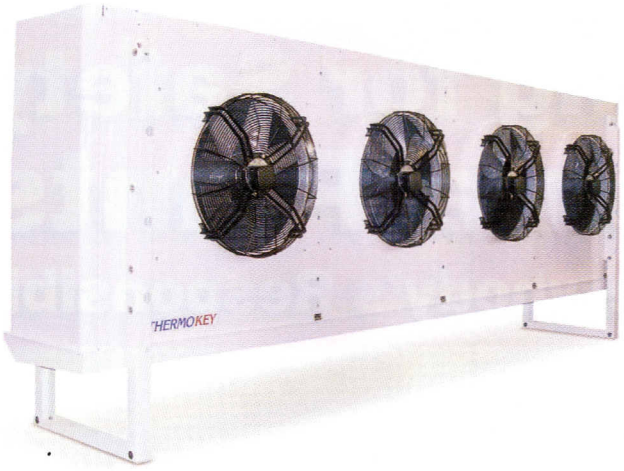

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Designing for Safety in Ammonia Plants

Safety is Everybody's Responsibility

Part 2 of 2

By Ramesh Paranjpey
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In the last issue (Part 1), we covered safety requirements for Ammonia plant design, with focus on design, application, and selection of equipment. We also covered machinery room design requirements to make safe ammonia installations.

The majority of ammonia-related accidents are a result of failure of, or damage to piping systems. Since ammonia plants are site erected where compressors, condensers, air coolers are at different locations and are piped at site, chances of installation errors are significant. Ammonia plant operators and users know very well that in more than 90% cases, ammonia leak takes place due to failure or damage in piping systems, valves, controls and their joints.

We shall therefore begin this article by discussing various requirements and methods to eliminate/minimize hazards from piping installations and taking measures to prevent accidents that could result from poor practices.

Pipe Safety Requirements-Considerations - ANSI /ASME B31.5-2006 & IIAR Standard 2

Material of construction: Carbon steel pipes of A53 grade A or B or type E (ERW) or seamless A106 Grade B should be used. ANSI standard permits use of this material up to –29°C (–20°F). The standard says A333 pipes should be used below –29°C, however, it also allows use of A106 pipes provided it passes the impact test. For refrigeration piping there is a provision in the standard which is normally overlooked by most of the consultants/designers.

Provision of the code states that no impact test is required for all carbon steel pipes when these are used for low temperature application below –20°F to –150°F (–28.9°C to –101.1°C) when most severe conditions are multiplied by 2.5 times in determining the thickness. In refrigeration systems, the high pressure and low temperature conditions do not occur simultaneously in the suction, or discharge piping. When temperature is low, pressure is also low and hence standard A106 pipe selected has more than adequate thickness from the safety angle. The code therefore permits use of any carbon steel piping without impact test even for low temperature applications.

Choice of Pipe and Fittings

a. Pipe sizes 40 mm diameter or smaller in size should use the thicker Schedule (Sch.) 80 pipe regardless of pressures, for all lines. This is recommended since smaller size pipes are required to be rigid to avoid accidental damage irrespective of pressure ratings.
b. For sizes from 50 to 150 mm Sch. 40 thickness is recommended.
c. For sizes between 150 to 200 mm Sch. 20 thickness is recommended.
d. Joints of pipes of sizes 32 and above should be welded and not threaded to avoid leaks. However, all welded piping systems irrespective of size are certainly preferred.
e. Use 6000 lb rating socket weld fittings upto 20mm and 3000 lb rating fittings for 25mm to 40mm Sch. 40 pipe. The fittings should be constructed from forged steel. Use standard fittings for standard pipe and extra heavy fittings for extra heavy pipe.
f. Use minimum number of bolted flanges and joints.

Supports & Anchoring of Pipes

a. Pipe hanger material should be galvanized & should be trapeze type. Hangers should be attached firmly to the building structure or to primary supports.
b. Pipe hangers to be placed at not more than 2 to 3m distance apart.
c. Pipe hangers to be located at not more than 0.7m for each change of direction.
d. Pipe supports taken from floor should be secured to concrete floor.
e. Piping design and resting/clamping on support should provide for expansion and contraction and loops if the straight lengths are long. Rigidly held piping may develop stresses when heated or cooled and can lead to fracture/ leaks.

About the Author

Ramesh Paranjpey is a mechanical engineer with an M.Tech in refrigeration from IIT Bombay with over 35 years experience. He has worked in very senior positions starting with Kirloskar Pneumatic in Pune, Carrier Transicold in Bangalore and Singapore as well as Voltas-Air International Pune. Presently, he works for himself as a technical advisor & consultant. He is an ASHRAE Fellow, past president ASHRAE W.I. chapter and past president ISHRAE Pune chapter. He can be contacted at *ramesh.paranjpey@gmail.com*

Location of Pipe Runs and Valves

a. Piping should be at least 2.3m above floor level.
b. Long pipe runs and valves when possible, should be run on the roof, terrace or outside the machine room. When they are inside the machine room, they should be well protected from moving machinery like forklifts, overhead cranes etc.
c. Cold room valve stations should be preferably outside the cold room with no flanged joints inside and the valve station should be easily operable.
d. Valves should be preferably of same size as pipes to avoid extra weld joints.
e. Valves should be installed so that they always close against flow.
f. Valve stems should be always oriented horizontally to avoid accumulation of dirt/dust on the valve seat and to reduce pressure drop as well as flow of liquid without hindrance.
g. Horizontal piping using eccentric reducers should be installed with straight side on the bottom, except for pumps where straight portion should be on top.
h. Piping should slope in the direction of flow (1:50) so that oil does not accumulate in the straight runs and flows along with the refrigerant.
i. The distance between insulated lines should be at least 3 times the thickness of insulation for screwed fittings and 4 times for flange fittings.

Cleanliness

a. Pipes must be clean from inside, new and free from rust, scale, sand or dirt and both ends capped before use.
b. Install liberal number of permanent/temporary strainers/ filters which are cleanable and replaceable.

Safety Requirements

a. All gate/globe ball/butterfly valves and cocks leading to atmosphere shall be capped or locked shut.
b. Purge, drain and charging valves shall be capped or blocked off when not in use.
c. No two shutoff valves will be positioned in the liquid line which will trap liquid, leading to abnormal hydrostatic pressure build up. The line should be open to one of the vessels at one end. If such liquid is getting trapped due to design constraints, then a safety valve in the trapped portion is a must to relieve the pressure since liquid cannot expand and the possibility of liquid line bursting arises and such incidences have been reported in some installations.
d. A liquid pressure relief valve on all liquid lines, oil pots to relieve hydrostatic pressure to another part of the system must to be installed.
e. Two stop valves in oil drain lines with the second valve of quick closing type or self closing type are required to be provided on all drain points.
f. All safety valve outlets need to be taken in pipes to discharge to atmosphere at a location not less than 4.5m above adjoining occupied location and 6m away from any window, ventilation or exhaust in any building should be provided.
g. Flanged joints, if necessary, should be tongue and groove type.
h. Before tightening flange bolts, proper alignment of pipes should be checked and no force to be applied for alignment of flanges and for inserting bolts.
i. Flanges at compressors and other system components must not move or indicate stress when all bolts are removed.
j. Pie-joints pipes should be cut and beveled before welding while ensuring enough gaps between pipe ends to ensure full penetration weld is obtained.
k. Valves which stop flow to the low side on liquid and hot gas lines shall be either operable from floor or from fixed platform.
l. All valves inaccessible from floor level shall be operated only from safety approved portable platforms, fixed platforms, and ladders or be chain operated.
m. Use qualified welder, approved under boiler and pressure vessel code.

Machinery Room Ventilation Requirements:

Standard IIAR Bulletin 111

1. The recommended concentration of ammonia is lower than 400 ppm in the machinery room.
2. Ventilation fans in the plant room should be provided based on 2cfm/sq.ft. running continuously. Such two additional fans should be provided, and in case of accidental leaks, both the fans should be activated so that the ammonia vapours are dispensed more effectively. ANSI/ASHRAE-15 indicates cfm=100 x √(Pounds of ammonia charge) and there are other recommendations, based on air changes and heat load of motors etc. that are also followed.
3. Do not use air inlet dampers with manual shut-off mode, and any dampers shall be fall open type.
4. Locate inlet louvers low, on the side walls, space them along the outside walls.
5. Keep exhaust fan motors out of air stream.
6. Keep exhaust fan discharge away from doors, windows, air intakes. Since ammonia is lighter than air, exhaust fan must be provided in the roof at highest level to prevent accumulation of gas, and ammonia sensors should be located near the exhaust fans in the air stream. Sensors are to be provided with alarm in case the concentration exceeds allowable 400 ppm limit.
7. Avoid short circuit of air from inlet to exhaust. There should be thorough mixing of outside air and plant room air.
8. Use quality ammonia detector sensors capable of sensing lower than 500 ppm concentration and locate them near ventilation exhaust fans.
9. Provide remote activation of fans outside plant room.

10. Alarm to be activated in case continuous air exhaust flow stops.
11. Minimum of two respirators are required as protection for persons operating in the plant.
12. Protecting clothes, gloves, goggles and hats is mandatory for people working in the plant room.
13. One easily accessible shower and eye wash basin in critical areas outside the machine room and at least 50 gallons of clean water with dip bucket in open-top container is required.
14. One bottle of boric acid and eye cup and one bottle of vinegar to be kept in machine room.
15. Ready water source with hose and nozzles to be made available.
16. Provide a 100ft length of ½" diameter sturdy rope to tie a person before entering in high concentration area.
17. Sulphur dioxide/hydrochloric acid to detect ammonia leaks may be made available.
18. First aid box with necessary treatment for possible injuries due to ammonia leaks should be available in plant room.
19. Liquid spills- the most dangerous is discharge or spill of liquid than gas since 1 kg of liquid volume can generate 800 times gas volume, hence draining of oil from vessels containing liquids should be done carefully.
20. An amount of 1m^3 of water is able to absorb 120 kgs of ammonia depending on its temperature, however in no circumstances water must be sprayed on liquid ammonia as this results in formation of enormous amount of gas and dissipation of liquid ammonia.
21. In case of liquid spills, they can be wiped out with cloth.
22. Ammonia is lighter than air and it ascends. Part of it combines with moisture in the air and forms white mist which descends.
23. Ammonia is easily absorbed in water, therefore in case of ammonia leaks, water curtains are used to precipitate vapours of ammonia and reducing their impact from going in other areas.

Dump Tanks

Some codes suggest provision of ammonia refrigerant dump tank. They are for use, if necessary, to relieve pressure or remove liquid charge from ammonia system. The water dump tanks are to be used only during an emergency condition.

Specifications for Ammonia dump tank are:

1. The water tank provided would be exclusively used for ammonia absorption dumping only.
2. At least 1 gallon of water per pound of ammonia should be provided.
3. Tank shall be constructed of not less than 1/8" or 11 gauge steel.
4. No horizontal dimension of tank shall be greater than one half the height.
5. The tank shall have hinged cover, or if closed, shall have vent hole on top.
6. All pipe connections shall be from top only.
7. The discharge pipe from pressure relief valve shall discharge the ammonia in the center of tank near bottom.
8. Normally, the tank should be provided for a system using refrigerant charge more than 100 lbs or where the installation is surrounded by high rise residential building or extremely heavily populated area.
9. Water supply line should be minimum ¾" dia & refrigerant line diameter should not be less than outlet size of relief valve.
10. Tank drain shall be provided but shall not be connected to or empty into public sewer system.

Basic Preventive Maintenance Recommendations (IIAR)

A. Keep piping and instrumentation diagram mounted on the wall to understand working of installed refrigeration system.
B. Keep design parameters of system components readily available in the plant room.
C. Keep operation and maintenance manuals for various equipments like compressors, pumps, handy in the plant room.
D. Machine room operator should be trained for
   a. evacuation/charging of ammonia in the system
   b. oil draining from various locations
   c. air cooler defrosting techniques – do not remove ice by hammering
   d. Maintaining proper brine concentration, if applicable
   e. Condenser tube cleaning procedures
   f. Periodic air/non condensable purging techniques
   g. Emergency procedures in case of ammonia leaks

Maintain permanent logs of pressures, temperatures and other parameters

1. Condenser pressure
2. Suction pressure high and low side
3. Oil pressure at compressor
4. Liquid pump pressure
5. Compressor jacket water temperature-in and out
6. Receiver liquid temperature
7. Oil temperature
8. Water temperature in and out of shell and tube condenser
9. Water temperature in sump of evaporative condenser or cooling tower
10. Compressor suction and discharge temperatures
11. Re-circulated liquid ammonia temperature
12. Storage room temperatures
13. Brine inlet and outlet temperatures, wherever applicable
14. Ambient temperatures (dry and wet bulb)
15. Operating hours of each compressor
16. Record of quantity of oil/refrigerant added in the system

Analyze these records each day. When they differ from the design parameters, determine the cause and make corrections immediately.