HALON ALTERNATIVES HEALTH EFFECTS ASSESSMENT

US **Environmental Protection Agency**

Halon Options Technical Working Conference
New Mexico Engineering Research Institute

Albuquerque, New Mexico
May 9,1995

Reva Rubenstein, PhD

Stratospheric Protection Division

This paper will review the different kinds of risk assessments the Significant New Alternative Policy (SNAP) program has conducted to determine the safety of halon alternatives. The four different types *of* agents examined are inert gases, water mists, powdered aerosols, and halocarbons (including HCFCs, HFCs, PFCs and iodinated compounds).

In reviewing the halocarbons, I will try to reconstruct the assessment of Halon 1301 from the evidence of the toxicology studies and the standards.

INERT **GASES**

Use of an inert gas atmosphere to extinguish a fire is based on reducing the oxygen content to prevent or inhibit combustion. Such gas mixtures are acceptable for occupied areas if the concentration of oxygen in the mixture does not pose a hazard. In evaluating the safety of an inert gas containing limited oxygen as a fire suppressant the Environmental Protection Agency (EPA) was concerned about the possibility that low oxygen atmospheres would present an undue stress on persons already compromised but who were otherwise able to be at work. Specifically, EPA wanted answers to a few questions:

- What is the minimum oxygen content to which people may be potentially exposed and what is the likely duration of the exposure?
- What is the effect of added gaseous agents other than oxygen?
- How would use of these agents in an occupied space fit with existing OSHA regulations concerning oxygen levels in occupied areas?
- Should EPA require special controls such as access to SCBA? Could personnel tolerate delay in egress?

To answer these and other related questions, EPA asked the manufacturers of these agents to convene an expert panel of clinical and other medical specialists. The summary opinion of these expert panels is as follows:

- Most people (including those with underlying disease) will tolerate oxygen concentrations of 12% to 14% for brief periods (approximately 5 minutes or less)

- Some experts believed the data supported longer duration times in the presence of increased CO_2. Others expressed doubt on extended durations of exposure with or without CO_2 in a fire scenario.

- All agree that SCBA equipment should be required in exposure situations likely to be longer than normal evacuation times.

Concurrence on these issues with OSHA occupational physicians was expedited in part because the medical specialties represented on the expert panel had addressed the significant clinical issues directly.

Never-the-less there is still some confusion in the industry about the benefits of addition of CO_2 to the inert gas-oxygen blend. We acknowledge that there is extensive research showing the physiological benefits of added CO_2 in a low oxygen environment, which may permit a longer duration in a low oxygen atmosphere when there is no fire. Such a situation may occur if there is an unintended discharge under the circumstances where the pre-alarm was not activated. An accidental discharge cannot be ignored no matter how benign the agent. An employer is obligated (even in the event *of* an accidental discharge) either *to* evacuate personnel or return the work environment to normal atmospheres, per OSHA's workplace safety requirement of 19.6% oxygen.

The benefits of added CO_2 do not affect the regulatory decisions that were made. The EPA's evaluations on the safety of alternatives were made in the context *of* evacuation from a fire area rather than a determination of the longest acceptable duration of exposure to an agent when there is no fire.

The egress times proposed have been set so that the EPA regulations were similar to existing OSHA regulations for other gaseous agents. EPA may revisit the egress times on inert gases in light of other potential changes we may propose for halocarbon agents (discussed below).

WATER MISTS

The benefits or efficacy of water mists derive from the ability of an aerosolized mist to reduce the temperature of a fire and to shield the fire from oxygen. The finer the mist, the greater the efficacy of the mist to suppress the fire.

In evaluating the safety of a water mist **EPA** was concerned with issues related to the size distribution of the mist which may be respirable as well as with physical properties of a mist which may obscure visibility. In addition, questions were raised concerning the toxicity of any additives.

In raising questions about the safe use of water mists systems the agency was interested in demonstrating the environmental desirability of these agents and in creating proper controls so that use of water mists would be encouraged and its commercialization would not be impeded by lack of evaluation.

In evaluating water mists the Agency was particularly interested in answers to the following questions, briefly:

- What are the water droplet sizes and mass that are of concern, which may be potentially inhaled?
- What would be the toxicological effects of foreign matter that could be carried in the water mist particles? Is there any particular concern for Legionnaires' disease?
- What are the size, distribution, and concentration of water mist droplets that would pose no problem to the healthy respiratory system? to the compromised respiratory system?

Under the auspices of the Halon Alternatives Research Committee (HARC) a panel of experts were convened to address **EPA's** issues.

Specialties represented by the panel included aerosol chemistry and physics, particle growth, smoke dynamics, combustion and inhalation toxicology, pulmonary medicine and aerosol therapy. The panel was comprised of experts from academia, industry and government other than **EPA.**

The panel report states that water mist systems, using potable water, do not present a toxicological or physiological hazard and are safe for use in occupied areas. The panel however recommended that additives be evaluated on a case-by-case basis, depending on the toxic properties of the additive and the concentration at which it may be used.

Regarding the potential threat of disease from microbial contamination, the panel concluded that existing standards for stored water are sufficient for protection.

Finally, the panel believed that persons with compromised respiratory systems such as asthmatics are not at any greater risk during a fire from these systems, as the products of combustion pose a greater risk. In situations other than a fire these patients may experience broncho-constriction, but such events are common for the asthmatic in modern life.

EPA has adopted these recommendations, and is listing potable and natural sea water mist systems as acceptable. Until further definition on the issue of additives is obtained, EPA requires all mist systems with any additive to be submitted for review on a case-by-case basis.

To date, EPA has not received any SNAP submissions designating a particular additive for use in a water mist system for occupied areas.

POWDERED AEROSOLS

Many of the same issues can be raised concerning the use of powdered aerosols as was initially raised in regard to water mists. But whereas many people suggested that the agency may be being too cautious with mists, others were concerned that the agency was not being cautious enough with powdered aerosols. The agency believes that powdered aerosols are an extremely promising technology, but some work is necessary to answer concerns regarding potential hazards of exposure, including the degree to which visibility is obscured.

Fortunately, the work of the expert panel on water mists help to frame the significant questions regarding powdered aerosols. HARC has convened a second expert panel to explore the general issues related to powdered aerosols during fire suppressant use. The Agency is most interested in the physical, chemical and biological properties which determine the effects of a given powdered aerosol. Questions specific to a given powdered aerosol may require toxicity testing. These agents will remain "pending" for use in occupied areas until EPA receives the needed data.

The questions the Agency is most concerned about and which have been discussed with HARC are:

- What are the likely effects of inhalation of the powdered aerosol particles assuming an accidental discharge? assuming a fire?

- What would be the size distribution and concentration of particles that would be expected to have minimal effects?

- Is there sufficient information to make a decision on the safe use of this powdered aerosol fire suppression system or are there additional studies that should be conducted?

HALOCARBONS

EPA's risk assessments for use of halocarbon substitutes for Halon 1301 were based on an evaluation of acute toxicity tests such as cardiotoxicity and developmental toxicity. Other longer term toxicity tests such as 90 day subchronic repeated exposure studies provided hazard information for setting manufacturing workplace standards. A minimum data set sufficient for EPA to base a risk assessment for a halocarbon fire suppressant follows.

- To set ambient exposure limits:
  - Genetic Toxicology Assays
  - 90 Day Subchronic Assay
  - Developmental Bioassay

- To set acute exposure limits for fire suppression and explosion inertion:
  - Cardiac Sensitization Study
  - Developmental Bioassay

EPA set egress times for halocarbons used as flooding agents based on the results of animal (dog) cardiotoxicity testing and based on our understanding of the Occupational Safety and Health Administration (OSHA) regulation. It has since been brought to EPA's attention that we may have erred in our reading of the basis of the OSHA standard and thus may have set limits for the alternative agents on a toxicity basis more conservative than was set for Halon 1301.

In a review of the clinical studies on the effect of Halon 1301 exposures in healthy volunteer men, given no added adrenaline, it was shown that the critical effects were on the nervous system, particularly the central nervous system (CNS). The dose which caused no effect was only 4.0%. Paresthesia was reported by one individual following exposure at 4.1% for at least 5 minutes. As the dose levels increase, the severity of these effects also increases as follows.

CENTRAL NERVOUS SYSTEM EFFECTS (human)

below 4%	no effect level
4%-7%	compromised cognitive performance
7%-10%	loss of equilibrium
10%	impending loss of consciousness

Cardiac effects in humans are also evident.

CARDIAC EFFECTS (human)

7%	no cardiac effects noted
10%-12%	depressed T-wave (CS LOAEL)
14%	multiple premature ventricular contractions (PVCs)

In contrast to the human cardiac effects, the dog cardiac effects (listed below) are seen to occur at lower or similar levels. All the dog effects however, were seen in the presence of added epinephrine. No dog cardiac effects occur at these levels in the absence of added epinephrine. The highest experimental values occurred in dogs given an amount of epinephrine just below a level large enough to sensitize the animal in the absence of added agent.

CARDIAC SENSITIZATION WITH ADDED EPINEPHRINE (dog)

YEAR	1969	1976'	1992
NOAEL	5%	7.5%	10%
LOAEL	7.5%	10%	15%

• EPA assumed that 7.5% and 10% were the levels used by OSHA to set acceptable exposure limits.