Ammonia Detection System
Codes and Design Specifications

January 15, 2020
Revision 8

CALIBRATION TECHNOLOGIES INC.
920 N Tradewinds Parkway
Columbia, Missouri 65201

Ammonia detection system codes and design specifications

Following is a discussion of ammonia detection system design for facilities utilizing ammonia refrigeration systems. There are numerous codes that may affect the system design, including ANSI/IIAR 2-2014, ASHRAE 15, NFPA-1, UMC, IFC, and IMC. In addition to these codes, many insurance carriers impose their own requirements to mitigate the risk of loss of life and product in a facility. These codes are updated periodically, and it is recommended that you check our website (www.ctiengineering.com) for the latest revision. What follows is a system design that respects all of the above-mentioned influences by choosing the most conservative approach where there are differences.

Table 1: Ammonia Detection System overview

Room	Sensor	Actions
Compressor Room (minimum 2 sensors)	GG-NH3-250	**25 ppm** - Alarm to monitored location **25 ppm** - Horn Strobe outside each entrance and inside engine room **150 ppm** - Emergency Ventilation
Compressor Room (minimum 1 sensor)	GG-NH3-2%	**10,000 ppm** - Redundant Emergency Ventilation **20,000 ppm** - De-energize pumps, compressors, and normally closed valves
Vent Line	GG-VL2-NH3	**1%** - Alarm to monitored location
Refrigerated Areas	GG-NH3-100	**25 ppm** - Alarm to monitored location **35 ppm** - Close liquid and hot gas solenoid valves
Packaged Systems	GG-NH3-100	**25 ppm** - Alarm to monitored location **35 ppm** - Horn Strobe inside room
Machinery under 100 HP and equipment Pits (not in machine rooms)	GG-NH3-100	**25 ppm** - Alarm to monitored location **25 ppm** - Close liquid and hot gas solenoid valves **25 ppm** - Horn Strobe inside room **25 ppm** - De-energize pumps, motors, and non-emergency fans **25 ppm** - Emergency Ventilation

Compressor Room (0-250 ppm sensors)

Codes require audio-visual indication inside the compressor room and outside each entrance to the compressor room at 25 ppm. From the gas detection control panel or PLC, the warning outputs can be set at 25 ppm to activate a horn / strobe unit inside the engine room and outside each entrance. Entrance monitor display units can be located outside each doorway to warn personnel of ammonia concentrations prior to entry.

Codes require emergency ventilation at 150 ppm. The alarm setpoints can be set at 150 ppm and trigger the emergency ventilation fan starter.

The compressor room is the highest risk location in most plants. It has the most potential leak sources, and the most ammonia available for disastrous concentrations. Using a minimum of two 0-250 ppm sensors is necessary for complete coverage and redundancy. Use two 0-250 ppm ammonia gas sensors in Engine Rooms 4,000 square feet or less. Install an additional sensor for each additional 2000 square feet. Locate sensors in the breathing zone ~ 5 feet off the floor. Locate one sensor below the ventilation fan so it samples airflow from throughout the room when the fan is on. Locate other sensor(s) evenly distributed throughout the room.

Compressor Room Shutdown (0-2% sensor)

In the compressor room, codes also require shutdown of compressors, pumps, and normally closed solenoid valves at a very high concentration (20,000 ppm is industry standard). The alarm output can be used to shut down at 2% (20,000 ppm). For redundancy at no cost, the warning output can be used to also trigger emergency ventilation at 1% (10,000 ppm). Use one 0-2% sensor located ~ 5 feet off the floor below the emergency ventilation fan so it samples airflow from throughout the room in an emergency condition. Note that a sensor in this range cannot be used to detect lower concentrations covered by the 0-250 ppm sensor.

Vent Line

Vent line sensors are used to provide an alarm to a monitored location in the event of a safety relief valve opening from an overpressure condition. This alerts operators to discharges of ammonia to atmosphere through the vent line so they can take action to mitigate the release. An alarm setpoint of 1.0% (10,000 ppm) is recommended for this application to minimize alarms due to “weeping” relief valves. Locate vent line sensors outdoors, 3 ft off the roof, utilizing the provided mounting kit with the tee test-port facing down.

Refrigerated Rooms

In refrigerated rooms, codes require alarming to a monitored location. Some insurance companies require shutdown of liquid feed and hot gas solenoids in the event of a leak (but the major codes currently do not). Use 0-100 ppm sensors in these rooms. This range gives the best accuracy at very low concentrations which is appropriate in these unrestricted areas. From the gas detection panel or PLC, the warning output can alarm to a monitored location at 25 ppm. Additionally, the alarm output can be used to shut down the liquid feed and hot gas solenoids at 35 ppm to mitigate the leak.

Locate sensors in the breathing zone ~ 5 feet off of the floor. The quantity of sensors should be determined by locating at least one sensor within 30 horizontal feet of each potential leak source (one sensor located between 2 evaporators could cover them both if they are 60 feet apart). In large, open cold storage warehouse rooms where this results in more than 3 sensors in a room, distances can reasonably be relaxed to 50 horizontal feet from a potential leak source, with a minimum of 3 sensors.

Machinery under 100 HP not in Machine Rooms, and Equipment Pits

Where an ammonia refrigeration system or equipment is installed outside of a machinery room, the area containing the system or equipment shall comply with the following. At 25 ppm, alarm to a monitored location, close liquid feed and hot gas solenoid valves, activate audio/visual devices inside the area, activate emergency exhaust and de-energize all pumps, motors and non-emergency fans.

Use 0-100 ppm sensors in these rooms. This range gives the best accuracy at very low concentrations which is appropriate in these areas. Locate sensor(s) in the breathing zone ~ 5 feet off of the floor.

Packaged Systems

Packaged systems and equipment shall comply with the following. At 25 ppm, alarm to a monitored location and activate audio/visual devices inside the area.

Use 0-100 ppm sensors in these areas. This range gives the best accuracy at very low concentrations which is appropriate in these areas. Locate sensor(s) in the breathing zone ~ 5 feet off of the floor.

Sensor Mounting Height

There is much confusion in the industry concerning the best height to mount ammonia sensors. This is because there are valid reasons for different heights. Codes simply say “locate where refrigerant from a leak is expected to accumulate”. Ammonia vapor is lighter than air so vapor leaks will rise to the ceiling in normal conditions. A liquid leak will drop to the floor and if large enough can cool down a room so quickly that high concentrations are found on the floor with very low concentrations at the ceiling. In refrigerated areas there is normally enough air flow from evaporator fans to mix the refrigerant fairly well in the room. In all locations, 25 ppm is the first alarm point and this is intended for personnel protection. To best protect personnel, the sample should be representative of what they are breathing ~ 5 feet off of the floor. Most importantly, the sensor needs to be easily accessible for the required 6-month calibration and output testing. An untested safety system only takes a few years to become a nonworking safety system. The breathing zone is the best height to satisfy all of the above concerns.

Gas Detection Panel (or PLC)

The gas detection system should be powered with a dedicated branch circuit from an emergency generator backup system that can operate the system in the event of a power outage. An uninterruptable power supply (UPS) that can run the system for a few minutes during the transition to emergency generator power should be utilized. All wire runs should be supervised with the controller indicating a fault if communication with a sensor is lost. Loss of power to the system should send a fault indication to a monitored location.

Any alarm condition should send a signal to a monitored location. This can be in the facility such as a control room or guard shack. It can also be a building monitoring company, an auto-dialer, or other notification system that notifies responsible personnel 24/7.

All output functions must be configured to latch, so even if ammonia concentrations fall below the setpoint, a manual reset is required under the supervision of a qualified operator. This is necessary to protect against repeating a leak scenario that has been successfully detected and mitigated.

CO2 Cascade systems

For CO2 cascade systems, ammonia and CO2 detection are both required in the compressor room which contains the ammonia system and the cascade heat exchanger. CO2 detection is required instead of ammonia detection in refrigerated and process areas. Detection system design and output functions are similar with the difference being the CO2 sensor selected, warning setpoints at 0.5% (OSHA 8 hour TWA) and alarm setpoints at 1.0%. One controller can support a combination of ammonia and CO2 sensors. One caveat to keep in mind is that unlike ammonia, CO2 is always present in air, and concentrations can build up to these levels in a facility from sources other than a leak in the refrigeration system. Common examples are dry ice usage and normal personnel respiration in a non-ventilated room. CO2 sensors should be mounted in the breathing zone ~ 5 feet off of the floor.

Specifications:

Table 2: Equipment table

Part Number	Description	Application
GG-6	Six channel controller	Monitor gas detection system
GG-XM	Eight channel expansion module	Additional monitoring capability
GG-RD1	Remote display for GG-6	Remote monitoring of gas detection system
EM2	Entrance monitor	Outside compressor room doorways
UPS-1000VA-LCD	Uninterruptible power supply	Backup Power for GG-6
SHA-24-BLUE	Strobe/Horn assembly 24vdc	Audio Visual
GG-NH3-100	0/100 ppm electrochemical sensor	Refrigerated Area
GG-NH3-250	0/250 ppm electrochemical sensor	Compressor Room
GG-NH3-2%	0/2% catalytic bead sensor	Compressor Room shutdown
GG-VL2-NH3	0/1% vent line sensor	HP relief header, above roofline
GG-CO2-3%	0/3% infrared sensor	CO2 refrigeration systems

Table 3: Warning and Alarm Setpoints table

Room	Warning / Alarm setpoints
Refrigerated areas	25 ppm / 35 ppm
Compressor Room (0-250 ppm)	25 ppm / 150 ppm
Compressor Room Shutdown (0-2%)	1% / 2%
Vent Line	1.0%
Carbon Dioxide refrigerated area	0.5% / 1.0%

1. Equipment
    a. Equipment notes
        i. All controllers and sensors shall be manufactured by Calibration Technologies, Inc. - phone number 866-394-5861.
        ii. See Equipment table for part numbers and function descriptions.
        iii. See Warning and Alarm setpoints table for recommended setpoints.
    b. Controller
        i. Provide a GG-6 controller and necessary Expansion Modules to monitor all fixed sensors. The controller shall be equipped with programmable alarm relays to activate external horn/strobes, exhaust fans, monitoring systems, and shut down equipment.
        ii. The controller shall provide three alarm setpoints per channel.
        iii. The controller and expansion modules shall provide 4/20 mA signal inputs.
        iv. The controller and expansion modules shall provide +24 Vdc to power all connected sensors.
        v. The controller shall provide an LCD operator interface for simple menu-driven programming.
        vi. The controller shall provide a watertight enclosure to protect electronics and allow for outdoor installations where necessary.
        vii. The controller shall provide a horn relay which is silenceable from front panel silence key.
        viii. The controller shall provide an alarm log to record and store all events.
        ix. The controller shall provide a calibration mode which locks relay outputs for sensor maintenance and calibration.
        x. Controller shall supervise wire runs and indicate a fault if communication with sensors is lost.
        xi. Power controller with dedicated branch circuit using Uninterruptable power supply (UPS) backed up by emergency generator to provide 24 hour operation in the event of a power outage.
    c. Entrance Monitors
        i. Provide an EM2 entrance monitor outside each compressor room entrance.
        ii. Entrance monitor shall terminate 4-20 mA signal from sensor and retransmit same to controller.
        iii. Entrance monitor to provide a digital display to warn operators of ammonia concentration present prior to entering compressor room.
        iv. Entrance monitor shall have on-board 8 amp relay.

v. Entrance monitor shall have potted electronics to protect circuit board and components from moisture and corrosion.
vi. Entrance monitor shall have a polycarbonate enclosure to prevent corrosion.
vii. Entrance monitor shall have a linear 4/20 mA output signal.

2. Sensors
   a. Compressor Room 0-250 ppm
      i. Provide (2) GG-NH3-250 ammonia gas sensors in Compressor Rooms 4000 square feet or less. Install an additional sensor for each 2000 square feet.
      ii. Locate sensors in the breathing zone – 5 feet off the floor.
      iii. Locate one sensor below the continuous ventilation fan so it samples airflow from throughout the room.
      iv. Locate other sensor(s) evenly distributed throughout the room.
      v. The sensor shall have potted electronics to protect circuit board and components.
      vi. The sensor shall have a polycarbonate enclosure to prevent corrosion.
      vii. The sensor shall provide a temperature controlled enclosure for use in any environment for improved cell life.
      viii. The sensor shall have a linear 4/20 mA output signal.
   b. Compressor Room Shutdown 0-2%
      i. Provide (1) GG-NH3-2% ammonia gas sensor for each Compressor Room.
      ii. Locate sensor 5 feett off the floor below the emergency ventilation fan so it samples airflow from throughout the room.
      iii. The sensor shall have potted electronics to protect circuit board and components.
      iv. The sensor shall have a polycarbonate enclosure to prevent corrosion.
      v. The sensor shall provide a temperature controlled enclosure for use in any environment for improved cell life.
      vi. The sensor shall have a linear 4/20 mA output signal.
   c. Vent Lines
      i. Provide (1) GG-VL2-NH3 ammonia vent line sensor for each high-pressure relief line discharge to atmosphere.
      ii. Install vent line sensor utilizing supplied mounting kit. Locate outdoors, 3 feet off of the roof. Install utilizing supplied mounting kit with tee test port pointed down.
      iii. The sensor shall have potted electronics to protect circuit board and components from moisture and corrosion.
      iv. The sensor shall have a stainless-steel enclosure to prevent corrosion.
      v. The sensor shall have a linear 4/20 mA output signal.
   d. Ammonia refrigerated areas
      i. Provide GG-NH3-100 ammonia gas sensors near evaporators, valve groups, and other equipment with sensors installed no further than 30 horizontal feet from the potential leak source (50 feet if more than 3 sensors in a room).
      ii. Locate sensors in the breathing zone – 5 feet off of the floor.
      iii. The sensor shall have potted electronics to protect circuit board and components from moisture and corrosion.
      iv. The sensor shall have a polycarbonate enclosure to prevent corrosion.
      v. The sensor shall provide a temperature controlled enclosure for use in any environment for improved cell life.
      vi. The sensor shall have a linear 4/20 mA output signal.
   e. Carbon Dioxide refrigerated areas
      i. Provide GG-CO2-3% carbon dioxide gas sensors near evaporators, valve groups, and other equipment with sensors installed no further than 30 feet from the potential leak source (50 feet if more than 3 sensors in a room).
      ii. Locate sensors in the breathing zone – 5 feet off of the floor.
      iii. The sensor shall have potted electronics to protect circuit board and components from moisture and corrosion.
      iv. The sensor shall have a polycarbonate enclosure to prevent corrosion.
      v. The sensor shall provide a temperature controlled enclosure for use in any environment for improved cell life.
      vi. vi. The sensor shall have a linear 4/20 mA output signal.

	ANSI/IIAR 2-2014	ASHRAE 15-2019	NFPA 1-2018	UMC-2018	IFC-2018	IMC-2018
General		Comply with IIAR 2	Comply with IIAR 2, UMC, & ASHRAE 15	Ammonia exception. Comply with IIAR 2	Comply with IMC & IIAR 2	Comply with IIAR 2, ASHRAE 15, & IFC
Alarm signal to monitored location	25 ppm		YES			
Machine Room De-energize compressors, pumps, NC valves	40,000 PPM or upper limit of detector. Manual reset inside machine room		40,000 PPM or upper limit of detector			40,000 PPM or upper limit of detector
Machine Room Audio Visual Alarms inside room and outside each entrance	25 PPM		25 PPM			
Machine Room activate emergency ventilation	150 PPM. Manual reset inside machine room		150 PPM			Not to exceed 1,000 PPM
Power and Supervision	Dedicated branch circuit. Trouble signal indicating power fault to monitored location		Dedicated branch, 24 hour UPS or backup generator. Trouble signal indicating fault in system			
Machine Room Concentration Display						
Refrigerated Areas	25 PPM, alarm to monitored location					Required per IIAR-2
Packaged systems	25 PPM, audio visual and alarm to monitored location					
Machinery under 100 HP not in Machine Room, and Equipment Pits	25 PPM, alarm to monitored location, close liquid feed and hot gas solenoid valves, audio/visual devices inside the area, activate emergency exhaust and de-energize all pumps, motors, and non-emergency fans					

Appendix 1: Summary of Ammonia Detection code requirements

Blank box indicates code does not address the issue

Ammonia detection system layout example

The example schematic below complies with IIAR, ASHRAE, UMC, NFPA and other regulatory codes.