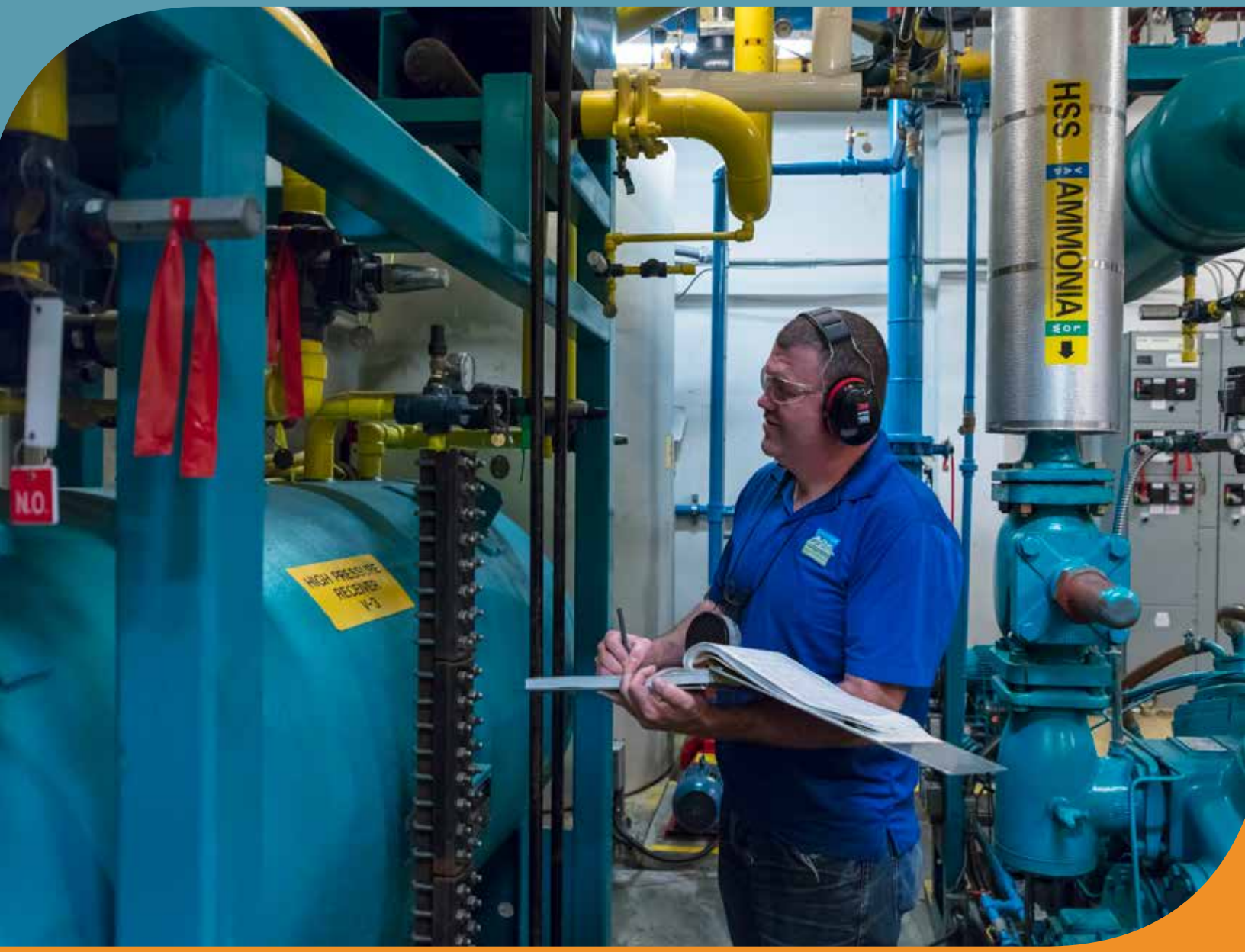
Ammonia in Refrigeration Systems



WorkSafeBC

About WorkSafeBC

At WorkSafeBC, we're dedicated to promoting safe and healthy workplaces across B.C. We partner with workers and employers to save lives and prevent injury, disease, and disability. When work-related injuries or diseases occur, we provide compensation and support injured workers in their recovery, rehabilitation, and safe return to work. We also provide no-fault insurance and work diligently to sustain our workers' compensation system for today and future generations. We're honoured to serve the workers and employers in our province.

Prevention Information Line

We provide information and assistance with health and safety issues in the workplace.

Call the information line 24 hours a day, 7 days a week to report unsafe working conditions, a serious incident, or a major chemical release. Your call can be made anonymously. We can provide assistance in almost any language.

If you have questions about workplace health and safety or the Occupational Health and Safety Regulation, call during our office hours (8:05 a.m. to 4:30 p.m.) to speak to a WorkSafeBC officer.

If you're in the Lower Mainland, call 604.276.3100. Elsewhere in Canada, call toll-free at 1.888.621.7233 (621.SAFE).

Ammonia in Refrigeration Systems

WorkSafeBC

Health and safety resources

You can find our health and safety resources on worksafebc.com, and many of them can be ordered from the WorkSafeBC Store at worksafebcstore.com.

In addition to books, you'll find other types of resources at the WorkSafeBC Store, including DVDs, posters, and brochures. If you have any questions about placing an order online, please contact a customer service representative at 604.232.9704, or toll-free at 1.866.319.9704.

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Contents

Introduction

Pure ammonia gas — when it's used as a refrigerant — is compressed to form pure liquid ammonia. Unlike ammonia compounds, pure ammonia gas or liquid is a toxic substance that can be hazardous, particularly for those who work with it or in close proximity to it.

This manual is designed as a guide for workers and employers in industries that pose a risk of exposure to ammonia, whether the ammonia is in its gas or liquid form.

Workplaces most commonly associated with potential ammonia exposure are those that use it as a refrigerant, such as ice rinks, cold storage plants, food and beverage manufacturing and processing facilities, and ice manufacturing plants. Ammonia exposure is also a risk during other workplace activities that use compressed ammonia gas, such as blueprinting, die hardening, and cleaning products manufacturing. Workers who repair or maintain ammonia systems can also be exposed to ammonia. Other workplaces subject to ammonia exposure are those that use liquid ammonia, which can include microorganism growers, wastewater treatment plants, or manufacturers of agricultural fertilizers. Liquid ammonia is also used directly in agricultural fields as a fertilizer.

As an employer, if you fail to provide the necessary precautions to protect your workers against exposure to ammonia, they can become seriously ill and even die from exposure-related illness. In order to prevent such exposures, WorkSafeBC has developed legal requirements for employers and workers in workplaces that use or work with ammonia. These requirements are detailed in the Occupational Health and Safety Regulation (the Regulation), and available in searchable form on worksafebc.com. The Regulation provides some of the mandatory minimums that must be followed to protect workers from illness and injury.

If you are an engineer or architect, this manual will provide you with information regarding the safe design of facilities destined for the use or storage of ammonia.

This manual is not meant to replace the Regulation or its requirements. It can instead be used as a tool to complement regulatory requirements and support workplace safety.

Terms associated with regulatory requirements

In this manual, the word *must* means that a particular safety step is specified in the Regulation. The word *should* indicates that — while it's not specified in the Regulation — a particular action will improve safety in the workplace. It's also important to note that for the purpose of this manual, the word *worker* includes supervisors, managers, and workers.

The workplace safety standards referenced in this publication are associated with the CSA (Canadian Standards Association) standards. Keep in mind that the Regulation may not list some standards, or it may list older versions of these standards. However, it's considered good industry practice to use the most up-to-date standards (and, if necessary, refer to the CSA standards online).

In addition to the information provided in this manual, specific information on how to work safely with ammonia is available from a variety of sources, including manufacturers and suppliers. *CSA Standard B52, Mechanical Refrigeration Code*, provides minimum requirements for the design, construction, installation, inspection, and maintenance of mechanical refrigeration systems. Worksites should have both a copy of this CSA standard and the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation (PEBPV and RSR) and ensure workers have easy access to this information as required.

For further information on working safely with ammonia, you can refer to one of our many related safe practices manuals, such as *Breathe Safer,* which outlines the use of respirators in the workplace. Copies of these manuals are available through the WorkSafeBC Store (worksafebcstore.com), or you may download a copy from worksafebc.com.

What is ammonia?

Pure ammonia versus household ammonia

The liquid ammonia referred to in this manual should not be confused with the liquid ammonia commonly found in households.

Household ammonia is actually a diluted mixture of ammonia and water. The liquid ammonia used in refrigeration systems is ammonia gas that has been compressed into a pure liquefied form, sometimes referred to as ***anhydrous ammonia***.

Pure ammonia comes in two forms: gas and liquid. When used in refrigeration, ammonia is anhydrous, meaning it is without water.

Ammonia gas is colourless and has a suffocating, pungent, penetrating odour. It is also much lighter than air and has a high affinity for water. If ammonia gas escapes from a refrigeration system or a storage container in dry air, it will tend to rise to high areas or ceilings. However, ammonia may stay low to the ground in moist air, as the reaction between ammonia and water will form a white cloud that is heavier than air. It is important to understand that a person may be exposed regardless of whether or not they can see a white ammonia cloud. Concentrations of ammonia can be hazardous over great distances.

As the amount of ammonia gas in the air decreases to parts per million (ppm) quantities, natural air convection currents spread the gas throughout a confined area.

What's more, ammonia gas is easily liquefied under pressure.

Liquid ammonia is a clear fluid that evaporates quickly at room temperature. Liquid ammonia also has a high compression ratio. The ratio of liquid to gas is 1 to 800, which means that 1 litre of liquid ammonia expands to form 800 litres of gas. A major ammonia spill is potentially disastrous, because liquid ammonia evaporates quickly when exposed to air, and at high concentrations, it creates an explosive fire hazard. Ammonia refrigeration systems may incorporate an emergency discharge valve. This valve provides a way of rapidly discharging the ammonia refrigerant into the atmosphere through a vent line during a fire or other emergency situation. Emergency procedures need to take into consideration that operating this valve could create an exposure hazard to people in the surrounding area due to the ammonia that is released to the atmosphere.

If all the liquid ammonia escaped from a 1,000 lb. refrigeration system, it would release enough pure ammonia gas to require 14 times the amount of air contained in BC Place stadium in order to safely dilute it. (This translates to a gas concentration of 25 ppm — the maximum allowable concentration a person can be exposed to in an eight-hour period.)

Hazards of ammonia

Do not heat ammonia systems

Never apply heat to any part of an ammonia system containing liquid ammonia. The immediate increase in pressure can rupture the tank or pipe.

Health

Ammonia gas is very irritating to the eyes, nose, and respiratory system. These health effects make it easy to detect low concentrations in the air. Because the gas is physically irritating, a person is unlikely to remain in an area contaminated with a detectable concentration of ammonia, unless that person is trapped or unconscious.

If you have been repeatedly exposed to ammonia gas, however, your ability to smell it may have been significantly diminished. In fact, workers regularly exposed to ammonia have shown a decreased ability to detect its odour at concentrations immediately dangerous to life and health (IDLH). (Note that the IDLH exposure level is the point at which a person without appropriate respiratory protection could be fatally injured or suffer irreversible or incapacitating health effects. Workers are considered to be in an IDLH condition if the airborne concentration reaches the IDLH level or if the airborne concentration is unknown.)

Depending on the concentration, exposure to ammonia can cause coughing, chest pain, breathing difficulty, bronchopneumonia, pulmonary edema, and death from bronchial spasm. Ammonia is a severe eye irritant; it can penetrate the eye quickly, causing permanent blindness. Contact with the skin or eyes can cause severe and potentially fatal burns.

Toxic effects of ammonia

Ammonia concentration (parts per million)	Health effect
2–55 ppm	Normal range of odour threshold*
70 ppm	Stinging or burning in eyes, nose, or throat; can cause watering of eyes, sneezing, and coughing*
300 ppm	Severe irritation of eyes, nose, or respiratory tract, which becomes intolerable after a few minutes; difficulty breathing; possible burning in lungs (IDLH level)*
2,000 ppm or more	Can be fatal after a few breaths

* If you've become desensitized by long-term exposure to ammonia, the concentrations listed in this table would not apply to you. You would likely require exposure to higher concentrations in order to notice initial health effects. **Long-term exposure to ammonia will not help you develop a tolerance to it; it will only weaken your ability to detect it.**

Exposure limits of ammonia

Exposure level (parts per million)	Exposure limit
25 ppm	Maximum allowable concentration averaged over an eight-hour period
35 ppm	Maximum allowable short-term exposure (15 minutes)
300 ppm or more, or concentration is unknown	Immediately dangerous to life and health (IDLH)

Related incident

Electrical spark ignites ammonia vapour

For several hours, no one noticed a leak of liquid ammonia from a deteriorated seal. When the engineer smelled ammonia in the area, he entered the machine room and found pools of liquid on the floor. He immediately activated the emergency discharge valve. A spark inside the electrical switch ignited the ammonia vapour, causing an explosion that blew out two walls. Fortunately, the engineer suffered only minor injuries.

Fire

Ammonia's fire hazard rating is usually stated as "slight." Ammonia is explosive in the air at concentrations of 16 to 27 percent (by volume).

Ammonia is extremely reactive, however, which means it easily combines with other materials to form products typically more hazardous than ammonia alone. The presence of oil or other combustible materials increases ammonia's fire hazard. And when it comes into contact with strong oxidizers, such as chlorine, bromine, iodine, and hypochlorite bleaches, ammonia can form explosive mixtures.

Corrosive action

Ammonia can cause chemical burns on all body surfaces. Ammonia vapour reacts with moisture in the air to form aqueous ammonia, which attacks copper, zinc, tin, cadmium, and most of their alloys. Ammonia will also corrode many rubbers and plastics.

Employer responsibilities

Health and safety programs

In accordance with the Regulation, you are obliged as an employer to develop and implement an effective health and safety program. Such a program would include training workers and supervisors to understand and apply relevant sections of that program. Addressing the hazards associated with ammonia exposure would be one element of that program.

A health and safety program helps ensure the workplace remains safe and productive by outlining and reinforcing specific tasks and responsibilities for workers, supervisors, and employers. An effective program for the use and storage of ammonia must include the following:

- A written health and safety policy that:
  - States the employer's commitment to health and safety
  - States the program's objectives
  - Defines the responsibilities and roles of the employer, supervisors, and workers
- Written safe work procedures and emergency response procedures
- Training for supervisors and workers
- Regular worksite inspections
- Regular health and safety meetings
- Incident investigations
- Records and statistics
- A joint health and safety committee or worker health and safety representative, if required

As an employer, it's important to remember that every worksite is unique. While the above requirements may be common features of health and safety programs across the province, you must develop and implement a health and safety program that adequately reflects your own operation.

Written safe work procedures

A health and safety program is an overall program that includes a number of individual written safe work procedures and specific, smaller programs. Written safe work procedures and programs show workers how to perform their duties safely. Employers must ensure that all workers understand these procedures well enough

Safe handling of ammonia: Where to look for information in the Regulation

You can use several elements of your health and safety program to ensure your workers safely handle ammonia. For the purposes of this manual, these key elements (and their location in the Regulation) include:

- Toxic process gases (Part 6)
- Emergency preparedness (Parts 4–6)
- Equipment preventive maintenance; critical parts inspections (Parts 4 and 6)
- WHMIS; exposure control programs (Part 5)
- Respiratory protection programs (Part 8)
- First aid requirements (Part 3)

to perform their duties competently. Employers must review all written safe work and emergency procedures jointly with workers and supervisors at least once a year and when there are any changes in operations or equipment.

WHMIS programs

A Workplace Hazardous Materials Information System (WHMIS) program helps ensure that workers who work with or near ammonia are instructed in its safe use, storage, handling, and disposal. This includes the use of labels or other means of identifying ammonia containers or systems. With the introduction of WHMIS 2015, some of this information has changed.

For the most updated version of WHMIS, go to worksafebc.com and search for "WHMIS 2015" or see Part 5 of the Occupational Health and Safety Regulation, available in searchable form on our website.

Exposure control plans

Written exposure control plans explain the work procedures and other controls employers will need to use in order to reduce workers' risk of exposure to ammonia. It's essential that specified exposure controls are strictly adhered to and appropriate respiratory and skin protection are used. Employers must also ensure that qualified persons perform a formal risk assessment to determine which workers may be affected by exposure to ammonia and the extent of any exposure. For more information about the elements of exposure control plans, see section 5.54 of the Regulation.

For more detailed information on preventing exposure (through building design, ventilation, and monitoring/alarm systems) and controlling exposure (using eye, skin, and respiratory protection), see "Preventing and controlling exposures" on page 25.

Risk assessment and written work procedures for toxic process gases

Ammonia is a toxic process gas. As an employer, you must ensure that a risk assessment is conducted for toxic process gases. This assessment can be the same one listed under "Exposure control plans." You must also ensure that written work procedures are developed providing instructions for the safe handling of ammonia at your workplace. These procedures must accord with the risk assessment results, critical technical information, and operations manuals.

Related incident

The importance of having and following proper procedures for upset conditions and emergencies

When a power failure occurred at a cold storage facility, an operator bypassed an alarm in order to get the system back online. As a result, cold ammonia liquid was allowed to enter a pipe. Ordinarily this pipe would be filled with cold liquid but, at the time, it was in a defrost cycle, so it was filled with hot gas. This combination of hot gas and cold liquid ammonia caused a fracture in the pipe, which caused a major release of ammonia. Dozens of workers were hospitalized as a result of 32,000 pounds of ammonia being released.

Less ammonia would have been discharged if an emergency shutdown had been started immediately. Instead, operators spent hours attempting to isolate the fractured pipe with the system still operating.

Personal protective equipment programs

Providing protective equipment and ensuring that workers use it are essential to any effective health and safety program. As an employer, you are required to develop and implement an effective personal protective equipment program to protect workers from chemical exposure, such as through inhalation and contact with the eyes and skin. This program must meet the requirements of the Regulation. For more information on personal protective clothing and equipment, see Part 8 of the Regulation.

As an employer, you must ensure that workers are trained in proper use and care of respirators. And when a worker is first fitted with a respirator, and at least once a year thereafter, you must provide fit testing. You'll need to conduct fit testing using a WorkSafeBC-accepted protocol, such as the one described in *CSA Standard Z94.4*. (One type of test, for instance, the qualitative fit test, determines if the worker can detect any amount of a test compound leaking through the respirator.)

Employers must also keep records of their fit tests. If your company uses self-contained breathing apparatuses (SCBAs), you must do air-testing on compressed breathing air, and retain records of this annual testing.

Respiratory, eye, and skin protection requirements are covered in more detail under "Personal protective equipment" on page 30. You can also find more information on respiratory protection in other WorkSafeBC publications, such as the *Breathe Safer* manual.

Written emergency procedures

To prepare for workplace emergencies, employers must do as follows:

- Keep an up-to-date inventory of hazardous substances.
- Conduct a risk assessment.
- Prepare an emergency plan with detailed response procedures, including:
  - Escape and evacuation protocols
  - Steps for notifying emergency services and other parties that may be interested or affected by a large leak (e.g., WorkSafeBC, neighbouring schools, shops, or care facilities)
  - Steps to bring the emergency under control
  - Steps to ensure that the workplace is safe for re-occupancy
- Train workers on these emergency procedures, which should include conducting drills.
- Inform your local fire department about your workplace emergency plan.

If the amount of ammonia on site ever exceeds 4.5 tonnes, workplaces must be registered with Environment and Climate Change Canada. If the amount of ammonia in a single refrigeration system exceeds 4.5 tonnes, workplaces must have an Environmental Emergency Plan (E2 Plan). Visit ec.gc.ca for details.

For more information on written emergency procedures, see "Preparing for emergencies" on page 15.

Written preventive maintenance procedures

In consultation with equipment manufacturers or suppliers, employers must ensure that all equipment is inspected regularly and replaced when necessary. You must also ensure everyone who works on the ammonia system has ready access to and understands the written preventive maintenance and emergency procedures you've developed for this type of work.

Employers must include plans for testing and replacing, where required, all ancillary (secondary) safety equipment, such as monitors and alarm systems, detection equipment, radios, eye washes, respiratory and skin protection equipment, and first aid kits. To ensure nothing is overlooked, you may find it useful to develop checklists for inspecting and testing equipment. You'll need to record all use and maintenance of safety equipment in a suitable logbook.

For more information on preventive maintenance, see "Repair and maintenance" on page 21.

Checking on a worker working alone

Employers must establish a system with written procedures to ensure the continued well-being of workers who enter an ammonia enclosure on their own, or for those who work in isolation. Depending on the situation, your person-check system may consist of visual checks, radio contact, or a telephone call-in procedure. The person-check system must include the following:

- A set interval between checks
- A record of each check
- A check at the end of the workshift
- Procedures to follow if the worker cannot be contacted or is injured

Training, instruction, and supervision

Workers may have special certification or other external training, but employers are ultimately responsible for providing them with thorough, site-specific training and continued instruction in the programs and procedures outlined earlier in this section. Written safe work procedures form the basis of your ongoing training program.

Employers are required to document the training and instruction provided to workers, and workers must be able to demonstrate competency in doing their work according to the work procedures. See the next section, "Examples of written safe work procedures," for more information and samples of these procedures.

Regulatory requirements

Employers must ensure that any person who is employed to operate an ammonia refrigeration system of any capacity is adequately trained and qualified for the safe operation of that system.

Employers must also ensure that any person who is employed to operate an ammonia refrigeration system that exceeds 50 kW prime mover nameplate rating is qualified in accordance with the requirements of the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation. For more information, contact Technical Safety BC.

Examples of written safe work procedures

Related incident

Lack of written procedures results in ammonia leak

A heavy buildup of ice had formed on the outside of the main ammonia feed-line. One of the maintenance staff was told to remove the ice. There was no written safe work procedure, so the employee attempted to break the ice away with an axe. He hit a pipe elbow, snapping it off and releasing liquid ammonia into the area. The emergency procedures had to be activated, and the plant was evacuated.

Some tasks that require written safe work procedures include, but are not limited to, the following:

- Cylinder hookup
- Leak detection and control
- Draining the chiller
- Checking on a worker working alone
- Respirator program
- Disposal of damaged containers
- Full and partial system startup
- Full and partial system shutdown
- Routine maintenance of equipment (such as pumps and piping)

Part 6 of the Regulation (toxic process gases) states that written safe work procedures must be detailed and complete, and must not assume that workers will know or remember any unlisted tasks. The following examples demonstrate the amount of detail required. (These examples will not apply to all worksites. Employers must create detailed, written safe work procedures to suit the individual worksite.)

Example 1: Leak detection and control

Situation 1: A minor leak occurs during routine operation (with an alarm system in place)

- If the alarm has been activated, leave the area and follow emergency procedures.
- If the alarm has not been activated (for example, when ammonia can be smelled), immediately locate your respirator and put it on. (See the respirator selection table, page 32.) Also, obtain and carry a recently calibrated and bump-tested portable ammonia gas detector. Then, follow these steps:
  (1) Moisten a strip of indicator paper with water (see the notes on page 13), then check for the approximate area of the leak.
  (2) After locating the approximate area of the leak, use fresh strips of indicator paper to determine the exact source of the leak.
  (3) Do not attempt to stop the leak until a second worker is present.
  (4) Perform minor maintenance to stop the leak.

(5) Wait a few minutes, then re-test the leak with indicator paper.
(6) If minor maintenance does not stop the leak, initiate the shutdown procedure to prepare for repair.

Notes on Situation 1

- The indicator paper contains phenolphthalein — do not attempt to moisten the strip using your mouth.
- Indicator paper can be used only for detecting leaks, not for measuring airborne ammonia concentrations. The indicator paper changes its colour to pink when it's near ammonia. You'll notice that the colour change is slow at 6 ppm, and moderately quick at 15 ppm.
- Do not store indicator paper in the machine room.
- Area ammonia monitors will provide information about the general conditions of a work area where a release is occurring. But the concentration at the release location will typically be higher than the concentration measured at the area monitor, depending on proximity between the release location and the monitor location.

Situation 2: A minor leak occurs during routine operation (with no alarm system in place)

(1) If you smell ammonia and/or feel eye irritation, leave the area.
(2) Notify the supervisor.
(3) While wearing appropriate respiratory protection (see the respirator selection table, page 32), measure the airborne ammonia concentration using a recently calibrated and bump-tested personal gas monitor with an ammonia sensor.
(4) Moisten a strip of indicator paper with water (see the notes below), then check for the approximate area of the leak.
(5) After locating the approximate area of the leak, use fresh strips of indicator paper to determine the exact source of the leak.
(6) Perform minor maintenance to stop the leak.
(7) Wait a few minutes, then re-test the leak with indicator paper.
(8) If minor maintenance does not stop the leak, initiate the shutdown procedure to prepare for repair.

Notes on Situation 2

- The indicator paper contains phenolphthalein — do not attempt to moisten the strip using your mouth.
- Indicator paper can be used only for detecting leaks, not for measuring airborne ammonia concentrations. The indicator paper changes colour to pink when it's near ammonia. The colour change is slow at 6 ppm, and moderately quick at 15 ppm.

Related incident

No respirators and inadequate training result in major ammonia spill

Two workers were draining the chiller oil when a 25-litre (5-gallon) bucket collecting oil froth was about to overflow. The operator left his untrained assistant holding the hose and crossed the room to fetch a second bucket. The assistant held the hose up out of the bucket by mistake, sending ammonia vapour into his own face. Physically distressed, he dropped the hose and ran. Liquid ammonia started to drain into the room. The operator was unable to approach the shut-off valve and also left the room. He was coughing and had trouble breathing, and his eyes and nose were burning. Had the operator realized that he had been acting as a supervisor in this instance, he might have properly instructed the untrained assistant.

- Do not store indicator paper in the machine room.
- If the exhaust ventilation is not automatically triggered (see "Ventilation" on page 27), the designated supervisor will determine when it is safe to ventilate the contaminated area.

Situation 3: A leak occurs during routine operation, and no method is immediately available to determine the airborne ammonia concentration

When no method is immediately available for determining airborne ammonia concentration, you must consider all leaks to be major leaks and activate full emergency procedures.

Example 2: Draining the chiller oil

Draining the chiller oil is a routine maintenance procedure that involves the release of ammonia gas. When you're developing written procedures, make sure you understand the unique requirements of your system, and follow the manufacturer's recommendations. To minimize the release of ammonia, consider the following steps:

(1) While this procedure is being performed, ensure the ventilation system is switched on and operating.
(2) Ensure the work procedure specifies how often this job will be done. Draining the chiller oil on a regular basis reduces the amount of oil drained, which will reduce the release of ammonia.
(3) Record measurements of ammonia levels in the air to ensure that the work procedure maintains ammonia levels below 25 ppm.
(4) Significantly reduce the release of ammonia gas by draining the chiller oil through a length of tubing into a bucket of water.
(5) Ensure all workers in the machine room wear appropriate respirators.
(6) Ensure at least two workers are present during this procedure, unless the system is equipped with a shut-off valve (deadman switch).
(7) Always close the drain valve before leaving the immediate area for any reason (except during an emergency escape).

Note that there are a number of different methods for isolating the oil-trap from the ammonia system by using an intervening valve (a valve between the oil-trap and the ammonia system). The valve will ensure that if an accident occurs, only the oil-trap will be drained, and not the whole system.

Preparing for emergencies

Preparing for emergencies includes planning for ammonia spills and any exposure that may require implementing procedures, such as evacuation and notification of local emergency response units. The preparation required for these types of emergencies is detailed below, under "Written emergency procedures," and should be included in a written emergency plan. For more information about the elements of this required emergency plan, see sections 5.97 through 5.102 of the Regulation.

Preparing for emergencies also includes making appropriate emergency equipment available to workers, and ensuring that they know how to use it. This equipment — eye-wash stations, shower facilities, and first aid kits — is discussed under "Emergency equipment" on page 16.

Written emergency procedures

Part 6 of the Regulation (toxic process gases) mandates that employers provide workers with formal written emergency procedures that give workers detailed directions in case of an emergency. A detailed emergency plan, however, does not provide sufficient protection. You must also conduct emergency drills to determine whether these procedures work in practice and to thoroughly familiarize workers with their roles in an actual emergency. You must also keep records of these drills in order to monitor their efficiency.

These written emergency procedures must include specific details concerning the following:

- Notifying workers of the emergency location
- Controlling materials that may become dangerous during the emergency
- Using and locating emergency personal protective equipment
- Locating the system's emergency discharge valve
- Using and accessing emergency lighting
- Using evacuation procedures and a person-check system to ensure all personnel are evacuated
- Using the search and rescue process
- Notifying police, fire department, hospital, and other emergency response units (such as suppliers)
- Notifying adjacent worksites and private homes about the emergency

As soon as the written emergency procedures are created, employers must do as follows:

- Provide each worker with a copy of the plan, and provide enough training to ensure workers clearly understand the procedures.
- Post the procedures and other relevant information, such as telephone numbers, in appropriate, conspicuous locations.
- Conduct regular tests of the procedures, including drills.
- Notify the fire department and other emergency response units of the nature, location, and safe handling of all hazardous materials that may endanger firefighters.
- Provide information about the nature of the hazard and a copy of appropriate emergency procedures to all adjacent worksites and private homes potentially affected by an emergency.

Besides these general emergency procedures, employers must have specific procedures to cover the following:

- The response to an alarm signal
- The control of potential leaks
- The response to the dispersal of leaked ammonia inside the plant
- When and how to perform an emergency shutdown
- If the system has a receiver or receivers capable of storing ammonia from the system, when and how to transfer the ammonia to the receivers
- The response when ammonia is released to the atmosphere through system vents from pressure relief valves or emergency discharge valves
- The first aid response to an incident
- The incident investigation

Emergency equipment

Eye-wash and shower facilities

Sections 5.85 to 5.96 of the Regulation describe requirements for emergency washing facilities. Employers must conduct a risk assessment for each workplace hazard. In the Regulation, use Table 5-2: Risk Assessment, to determine risk levels relating to hazardous materials, including ammonia. Use Table 5-3: Provision and Location of Emergency Washing Equipment, to determine what type of eye-wash equipment to use and where to locate it.

When conducting a risk assessment, you must consider the following:

- The nature of the workplace chemical (corrosive or irritant)
- The state of the substance (gas, liquid, or solid)

- The potential for exposure to skin or eyes and the extent of any exposure
- The number of potentially affected workers
- The availability of first aid and professional medical help

Employers will need to meet these requirements for eye-wash and shower facilities:

- Ensure that the facilities have a supply of tempered water (15 to 30°C, 59 to 86°F) for at least 15 minutes, or longer if the ammonia safety data sheet requires it.
- Determine the most appropriate location for emergency equipment. (It is not appropriate, for example, to install emergency equipment in the machinery room.)
- Take into account the geographical location of the facility when deciding whether or not an outdoor location will be practicable during the winter.
- Do not locate emergency equipment where the public may access and possibly damage it.

First aid kits

Workers must have immediate access to an appropriate first aid kit at each ammonia location. To determine the appropriate first aid kit required for a particular worksite, see Part 3 of the Regulation. For more information about first aid treatment for exposure to ammonia, see page 34.

Investigating incidents

Incident investigations are an important way to learn about the cause of hazardous incidents or injuries as a means of preventing them in future. Under the Regulation, employers must immediately notify WorkSafeBC of any major release of a toxic substance. In the case of ammonia, a major release would result in one of the following:

- An injury that requires immediate medical attention beyond the level of service provided by a first aid attendant, or injuries to several workers that require first aid
- A situation of continuing danger to workers, such as when the release of a chemical cannot be readily or quickly cleaned up

Any time enough ammonia is released to set off the alarm, employers must conduct a formal investigation to discover the causes of the incident. This investigation must also examine measures to prevent recurrence. You must forward copies of your investigation report to your joint health and safety committee and to WorkSafeBC. (For more information on how to develop and submit these reports, go to worksafebc.com and search for "Employer Incident Investigation Report.")

Ammonia releases must also be reported to:

- Technical Safety BC (previously known as the BC Safety Authority) — 1.866.566.7233 or technicalsafetybc.ca
- B.C. Environmental Emergency Program — 1.800.663.3456 or go to www2.gov.bc.ca/gov/content/environment and click the "B.C. Spill Response" link

For more information about the reporting requirements for these and other agencies, contact the agencies directly.

Working safely around ammonia

This section will be useful to anyone who works with or around ammonia. It includes information on storing ammonia, handling ammonia, and the repair and maintenance of ammonia systems.

Personal protective equipment — particularly eye, skin, and respiratory protection — is essential to working safely around ammonia. For more information, see "Personal protective equipment" on page 30.

Storing ammonia

Liquid ammonia is stored in a variety of containers: cylinders, pressure vessels, and tank trucks. This section describes what you must and must not do when storing ammonia.

Note that all ammonia and refrigeration equipment must meet the requirements of the *Safety Standards Act,* the Electrical Safety Regulation, the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation (PEBPV and RSR), and applicable CSA standards (such as *B52, Mechanical Refrigeration Code,* and *B339, Cylinders, Spheres, and Tubes for the Transportation of Dangerous Goods*).

Signage

- Use signs to clearly identify all ammonia enclosures and tanks, to state that only designated qualified personnel are permitted to enter an ammonia storage area, and to provide precautions required for safe entry.
- Indicate the total weight of ammonia contained in the system on a sign that is both readable and accessible.

Refer to *CSA Standard B52* for other sign-posting requirements.

Quantity and location

- Do not allow the amount of stored ammonia to exceed 136 kg (300 lb.) or 20 percent of the normal ammonia charge (total amount in the system), whichever is less.
- Store ammonia cylinders and containers in a cool, dry, and relatively isolated area, protected from weather and extreme temperatures. If cylinders and containers are stored outside,

shield them from direct sunlight unless they are specifically designed for unshaded, outdoor storage. (Note: Never apply heat to containers or their valves.)
- When storing ammonia inside, store ammonia cylinders and containers in a well-ventilated building and away from any heat sources. Never allow cylinders and containers to reach 50°C.
- Store cylinders upright, and secure them against falling. Cylinders will discharge vapour when upright, and liquid when upside-down.

Housekeeping

- Do not store materials that may react violently with ammonia in the same room as ammonia (for example, iodine, bromine, chlorine, and hypochlorite bleaches).
- Do not block access to emergency equipment and doors.
- Use cylinders on a "first-in, first-out" basis.

Empty cylinders

- Clearly tag or mark empty cylinders, and separate them from full cylinders.
- Do not consider cylinders or other ammonia system containers empty and safe until they have been thoroughly purged with nitrogen, steam, or water.

Fire precautions

- Do not use open flames in ammonia storage or holding areas.
- Do not smoke in ammonia storage or holding areas.
- Always ground storage containers to minimize the buildup of static electricity.

Handling ammonia

This section describes what you must and must not do when handling ammonia. As a first point, never wear contact lenses during any ammonia-handling task. Ammonia can become trapped under the lenses and cause extensive eye damage.

Moving cylinders

- Handle cylinders with care when moving or storing them. Do not allow cylinders to strike objects, and do not drop cylinders.
- Do not use slings or magnetic devices to move ammonia cylinders.
- Do not stand in line with valve or fitting openings, particularly pressure-relief valve openings.

Working with valves

- Ensure that cylinders have valve protection hoods in place when not connected to a system.
- Do not lift a cylinder by its valve protection hood. The hood is not designed to carry the weight of a cylinder.
- Do not modify, alter, or repair cylinders and valves. Only the supplier should carry out these tasks.

Repair and maintenance

As an employer, you are responsible for providing written preventive maintenance procedures and emergency procedures to any person who works on an ammonia system. You must ensure that only fully trained and qualified persons are permitted to perform any repairs and maintenance of the ammonia system under the Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation, which is enforced by Technical Safety BC.

Qualified personnel must supervise the cleaning and repair of ammonia systems. They must be familiar with all the hazards and the safeguards necessary to safely perform the work. You must also ensure that workers are familiar with these procedures before carrying out repairs or maintenance on the ammonia system.

If repairs present an ammonia hazard, shut down the ammonia system before proceeding. Isolate from the system the part that needs repair, either by physically removing it or by effective blanking (blocking off lines to cut off the flow of ammonia). Before any work is done, ensure the isolated part is thoroughly purged with water or steam to remove all traces of ammonia.

Requirement to test and maintain

The following is a brief outline of the minimum requirements for maintenance of refrigeration systems in accordance with section 8.4 of *CSA Standard B52, Mechanical Refrigeration Code*, which is adopted and enforced by Technical Safety BC.

If any tests result in failure, then employers are required to take corrective action.

Note that testing for refrigerant leaks must be done in all of the following cases:

- As frequently as specified, and in the manner described, in the manufacturer's instructions
- As frequently as required to prevent workers from being injured or to prevent system failure
- Any time physical evidence indicates a possible leak
- Any time the system operating conditions indicate a loss of refrigerant
- Any time the vapour detector is activated

As an employer, you must ensure that all of the following testing and maintenance is done on your refrigeration systems.

Testing and maintenance activity	Minimum frequency	Details
Check all power and control electrical terminations.	1 year	Tighten if necessary; verify for integrity, continuity, corrosion, no excessive temperatures.
Inspect all refrigerant lines, vent lines, and system components for vibration, corrosion, and/or physical damage.	3 months	
Inspect all lines, including vent lines and outlets, for blockages and insulation condition.	3 months	Include vessel insulation.
Inspect for operational performance all ancillary devices, components, and fluids integral, external, or remote to refrigeration equipment.	Prior to initial startup and annual startup, and monthly thereafter during operation	Indirect systems, hydronic systems, cooling towers, air distribution systems, etc.
Visually inspect, in conjunction with operational system inspections, the logging and operating characteristics of the equipment and system components.	Ongoing and periodic	Where visual inspection is not possible, use system operational characteristics and relevant sensors to identify existing or pending problems.

In addition, employers must ensure that all the following testing and maintenance is done on any refrigeration system, unless the system has been tested and verified by an approved laboratory (contact Technical Safety BC for more details). For systems that are listed by an approved testing laboratory, employers are responsible for ensuring that the refrigeration systems are maintained in accordance with the manufacturers' minimum recommendations.

Testing and maintenance activity	Minimum frequency	Details
Replace or recertify pressure-relief valves.	5 years	Not required if not equipped by the original manufacturer.
Test pressure-limiting devices for set point accuracy and ability to properly stop the affected equipment.	1 year	Not required if not equipped by the original manufacturer.
Test other safety devices for set point accuracy and ability to properly stop the affected equipment.	1 year	Not required if not equipped by the original manufacturer.
Test permanent space leak detectors.	• Bump test: 1 month • Calibration: 1 year	Concentration must be in accordance with manufacturer's instructions — audible and visible alarms and ventilation must begin.
Test for refrigerant leaks.	Variable (see "Details" column)	Test for refrigerant leaks: • Periodically as per regulations • As required by the manufacturer • If there is physical evidence that may indicate a leak • If the system operating conditions indicate a loss of refrigerant • If the vapour detector alarm is activated
Perform all safety-related maintenance recommended by the manufacturer.	As indicated in documentation	

Logging test and maintenance data

At the end of each test, a tag noting the test date and tester's name must be attached to and remain on the device. In addition, systems shall be logged regularly in accordance with the manufacturer's and industry guidelines. Logs and records shall consist of operational characteristics, environmental issues, and safety design criteria/issues.

Welding hazard

Welding or any other heating of an ammonia system is extremely hazardous. Isolate and purge system parts before welding.

Requirement to keep equipment clean

As an employer, you must ensure all of your refrigeration systems are kept clean, which means that they are free of accumulations of water, oily dirt, and other debris, and readily accessible at all times. Prior to the introduction of refrigerant into a system, you must ensure systems are dehydrated, clean, and evacuated to levels of 500 micrometres Hg or lower (according to regulated requirements). Refrigerant quality shall meet acceptable values.

For secondary coolant systems, such as brine- or glycol-based cooling systems, you must ensure the following:

- The water quality is tested to prevent corrosion.
- Flow rates are set to prevent erosion and maintain adequate heat transfer as per the manufacturer's criteria.
- System fluids having the potential to solidify, and their specific gravity or refractive index, are verified to prevent damage to equipment and potential loss of refrigerant.

Fall protection during inspection and maintenance

Workers, especially refrigeration system operators, will encounter fall hazards when they need to access piping at higher elevations. Typically, they would associate these hazards with their regular inspection and maintenance duties.

Guardrails are required to protect workers in any situations where they can:

- Fall 122 cm (4 ft.) or more from:
  - An open-sided floor or similar structure
  - Around the perimeter of an open container or containment area
- Fall onto machinery
- Fall into work areas or other hazardous environments
- Fall 3 m (10 ft.) or more

In fixed workplaces, employers must ensure guardrails are in place to prevent falls from elevated areas that require regular worker access, such as rooftop edges.

To address these concerns, employers will need to conduct a risk assessment to identify all possible fall hazards in their workplaces. Employers can find more information about developing a risk assessment by referring to WorkSafeBC Guideline G11.2-2. This guideline outlines the fall protection requirements associated with working on roofs or in elevated work areas and outlines the risk assessment criteria.

Preventing and controlling exposures

Engineering and administrative controls are the first line of defence against exposure to ammonia, and proper building design and ventilation offer important engineering considerations. Effective monitoring and alarm systems are also essential to preventing ammonia exposure.

Personal protective equipment (PPE) represents the last line of defence against exposure. However, when an ammonia leak has occurred or is likely to occur, PPE is vital for controlling exposure. PPE in this case would include eye, skin, and respiratory protection.

To reduce the effect of a release, it is also imperative to have emergency response equipment such as eye-wash and shower facilities and first aid kits.

Engineering controls (building design)

This section is mainly for engineers and architects who are involved in designing ammonia systems and storage facilities.

Machine rooms

Technical Safety BC enforces the requirement that ammonia machine rooms must conform to the Canadian Electrical Code, Part 1.

In a few municipalities in B.C., it's up to the municipalities to enforce these electrical code requirements. Part 6 of the Regulation (toxic process gases) provides requirements for the design, ventilation, and monitoring of enclosures for toxic process gases, including ammonia.

Consider the following points when designing an ammonia system or storage facility:

- All electrical installations must be explosion-proof.
- Shipping containers and equipment containing ammonia must be located indoors, in a suitable fire-resistant building. If a separate building is not provided, containers and equipment must be located in an enclosure with fire-resistant floors and walls.
- The machine room must be sealed from the rest of the building. All pipe openings must also be sealed.
- Machine rooms with a floor area larger than 60 m^2 (200 sq. ft.) must have two or more exit doors to ensure accessible escape routes.

- The machine room must provide free and unrestricted access to exit doors. At least one exit door must open to the outside of the building.
- All exit doors must open outward, be self-closing, and be fitted with panic hardware (a crash bar for easy exit).
- Doors should not be self-locking.
- If the room is heated for comfort, ammonia containers and equipment must not be overheated.
- The machine room or storage rooms must not be designed or used for any of the following:
  - Storage of other materials (such as ice skates, in the case of arenas)
  - Any other work processes
  - A worker rest area
- Emergency controls to shut down the ammonia compressor must be located outside the machine room.
- Cold storage rooms must have a door that opens easily from the inside. These rooms must also have a means of alerting other workers if a person is unable to exit the room.
- The machine room must be equipped with emergency lighting.
- All piping carrying ammonia must be identified according to WHMIS requirements.

Class "T" machine rooms

Consider the following points for Class "T" ammonia machine rooms:

- The room must not contain any permanently installed flame-producing devices or hot surfaces over 427°C.
- The room's walls, floor, and ceiling must be sealed from the rest of the building and must be constructed to have at least a one-hour fire-resistance rating. All pipe openings must also be sealed.
- At least one exit door must open to the outside of the building. Any exit to another area in the building must be through a vestibule equipped with approved, self-closing, tight-fitting fire doors.
- Exterior openings must not be under any fire escape or open stairway.
- Emergency controls to shut down the mechanical equipment must be located outside the machine room.
- The purpose of all valves must be conspicuously marked, and a schematic diagram of the system should be available.
- The machine room must have an independent mechanical ventilation system. If the machine room is in a basement, the ventilation system must operate continuously. Machine rooms

in any other locations must have the following:
  - Continuous ventilation when they are operating or occupied
  - Mechanical ventilation to exhaust a potential accumulation of refrigerant if the ammonia detector is activated
- Ventilation fans must have a control switch on a separate circuit located outside the machine room. Ventilation fans must be allowed to run as long as power is available.

For more specific building design information, refer to the following:
- Province of British Columbia Building Code
- Ammonia system manufacturer/supplier
- Technical Safety BC
- Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation (PEBPV and RSR)
- *CSA Standard B52, Mechanical Refrigeration Code*

Ventilation

A suitable fan must ventilate the machine room and storage rooms. All ventilating fans must provide at least 15 air changes per hour, and must have switches outside the machine room, even when an inside switch is installed.

Because ammonia gas is lighter than air and tends to collect at ceiling level, the suction of ventilating fans must be at or near ceiling level. Air inlets must be located to provide cross-ventilation using outside air.

Ammonia must not be discharged into areas where it may cause damage or injury, such as schools, worksites, private homes, or shopping centres. Ventilation exhaust must not be positioned where it can be captured by the air intake system of the same or another building.

As per *CSA Standard B52,* ventilation exhaust from a machinery room must be vertically upward from the roof. The system must have rated ducts with an upblast fan. The required rate of ventilation must be calculated from the information contained in the standard. The minimum stack height will be determined by the distance from the edge of the roof, in accordance with the ACGIH publication *Industrial Ventilation: A Manual of Recommended Practice.*

If a machinery room is not vented upward from the roof, modifications to the exhaust system are required to meet the specifications of *CSA Standard B52.*

Emergency shutdown devices

Where practicable, the refrigeration system must be designed to allow for remote or automatic emergency shutdown, so as to isolate the reserve supply within the system and the flow of gas. This will prevent workers from being put at risk when shutting down the system.

Administrative controls

Monitoring/alarm systems

An effective alarm system includes a monitor that constantly tracks ammonia levels and an alarm that responds if ammonia concentrations reach a certain preset level.

A 24-hour continuous ammonia monitor must be connected to the alarm system. In case of an ammonia leak or emergency, all facilities must have a working alarm that workers can see and hear.

The continuous monitor needs to have a direct readout of the ammonia concentration that can be seen from outside the enclosure to allow workers to know whether hazardous conditions are present.

Without a direct readout from the monitor, every leak must be considered immediately dangerous to life or health (IDLH), because the ammonia concentration will be unknown. This requires a self-contained breathing apparatus (SCBA) to be worn, with emergency backup, as outlined in the detailed emergency response procedures.

There are several types of commercial monitoring/alarm systems. Each type has its advantages and disadvantages. Before buying an alarm system, consider the following:

- Reliability
- Accuracy
- Response speed
- Calibration and system drift
- Operating temperature range
- Sensor type
- Service and maintenance
- System testing

It is also important to determine what other gases may activate the alarm. Employers may need a more selective system if interfering compounds may be present in the facility. Equipment suppliers and other alarm system users can provide more information to help determine particular monitoring and alarm requirements.

Basic alarm system requirements

- Install the system according to the manufacturer's instructions. Follow a strict timetable for conducting regular maintenance procedures and tests, and keep maintenance records.
- Qualified workers must test and calibrate the system using the manufacturer's instructions. Systems must be tested for proper operation at least monthly and calibrated annually. Systems must also be tested and calibrated after any significant exposure. (See the manufacturer's instructions to determine what constitutes a significant exposure.)
- Workers must know the alarm level (the ammonia concentration that triggers the alarm), and this information must be clearly posted outside the enclosure. Ensure the posting of necessary safety precautions for any given concentration level.
- The preset alarm level should be at or below 35 ppm. Alarm response procedures must account for minor leaks that may not require the services of an emergency response team.
- The system must include a visible and audible alarm at the ammonia location, preferably connected to a radio or telephone system to alert the operator in case of an emergency.
- The system must be able to trigger exhaust ventilation automatically, although this will not be appropriate in all locations.
- If the alarm system reacts to compounds other than ammonia, you must determine whether these interfering gases are present and, if so, whether they will affect the alarm's response to ammonia.

Handheld and personal monitors

Handheld and personal monitors are important tools in response to a leak or release. They ensure workers responding to a leak are continually kept informed about the airborne concentration of that leak at the workers' location. With the use of these monitors, workers can make informed decisions about the suitability of their personal protective equipment for the conditions in question. These monitors can also help identify the approximate location of a leak or release.

Workers must be properly trained in the use and maintenance of monitoring equipment. This monitoring equipment must be calibrated in accordance with the manufacturer's instructions and bump-tested prior to use. Docking stations can automate the calibration and bump-testing process.

Fixed gas monitors

The continuous monitor needs to have a direct readout that can be seen from outside the enclosed hazard area. A digital readout is preferable, but a needle/scale is acceptable. The readout ensures

that emergency response personnel know enough about the concentration of ammonia to make an informed decision with respect to necessary personal protective equipment. The alarm's upper set point should be lower than the IDLH concentration of 300 ppm, because the concentration of ammonia will generally be higher at the leak point than at the fixed monitor location. Remember that the lower limit should be no higher than 35 ppm.

Employers will need to perform a risk assessment to determine other areas subject to potential release of ammonia, and whether to place fixed monitors in these locations.

Pressure-relief device monitoring

Monitoring must be in place to detect and trigger alarms in the event that a pressure-relief device activates or fails. An example of this would be gas monitors designed for use on pipes that direct ammonia from pressure-relief devices toward the atmosphere.

When taking measurements to determine the extent and severity of a leak, workers must wear appropriate respiratory protection. (See "Choosing the right respirator" on page 32.)

Personal protective equipment

Controlling exposure requires strict attention to ammonia exposure limits. Appropriate respiratory, eye, and skin protection are essential. Workers should be familiar with and understand the requirements of a written exposure control plan.

Eye protection

Eye irritation from exposure to ammonia gas normally does not occur until concentrations reach about 70 ppm. As a consequence, eye protection is not mandatory under normal working conditions (in other words, below 25 ppm). All respirators, except escape respirators, must provide full face protection or be used with effective eye protection. Workers who could be exposed to ammonia should not wear contact lenses.

Skin protection

Workers who are controlling any liquid ammonia leak must have access to full-body chemical protective suits. This equipment must also be available to workers exposed to airborne ammonia concentrations above 300 ppm for more than a few minutes, which causes immediate irritation of moist body areas. (Ammonia reacts instantly with moisture.)

Respiratory protection

A variety of respirators are available to protect workers from exposure to ammonia, and each of these respirators has specific limitations. Choosing the right respirator must be based on both the needs of each individual worksite and the requirements of written safe work procedures.

Respirators fitted with ammonia cartridges or canisters must be worn when performing work where there is a risk of toxic process gas being released directly into the breathing zone. Examples of these situations include transferring of ammonia using cylinders, system or line purging or draining, and leak detection and repair.

Respirators must also be worn in any situation when workers will be exposed above 35 ppm during a 15-minute period or above 25 ppm during an eight-hour period.

Respirators must be carried or worn whenever a worker goes into a restricted access area, such as a machine room enclosure.

Safe respirator use

To ensure that the respirator fits properly, workers must be clean-shaven so that the respirator seals with the face.

Full-facepiece air-purifying respirators with cartridges or canisters

We recommend the use of full-facepiece air-purifying respirators instead of half-facepiece air-purifying respirators in all non-IDLH situations, namely when ammonia concentration is below 300 ppm. Respirators should be fitted with ammonia cartridges or canisters.

Keep in mind:

- If the concentration of ammonia is greater than 300 ppm, cartridges or canisters cannot be worn, and a self-contained breathing apparatus (SCBA) must be used. If the concentration is approaching 300 ppm, work in anything other than an SCBA should be discontinued. (Remember that concentrations can spike suddenly.)
- Canisters or cartridges with an indicator window must be replaced when the material in the window has changed colour. Canisters or cartridges without an indicator window must be replaced after each use. In either case, canisters or cartridges must never be used after the expiration date indicated on the label.

Half-facepiece air-purifying respirators with goggles

Workers working in air contaminated by ammonia concentrations up to 250 ppm may use half-facepiece air-purifying respirators. However, because ammonia vapour causes immediate eye irritation, workers must always use gas-rated, vapour-tight chemical goggles with their half-facepiece respirators. Instead of this combination, we recommend the use of full-facepiece respirators.

A self-contained breathing apparatus (SCBA) provides air from a cylinder carried by the wearer.

Bite blocks are often used by workers in ammonia refrigeration facilities, pulp mills, and chemical manufacturing plants.

Self-contained breathing apparatus

Workers must use a self-contained breathing apparatus (SCBA) when the ammonia concentration is unknown or once it reaches or exceeds 300 ppm. A worker wearing an SCBA must not enter a contaminated atmosphere until a second qualified person is present, also equipped with an SCBA and ready to perform a rescue.

Air filled into compressed breathing air cylinders must be tested at least annually. Compressed breathing air cylinders must be slowly depressurized to atmosphere and refilled at least annually. Cylinders must have a hydrostatic test at least every five years. Since workers rely on this equipment in IDLH conditions, it is essential to carry out maintenance and inspections according to the manufacturer's instructions.

Escape respirators

Anyone entering a restricted access area, such as an ammonia enclosure, must carry an escape respirator and keep it within arm's reach at all times. In addition to the respirators discussed above, bite-block respirators rated for ammonia may be used for escape purposes. Bite-block respirators must be worn with a nose plug. Bite-block respirators are only intended for escape purposes.

Choosing the right respirator

The correct selection of respiratory protection requires an accurate knowledge of the ammonia concentration in the hazard area. The table below shows respirator choices for different situations and ammonia concentrations.

Situation	Ammonia concentration	Respirator choice
Routine work in ammonia room; leak occurs	None prior to leak; exit room immediately upon leak occurring	Escape respirator
Working on ammonia system; chance of leak	None prior to leak; exit room immediately if personal monitor indicates potential IDLH condition	Full-facepiece respirator
Leak occurs; enter to repair	25 to <300 ppm	Full-facepiece respirator
	300 ppm or more*	SCBA
	Unknown; always assume IDLH level	SCBA

* Concentrations above 300 ppm also require full skin protection. Also, if concentrations are approaching 300 ppm, SCBAs should be used.

Person-check system

Employers must establish a check system to ensure the continued well-being of workers who are working alone or at an isolated worksite. Where visual checks are not possible, the check system may require a radio or telephone. Employers must ensure workers needing to use such a system are trained in the associated written procedures.

Emergency equipment

Emergency equipment includes eye-wash and shower facilities and first aid kits. Workers must have immediate access to each of these items and must know how to use them in case of emergency. (Emergency equipment requirements are covered in more detail on page 16. For first aid information, see page 34.)

For more detailed information on the use of personal protective equipment in the workplace, contact any of the following:

- Ammonia suppliers
- Equipment manufacturers
- Safety equipment suppliers

For further information, please contact the Prevention Information Line noted on the inside front cover of this manual.

First aid

When a worker is injured in an ammonia-related accident, first aid can help reduce the impact of the injuries and prevent further injuries from occurring. Follow these steps:

(1) Do not panic.
(2) Ensure that there is no more danger to yourself or the injured worker.
(3) Activate the workplace emergency response plan.
(4) Using appropriate safety gear and following rescue procedures, remove the injured worker from the contaminated area.
(5) Send for medical help.

Ammonia inhalation

A worker who has inhaled ammonia may be unconscious, and may have difficulty breathing or may have stopped breathing. Follow these steps when providing treatment:

(1) Assess responsiveness by calling the injured worker's name. If the worker doesn't respond to your voice, pinch one of the worker's fingernail beds hard or cause pain in another appropriate manner.
(2) If the injured worker remains unresponsive to voice and pain, ensure the worker is on a firm, preferably flat, surface. Then open the airway by tilting the head back with one hand and pulling up on the jaw with the other. Assess the worker's breathing for 5 to 10 seconds.
   - If the injured worker is unresponsive and not breathing normally, or if breathing has stopped, begin cardiopulmonary resuscitation (CPR) and use an automated external defibrillator (AED) if available. If a pocket mask is not available, provide chest compressions only and use an AED.
   - If the injured worker is responsive and is having difficulty breathing (gasping or coughing), place the worker in the most comfortable position, usually semi-sitting.
(3) If an oxygen therapy unit and trained personnel are available, administer high-flow oxygen.
(4) If the injured worker suffers a delayed reaction in the form of pulmonary edema (fluid in the lungs), ensure that the worker is transported to hospital. Any physical exertion, excitement, or apprehension increases the chances and severity of a delayed reaction. Keep the worker warm and at rest. Reassure the worker while waiting for assistance and transportation to hospital by ambulance.

How to deal with unconscious workers

As soon as they resume breathing normally, always place unconscious workers in the 3/4 prone or drainage position (on their side, so fluids can drain from the mouth and airway). Never give unconscious workers anything by mouth. Check frequently that the mouth is clear and the worker is breathing normally. If normal breathing stops, position the worker on his or her back and resume CPR/AED.

Ammonia skin contact

Skin contact with ammonia can result in severe — even fatal — burns. Before attempting to flush contaminated skin, make sure the injured worker is breathing normally. Follow these steps:

(1) Open the unresponsive worker's airway and assess breathing for up to 10 seconds.
   - If the injured worker is not breathing normally or if breathing has stopped, begin CPR.
   - If the injured worker is responsive and is having difficulty breathing (gasping or coughing), place the worker in the most comfortable position, usually semi-sitting.

(2) Flush the injured worker's contaminated skin and clothing with large amounts of water. Flush for at least 15 minutes, or longer if stated on the safety data sheet.

(3) Remove all contaminated clothing while flushing.

(4) Continue flushing until all traces of ammonia have been removed.

(5) Dress obvious burns with sterile gauze and bandage them loosely.

(6) Call for an ambulance to take the injured worker to a hospital.

Notes

- Do not attempt to neutralize ammonia with other chemicals.
- Do not apply salves, ointments, or medications to the injured worker unless they're prescribed by a doctor.
- Keep in mind that skin contact with liquid ammonia or an ammonia gas stream leaking under high pressure can cause frostbite. Pure liquid ammonia can cause severe burns.

Ammonia eye contact

Eye contact with liquid ammonia for even a short period can cause permanent disability, such as blindness. Flushing must begin within 10 seconds. Follow these steps:

(1) Flush the eyes immediately with large amounts of running water (preferably lukewarm) in the following instances:
   - Any amount of liquid ammonia has entered the eyes.
   - Exposure to gaseous ammonia causes persistent eye irritation.

(2) Hold the eyelids apart forcibly to ensure full flushing of the eyes and eyelids.

(3) After flushing has removed all traces of ammonia, cover both eyes with moistened sterile gauze pads, and bandage enough to keep light out.

(4) Call for an ambulance to take the injured worker to a hospital.

Notes

- Do not attempt to neutralize ammonia with other chemicals.
- Do not apply oils, ointments, or medications to the injured worker's eyes.

For further information, please contact the Prevention Information Line noted on the inside front cover of this manual.

Notes

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