PERSONAL PROTECTIVE EQUIPMENT (PPE) IN CBRN INCIDENTS

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Abstract

The information referred to in this article was used when teaching the course "Specialized Training Session Sixth for the Prevention of Weapons of Mass Destruction for Civil Defence Officers Gulf Cooperation Council for the Arab Gulf States", which was held in Kuwait from 30th November to 12th December 2014.

The Cooperation Council for the Arab States of the Gulf invited 'NATO's Civil Protection Group' to provide a training course for the staff of Civil Protection focused on protection against weapons of mass destruction. The training took place at the training center of the Ministry of Interior in Kuwait with the participation of representatives of the four Gulf States: Kuwait, Saudi Arabia, United Arab Emirates, and Bahrain. Officers from various authorities including the National Guard, Army, Police, Customs Department, Fire Department, and Medical Emergency took part in the training. The course consisted of practical and theoretical sessions and was presented by experts of the training team of the civil protection group of NATO in cooperation with the Fire Department and the Hazardous Materials Center. It aimed to train the officers and improve their skills in civil protection so they would be able to deal with weapons of mass destruction and other dangerous materials and get rid of its effects.[1)]

Lessons were based on the "Guidelines for First Responders to a CBRN Incident" developed by the 'NATO's Civil Protection Group', whose member is also the author of this article. The article focuses on the area number 3 in the "Guidelines for First Responders to CBRN Incident" entitled "Scene Management: Isolate scene to mitigate the Consequences".

The aim of the response guidelines is to establish procedural guidelines for midlevel strategic/tactical planners responsible for CBRN preparedness and response. The response guidelines provide generic advice and guidance on procedures, capabilities and equipment required to implement an effective response. They are designed to improve multi-agency interoperability in first response to a CBRN incident and provide guidance on when regional, national or international assistance may be required. The guidelines have been prepared to help planners in EAPC nations determine their own level of capability through self-assessment. They serve as a checklist. Implementation of the guidelines is entirely optional.[2)]

Key words
Personal Protective Equipment, CBRN incidents, emergencies, protection, contamination.

Introduction

The world is changing rapidly. Various terrorist events or military conflicts in the past highlighted the importance of armed or emergency response procedures for dealing with terrorist and military related events involving chemical, biological, radiological, or nuclear (CBRN) agents. The consequences of Chemical, Biological, Radiological and Nuclear (CBRN) emergencies may stretch national capabilities to their maximum extent. Responsibility for the first response remains with individual nations. It is essential that nations build on their resources to respond and mitigate the consequences of an emergency situation to lives, property, and the environment. Numerous response agencies worldwide continue to work to provide accurate,

current information to help prepare these on-scene responders. As more nations become industrialized and prosper, they develop a greater need for personal protective equipment, from war fighters, first responders to industrial workers.

1 Need for PPE

Personal protective equipment is designed to provide protection from serious injuries or illnesses resulting from interaction with chemical, radiological, physical, electrical, mechanical, or bio hazards and airborne particulate matter. Careful selection and use of suitable PPE should protect individuals involved in chemical, biological a radiological emergencies from hazards effecting the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Achieving total individual protection requires an integrated approach. The primary protective mechanism against chem-bio agents is respiratory protection. A properly fitted protective mask, when combined with an over garment, gloves and boots, can provide excellent protection. The primary protective equipment to use against radiological agents are respiratory protection along with skin coverage, consisting of properly fitted protective mask combined with 100% cotton over garment, gloves and boots. PPE should also be used in conjunction with other protective methods, including exposure control procedures and equipment.

2 PPI Selection

Survival of persons in the environment contaminated by toxic substances is among others also a subject to the type and quality of protective means. Protection of individuals will depend mainly on the type of toxic substances, its latent state and concentration, on the disposition of the substance to be captured in protective filters, on the nature and duration of activities carried out in the contaminated environment, on the quality of the available protective equipment, and on meteorological conditions or temperature conditions at the site of action.

Proper selection of PPE for individual responders must be based upon a careful assessment of two factors:

1. hazards anticipated to be present, or are present at the scene,
2. a probable impact of those hazards, based upon the mission role of the individual.

The emergency responder must be provided with appropriate respiratory and dermal protection from suspected or known CBRN hazards. The amount of protection required is material and hazard specific. Physical and durability properties of PPE must meet or exceed minimum requirements for operations at a CBRN terrorism incident scene. The selection of appropriate PPE is the responsibility of the Incident Commander and/or the on-scene Safety Officer.[2)]

Other PPE Considerations

The responder's actions during a job are largely based on common sense combined with a blend of knowledge, experience, tact, diplomacy, and general good judgment.

The responder should be alert for changes in personnel dose rates or contamination status resulting from equipment repositioning, disassembly, drainage, drying out of wet surfaces, and changes in personnel location, or changes in the scope of work to be done.

Additional protective clothing which may be required to safely complete a task may include, but is not limited to the following:

- Water resistant/waterproof protective clothing is required in highly contaminated areas when there is a potential for encountering moisture or where excessive perspiration is likely to occur. Examples of such clothing are: rain wear, plastic suits, veterinarians gloves, canners gloves, etc.
- When it is anticipated that moisture and heat stress conditions are to be encountered, GORTEX suits should be used.
- Canvas, cotton or leather gloves should be worn as the outer pair of hand protection when working with duct tape.
- Leather gloves should be worn as the outer pair of hand protection when working with sharp objects or heavy work that may penetrate rubber gloves during normal activities.
- Rubber knee boots if working in areas with standing water.
- Welders coveralls if a rescuer is doing any cutting, grinding or welding.

3 Types of PPI

In general, the personal protective equipment is divided into two major groups: respiratory protective devices and body surface protective equipment. Both groups have relatively complex additional internal division.

3.1 Respiratory protection

forms an essential part of the basic protection. Respiratory Protective Equipment is divided into two distinct types: Air-Purifying Respirators, in which the atmospheric air is purified or filtered before reaching the user; and Self-Contained Breathing Apparatus (SCBA) that supply clean air to the user independent of the surrounding atmosphere. This may be from bottled supplies or a re-breather.

3.1.1 Air-Purifying Respirators

can reliably protect only against known compounds or mixtures of known composition and concentration, and only when selecting a suitable and appropriate filter-piece, which could be half and full-face masks, hood helmets, etc. Purifying respirators are not always appropriate for use by first responders operating within areas of suspected contamination. They cannot be used in an environments with unsufficient amount of oxygen in the atmosphere, i.e. in an environment containing less than 17 vol.% oxygen, or when the nature of the hazard has not been quantified. Air-Purifying Respirators today include a wide range of devices, whose protective properties are dependent on the type of face-piece, their technical and protective characteristics, and the type and class of filter applied. Proper training, mask fit, and medical clearance must be completed prior to wearing respirators.

Fig. 1
Full-face piece respirator

Fig. 2
Powered Air Purified Respirators

3.1.2 Self-Contained Breathing Apparatus

provides complete respiratory protection as breathing air enters the faceplate from an independent source, usually an air tank worn on the back. An SCBA consists of three main components: a high-pressure tank, a pressure regulator, and an inhalation connection (mouthpiece, mouth mask or face mask), connected together and mounted to a carrying frame. This apparatus has two disadvantages: the weight of the air pack (about 18kg) is burdensome, and the air supply is limited (30 minutes or less).

Oxygen rebreathers (systems where exhaled air is cleaned, re-oxygenated and then re-breathed) are similar in size and weight but have a greatly extended working duration (up to 4 hours depending upon workload).

Fig. 3
Self-Contained Breathing Apparatus

3.2 Body surface (dermal) protective equipment

All personnel entering areas with removable contamination are required to wear certain items of protective clothing. The types of clothing required vary depending on the contamination levels and the nature of the work to be performed. Some additional factors to consider when selecting protective clothing include the type and form of contamination; potential for increased levels of contamination, area of the body at risk, and competing hazards, i.e., heat stress, asbestos, etc.

Some types of respiratory protective equipment will be required for work in areas where very high contamination levels exist or airborne contamination is present.

Basic terms with regard to the body surface protection are **endurance time** and **breakthrough time** of the protective equipment.

Endurance time is the time during which, under given conditions (temperature, humidity, nature of performed work, etc.), it is possible to stay in protective clothing. It depends largely on the individual dispositions of each person - i.e. physical fitness, mental endurance, and practice.

Approximate recommended times for insulating protective clothing are listed in Table 1.

Table 1
Endurance time norms for chemical protective clothing

Ambient air temperature (^{0}C)	**Maximum continuous time of wearing chemical protective clothing (in minutes)**	
	Light work	**Heavy work**
over 32	20	15
30 to 32	45	30
27 to 29	75	45
21 to 26	120	60
16 to 20	180	90
10 to 15	240	120
4 to 9	360	180
0 to 3	480	240
bellow 0	more than 480	Up to 300

Breakthrough time - Permeation is the time it takes from an initial contact of the chemical with the material until it is detected on the opposite side of the material (essentially, when it begins to soak through). The greater the breakthrough time, the more protective the material is for that particular chemical.

4 Levels of PPE

All hazards must be considered when determining the appropriate PPE and respirators to be worn. Once the types of protection needed are established, the most efficient protective clothing must be selected from the different articles of protective clothing available for use.

Generally accepted designations for levels of protection are the following:

Level A – this consists of a SCBA or supplied-air respirator with an escape cylinder, in combination with a fully encapsulating chemical protective suit capable of maintaining a positive air pressure. The ensemble includes both outer and inner chemical-resistant gloves, chemical-resistant steel-toed boots, and two-way radio communications. It provides the highest level of protection for skin, eyes, and the respiratory system. It also makes rapid and effective decontamination easier because the breathing apparatus is contained within the protective suit.

Fig. 4
Level A Encapsulated chemical protective suite

Fig. 5
Level B protective suit

Level B – this has the same respiratory protection as Level A plus hooded chemical-resistant clothing, outer and inner chemical-resistant gloves, chemical-resistant steel-toed boots, and other, optional, items. It should be used when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

Level C – this is similar to Level B, except that a full- or half-face air-purifying respirator is worn, instead of the SCBA or 'supplied-air' respirator. This should be used when:

- the concentration and a type of an airborne substance is known,
- the criteria for using air-purifying respirators are met,
- the atmosphere is breathable.

Fig. 6
Level C protective suit

Cloth coveralls are permeable, and therefore not effective against radionuclides with high permeability properties (gases, tritium, etc.).

Plastics coveralls provide protection from high levels of both dry and wet contamination. They provide limited protection from tritium and other highly permeating radionuclides (which may be transported through coveralls to the skin surface).

Disposable coveralls, e.g., TYVEK suits, provide moderate protection from radioactive contamination and are used for work involving mixed hazards, i.e., asbestos, PCBs, etc., where reuse is not required.

Fire Fighter turn-out gear is another example of PPE that is adequate for protection from radiological contamination.

Fire fighters' protective clothing (pants and jacket) is a three-component ensemble intended to protect a fire fighter from radiant and thermal exposure, unexpected flashover conditions, and puncture and abrasion hazards while still maintaining an adequate level of dexterity and comfort. The performance requirements for the individual components (moisture barrier, thermal liner, and outer shell) and the ensemble are described in NFPA 1971, whereas the selection, care, and maintenance of the "turnout gear" is described in NFPA 1851. Considerable research has been devoted to the development and testing of turnout gear. However, little information is available as to how environmental stresses on the turnout gear during routine activities and storage deteriorate its performance and service life.[3)]

Fig. 7
Fire Fighter turn-out gear

The purpose of wearing protective clothing at a potential radiological exposure area is to prevent contamination and minimize skin and clothing contact. In a radiation emergency, the choice of appropriate personal protective equipment (PPE) depends on a response role and specific tasks, and a risk of contamination.

PPE can during a radiological incident protect against an external contamination, and an internal contamination via inhalation, ingestion, or absorption through open wounds. PPE cannot protect against exposure from high energy, highly penetrating forms of ionizing radiation associated with most radiation emergencies.

PPE should include a personal radiation dosimeter whenever there is concern about exposure to penetrating ionizing radiation. Direct-reading personal radiation dosimeters may be used to monitor radiation dose and can help responders stay within recommended Dose Limits for Emergency Workers. Direct-reading dosimeters should be worn so that a worker can easily see the read-out and/or hear warning alarms.

Recommended respiratory PPE includes a full-face piece air purifying respirator with a P-100 or High Efficiency Particulate Air (HEPA) filter.

5 How to safely use PPE?

There are four key points to remember about PPE use. First, put it on before you have any contact with the possible contaminant, generally before entering the contaminated area. The suit should be donned first. The mask or respirator should be put on next and correctly adjusted to fit; remember to fit check the respirator. The goggles or face shield (if used) should be donned next and the gloves are donned last. Keep in mind, the combination of PPE used, and therefore the sequence for donning, will be determined by the precautions that need to be taken.

Once you have PPE on, use it carefully to prevent spreading contamination. When you have completed your tasks, remove the PPE carefully and discard it in a proper manner, then

immediately perform decontamination before leaving the site. When using PPE on the scene of a CBRN incident you should perform the following steps:

- Ensure you have everything needed before beginning a task
- Ensure that no mucosal surface is unprotected
- Check PPE is being correctly put on (mirror / observer)
- Avoid self-contamination while using the PPE
- Do not touch face, mask, eye wear etc.
- Avoid self-contamination on removal of the PPE
- Remember what could be contaminated
- Avoid contaminating others
- Avoid contamination of the environment
- Dispose of PPE immediately and safely after use
- Help each other while wearing or removing PPE

6 Difficulties in use of Chemical Protective Clothing

There is a number of complications with the use of PPE:

- Thermal stress
- Limited mobility and dexterity
- Limited visibility
- Communication difficulties
- Physical fatigue

Only first responders who are physically fit and have proper training should be allowed to wear PPE during an incident. Medical surveillance should be conducted on all entry personnel both before and immediately after their use of PPE. Proper donning and doffing procedures must be followed. Upon completion of technical decontamination, all personnel should be examined to find marked changes in health, and medical care should be provided when illness or injury is found.[5)]

Conclusion

At a CBRN emergency scene, it is not possible to design or engineer controls to minimize the spread of contamination. The method used for personnel protection is protective clothing and respiratory equipment.

Protective clothing allows personnel to work in an area with removable contamination and to exit the area without spreading contamination to uncontrolled areas and to minimize the adverse effects of chemicals, biological agents, and radiological particulates. The use of protective clothing alone will not guarantee complete elimination of personnel contamination and is not a substitute for implementing proper controls, but if used properly, protective clothing will afford a high degree of protection.

Presently, no single personal protective equipment can protect the user from exposure to all hazards. It is vital that the correct combination of respirator, protective clothing, and other equipment is carefully chosen based on a conclusive hazard assessment at the scene of an incident.

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