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Expedient Respiratory and Physical Protection: Does a Wet Towel Work to Prevent Chemical Warfare Agent Vapor Infiltration?

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ABSTRACT

The purpose of this paper is to examine the effectiveness of expedient protection strategies to reduce exposure to vapors from chemical warfare agents. This includes an examination of the physical and the psychological effectiveness of measures such as using a wet towel to seal a door jam against the infiltration of chemicals while sheltering in place or to provide expedient respiratory protection.

Respiratory protection for civilians has never been considered a viable option for population protection in the CSEPP. Problems of storage, ability to effectively don respirators, and questionable fit have been primary factors in rejecting this option. Expedient respiratory protection seems to offer little benefits for population protection for chemical agent vapors.

Furthermore, using wet towels as a vapor barrier at the bottom of a door should be discouraged. The wetted towel provides no vapor filtration and its effectiveness in infiltration reduction is unknown. Taping the bottom of the door will still likely provide greater infiltration reduction and is recommended as the current method for use in sheltering.

1. INTRODUCTION

Several public information efforts in the Chemical Stockpile Emergency Preparedness Program (CSEPP) advocate the use of wet towels to (1) seal a door jam against the infiltration of chemical vapors and (2) provide expedient respiratory protection.

A wet towel has been a common respiratory protection practice for fires to reduce inhalation of soot and smoke, but will this strategy protect against chemical vapors? Using a wet towel to reduce infiltration of chemicals into a room by sealing the gap between the floor and the door is frequently cited in the shelter-in-place (SIP) literature (see Blewett et al. 1996).

The purpose of this paper is to examine the effectiveness of such measures to reduce exposure to vapors from chemical warfare agents. This evaluation includes an examination of the physical and the psychological effectiveness of these measures. Little research has been conducted to examine the effectiveness of expedient protection against chemical vapors and aerosols. More is known about the penetration of aerosols than vapor. In this paper, we summarize the research to date and offer several recommendations for CSEPP.

2. PREVIOUS RESEARCH ON EXPEDIENT PROTECTION

The first documented research on expedient respiratory protection was conducted by Guyton et. al. (1959). They performed a series of tests to determine whether common household items provided respiratory protection against a release of radiological or biological aerosols. The materials they tested included

- a man's cotton handkerchief,
- a women's cotton handkerchief,
- cotton clothing material,
- muslin bed sheet,
- cotton shirt,
- rayon slip,
- cotton terry bath towel, and
- toilet paper.

In total, 18 variations of the 8 materials were tested. The tests performed used human subjects who inhaled *B. globigii* (a bacteria aerosol) through the various materials into a mouthpiece collector. The results of the testing indicated that 5 of the variations had filtration efficiency of greater than 85%. These included a folded (16 and 8 thickness) or crumpled handkerchief, 3 thickness of toilet paper, and a bath towel folded in half. Tests were performed on wetted items, but the efficiency was lower than for dry items. In addition, only the bath towel was feasible to breath through when wet. No testing for vapor protection was performed.

A series of experiments was performed by the Harvard School of Public Health in the early 1980's (Cooper, Hinds, and Price 1981; 1983; Cooper et al. 1983a,b; Price, Cooper, and Yee 1985). These efforts sought to build on the work of Guyten et al. by examining the penetration of expedient materials by particle size and by examining penetration by vapors. Materials similar to those in the earlier studies were used; but instead of human subjects, several test chambers were designed. Mineral oil was used for the aerosol tests and methyl iodide and iodine were used in the vapor tests. Methyl iodide is a difficult vapor to capture, while iodine, a highly reactive gas, was chosen because it is readily removed by wet filtration, thus setting the upper boundary for effectiveness against a gas.

The first set of tests examined the effectiveness of the materials in filtering the aerosols and vapors. For aerosols, the reductions by a factor of 30 were achieved with the dry materials across the range of aerosol sizes. Reductions by a factor of five were achieved with wet materials. No filtration was achieved with dry materials for both vapors. As predicted, wet materials had no effectiveness for methyl iodide but were effective in filtration of iodine vapors (60 % filtration) (Cooper, Hinds, and Price 1981; 1983).

Additional experiments were performed using a manikin to evaluate aerosol leakage around the protective materials assessed in the first experiments. These tests showed that the leakage rates around the edges of the expedient materials (in addition to the leakage of the materials), ranged as high as 63%. The study concluded that holding expedient materials over the face would not provide significant protection against aerosols due to the leakage problem. The study also concluded that some material, such as a panty hose, was needed to secure the expedient protective materials around the mouth and nose in order to minimize leakage (Cooper et al. 1983a,b). Although vapors were not included in this study, it is reasonable to assume that leakage around the perimeters of the materials would also be problematic for vapors.

Additional tests were performed with aerosols in the extremely small particle size range (Price, Cooper, and Yee 1985). These tests, as with the other aerosol tests, are not relevant for civilian protection in CSEPP SIP actions because of the extremely low likelihood of aerosol contamination off-post.

A major concern in all studies was the ability to inhale through the expedient materials. This proved problematic for all wet materials except for wet toweling. For the thick dry materials, such as the folded handkerchief—which was the most effective filter, breathing comfortably would be possible for only short periods of time.

Additional work on the effectiveness of expedient protection against chemical warfare agent simulants was conducted as part of a study on chemical protective clothing materials (Pal et al. 1993). Materials included a variety of chemical-resistant fabrics and duct tape. The materials were subject to liquid challenges by the simulants DIMP (GB simulant), DMMP (VX simulant), MAL (organoposphorous pesticide), and DBS (mustard simulant). The study concluded that "Duct tape exhibits reasonable resistance to permeation by the 4 simulants, although its resistance to DIMP (210 min) and DMMP (210 min) is not as good as its resistance to MAL (>24 h) and DBS (> 7 h). Due to its wide availability, duct tape appears to be a useful expedient material to provide at least a temporary seal against permeation by the agents" (Pal et al. 1993, p. 140).

3. ADDITIONAL CONSIDERATIONS

Expedient respiratory protection may have social-psychological benefits as well as problems that need to be examined as well.

Problems

Expedient respiratory protection can cause or exacerbate problems by

- deterring oral communications among a family in a sheltered room and communications are very important in a SIP situation,
- deterring taping a room if people attempt to use expedient respiratory protection from the onset of SIP,
- being an additional resource for a SIP kit or materials that would need to be located at the time of a SIP warning,
- hampering driving ability during evacuation because of impairment of hand use and possible visual difficulty, and
- causing hyperventilation in some people with a tendency to be claustrophobic about impediments to breathing.

Benefits

Expedient respiratory protection can also

- have a placebo effect, making people believe they are safe while they are in a SIP and
- reinforcing the concept of proactive protection during SIP.

Overall, it appears that the non-physical benefits of expedient respiratory protection do not exceed the potential problems. However, it will be important to communicate to the public that expedient respiratory protection is beneficial in other emergency situations (such as a fire or for volcanic ash).

4. RECOMMENDATIONS FOR CSEPP

Respiratory protection for civilians has never been considered a viable option for population protection in the CSEPP. Problems of storage, ability to effectively don respirators, and questionable fit have been primary factors in rejecting this option. Expedient respiratory protection seems to offer little benefit for population protection.

Because chemical warfare agent vapors are not reactive with water—or, in some cases, not very soluble, even if easily hydrolyzed (Munro et al. 1999)—it is unlikely that wetted towels will provide significant respiratory protection while a person is sheltering in place. In no case would it be recommended that people attempt to evacuate through a vapor plume with or without expedient respiratory protection. Because of the physical ineffectiveness of the practice and the fact that the social-psychological benefits do not outweigh the social-psychological problems, we recommend that expedient respiratory protection should not be used in CSEPP protective action strategies.

Furthermore, we believe that using wet towels as a vapor barrier at the bottom of a door should be discouraged in favor of using duct tape to seal the bottom of doors. A wet towel provides no vapor filtration; and while it will reduce infiltration, its effectiveness in doing so is not known. A towel wetted with a 0.5% solution of hypochlorite (a 1:9 dilution of household bleach) may provide some protection. A hypochlorite solution is an effective decontaminant for nerve agent vapors and would provide dual protection, both physical and chemical (Munro et al. 1990). Taping the bottom of the door will still likely provide greater infiltration reduction and is recommended as the current method for use in SIP for CSEPP.

5. ACKNOWLEDGEMENTS

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