Fixed Ammonia Gas Detection

Why it's needed and what it can do for you.

Presented by:

Marc Shoub
Crown Systems, Inc.
Phoenix, AZ
PH: 602-381-8855
email: CrownPhx@aol.com
Ammonia Detection

Applications:
- Food production, freezing tunnels, slaughter houses
- Power Plant CEM NOx, Semiconductor Industry
- Chemical industry, institutes, laboratories, hospitals
- Sports, ice-arenas, refrigeration warehouses

Areas for ammonia detection:
- Compressor-room- Excellent First Step
- Cold storage
- Vent line-sensor mounted directly into relief line giving immediate response upon release of NH3
- Process Areas
- Roof Intakes
- Blast Freezers
Ammonia Releases Causes:

- Risk Personal Injury
- Product Loss Due to Ammonia Contamination
- Product Loss Due to Interruption of Refrigeration Capacity
- Potential for Equipment and Property Damage
- Factory Mutual Loss Prevention Data Bulletin 12-61 – several incidents causing $100k – $1 million in damage
- Gas detectors may help prevent an accident, and they alert operators of leaks and the potential for the above.
- And help operators, owners and first responders to mitigate the above.
NH3 Characteristics

At room temperature, ammonia is a colorless, pungent-smelling gas, which is lighter than air.

At minus 28 ° Fahrenheit, ammonia becomes liquid, which is heavier than air.

Ammonia will readily dissolve in water.

Ammonia acts principally on the upper respiratory tract.
Inhalation Symptoms & Health Effects NH3

- **Potential symptoms:** Eye, nose, throat irritation; corneal burns, difficult breathing; coughing; shortness of breath, bronchospasm; chest pain; pulmonary edema or pneumonitis; pink frothy sputum; skin burns
- **Health Effects:** Respiratory Effects---Acute lung damage/edema, Asthma, pulmonary fibrosis, bronchiolitis obliterans, Irritation-Eye, Nose, Throat, Bronchi, Skin---Marked, Blindness
- **Affected organs:** Respiratory system, eyes, skin
- **Animal Studies:** Coronary palpitations, renal effects
### Inhalation Health Effects of NH₃

- **Odor Threshold**: 5 ppm
- **IDLH (NIOSH 05)**: 300 ppm
- **Throat Irritation**: 400 ppm
- **Eye Irritation**: 700 ppm
- **Acute Toxicity**: 1,000 ppm
NH$_3$ Flammability Limits

- NH$_3$ / Air
  - 15-28 % Volume

- NH$_3$ / Oil
  - 8% Volume + 150,000 ppm
  - 8% 80,000 ppm

- NH$_3$ should be treated as a Flammable Gas even though it doesn’t meet the DOT definition (for labeling purposes). – NIOSH Pocket Guide 2005
IH Hierarchy of Controlling Exposure

- Engineering Controls
- Work Practice
- Administrative Controls
- Personal Protective Equipment
- Want an “Inherently Safer Design”
Key Concentration Levels

- 25 ppm 8-hr exposure level TLV (NIOSH, ACGIH)
- 35 ppm 15-minute exposure limit (NIOSH, ACGIH)
- 50 ppm 8-hr working exposure PEL (OSHA)
- 300 ppm IDLH (NIOSH)
- 1720 ppm Convulsive Cough – Fatal <30min.
- 5000 ppm Respiratory Spasm – Rapidly fatal.
OSHA Definition of PEL

29 CFR 1910.1000 and in other substance-specific health standards.

• “TWA is the employee's average airborne exposure in any 8-hour work shift of a 40-hour work week which shall not be exceeded.“
• Level of exposure established as the highest level of exposure an employee may be exposed to without incurring the risk of adverse health effects.
• OSHA would be justified in issuing a citation when personal air sampling indicates employee exposure to be in excess of the PEL on the day sampled.
Each refrigeration machine room shall contain a gas detector located in an area where refrigerant from a leak will concentrate.

Actuates an alarm and ventilation

Alarm at TLV-TWA (25 ppm)

Visual / Audible alarms inside the room and outside each entrance.

Alarms shall be manual reset type with reset located in the room
• Alarms set at other levels (such as IDLH) and automatic reset alarms are permitted in addition of those required by this section.

• The meaning of each alarm shall be clearly marked by signage near the annunciators.
When ammonia is used the machinery room is not required to meet Class 1, Div 2 NEC if:

- Ventilation is run continuously
- Failure of the ventilation system alerts operators

OR

- Machinery room has an ammonia gas detector that alarms at 1,000 ppm
ANSI / ASHRAE 15

• Problems with above:
  – Might meet ASHRAE 15, but when things don’t work right
dangerous situations occur because you’re depending on
them. If ventilation goes, it is not itself a gas leak, but now
there is no fixed detection to alert in the event of a gas leak
(assume repair workers hv wearable detectors that alarm).
  – In the event of a major gas leak, you don’t know the levels
in rooms (from a 1\textsuperscript{st} Responder & automated point of view).

• Don’t treat ammonia gas detectors as HVAC
activation devices. They are Life-Safety Equipment.
• Install, Maintain and Inspect Ammonia Detector Systems
• It is good practice to use ammonia detectors to help monitor anhydrous ammonia systems for leaks.
• Install detectors in areas where a leak could occur or an area which is not manned 24 hours per day and 7 days a week.
• Detectors could be monitored by a local alarm company or linked into an automated system that contacts offsite personnel.
• Operation of ammonia sensors and alarms should be checked and calibrated regularly to ensure the alarms are set to alert personnel of a release.
EPA Region 7

- Ammonia detectors should be calibrated every six months with a NIST traceable ammonia concentration. The alarm set at or below 50 ppm for detectors located out of the engine room. Ammonia detectors located in the engine room should trigger the alarm at or below 300 ppm.
- Facilities have also used ammonia detectors signals to activate ventilation fans in compressor rooms and to trigger remote alarms to notify facility security personnel about accidental releases of ammonia.
- In order for the alarm to be protective within the facility’s operation, the alarm set points should be site specific and range specific. Each alarm should also activate a call down system that alerts key ammonia refrigeration personnel. Example:
# EPA Region 7

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Set Point</th>
<th>Alarms / Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caution</td>
<td>25-60 ppm</td>
<td>Local alarm horns &amp; strobe Call down system on.</td>
</tr>
<tr>
<td>Warning</td>
<td>60-130 ppm</td>
<td>Alarms Ventilation Call down</td>
</tr>
<tr>
<td>Alarm</td>
<td>130-225 ppm</td>
<td>Alarm Ventilation Automated announcement Compressor shuts down. Call down</td>
</tr>
</tbody>
</table>
EPA Region 7

- Problems noted during inspections:
  - Ammonia detectors were calibrated to alarm at 600 ppm, twice the IDLH level
  - Ammonia detectors did not function properly
  - Ammonia detectors were not properly calibrated
OSHA ACT – GENERAL DUTY CLAUSE
Section 5:
A. Each Employer:
  • shall furnish...a place of employment...free from recognized hazards that are causing or likely to cause death or serious physical harm to employees;
  • shall comply with occupational safety and health standards promulgated under this Act.
B. Each employee shall comply with occupational safety and health standards and all rules, regulations and orders issued pursuant to this Act which are applicable to his own actions and conduct.
Regulations

- **EPA General Duty Clause** Clean Air Act Section 112(r) – Facilities have a general duty to prevent and mitigate accidental releases of extremely hazardous substances, including ammonia.
An employer can be found to be in violation of the general duty clause if it can be shown that:

- A hazard existed.
- The hazard was likely to cause death or serious physical harm.
- You had knowledge of the hazard or should have had knowledge because the hazard had been recognized by you, your industry, or common sense.
- The hazard was foreseeable.
- Workers were exposed to the hazard.
Sensor Technologies

- Solid State
- Infrared
- Catalytic
- Electrochemical
- PID – doesn’t work well
- Gas Chromatograph (GC) - expensive
Ideal Gas Detector

- Capital Cost is $0
- Installation Cost is $0
- Operation Cost is $0
- No power required
- Always Operates – Never breaks – At least tells you if it did.
- Reaction time to detect gas is 0 seconds
- Perfect Analysis - Correlation is 1:1 for the level of gas reported vs. actual concentration
  – Not influenced by other gas / vapor (cross sensitivity)
Ideal Gas Detector cont’d

- Never causes the spark for flammable levels of gases / vapors – ex proof or intrinsically safe
- Real-Time information
  - easily accessed during an emergency
- Perfect Environmental Stats
  - Can take direct water spray – food industry
  - Can take weather for outdoor applications
  - Temperature $-\infty ^\circ$ for flash freezing applications
  - Temperature $+\infty ^\circ$ for outdoor desert applications
Ideal Gas Detector cont’d

• Requires no maintenance
  – Calibration is not required – drift is 0 ppm
  – Replacement Consumables – when you do have to replace a sensor you can hot swap it, without declassifying the area
  – Repair
Solid State

- Theory: Metal oxide with catalyst which in the presence of gas allows the signal to rise.

- Characteristics
  - Long life
  - Inexpensive
  - Low Maintenance
  - Broad Spectrum (not specific, detects many gases)
  - Lowest Measurement Range ~30 ppm
  - Non-linear – calibr.
Solid State Sensors

- The gas to be detected enters the sensor by diffusion or is delivered by a pump, passing through a filter to the porous metal oxide semiconductor surface. The gas reacts with the surface and the resistance changes proportionally to the amount of gas present.
Infrared

- Theory - Gas absorbs energy at a specific wavelength on the IR Spectrum, absorption is measured, and amplified, then converted to gas concentration.

- Characteristics
  - Gas Specific
  - Temperature limits
The detector’s signal voltage is a measure for the gas concentration.
FUNCTION AND OPERATION
INFRARED ABSORPTION MEASURING PRINCIPLE

NH₃ + energy (IR) → NH₃ (excited state)
Electrochemical

- Theory - Gas reacts with electrolyte causing a current change, which is proportional to the concentration of the gas.

- Characteristics
  - Gas Specific
  - Stable performance
  - Linear Output
  - Temperature Compensated
  - Resistant to EMI/RFI
  - 3-5 year life
Electrochemical

\[ \text{NH}_3 \rightarrow \frac{1}{2} \text{N}_2 + 3 \text{H}^+ + 3 \text{e}^- \]

\[ \frac{1}{2} \text{O}_2 + 3 \text{e}^- + 3 \text{H}^+ \rightarrow \frac{3}{2} \text{H}_2\text{O} \]
Electrochemical

- Temperature sensor
- Counter electrode
- Reference electrode
- Sensing electrode
- Connector
- PCB
- Memory
- Porous core
- Electrolyte
- Replaceable dust or selective filter
Electrochemical

No internal pressure variation due to barometric pressure, temperature or humidity

unique, patented, orientation independant pressure release system:

TEFLON housing:
porous, gas permeable, chemically inert
Catalytic

- **Theory**- Combustible gases are oxidized by catalysis on a small heated bead, the heat of the reaction causes the pellistor temp to rise. The change in resistance is proportional to the concentration of the gas.

- **Characteristics**
  - Specific to combustibles
  - Long life
  - Linear output.
  - Measurement Range %LEL
  - 1% = 10,000 ppm
Catalytic Bead

Hot catalyst purged with air (activated oxygen)

Platinum coil

Methane

Water

Carbon dioxide

Heat 450 °C

Resistance approx. 3 Ohms

Resistance approx. 3.05 Ohms

CH₄ + 2 O₂ → CO₂ + 2 H₂O + heat of reaction

Measurable rise of temperature
Catalytic Bead

The sinter disk is an explosion protection measure.
Calibration & Maintenance

- Regulatory requirements are increasing and in most areas of the Country, the use of gas sensors has become critical to the operation of a facility that uses ammonia.
- Local code officials are requiring that sensor calibration be performed at intervals recommended by the sensor manufacturer.
- This requirement is going to become more stringent and is a particular challenge in the case of ammonia because of the instability of ammonia and the difficult environments in which the sensors operate. i.e. blast freezers, wet processing areas, etc.
Why Calibrate?

- To Test sensor at recommended intervals, determining that the sensor and all connecting devices react properly to a certified target gas.
- It is especially important in hostile environments (such as damp and cold areas). To verify the sensor actually works in the environment where it must operate.
- Zero and Span adjustments can be made (if required).
- All calibration should be documented and kept in the PSM.
What is NIST certified ammonia gas?

- A measured concentration of gas balanced in dry air, traceable to NIST (National Institute of Standards and Technology)
Why Balance Ammonia in Dry Air?

• Because of ammonia’s extreme affinity for water, ammonia calibration gas degrades rapidly in the presence of even minute amounts of water.
How do you apply Calibration Gas to sensors?

• Use a calibration kit provided by the sensor manufacturer to insure proper technique of applying the gas sample to the sensor.

**All sensors are unique, so it is very important to follow the sensor manufacturer’s recommendations.
For optimum performance

Make sure discharge **does not** hit the vent line sensor

**IMPORTANT**
The vent line sensor **must** be mounted **no farther than** 1 to 2 feet from discharge

Vent line header

nipple

nee

2" plug

Nema 4

(keep away)

3/4" plug for testing

Roof line
THANK YOU FOR YOUR ATTENTION!