AMMONIA SYSTEMS: TESTING, CHARGING AND SAFETY

This month’s Skills Workshop looks at testing, commissioning and safe use of ammonia systems.

As the HVAC&R industry increasingly looks toward low global warming potential (GWP) refrigerants, technicians are more likely to come across natural refrigerant systems. Ammonia is one such refrigerant that has been successfully used in a range of applications in Australia. The testing, commissioning and safe use of these systems requires special attention to particular details.

TESTING AN AMMONIA SYSTEM

During construction, all care should be taken to prevent ingress of dirt and moisture. Before placing a new plant into service – or when putting an old one back into operation after making alterations – the entire piping system should be tested for leaks and the system thoroughly blown out by compressed air to remove all dirt and other foreign matter.

Note: Care should be taken when testing the system above 1300kPa, that thermostatic expansion valves (if any) are isolated by means of shut-off valves, and if no bypass is provided, that the thermostatic expansion valve is removed and replaced for the test by a piece of pipe.

In place of air, compressed dry nitrogen may be used. Oxygen, carbon dioxide or any combustible gas or combustible mixture of gases should never be used for testing.

It is illegal to connect an air compressor or a compressed gas cylinder directly to the system to be tested. Any such connection to any plant to be tested with compressed air or nitrogen must be via an auxiliary testing receiver, fitted with the necessary pressure gauges, valves and relief devices, as required per state regulations.

Prior to the air pressure tests, all line stop and expansion valves should be opened, but all drain valves should be closed. Remove all relief valves, and plug or cap the connections to them.

The plant should be tested and blown out in sections. Select a convenient section of the system, for example, from compressor to condenser outlet. Close the valve at the end of the selected circuit and disconnect the next pair of flanges beyond this valve. Then start up the compressor. Test pressures should be established from high- or low-stage settings, and should not exceed pressure vessel test pressures.

Do not attempt to reach the final test pressure at one continued pumping. Do not use the ammonia compressor to supply the required air pressure on the system. Doing so might cause excessive heating of the air and compressor, resulting in an explosion if the system happens to have too much oil in it.

Build up the pressure in 350kPa stages, with rest periods between, to dissipate the high temperature of compression. When the selected section has been pumped up to the final test pressure, test every flange, gland, joint, weld or connection in it with a thick soapy solution that will quickly reveal leaks. The pressure must be released before repairing these. This is done by opening the closed valve and blowing out air and scale at the open pair of flanges. Repeat this procedure until all leaks have been repaired and all foreign matter blown out.

Then extend the circuit being tested – say, to the expansion valves. It is advisable to blow out each condenser coil separately if there is more than one. Similarly, each expansion circuit should be treated separately.

After testing the system under pressure and blowing out the scale, the entire system should then be tested under a vacuum of at least 50kPa, for 12–18 hours at a final check for leaks. Even at this pressure, water will not boil at ambient temperature, say, 22°C (the pressure needs to be reduced to around 2.6kPa for this to happen). However, this is normally acceptable with ammonia systems, which are generally more tolerant of moisture. At this internal test pressure – when subjected to external atmospheric pressure – small pin holes, which were closed by dirt or scale while under internal pressure, will often show up. Excessive atmospheric temperature changes during these hold-over test periods may cause a marked change in pressure due only to the change in temperature.

Relief valves should be in place for this test. Start up the vacuum pump and run until gauges show about 50kPa of vacuum. When this vacuum is reached, stop the pump. Allow plant to stand for at least 12 hours, during which time the vacuum should be held. If the plant fails to do so, the pressure tests should be repeated.

CHARGING THE SYSTEM

When the vacuum holds, the plant is ready for charging.

Couple a refrigerant cylinder to the liquid line charging valve, making sure that the cylinder is slightly tipped towards the head, and that it is lying the correct way for the bent internal discharge pipe to be at its lowest point. Make sure charging hose connections are secure.

Set all valves on the plant into their normal running positions. Connect high pressure cut-out (if used) into the electrical circuit. If TX valves are fitted, shut the bypasses and open the stop valves on both sides of the TX valves. Open the charging valve and slowly open the valve on the refrigerant cylinder and allow refrigerant into the plant.

Now close the valve on the refrigerant cylinder and check over the whole plant with test paper for ammonia leaks. If there are leaks on "the low pressure side" (from the expansion valve to the compressor suction valve), close the outlet valve on the liquid receiver and start up the compressor.

Pump out this section until the suction pressure gauge shows 0kPa (gauge). Then stop the compressor, close its suction stop valve. Isolate the section where leak was found by closing valves on both sides of it, and repair the leak.

When the system is free from leaks, close the liquid outlet valve on the liquid receiver, start the compressor, and slowly open the valve on the refrigerant cylinder to maintain a pressure of approximately 200kPa on the suction gauge. It will be noticed the high-pressure gauge mounts rapidly to a pressure between 900–1300kPa (depending on prevailing atmospheric conditions, at which pressure it remains constant for some time). When the level in the liquid receiver reaches 30–40 per cent full, the valve on the ammonia cylinder should be closed.

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Relief valves should be in place for this test. Start up the vacuum pump and run until gauges show about 50kPa of vacuum. When this vacuum is reached, stop the pump. Allow plant to stand for at least 12 hours, during which time the vacuum should be held. If the plant fails to do so, the pressure tests should be repeated.
An inadequate charge will be indicated by hissing at expansion valves, so much so that some form of calculation is necessary for guidance. The quantity of refrigerant required for a full charge will vary from plant to plant, and does not give adequate refrigeration.

When disconnecting the ammonia cylinder and hose from the charging valve, first slacken the flange bolts to allow the ammonia in the hose to escape or pump down. It may be necessary to add more ammonia if this initial charge be closed. Allow the suction pressure gauge to fall to approximately 35 kPa or less. In properly sized lines, this can easily be rectified.

As a preliminary setting, liquid recirculation evaporator feed regulators could be set at one turn open. Too small an opening will starve the evaporators, which will not cool adequately and will have a superheated suction. Too wide an opening will overfeed the evaporators, and the result is poor evaporation, so that the evaporators will not cool adequately and will have a cold suction.

If cold rooms form part of the load, it is good practice to cool them to 3–5°C and hold that temperature, to fully dry out the concrete floors to avoid cracking. If cold rooms form part of the load, it is good practice to cool them to 3–5°C and hold that temperature, to fully dry out the concrete floors to avoid cracking.

Before proceeding, any observed defects should be rectified promptly.

The store should be cooled slowly to prevent the floor cracking and carefully controlled as the temperature approaches 0°C. This is to promote drying before cooling below freezing. The temperature should not drop below 1°C until after the wearing floor curing time. A typical cooling program is set out in Table 3.

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Prior to the use of a cold store, correct functioning of the following should be established and, where appropriate, details recorded:

- Internal and external joints and panel seals
- Doors, door seals and door heaters
- Lighting and electrical equipment
- Refrigeration equipment
- Underfloor ventilation.

For liquid recirculating systems, the low-pressure liquid line volume is doubled to cover the wet-return-line liquid and vapour content. The volume of liquid contained in pressure vessels can be readily calculated.

Table 2 lists the mass of ammonia for different pipe sizes in liquid lines, and also rule-of-thumb values for wet suction lines. These may be used for calculating the charge necessary.

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### COMMISSIONING

After charging the system, and with the compressor operating, check that the liquid levels in any liquid recirculation accumulators, surge receivers, etc., are at or about the correct operating levels and adjust these. If it is necessary to lower the level, the accumulator feed should be shut manually and liquid fed to evaporators until the liquid level drops.

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As some load is generated by the evaporators, first check that the compressor is operating at conditions that are safe and somewhere near design conditions. Oil pressure should be adequate to prevent damage, and oil cooling, if provided, should maintain cool oil. Discharge pressure and temperature should be checked. Both would be expected to be low at this stage. If abnormalities occur, it is preferable to diagnose and cure the cause of the problem with the plant in operation, if this can be done without danger. Otherwise, stop the plant and find and correct the cause of the abnormality.

If cold rooms form part of the load, it is good practice to cool them to 3–5°C and hold that temperature, to fully dry out the concrete floors to avoid cracking.
Moisture removal from concrete floors can be monitored by checking the rate of collection of condensate from the evaporators. Once the flow of condensate stops, the concrete is dry and the air temperature may be safely lowered to approximately -2°C for a period, to ensure no structural damage will occur to the building.

As the engine room equipment approaches normal operation, additional evaporators may be progressively commissioned, adding compressors to match the available load.

At this stage, operating controls should be adjusted to take over from the purely manual control used for initial commissioning, and thus the plant progressively commissioned.

The next stage of commissioning is the final adjustment of the controls to achieve practical operation under load. At this stage, the adjustments are likely to be much smaller than the rather gross adjustments made when first commissioning the system.

COMMISSIONING REPORTS

Commissioning reports are often overlooked or not considered. However, such reports can be used to ensure that the system is operating as the designer intended.

Samples of such commissioning reports can be seen in AIRAH’s DA21 Ammonia Refrigeration.

PERFORMANCE CHECKING

Having established that the individual plant items are performing as the designer intended, the ultimate test is to ensure that the system is achieving the results that the customer specified. The criteria for this are those that are expressed in product temperatures to be achieved in given times or at given flow rates, and are really what the system was created to achieve.

One must be careful not to assume that because all the components are functioning correctly that the end result, satisfactory performance, will follow. A refrigeration system is there to do a job and this is the criterion by which success is measured.

Performance checking can only be effectively carried out when the plant is operating with the design produce at the design ambient conditions, and this can – in some situations – be months after the commissioning. If performance testing is carried out at a time when design conditions do not prevail, then the design conditions and/or produce load will have to be simulated or test results extrapolated.

In the rush to get a plant up and running on time, performance is all too often overlooked, until the occurrence of unsatisfactory conditions indicates a shortfall in plant performance.

COMPETENCY STANDARDS

Competency standards for refrigeration plant operation are listed in Worksafe Australia NOHSC:7019. This covers refrigeration plant, safety checks, health and safety standards, and maintenance requirements.

PLANT SAFETY AND GOOD PRACTICE

In order to provide a safe working environment for employees, there are a number of aspects that should be considered. These are described in the following clauses. The designer should also refer to AS/NZS16772-1998 Section 5 (Testing, Inspection, Documentation and Marking).

Pipe identification provides a degree of assurance to emergency service officers who may need to take quick action to save lives, under very difficult conditions as well as being of assistance to personnel working in the plant.

The means of identification should be determined by the owner of the premises. AS 1345-1995 – Identification of the contents of piping, conduits and ducts is one suitable basis to use to identify pipes. Another method involves the use of adhesive labels, which are commercially produced.

Valve identification is usually provided by the use of numbered tags fixed to the valve. These tags may also be used to indicate the normal operating position of the valve, for example: open, shut, half-turn open, etc.

Plant diagrams form the basis for valve identification, as well as being an integral part of safe-work procedures. These diagrams should show every pipe and valve in the refrigeration system, arranged as far as possible so that the layout matches the plant layout. In this way, the plant diagram (with valve identification) if kept at the gate house, for example, would provide the best available information for emergency services upon arrival at the site. Copies of these diagrams should also be displayed in the plant rooms for easy access by plant operators.

Safe-work procedures should be established and printed. Thus any personnel can safely work on the plant and the legal responsibilities of the employer are met in such a way as to satisfy inspection by statutory authorities. These procedures should cover all work on the site, not only on the refrigeration system, although this may well be the system posing the greatest risk.

Personal protective equipment recommended for use with ammonia refrigeration systems is set out, in full detail, in AS/NZS16772-1998, Section 5.3. The following is a brief overview of the requirements:

- In smaller plants: one or two full-face respirators, with suitable canisters should be provided
- In plants with a quantity of ammonia refrigerant in excess of 900kg: one self-contained breathing apparatus with 25-minute effective life, and one set of protective clothing should be provided
- It is important that these be located outside the area that would be affected by any ammonia leakage, that they be properly maintained, and that persons likely to use them are practiced in the fitting and use of the equipment.

OTHER ITEMS

Other items to be considered include:

- Evacuation areas
- Wind socks
- Emergency procedures
- Plant operation training
- First aid training and procedures
- Plant safety audits
- Eye wash and water availability
- Relief valve and blow-down tank.

CONDENSATE DRAINS

Evaporators need a condensate tray and a condensate drain. These, if the cold room is below approximately 2°C, should be insulated where it runs within the cold area. To prevent freezing, a heating cable can be used. This may be located either inside the condensate pipe, outside the condensate pipe, or under the insulation. Condensate drains, when fitted with electric trace heating, must be fitted with warning signs, and be installed to comply with current electrical standards.

Table 3: Typical cold store cooling program.

<table>
<thead>
<tr>
<th>Day</th>
<th>Temperature</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
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<td>-29°C</td>
</tr>
</tbody>
</table>

This month’s Skills Workshop was adapted from AIRAH’s technical manual DA21 Ammonia Refrigeration, which is available for purchase online at www.airah.org.au.

AIRAH also runs a series of courses on ammonia refrigeration; for more detail on the course offerings, visit www.hvacrnation.com.au.

MORE INFORMATION