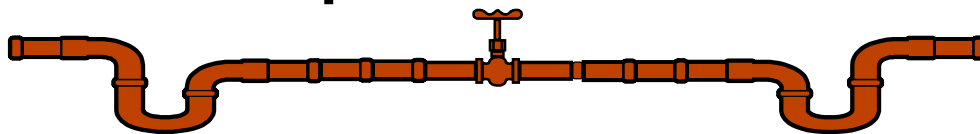


Ammonia Spills in New York State



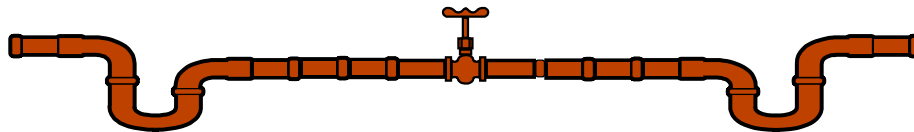
HSEES*, 1993-1998

- Of 2,415 reported releases of hazardous substances, 107 (4.4%) involved ammonia.
- Of the 814 people injured during releases of hazardous substances, 61 (7.5%) were injured following ammonia events.
- Equipment failure caused 58% of the ammonia releases and injured 38 people.
- Most ammonia releases involved piping (44%).
- 44% of injured people were employees, 41% were members of the general public, and 15% were responders.
- 7 of the 9 injured responders sustained chemical burns.
- 39% of the ammonia releases required a hazmat response.
- More than 1,889 people were evacuated following 107 ammonia releases.
- Most ammonia releases occurred in food/beverage processing (29%) or chemical/metal/equipment manufacturing (27%).

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*Hazardous Substances Emergency Events Surveillance
New York State Department of Health, Bureau of Toxic Substance Assessment, September, 2000

Ammonia Spills in New York State



HSEES, 1993-1998

This fact sheet is produced by the Hazardous Substances Emergency Events Surveillance (HSEES) project staff to protect human health and the environment by preventing future releases. HSEES is investigating events to learn the causes and contributing factors associated with releases. An understanding of the root causes, sharing the lessons learned and integrating these lessons into training and maintenance can be a major part of a prevention plan.

Ammonia is a corrosive, colorless toxic gas with a sharp odor. It is generally not flammable, but mixtures of ammonia and air will explode when ignited under certain conditions. Pure ammonia is usually stored as a liquid under high pressure in steel cylinders. It is also known as anhydrous ammonia. Safe storage requires specially-designed and well-maintained equipment. Ammonia readily mixes with water to form ammonium hydroxide, a highly caustic solution.

Ammonia is widely used in large quantities for a variety of purposes. In 1999, anhydrous ammonia ranked third by weight¹ for all chemicals produced in the U.S. More than 80% of the ammonia produced in the United States is used in agriculture; less than 2% is used for refrigeration. Important uses of ammonia include the manufacture of dyes, drugs, synthetic fibers, plastics and explosives; for large-scale cooling of fruits, vegetables and meats; as a component in cleaning materials; to control nitrogen oxides emissions at power plants; and to freeze water in ice rinks.

HAZARD AWARENESS

Exposure to ammonia is extremely irritating to 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. Liquid ammonia has a boiling point of minus 28 degrees Fahrenheit. At this temperature, it can cause freezing burns or frostbite very quickly.

The Occupational Safety and Health Administration (OSHA) has set a Permissible Exposure Limit (PEL) for the workplace of 50 parts per million (ppm, 35 mg/m³) time weighted average. The IDLH (immediately dangerous to life and health) level has been set at 300 ppm. Most people smell ammonia before it causes health effects. Generally, people will detect ammonia at 5 ppm and will become uncomfortable by 100 ppm. People who work near this chemical, particularly if it is under pressure, are at risk of serious injury if a release occurs.

Liquid anhydrous ammonia expands 850 times when released to ambient air and can form large vapor clouds. These clouds are normally lighter than air and will rise. However, liquid anhydrous ammonia may also form an aerosol which means that some of it may form small liquid droplets. As an aerosol, the droplets of ammonia are heavy and sink toward the ground. Anhydrous ammonia may also cause water vapor to condense in the air forming a visible white cloud. Therefore, when anhydrous ammonia is released to the air, it may rise and disperse as a gas or it may be heavy and travel along the ground as an aerosol or because it has trapped water vapor. In either

¹ Chemical and Engineering News, 78(26), 50-56 (June 26, 2000).

case, the cloud may remain low instead of rising into the air. This behavior may increase the risk of exposure and injury for workers and the public. Being aware that ammonia may persist near the ground may help prevent injury in future ammonia releases.

Although pure ammonia vapors are not flammable at concentrations of less than 16%, it may explode or catch fire at concentrations between 16 and 25%. Ammonia contaminated with lubricating oil from a system, however, may catch fire or explode at concentrations as low as 8%. Ammonia cooling systems such as those for foods or ice rinks may be at risk due to oil contamination.

Anhydrous ammonia is a key ingredient in the illegal production of amphetamines. Illegal drug makers may steal ammonia from areas where it is stored and used. When stolen, the toxic gas may be released accidentally in unexpected locations, and may injure law enforcement personnel, emergency responders and the public, particularly because the location is unexpected.

AMMONIA RELEASES IN NEW YORK STATE

This fact sheet² summarizes information on 107 ammonia spills investigated by the New York State Department of Health for the Hazardous Substances Emergency Events Surveillance (HSEES) project. This state-based project is funded by the Agency for Toxic Substances and Disease Registry to describe and evaluate the public health consequences of spills involving non-petroleum hazardous substances. For details about the project, please refer to the last page.

² This fact sheet was supported by Cooperative Agreement Number 296968 from the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of ATSDR.

Number of Ammonia releases ¹	107
Fixed facility	101
Transportation	Road – 5 Rail – 1
Range of amounts released ²	1-850 gals. 1-4,000 lbs.
Number of events with injury	21 (19%)
Number of injured persons and fatalities	61
Employees	27
Responders	9
General Public	25
Maximum number of persons injured in one event	13
Number of releases with hazmat response	49 (46%)
Number of events involving an evacuation	42 (39%)
Number of persons evacuated ³	>1,889
Maximum number of persons evacuated in one event	500
Duration of all evacuations (person-hours) ⁴	>8,452

¹Two threatened and 105 actual ammonia releases.
²A release may be reported in pounds or in gallons, not both. For spills reported in gallons, the median was 18 gallons and the average was 128 gallons. For spills reported in pounds, the median was 202 pounds and the average was 530 pounds.
³This number is a minimum count. For some events, no data were recorded because the evacuation time or the number of evacuated persons were unknown and could not be estimated from available information.
⁴Person-hours is calculated by multiplying the number of persons evacuated by the length of the evacuation for each event, and summing the results for all events.

Since 1993, the HSEES project has recorded information on 105 actual and two threatened ammonia releases (Table 1). A threatened release qualifies for inclusion in the project if it leads to a public health action that protects people (such as an evacuation or a road closing). Most ammonia events (101) occurred at fixed facilities; six releases were during transportation. The quantities of ammonia released ranged in volume from one to 850 gallons, and in weight from one to 4,000 pounds.

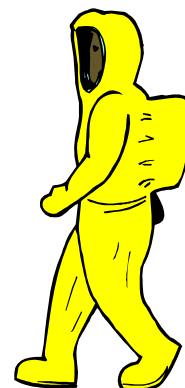
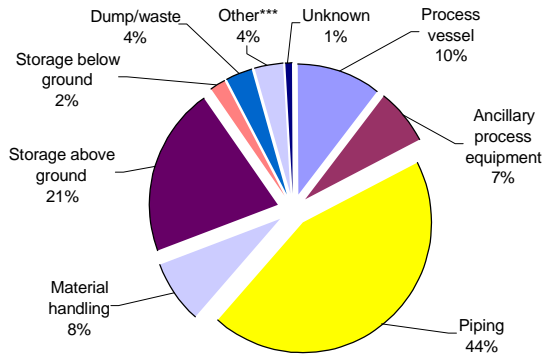


Figure 1. Location* of 101 Reported Ammonia Events at Fixed Facilities**



*Study design allows a maximum of two locations per event. Total number of locations is 114.

**6 ammonia events were transportation-related and are not included.

***Other: entire facility (2), hotel restroom (1), construction site (1).

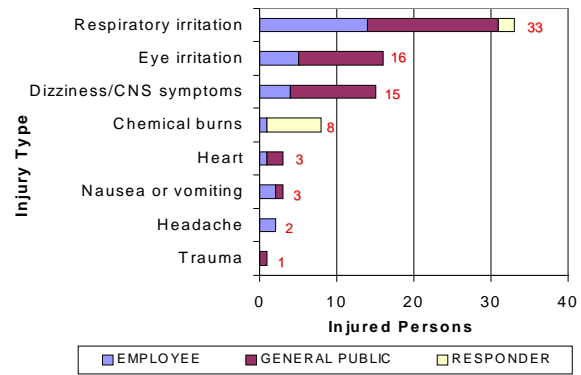
Twenty-one events (19%) resulted in injuries to 61 people, one of whom died. The fatality was a forklift operator on the second floor of a produce cold storage facility. The forklift broke through the wooden floor and ruptured the ammonia pipes on the floor below. The trapped operator died from inhaling ammonia. Forty-nine of the releases (46%) required a hazmat response.

Forty-two events (39%) led to evacuations totaling more than 1,889 people. The evacuation data are minimum numbers since only confirmed data are included. For example, if an evacuation involved more than 50 people but no one knew how many more, then staff recorded only 50 in the project database. Similarly, if the evacuation time was at least two hours but no one knew how much longer, then staff recorded the time as two hours. For some events, no data were recorded because the evacuation time or the number of evacuated persons were unknown and could not be estimated. The duration of known evacuations totaled >8,452 person-hours.

ON-SITE LOCATIONS

The 101 ammonia events which occurred at fixed facilities are summarized in Figure 1. The total of locations (114) exceeds the number of events (101) because 13 events are described by two types of locations. The most frequently reported locations were piping (44%), storage above ground (21%), process vessel (10%) and material handling (8%).

Figure 2. Injuries Following Reported Ammonia Events



* The injured persons (61) belong to the following categories: employees (27), general public (25) and responders (9).

**The total number of injury types (81) exceeds the total number of injured persons (61) because some people had more than one injury.

INJURIES and MEDICAL TREATMENT

Figure 2 summarizes the injury data collected for 61 people injured in 21 events. The injury total exceeds the number of injured persons because some people sustained more than one injury. The predominant injuries associated with releases of ammonia were respiratory irritation (54%), eye irritation (26%) and dizziness/central nervous systems effects (24%). Respiratory irritation was the most common symptom reported by both employees (52%, 14/27) and the general public (68%, 17/25); the symptom most frequently reported by responders was chemical burns (78%, 7/9).



Medical Treatment	Number of injured persons			
	Employee	General Public	Responder	Total
Treated at the scene	9	12	1	22
Transported to the hospital for observation	2	0	3	5
Transported to the hospital, treated and released	13	11	4	28
Transported to the hospital and admitted	1	2	1	4
Seen by private MD within 24 hours	1	0	0	1
Fatality*	1	0	0	1
Total	27	25	9	61

* One death occurred when a forklift operator on the second floor of a building broke through the wooden floorboards and ruptured the ammonia pipes below. The trapped operator died from inhaling ammonia.

Data on medical treatment (Table 2) indicate that 46% of injured people (28/61) were transported to the hospital, treated and released, and that 36% (22/61) were treated at the scene. Five people (8%) were released from the hospital after observation and 4 people (6%) were admitted. One fatality was caused by ammonia exposure following an accident in a cold storage facility.

In the project, an injured person can be classified as using up to four different pieces of personal protective equipment (PPE). A review of PPE worn by people injured during



Personal Protective Equipment (PPE)	Employees	General Public	Responders	Total
None	13	25	1	39
Gloves	3	0	0	3
Eye protection	2	0	0	2
Hard hat	1	0	0	1
Steel-toed shoes	2	0	0	2
Firefighter turnout gear**	0	0	8	8
Level B***	0	0	4	4
Unknown	10	0	0	10
Total PPE	31	25	13	69****

* Employees (27), general public (25) and responders (9).
 ** Firefighter turnout gear: fire resistant outerwear including coat, boots, gloves and helmet with face shield. SCBA or a supplied-air respirator is used, as needed.
 *** Level B protection: encapsulating suit which does not have to be vapor tight: same level of respiratory protection as Level A.
 **** Number of PPE (69) exceeds number of injured people (61) because some people wore multiple PPE.

accidental ammonia releases (Table 3) shows that the majority of injured people (64%, 39/61) wore no PPE. Among the injured people without any PPE, the majority were general public (25/39), but thirteen were employees and one was a responder. PPE worn by injured responders included Level B suits (4) and firefighter turnout gear (8).

Four of the injured responders wore firefighter turnout gear and, later, Level B protection. This occurred in two events because members of the fire department were also members of the hazmat team. The responders first entered wearing firefighter turnout gear and then re-entered in Level B as part of the hazmat team. In one incident, the newly-established hazmat team was responding to its first event and one firefighter was burned by ammonia trapped inside his entry suit. In the other incident, three firefighters sustained burns to the groin (1), ears and ear lobes (2). These injuries indicate the need for improved training and education of employees and responders on the hazards of ammonia and the importance of appropriate PPE.

Cause	Number of events	Events with injuries	Injured persons
Equipment failure	62	10	38
Operator error	15	4	4
Improper mixing	4	2	4
Improper filling	2	0	0
Beyond human control	1	0	0
Power failure	1	0	0
Dumping	3	0	0
Deliberate action*	1	0	0
Transportation	6	1	1
Other**	8	3	11
Unknown	4	1	3
Total	107	21	61

* Deliberate action: Illegal activity such as theft, vandalism, or assault.
 ** Other: fire (5), structural collapse (3).

Of the 27 injured employees, nearly half (13/27, 48%) wore no PPE and others wore items such as gloves or steel-toed shoes that did not provide respiratory protection.

CAUSES

Table 4 summarizes the causes of ammonia releases and the associated injuries. The most commonly reported causes for ammonia releases were equipment failure (62 events, 58%) and operator error (15 events, 14%). Ten events with equipment failure as the cause resulted in 62% of the injured people (38/61). The eight events with cause listed as other (fire, 5; structural collapse, 3) resulted in 18% of the injured people (11/61).

Table 5 summarizes the causes of ammonia releases and associated evacuations. The most commonly-reported cause of ammonia releases was equipment failure (62 events, 58%) which resulted in more than half of the evacuations (22 events, 52%). These 22 evacuations displaced more than 1,210 people for more than 5,221 person-hours. Operator error resulted in 17% of the evacuations (7 events) which effected more than 250 people for more than 316 person-hours.

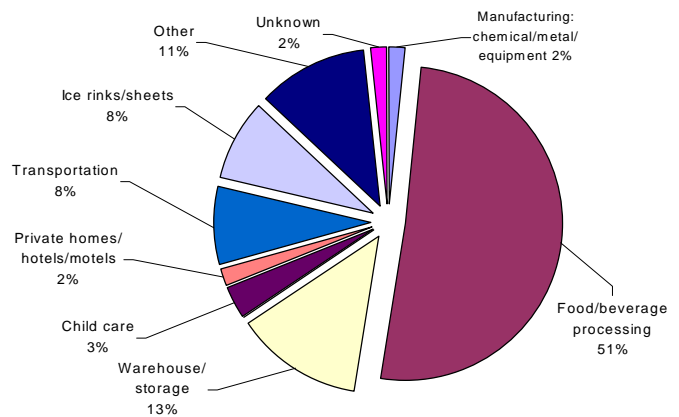
Cause	Number of events	Events with evacuation	Number of people evacuated	Evacuation time (person-hours)
Equipment failure	62	22	>1,210	>5,221
Operator error	15	7	>250	>316
Improper mixing	4	2	40	50
Improper filling	2	0	0	0
Beyond human control	1	0	0	0
Power failure	1	0	0	0
Dumping	3	1	3	3
Deliberate action*	1	0	0	0
Transportation	6	2	>15	>300
Other**	8	4	246	2,040
Unknown	4	4	125	522
Total	107	42	>1,889	>8,452

* Deliberate action: Illegal activity such as theft, vandalism, or assault.
 ** Other: fire (5), structural collapse (3).

INDUSTRY-SPECIFIC ANALYSIS

An analysis of the number of injured people by facility type (Figure 3) shows that most people (51%) were injured in food/beverage processing. Similar numbers of ammonia releases (Table 6) took place in the categories of chemical/metal/equipment manufacturing (29) and food/beverage processing (31), but the number of

Figure 3. Injured People Following Accidental Ammonia Releases by Facility Type



*Other: paper/printing (4), other metal products (1), sanitary services (3), research and development (2), public order/safety (1), agricultural services/production and livestock (2), and construction (1).

Table 6. Injuries Following Accidental Ammonia Releases at Various Facilities

Industry Type	Number of events	Events with injuries	Injured persons
Chemical/metal/equipment mfg.	29	1	1
Food/beverage processing	31	7	31
Warehouse/storage	9	2	8
Grocery/retail	3	0	0
Child care	3	1	2
Private homes/hotels/motels	4	1	1
Transportation	2	1	5
Ice rinks/sheets	5	3	5
Other*	14	4	7
Unknown	7	1	1
Total	107	21	61

*Other: paper/printing (4), other metal products (1), sanitary services (3), research and development (2), Public order/safety (1), agricultural services/productions and livestock (2), and construction(1).

injuries was much lower in the manufacturing sector (1) than in the food/beverage processing industry (31).

An examination of the causes of ammonia releases in these two industries (Table 7) shows that equipment failure was the major cause in each: 69% (20/29) in manufacturing and 84% (26/31) in food/beverage processing. Within the category of equipment failure, a significant number of releases involved piping: 12/29 in manufacturing and 17/31 in food/beverage processing. Far fewer releases were due to operator error: 14% (4/29) in manufacturing and 10% (3/31) in food/beverage processing. An analysis of causes by industry for the 21 ammonia events associated with injury (Table 8) shows that equipment failure was the predominant factor, particularly in the food/beverage processing sector.

Table 7. Causes of Ammonia Releases by Industry Type

Industry Type	Causes											Total
	Improper mixing	Equipment failure	Operator error	Improper fill	Beyond control**	Power failure	Dumping	Deliberate	Other	Unknown		
Chemical/metal/equipment mfg.	1	20	4	2	1	1						29
Food and beverage processing		26	3						1	1		31
Warehouse/storage		4	1				1		2	1		9
Grocery/retail		1	1						1			3
Child care		2	1									3
Private homes/hotels/motels	2	1								1		4
Transportation							1		1			2
Ice rinks/sheets		3	2									5
Other*	1	4	3				1	1	2	1		13
Unknown		1							1			2
Total	4	62	15	2	1	1	3	1	8	4		101

* Other: paper/printing (4), other metal products (1), sanitary services (3), research and development (2), public order/safety (1), agricultural services/productions and livestock (2), and construction (1).

** Beyond control: factors beyond human control such as weather.

Table 8. Causes of Ammonia Releases with Injuries by Industry Type						
Industry Type	Causes					Total
	Improper mixing	Equipment failure	Operator error	Other	Unknown	
Chemical/metal/equipment mfg.		1				1
Food/beverage processing		4	2		1	7
Warehouse/storage		1		1		2
Grocery/retail						0
Child care		1				1
Private homes/hotels/motels	1					1
Transportation				1		1
Ice rinks/sheets		1	2			3
Other*	1	2		1		4
Unknown		1				1
Total	2	11	4	3	1	21

* Other: paper/printing, sanitary services, public order/safety, agricultural production.

EVACUATIONS

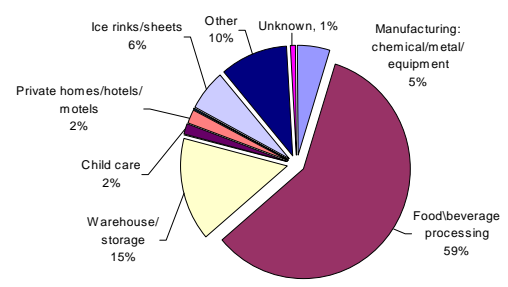
Table 9 summarizes evacuations by industry type. More than 60% of the evacuations following ammonia releases occurred in the food/beverage processing industry (40%, 17/42) and in grocery/retail (21%, 9/42). Nearly three-quarters of people evacuated due to ammonia (Figure 4) were in the food/ beverage processing industry (1,112 people, 59%) and in warehouse/storage (285 people, 15%).



Table 9. Evacuations Following Accidental Ammonia Releases at Various Facilities				
Industry Type	Number of events	Events with evacuations	Persons evacuated	Person-hours evacuated
Chemical/metal/equipment mfg.	29	4	92	190
Food/beverage processing	31	17	1,112	4,852
Warehouse/storage	9	5	285	>2,163
Grocery/retail	3	9	0	0
Child care	3	2	35	50
Private homes/hotels/motels	4	3	36	42
Transportation	2	1	3	3
Ice rinks/sheets	5	2	115	Unk.
Other*	14	6	196	952
Unknown	7	2	>15	>300
Total	107	42	>1,889	>8,104

*Other: paper/printing (4), other metal products (1), sanitary services (3), research and development (2), public order/safety (1), agricultural services/productions and livestock (2), and construction (1).

Figure 4. People Evacuated Following Accidental Ammonia Releases by Facility type**



*Other: public order/safety (1), agricultural services/production and livestock (2), construction (1).
 **Unknown: at least 15 people were evacuated in events where the industry type was unknown.

CASE STUDIES

The following are examples of ammonia events that are included in the data:

- Late one Wednesday evening, a lone workman wearing no personal protective equipment was repairing a compressor at a college ice rink. After adding oil to the system, he accidentally punctured a line carrying anhydrous ammonia and 1,000 cubic feet of the liquid refrigerant was rapidly released. Hot oil contaminated with ammonia sprayed his face and caused eye injuries which required hospitalization. Firefighters who responded to the incident were concerned about the potential for an explosion and used large exhaust fans to vent the sports facility.

- Two young male employees were overcome by chemical fumes and the entire floor of an office building was evacuated (approximately 20 people for one hour) after a half gallon of ammonium hydroxide spilled in an engineering consultant's office. The chemical was used to operate the company's blueprint machine and spilled when a shelf broke. The injured men were treated at the hospital for respiratory irritation. Although the amount seems small, the chemical soaked the carpet and powerful fumes circulated throughout the floor. The fire and police departments evacuated all second floor occupants including an oral surgery clinic. Firefighters cut the portion of the carpet where the chemical spilled and removed it in a metal container for disposal as hazardous waste.

- Twenty-five pounds of ammonia were released at a commercial blueprint shop when the protective domed cover on a 100-lb tank sheared the valve as it was being opened. During

the evacuation, one woman fell down the stairs and broke her leg. As a result, she was exposed to the ammonia vapors, suffered dizziness and respiratory irritation, and required hospitalization. One hundred and fifteen people were evacuated for four hours.

- A relief valve on a refrigeration unit at a bottling plant malfunctioned in the open position and released 200 gallons of ammonia. Employees were exposed when they were evacuated into an area downwind of the plume. Eleven employees sustained injuries including eye and respiratory irritation, headache, chest tightness, sore throat and dizziness. Nine employees received on-scene first aid and two were transported to the hospital for treatment. Thirty-five people were evacuated for about four hours from other facilities located downwind.

- An inmate at a correctional facility generated a noxious gas by mixing bleach and ammonia. The inmate and two facility employees sustained respiratory irritation. The employees were treated and released at a local hospital and the inmate was treated at the facility health clinic. Ten people were evacuated for about 1.5 hours.



The HSEES Study

The Hazardous Substances Emergency Events Surveillance (HSEES) is an on-going, state-based project to collect data on spills involving non-petroleum hazardous substances. It is funded by the Agency for Toxic Substances and Disease Registry (ATSDR). In 1992, the New York State Department of Health joined the project that now includes sixteen states³.

The goal of this project is to reduce morbidity (injury) and mortality (death) resulting from hazardous substance emergency events by identifying risk factors in the spill data and providing the information to appropriate audiences such health and safety officers or emergency responders. Measures to reduce morbidity and mortality may include improved employee training, improved use of appropriate personal protective equipment, improvements in equipment maintenance or, perhaps, a process change. The objectives of this surveillance are:

- Describe the distribution and characteristics of hazardous substance emergencies in New York State.
- Describe the morbidity and mortality experienced by employees, responders and the general public that result from hazardous substance emergency events.
- Identify risk factors associated with morbidity and mortality from the release of hazardous substances.
- Identify or develop prevention strategies that might reduce future morbidity and mortality associated with hazardous substance releases.

This factsheet summarizes HSEES data on ammonia releases in New York State from January 1, 1993, to December 31, 1998. For the HSEES project, a reportable event is defined as: an uncontrolled or illegal release or threatened release of hazardous substances excluding petroleum products which involves substances that need to be removed, cleaned up or neutralized according to federal, state or local law.

Health Department staff collects spill data through several means. Most spills are identified by the New York State Department of Environmental Conservation Spill Hotline or the New York City Department of Environmental Protection. Other notices are from the New York State Emergency Management Office and the New York State Office of Fire Prevention and Control. To gather information about each incident, Health Department staff also contacts the people involved: company representatives, responders or medical personnel. Information about each release or threatened release is entered into a database maintained by ATSDR.

Although the HSEES data are useful in generating information that can be used to prevent future releases of hazardous substances and the injuries they cause, the data have limitations. One major limitation is that the HSEES database does not capture every spill, i.e. if a homeowner breaks a thermometer or spills some pesticide. A second limitation is that the analyses are limited by the specific information collected about the spills. For example, identifying causes are limited to "equipment failure" or operator error" without additional details.

The success of this project depends on the cooperation of the people with information. If you are contacted, please

³ Other States participating in the study are Alabama, Colorado, Iowa, Louisiana, Minnesota, Mississippi, Missouri, New Jersey, North Carolina, Oregon, Rhode Island, Texas, Utah, Washington and Wisconsin.

provide the information requested. If you have any questions or comments, please call HSEES staff at 1-800-458-1158, ext.

2-7810, or (518) 402-7810. You can also visit us at our website:

www.health.state.ny.us/nysdoh/environ/hsees/hsees.htm

Additional Reading

U. S. Environmental Protection Agency and Office of Solid Waste and Emergency Response. 1998. Hazards of Ammonia Releases at Ammonia Refrigeration Facilities. EPA 550-F-98-017.

U. S. Environmental Protection Agency and Office of Solid Waste and Emergency Response. 2000. Chemical Accident Prevention: Site Security. EPA-K-550-F00-002.

U. S. Environmental Protection Agency and Office of Solid Waste and Emergency Response. 2000. Anhydrous Ammonia Theft. EPA-F-00-005.