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Due to its low cost, zero ODP and GWP, ammonia is suitable for refrigeration plants. However, its toxic and flammable nature makes it necessary to build safety into the design of refrigeration plants. Safety devices like pressure switches, pressure relief valves, dead man valves and refrigerant leak detection systems make an ammonia refrigeration plant safe.

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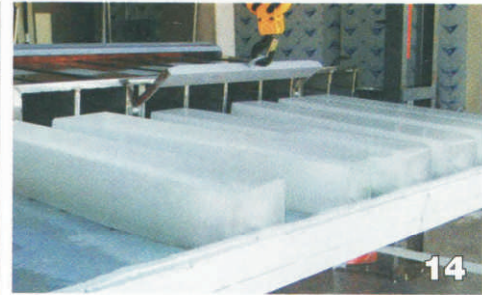
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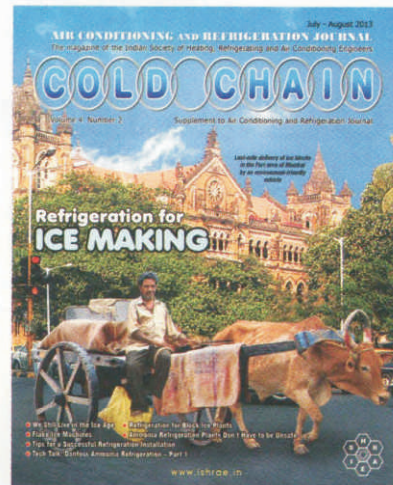
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Cover design by Fezisons shows last-mile delivery of ice blocks in the Fort area of Mumbai by an environment-friendly vehicle

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*Ammonia receiver with dual manifold, safety valves and vent piping*

# Ammonia Refrigeration Plants Don't Have to be Unsafe

**By Anand S. Joshi**  
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## Introduction

Refrigeration plants using ammonia as refrigerant have been popular in India for a long time. Ammonia is a natural refrigerant available at very low cost and is environment friendly. The Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) are zero for ammonia. In the early days, ammonia refrigeration plants were of smaller capacities and designed with a conventional rule of thumb approach. However, in the past few years, with growth in the export market for frozen products and use of cold storages, the number of ammonia based plants have increased significantly. Unfortunately, the Indian Standard IS 660, *Safety Code for Mechanical Refrigeration*, is outdated – it was last revised in 1963. The information available in this standard is old and very limited, compared to IAR Standard 2-2008 issued by the International Institute of Ammonia Refrigeration, USA. Hence, ammonia refrigeration plants in India are built as per the will of the contractor or customer. This has raised the possibilities of serious accidents in these plants. An evaluation of various accidents that have occurred all over India shows that they are mainly caused by inadequate system design and lack of knowledge of plant operation. The common reasons for the accidents are:

- Lack of over-pressure protective devices
- Liquid hammer
- Thermal shock
- Liquid expansion
- Stresses in excess of yield strength

- Fatigue cracks due to cyclic thermal and mechanical stresses
- Inadequate supports and restraints in the piping system

There are other system deficiencies including the selection of inadequate materials of construction and/or installation procedures. The lack of proper operator training results in human errors and mistakes during the operation and maintenance activities, and inadequate response in the event of a leak. Some incidents indicate a failure to provide adequate maintenance resulting in the corrosion of piping and vessels.

Hazards due to the states of pressure and temperature in refrigeration systems are essentially due to the simultaneous presence of liquid and vapour phases. It may be noted that overfeed refrigeration systems provide liquid and vapour return to the accumulator vessel without incident. It is the improper control of defrost systems that typically results in hydraulic shock. One common factor in all cases is negligence or ignorance of design, operation and maintenance of safety devices.

## About the Author

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## Ammonia Refrigeration Plants Don't Have to be Unsafe

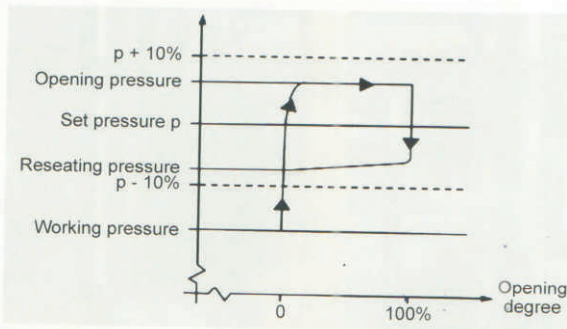


Figure 1: Operation of safety valve

The main purpose of this article is to introduce proper installation and maintenance of safety devices. The main safety devices in a refrigeration plant are:

- Pressure switches
- Safety valves (pressure relief valves)
- Self closing or "dead man" valves
- Refrigerant leak detection system

### Pressure Switches

The pressure switches, popularly known as pressure cut outs, are normally provided by the compressor manufacturer as part of the equipment package.

These devices must be checked periodically and calibrated every year. They must never be bypassed.

### Safety Relief Valves

The definition of a safety relief valve or pressure relief valve, as per ANSI/IIAR Standard 2, *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*, is, "... pressure actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting, also called a safety valve."

These are provided on various pressure vessels. The main purpose of a safety relief valve is to protect the pressure vessel from over-pressure when ammonia pressure exceeds the set value. Normally, on a rise in pressure above the set pressure, the safety relief valve will initially start opening slightly, to minimize the outlet of refrigerant. If the pressure continues to increase, the valve will open fully. The safety relief valve will be fully open before the pressure is 10% higher than set pressure, and fully closed before the pressure is 10% below set pressure. Please see Figure 1.

The relief valve is of the conventional positive self-seating type. The cross sec-

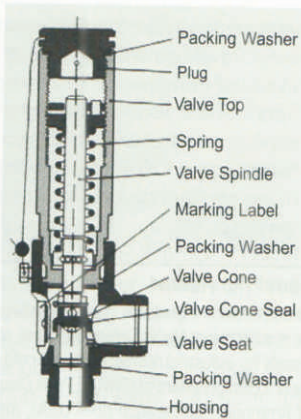


Figure 2: Safety valve cross section

tion of a typical safety valve is shown in Figure 2.

Pressure relief valves must meet the requirements of ANSI/ASHRAE Standard 15, *Safety Code for Mechanical Refrigeration*, and ANSI/IIAR Standard 2, *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*, as well as other worldwide codes. These codes require pressure vessels of all refrigeration systems to be protected by a pressure relief device or other approved means to safely relieve pressure in the event of fire or other abnormal conditions. Once installed, a properly selected pressure relief valve will vent to atmosphere any temporary excessive overpressure inside of a vessel. After discharge, these valves will reseal to minimize loss of refrigerant. However, once any relief valve has discharged, it must be replaced/ serviced as soon as possible because debris may have settled on the seat during discharge.

Pressure relief valves should be connected to the refrigerant vessels, many heat exchangers, oil pots, oil stills, pilot receivers, and elsewhere as may be required by various codes.

### Dual Manifold/ T Valve/ Three Way Valve for Safety Valves

The definition of a dual Manifold as per ANSI/IIAR Standard 2-2008 and ASHRAE Standard 15-2010 is: "Three-way valve is a service valve for dual pressure-relief devices that allows using one device while isolating the other from the system, maintaining one valve in operation at all times. No other valve is permitted to be installed between the pressure vessel and the three-way manifold valve."

In accordance with ANSI/IIAR Standard 2-2008 and ASHRAE Standard 15-2010, pressure vessels having 10 cubic feet or more of internal gross volume, should be fitted with dual pressure-relief valves. This is typically accomplished using a pair of pressure-relief valves interconnected via a three-way dual shut-off valve. Even on smaller vessels this arrangement is often preferred because one valve remains operational, while the other is being replaced; thereby eliminating the need to remove refrigerant from the vessel. Because three-way valves will not isolate both pressure-relief valves simultaneously, they are considered the only acceptable type of shut-off valve for use with refrigerant relief piping.

Figure 3 shows a three-way dual shut-off valve in the stem out position (back seated). The valve stem should be positioned so

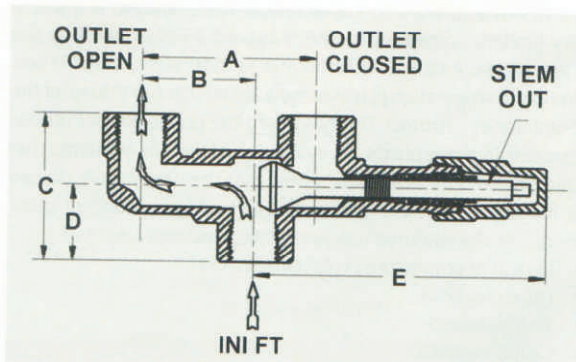


Figure 3: Three-way dual shut-off valve (shown back-seated)

that only one pressure-relief valve is activated. While the valve can be either front-seated (front port is closed) or back-seated (back port is closed), the back-seated position (shown) is recommended for normal use because it takes pressure off the packing and reduces the possibility of packing leaks.

**Selection of Safety Valve**

**A1. Pressure setting**

The pressure setting is one of the most important parameters when selecting a relief valve. The relief valve setting should be 25% above the maximum allowable operating pressure to avoid "seeping". And it must never be higher than the design pressure of the vessel. The set pressure should be 10% below the leak test pressure. This allows a perfect re-seating of the safety relief valve after being activated.

Considering Indian ambient conditions, where most of the plants are designed at a condensing temperature of 40°C, the typical maximum allowable working pressure is 15 kg/cm<sup>2</sup>g and the leak test pressure is 22.5 kg/cm<sup>2</sup>g. The pressure setting for the safety valve on a high pressure receiver should be 20 kg/cm<sup>2</sup>g, whereas for a low pressure vessel it can be 18 kg/cm<sup>2</sup>g.

**B2. Safety valve sizing and selection**

**Step 1:** Use the formula below, per ANSI/ASHRAE Standard 15, to calculate the minimum required discharge capacity in kg/s. When selecting a dual pressure relief valve system, be aware that each individual valve must have sufficient capacity to protect the vessel.

$$C = F \times D \times L$$

Where,

C = minimum required discharge capacity of the relief device, kg/s.

D = outside diameter of vessel, m

L = length of vessel, m

A = overall external surface, m<sup>2</sup>

F = factor dependent upon type of refrigerant; for ammonia refrigerant, F = 0.04\*, for other refrigerants see ANSI/ASHRAE Standard 15-2010

\*When combustible materials are used within 6.1 m of a pressure vessel, multiply the value of F by 2.5,

i.e.  $C = 2.5 \times F \times D \times L$

For plate heat exchanger or double-pipe condenser, the formula to calculate minimum required discharge capacity of the relief device is

$$C = F \times A/2$$

Example: To determine the minimum required capacity of a relief valve for a vessel containing ammonia to be used as a high pressure receiver that measures 6 meter in length and 1 meter in outside diameter, the equation would be as follows:

$$C = 0.04 \times 6 \times 1 = 0.24 \text{ kg/s}$$

**Step 2:** Determine the pressure setting needed as mentioned in A1. This should be below the design pressure of the vessel.

$$P_{SET} = 20 \text{ kg/cm}^2$$

**Step 3:** Refer to the Valve Capacity Ratings given in Table 1 and select the valve with the required capacity (C) at the desired pressure setting.

Table 1: Valve capacity ratings

Discharge capacities of safety valves in kg/s for various set pressures in kg/cm <sup>2</sup>							
Size NB	10	12	14	16	18	20	22
15	0.22	0.25	0.29	0.33	0.36	0.41	0.45
20	0.3	0.36	0.42	0.47	0.55	0.61	0.66
25	0.44	0.51	0.61	0.68	0.78	0.86	0.94

Based on our requirement 0.24kg/s at a set pressure of 20kg/cm<sup>2</sup>, the 15 NB safety valve with discharge capacity of 0.41kg/s at 20kg/cm<sup>2</sup> would be suitable for our requirement.

**Installation and Maintenance Tips**

1. Pressure relief valves for ammonia refrigeration are subject to preventative inspection and maintenance or periodic replacement.
2. Protect pressure relief valves from dirt and moisture.
3. Pressure relief devices should be connected as close as practicable to the refrigerant container or evaporator it serves, and above the liquid refrigerant level in such container.
4. Pressure relief valves should be installed upright, although horizontal installation is possible.
5. Do not install valves in a refrigerated space unless precautions are taken to prevent moisture migration into the valve body or the relief vent line. Avoid trapped ice build-up between valves and other equipment.
6. Apply thread sealing compound only to external pipe threads and use a modest amount to avoid getting the compound inside the valve. Use brackets or hangers to support the pipe and prevent the valve from being overly stressed. Do not put undue stress on the valve by using it to stretch or align pipe.
7. When a dual pressure relief system is being put into service, the three-way valve stem should be positioned so that only one valve is exposed to pressure. While the valve can be either front seated (front port is closed) or back seated (back port is closed), the back seated position is recommended because it takes pressure off the packing and reduces the possibility of packing leaks.
8. Do not install a stop valve before safety valve or the three-way valve.
9. For leak testing of the plant, remove all safety pressure relief devices and cap or plug the openings.
10. The discharge pipe should be not less than the size of the relief-device outlet. In many cases, it will be necessary to immediately increase the outlet size to meet pressure drop limitations of the header.

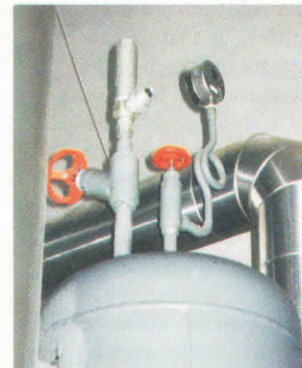


Figure 4: Do not install stop valve below safety valve

## Ammonia Refrigeration Plants Don't Have to be Unsafe



Figure 5: Do not install stop valve below dual manifold

11. Pressure relief devices should discharge to the atmosphere at a location not less than 15 feet above the adjoining ground level, not less than 20 feet from any window, ventilation opening or exit in a building.
12. Every six months, relief valves should be visually inspected for corrosion or accumulation of scale and for leaks.
14. Replace safety valve after every 5 years. IIAR Bulletin 109, *Guidelines for IIAR Minimum Safety Criteria for a Safe Ammonia Refrigeration System*, states, "Pressure relief valves discharging to atmosphere should be replaced or inspected, cleaned and tested every five years of service."
15. Always replace relief valves once they have discharged. Do not discharge relief valves prior to installation or when pressure testing.
16. Only knowledgeable, trained refrigeration mechanics should install, operate, or service the valves.
17. Stated temperature and pressure limits should not be exceeded.
18. Valves should not be removed unless the system has been evacuated to zero pressure. Escaping refrigerant might cause personal injury, particularly to eyes and lungs.

### Dead Man's Valve

The dead man's valve or quick closing valve is required to be installed on every oil drain connection on a vessel or evaporator. A dead man's valve is a fail-safe valve which will close automatically in case the human operator becomes incapacitated, such as through death or loss of consciousness. It is a manually-operated stop valve that will automatically return to the closed position by means of a spring or other device when the operating handle is released. Please see Figure 6.

Quick closing oil drain valves are designed particularly for draining oil from systems containing refrigerant (ammonia) under pressure. The valve will close immediately on

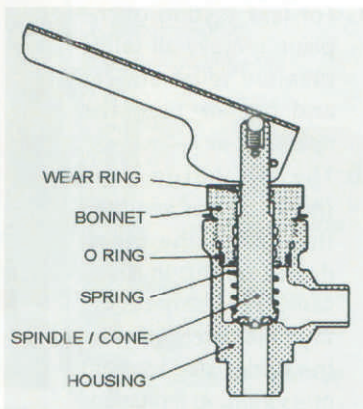


Figure 6: Cross Section of dead man's valve

release of the handle, thus protecting the user and environment against unnecessary refrigerant leaks. The valve should, as a rule, be installed as illustrated in Figure 7. In order to prevent hydraulic pressure building up between the stop valve and the quick closing oil drain valve, an integral relief device must be included as a part of the cone arrangement, which will open at approximately 25 bar g (363 psig).

### Ammonia Refrigerant Leak Detection Systems

Ammonia is a toxic gas. It can be hazardous to human beings if they are exposed to it in large quantity and for long durations.

#### Limits of Toxicity of Ammonia

Minimum detectable concentration	5-10 parts per million by volume (ppmv)
TLV - TWA Value**	25 ppmv
Serious irritation level	250 ppmv
Limit to tolerable breathing	500 ppmv

(\*\*Threshold Limit Value - Time Weighted Average)

ANSI/IIAR Standard 2, *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*, recommends installing Ammonia Leak Detection Systems as follows:

Each refrigerating machinery room shall contain at least two refrigerant detectors that actuate an alarm and mechanical ventilation.

A monitored location shall be notified when the ammonia leak detector is activated so that corrective action can be taken. "Monitored" is defined as a means of continual oversight such as pagers, on-site staff, third party alarm service or a responsible party.

The detectors shall activate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room.

#### Location of Detector

Detectors, or sampling tubes that draw air to the detectors, shall be located in an area where refrigerant from a leak is likely to concentrate. Typically, one sensor can cover 1500ft<sup>2</sup> to 2000ft<sup>2</sup>; however, the number of sensors shall be selected on the basis of concentration and quantity of ammonia.

#### Detection Levels

One detector shall be utilized to activate an alarm and actuate the normal mechanical ventilation system (at its maximum design capacity of 20 air changes per hour) at a value not greater than the corresponding TLV-TWA.

The second detector shall be utilized to activate an alarm and actuate the emergency mechanical ventilation system (at a capacity of 30 air changes per hour) at a level not exceeding 1000 ppm. Additional ammonia detectors can be utilized to monitor refrigerant levels exceeding the range of the detectors.

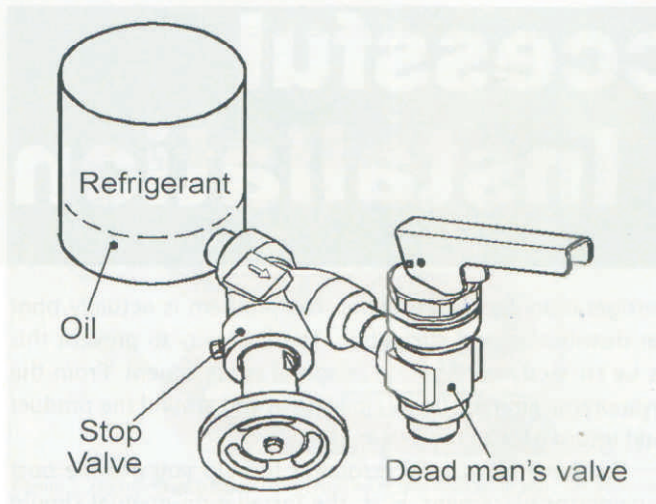


Figure 7: Recommended installation of dead man's valve

Hence, the detection system consists of two parts: an ammonia sensor (detector) and an alarm unit.

The alarm unit is normally provided with three levels of warning:

25 ppmv and above	as Contamination
150 ppmv and above	as Early Warning
250 ppmv and above	as Continuous Alarm

When ammonia concentration exceeds 250 ppmv, emergency systems such as ventilation fans should be started and the plant should be stopped.

Ammonia sensors are categorized based on the manufacturing and sensing technology. The four most commonly used types of fixed sensors used to detect ammonia vapour are:

- Electrochemical
- Infrared
- Chemosorption (frequently referred to as 'MOS' sensors) and
- Solid-state charge carrier-injection (CI) sensors.

However, all the above types of ammonia sensors have their own limitations! The secret to choosing and installing a trouble free system is to understand the limitations of the sensors. The various issues that can affect the choice of sensors are

- Continuous or high exposure levels
- Cross sensitivity – false alarms
- Temperature of environment to be monitored
- No one sensor type is suitable for all applications
- Select the best sensor based on the conditions in which it will be used

#### Limitations of Ammonia Sensors

The environment is just plain tough on sensors; the operating temperatures range from  $-40^{\circ}\text{C}$  (in some flash freezing operations) to  $+40^{\circ}\text{C}$  (during defrost periods). Strong jets of water, steam and detergents used during wash-down procedures can potentially damage sensors and other system components. Interfering contaminants from propane powered forklifts, alcohol based disinfectants, or even the products being stored or manufactured can have an adverse affect on the performance of the sensors.



Figure 8: Ammonia leak detectors

#### Conclusion

Due to its low cost, zero ODP and GWP, ammonia is suitable for refrigeration plants. However, its toxic nature makes it imperative to build safety into the design of ammonia refrigeration plants. In this article, we have discussed an important aspect of safety, viz. safety devices.

#### Bibliography

1. ANSI/IIAR Standard 2-2008, *Equipment, Design, and Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems*.
2. ASHRAE Standard 15-2010: *Safety Code for Mechanical Refrigeration*.
3. IIAR Piping Handbook, updated version 2012
4. ASHRAE Refrigeration Handbook 2010