

Iowa Hazardous Substances Emergency Events Surveillance (HSEES)

2001-2002 Report on Anhydrous Ammonia



Bureau of Toxicology
Division of Health Protection and Environmental Health
Iowa Department of Public Health

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(ATSDR)

INTRODUCTION

The culture and economy of Iowa is deeply rooted in farming. There are 99 counties in Iowa, 88 of which are considered rural. Agriculture remains the primary industry. Because of the high volume of anhydrous ammonia used in agriculture in Iowa, it continues to be the most commonly released hazardous substance. There are approximately 850 storage sites in Iowa and approximately 25,000-26,000 nurse tanks. There are two underground pipelines covering 668 miles. Approximately 650,000-700,000 tons of agricultural ammonia is used per year. Two ammonia producers are located in Iowa.

Ammonia is a chemical compound containing the elements nitrogen and hydrogen. It is one of the most elementary compounds and is present naturally in our atmosphere. Ammonia is often used for agricultural purposes, for refrigeration, and as a cleaner when dissolved in water. To avoid confusion, the term “ammonia” will be used consistently throughout this report. Although other terms such as anhydrous ammonia, aqueous ammonia, or ammonia gas may be more accurate, the toxicity varies only because of the route through which anyone may be exposed to the various forms of ammonia. Examples of these routes are breathing or skin contact.

Eighty percent of ammonia produced in the world is used for agricultural application where it serves as a fertilizer delivered by bubbling into irrigation water or by direct injection into the soil. Less than two percent is used for refrigeration. Other uses for ammonia include the manufacture of dyes, drugs, synthetic fibers, plastics, explosives, and as a component in cleaning materials. Over a million employees and customers of the ammonia industry use it daily, creating a serious potential for accidental release and injury.

Exposure to ammonia is extremely irritating to the eyes, nose, throat, lungs, skin and mucous membranes. Exposure to high levels of ammonia can cause dizziness and central nervous system symptoms, chemical burns and death.

BACKGROUND

Since 1990, the Agency for Toxic Substances and Disease Registry (ATSDR) has maintained an active, state-based Hazardous Substances Emergency Events Surveillance (HSEES) system to describe the public health consequences associated with the release of hazardous substances. Since 1990, the Iowa Department of Public Health (IDPH) has participated in this surveillance system.

The information in this report was collected for a two-year period (2001-2002) by staff in the Iowa Department of Public Health’s HSEES program. Various sources were used to obtain information about emergency or accidental releases. These sources included written records and oral reports from the Iowa Department of Natural Resources - Environmental Services Division, Iowa Department of Public Safety – Division of Narcotics Enforcement, the National Response Center, hazmat teams, local police and fire departments, and responsible parties. For an ammonia release to be included in the HSEES system, it must meet the following criteria.

- 1) An acute, accidental or illegal release; or
- 2) A threatened release that results in a public health consequence such as an evacuation.

The purpose of this paper is to identify the causes of acute ammonia releases in Iowa. The following are typical examples of acute ammonia releases and relevant questions related to their cause.

–A farmer was applying ammonia in his farm field. The nurse tank disconnected from the tool bar and the hose broke releasing ammonia. Why did the nurse tank disconnect from the tool bar? Was it due to such problems as poor maintenance, faulty equipment, or an inexperienced or improperly trained worker?

–A release occurs at an ammonia storage facility when a pressure relief valve is activated. What caused the pressure relief valve to “pop-off?” Was it because of faulty equipment, high heat conditions, improper filling of the vessel, or storage procedures?

–An ammonia tank was being transported on a roadway and rolled into a ditch. When the tank rolled, a valve was sheared and ammonia was released. Why did the tank roll into the ditch? Was it due to faulty equipment, poor road conditions, inexperienced driver, or factors beyond human control such as a driver swerving to miss an oncoming car?

Letters were sent to the responsible party (such as the farmer, manufacturer, fertilizer dealer) asking for specific information as mentioned above regarding the ammonia release. For releases involving the theft or manufacture of methamphetamine, a letter was sent to the responding law enforcement agency.

RESULTS

In 2001 and 2002 there were 219 ammonia releases reported to the HSEES program. Of the 219 letters sent to the responsible parties, the HSEES program received 140 (64%) responses.

Figure 1 displays a monthly distribution of all reported ammonia releases.

Figure 1
Total Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002

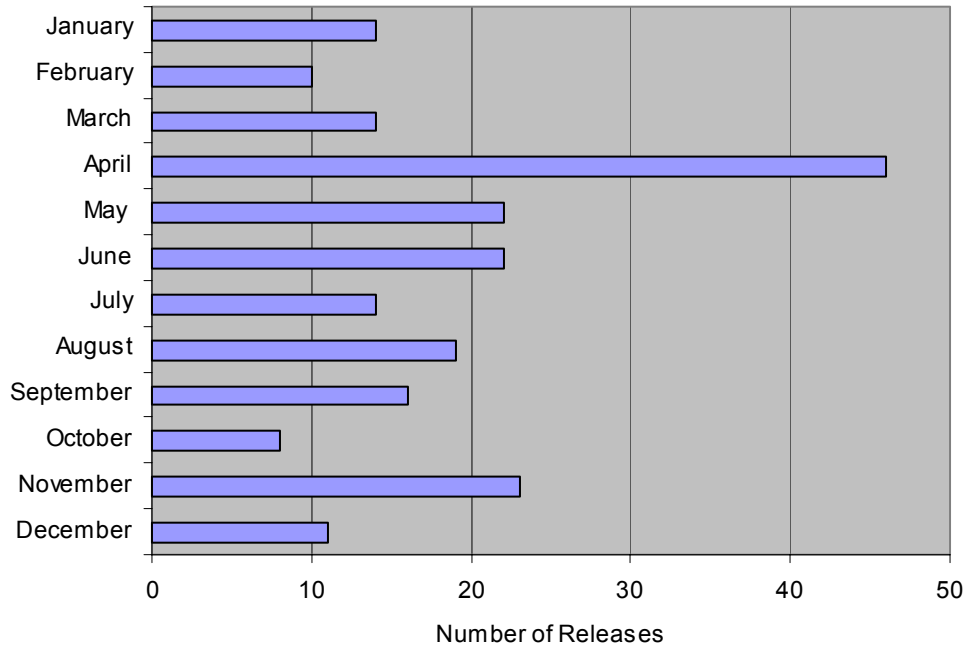
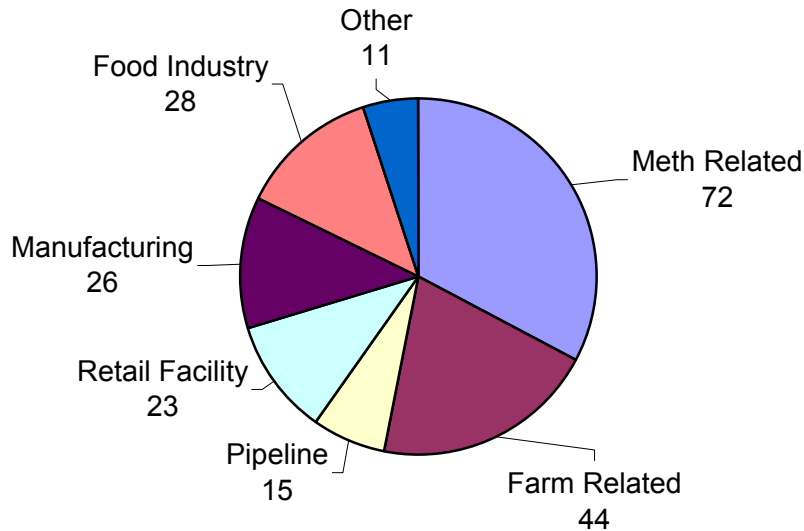


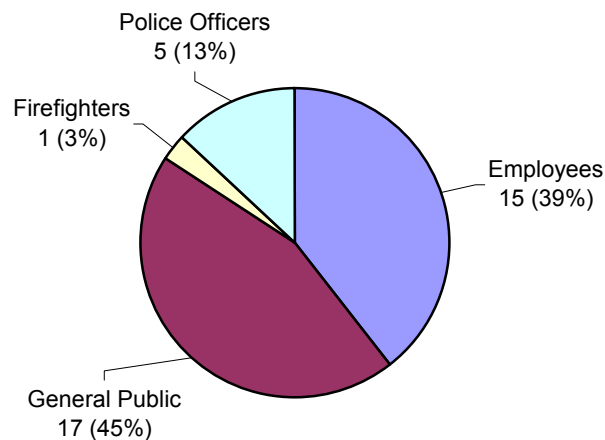
Figure 2 displays the categories of the responsible parties of all ammonia releases.

Figure 2
 Ammonia Releases by Responsible Party Category
 Hazardous Substances Emergency Events Surveillance System
 Iowa
 2001-2002



Victims of ammonia releases are those individuals with symptoms or injuries that result from the event and who sought some type of medical attention or died as a consequence of the event. Figure 3 displays the victim category for all victims associated with ammonia releases.

Figure 3
 Total Number of Victims in Ammonia Releases by Victim Category
 Hazardous Substances Emergency Events Surveillance System
 Iowa
 2001-2002



Ammonia Releases Related to the Manufacturer of Methamphetamine (Meth)

For this type of event to be included in the HSEES, there must have been a known acute release, an associated injury, or an evacuation resulting from an actual release or a threatened release. During 2001-2002, there were 72 reported ammonia releases associated with the manufacture of methamphetamine. These events resulted in 32 official evacuations. Twenty-six of the releases occurred during or after the theft of ammonia, 42 occurred at a methamphetamine manufacturing laboratory and four of the releases occurred from some type of container used for transporting the ammonia. Figure 4 displays a monthly distribution methamphetamine related ammonia releases.

Figure 4
Methamphetamine Related Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002

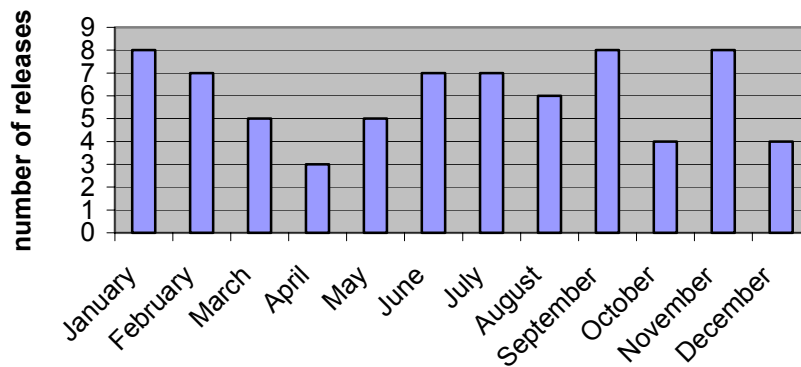


Table 1 displays a breakdown of the action type and location of methamphetamine related ammonia releases.

Table 1
Methamphetamine Related Ammonia Releases by Action and Location
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002

Action	Location	Number of Releases
During or after theft	Farmstead	8
	Retail Facility	17
	Wholesale Facility	1
Release from transporting container such as a thermos	Vehicle	3
	Gravel Road	1
Clandestine drug lab	Private Property	42
Total		72

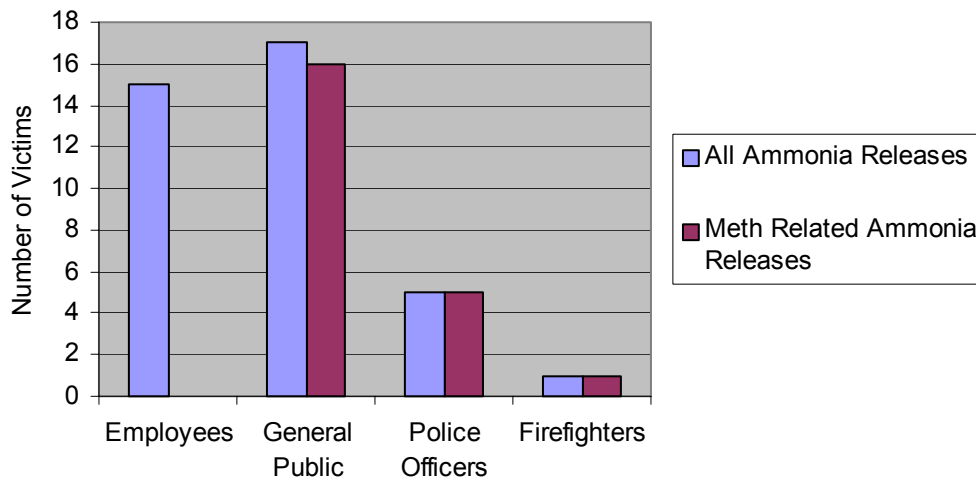
Table 2 displays the location and times of day for ammonia releases involving theft.

Table 2
 Times of Day and Location of Methamphetamine Related Ammonia Releases Involving Theft
 Hazardous Substances Emergency Events Surveillance System
 Iowa
 2001-2002

Location	Early Morning	Daytime	Night
Farmstead	7	1	0
Retail Facility	10	4	3
Wholesale Facility	1	0	0
Total	18	5	3

There were 22 people injured in the 72 ammonia releases associated with methamphetamine labs. Sixteen of the victims were members of the general public (includes cooks), five were police officers, and one was a firefighter. Most of the members of the general public and all the responders injured in ammonia events were associated with methamphetamine events. Figure 5 displays the distribution of victims by population group. There were 32 official evacuations.

Figure 5
 Distribution of Victims by Population Group for All Ammonia Releases and
 Methamphetamine Related Ammonia Releases
 Hazardous Substances Emergency Events Surveillance System
 Iowa
 2001-2002



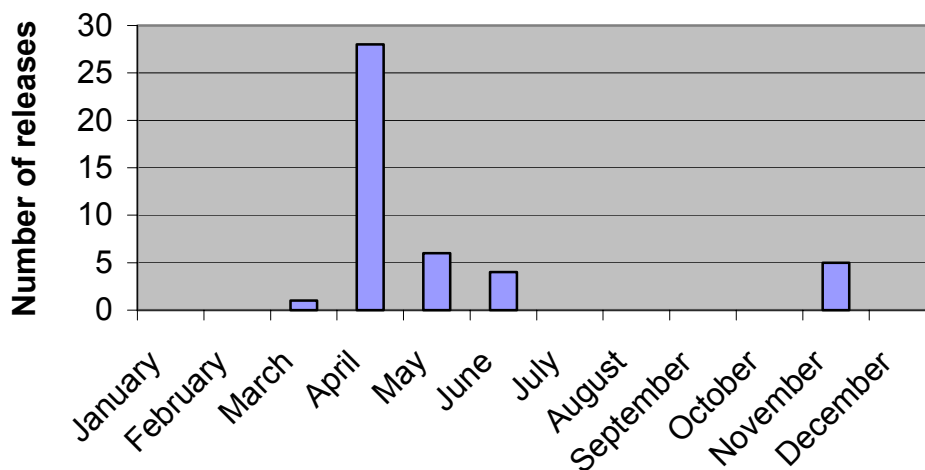
Seizure of methamphetamine laboratories in Iowa has increased dramatically over the past few years. The agricultural industry has depended on anhydrous ammonia as a low cost fertilizer for many years but drug dealers have discovered it can also be used for an inexpensive way to manufacture methamphetamine. The agricultural community has been targeted as a source for this chemical. Since ammonia is a critical element of the methamphetamine manufacturing process, the community can play an important role in protecting itself by limiting unsuitable access to this material and by educating the citizens on the signs of an existing or abandoned methamphetamine lab. Police and firefighters should take special safety courses on handling methamphetamine situations because of the

likelihood of explosions, invisible poison gases, and other dangers such as corrosive and flammable materials.

Ammonia Releases Related to the Farm

Forty-four ammonia releases occurred with farmers being the responsible party. Figure 6 displays the monthly distribution of farm related ammonia releases. As would be expected, most of these releases occur during planting season.

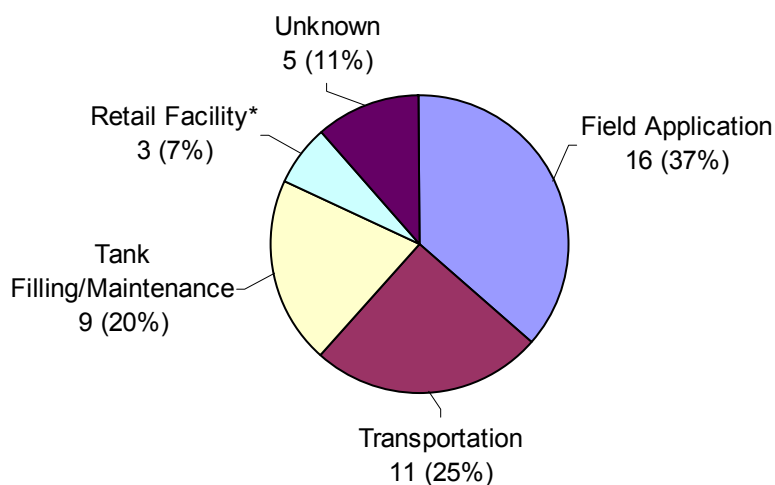
Figure 6
Farm Related Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002



Sixteen releases occurred in the morning (6 a.m. – noon), 11 occurred in the afternoon (noon – 5 p.m.), 14 happened during the evening hours (5 p.m. – 10 p.m.), and the time of three events was unknown.

Figure 7 displays the areas involved in farm related ammonia releases.

Figure 7
Areas Involved in Farm Related Ammonia Releases
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002



*Although these events occurred at a retail facility, the farmer was the responsible party.

The primary factors in farm related ammonia releases are shown in Table 3.

Table 3
Primary Factors Reported as Contributing to Farm Related Ammonia Releases
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002

Factor	Number of Releases	Percent
Equipment failure	26	52%
Human error	14	32%
Unknown	4	9%

- Sixteen releases occurred while ammonia was being applied in the field. These 16 releases resulted in no injuries and only one report of an evacuation. Factors associated with the releases are as follows:
 - Hitch pin breaking or pulling out (n=9)** was the primary cause. Eight of those accidents were followed by a **quick coupler failure** and consequently the **hose breaking**. The ninth was due to the fact that the **tank was not connected to the applicator correctly** and the **hose disconnected**.
 - Actual hitch broke (n=3)**.
 - Pinched line** with no additional information available.
 - Hose breaking** with no additional information.

–**Hose was left dragging** and consequently ruptured.

–Farmer **unlatched an extendable hitch and forgot to re-latch it** – the safety catch failed followed by a quick coupler failure.

•Eleven ammonia releases took place while a farmer was transporting the ammonia. In these 11 transportation events, no one was injured and there were no reported evacuations. The factors contributing to the release were as follows:

–**Tanks overturned due to inadequate negotiations (n=4).**

–**Hitch pin broke or pulled out (n=3).**

–**Improper hookup of tank (n=1).**

–**Frame broke (n=1).**

–**Running gear came off and hit the release valve (n=1).**

–**Tank hit loose gravel and fishtailed out of control (n=1).**

•Nine ammonia releases occurred while a farmer was either **filling a tank or doing some type of maintenance work on the tank**. Although the amount of ammonia released was relatively small, these types of releases resulted in eight injuries. There were no reported evacuations.

•Three releases occurred at co-op facilities when farmers returned nurse tanks and **did not tighten the valves** sufficiently allowing ammonia to escape. No one was injured and no evacuation was reported for these three events.

•Adequate information was not available to discuss the remaining five events. One involved a **hose breaking** for unknown reasons and in four events no descriptive information was available. Four people were injured in these events but no evacuations were reported.

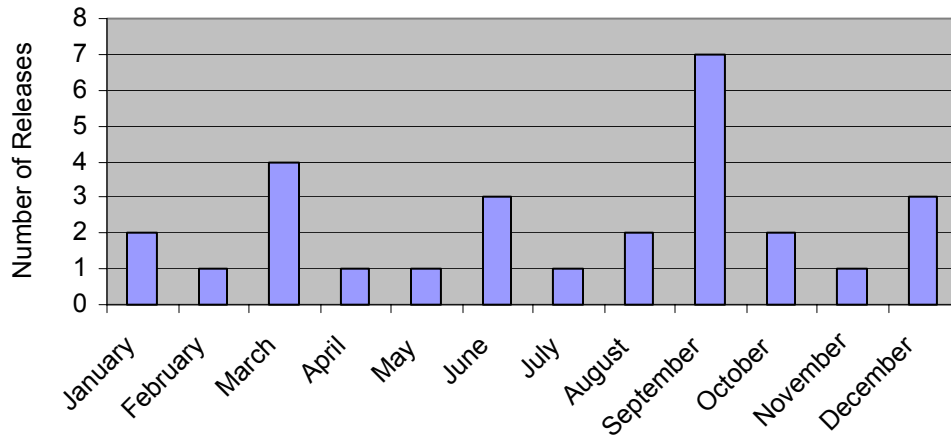
Iowa farmers use anhydrous ammonia extensively. It is relatively easy to apply and few problems occur when ammonia is being handled and applied as intended. Safe handling must be a priority when working with ammonia. In addition to making sure that it is properly stored and handled under pressure, farmers must be aware of the procedures and equipment required to ensure safe application.

Ammonia Releases Related to the Food Industry

Anhydrous ammonia is used widely as a refrigerant in food processing facilities. Common industries in Iowa that use ammonia are meat and poultry processing plants, dairy and ice cream plants, and cold storage warehouses. The food industry was responsible for 28 of the 219 releases occurring during 2001 and 2002.

Figure 8 displays a monthly distribution of ammonia releases related to the food industry. The largest proportion of releases occurred in September.

Figure 8
 Food Industry Related Ammonia Releases by Month
 Hazardous Substances Emergency Events Surveillance System
 Iowa
 2001-2002



Six of the releases happened during the morning hours, ten occurred during the afternoon, three happened in the evening, and nine occurred during the night. There were nine evacuations and no injuries that resulted from these releases.

Factors associated with these releases are listed below.

- **Valve failure (n=6).**
- **Over pressurized refrigeration system (n=3).**
- **Leaks developing in ammonia line (n=2).**
- **Seal failure (n=2).**
- **Faulty pressure gauge (n=2).**
- **Maintenance repair (n=2).** While preparing for maintenance, the ammonia line was thought to be isolated but it was not.

The following factors were associated with single releases:

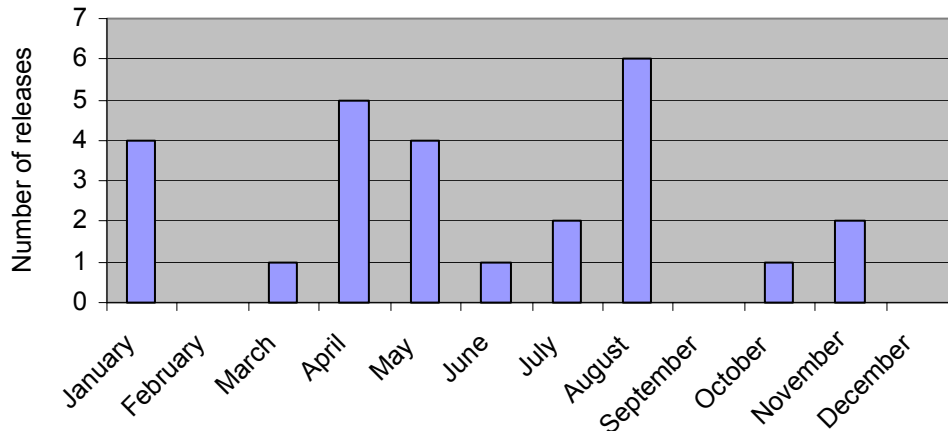
- Development of a **leak in a condenser.**
- Equipment failure** not otherwise specified.
- Fluctuation in weather** caused a valve to loosen.
- Fitting broke.**
- Failure of bolts on a motor mount.** This caused the motor to fall on the refrigeration line.
- Flange failure.**
- Gasket failure.**
- Suction regulator stuck.** As a result, liquid was not removed from tank jacket.
- Ammonia line hit by forklift operator.**
- Operator error.** This resulted in a release of material from a compressor.
- Employee was removing lockout tag when a **chain caught on the valve** knob causing valve to open.

Because refrigeration systems operate at elevated pressures, care must be taken to maintain and operate these systems so as to prevent releases with potential catastrophic consequences.

Ammonia Releases Related to Manufacturing

Manufacturing facilities were responsible for 26 of the 219 reported ammonia releases in 2001 and 2002. Figure 9 displays the monthly distribution of ammonia releases associated with manufacturing.

Figure 9
Manufacturing Related Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002



Thirteen of the releases occurred during morning hours, five during the afternoon, three in the evening, and five releases happened at night. There were no injuries and one evacuation.

•Equipment failure (n=21).

–Faulty valve (n=16). One event resulted in an evacuation.

–Gasket failure, pipe fitting, and flange (n=3).

–Power failure (n=2).

•Human error (n=3).

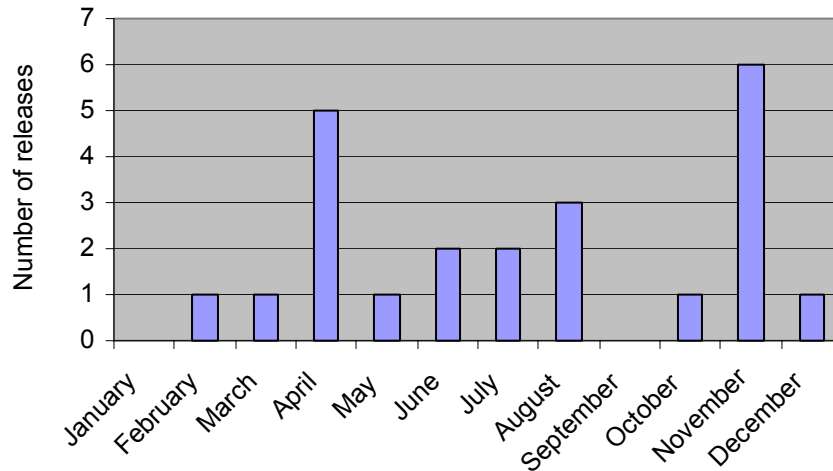
•Adverse weather conditions (n=2).

As in retail facilities, equipment failure plays a major role in emergency ammonia releases at manufacturing plants. Full attention to preventative maintenance should be a priority and companies must continue to emphasize preparation for an emergency ammonia release.

Ammonia Releases Related to Fertilizer Dealers

Fertilizer dealers were responsible for 23 of the 219 reported ammonia releases. These 23 releases resulted in two injuries and three evacuations. Nine releases occurred during morning hours, six during the afternoon, seven during evening hours, and one time was unknown. Figure 10 displays the monthly distribution of ammonia releases associated with fertilizer dealers.

Figure 10
Fertilizer Dealer Related Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002



A summary of the factors and areas of the releases follows.

•**Leaking valves (n=4)**, of which one resulted in evacuation.

–One of these events occurred when the **operator made an error** in believing the return line was empty.

–Three events the release resulted from **valves not being properly tightened**.

•**Driver inexperience or negligence (n=6)**. The events occurred when employees were transporting ammonia, rolled the nurse tanks, and broke valves. Two of these incidents involved employees pulling two tanks.

•**Broken hitch pins (n=3)**.

–One event occurred when an employee was applying ammonia in a customer’s field and the hitch pin broke causing the hose to rupture.

–One event involved a hitch pin that had hairline fractures that did not show up during a routine inspection.

–The cause for one event involving a hitch pin was not known.

•**Employees were bleeding fumes from a tank (2=n)**.

–One event occurred when the **amount of water being used was inadequate**.

–One event occurred when the **water tank broke**.

•**A failed pipe from a bulk storage tank (n=1)**. The excess flow valves in the tank also failed. One employee was injured and an evacuation occurred.

•**Transfer hose ruptured (n=1)** while off loading ammonia from a truck.

•**Unintentional (n=1)**. A release occurred when an employee slipped. As he fell, he grabbed the fill hose for the tank he was filling. The hose pulled away from the break away coupler. The **coupler came apart as designed but did not shut off the flow of ammonia**. One employee was injured and an evacuation occurred.

•**Gasket failure (n=1)**. It was determined that winter weather created weak areas in the gasket that were not detectable.

●**Shut off valve failure (n=1).** The valve that controlled ammonia pressure failed while employees were performing maintenance.

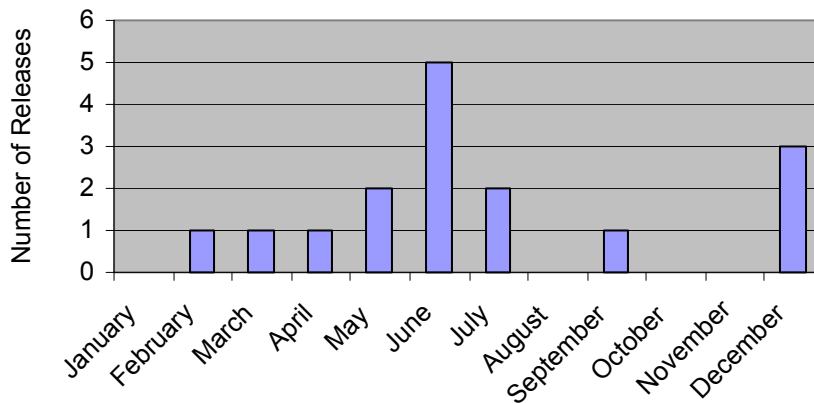
There are approximately 865 ammonia retail facilities that exist in Iowa. Although ammonia is a dangerous chemical, few problems occur when it is stored, handled and transported properly. Emergency releases, which are primarily due to equipment failure or human error, lead to evacuation and injury. There are many safety features built in to the ammonia handling and application procedures. Full attention to preventive maintenance and worker training and awareness must be given to reduce the health and financial burdens of ammonia releases.

Ammonia Releases Related to Pipeline Transportation

The pipeline industry was responsible for 16 of the 219 emergency ammonia releases reported in 2001 and 2002.

Figure 11 displays the monthly distribution of pipeline transportation related releases.

Figure 11
Pipeline Related Ammonia Releases by Month
Hazardous Substances Emergency Events Surveillance System
Iowa
2001-2002



Seven releases occurred in the morning, five occurred during afternoon hours, and four occurred in the evening. In the 16 events, one person was taken to the hospital for observation and there was one unofficial evacuation.

The factors associated with these releases are as follows:

- Some type of equipment failure (n=11).** This included leaks in the pipeline itself, a valve and two pump seals.
- Maintenance work (n=3).**
- Intentional blow down (n=1).** During this process material was being released from a flare stack.
- Excavator hit a fitting (n=1).** The consequence was the opening of the pipeline. This event resulted in an employee being taken to the hospital for observation and an unofficial evacuation.

“Other” Related Ammonia Releases

The remaining 11 ammonia releases were combined into an “other” category. This group includes wholesale facilities, a carbon dioxide producer and a trucking company. All releases were due to either equipment failure or human error. There was one injury and no evacuations associated with these events. A brief summary of the remaining events follows.

Nine events occurred at wholesale facilities. These events were associated with the following factors:

- **Compressor failure (n=1).** This caused tank to over pressurize.
- **Leak in a tank (1=n).**
- **Failure of a seal on pump (n=2).**
- **Faulty check valve (n=1).**
- **Over pressurized tanks (n=2).**
- **Operator error (n=2).**
 - A block valve was **accidentally left closed** causing a discharge line to over pressurize.
 - A bleeder valve was **accidentally left open.**

• **Seal failure (n=1).** This event occurred at a carbon dioxide producer when a **seal on an ammonia pump failed.**

• **Human error (n=1).** This event occurred when a trucking company was transporting ammonia and the **driver lost control of the vehicle.** In this event one person was injured but the injuries were trauma related rather than chemical related.

SUMMARY

Anhydrous ammonia releases were studied during a two-year period (2001-2002) by the HSEES program in Iowa. Of the 643 events entered into the surveillance system, 219 (34%) involved ammonia. This study found that the most common release of ammonia was associated with some phase of the methamphetamine manufacturing process (33%). Given the amount of ammonia handled every year in Iowa, the number of victims and evacuations is relatively small. Nevertheless, most accidents resulted from equipment failure or human error both of which are preventable. This data suggests that more stringent safety and security measures must be taken, and education of employees, responders, and the general public about the hazards of anhydrous ammonia must be reinforced. IDPH is in the process of identifying better ways to provide assistance in reducing the number of ammonia releases and the associated public health consequences resulting from those releases.