where equipment will be deployed and under what conditions it will be required to operate. This being the case any equipment considered for use must be ruggedly constructed and able to adapt to a variety of applications and working conditions.

[3] * Excerpt from U.S. Navy J & A 99-006 Issued by Department of the Navy, Office of the Assistant Secretary (Installations and Environment) Director, Safety and Survivability

The following is a list of questions that when answered will give a good indication of a piece of equipment's capabilities during the selection process:

Q. Is voice communication continuous?
Q. What is the level of Intrinsic Safety? (See Appendix A)
Q. What materials are used in the construction of the equipment?
Q. What is the chemical resistance of the equipment?
Q. Is the equipment Waterproof? Immersion Proof?
Q. What is the power source? Batteries (type)? Other?
Q. What is the Battery life? Is there a Low Battery warning?
Q. Can it be used while wearing Breathing Apparatus?
Q. What kind of accessories are available for the equipment?
Q. Are System Components and accessories interchangeable?
Q. How quickly can the equipment be deployed?
Q. Is the equipment shielded against RF or Electro magnetic interference?
Q. How easy is it to use? How much training is required?
Q. How many people can be on the communication system at once?
Q. What type of warranty does it come with?
Q. Is the equipment built to a quality standard? What standard?

*Special Note: The question lists included herein are meant as a starting point only, add anything you feel pertinent to your particular application(s).*

**A Note on Communication/ Rope**

Hardline Communication equipment designed for dive or high angle rescue is sometimes considered for use in hazardous location applications Confined Space, etc. The equipment utilizes communication wires embedded in the core of kernmantel rope. Following are some issues to consider regarding this type of equipment; rope cannot be decontaminated, the life of a rope is limited and replacement costs are ongoing, life safety rope that has been "shock loaded" should be removed from service immediately thereby losing communication as well, interior wires cannot be inspected for wear or damage, diving equipment does not require Intrinsic Safe Approvals.

**Examples of Equipment Applications**

- Bomb Squads
- Structural Collapse Rescue
- Victim Search Operations
- Underground Search Operations
- Void Space Entry
- Confined Space Rescue
- HAZMAT Response
- Gross De-Contamination Stations
- Fixed Location “In Suit” Operations
- Hospitals
- Patient Decontamination & Triage
- Explosive Ordinance Disposal
- De-Militarization Operations

## Conclusion

At the heart of any successful operation lies effective communication. Any equipment that has been correctly selected and applied to meet operational demands can produce measurable results and increase efficiency and safety of users in the field.

Probably the best advice to those tasked with the evaluating and specifying communication equipment of any kind is to take a common sense, practical approach during the selection process. Some manufacturers make outrageous claims about their equipment’s capabilities and usually, if it sounds too good to be true it probably is. However, there is one sure way to separate the wheat from the chaff and that is to try it for yourself! Equipment trials when done in the context of a specific application or task are the best way to see how equipment will perform under real life situations. Communication equipment manufacturers and their local representatives spend a lot of time, money and effort on product training, information and demonstration equipment to address the needs of potential customers. This resource is there for the asking. Use it!

## APPENDIX A

### Types of Electrical Equipment

Follows are some examples of commonly used electrical equipment used by rescuers in hazardous locations; two-way radios, Hardline and sound powered communication systems, gas detectors PASS devices, pagers, ventilation equipment. However, it doesn't end there electrical equipment is defined by Factory Mutual Research in their Approval Standard 3600 as; “All items applied as a whole or in part for the utilization of electrical energy. These include, among others, items for the generation, transmission, storage, measurement, regulation, conversion, and consumption of electrical energy and items for telecommunications”.

### Equipment Safety

When selecting electrically powered communication equipment destined for use in a hazardous or potentially hazardous environment, it is important to choose equipment that has been designed and approved to be spark proof, explosion proof or intrinsically safe. To do this properly you must have an understanding of the classification for hazardous locations set out in the National Electrical Code (NFPA 70). The following is an abbreviated list of the different classifications and what they mean. If there is any doubt about the approval rating on a particular piece of equipment “Check the Label”. In North America, all intrinsically safe or explosion proof equipment has to carry a label that lists the hazardous location or hazardous locations, for which it has been tested and approved. Simply put, if it doesn't say it on the label, it's not approved for that location and if there is no label, the equipment is not approved. In instances where physical size prohibits a listing of approved locations, the equipment will have, as a minimum requirement, the mark of the Nationally Recognized Test Laboratory (NRTL) that did the testing. If there is any question about the approval status for a piece of electrical equipment, request a copy of the certification record or approval agreement from the equipment manufacturer or distributor and keep it on file for future reference.

**Appendix A**

# National Electrical Code (NEC) classifications for hazardous locations.

**Class I**

Locations where there is a danger of explosion due to flammable Gases or vapours present in quantities sufficient to produce explosive or ignitable mixtures.

**Class II**

Locations where there is a danger of explosion due to the presence of combustible or electrically conductive dust.

**Class III**

Locations where there is a danger of explosion or flash fire due to the presence of easily ignitable fibres or flyings.

**Classes are separated into Divisions 1 & 2**

**Div I** Locations where the gases, vapors, conductive dust, combustible dust, flyings and/or fibres are present in the air in potentially flammable concentrations continuously, frequently or intermittently under normal operating conditions.

**Div II** Locations where the gases, vapors, conductive dust, combustible dust, flyings and/or fibres might become hazardous in the event of mechanical breakdown, accident, failure or the abnormal operation or equipment.

**The Classes are further divided into Groups;**

**Class I**

| | |
|---|---|
| Group A | Acetylene |
| Group B | Butadiene, Hydrogen, Ethylene Oxide, Propylene Oxide & Acrolien |
| Group C | Acetaldehyde, Ethylene, Ether Vapours, |
| Group D | Acetone, Ammonia, Benzene, Butane, Cyclopropane, Gasoline, Hexane, Methane, Methanol, Natural Gas, Naptha, Propane, |

**Class II**

| | |
|---|---|
| Group E | Combustible metal dust including Aluminium, Magnesium and their Commercial Alloys |
| Group F | Combustible carbonaceous dusts including Carbon Black, Coal, Charcoal, |
| Group G | Combustible dusts not listed in groups E or F including Flour, Grain, Wood, Plastic |

**Class III**

No Groups

## Appendix A continued. . . .

### ZONES

The 1996 version of the National Electrical Code included for the first time, Article 505 - Class I,

Zone 0,1, and 2 Locations. Article 505 specifies an alternative hazardous location identification scheme for "Class I" environments only. It must be noted that the Zone system does not replace the aforementioned classification system. Zones are common classifications elsewhere in the world and its inclusion in the NEC could be considered a step toward harmonization with other countries I.S. approval standards. Appeals to delete article 505 and related issues in articles 501 and 502 were filed at the time of 1996 printing, however, the appeals have since been denied and Article 505 and all related references will stand.

**Class 1 - Zones ***

| | |
|---|---|
| **Zone 0** | Location in which ignitable concentrations of flammable gases and vapors are present either continuously or for long periods of time. |
| **Zone 1** | Location in which ignitable concentrations of flammable gases or vapors that are likely to exist under normal operating conditions or may exist frequently because of repair maintenance, leakage or breakdown. Or the location is adjacent to a Class I, Zone 0 from which ignitable concentrations could be communicated, unless prevented by adequate positive pressure ventilation and safeguards are in place to prevent ventilation failure. |
| **Zone 2** | Location in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and if they do occur will exist only for a short period of time. An area where liquids gases or vapors are normally confined in closed containers or systems that could escape due to an accidental rupture, breakdown or abnormal operation of equipment. Or where the ignitable concentrations are normally prevented by positive mechanical ventilation but could become hazardous due to the failure or abnormal operation of the ventilation equipment. Or the location is adjacent to a Class I, Zone 1 from which ignitable concentrations could be communicated, unless prevented by adequate positive pressure ventilation and safeguards are in place to prevent ventilation failure. |

Groups - Equivalents

| Zone System | | Current System |
|---|---|---|
| Class I, Group IIc | = | Class I, Groups A & B |
| Class I, Group IIb | = | Class I, Group C |
| Class I, Group IIa | = | Class I, Group D |

* The above is a abbreviated version of the Zone/Group system and is for information purposes only, refer to the NEC Article 505, for complete descriptions of Class I, Zones and Groups.

Special Precaution : NEC Article 500-3 states that; if article 505 is used, area classification, wiring and equipment selection must be done under the supervision of a qualified Registered Professional Engineer.

**Appendix A… Cont…**

**Examples of Classifications and Corresponding Rescue Sites;**

**Class I, Div 1 & 2**

Petroleum Refineries, Dry Cleaning Plants, Petrochemical Plants, Hospitals, Utilities, Aircraft Hangers, Paint Manufacturers, Dip Tanks Containing Flammable or Combustible Liquids, Spray Finishing Areas

**Class II, Div 1 & 2**

Grain Elevators, Flour and Feed Mills, Confectionery Plants, Fireworks manufacturing and storage, Grain Ships, Areas for packaging and handling of pulverized sugar and cocoa, Manufacturing and Storage of Magnesium or Aluminium, Spice grinding Mills, and some Coal handling plants,

**Class III, Div 1 & 2**

Wood Working Plants, Textile Mills, Cotton Gins, Cotton Seed Mills, Flax producing Plants, Knitting Mills, Weaving Mills

NOTE:

The above is meant as an example only, Individual group classifications also apply to the above and were omitted for brevity. To determine Classifications for specific locations consult with your safety officer.

**Note**: Refer to the National Electrical Code Articles 500,501,502,503, 505 for a complete description of Hazardous Area Classifications and Group descriptions including an alternative hazardous location identification scheme (Zone Classification System)

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- Hazardous Locations, A guide for the design Construction and Installation of electrical Equipment, Published; Canadian Standards Association; Authors John Bossert and Randolf Hurst
- ANSI/NFPA 70 - National Electrical Code; Author: National Fire Protection Association
- ANSI/NFPA 497M - Manual for Classification of Gases Vapours and Dusts for Electrical Equipment in Hazardous (Classified) Locations ; Author National Fire Protection Association
- ANSI/UL 913 - Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I,II,III, Division 1, Hazardous (Classified) Locations
- Approval Standard, Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements, Class Number 3600, March 1989, Factory Mutual Research
- Department of Labour, Occupational Health and Safety Administration, 29CFR 1910.7, Docket No. NRTL-2-92, Canadian Standards Association


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