REFRIGERATION PLANT SAFETY AND COMPLIANCE

by

Scott Clydesdale (B.E. Mech. Hons.)

GORDON BROTHERS INDUSTRIES PTY LTD

WINERY ENGINEERING ASSOCIATION

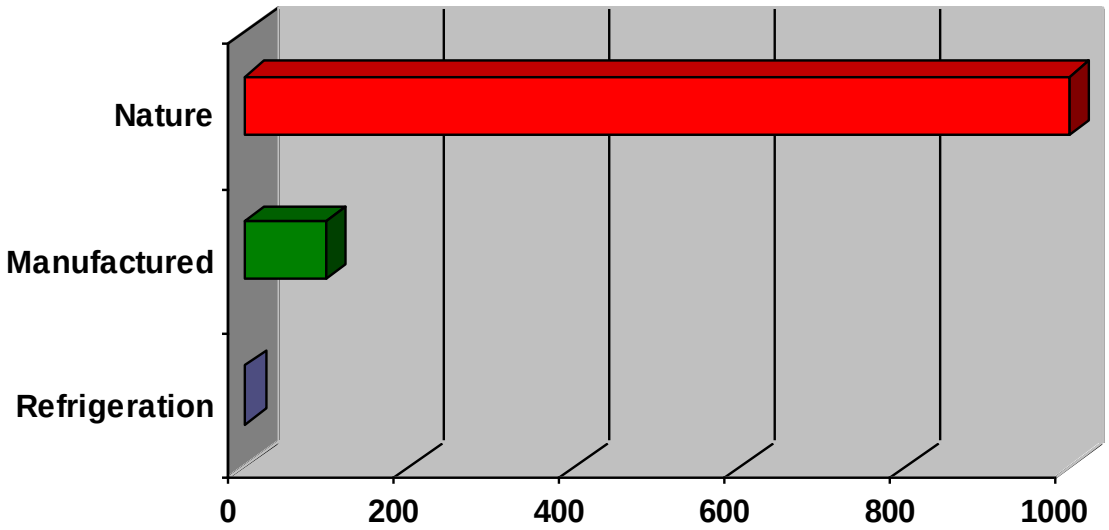
18 SEPTEMBER 2008

Refrigerant Safety Presentation Overview

- Ammonia as a refrigerant
- Effects of an ammonia leak on humans
- Flammability of ammonia
- OH&S and risk management approach
- Safety requirements of the standards
- Safety issues with plant maintenance

Where is Ammonia Found?

- 1,000,000,000 tonnes in nature
- 100,000,000 tonnes manufactured annually
- 1,000,000 tonnes used in refrigeration



Uses of Ammonia

- Refrigerant (just 1 % of all manufactured)
- Fertiliser
- Disinfectant
- Industry (steel hardening, metal extraction from ores etc)

Ammonia as a Refrigerant

- Excellent refrigerant properties
  - Good COP (coefficient of performance)
  - Excellent heat transfer properties
- Environmentally friendly
  - Zero ozone depletion potential (ODP)
  - Zero greenhouse warming potential (GWP)
  - No phase out
- Low cost gas

Ammonia as a Refrigerant

- Often plant treated like a ‘black box’
- Plant must be well designed
- Care taken when working on plant
- Site personnel should be trained in emergency response

Don’t Let This Happen to You!

Or This!

Or This!

How Does an Ammonia Leak Affect You?

- Effects respiratory system (irritation, coughing, lung tissue)
- Effects eyes (tears, contact lenses)
- Effects skin (irritation, burns, frostbite)
- Self alarming due to pungent nature of gas odours
- Non-cumulative effect in system
- For further details refer to the MSDS

Material Safety Data Sheet

Material Safety Data Sheet

ORICA CHEMICALS

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product name: Ammonia - anhydrous

Synonyms: Ammonia liquid
Ammonia, Ammonia gas, Anhydrous ammonia
CAS-No.: 7664-41-7

Molecular Formula: NH3

Supplier: Orica Australia Pty Ltd
ACN: 004 117 828
Street Address: 1 Nicholson Street
Melbourne 3000
Australia
Telephone: + 61 3 9665 7111
Facsimile: + 61 3 9665 7937

Emergency telephone number: **1 800 033 111 (ALL HOURS)**

2. COMPOSITION/INFORMATION ON INGREDIENTS

Recommended use: Fertiliser; preparation of fertilisers; chemical synthesis; condensation catalyst; latex preservative; manufacture of explosives; rocket fuel.

Appearance: Colourless gas with a sharp, intensely irritating odour. Liquid under pressure.

CHEMICAL ENTITY	CAS NO.	PROPORTION (% weight per weight)
Ammonia	7664-41-7	>99.5%
Process related by-products	-	<0.5%
		100%

This chemical is listed on the Austrlaian Inventory of Chemical Substances (AICS).

3. HAZARDS IDENTIFICATION

Hazardous according to criteria of Worksafe Australia.

Hazard Category

T	Toxic
C	Corrosive

R-phrase(s)

R10	Flammable.

Ammonia Concentration Levels

Concentration (ppm)	General Effect	Exposure Period
0.6	Detection	
0.7	Recognition	
5	Odour detectable by most persons	
25		Exposure standard (8 hr TWA)
35		Short term exposure limit (STEL)
50	Irritation just detectable but not persistent	
70	No prolonged effect for average worker.	Exposure for long periods not permitted.
133	Causes nose and throat irritation	5 minutes
400-700	Immediate nose and throat irritation	½ to 1 hour exposure causes no serious effect
1,700	Severe coughing, eye, nose and throat irritation	Could be fatal after ½ hour
2,000-5,000	Severe coughing, eye, nose and throat irritation	Could be fatal after ¼ hour
5,000-10,000	Respiratory spasm. Rapid asphyxia.	Fatal within minutes

Toxic Release Scenario

- Assume we are in a room 30 m long x 15 m wide x 3 m high
- Room volume is 1,350 m^3
- For STEL of 35 ppm, an ammonia volume of 60 ml or 42 g
- A quarter cup of ammonia gives STEL

Flammability

- Ammonia is flammable in certain concentrations (18 - 25%)
- Can be ignited by a suitable heat source
- Oil entrained in an ammonia vapour stream (e.g. discharge pipe) can increase the likelihood of ignition

Current OHS Regime

- Responsibility of the site owner to ensure the plant and access are safe for their own employees and contractors
- Carry out risk assessments for all tasks
- Find ways to reduce the risk of each task
- Ensure and document training for those carrying out tasks
- Have correct documentation and procedures (e.g. confined space, high level etc)

Safety Starts with Risk Management

- Elimination
- Substitution
- Isolation
- Engineering Control
- Administrative Controls
- PPE

Best Control

Worst Control

Risk Management – Refrigerant Volume

- Design for low charge
- Smaller heat exchangers
  - Plate heat exchangers
  - Optimised shell and tube
  - Low charge flooded
  - Direct expansion

Risk Management - Isolation

- Containment of refrigerant in a ventilated plant room
- Use of secondary refrigerants (chilled water, Alcool etc)
- Correctly designed pressure pipework and vessels
- Correct maintenance procedures

Risk Management – Engineering Controls

- Design for minimum charge
- Leak containment
  - Scrubber system
  - Ventilation fans
  - Relief valve venting methods
- Refrigerant leak detectors
- Alarm systems for early warning
- Designs to the relevant Australian / New Zealand standards

Risk Management – Administrative

- Restrict access to the plant room etc
- Use qualified personnel for service
- Job safety analysis and procedures
- Safety audits
- Training

Risk Management – PPE

Signage and safety notices

Risk Management – PPE

Signage and safety notices

Risk Management – PPE

- Self contained breathing apparatus (SCBA)
- Emergency escape hoods
- Gas masks with ammonia canisters
- Gloves
- Face Shields
- Eye wash and showers
- Full chemical suits
- Portable ammonia sensor and confined space meters

Applicable Standards

- AS/NZS 1677.2 Refrigerating systems
- AS/NZS 1210 Unfired pressure vessels
- AS/NZS 4041 Pressure piping code
- AS/NZS 3788 Boilers and pressure vessels in service

- Not AS/NZS 2022 Ammonia storage

Applicable Standards

- AS/NZS 1677.2 Refrigerating systems is not legislated.
- Is not prescriptive but based on risk management
- Difficult to argue that design should not be compliant

Requirements of AS1677.2

- Design pressure
- Plant room ventilation
- Ammonia detectors
- Relief valve recalibration
- Non-removable sight glass guards
- Auto-closing oil drain valves
- Personal Protection Equipment (PPE)

AS1677.2 – Design Pressure

- Previous Standard (for all Australia and New Zealand) was 1150 kPa low side & 1700 kPa high side
- Now varies with ambient conditions
- Dependent on AIRAH DA9 Critical Process Temperature
- Note that previously a factor was applied, but was removed in later amendments

AS1677.2 – Table of Design Pressures

Region	Low Side Design Press.	High Side Design Press. (Evap. Cooled)	High Side Design Press. (Air Cooled)
Coonawarra	1369 kPa	1356 kPa	2191 kPa
Barossa Valley	1453 kPa	1440 kPa	2309 kPa
Mildura	1519 kPa	1419 kPa	2400 kPa
Riverina	1410 kPa	1419 kPa	2249 kPa
Hunter Valley	1241 kPa	1479 kPa	2012 kPa

AS1677.2 Plant Room Ventilation

- The required free ventilation area or forced flow rate is dependent on ammonia charge
- Simple formulae for calculation
  - Forced ventilation (l/s) = 13.9 x (mass kg)$^{2/3}$
  - Free air space (m^2) = 0.14 x (mass kg)$^{1/2}$

AS1677.2 – Ammonia Detection

- Required for both personnel detection and for detecting 1/5 of Lower Explosive Limit (LEL) or 20% of 180,000 ppm (which is 36,000 ppm).
- LEL detector wired to explosion proof exhaust fan (EXn class)
- Exhaust fan fed from external board
- Trip all power in plant room once LEL reached

AS1677.2 – Relief Valve Recalibration

- Relief valves to be recalibrated every 5 years
- Gordon Brothers offers exchange program for valve calibration

Relief Valve Recalibrations

for Industrial Refrigeration

All pressure relief valves on refrigeration systems need to be visually inspected annually and recalibrated every five years.

This is required under AS/NZS 3788:2001

Recalibration

We can recalibrate most models and sizes of Valco relief valves. We stock replacement parts for the valves to provide complete reconditioning as required.

Test Certificate

A test certificate is provided with each recalibrated valve including all necessary information. See sample certificate on reverse side.

Client Relief Valve Register

We can prepare a relief valve register upon request. The register will help keep track of inspections and recalibrations.

Test Rig

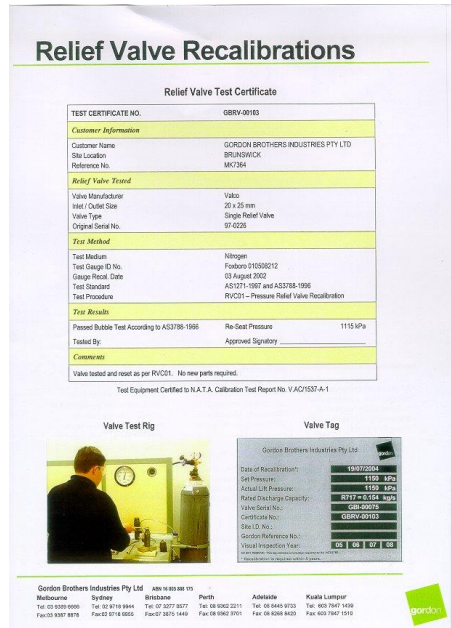
All recalibrations and settings are carried out on our test rig using N.A.T.A. calibrated instruments.

Valve Tag

Each recalibrated valve is provided with an anodised aluminium valve tag attached to the seal. The tag includes "punch outs" for four years worth of visual inspections. Details of the valve tag are included on the reverse side.

Changeover Service

For your convenience we can provide a changeover service on the popular sizes of recalibrated relief valves. Once the old valve is returned to us you will receive a credit subject to its condition.



Relief Valve Recalibrations

Relief Valve Test Certificate

TEST CERTIFICATE NO.	GBRV-00103
Customer Information	
Customer Name	GORDON BROTHERS INDUSTRIES PTY LTD
Site Location	BRUNSWICK
Reference No.	MK7364
Relief Valve Tested	
Valve Manufacturer	Valco
Inlet / Outlet Size	20 x 25 mm
Valve Type	Single Relief Valve
Original Serial No.	97-0226
Test Method	
Test Medium	Nitrogen
Test Gauge ID No.	Foxboro 010506212
Gauge Recal. Date	03 August 2002
Test Standard	AS1271-1997 and AS3788-1996
Test Procedure	RVC01 – Pressure Relief Valve Recalibration
Test Results	
Passed Bubble Test According to AS3788-1996	Re-Seat Pressure 1115 kPa
Tested By:	Approved Signatory
Comments	
Valve tested and reset as per RVC01. No new parts required.	

Test Equipment Certified to N.A.T.A. Calibration Test Report No. V.AC/1537-A-1

Valve Test Rig

Valve Tag

Gordon Brothers Industries Pty Ltd

Date of Recalibration*:	19/07/2004
Set Pressure:	1150 kPa
Actual Lift Pressure:	1150 kPa
Rated Discharge Capacity:	R717 = 0.154 kg/s
Valve Serial No.:	GBI-00075
Certificate No.:	GBRV-00103
Site I.D. No.:	
Gordon Reference No.:	
Visual Inspection Year:	05 06 07 08

Gordon Brothers Industries Pty Ltd ABN 16 003 588 173

Melbourne	Sydney	Brisbane	Perth	Adelaide	Kuala Lumpur
Tel: 03 9389 6666	Tel: 02 9719 9944	Tel: 07 3277 8577	Tel: 08 9302 2211	Tel: 08 8445 9733	Tel: 603 7847 1439
Fax:03 9387 8878	Fax:02 5718 0555	Fax:07 3875 1449	Fax: 08 9362 3701	Fax: 08 8268 8420	Fax: 603 7847 1510

AS1677.2 – Sight Glass Guards

- Sight glasses to have non-removable guard
- Gordon Brothers offers LevelGuard

LevelGuard

Retrofit AS/NZ1677 compliant guard kit for Valco/YK Liquid Level Indicators.

Aluminium LevelGuard – Heat Traced for Oil Separator | Stainless Steel LevelGuard | Scale Set

The new refrigeration standard AS/NZS1677 Part 2, "Safety requirements for fixed applications", was introduced in 1998. New provisions in the standard mean that the common Valco/YK Liquid Level Indicator assemblies no longer comply, since the glass tube can be fitted without a guard.

Gordon Brothers has developed LevelGuard™ as a retrofit guard kit, which converts the standard assembly to comply with the new standard.

AS/NZS1677 Details

Clause 3.9 states that Liquid Level Indicators "... may be tubular glass type with integral full length machined bar stock housings incorporating connection attachments". It also states that "Glass tube type indicators with removable or detachable metal or plastic guards shall not be used".

Since the standard Valco/YK Liquid Level Indicator assemblies can have the glass tube fitted and placed into operation without a guard, they are clearly non-compliant with the new standard.

Patent

'LevelGuard' is patented, and is a registered Trademark.

LevelGuard Concept

Gordon Brothers' patented LevelGuard system complies with the standard by incorporating the connection attachments with a full-length guard, in an arrangement that cannot be disassembled.

Once installed as a retrofit kit, the glass tube cannot be installed and placed into operation, without the guard.

Construction

The heat traced LevelGuard body is an anodised 6106-T6 aluminium extrusion. The non-heat traced body is 304 stainless steel. The connection attachments for all LevelGuards are 304 stainless steel.

Dimensional Flexibility

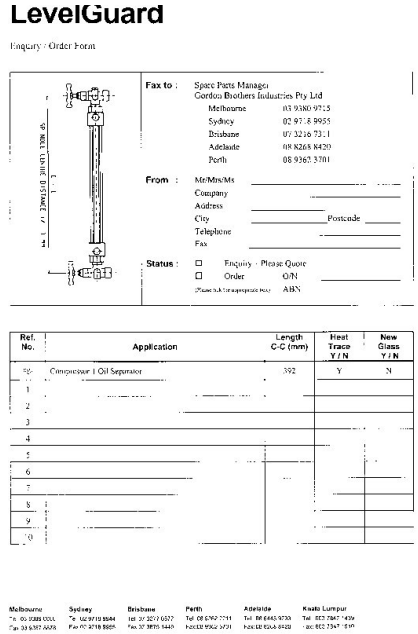
LevelGuard is assembled for each individual application, providing total dimensional flexibility to suit all existing installations.

Scale Set

A self-adhesive scale set is supplied with each LevelGuard.

Heat Tracing

Heat tracing is available only for the aluminium body units. The stainless steel body LevelGuards cannot be heat traced.



LevelGuard

Enquiry / Order Form

Fax to : Spare Parts Manager
Gordon Brothers Industries Pty Ltd
Melbourne 03 9380 9715
Sydney 02 9748 9955
Brisbane 07 3216 7311
Adelaide 08 8268 8420
Perth 08 9267 3701

From : Mr/Mrs/Ms
Company
Address
City Postcode
Telephone
Fax

Status : ☐ Enquiry - Please Quote
☐ Order O/N
ABN

Ref. No.	Application	Length C-C (mm)	Heat Trace Y / N	New Glass Y / N
00	Compressor / Oil Separator	392	Y	N
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Melbourne | Sydney | Brisbane | Perth | Adelaide | Kuala Lumpur

AS1677.2 – Oil Drain Valves

- Oil drain points to have auto-closing valve fitted downstream of the main isolation

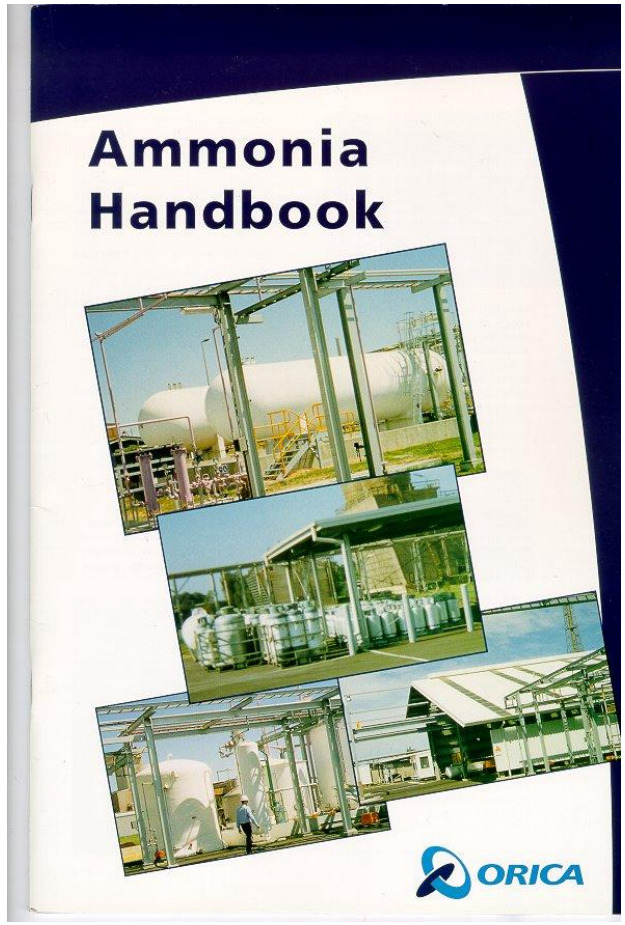
AS1667.2 – Personal Protective Equipment

- Personal protective equipment
- One respirator for <225 kg plant
- Two respirator For >225 kg plant
- One SCBA and protective clothing for >900 kg plant
- Charge of small industrial plant with 2 reciprocating compressors and a flooded surge drum is 600 – 1000 kg

Limitations with Standard

- Two (2) people should attend any leak
- Therefore need two (2) sets of PPE
- Also covers requirements of confined space legislation
- For further information on hazards etc refer to MSDS and the Orica Ammonia Handbook

Orica Ammonia Handbook



Maintenance

- Any industrial refrigeration plant requires regular maintenance if it is expected to operate satisfactorily
- Maintenance should go beyond draining and charging oil
- Include regular evaluation of all system components
- Regular testing of valves and safety cut out devices

Maintenance – Valve Lock Out Device and Record

VALVE & ELECT EQUIP TAG RECORD

Written By: R. Gallagher	Date: 23/11/05	Revision: 2	No: WPS108
Approved By: R. Gallagher	Date: 23/11/05	File Name: WPS108.doc	Page 1 of 1

1. Client Name:.....
2. Site Location:.....
3. Contract No:.....

		Valves		Electrical	
Equipment No/Type	Equipment Locality	Valve Closed	Valve Opened	Equip. Off	Equip. On

N:\Forms_Procedures\Safety Management System\Personnel Safety and Guidelines Folder.doc Rev 9 April 2005

Maintenance - Old Valve Bonnets

Maintenance – Temperature Probe Pockets

Maintenance – Heater Element Pocket Failure

IIAR Surveys

- International Institute of Ammonia Refrigeration
- Gordon Brothers performs these surveys for clients
- Give an indication of good practice and compliance with safety requirements
- Includes written report with priorities of works to be completed

Safety Inspections

Safety Inspections

for Ammonia Refrigeration Systems

The Safety Inspections will be carried out in accordance with the International Institute of Ammonia Refrigeration Checklists and Gordon Brothers Checklists covering:-

AS/NZS 1677.2:1998

AS/NZS 3666. :2002

Relief Valves

All relief valves need to be visually inspected annually and recalibrated every 5 years. This is required under AS/NZS 3788:2001 and forms part of the checking requirements of the safety inspections.

Frequency

A full safety inspection should be carried out every five years and a visual check/safety device check every year.

Safety Devices

Part of the checklist requirements is to simulate abnormal high pressure conditions to ensure the safety devices actually shut down the compressors. A special time may need to be arranged to perform this work.

Report

A report will be prepared detailing any non-conformances against the checklists. See examples on reverse side.

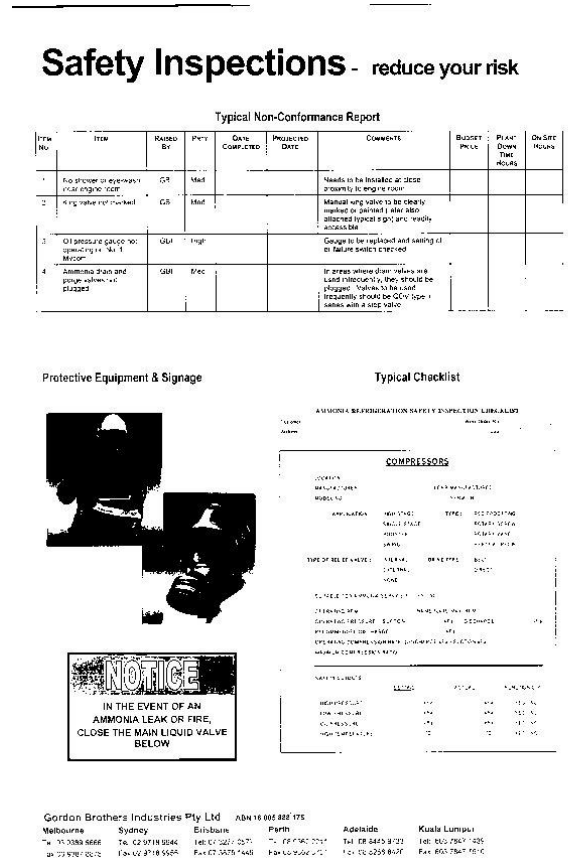
Items Covered

The Safety Inspection will cover items including:

- Piping and valve systems
- Pressure equipment and vessels
- General condition and operation
- Building considerations and access
- Mechanical safety devices
- Electrical safety devices
- Ventilation and detection
- Instructions and signage
- Personal safety equipment

Other Refrigerants

Safety inspections can be carried out on systems using refrigerants other than ammonia. These would be based on a separate series of checklists.



Safety Inspections - reduce your risk

Typical Non-Conformance Report

Item No	Item	Raised By	Priority	Date Completed	Projected Date	Comments	Budget Price	Plant Down Time Hours	On Site Hours
1	No shower or eyewash near engine room	GB	Med			Needs to be installed at close proximity to engine room			
2	King valve not marked	GB	Med			Manual king valve to be clearly marked or painted / also attached typical signs and readily accessible			
3	Oil pressure gauge not operating on No. 1 Mycom	GBI	High			Gauge to be replaced and setting of oil failure switch checked			
4	Ammonia drain and purge valves not plugged	GBI	Med			In areas where drain valves are used infrequently, they should be plugged. Valves to be used frequently should be GOV type / series with a stop valve			

Protective Equipment & Signage

NOTICE

IN THE EVENT OF AN AMMONIA LEAK OR FIRE, CLOSE THE MAIN LIQUID VALVE BELOW

Typical Checklist

AMMONIA REFRIGERATION SAFETY INSPECTION CHECKLIST

COMPRESSORS

Gordon Brothers Industries Pty Ltd ABN 16 005 888 175

Melbourne	Sydney	Brisbane	Perth	Adelaide	Kuala Lumpur
Tel: 03 9389 6666	Tel: 02 9718 9944	Tel: 07 3275 [illegible]	Tel: 08 [illegible]	Tel: 08 8445 [illegible]	Tel: 603 7847 [illegible]
Fax: 03 9389 [illegible]	Fax: 02 9718 9955	Fax: 07 3275 [illegible]	Fax: 08 [illegible]	Fax: 08 8255 [illegible]	Fax: 603 7847 [illegible]

Leak Response Plan

- Prepare for a leak before it occurs!
  - Each site should have a 24 hour system where personnel familiar with the plant can be contacted in emergency
  - Formulation of the leak response plan should include communication with refrigeration personnel, engineering, fire brigade and other authorities
  - If the fire brigade are familiar with the site and the plant, their reaction will be more appropriate in an emergency.

Leak Response Plan Cont'd

- Ammonia's pungent odour means that it is self alarming
- Small leaks can be identified with burning sulphur sticks
- Site plan should include identification of key isolation valves
- Have evacuation policy ready
- Train staff in readiness for a leak
- Learn first aid and CPR
- Water readily absorbs ammonia
- Water will save a life! Keep hoses with fogging nozzles on hand

Summary

- Ammonia is a great refrigerant, but don’t be complacent
- Ammonia is toxic, but odour means it is self alarming
- Be aware of the hazards
- Follow hierarchy of controls
- Always wear appropriate PPE
- Design it correctly in the first place
- Plan for emergencies before they occur

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