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Technical Paper #7

Establishing Safe Criteria for Wearing Level B Chemical Vapor Protective Clothing While Working in Atmospheres of Less Than 15,000 PPM of Ammonia Vapor

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I. Objectives of the research
II. Research methods and findings
III. Data Collected
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V. ASTI Board Recommendation

Abstract

The original limitations placed on using Level B chemical vapor protective clothing for emergencies involving ammonia vapor were created by an OSHA Interpretation letter written by an OSHA regional director in 1991. The original criteria established a 5,000 PPM limit on Level B chemical protective equipment. The Ammonia Safety and Training Institute (ASTI) has evaluated current chemical vapor protective equipment through live ammonia testing and recommends that the original 5,000 PPM limit be increased to 15,000 PPM for Level B chemical vapor protective clothing that meets degradation, penetration, and permeation standards described within this Technical Paper.

I. Objectives of the research

This Technical Paper evaluates ammonia exposure threats to those wearing Level B chemical vapor protective clothing (CVPC) in atmospheres between 15,000 and 25,000 PPM of ammonia vapor.

The purpose of this paper is to build upon the OSHA Interpretation letter that served as background in 1991 to establish the 5,000 PPM regulatory limit on the use of Level B PPE. ASTI has gathered new information, identified new technology, and has additional experience to recommend the use of a Level B ensemble in less than 15,000 PPM of ammonia vapor. We are recommending that OSHA approve a performance-based PPE ensemble created with a combination of protective clothing options to address identified hazards rather than rely exclusively on one of the four EPA-created levels of PPE (Level A, B, C, or D).

The recommendation to increase the exposure limit of Level B CVPC ensembles (recommended herein) from 5,000 PPM to 15,000 PPM for ammonia vapor does NOT require any alteration or change to existing personnel protective equipment safety standards used for selecting and wearing CVPC, e.g., 29 CFR 1910.134, NFPA 1991, NIOSH, and ASTM requirements.

Specifically, the recommendation to increase the vapor exposure limit from 5,000 PPM to 15,000 PPM is supported by the following:

- The history of how and why the 5,000 PPM limit for Level B CVPC was created.
- Understanding of the levels of exposure that create risk and threat to responders.
- Understanding the benefits of utilizing Level B CVPC rather than Level A fully encapsulated suits.
- Recognition of the value of the Technician-certified Incident Commander in understanding the hazards, risks, and threats prior to committing to a specific level of chemical protective clothing.

- Understanding that the purpose of utilizing Level B CVPC is to work in known levels of exposure, with emphasis on monitoring conditions and assuring that the hazards, risks, and threats are stabilized and will not increase to cause a greater than 15,000 PPM level of escape.
- Understanding the regulatory conditions that set the standard for how chemical protective clothing is selected and utilized during an emergency event.

OSHA standard1910.120 uses a performance-based standard for requiring PPE. 1910.120 (g)(3)(i) states "Personal protective equipment (PPE) shall be selected and used which will protect employees from the hazards and potential hazards they are likely to encounter as identified during the site characterization and analysis." When specifically talking about totally encapsulating protective clothing section (g)(3)(iv) states "Totally-encapsulating chemical protective suits (protection equivalent to Level A protection as recommended in Appendix B) shall be used in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape." NOTE: Appendix B to 1910.120 is a non-mandatory appendix.

The PPE ensembles merely give a short hand to simplify discussions of protective clothing ensembles. This paper actually recommends, based on the data developed, that the performance threshold for Level B be readjusted to 15,000 ppm.

NOTE: Many of the terms and acronyms used in this document are defined in Appendix C Glossary (last three pages of this document).

II. Research Methods and Findings

Understand that the utilizing Level B Chemical Vapor Protective Clothing (CVPC) is to work in known levels of exposure, with emphasis on monitoring conditions to assure

that changes in the hazards, risks, and threats are recognized by the responders, allowing for escape from greater than 15,000 PPM of ammonia.

ASTI conducts a 32-hour course on advanced subject matter related to managing ammonia emergencies. In October 2010, November 2011, and October 2013 the subject of personal protective equipment was evaluated by ASTI team members and observed by class participants and experts from OSHA, Department of Homeland Security, Center for Toxicology and Environmental Health, and EPA.

ASTI- testing of Level B PPE – non-scientific in nature: On three different occasions, March of 2008, September of 2010, and October of 2013 ASTI has tested Level B ensembles in high levels of ammonia vapor (10,000 to 25,000 PPM).

In September of 2012 ASTI tested four different PPE ensembles within the ammonia vapor:

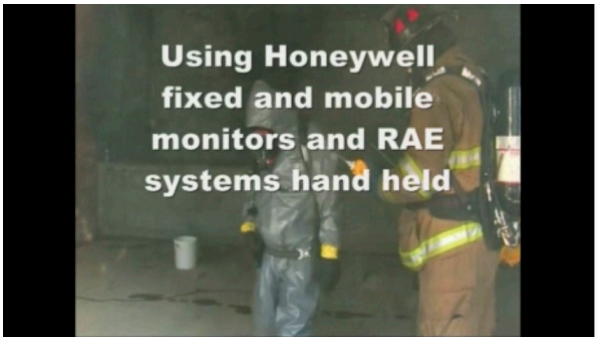
1) Coveralls, Nomex hood, cotton pants and shirt under-clothing, and a SCBA,
2) CBRN first responder coveralls, shorts and cotton t-shirt under-clothing, and SCBA
3) Fire turnouts, cotton pants and shirt underclothing, and a SCBA
4) Level B chemical vapor protective suit (un-taped), cotton coveralls under-clothing and SCBA
5) Lakeland Industries ChemMAX 3 Level B (taped) cotton coveralls under-clothing and SCBA

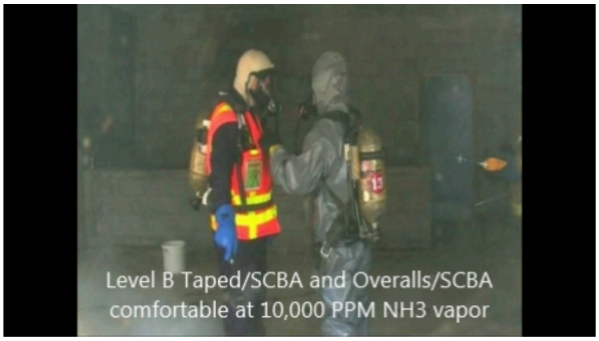
ChemMAX 3 Chemical Permeation Data – ASTM and ISO 30, July 2008 (Note: There are many other chemical suits available from other manufactures that meet the standard listed below. The only reason for quoting the ChemMAX3 specifications is to validate the cited test experience that is described within this paper (numerous other manufacturers have similar designs such as Kappler, Tychem/ Dupont, etc)

Chemical	CAS Number	Phase	Conc.	ASTM F1001 List	ASTM F739 (0.1 µg/cm²/min.)	Max. Perm. Rate (µg/cm²/min.)	EN369 Time to 150 µg cumulative permeation
Ammonia Gas	7664-41-7	Gas	100.0%	X	>480	0.07	nt

The tests were conducted inside training buildings at the Military Operations on Urban Terrain (MOUT) training facility at Fort Ord in California. OSHA and EPA officials witnessed the tests. ASTI team members, the Salinas Fire Department Hazmat Team, and the 95th Civil Support Team from Hayward, California, participated in the ammonia vapor PPE evaluations.

The test was conducted within an enclosed 20' x 30' room with an 8' ceiling. Small amounts of liquid ammonia (approximately 2 cups per spill) were dropped on the cement floor. The ammonia vapor evaporated into a small cloud and then dispersed into the room, slowly building up the ammonia vapor concentrations. The level of ammonia reached 10,000 ppm within 3 minutes and 15,000 within five minutes; the 20,000 to 25,000 ppm level was maintained for the last five minutes of the test. Five entry team responders were dressed in different levels of PPE for two separate entry tests, each lasting 10 minutes: 1) CBRN protective overalls with charcoal-filtering protective layer; the entry person wore shorts; they left the room within five minutes with mild skin irritation 2) Nomex overalls with cotton blend pants and shirt under the overall; experienced 17,000 ppm before mild skin irritation required that the responder leave the room after 7 minutes, and 3) Fire turnouts meeting NFPA standards for fire protection; stayed for the full term of both tests at 25,000 ppm (mild skin irritation) 4) Level B over-suit with no taping of the arms, legs, and face mask; left the room at 10 minutes with mild skin irritation 5) Level B over-suit taped at the arms, legs, and zipper flap (upper torso). The face mask seal was a built-in gasket connection (available with some suits) and/or a Nomex hood that overlapped the face mask. The responder had no discomfort at 25,000 and he stayed in the environment for the entire time of the tests.





The room was monitored by two handheld ammonia monitors and Honeywell ammonia sensors strategically located within the room. The concentration of ammonia vapor was monitored as those who were exposed walked about the room to simulate working in ammonia vapor conditions.

The ASTI findings associated with the MOUT Personal Protective Equipment (PPE) testing are summarized as follows:

NOTE: The responders were removed from the vapor environment when they experienced skin irritation. In all cases the responder went to air decontamination. In no case did 'minor skin irritation' result in any skin redness…only a slight sting that quickly disappeared with air decon.

- CBRN Overalls (under clothing–shorts with unprotected legs from the knees down): Those who wore overalls with no second layer of clothing (long-legged pants) and open cuffs were the first to experience skin irritation on the legs and crotch area at approximately 8,000 to 10,000 PPM (at five minutes).
- Nomex coveralls with cotton pants and shirt under the coveralls: skin irritation began with a sense of cold and slight stinging sensation at approximately 17,000 PPM (at seven minutes).
- Fire Turnouts (with inner cotton jeans and shirt): at 20,000 PPM minor skin irritation in moist areas of the body was felt.
- Level B (two piece – coat and overalls) Un-Taped; with cotton overalls inner dress: resulted in minor irritation at approximately 25,000 PPM.

- Level B (one piece coverall – disposable Lakeland ChemMax 3, Taped with cotton inner coveralls: experienced no discomfort at levels of 25,000 PPM.

In all cases of skin irritation, the problem was resolved by use of decontamination with a portable fan.

The same Level B one piece disposable Lakeland ChemMax 3, fire turnouts, and coveralls evaluation occurred during the October 26, 2013 ASTI training at the MOUT with similar results as documented in September of 2010.

Responders must comply with OSHA requirements for PPE response and be properly equipped with appropriate respirators. The Hot Zone environment, where entry takes place, must be monitored with handheld or fixed system monitoring that reads the constant exposure levels. Decontamination, medical readiness, safety oversight, and other applicable OSHA requirements must be in place as per the emergency response plan SOP.

Even without PPE, people have survived dense gas cloud exposures. The following anecdotal evidence shows that survival is possible when humans are exposed to high levels of ammonia (greater than 15,000 ppm of vapor). This is NOT to support a lack of concern for providing more than adequate PPE recommendations for the Level B ensemble.

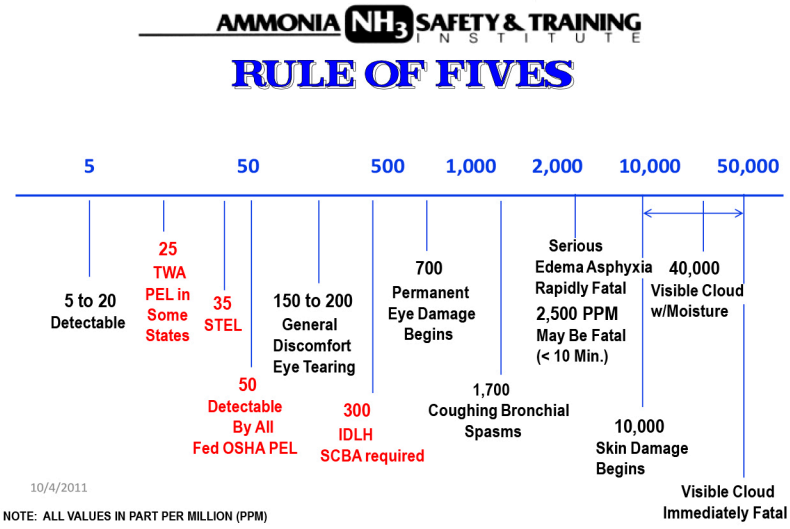
1975 survival of Mickey Johnson and her son who were caught in an ammonia cloud on a Houston freeway: Mickey experienced no skin injury but did experience significant respiratory damage. Her 2-year-old son experienced no significant long-term injury because Mickey covered him with a coat that shielded him from dense gas exposure.

2010 Minot, North Dakota, train derailment: Approximately 1 million pounds of ammonia traveled through Minot. Exposures within some of the homes exceeded 1,000 PPM. There was no evidence of ammonia skin burns.

2012 survival of Jose Mata in Yuma, Arizona: He was thrown to the ground when a condenser failed due to over-pressure that instantaneously released a large volume of ammonia. The concussion of the mechanical explosion threw Jose on his back and he was completely covered in an aerosol dense gas cloud. He held his breath, closed his eyes, and ran out of the ammonia cloud. He suffered thermal burns and chemical burns to his lower torso because his clothing (pants and boots) were left on during and after initial decontamination. The high pH of the aqua-ammonia solution caused serious chemical burns. Jose's face and upper torso did not show any evidence of vapor burn.

In February of 2012 the fire department in Yuma, Arizona, worked with ASTI to test the protection of firefighter turnout gear while performing a tarp and cover evolution over a high-pressure/high-volume aerosol ammonia release (150 psi through a 3/4" outlet). Two firefighters got too close to the aerosol release and were caught in a visible dense gas cloud. The ammonia vapor (at about 30,000 PPM) entered the legs of their turnout pants. They immediately went to the decontamination fan for decontamination. The vapor burning sensation was mitigated within several minutes and there was no evidence of skin irritation. The firefighters were wearing knee-length shorts under their turnouts, so the irritation factor was more significant than if they had been wearing long underwear or cotton pants.

Understanding of the levels of exposure that create risk and threat to responders.



AIHA ERPG-2 (Emergency Response Planning Guideline): Nearly all individuals could be exposed for up to 1 hour to 150 PPM of ammonia without experiencing or developing irreversible or serious health effects which could impair the ability to take protective action.

AEGLs (Acute Exposure Guideline Levels adopted by EPA) represent threshold exposure limits for emergency exposure periods ranging from 10 minutes to 8 hours. It is believed that the recommended exposure levels are applicable to the general population including infants and children, and other individuals who may be susceptible.

Ammonia 7664-41-7 (Final) - Expressed in PPM					
	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	30	30	30	30	30
AEGL 2	220	220	160	110	110
AEGL 3	2,700	1,600	1,100	550	390

AEGL-1 is the airborne concentration above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Understanding of the levels of exposure that create risk and threat to responders.

The hazard analysis described above would reveals that 15,000 PPM of anhydrous ammonia would be a threat for eye injury and would be a significant inhalation hazard. Skin damage begins at 10,000 ppm. OSHA mandates the supplied air (which includes SCBA) is required at IDLH (300 ppm for ammonia). Refer to 1910.134 for exact wording. Eye injury and inhalation hazard are mitigated by proper use of an SCBA.

The next and only other life and health concern when working in atmospheres below 15,000 PPM involves risk of skin injury from thermal (low temperature) exposure or chemical burns. A technical data search on skin injuries from ATDSR (Agency for Toxic Substances and Disease Registry), NIOSH (National Institute for Occupational Safety and Health), and AMA (American Medical Association – research used by EPA to validate the Acute Exposure Guideline Levels of Ammonia) yields limited information about skin injuries related to vapor exposure to anhydrous ammonia.

Aerosol and liquid ammonia skin exposure injury is far more threatening than exposure to low levels of ammonia vapor (under 15,000 PPM).

ASTI testing involved multiple entries into vapor levels of 10,000 to 20,000 PPM while wearing coveralls and an SCBA. The test time for exposure was simulated for a 15 minute task assignment which is normal for entry into the hot zone to achieve an incident action plan objective. The temperature during the test day was 68°F. Those wearing the PPE were encouraged to walk around the room and generate similar type of energy as would be used during a live event. Four different responders used the Level B ensemble during live ammonia releases. The 85th Civil Support Team sent four responders into 10,000 PPM with CBRN overalls. They stayed in the environment for about five minutes before feeling the burning sensation of the ammonia vapor. They left the room and went to air decon. The skin irritation did not cause any problems. The three responders continued to work in PPE for the rest of the day.

The tests were witnessed by OSHA, EPA, and fire service and industry emergency responders. This testing was mostly non-scientific. It is a good first step for preliminary results and to direct additional scientific, research-based studies.

The purpose of wearing coveralls into a high vapor concentration was to demonstrate the effect of Level B suit failure. The exposure while wearing the coverall ensemble resulted in a slight skin irritation where the mask meets the face at approximately 10,000 PPM and a stronger stinging sensation at 17,000 PPM (in the sweat moisture around the groin and armpits); the stinging was followed by a cold chill around the arm pits, back of the neck, and in the groin area. Air decontamination (using a portable fan) removed the vapor irritation and allowed for return to work after a short rehab period. This is consistent with the experiences documented in the Patty handbook (described below). It is important to note that the level of skin irritation increases when ammonia meets high levels of skin moisture.

More information on skin-related threat is discussed later in this Paper. Further research will also be needed to test female responders, and personnel of various body types, ethnicities. ASTI will attempt to find individual susceptibilities.

The irritation associated with ammonia mixing with body moisture results in an early warning to the entry team members to retreat before levels exceed the protection afforded by a Level B chemical vapor protective clothing ensemble (described in detail later in this Technical Paper).

The following is a quote from the Industrial Hygiene and Toxicology Volume II, also known as the Patty Handbook (Frank Patty, Editor, published in 1963, Library of Congress number 58-9220).

"During the approval testing of respiratory protective devices, the author has observed that atmospheres of 1 percent ammonia (10,000 PPM) are mildly irritant to the moist skin, those of 2 percent (20,000 PPM) have a more pronounced action, and concentrations of 3 percent (30,000 PPM) or greater cause a stinging sensation and may produce chemical burns with blistering after a few minutes of exposure."

The range of concern for ammonia vapor begins with mild irritation at 10,000 PPM and increases to a stinging sensation felt at 30,000 PPM. The decontamination procedure for dealing with a vapor irritation is to aerate the skin and PPE clothing with fresh air from a portable fan.

If the responder is exposed to aerosol liquid plume (droplets) or receives chemical blister burns from liquid or aerosol releases of ammonia, a thorough washing with tepid water for 15 to 30 minutes with total clothing removal, including socks and shoes, must be accomplished.

III. Data Collected

Federal OSHA sets the minimum employer/employee safe work practices nationally. Most employees in the nation come under OSHA's jurisdiction. OSHA covers private sector employers and employees in all 50 states, the District of Columbia, and other U.S. jurisdictions either directly through Federal OSHA or through an OSHA-approved state program. State-run health and safety programs must be at least as effective as the Federal OSHA program. https://www.osha.gov/workers.html

The information used to produce the recommendations in this document was gathered from Federal OSHA requirements, ASTI-related experiences in handling anhydrous ammonia releases, and from related technical information about personnel protective equipment standards.

OSHA contains a general requirement applicable to every employer that imposes an obligation to maintain a safe workplace. The general duty clause requires every employer to provide every employee with a place of employment that is free from recognized hazards that are causing, or are likely to cause, death or serious physical harm. This obligation is open-ended because it is designed to protect employees in situations in which there are no established standards. Thus, an employer's potential liability under the Act is also open-ended.

When the general duty clause and a specific OSHA standard address an identical hazard, an employer must comply with the most specific standard (which is generally more stringent). However, complying with specific requirements that apply to known hazards is far easier than anticipating and correcting hazards that have yet to be officially identified. In any event, the general duty clause highlights the value of developing workplace safety plans in order to identify potential hazards that are unique to a particular workplace.

OSHA recognizes the valuable contribution of national consensus standards and these voluntary standards may be used as guidance and recognition of industry accepted practices.

Also, OSHA may, in appropriate cases, use these consensus standards as evidence that hazards are recognized and there are feasible means of correcting the hazard. For example, IIAR Technical Bulletin 109 is often cited as an industry standard that OSHA will enforce when identifying a specific hazard or safety concern regarding the minimum safety criteria for operating an ammonia refrigeration system.

The IIAR Ammonia Data Book is also referenced by regulators when developing solutions to specific questions related to the storage, use, and personal protective equipment requirements for working around anhydrous ammonia. With that in mind, we plan to use this peer-reviewed Technical Paper as the impetus for changing the PPE reference in the IIAR Data Book for Level B CVPC from 5,000 PPM to 15,000 PPM.

The history of how and why the 5,000 PPM limit for Level B Chemical Vapor Protective Clothing (CVPC) was created.

Levels of response into environments containing ammonia vapor were defined in October of 1991 in an OSHA Standard Interpretation Letter that was answering a question from a firefighter who wanted clarification on the most appropriate level of PPE to wear within ammonia vapor during an emergency event. Following is the key summary provided in the Interpretation Letter:

Question 4. At what parts per million (ppm) level of exposure would you expect a person responding to an ammonia leak to use a level A suit?

Answer: "Generally, we would expect emergency responders to respond in Level A suits to unknown concentration levels and levels at or above one-half the Immediate

Dangerous to Life and Health (IDLH) level. The IDLH for ammonia is 500 PPM (now 300 PPM) and one half that level is 250 PPM (now 150 PPM). However, ammonia is an inhalation hazard at 1,000 PPM and not a skin absorption hazard. Ammonia begins to affect moist skin at exposures greater than 10,000 PPM (1%) (mild irritation); at concentrations greater than 30,000 PPM (3%) a stinging sensation is observed. Therefore, the general procedure of using Level A equipment at ½ the IDLH may be unduly conservative. For ammonia it may be appropriate to respond in Level B gear to exposures of ½ the threshold for skin irritation, or 5,000 PPM."

Based on this interpretation letter, the International Institute of Ammonia Refrigeration (IIAR) Ammonia Safety Data Book adopted the 5,000 PPM standard for setting the maximum limit for using Level B ensembles in ammonia vapor.

Understanding the benefits of utilizing Level B Chemical Vapor Protective Clothing (CVPC) rather than Level A fully encapsulated suits.

Case History – New York City Fire Department found an alternative to Level A entry for all hazardous vapor-related emergency threats:

The risk to the responder using Level A ensemble is high, especially when the responder is not comfortable or experienced in emergency circumstances. An article published in Fire Chief magazine (September 2011), revealed that the New York Fire Department (FDNY) made the decision to reduce the level of risk to the responder by creating an optional PPE clothing ensemble rather than mandating Level A fully encapsulated suits to handle all vapor releases of toxic inhalation hazardous vapor. The following is a quote from that article:

"While all of the units are trained for life-safety operations (assessment, packaging and removal) in the Hot Zone, only the Hazmat Technician II units and Hazmat Company 1 are trained for the mitigation of incidents that require vapor protection.

Prior to upgrading its chemical protective clothing (CPC) program, the FDNY issued Level A suits to these units.

New Options: The department discovered that for hot-zone responses, fully encapsulated gas-tight garments, i.e., Level A suits, pose several challenges for the first responder. For instance, such suits trap heat and put the responder at risk for heat injury. Also, vision is obscured when moisture (sweat and respiration) condenses on the inside of the visor. If that wasn't problem enough, the bulkiness of the suit material required the wearing of oversized boots, and the glove system compromised dexterity. The combination of obscured vision, ill-fitting footwear and decreased dexterity, increased the potential for injury. The packaging and removal of exposed victims are physically demanding tasks that underscore the limitations of using fully encapsulated CPC for hazmat rescues.

It should be noted that the levels of protection (A, B, C, D) outlined in CFR 1910.120 are design standards, not performance standards. In contrast, NFPA standards are performance-based, and they influenced the FDNY's decision to upgrade its CPC program.

NOTE: It should be pointed out that the levels of protection are not actually mandated in the standard. The levels of protection are in a non-mandatory appendix. The actual standard requires a totally encapsulating chemical protective suit and does not refer to level A as a requirement. Also, NFPA 1991 has some required testing for PPE similar to that discussed in appendix B of 1910.120.

NFPA standards that are applicable to this discussion include the following:

NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting

NFPA 1991: Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies

In 2007, NFPA 1994, Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents, was released. This standard parallels the rescue mission of FDNY's tiered-response system. Because of this standard, as well as innovations that were occurring at the time, the department further evaluated its hazmat equipment and tactics, with the following objectives:

Increase department response capabilities with mission-specific protection; Improve responder safety; Decrease physical impact on responders; As a result, two garments were selected for inclusion in the department's CPC program.

The Trelleborg Trellchem VPS Flash Suit was selected as an upgraded and improved Level A suit for mitigation missions performed by Hazmat Company 1 and Hazmat Technician II units.

Performance improvements include the following:

- It meets the optional flash-fire standard in NFPA 1991
- No over-garment yields a 7.3-pound weight savings, which decreases physical strain
- Anti-fog hard-impact visor increases safety by improving vision

- Improved dexterity
- Streamlined suit material does not require the use of oversized boots

The VPS Flash Suit improves safety and decreases the demands placed on hazmat technicians. Mitigation missions often require fine motor skills to make repairs; consequently, improvements in vision and dexterity increase the chance of a successful response using one entry team.

In addition, the Lion MT-94 was selected for rescue missions within the Hot Zone.

Performance improvements compared with the legacy Level A suits include the following: A 3- to 4-minute donning time, which improves the time-to-victim contact; visibility is not an issue due to the non-encapsulating design; a glove system that provides superior dexterity and protection; a substantial reduction in heat stress and physical demand on the first responder; and enhanced garment durability.

The MT-94 is a non-encapsulated, gas/vapor-tight garment that is 13 pounds lighter than the previous Level A suit. The substantial improvements in decreasing heat stress are due in large measure to the garment's unique material, W.L Gore's Chempak fabric, that was developed in response to military and first responder requests for a lightweight, highly mobile and durable garment for use in chemical and biological incident response. The fabric sandwiches a protective barrier between two layers of Nomex fabric. Reduced heat generation was achieved primarily through the dramatically decreased weight of the garment, but also by increasing its flexibility compared with the Level A suit. Heat stress can be reduced further by wetting the garment with water.

Technical Note: Even though the use of water will help reduce heat stress, it is NOT recommended for those entering an ammonia release. The high solubility of ammonia into water will bring on significant skin irritation. Those entering ammonia vapors should remain as dry as possible.

A combination of conductive and evaporative cooling occurs when the garment is wetted, which decreases the thermal load on the responder. In turn, reducing heat stress and physical exertion decreases air consumption. So, the responder can remain safely in the Hot Zone for longer periods. In training exercises, the department has seen a marked increase in the number of extractions a CPC team can complete before members deplete their air supplies. Moreover, the garment's improved durability has allowed an expansion of tactical areas of operations to include incidents that were considered too damaging to the Level A suit, e.g., collapsed debris areas. Finally, the MT-94 also can be utilized by a rapid-intervention team to respond to injured members of a mitigation team."

Technical Note: There are many choices in materials and PPE ensemble protection available for emergency responders. The employer should work with hazmat PPE vendors to make sure their PPE decision based upon the OSHA safety expectations as summarized below:

- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** H
- ***Subpart Title:*** *Hazardous Materials*
- ***Standard Number:*** *1910.120 App B*
- ***Title:*** *General description and discussion of the levels of protection and protective gear.*

As required by the standard, PPE must be selected which will protect employees from the specific hazards which they are likely to encounter during their work on-site.

Selection of the appropriate PPE is a complex process which should take into consideration a variety of factors. Key factors involved in this process are identification of the hazards, or suspected hazards; their routes of potential hazard to employees (inhalation, skin absorption, ingestion, and eye or skin contact); and the performance of the PPE materials (and seams) in providing a barrier to these hazards. The amount of protection provided by PPE is material-hazard specific. That is, protective equipment

materials will protect well against some hazardous substances and poorly, or not at all, against others. In many instances, protective equipment materials cannot be found which will provide continuous protection from the particular hazardous substance. In these cases the breakthrough time of the protective material should exceed the work durations.

Other factors in this selection process to be considered are matching the PPE to the employee's work requirements and task-specific conditions. The durability of PPE materials, such as tear strength and seam strength, should be considered in relation to the employee's tasks. The effects of PPE in relation to heat stress and task duration are a factor in selecting and using PPE. In some cases layers of PPE may be necessary to provide sufficient protection, or to protect expensive PPE inner garments, suits or equipment.

The more that is known about the hazards at the site, the easier the job of PPE selection becomes. As more information about the hazards and conditions at the site becomes available, the site supervisor can make decisions to up-grade or down-grade the level of PPE protection to match the tasks at hand.

A Level B environment with less than 15,000 ppm of vapor would require an ensemble that would provide self-contained-breathing-apparatus compliant with National Institute for Occupational Safety and Health (NIOSH). The vapor threat will require a hooded chemical-resistant coverall and gloves that are compatible with ammonia and also withstands the permeation rate, degradation and breakthrough time needed to protect the responders. The 8 hour permeation, degradation, and breakthrough time for the chemical suit will assure a safe experience for the responder.

Permeation rate: Permeation rate is a measurement of how quickly a chemical passes through a material at the molecular level. It can be thought of as a slow leak, similar to how air seeps through plastic soda bottles and makes your soda go flat (hence the

expiration date on the bottles!). Thicker materials tend to have slower permeation rates. Permeation rates are reported differently by different manufacturers, but a higher number generally means a quicker penetration rate.

Degradation: *Degradation is the physical changes to the material caused by the chemical, which can include swelling, stiffening, wrinkling, changes in color, and other physical deterioration. The slower the degradation occurs in the presence of a chemical, the more protective the material is for that specific chemical.*

There are no standardized tests for degradation; each manufacturer generally has its own test.

Penetration *is the movement of chemicals through zippers, seams, or imperfections in a protective clothing material. It is important to note that no material protects against all chemicals and combinations of chemicals, and that no currently available material is an effective barrier to any prolonged chemical exposure.*

Breakthrough time: *Breakthrough time is how much time it takes from the 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). Obviously, the greater the breakthrough time, the more protective the material is for that particular chemical.*

Breakthrough is measured using a standardized test (ASTM F739).

Reference: http://www.ca-safety.com/public/1728.cfm

As an aid in selecting suitable chemical protective clothing, it should be noted that the National Fire Protection Association (NFPA) has developed standards on chemical protective clothing. The standards that have been adopted by include:

NFPA 1991–Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies (EPA Level A Protective Clothing)

NFPA 1992–Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies (EPA Level B Protective Clothing)

NFPA 1993–Standard on Liquid Splash-Protective Suits for Non-emergency, Non-flammable Hazardous Chemical Situations (EPA Level B Protective Clothing)

These standards apply documentation and performance requirements to the manufacture of chemical protective suits. Chemical protective suits meeting these requirements are labeled as compliant with the appropriate standard. It is recommended that chemical protective suits that meet these standards be used.

Recognition of the value of the Technician-certified Incident Commander in understanding the hazards, risks, and threats prior to committing to a specific level of chemical protective clothing.

The PPE recommendations made herein are designed to protect the responder (person wearing the gear) within the specifications of the outer protective suit plus a buffer protection provided by clothing worn under the outer suit in case the responder experiences a sudden and unforeseen exposure to threats beyond what was evident when entering the Hot Zone, e.g., a small aerosol release suddenly becomes a large aerosol release (greater than 3 cubic feet) or suit damage results in a vapor leak through the outer suit.

The Incident Commander and responders must be trained Technicians to engage any offensive operation within the Hot Zone. They must have a full understanding of the hazards, risks, and threats, and they must be equipped with proper monitoring equipment to determine that entry into the Hot Zone is safely within the scope of the adopted PPE emergency response SOP(s). The Hot Zone hazards, risks, and threats

may be pre-defined in a Hazard Zone Checklist that is included in the emergency plan, or within an ICS 215A form and/or an ICS 208 form that defines hazards and mitigations for the hazards within the Hot Zone BEFORE entry is allowed by the responders.

Hazard Zone Disclaimer: The PPE recommendations defined within this document are NOT intended to cover a circumstance in which the responder is entering a Hot Zone that involves an out-of-control aerosol release that is developing into a dense gas cloud (greater than three cubic feet) and is moving towards a source of ignition, or spreading at a rate that will place responder(s) at an uncertain level of risk. An out-of-control aerosol stream may have the potential to transition into a highly flammable and extremely cold environment within several minutes. This would require the highest level of PPE with a fully encapsulated entry suit, flash-fire protection, and thermal insulated clothing and gloves that resist damage at temperatures as low as -80°F. Entry into an atmosphere that threatens to transition to this type of circumstance is NOT within the scope of the PPE recommendations provided herein.

Identification of the hazards or suspected hazards: The Incident Commander and entry team members who engage action within the “hot” zone must be trained as hazmat technicians (24 hour with 8 hour annual tech-refresher training complying with 1910.120q requirements). The training will include the ability to understand the hazards, risks, and threats associated with entering a “hot zone” during release situations.

Understanding the regulatory conditions that set the standard for how chemical protective clothing is selected and utilized during an emergency event (see Appendix C for more regulatory details regarding OSHA PPE requirements)

OSHA 1910.120 Appendix B (non-mandatory appendix) – definition of Level B

II. Level B–The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

The following constitute Level B equipment; it may be used as appropriate.

1. Positive pressure, full-face piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls–Optional as applicable

NOTE: When working in 15,000 PPM of ammonia vapor ASTI recommends that either a 100% cotton or fire resistant coverall be required for under-clothing for a One-Piece chemical vapor protective over-suit meeting similar specifications as the Lakeland ChemMax3

4. Gloves, outer, chemical-resistant
5. Gloves, inner, chemical-resistant
6. Boots, outer, chemical-resistant steel toe and shank
7. Boot-covers, outer, chemical-resistant (disposable)–Optional as applicable
8. Hard hat – Optional as applicable
9. [Reserved]
10. Face shield–Optional as applicable

The elements of the PPE Program (29CFR 1910.120 (g) (5)

PPE selection based upon site hazards: Pre-Entry Hazard Analysis to enter an atmosphere above the PEL and for entry into a Hot Zone

Selection of the proper PPE ensemble to meet the hazards, risks, and threats existing in the Hot Zone

Buddy system and PPE readiness review of entry Incident Action Plan objectives, Safety Plan, and a review of emergency communications. The physical and mental readiness, as well as hydration, of the entry team to enter the Hot Zone is also a priority.

IC approval to enter the Hot Zone with an Incident Action Plan describing the entry objective(s) designed to be accomplished within 10 minutes of entry time (or in a timeframe consistent with air bottle time and personnel readiness training limits); and IC or Safety Officer monitoring of on-air time while in the Hot Zone, and clarification of the Safety Plan to include a review of the hand signals and other means of communications prior to entry

While in the Hot Zone

Visual, verbal, and/or tag line communications between Entry Team, Back-Up, and the Incident Commander

Decon, medical evaluation, and rehab (hydration) upon leaving the Hot Zone

Pre- and post-entry briefing: Prior to entry into the Hot Zone, the Incident Commander must be assured that the Entry Team is briefed as defined in the PPE standard of operation.

Work mission duration: The work mission will be defined within an Incident Action Plan approved for implementation by the Incident Commander. The entry time will be monitored, especially for on-air time (SCBA). The maximum working time within the Hot Zone must be 15 minutes or less. The work mission will be described, assuring that the dexterity and construction of the PPE entry suit is within safe standards to minimize damage to the suit.

PPE Procedures not discussed in this document: The code requirements that govern the use of PPE during a hazmat emergency are clearly defined within the 29 CFR 1910.120 requirements and within the state-adopted safety requirements that fulfill the OSHA requirements in 1910.120. The following is a list of the subject matter NOT specifically covered within this document:

- PPE maintenance and storage
- PPE decontamination and disposal
- PPE training and proper fitting
- PPE donning and doffing procedures
- PPE inspection procedures
- Evaluation of program effectiveness
- Limitation due to external or medical conditions
- 1910.134 Respiratory program requirements

IV. Conclusions from the Data

The strongest argument for changing the interpretation that limits the use of Level B ensemble is that the interpretation is not consistent with the wording of the standard. 1910.120(g)(3)(iv) states "Totally-encapsulating chemical protective suits (protection equivalent to Level A protection as recommended in Appendix B) shall be used in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape." All of the evidence, including the evidence from the

Patty book, stated that exposure results in mild cutaneous irritation, which does not constitute a substantial possibility of IDLH, immediate serious illness or impairment of ability to escape.

The threats associated with an ammonia vapor release (under 15,000 PPM) are predominantly inhalation threats rather than skin damage. The utilization of Level B PPE and, to a lesser degree, fire turnouts or coveralls with self-contained breathing apparatus is a reasonable alternative to Level A fully encapsulated suits when working exclusively in ammonia vapor for short durations of time (under 10 to 15 minutes per entry).

The following is a summary of the findings that support ASTI's desire to define a safer PPE alternative to using Level A PPE for working in atmospheres less than 15,000 PPM of anhydrous ammonia vapor.

> Reducing the stress associated with PPE suit-up by allowing the use of a Level B ensemble to enter low-level vapor (under 15,000 PPM of ammonia) will encourage more employers to allow their response teams to engage emergency response objectives needed for the first 30 minutes of an emergency event. The need for rapid entry rescue, defensive mitigation of the emergency event, and ability to perform reconnaissance to secure the information needed to plan a longer-term response strategy occurs during the first 30 minutes. The overall risks and threats that materialize in the first 30 minutes can be quickly and effectively mitigated using a Level B ensemble to contain and control an emergency event that might otherwise increase to higher concentrations and a greater level of risk and threat to responders and downwind receptors.
>
> The assumption that most employers use a Level A response team is incorrect. The trend for employers who work with ammonia has been to drop all emergency response that requires an offensive strategy and, instead, count on public safety to engage hazmat response teams to contain and control

an emergency event. Also, rural public response organizations may rely on volunteers or may have mutual aid agreements that could result in the response organization being otherwise engaged when the emergency response occurs. Many public agency responders do NOT have a Level A, Technician-trained response team immediately available. They may count on a regional response team that takes more than an hour to become operationally available.

The life threat and damage from an unattended ammonia emergency can be mitigated if employers are given a more realistic PPE emergency response plan option to engage offensively to contain and control an ammonia release during the first thirty minutes.

The discomfort and lack of peripheral vision adds to the stress associated when wearing Level A ensemble. The Level A ensemble also results in higher threat for heat stress, physical and psychological stress, and impaired vision, mobility, and inability to communicate than does a Level B ensemble.

OSHA Technical Manual (OTM) Section VIII: Chapter 1 – I. INTRODUCTION (SECTION C.)

It is important that protective clothing users realize that no single combination of protective equipment and clothing is capable of protecting you against all hazards. Thus protective clothing should be used in conjunction with other protective methods. For example, engineering or administrative controls to limit chemical contact with personnel should always be considered as an alternative measure for preventing chemical exposure. The use of protective clothing can itself create significant wearer hazards, such as heat stress, physical and psychological stress, in addition to impaired vision, mobility, and communication. In general, the greater the level of chemical protective clothing, the greater the associated risks. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. Overprotection as well as under-protection can be hazardous and should be avoided.

ASTI recommends that a Pre-Emergency Readiness Checklist and a Hazard Zone Checklist (provided as an appendix to this document) be created for every facility using anhydrous ammonia. This information helps define the level of PPE engagement using a faster and more accurate hazard analysis. The pre-arranged hazard analysis provided within the Pre-Emergency and Hazard Zone checklists defines the hazards, risks, and threats, as well as the defensive measures used to reduce the impact of the ammonia release.

There are seven hazard scenarios that the SOP for entering any atmosphere above PEL (Permissible Exposure Level), Isolation Zone, or Hot Zone must address:

Defensive action in atmospheres less than IDLH and greater than PEL: Evaluate and prepare for the hazards, risks, and threats associated with entry into the Hazard Zone by reviewing the Pre-Emergency Readiness Checklist and/or the Hazard Zone Checklist provided in the Emergency Plan, or develop an ICS 215A Hazard Analysis.

Engaging in command and support functions: Those conducting command assignments on the outer perimeter of the Isolation Zone or Protective Action Zone may experience an occasional shift of vapor and may need an escape hood or APR. Levels of ammonia may temporarily exceed the IDLH. This could also happen to those performing decontamination on a person who has aerosol or liquid burns.

Those trapped in an ammonia-contaminated environment may use an escape hood to move through ammonia vapor that exceeds the IDLH limits. ASTI recommends that a person should not escape through a dense gas cloud of ammonia without the highest level of respiratory protection.

Incidental control of an emergency event as defined by OSHA limits: The definition of Incidental control is provided in the Definitions section of this document.

Entry into the Hot Zone for levels of risk above the IDLH: The Incident Commander and Entry team must be Technician trained. They will conduct a pre-entry briefing to assure that the Incident Action Plan (IAP) and Safety Plan address the acknowledged hazards and risks. The Hazard Zone Checklist, ICS 215A, and/or ICS 208 may be used to support the IAP. The Entry Team must be supported by back-up, decontamination set-up, and rehab support. On-air time must be monitored by the IC or Safety Officer.

Entry to perform reconnaissance and hazard assessment: Responders may not have all the evidence needed to properly judge the Hot Zone and will need to enter to assess the conditions before initiating containment and control measures, other than incidental control, on the way to and from the Hot Zone. Entry into IDLH conditions requires the same level of oversight as described in the previous bullet statement.

Entries for Rapid Extrication "grab and go" Rescue: Rescuing a person who is down within the Hot Zone is the most challenging response protocol for the employer to create. The first steps of the rescue will require a hazard assessment. Those participating in Rapid Extrication Rescue must be trained on how to perform the rescue evolution. The options for rescue include: defensive measures (reduce risk by managing the release using mitigations), placement of a portable fan to move the ammonia vapor away from the rescue victim, entry to supply the victim with PPE to survive the exposure, and entry to remove the victim from the Hot Zone.

Potential exposure, e.g., inhalation, ingestion, and skin absorption: Ammonia vapor presents a high level of respiratory threat and a reduced level of concern for skin damage, especially at exposure levels of 10,000 PPM or less (based upon the conditions defined in PPE Parameters and Limitations prescribed by ASTI and described within this document). The OSHA standard is clear that the transition from APR (Air Purifying Respiratory) to SCBA occurs at the IDLH of 300 PPM.

Inhalation Hazard: The hazards of vapor exposure of 15,000 PPM or less represent a respiratory threat that can be mitigated with the proper respiratory equipment. A Self-Contained Breathing Apparatus (SCBA) is required at levels above the IDLH (300 PPM). The need for thermal (cold temperature) protection (e.g., Level A encapsulated suit) of an SCBA would become vital when an aerosol cloud is present and/or levels of ammonia contained within a room are approximately 30,000 PPM or greater.

Ingestion Hazard: The full-face mask APR or SCBA will provide adequate protection from the threat of ingesting ammonia. There will be no other details provided to address ingestion of ammonia because the PPE SOP begins with the mandatory use of an APR or SCBA to mitigate this threat.

Skin Absorption: Exposure to ammonia vapor has been characterized in the 1991 OSHA Interpretation Letter as being “mild irritation” at 10,000 PPM and a “stinging sensation” at 30,000 PPM. ASTI has conducted live ammonia PPE testing that confirms that assessment.

ASTI conducted a data search for medical reports and specific medical findings regarding skin tissue burns associated with exposure to anhydrous ammonia vapor. The conclusions of the medical advisors[1] who were consulted reveal that there is little or no medical evidence in recent history of serious injury due to exposure to ammonia vapor in atmospheres less than 15,000 PPM. There is plenty of medical evidence of inhalation injury and thermal/chemical burns associated with exposure to aerosol stream and liquid ammonia exposure.

[1] Dr. Steve Curry, MD, FACMT, FAACT, is the Director of the Department of Medical Toxicology, Banner Good Samaritan Medical Center, and is an experienced lecturer about the toxic effects of ammonia. He is the medical advisor for the Phoenix Fire Department.

Timothy Brady, Ph.D., FACHE, FHFMA, is the Regional Inspector General at the US Department of Health and Human Services in San Francisco, California, and is a 20-year supporter of ASTI training. Dr. Brady has repeatedly presented on the health risks associated with ammonia at Safety Day presentations for many thousands of end-users, public safety personnel, and regulators of anhydrous ammonia.

Dr. Paul Nony, Senior Toxicologist from the Center for Toxicological and Environmental Health, is an experienced emergency responder to major events involving toxic inhalation gases. Dr. Nony is a respected speaker at hazmat conferences and has worked with ASTI for the last five years.

Richard A. Nickle, Agency for Toxic Substances and Disease Registry (ATSDR), performed a data search for medical reports on injury related to exposure to anhydrous ammonia vapor. This search revealed no technical data that would clarify the levels of exposures to ammonia vapor.

Dr. Shelley DuTeaux, Emergency Services Coordinator for the Office of Emergency Response, California Air Resources Board. Dr. DuTeaux provides toxicological and health-based technical support to incident command, local air districts, and state agencies during major toxic air releases and other emergencies with air quality impacts. She has been a featured speaker at Ammonia Safety Day training in Salinas, CA, and Phoenix, AZ.

The following chemical vapor protective clothing criteria for working within atmospheres of ammonia vapor should apply:

- Maximum of 15,000 PPM exposure with Level B one-piece chemical vapor protective splash suit similar in design to the Lakeland ChemMax 3 (numerous other manufacturers have similar designs such as Kappler, Tychem/ Dupont, etc)
- 100% cotton or fire-resistive coverall under-clothing,
- Sealed chemical splash suit cuffs to the gloves and ankle connections to the boots.
- Nomex or 100% cotton hood located under the chemical coverall hood
- SCBA
- Gloves, inner and outer, chemical-resistant
- Boots, outer, chemical-resistant steel toe and shank or boot-covers, outer, chemical-resistant (disposable)

The criteria described within this document define the conditions by which the PPE judgment can be made by the Incident Commander to consider the use of Level B CVPC at levels less than 15,000 PPM. Specific situations where a Level B ensemble would be used are to perform reconnaissance to find a leak; conducting emergency shut-down and when performing emergency ventilation operations. The responder would also use the Level B ensemble to perform a rescue or to evaluate plume movement in and around buildings located in the hot zone.

When working on a leaking cylinder or tank located outside or in a well-ventilated room, the Level B ensemble may be used to place a tarp over the release as long as the responders stay out of the dense gas. A portable ventilation fan is helpful in directing ammonia vapor away from the responders.

V. ASTI Board Recommendation

ASTI has provided evidence and related experiences that show that alternative levels of PPE (other than Level A) provide protection to the responder and an overall improvement of the health and safety concerns, especially when the risks and threats of wearing Level A ensembles are considered. Level B provides more comfort, mobility, faster ability to don/doff the suit and to change SCBA air bottles, and less stress and physical strain on the emergency responder.

The availability of the use of Level B PPE as described within this document will provide first responders with the ability to engage rapid entry rescue, a defensive mitigation strategy, and control small releases before they have time to develop into major life threatening events.

Technical Report Author

The principle author of this Technical Paper is Gary W. Smith, President of the Ammonia Safety and Training Institute (831-288-0576). Gary has spent 42 years in the emergency management business: 33 of those years were in the fire service, with 20 years as a fire chief. For the last 10 years he has been the President of the Ammonia Safety and Training Institute (ASTI), a non-profit organization that Doug Hill, President of Hill Brothers Chemical, and he created in 1987. The ASTI team is dedicated to making ammonia the most safely managed hazardous material in the world. ASTI continues to work on ways to accurately portray the hazards, risks, and threats of ammonia and to educate public safety and end-user emergency responders on how to properly manage an emergency event using the One Plan.

Technical experts that have observed ASTI work on Level B PPE ensembles:

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Kyle Kebrow, Western Regional Director, Lakeland Industries; manufacturers of the Lakeland ChemMax 3 used as a Level B ensemble as described within this Technical Paper

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Appendix A: Hazard Analysis and Pre-Entry Readiness

ONE PLAN PRE-EMERGENCY READINESS www.ammonia-safety.org (831) 761-2935

PRE-EMERGENCY: Odor Investigation, Line Break, and High Risk Maintenance/Service

PROJECT TEAM: Pre-assign the team members (red print).

Date:_____Time:_____Project Objective: _____

☐ **Lead Responder:** _____ ☐ **Plant IC:** _____

☐ **Evacuation Lead:** _____ ☐ **Notification:** _____

☐ **Production Control Supervisor:** _____ ☐ **Access Control Officer:** _____

PERSONAL PROTECTIVE EQUIPMENT: Check boxes for the appropriate Safety and PPE.

☐ APR ☐ SCBA ☐ Radio ☐ Handheld or lapel monitor ☐ Nomex hood ☐ Valve wrench ☐ Flashlight
☐ Hard hat ☐ Fan ☐ Hearing protection ☐ Gloves ☐ Cotton or fire–resistive overalls ☐ Containment tarp
☐ Identification vest ☐ Safety boots ☐ Chemical suit ☐ Hand tools ☐ Arc-flash protection

REPAIR READINESS: Review each box with the project team.

☐ Review Hazard Zone Checklist ☐ Review P&ID and SOPs ☐ Digital pictures ☐ Lock out tag out
☐ Hot works permit ☐ Confined space permit ☐ Define Isolation Zone and Post Hot Zone ☐ Fall Protection
☐ Eye-level wind ☐ Exitways clear ☐ Use "buddy system" ☐ Verify contractor readiness
☐ Identify most appropriate shower/eye wash ☐ Review 30-Minute Plan ☐ Other: _____

DISCOVERY ACTIONS In the First Five Minutes—Engage LANCE

Life Safety: Call out, move out of Hot Zone, and set Isolation Zone!

Alert and Alarm: What is the problem? *(reference boxes below)* _____

☐ Fire ☐ Release (liquid, vapor, dense gas, aerosol) ☐ Overpressure (PSI gauge) ☐ Rescue
☐ Injury—fall, chemical exposure, burns, cardiac, heat stress, other: _____

Where is the problem? *(building location/component)* _____

Level of Concern

☐ 1. Incidental/Small ☐ 2. Contained but not controlled ☐ 3. Out of control

Notify: Plant IC assigns Notification Leader and gives response route and command post location:

☐ 9-1-1, LEPC _____, SERC _____, NRC (800) 424-8802,

Other _____

Command/Control/Contain: Company IC move to command post and announces the following:

> "Attention, this is *(your name)*, I am assuming command of a Level *(1, 2, or 3)* emergency located at *(Hazard Zone location)*. The emergency involves *(situation)*. The Command Post will be located at *(location)*. The Emergency Response Team will meet at *(Command Post or Ops set-up area)*."

Plant IC to assign Lead Responder: engage emergency shut-down. See SIMPLE Playbook

Escape, Evacuate, or Shelter In Place (SIP): Plant IC assigns Evacuation Group Supervisor to create a movement plan (lateral/upwind) or shelter-in-place (SIP), open safe refuge location(s) and assure personnel accountability.

Initial Response: See reverse side of this clipboard.

HAZARD ZONE: MACHINE ROOM: HAZARD, RISK and THREAT FIRST AWARENESS CONCERNS: Define the first action size up concerns		
HAZARDS: Chemical and Physical Properties	**RISKS: Life, Environment, and Property**	**THREATS: Fire, Reactivity, Overpressure,**
Total NH_3 Charge: ___________#; Capacity/working amount: HPR:_____# Accumulator:____#; Flash Cooler: _____# (Other special chemical concerns)	(Risks located in the Isolation Zone)	(Risks located in the Isolation Zone)
LEVEL 1: SMALL or INCIDENTAL	**LEVEL 2: CONTAINED BUT NOT CONTROLLED**	**LEVEL 3: EMERGENCY – OUT OF CONTROL**
1. **Life: Control Isolation Zone** (100' to 300') based upon threat of the release growing 2. **Notification Leader** Pre-Authorized: Two (2) Hazmat Techs mutual aid request **Plant IC approval** for the following: Courtesy call to receptor within IZ Regional Manager – Plans Section Chief Contractor: Fire department for back-up 3. **Control/Contain:** Pre-Emergency Readiness; tarp, close doors, or redirect with portable fan 4. **Evacuation** Group Supervisor on stand-by; determine wind movement and establish access controls to/from Isolation Zone for non-essential personnel	1. **Life: Control Isolation Zone** (100' to 500') based upon threat of the release growing 2. **Notification Leader** Decide which of the following are Pre-Authorized or require Plant IC Approval: Notify 9-1-1 and Americold Regional Manager Plans Section Chief Regulator notification: Local, State and/or Federal Number of Hazmat Techs requested by mutual aid and where they will be called from Courtesy call to receptor within IZ Regional Manager – Plans Section Chief Contractor: Fire department for back-up 3. **Control/Contain:** Emergency Shut-down (backside of this form), tarp, close doors, or redirect with portable fan 4. **Evacuation** Same as Level I plus organize safe movement to the Safe Refuge location or if blocked by vapor move laterally and upwind; head count and personnel tracking	1. **Life: Set Isolation Zone** (100' to 1,000') based upon threat of the anticipated spread of the release 2. **Notification Leader** Decide which of the following are Pre-Authorized or require Plant IC Approval: Notify 9-1-1 and Americold Regional Manager Plans Section Chief Regulator notification: Local, State and/or Federal Number of Hazmat Techs requested by mutual aid and where they will be called from Courtesy call to receptor within IZ Regional Manager – Plans Section Chief Contractor: Fire department for back-up 3. **Control/Contain:** Emergency Shut-down (backside of this form), tarp, close doors, dilute or redirect with portable fan 4. **Evacuation** Same as Level I and II plus consider the need for evacuation, shelter-in-place and/or movement to safe refuge

HAZARD ZONE FIRE CONTROL	SIMPLE Playbook Pgs.
1. Location of Fire Control and Emergency Power Systems: Fire extinguisher, fire sprinkler control valves, master water control, fire pump(s), emergency power	**1.**
2. Building Construction: Access and exit, fire wall location, roof access and ventilation opportunities, hazard zone locations, roof and building structural integrity, roof drainage, high weight concerns, other hazards, risks, or threats	**2.**
3. Fire Spread Concerns: Wall insulation, stored pallets, combustible/flammable liquids, stored product flammability, smoke and heat movement	**3.**
4. Ventilation Options: Entry/exit ventilation options, roof and wall emergency access options (cut-out options)	**4.**
5. Emergency Command Center (ECC): Building plans, site map, fire sprinkler plan, monitoring system plans, site drainage plan, roof structure	**5.**
6. Ammonia Pump Down: Procedure described in DEFENSIVE ACTION OBJECTIVE (above)	**6.**

DEFENSIVE ACTION OBJECTIVES: SOURCES OF IGNITION, ISOLATION, PUMP DOWN, and MANAGEMENT OF PRESSURE	SIMPLE Playbook Pgs.
1. Control sources of ignition: When NH_3 vapor is above 20,000 PPM or a visible cloud of ammonia is forming	1.
a. Turn on exhaust fans and control sources of ignition by engaging emergency shut-down and set up for fire control (fire hose line)	a)
b. Power to Motor Room: Compressor shut down at doorway; 4160 power control in parking lot electrical control panels	b)
c. Remote system control and NH_3 monitoring from Engineering Office computer and laptops	c)
2. Emergency ventilation: Engine room fan controls at entry door, portable fan located in emergency equipment storage building	2.
3. Cool the ammonia by moving/storing the high side liquid to the low side: Cross over or move around the leak site to keep the flow of ammonia moving safely	3.
4. Isolate and Pump-down leak area: Use the compressors to move the ammonia to a safe storage location (preferably an insulated vessel) Identify the location and source of the leak and choose a control option:	4.
a. When safe and immediately available isolate the release upstream and downstream (without trapping liquid)	a)
b. When unable to isolate the release, pump down by moving ammonia from the leak zone to a safer location (insulated vessel);	b)
c. Lower suction pressure set point to 5" Hg by using computer control;	c)
d. Shutdown the appropriate zone and move ammonia to safe location.	d)
e. **Exception:** Low pressure release downstream of all, or any, zone(s), including the liquid pumps; lower suction pressure set point to 0 psig or to 5" Hg, and shut off the Liquid Pumps from MCC in the Motor Room.	e)
5. Put the ammonia to sleep: Stop all heat loads that increase liquid vapor pressure; reduce the temperature of ammonia to -28°F and 0 psig	5.
a. Turn on all condenser fans	a)
b. Turn on all condenser pumps	b)
c. Set all compressors to 0 psig at the suction	c)
d. Disable all of the evaporators	d)
e. **Exception:** Shut down compressor when feeding high pressure vapor DIRECTLY to the leak site: e.g. high pressure leak is located between the compressor and the condenser; or when two-stage compressor system has a leak is between the primary and secondary compressors	e)
6. Emergency pressure management, e.g. equalizer or ammonia diffuser	6.

INCIDENT ACTION PLAN SAFETY ANALYSIS	1. Incident Name				2. Date	3. Time
Division or Group	**Potential Hazards – Likeliness and Severity**				**Mitigations (e.g., PPE, buddy system, escape routes)**	
	Type of Hazard:	Type of Hazard:	Type of Hazard:	Type of Hazard:		
Prepared by (Name and Position)						

ICS 208 - NH_3 SITE SAFETY AND CONTROL PLAN	1. Incident Name:	2. Date Prepared:	3. Operational Period: Time:

Section I. Site Information

4. Incident Location:

Section II. Organization

5. Incident Commander:	6. HM Group Supervisor:	7. Tech. Specialist - HM Reference:
8. Safety Officer:	9. Entry Leader:	10. Site Access Control Leader:
11. Asst. Safety Officer - HM:	12. Decontamination Leader:	13. Safe Refuge Area Mgr:
14. Environmental Health:	15.	16.

17. Entry Team: (Buddy System) Name:	PPE Level:	18. HM Group Supervisor; Decontamination Element: Name:	PPE Level:
Entry 1		Decon 1	
Entry 2		Decon 2	
Entry 3		Decon 3	
Entry 4		Decon 4	

Section III. Hazard/Risk Analysis

19. Material:	Container type	Qty. #'s or gal.	Phys. State	pH	IDLH AEGL-2	F.P. and B.P.	Ign. Temp.	Vapor Pres.	Vapor Den. @ 32°F	Sp. Grav. Gas/Liquid	LEL	UEL
Anhydrous Ammonia	High/ Low Receivers, Pressure vessels, and/or cylinders		Aerosol, Dense Gas, Vapor, liquid	Aqua NH_3 11.6 -13.2	IDLH 300PPM AEGL2 220PPM	F.P -N/A B.P. -28°F	1204° f	129 psia @ 70°F	0.06 (air =1) 0.0481 lb/ft^3	Gas = 0.6 @ 32°F Liq. = 0.68 @ -28°F	15 to 16%	25 to 28%

Comment: SEE back page for summary of hazards, risks, threats, and response recommendations. Dalton's law of partial pressure establishes that an aerosol release can create temperatures as low as -80°F. The vapor expansion rate from liquid to vapor: 840:1 at standard temperature and pressure (STP) conditions of 32°F/0°C and 1 atmosphere; Approximate absorption rate of vapor to water = 1300:1. For Acute Exposure Guide Level (AEGL) - See Box 28 "Medical Monitoring." NH3 released from a refrigeration system could include combustible compressor oil that can lower the LEL to 8% or 80,000 PPM.

Section IV. Hazard Monitoring

20. LEL Instrument(s):	21. O_2 Instrument(s):
22. Toxicity/PPM Instrument(s):	23. Radiological Instrument(s):

Comment: Monitor ammonia vapor to set limits for the protective action zone, PPE requirements, evacuation movement, and personnel accountability.
Safety Plan should include reference to entry team checklist, safety checklist, decontamination, rehab, and the Technical Specialist - Planning checklist. Flammability concern starts at 1/4 of LEL (20,000 to 40,000 PPM) when the ammonia vapor is contained within a room or confined area where sources of ignition are present.

Section V. Decontamination Procedures

24. Standard Decontamination Procedures: YES: NO:

Comment: Vapor exposure can be removed with an exhaust fan (monitor for signs of residual ammonia within clothing). Gross decontamination using water is required when the victim or responder has liquid or aerosol stream exposure that has absorbed into clothing. Use water to thaw potentially frozen clothing (could be frozen to skin tissue). If freezing is not an issue, remove clothing immediately and then flush with water for 15 to 30 minutes (depending on the depth of skin tissue burn). Eye exposure will require support to open eyelids while performing water flush. Caution: flushing with unheated tap water may cause the victim extreme discomfort and potential thermal health risk. Move the victim to a warm (60°F to 70°F) shower unit when possible and be prepared to treat for thermal shock or cardiac risk.

Section VI. Site Communications

25. Command Frequency: 26. Tactical Frequency: 27. Entry Frequency:

Section VII. Medical Assistance

28. Medical Monitoring: YES: NO: 29. Medical Treatment and Transport In Place: YES: NO:

Comment: See Box 24 regarding thermal and cardiac threat; Utilize ICS 206 Medical Plan and Entry Checklist for emergency medical and responder medical information support. Chemtrec - 800-424-9300; also see MSDS or poison control at 800-222-1222.

Acute Exposure Guideline Levels	10 min	30 min	60 min	4 hr	8 hr
AEGL 1 Not disabling	30 PPM	30	30	30	30
AEGL 2 Could be serious	220 PPM	220	160	110	110
AEGL 3 Serious injury or death imminent	2,700 PPM	1,600	1,100	550	390

Ammonia Response Procedures: Hazard, Risk, and Threat Analysis

General Description of a Release: Ammonia contained in storage vessels is made up of both liquid and gaseous forms of ammonia. The gaseous ammonia collects in the top of the tank and builds pressure in accordance with the temperature of the liquid (see vapor pressure table below). Usually, only the gaseous form is withdrawn for industrial purposes. Industrial refrigeration systems circulate liquid NH3 to absorb heat. The liquid flashes to vapor to absorb heat in the evaporator, and returns to the compressor as a vapor to become a high pressure gas. This gas transitions back to a high pressure liquid in the condenser, returning to the receiver to be pumped to the cold room evaporator. When the release point involves liquid under pressure, a sub-zero temperature aerosol that changes to a heavier-than-air dense gas cloud will roll along at ground level until ambient air thins it out and vaporizes it to the atmosphere. Ammonia is caustic and will create a high pH when mixed with water.

A. Hazard Information: Pungent odor; aerosol and dense gas may look white because of condensation in the air

   1. Ammonia vaporizes at room temperature. It boils at -28°F, has a liquid to vapor expansion rate of 1:840, and a vapor density of 0.07 (air = 1). Aerosol streams and dense gas clouds are extremely cold and will lay low until heated with ambient air.

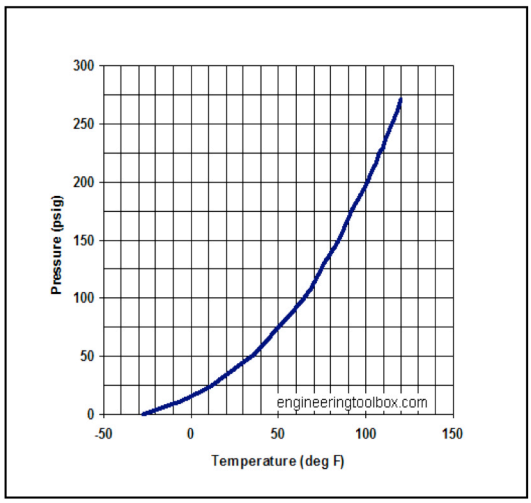
2. CAS Registry No. 7664-41-7 and UN# 1005

3. NH_3 produces a relatively violent reaction with fluorine, chlorine, bromine, and iodine, especially when liquid or dense gas mix.

4. Ammonia is a base that reacts exothermically when mixing in water and with all acids, and has a 1:1300 water to vapor absorption rate.

5. Ammonia is soluble in water (generates heat), creating ammonium hydroxide. Aqua solutions of ammonia will kill fish due to O_2 depletion.

6. Vapor Pressure PSIG (PSIA = add atmospheric pressure to PSIG)



B. Risk: Life, Environment, Facility/Equipment

1. DOT label–NON-FLAMMABLE GAS–inhalation hazard

2. Toxic gas irritates the respiratory system and damages skin tissue. Emergency medical care includes oxygen therapy for respiratory injury and at least 15 minutes of flushing with water to reduce impact of eye injury and for skin damage exposure.

3. Contain contaminated solutions and do not allow entry into storm drain system or to a live body of water.

C. Threats: Fire, Overpressure, Release

1. Anhydrous ammonia contained within a room or confined area has flash fire potential when mixtures reach 15%-28%. Industrial refrigeration systems use compressor oil that may reduce the LEL significantly.

2. Cylinders may burst when exposed to elevated temperatures (partially full cylinders are higher risks than full or completely empty vessels). Minimum evacuation distances are 500 feet for a small cylinder (125#) to 2,000 feet for a large vessel (500 gallon).

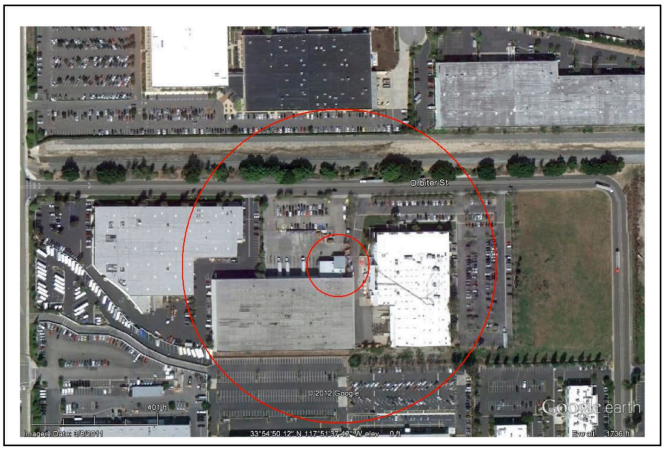
3. Evacuees that are sheltered-in-place with controls on outdoor air ventilation are usually safer from the impact of dense gas and explosion than those who escape through dangerous levels (above AEGL 2) of vapor.

D. Response and Decontamination

Approach upwind with SCBA and appropriate PPE (fire turnouts Level B). Response threat increases (higher concern for skin damage) as the level of ammonia vapor exceeds 5,000 to 10,000 PPM. Always wear fully encapsulated entry suits (level A) when working in or near dense gas and aerosol releases. Cover or contain the release until the source can be controlled; reduce pressure, if possible, by venting gas (not aerosol or liquid). Avoid applying water to liquid or aerosol/dense gas release. Water can be used to contain vapor (ahead of the dense gas cloud) while protecting downwind escape. Ventilation fans help move and dissipate vapor and are helpful in decontaminating those who have been exposed to vapor. Flush with water for aerosol or liquid exposure, being cautious with frozen clothing attached to skin: thaw before removing clothing.

Section VIII. Site Map

30. Site Map: use Field Operations Guide for a reference. Diagram the release pattern: fanning (stable - warming on the rise), conning (normal slow cooling on the rise), looping (unstable - fast cooling on the rise) and the downwind pattern (Isolation Zone and Protective Action Zone). High wind speed (>12 mph) causes faster diffusion of gas plume than low wind speed (<6 mph); cold and wet = low cloud and longer time for plume diffusion.



Toxic Inhalation Hazard (2008 DOT ERG)

ID# Material	SMALL SPILL First ISOLATE (feet)	Protect Downwind (miles) Day	Protect Downwind (miles) Night	LARGE SPILL First ISOLATE Feet	Protect Downwind (miles) Day	Protect Downwind (miles) Night
1005 Ammonia	100	0.1	0.1	500	0.5	1.4
1017 Chlorine	200	0.3	1.0	2,000	2.2	5.0
1052 Hydrogen Fluoride	100	0.1	0.3	1,000	1.1	2.2
1079 Sulfur Dioxide	200	0.2	0.7	1,250	1.3	3.6
2188 Arsine	600	0.7	2.5	3,000	4.4	9.5

Define the Hot Zone, Initial Isolation Zone, Command Post location, staging area, control zones, evacuation gathering points, escape routes, etc.

Section IX. Entry Objectives

31. Entry objectives:

Section X. SOPs and Safe Work Practices

32. Modifications to documented SOPs or work practices: ☐ YES ☐ NO
Comment:

Section XI. Emergency Procedures

33. Emergency Procedures:

Section XII. Safety Briefing

34. Asst. Safety Officer - Hazmat Signature: Safety Briefing Completion Time:
Comments:

35. Hazmat Group Supervisor Signature:	36. Incident Commander Signature:
Comments:	Comments:

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Appendix B: Selected Federal OSHA regulations on PPE cited from 1910.120 (q)

OSHA Personal protective equipment selection.

1910.120(g)(3)(i)
Personal protective equipment (PPE) shall be selected and used which will protect employees from the hazards and potential hazards they are likely to encounter as identified during the site characterization and analysis.

1910.120(g)(3)(ii)
Personal protective equipment selection shall be based on an evaluation of the performance characteristics of the PPE relative to the requirements and limitations of the site, the task-specific conditions and duration, and the hazards and potential hazards identified at the site.

1910.120(g)(3)(iii)
Positive pressure self-contained breathing apparatus, or positive pressure air-line respirators equipped with an escape air supply shall be used when chemical exposure levels present will create a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.

1910.120(g)(3)(iv)
Totally-encapsulating chemical protective suits (protection equivalent to Level A protection as recommended in Appendix B) shall be used in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.

1910.120(g)(3)(v)
The level of protection provided by PPE selection shall be increased when additional information or site conditions show that increased protection is necessary to reduce

employee exposures below permissible exposure limits and published exposure levels for hazardous substances and health hazards. (See Appendix B for guidance on selecting PPE ensembles.)

NOTE TO PARAGRAPH (g)(3): The level of employee protection provided may be decreased when additional information or site conditions show that decreased protection will not result in hazardous exposures to employees.

1910.120(g)(3)(vi)
Personal protective equipment shall be selected and used to meet the requirements of 29 CFR Part 1910, Subpart I, and additional requirements specified in this section.

1910.120(g)(4)
Totally-encapsulating chemical protective suits.

1910.120(g)(4)(i)
Totally-encapsulating suits shall protect employees from the particular hazards which are identified during site characterization and analysis.

1910.120(g)(4)(ii)
Totally-encapsulating suits shall be capable of maintaining positive air pressure. (See Appendix A for a test method which may be used to evaluate this requirement.)

1910.120(g)(4)(iii)
Totally-encapsulating suits shall be capable of preventing inward test gas leakage of more than 0.5 percent. (See Appendix A for a test method which may be used to evaluate this requirement.)

1910.120(g)(5)
Personal protective equipment (PPE) program. A personal protective equipment program, which is part of the employer's safety and health program required in

paragraph (b) of this section or required in paragraph (p)(1) of this section and which is also a part of the site-specific safety and health plan shall be established. The PPE program shall address the elements listed below. When elements, such as donning and doffing procedures, are provided by the manufacturer of a piece of equipment and are attached to the plan, they need not be rewritten into the plan as long as they adequately address the procedure or element.

1910.120(g)(5)(i)
PPE selection based upon site hazards,

1910.120(g)(5)(ii)
PPE use and limitations of the equipment,

1910.120(g)(5)(iii)
Work mission duration,

1910.120(g)(5)(iv)
PPE maintenance and storage,

1910.120(g)(5)(v)
PPE decontamination and disposal,

1910.120(g)(5)(vi)
PPE training and proper fitting,

1910.120(g)(5)(vii)
PPE donning and doffing procedures,

1910.120(g)(5)(viii)
PPE inspection procedures prior to, during, and after use,

1910.120(g)(5)(ix)
Evaluation of the effectiveness of the PPE program, and

1910.120(g)(5)(x)
Limitations during temperature extremes, heat stress, and other appropriate medical considerations.

1910.120(h)
Monitoring. —

1910.120(h)(1)
General.

1910.120(h)(1)(i)
Monitoring shall be performed in accordance with this paragraph where there may be a question of employee exposure to hazardous concentrations of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment so that employees are not exposed to levels which exceed permissible exposure limits, or published exposure levels if there are no permissible exposure limits, for hazardous substances.

1910.120(h)(1)(ii)
Air monitoring shall be used to identify and quantify airborne levels of hazardous substances and safety and health hazards in order to determine the appropriate level of employee protection needed on site.

1910.120(h)(2)
Initial entry. Upon initial entry, representative air monitoring shall be conducted to identify any IDLH condition, exposure over permissible exposure limits or published exposure levels, exposure over a radioactive material's dose limits or other dangerous

condition such as the presence of flammable atmospheres, oxygen-deficient environments.

1910.120(h)(3)
Periodic monitoring. Periodic monitoring shall be conducted when the possibility of an IDLH condition or flammable atmosphere has developed or when there is indication that exposures may have risen over permissible exposure limits or published exposure levels since prior monitoring. Situations where it shall be considered whether the possibility that exposures have risen are as follows:

1910.120(h)(3)(i)
When work begins on a different portion of the site.

1910.120(h)(3)(ii)
When contaminants other than those previously identified are being handled.

1910.120(h)(3)(iii)
When a different type of operation is initiated (e.g., drum opening as opposed to exploratory well drilling.)

1910.120(h)(3)(iv)
When employees are handling leaking drums or containers or working in areas with obvious liquid contamination (e.g., a spill or lagoon.)

1910.120(h)(4)
Monitoring of high-risk employees. After the actual clean-up phase of any hazardous waste operation commences; for example, when soil, surface water or containers are moved or disturbed; the employer shall monitor those employees likely to have the highest exposures to those hazardous substances and health hazards likely to be present above permissible exposure limits or published exposure levels by using personal sampling frequently enough to characterize employee exposures. The

employer may utilize a representative sampling approach by documenting that the employees and chemicals chosen for monitoring are based on the criteria stated in the first sentence of this paragraph. If the employees likely to have the highest exposure are over permissible exposure limits or published exposure limits, then monitoring shall continue to determine all employees likely to be above those limits. The employer may utilize a representative sampling approach by documenting that the employees and chemicals chosen for monitoring are based on the criteria stated above.

NOTE TO PARAGRAPH (h): It is not required to monitor employees engaged in site characterization operations covered by paragraph (c) of this section.

1910.120(i)
Informational programs. Employers shall develop and implement a program which is part of the employer's safety and health program required in paragraph (b) of this section to inform employees, contractors, and subcontractors (or their representative) actually engaged in hazardous waste operations of the nature, level and degree of exposure likely as a result of participation in such hazardous waste operations. Employees, contractors and subcontractors working outside of the operations part of a site are not covered by this standard.

Appendix B, Federal OSHA sets the stage with a general overview for the selection of the proper level of personal protective equipment. The employer has the right to perform a comprehensive hazard analysis that may reveal that a combination of protective gear from the various levels of protective gear outlined within Appendix B is most appropriate for a given PPE ensemble for entry into the given hazard situation. Employers must certify in writing that a workplace hazard assessment has been performed and that the recommended PPE adequately protects the employee from the hazards or the likelihood of hazards found in the contaminated work area that the employee is to enter.

Part Number:	1910
Part Title:	Occupational Safety and Health Standards
Subpart:	H
Subpart Title:	Hazardous Materials
Standard Number:	1910.120 App B
Title:	General description and discussion of the levels of protection and protective gear.

This appendix sets forth information about personal protective equipment (PPE) protection levels which may be used to assist employers in complying with the PPE requirements of this section.

As required by the standard, PPE must be selected which will protect employees from the specific hazards which they are likely to encounter during their work on-site.

Selection of the appropriate PPE is a complex process which should take into consideration a variety of factors. Key factors involved in this process are identification of the hazards, or suspected hazards; their routes of potential hazard to employees (inhalation, skin absorption, ingestion, and eye or skin contact); and the performance of the PPE materials (and seams) in providing a barrier to these hazards. The amount of protection provided by PPE is material-hazard specific. That is, protective equipment materials will protect well against some hazardous substances and poorly, or not at all, against others. In many instances, protective equipment materials cannot be found which will provide continuous protection from the particular hazardous substance. In these cases the breakthrough time of the protective material should exceed the work durations. (end of sentence deleted–FR 14074, Apr 13. 1990)

Other factors in this selection process to be considered are matching the PPE to the employee's work requirements and task-specific conditions. The durability of PPE materials, such as tear strength and seam strength, should be considered in relation

to the employee's tasks. The effects of PPE in relation to heat stress and task duration are a factor in selecting and using PPE. In some cases layers of PPE may be necessary to provide sufficient protection, or to protect expensive PPE inner garments, suits or equipment.

The more that is known about the hazards at the site, the easier the job of PPE selection becomes. As more information about the hazards and conditions at the site becomes available, the site supervisor can make decisions to up-grade or down-grade the level of PPE protection to match the tasks at hand.

The following are guidelines which an employer can use to begin the selection of the appropriate PPE. As noted above, the site information may suggest the use of combinations of PPE selected from the different protection levels (i.e., A, B, C, or D) as being more suitable to the hazards of the work. It should be cautioned that the listing below does not fully address the performance of the specific PPE material in relation to the specific hazards at the job site, and that PPE selection, evaluation and re-selection is an ongoing process until sufficient information about the hazards and PPE performance is obtained.

Part A. Personal protective equipment is divided into four categories based on the degree of protection afforded. (See Part B of this appendix for further explanation of Levels A, B, C, and D hazards.)

I. Level A–To be selected when the greatest level of skin, respiratory, and eye protection is required.

The following constitute Level A equipment; it may be used as appropriate;

1. Positive pressure, full face-piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA, approved by the National Institute for Occupational Safety and Health (NIOSH).

2. Totally-encapsulating chemical-protective suit.
3. Coveralls. (1)
4. Long underwear. (1)
5. Gloves, outer, chemical-resistant.
6. Gloves, inner, chemical-resistant.
7. Boots, chemical-resistant, steel toe and shank.
8. Hard hat (under suit). (1)
9. Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally-encapsulating suit).

(1) Optional, as applicable.

II. Level B–The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

The following constitute Level B equipment; it may be used as appropriate.

1. Positive pressure, full-face piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls. (1)
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical-resistant.
6. Boots, outer, chemical-resistant steel toe and shank.

7. Boot-covers, outer, chemical-resistant (disposable). (1)
8. Hard hat. (1)
9. [Reserved]
10. Face shield. (1)

(1) Optional, as applicable.

III. Level C–The concentration(s) and type(s) of airborne substance(s) is known and the criteria for using air purifying respirators are met.

The following constitute Level C equipment; it may be used as appropriate.

1. Full-face or half-mask, air purifying respirators (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls. (1)
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical-resistant.
6. Boots (outer), chemical-resistant steel toe and shank. (1)
7. Boot-covers, outer, chemical-resistant (disposable). (1)
8. Hard hat. (1)
9. Escape mask. (1)
10. Face shield. (1)

(1) Optional, as applicable

IV. Level D–A work uniform affording minimal protection: used for nuisance contamination only.

The following constitute Level D equipment; it may be used as appropriate:

1. Coveralls.
2. Gloves. (1)
3. Boots/shoes, chemical-resistant steel toe and shank.
4. Boots, outer, chemical-resistant (disposable). (1)
5. Safety glasses or chemical splash goggles. (1)
6. Hard hat. (1)
7. Escape mask. (1)
8. Face shield. (1)

(1) Optional, as applicable.

Part B. The types of hazards for which levels A, B, C, and D protection are appropriate are described below:

I. Level A–Level A protection should be used when:

1. The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either the measured (or potential for) high concentration of atmospheric vapors, gases, or particulates; or the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the skin,
2. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible; or

3. Operations must be conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A has not yet been determined.

II. Level B protection should be used when:

1. The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection.

2. The atmosphere contains less than 19.5 percent oxygen; or

3. The presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.

Note: This involves atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.

III. Level C–Level C protection should be used when:

1. The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin;

2. The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants; and

3. All criteria for the use of air-purifying respirators are met.

IV. Level D–Level D protection should be used when:

1. The atmosphere contains no known hazard; and

2. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Note: As stated before, combinations of personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

As an aid in selecting suitable chemical protective clothing, it should be noted that the National Fire Protection Association (NFPA) has developed standards on chemical protective clothing. The standards that have been adopted by include:

NFPA 1991–Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies (EPA Level A Protective Clothing)

NFPA 1992–Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies (EPA Level B Protective Clothing)

NFPA 1993–Standard on Liquid Splash-Protective Suits for Non-emergency, Non-flammable Hazardous Chemical Situations (EPA Level B Protective Clothing)

These standards apply documentation and performance requirements to the manufacture of chemical protective suits. Chemical protective suits meeting these requirements are labeled as compliant with the appropriate standard. It is recommended that chemical protective suits that meet these standards be used.

[59 FR 43268, Aug. 22, 1994]

Appendix C: Glossary

The following is a list of definitions selected from the **HAZWOPER Glossary http://zachry.advanceonline.com/cm/library/haz_glossary.htm and from Federal OSHA and DOT** for terms frequently used within this document to explain the parameters of the PPE standards of operation.

APR, Air-Purifying Respirator: Air-purifying respirator means a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

Buddy System: Regarding the use of buddy systems, OSHA understands the HAZWOPER standard that a buddy shall be assigned who is able to: (1) provide the partner with assistance; (2) observe the partner for signs of chemical, heat, or other hazardous exposure; (3) periodically check the integrity of the partner's personal protective equipment/clothing; and (4) if emergency help is needed, notify the appropriate individual (i.e., the Command Post Supervisor, the On-Scene Incident Commander). The standard defines a "buddy system" and "IDLH" below as:

Buddy system means a system of organizing employees into workgroups so that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

CBRN: Chemical–Biological–Radiological–Nuclear (CBRN)

CPC, Chemical Protective Clothing: The purpose of chemical protective clothing and equipment is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered during hazardous materials operations. During chemical operations, it is not always apparent when exposure occurs. Many chemicals pose invisible hazards and offer no warning properties.

CVPC: Chemical Vapor Protective Clothing – specifying the type of vapor protection provided by various PPE ensembles.

DOT: Department of Transportation

HAZWOPER: is an acronym for **Haz**ardous **W**aste **Op**erations and **E**mergency **R**esponse. It refers to many types of hazardous waste operations and emergency response conducted in the United States under Occupational Safety and Health Administration (OSHA) Standard 1910.120.

Hot Zone: Area immediately surrounding a hazardous materials incident, which extends far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the Exclusion Zone or Restricted Zone.

Incident Commander: The Incident Commander (IC) is responsible for directing and/or controlling resources by virtue of explicit legal, agency, or delegated authority. The individual responsible for the overall management of the response is called the Incident Commander. For responses under the National Response System (NRS), the pre-designated On-Scene Coordinator (OSC) generally assumes the role of Incident Commander.

The IC is responsible for all aspects of the response, including developing incident objectives and managing all incident operations. The IC sets priorities and defines the ICS organization for the particular response. Even if other positions are not assigned, the IC will always be designated.

The IC may assign deputies, who may be from the same agency, or from assisting agencies. Deputies may also be used at section and branch levels of the ICS organization. Deputies must have the same qualifications as the person for whom they work, because they must be ready to take over that position at any time.

Incident Command System Form 215a – ICS 215a: This form is used by first responders to define the hazards and risk management mitigation(s) recommendations located within the Hot Zone. (see Appendix A)

Incident Command System Form 208 – ICS 208: This form is used to prepare the Hazmat Team for Site Safety and Control. The hazards, risks, and threats are summarized, as well as the site diagram and control zone recommendations. The ASTI 30-Minute Plan can also be used to support the details needed to address the ICS 208 requirements. (See Appendix A)

Incidental Release: An incidental release is a release of a hazardous substance which does not pose a significant safety or health hazard to employees in the immediate vicinity or to the employee cleaning it up, nor does it have the potential to become an emergency within a short time frame. Incidental releases are limited in quantity, exposure potential, or toxicity, and present minor safety or health hazards to employees in the immediate work area or those assigned to clean them up. An incidental spill may be safely cleaned up by employees who are familiar with the hazards of the chemicals with which they are working.

The properties of hazardous substances, such as toxicity, volatility, flammability, explosiveness, corrosiveness, etc., as well as the particular circumstances of the release itself, such as quantity, confined space considerations, ventilation, etc., will have an impact on what employees can handle safely and what procedures should be followed. Additionally, there are other factors that may mitigate the hazards associated with a release and its remediation, such as the knowledge of the employee in the immediate work area, the response and personal protective equipment (PPE) at hand, and the pre-established standard operating procedures for responding to releases of hazardous substances. There are some engineering control measures that will mitigate the release that employees can activate to assist in controlling and stopping the release.

These considerations (properties of the hazardous substance, the circumstances of the release, and the mitigating factors in the work area) combine to define the distinction between incidental releases and releases that require an emergency response. The distinction is facility-specific and is a function of the emergency response plan.

Initial Isolation Zone (IZ) as defined by DOT: The IZ is the distance within which all persons should be considered for evacuation in all directions from the actual spill/leak source. It is a distance (radius) that defines a circle within which persons may be exposed to dangerous concentrations upwind of the source and may be exposed to life threatening concentrations downwind of the source.

IDLH (Immediately Dangerous to Life and Health): These are exposure concentrations established by NIOSH/OSHA that are likely to have an adverse effect on health. They are used as a guideline for selecting breathing equipment for some chemicals. IDLH concentrations pose an immediate threat of severe exposure to contaminants.

Note: the IDLH for ammonia is 300 PPM of vapor

One Plan: The One Plan is a federally developed Integrated Contingency Plan based upon four phases of emergency response: discovery, initial response, sustained response and termination of the emergency event. ASTI has enhanced the One Plan by providing quick guides and checklists that improve emergency responder connection to the emergency plan expectations.

OSHA: Occupational Safety and Health Administration

Personal Protective Equipment (PPE): The equipment includes all clothing and other work accessories designed to create a barrier against workplace hazards. PPE is provided to shield or isolate a person from the chemical, physical, and thermal

hazards that may be encountered at a hazardous materials incident. Adequate personal protective equipment should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. Personal protective equipment includes both personal protective clothing and respiratory protection.

Permeation of PPE: A chemical action involving the movement of chemicals, on a molecular level, through intact material

Permissible Exposure Limit (PEL): An exposure limit established by an OSHA regulatory authority. This is the 8-hour, time-weighted average or ceiling concentration above which workers may not be exposed. The use of personal protective equipment may be advisable where there is a potential for exposure.

Protective Action Zone as per DOT definition: The PAZ defines an area downwind from the incident in which persons may become incapacitated and unable to take protective action and/or incur serious or irreversible health effects.

Self-Contained Breathing Apparatus (SCBA): Federal OSHA defines SCBA to mean an atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

Standard Operating Procedure (SOP): Definition from Federal OSHA 1910.1450(e)(3)(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment, and hygiene practices. Particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous.

The 30-Minute Plan: ASTI has created a 30-Minute Plan that defines the critical steps of engaging the four phases of the One Plan beginning with Discovery, and then transitioning to Initial Response, Sustained Response, and Termination of the emergency event.