Summary of Ammonia Accidents In the United States To Which OSHA Responded

Ammonia is widely used as a refrigerant in many industrial facilities, including:

- Meat, poultry, and fish processing facilities
- Dairy and ice cream plants
- Wineries and breweries
- Fruit juice, vegetable juice, and soft drink processing facilities
- Cold storage warehouses
- Other food processing facilities
- Petrochemical facilities

The hazards posed by ammonia spills and releases are a significant threat to workers from skin contact, inhalation, and fire and explosion. As noted by the attached tables numerous accidents (and fatalities) have occurred involving the release of ammonia.

OSHA ENFORCEMENT FINDINGS - ACCIDENTS INVOLVING THE RELEASE OF AMMONIA

CALENDAR YEAR	NUMBER OF ACCIDENTS	NUMBER OF FATALITIES
2006	6	1
2005	3	0
2004	6	2
2003	6	2
2002	5	2
2001	9	3
2000	8	3
1999	8	2
1998	8	3
1997	10	1
1996	7	2
1995	10	2
1994	13	5
1993	15	4
1992	12	1
1991	14	2
1990	20	4
1989	8	1
1988	6	2
1987	9	1
1986	12	2
1985	17	1
1984	12	4
TOTAL	**224**	**50**

A key provision or compliance tool useful in protecting workers, the environment, and surrounding communities from the hazards associated with ammonia spills is contained in OSHA's process safety management rule - process hazard analysis (PHA). PHA's offer a careful review of what could go wrong and what safeguards must be implemented to prevent releases of hazardous chemicals. In addition to the process safety management regulation (29 CFR 1910.119) there are numerous OSHA rules which are applicable AND industry consensus documents.

OSHA REGULATIONS APPLICABLE TO AMMONIA

1) Section 5(a)(1) of the OSH Act, often referred to as the General Duty Clause, requires employers to "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees

2) 1910 Subpart E, Exit routes, emergency action plans, and fire prevention plans

3) 1910.38, Emergency action plans

4) 1910 Subpart H, Hazardous materials

5) 1910.119, Process safety management of highly hazardous chemicals. This standard applies to systems containing 10,000 lbs. of ammonia or greater.

6) 1910.120, Hazardous waste operations and emergency response.

7) 1910 Subpart I, Personal protective equipment. Employers are required to provide personal protective equipment to employees who may be exposed to ammonia. Employees who wear a respirator during the course of their job, or who would be expected to wear a respirator in an emergency response situation, must also follow the requirements of the respiratory protection standard.

    - 1910.132, General requirements
    - 1910.133, Eye and face protection
    - 1910.134, Respiratory protection
    - 1910.138, Hand protection

8)1910 Subpart S, Electrical

    - 1910.307, Hazardous (classified) locations. There may be locations in an ammonia refrigeration system that are Class 1 Division 2 hazardous locations.

9)1910 Subpart Z, Toxic and hazardous substances

    - 1910.1200, Hazard communication. Employers are required to communicate the hazards associated with working with ammonia to appropriate

employees.

National Consensus Standards Enforced thru Section 5a1 (General Duty Clause)

American National Standards Institute (ANSI)/International Institute of Ammonia Refrigeration (IIAR)

- *2-1992*, American National Standard for Equipment, Design and Installation of Ammonia Mechanical Refrigerating Systems. Applies to closed circuit mechanical refrigerating systems utilizing ammonia as the refrigerant. Written as a guide to the design, manufacture, installation and use of ammonia mechanical refrigerating systems and equipment in industrial occupancies. Not intended to supplant existing requirements that are more stringent than those in the standard, that authority shall prevail.
- *7-13*, Mechanical Refrigeration. Factory Mutual Property Loss Prevention Data Sheets. (1998).
- *15-1994*, Safety Code for Mechanical Refrigeration. Promotes the safe design, construction, installation, and operation of refrigerating systems. The provisions of this code are not intended to apply to the use of water as a refrigerant. Establishes reasonable safeguards of life, limb, health, and property; defines practices that are consistent with safety; and prescribes safety standards.

American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE).

- *26-1996*, Mechanical Refrigeration and Air-Conditioning Installations Aboard Ship. Provides recommendations and requirements for the safe and efficient design, construction, installation, operation, inspection, and maintenance of mechanical refrigeration equipment aboard ships.

American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE)

- *1998 Handbook - Refrigeration*. Covers the refrigeration equipment and systems used for applications other than human comfort. Includes information on cooling, freezing, and storing food; industrial applications of refrigeration; and low-temperature refrigeration. Primarily a reference for the practicing engineer, but also a useful reference for anyone involved in the cooling and storage of food products.
    - Chapter 3, System Practices for Ammonia Refrigerant
    - Chapter 6, Control of Moisture and Other Contaminants in Refrigerant Systems

American Society of Mechanical Engineers (ASME)

- *B31.5-1992*, Refrigeration Piping Code
- *Boiler and Pressure Vessel Code*
    - Section V, Nondestructive Examination
    - Section VIII, Pressure Vessels

Compressed Gas Association (CGA)

- *G-2*, Anhydrous Ammonia. (1995). Reviews the properties, physiological effects, first

aid, safety, security and emergency actions, manufacture, transportation, storage, handling, and use of anhydrous ammonia.

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION (IIAR)

- *Ammonia Data Book*. (1992, December). Provides a variety of information on ammonia and includes a data on the various properties of ammonia and information on its use.
- IIAR Bulletins
  - *Ammonia Machinery Room Design*. No. 112-1998.
  - *Ammonia Machinery Room Ventilation*. No.11-1990. Provides a practical ventilation design criteria that will satisfy existing code requirements and improve machinery room safety. Major differences can be found between codes when determining ventilation requirements for ammonia machinery rooms. These differences result in confusion for the engineer and possible code misapplication.
  - *Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock*. No. 116-1992. Identifies three significant factors that can lead to ammonia refrigeration system damage and personnel injury: trapped liquid, sudden liquid deceleration, and vapor propelled liquid. Explains the most likely causes for each of these problems and provides design, operation and servicing tips that can minimize the chances of them occurring. Offers numerous suggestions on making hot gas defrost operations safer and more effective.
  - *Identification of Ammonia Refrigeration Piping and System Components*. No. 114-1991. Provides a comprehensive ammonia labeling scheme for companies in need of an identification system that "covers it all." Offers recommendations on label sizes, colors, installation locations, and label material requirements.
  - *Minimum Safety Criteria for a Safe Ammonia Refrigeration System*. No. 109-1988. Embraces an IIAR goal of ensuring that ammonia refrigeration systems are engineered, constructed and operated in a safe manner. Provides detailed lists of items to consider when designing, inspecting, or operating a system. Addresses such issues as housekeeping, recordkeeping, code considerations and personnel safety equipment. Provides inspection checklist forms for compressors, condensers, evaporators, vessels and heat exchangers to check system installation against recognized industry safety requirements.
  - *Start-Up, Inspection and Maintenance of Ammonia Mechanical Refrigerating Systems*. No. 110-1993. Covers ammonia characteristics and hazards, inspection and maintenance of equipment, start-up issues, reference standards, safety equipment, and log book recordkeeping. Provides definitions of system components and terms to help in understanding ammonia systems.
  - *Suggested Safety and Operating Procedures When Making Refrigeration Plant Tie-Ins*. No. 107-1997. Addresses the need to approach ammonia refrigeration system tie-ins in a safe and methodical manner. Provides owners and contractors with a general checklist of safety and logistical items that should be reviewed when planning system shutdowns and tie-ins. Provides engineers with ideas on how and where to design for future connections and taps that can make future tie-ins easier and safer.
  - *Water Contamination in Ammonia Refrigeration Systems*. No. 108-1986. Addresses the water contamination in ammonia refrigeration systems that has always been a problem, as owners typically know they have water in a

system, but may not be familiar with how it got there; measures to quantify the amounts, analyzing the specific penalties it causes on the system performance; and removing the water in a safe manner. Offers insights on where the water can come from and how to minimize continued infiltration. Provides an analytical approach to quantifying water concentrations, and recommends apparatus to remove the water.

- *Process Safety Management Guidelines*. (1998). Provides guidance on the interpretation and implementation of the OSHA Process Safety Management standard. Contains a chapter discussing each of the fourteen elements and includes a series of work practices, checklists, and other guidance materials to assist employers in developing a Process Safety Management program.
- *Risk Management Program Guidelines for Ammonia Refrigeration*. (1998). Provides guidance on the interpretation and implementation of EPA's Risk Management Rule. A good companion to the Process Safety Management Guidelines manual also published by IIAR.

GENERAL DUTY CLAUSE CITATIONS INVOLVING AMMONIA

CALENDAR YEAR	INSPECTIONS	# 5A1 CITATIONS
2007	2	2
2006	7	8
2005	14	15
2004	11	12
2003	6	7
2002	8	8
2001	6	7
2000	4	8
1999	17	20
1998	5	5
1997	7	8
1996	6	9
1995	1	1
1994	6	6
1993	2	28
1992	5	8
1991	6	8
1990	6	7
1989	8	9
1988	3	3
1987	2	2
1986	1	1
TOTAL		**183**

Some of the reoccurring and primary regulatory issues addressed by OSHA through enforcement activities include:

1. Insufficient and improperly located safety showers and body quench systems
2. Operators, maintenance workers and other employees have poor or non existent training in procedures, emergency systems and evacuation/emergency response.
3. Pressure vessel and piping systems are subject to external corrosion and CUI (corrosion under insulation) and proper inspections are not performed, documented and tracked to determine extent of corrosion problem and replacement schedule.
4. Ammonia detectors or alarms not located to prevent workers from entering and area or enclosed space where an ammonia leak can occur.
5. At 15% concentration, ammonia is explosive. Compressor rooms are not explosion proof or in lieu of explosion proof equipment, emergency exhaust ventilation systems not provided to keep below the 15% LEL.
6. Inventory of ammonia is not documented. Process Safety Management standard applies where 10,000 pounds or more of ammonia is present. Employers claim to have less than the required amount however when the system is pumped down, the threshold quantity is greatly exceeded.

INDUSTRIES (EXPERIENCING ACCIDENTS) MOST COMMONLY AFFECTED BY OSHA ENFORCEMENT ACTIVITIES INVOLVING AMMONIA

SIC (2 DIGIT)	SIC DESCRIPTION	# OF INSPECTIONS
01	Agriculture	10
15	Construction	18
16		
17		
20-39	Manufacturing ➢ Food Processors ➢ Chemical Mfg	129 ➢ 98 ➢ 17
40 - 49	Transportation, Communications, Utilities ➢ Freight Transport & Warehousing	14 ➢ 11
50 – 59	Trade ➢ Wholesale Trade (Nondurable)	32 ➢ 20
70 – 89	Services ➢ Business Services	18 ➢ 11
90 – 97	Public Administration	4
Total ➢ **Food Processing**		**225** ➢ **44% of total**

AMMONIA: FACT, FICTION MYTHS AND LEGENDS

- What is it?
  - Ammonia without water
  - NH3
  - Any liquid ammonia released to the atmosphere will aerosolize producing a mixture of liquid and vapor at a temperature of -28≅ F
  - The liquid ammonia quickly returns to the gas state at the expansion rate of 850 gallons of ammonia gas for every gallon of liquid.
- What is ammonia used for:
  - Agricultural applications (fertilizer)
  - Refrigeration (primarily food production and storage)
  - Metallurgical applications
  - Medical applications
- Worldwide production estimated at well over 100 million metric tons
- Over 80% used for agriculture
  - direct injection into soil as a fertilizer
  - production of urea (used as fertilizer and in feed)
  - pre-harvest cotton defoliant
  - anti-fungal agent on certain fruits
- Less than 2% used for refrigeration (closed systems)

ANHYDROUS AMMONIA HYGROSCOPIC AND CORROSIVE

One volume H2O will absorbabout 700 volumes of NH3
Corrosive to the eyes, skin and respiratory system

ANHYDROUS AMMONIA FORMS A COLD LIQUID

Boiling Point of NH3 is - 28 degrees F.
NH3 Liquid is refrigerated by evaporation when released
Contact with NH3 liquid has a 'freeze drying' effect
Thaw and remove frozen clothing quickly and carefully to avoid Increasing severity of injury; and,
Victims and their clothing may be giving off dangerous vapors.

ANHYDROUS AMMONIA REACTIVITY

Attacks copper, zinc and alloys of copper and zinc
forms ammonium hydroxide, a strong base.

EXPLOSIVE PROPERTIES

< One volume of NH3 liquid = about 850 vapor volumes
< Vapor density = .6 (air =1)
< 15% LEL

< 25% UEL
< 386 Btu/ft3
< Ignition temperature 1562 F
< Ignition temperature 1204 F. in the presence of iron

TOXICITY OF ANHYDROUS AMMONIA

< 5000 PPM may cause death in minutes
< IDLH = 500 PPM
< PEL = 50 PPM
< STEL = 35 PPM (Vacated)

Corrosive Effects to Body Surfaces

- Ammonia Vapor primarily effects the mouth and upper airway, trachea, lungs, skin and eyes.
- NH^3 gas + Water->Heat +Ammonium Hydroxide->OH- Anion (caustic penetration).
- Anhydrous Ammonia is "without water", kept as a liquid under pressure.
- When released expands to a gas phase or "vapor".
- Is Highly Toxic due to its Corrosive effects, similar to Lye (or Sodium Hydroxide)- continues to penetrate tissues after contact.
- However, it is not a Systemic Poison, no damage at the enzymatic level of cells (unlike for example- Cyanide).

Effects of Anhydrous Ammonia

Vapor Conc. (ppm)	Effects	Period
5-10	odor threshold	-
25	noticeable odor	NIOSH REL (8 hr TWA exposure limit)
35	"	NIOSH 15 min max. exposure (STEL)
50	Detectable by most people	OSHA Permissible Exposure Limit (PEL) No injury from prolonged, or repeated exposure
100	strong odor	
134	Irritation of the nose & throat	Eight hours maximum exposure
150	very strong odor	½ Immediately dangerous to life & health (IDLH)
300		IDLH
400	major throat irritation	Ordinarily, no serious results following short exposures

700	Coughing, severe eye irritation, may lead to loss of sight	One hour, maximum exposure
1,700	convulsive coughing, Serious lung damage, death unless treated	No exposure permissible (may be fatal < 1/2 hr)
2,000	Skin blisters and burns within seconds	No exposure permissible
5,000	respiratory spasms, strangulation, asphyxia, suffocation within minutes	No exposure permissible (rapidly fatal)
15,000	burns & blisters skin	

Anhydrous Ammonia Theft

Why would someone want to steal ammonia?
methamphetamine production
lab set-up is quick and relatively inexpensive
relatively high yields with minimal infrastructure

Anhydrous Ammonia is covered by OSHA's Process Safety Management standard when the 10,000 pound threshold quantity is met or exceeded.