Improving Health and Safety with Magnetic Level Indicators in Ammonia Refrigeration Applications

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Objective

Anhydrous ammonia is a versatile and commonly used chemical in many industrial applications, including cold storage & food processing facilities. Conversely, anhydrous ammonia poses a number of safety and environmental concerns that must be considered when specifying any type of process instrumentation. Traditionally, visual level indication of anhydrous ammonia has been achieved through the use of sight glasses. This paper will identify key areas in the ammonia refrigeration cycle where magnetic level indicators (MLIs) can offer a safer, more reliable form of level measurement over traditional technologies.

The objective of this document is to highlight the advantages of MLIs that will lead to increased personnel safety, reduced risk of fugitive emissions, reduced environmental impact, and decreased maintenance costs in large commercial and industrial ammonia refrigeration systems.

MLI in ammonia service with cryogenic insulation

Overview

- Anhydrous Ammonia use in industrial refrigeration systems.
- Current Federal Regulations for AA Storage Facilities
- Current measurement technologies
- Why Magnetic level indicators?
  - » Principle of Operation for MLIs
  - » Safety and Environmental Advantages of MLIs
  - » Maintenance Cost Advantages of MLIs
- Aurora: Visual and Control indication in one redundant system
  - » Additional Accessories for Aurora

> "Ammonia is considered a high health hazard because it is corrosive to the skin, eyes, and lungs. Exposure to 300 parts per million (ppm) is immediately dangerous to life and health. Ammonia is also flammable at concentrations of approximately 15% to 28% by volume in air."
>
> ***Occupational Safety and Health Administration***
> https://www.osha.gov/SLTC/ammoniarefrigeration/

Anhydrous Ammonia Use in Industrial Refrigeration Systems

In large refrigeration systems, anhydrous ammonia is a common refrigerant of choice. There are several reasons for choosing ammonia as a refrigerant. The following list shows the most common of these reasons.

Abundance

There is a large worldwide production of anhydrous ammonia for other applications (mainly fertilizers). The cost of anhydrous ammonia is significantly lower than that of CFCs (chlorofluorocarbons).

Efficiency

According to the International Institute of Ammonia Refrigeration (IIAR). Ammonia is a 3-10% more efficient refrigerant than CFCs, therefore an ammonia-based system requires less electricity and thus resulting in lower operating costs.

Cost

On average, ammonia-based refrigeration systems cost 10-20% less to build than one that uses CFCs.

Environment

Ammonia breaks down quickly in the environment. It carries an Ozone Depletion Potential (ODP) and a Global Warming Potential (GWP) rating of zero.

Despite of the many benefits of using ammonia as a refrigerant, there are also some dangers that must be well-understood. Ammonia is poisonous in high concentrations. Two factors, however, mitigate this risk: ammonia's distinctive smell is detectable at concentrations well below those considered to be dangerous. Because anhydrous ammonia is lighter than air, any released gasses will rise and dissipate in the atmosphere (except in areas with high relative humidity). Anhydrous ammonia is also flammable at certain concentrations and a large leak could create an explosion in the facility.

Current Regulations for Anhydrous Ammonia Storage

There is a history of accidents and equipment failures in companies that utilize anhydrous ammonia for refrigeration. Some of these accidents have lead to substantial fines, lawsuits and more importantly injury and even death of personnel. Some of these include:

- In 2010 the EPA fined a refrigeration company 3 million dollars for a large anhydrous ammonia spill that sickened 150 people who were responding to the BP gulf oil spill
- 2015: a poultry manufacturer in Waco Texas was fined $122K for failing to address a prior leak at their facility and failing to update existing equipment.
- In 2016 a Boston seafood processing facility was fined 178K for an anhydrous ammonia leak that caused the death of one of their employees

Because of accidents and the volatile and dangerous nature of anhydrous ammonia both the EPA and OSHA have federal regulations that are meant to prevent accidents of this dangerous chemical.

The EPA requires that companies with large quantities of anhydrous ammonia develop risk management plans for their facilities. Having these risk management plans in place is part of section 112(r) of the Clean Air Act. These risk management plans require that equipment used is under a maintenance schedule and that the equipment is up to industry standards.

OSHA also has a say in the storage of hazardous materials and how it relates to worker safety. Companies that store over 10,000 lbs. of anhydrous ammonia in their facilities must follow the rules spelled out in CFR 1910.119. These requirements are mandatory.

Current Measurement Technologies

According to C&L Refrigeration (a large refrigeration contractor from Southern California) a common device used to measure the level of anhydrous ammonia is the sight glass level indicator. Sight glasses are measurement instruments in which the process can be seen directly

POISON

FLAMMABLE

VAPOR RISK

through a glass window, either directly into the tank or more commonly via vessel process connections. The glass sections in this instrument are sealed off from the atmosphere through a series of cushions and gaskets that run the length of the assembly. A catastrophic failure of this instrument due to user error or accident could result in the loss of life and millions of dollars worth of damages and fines.

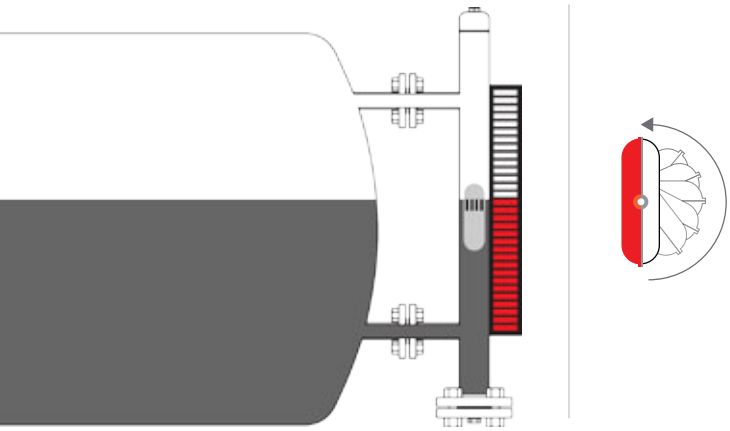


Figure 1

Why a Magnetic Level Indicator?

The appeal of magnetic level indicator technology can be summarized into three key benefits:

Increased Safety, Improved Visibility, and Reduced Maintenance

In an MLI, ammonia is contained within a sealed metallic chamber constructed from a user-specified material that is compatible with the process. (Figure 1) The chamber design lends itself to a significant reduction in potential leak points compared to a sight glass. The high-reliability flange, bolting, and gaskets used are the same ASME/ANSI code-approved designs found in piping systems all over the world. This elimination of leaking seals, clouded or etched or hard-to-read viewing windows, and the risk of broken glass makes a magnetic level indicator an excellent choice for ammonia level measurement.

MLI Principle of Operation

Inside the chamber, a magnetic float rises and falls as the liquid level changes, causing the high-visibility magnetic flags to rotate from one color to the other. The result is a clear and indisputable representation of the liquid level in the vessel.

The indicator assembly containing the magnetic flags is simply clamped to the exterior of the chamber in total isolation from the process media. The 316 stainless steel construction ensures a long service life in harsh process environments.

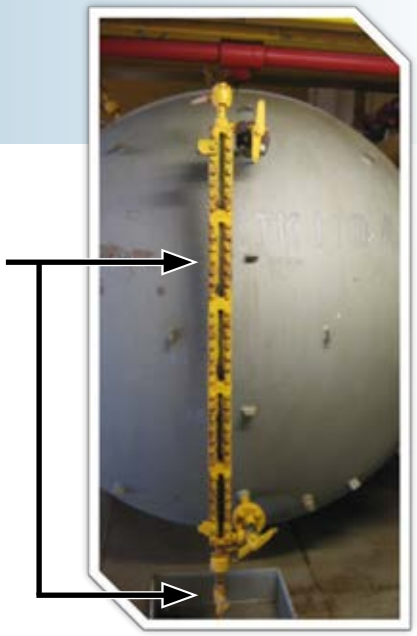
With Orion's magnetic level indicator design, the flags are sealed in a high-strength, shatter-proof polycarbonate enclosure. The use of glass, along with the risk of breakage, is completely eliminated.

MLI Safety & Environmental Advantages

Magnetic level indicators offer superior safety and environmental integrity compared to standard sight glass indicators for several reasons. Because the flag indicator is externally mounted, there is no risk of the indicator rupturing and creating a dangerous ammonia leak.

Common Sight/Gauge Glass Issues

- Broken/Cracked glass
- Integral valve failure
- Gasket/seal leakage
- Glass erosion



This particular sight glass contains 70 bolts sealing 5 separate gaskets. Note the rust accumulation, poor liquid visibility, and the drip pan positioned directly beneath the gauge on the floor.

Since the liquid level in the MLI chamber never comes into direct contact with the visual indication assembly on the MLI, the risk of ammonia leaking through or around the viewing window is completely eliminated.

MLI Maintenance Cost Advantages

The cost of implementing an MLI measurement solution should be weighed by two factors:

The initial expense and the projected cost of maintenance over the life of the instrument.

In many cases, magnetic level indicators are surprisingly affordable compared to sight glasses. While the optional addition of external switches and transmitters will add to the investment, the total cost of ownership compared to a properly maintained sight glass will likely be far less. Because so many critical components in sight glass assemblies are in continuous contact with the process media, pressure, and temperature, mechanical wear and damage can occur which will, in turn, require a more aggressive maintenance schedule. Repair costs for damaged sight glasses can range from 2000-5000 USD every time the units break, not including down time. By design, MLIs are virtually maintenance-free in most process applications.

Aurora®: Visual Indication & Level Control in One Redundant System

A typical sight glass level indicator is not a control instrument and cannot be wired to a PLC. This means that sight glass installations require a separate instrument to generate a control signal (i.e. 4-20mA/HART). These additional instruments must be purchased and installed separately from the sight glass, thereby increasing the connections to the vessel and costs in both capital expenditures and maintenance costs of the two separate instruments.

Orion Instrument's Aurora® MLI combines a conventional float-based MLI technology with the Eclipse® Guided Wave Radar transmitter. These devices operate seamlessly to provide a continuous 4-20mA & HART output and visual indication. The result is true level measurement redundancy in a single chamber.

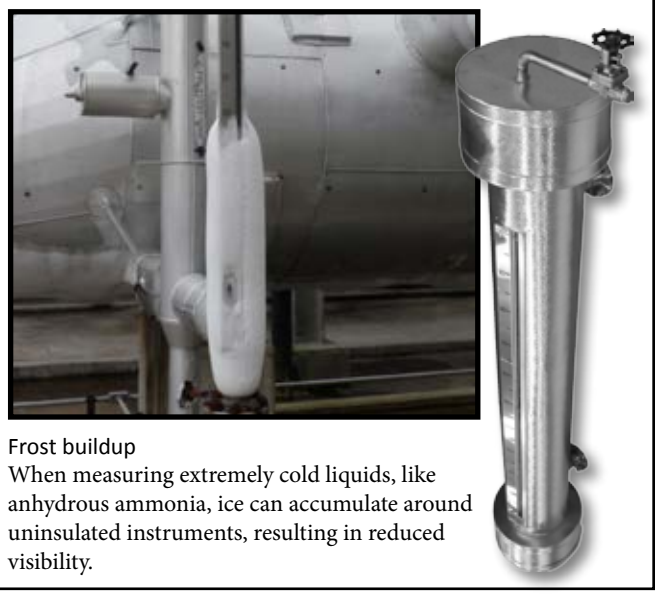
When selecting a guided wave radar probe for use in ammonia service, it is critical to ensure that devices with o-ring process seals are not used. Ammonia has shown to permeate through soft seals, resulting in a unwanted leaks and fugitive emissions.

Magnetrol's Eclipse® GWR probe designed specifically for ammonia service contains a hard seal constructed out of a glass ceramic alloy that prevents leaks from occurring.

Accessories for Aurora®

Any magnetic level indicator can be outfitted with a number of accessory items to further expand the overall capability of the instrument. Examples include:

- High & low level alarm switches
- Integral and external transmitters
- Insulation
- Vent & drain valves
- Custom indication scales (%, gallons, liters)
- Float submergence diagnostic



Frost buildup
When measuring extremely cold liquids, like anhydrous ammonia, ice can accumulate around uninsulated instruments, resulting in reduced visibility.