Association of AMMONIA REFRIGERATION

Advantage Ammonia
23 July 2026
Chennai

"Essential Refrigeration Safety Controls"

by
Anand Joshi
Past President AAR
Past President ISHRAE Pune
Member ASHRAE (USA), IDA, IETE, IGCC, RATA

MANIK ENGINEERS INDIA

1

ORGANIZER
Association of AMMONIA REFRIGERATION
Technical Training Program
ADVANTAGE AMMONIA

23 JULY 2026 THURSDAY
Time: 9:00 am to 6:00pm
CHENNAI

Venue: JP HOTEL CHENNAI
#1131, Inner Ring Road,
Koyambedu, Chennai-600107

Topics:
- Safe Plant Operation & Hazop study
- Improving Plant safety using proper controls
- Emergency Response Planning and SOP Preparation
- Factory Inspection Requirements and Applicable Laws in Tamil Nadu

Fees: Rs. 500/- (including GST)

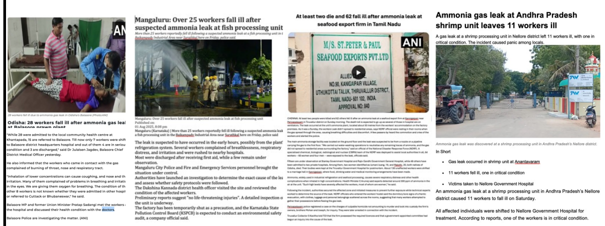
FOR REGISTRATION CONTACT
Nikhil Raj 9940641168
Murugeshan 9176369743
Rajshekar 9944964932

AAR CONTACT
ASSOCIATION OF AMMONIA REFRIGERATION
E8 Rahul Complex, Paud Road, Kothrud, Pune - 411038
Phone: 7447454586 Email : ammoniaindia@gmail.com
Website : www.ammoniaindia.org
Useful and informative design guides on sale at venue

PARTNERS
Manik Engineers | Frick India Limited | Neptune Refrigeration Co. P. Ltd.
Darren Brown | PM Refrigeration | Kahan Controls

2

Why Plant Safety Matters ?



3

Why Plant Safety Matters ?

- **Protects Human Life**
  - Prevents exposure to toxic ammonia leaks
  - Ensures safe working conditions for plant personnel
- **Prevents Major Accidents**
  - Minimizes risk of leaks, overpressure, and equipment failure
  - Reduces chances of fire, explosion (under specific conditions), and emergency shutdowns
- **Ensures Continuous Production**
  - Prevents unplanned plant shutdowns
  - Protects production schedules and customer commitments
- **Protects Product Quality**
  - Maintains uninterrupted refrigeration
  - Prevents spoilage of food, dairy, seafood, pharmaceuticals, and other temperature-sensitive products
- **Improves Energy Efficiency**
  - Removes non-condensable gases to reduce condensing pressure
  - Eliminates moisture to improve heat transfer and system performance
  - Reduces compressor power consumption

4

Why Plant Safety Matters ?

- **Extends Equipment Life**
  - Prevents corrosion and moisture-related damage
  - Reduces wear on compressors, valves, and heat exchangers
  - Lowers maintenance costs
- **Protects the Environment**
  - Prevents ammonia releases
  - Supports sustainable operation with a natural refrigerant (Zero ODP & Zero GWP)
- **Ensures Regulatory Compliance**
  - Meets safety standards and statutory requirements
  - Reduces legal and insurance risks
- **Enhances Plant Reliability**
  - Early detection of abnormal operating conditions
  - Reduces unexpected equipment failures
- **Improves Business Performance**
  - Lower operating costs
  - Higher plant uptime
  - Better return on investment (ROI)
  - Increased customer confidence

5

Refrigerant Grade Anhydrous Ammonia Specifications-AAR-01

Purity Requirements	
Ammonia Content	99.95%Min.
Non-Basic Gas in Vapor Phase	25PPM Max.
Non-Basic Gas in Liquid Phase	10 PPM Max.
Water	33 PPM Max.
Oil (as soluble in petroleum ether)	2 PPM Max.
Salt (calculated as NaCl)	None
Pyridine, Hydrogen Sulfide, Naphthalene	None

6

TABLE AMMONIA (R-717) PROPERTIES OF SATURATED LIQUID AND SATURATED VAPOR *

°C	Bar g	PSI g
-50	-0.59	-8.41
-40	-0.28	-4.03
-38	-0.20	-2.89
-36	-0.12	-1.64
-34	-0.02	-0.29
-33.33b	0.01	0.19
-32	0.08	1.17
-30	0.19	2.76
-28	0.32	4.48
-26	0.45	6.34
-24	0.59	8.34
-22	0.74	10.50
-20	0.90	12.81
-18	1.08	15.30
-16	1.26	17.96
-14	1.46	20.82
-12	1.68	23.87
-10	1.91	27.13
-8	2.15	30.60
-6	2.41	34.30
-4	2.69	38.23
-2	2.98	42.41
0	3.29	46.85

°C	Bar g	PSI g
2	3.62	51.55
4	3.97	56.53
6	4.35	61.80
8	4.74	67.38
10	5.15	73.26
12	5.59	79.46
14	6.05	86.00
16	6.53	92.88
18	7.04	100.12
20	7.57	107.74
22	8.14	115.73
24	8.73	124.12
26	9.35	132.92
28	9.99	142.13
30	10.67	151.79
32	11.38	161.89
34	12.12	172.44
36	12.90	183.48
38	13.71	194.99
40	14.55	207.01
42	15.44	219.54
44	16.35	232.59
46	17.31	246.21
48	18.31	260.36
50	19.34	275.08

b = Normal boiling point   g = Gauge pressure

* *ASHRAE Fundamentals 2013, page 30.39*

7

Standards

AAR Standard AAR01-2016

BIS Standard 1773-2022

ASHRAE Standard 15 -2013

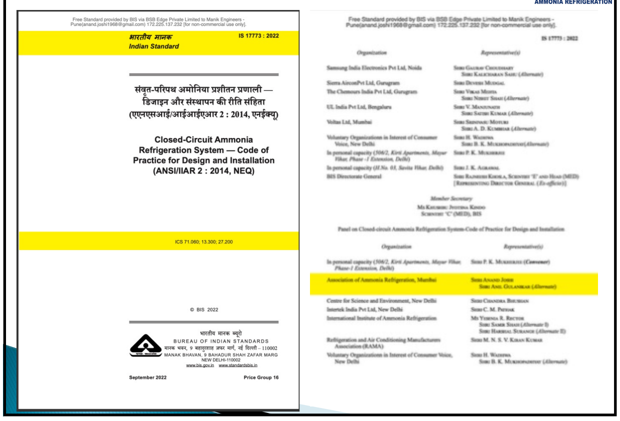
IIAR Standard 2A-2022

ISO 5149-1993

EN/BS 378

Plant safety begins with compliance.

8


Free Standard provided by BIS via BSB Edge Private Limited to Manik Engineers - Pune(anand.joshi1968@gmail.com) 172.225.137.232 [for non-commercial use only].

भारतीय मानक
Indian Standard

IS 17773 : 2022

संवृत-परिपथ अमोनिया प्रशीतन प्रणाली — डिजाइन और संस्थापन की रीति संहिता (एएनएसआई/आईआईएआर 2 : 2014, एनईक्यू)

Closed-Circuit Ammonia Refrigeration System — Code of Practice for Design and Installation (ANSI/IIAR 2 : 2014, NEQ)

ICS 71.060; 13.300; 27.200

© BIS 2022

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in www.standardsbis.in

September 2022 **Price Group 16**

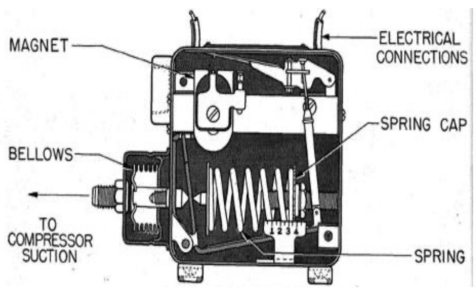
9

PLANT SAFETY DEVICES

- Pressure Switches
- Flow Switches
- Safety Valves & Dual Manifolds (T valves)
- Ammonia Leak Detection System
- Dead Man's Valve
- Level Gauges
- Level Switches
- Air Purger
- Ammonia Dehydrator
- Ultimate Solution

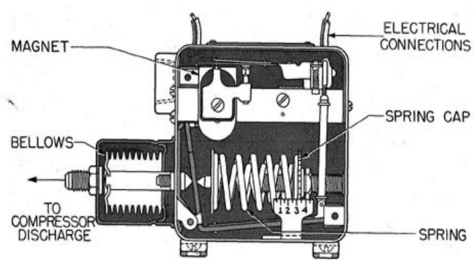
10

LOW PRESSURE SWITCHES



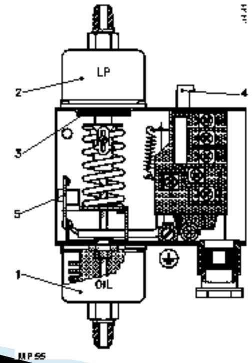
11

HIGH PRESSURE SWITCHES



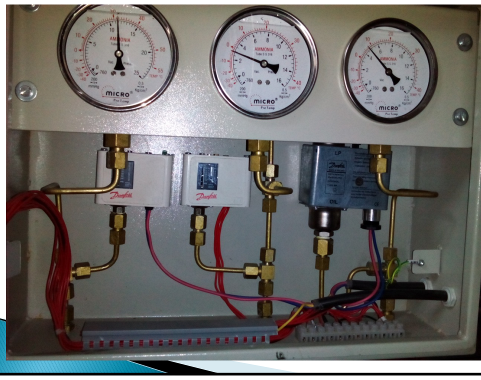
12

DIFFERENTIAL OIL PRESSURE SWITCHES



13

Typical panel with gauges & switches

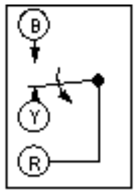


14

Typical panel with gauges & switches

15

Flow Switches



Action on Increase of Flow

16

Safety Valves, Dual Manifold & Safety valve Indicator

17

Safety Valve & Dual Manifolds

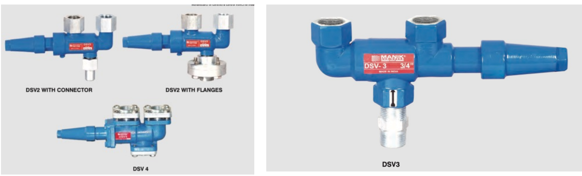
Single Safety Valve or Dual Manifold ?

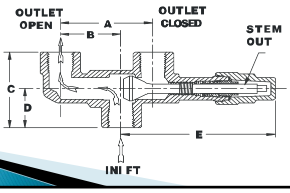
- Single Pressure Relief Valve for Vessel of internal gross volume more than 3 cu. ft or less than 10 cu. Ft

- Dual Manifold for all pressure vessels with internal gross volume more than 10 cu. Ft.

18

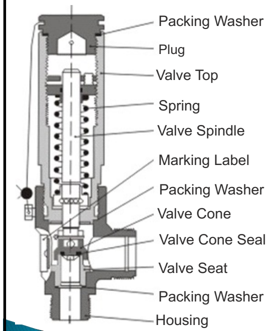
Dual Manifold/T Valve

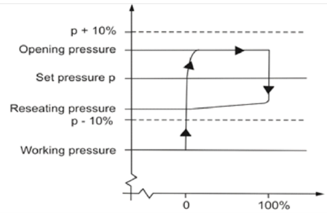




19

SAFETY VALVE OPERATION





20

SIZING OF SAFETY VALVE

The minimum required rated discharge capacity for a vessel shall be:

C = F x D x L

C = Discharge capacity of the relief device
D = Outside diameter of the vessel
L = Outside length of the vessel

Refrigerant	Value of F
R-717	0.5 [0.041]
R-22, R-134a,R-401A, R-407c	1.6 [0.131]
R-404a, R-410a, R-502, R-507a	2.5 [0.203]

See Table 2/ASHRAE 15.
When combustible materials are used within 20 ft (6.1m) of a pressure vessel, multiply the value of F by 2.5.

21

SIZING OF SAFETY VALVE

Ammonia Pressure Vessel	IP	SI
General	C = 0.5DL	C = 0.04DL
If combustible materials are used within 20 ft (6.1 m)	C = 1.25DL	C = 0.1DL
For plate heat exchanger or double-pipe condenser	C = 0.5(A/2)	C = 0.04(A/2)

The minimum required rated discharge capacity for a vessel shall be:

C = F x D x L

where
C = required discharge capacity , lb(air)/min [kg/s]
D = OD of vessel, ft [m]
L = length of vessel, ft [m]
A = Overall external surface, ft2 [m2]

22

SIZING EXAMPLE

Select a relief valve for an ammonia vessel 6 feet diameter by 16 feet long.

C = f D L = 0.5 x 6 x 16 = 48 lb-air/min

Select the desired pressure setting of 225 psig.

Refer to the capacity table / Use Discharge Capacity Graph Provided by Manufacturer.

select model.

PRESSURE-RELIEF VALVE CAPACITY RATINGS

Cat. No.	Air Capacity	Standard Pressure Settings (psig)									
		150	175	200	225	250	275	300	325	350	400
SH5600R	lb/min.	10.6	6.12	13.9	15.6	17.2	18.9	20.5	22.1	23.8	27.1
SH5602R	scfm	141	166	185	207	229	251	273	294	317	360
SH5600A	lb/min.	31.3	36.1	40.9	45.7	50.5	55.3	60.1	64.9	69.7	74.5
	scfm	417	480	544	608	672	736	799	863	927	992
SH5601	lb/min.	35.8	41.3	46.8	52.2	57.7	63.2	68.6	74.1	79.6	
SH5602	scfm	476	549	622	695	768	841	913	986	1059	

23

SIZING EXAMPLE

Capacity

Set pressure	qm	R22	R134a	R404A	R410A	R717	R744 (CO_2)	Air (20°C)
MSRV15								
10 bar g 145 psi g	kg/h lb/min	1749 64	1881 69	1888 69	1652 61	779 29	1424 52	1003 37
15 barg 218 psi g	kg/h lb/min	2592 95	2793 103	2842 104	2459 90	1135 42	2072 76	1462 54
20 bar g 290 psi g	kg/h lb/min	3471 128	3804 140	3883 143	3305 121	1492 55	2747 101	1922 71
25 bar g 363 psi g	kg/h lb/min	4409 162	4921 181	5101 187	4248 156	1853 68	3441 126	2381 87
30 bar g 435 psi g	kg/h lb/min	5437 200	6269 230	6659 245	5250 193	2227 82	4163 153	2841 104
35 barg 508 psi g	kg/h lb/min	6633 244	8370 308		6450 237	2608 96	4936 181	3301 121
40 bar g 580 psi g	kg/h lb/min	8104 298			7911 291	2989 110	5718 210	3760 138

MSRV-20

13 bar g 189 psi g	kg/h lb/min	3220 118	3430 126	3500 129	1415 52	1790 66
18 bar g 261 psi g	kg/h lb/min	4440 163	4800 176	4900 180	1925 71	2435 89
21 bar g 305 psi g	kg/h lb/min	5215 192	5680 209	5770 212	2235 82	2820 104
25 bar g 363 psi g	kg/h lb/min	6285 231	6980 257	7125 262	2660 98	3335 122

MSRV-25

13 bar g 189 psi g	kg/h lb/min	4670 172	4980 183	5075 186	2050 75	2600 96
18 bar g 261 psi g	kg/h lb/min	6445 237	6965 256	7115 261	2790 103	3530 130
21 bar g 305 psi g	kg/h lb/min	7565 278	8240 303	8370 308	3240 119	4090 150
25 bar g 363 psi g	kg/h lb/min	9120 335	10135 372	10340 380	3860 142	4835 178

24

Safety Valve : Installation & Maintenance Tips

- No stop valve before safety valve
- For Leak testing of the Plant remove all safety pressure relief devices and cap or plug the openings.
- The discharge pipe shall be not less than the size of the relief-device outlet
- Pressure-relief devices shall be connected as close as practicable to the refrigerant container or evaporator it serves and above the refrigerant level in such container.
- Pressure-relief devices shall 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.

25

Safety Valve : Installation & Maintenance Tips

- Calibration of safety valve every year

- Replace safety valve after every 5 years

Always replace relief valves once they have discharged. Do not discharge relief valves prior to installation or when pressure testing.
AAR-01 Standard ((**IS 17773:2022)**
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."

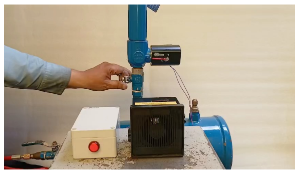
26

Safety Valve Indicator

27

Safety valve Indicator with feedback

SFI-25-NX Safety valve indicator with electronic feedback



28

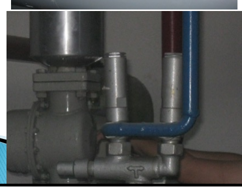
Safety Release System

Safety valve outlet was connected to common header and such that discharge of safety valve to the atmosphere above 20 feet from any window, ventilation opening or exit in nearby building.

29

Safety Release System

Safety valve outlet was connected to common header and such that discharge of safety valve to the atmosphere above 20 feet from any window, ventilation opening or exit in nearby building.

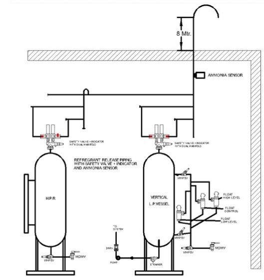


30

Ammonia leak detector and safety valve indicator for Safety Release System

31

Safety Release System



32

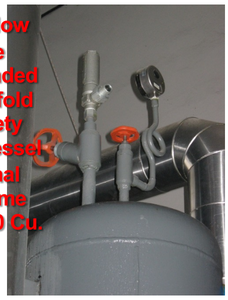
Safety Valve: Installation practices

Flange Connection Dual Manifold
Safety Valve Indicator

33

Safety Valve: Wrong Practices

Stop valve Below Safety Valve Not Recommended
Use Dual Manifold with 2 Safety valves for vessel with internal gross volume more than 10 Cu. ft

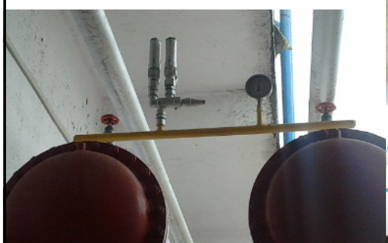


34

Safety Valve: Wrong Practices

Don't Install common Safety Valve for two Pressure vessel

Safety Valve on Dual Manifold is not provided as spare



35

Safety Valve: Wrong Practices

36

Safety Valve: Wrong Practices

Avoid using Teflon tape for installation of safety valves, as it can hamper the reseating function of the valve.

37

Safety Valve: Service and Calibration every year

38

Types of Leak Detection System

Enclosure :
- IP 65 Stand Alone Installations
- Panel Mounting Enclosure
- Panel with External Hooter

Standard Unit Features
- Site adjustable three Level Alarm for each channel Contamination, Second "Early Warning & Alarm
- LED Indication for Each Channel Contamination, Early
- Warning and Alarm Status
- Single point and multi-point Alarm Units
- Operates on 230VAC, 50Hz,
- In-built Alarm Hooter (60 DB)
- Relay out put for external Hooter and emergency exhaust
- Optional RS485

Additional Features on PLC Unit
- 7" TFT Color touch screen graphic display
- Set point and relay output for individual channel.
- SMS alert on 5 phone numbers
- LAN / Rs485 modbus protocol PLC / SCADA interface

39

Types of Sensors: Selecting Sensor: Typical Applications

Semiconductor Sensors
Ice Plants
Cold Storages (temperature above -25^{O}C)
Machine Rooms where possibility other gases in air doesn't exist

Electrochemical Sensors
Seafood processing plants
Dairies
Meet processing plants
Chemical
Dyestuff
Pharmaceutical
Freezing Plant
Cold Storages (temperature below -25^{O}C)
Paint manufacturing

40

Types of Sensors: Selecting Sensor

Sensor Life
The semiconductor sensor will typically last much longer than an electrochemical or a catalytic sensor. Another advantage is that it costs less to replace.
The electrochemical sensor have less life as compared to Semiconductor sensor and sensor replacement cost is high

Operating temperature
- 25 to 50° C Semiconductor Sensors
- 50 to 50°C for Electrochemical Sensors with heater

Response to gases in nearby spectrum
The semiconductor sensor are more susceptible to gases in spectrum near to Ammonia like Chlorine, Sulphur, hydrochloric solutions, Sulphur die oxides, ethylene etc.
The electrochemical sensors responds only to Ammonia and doesn't react to other gases

41

Ammonia Level Definations

- REL – Recommended Exposure Limit (NIOSH)
  - TWA (Time Weighted Average) concentrations for up to a 10 hour workday during a 40 hour week
- ST – Short Term Exposure Limit (NIOSH)
  - 15 minute TWA exposure that should not be exceeded at any time during a workday
- TLV (ACGIH) Threshold Limit Value
  - Exposure level for hazardous materials in air that can be experienced day after day for a working lifetime without ill effect.
- TWA Time Weighted Average
  - Average exposure over an 8 hour working day
- IDLH (NIOSH)
  - Immediately Dangerous to Life and Health

42

Ammonia Levels

- 25 ppm:
  - NIOSH REL (TWA)
  - ACGIH TLV (TWA)
  - CAL/OSHA PEL (TWA)
- 35 ppm:
  - NIOSH STEL
  - ACGIH STEL
  - CAL/OSHA STEL
- 50 ppm:
  - OSHA PEL (TWA)
- 300 ppm:
  - NIOSH IDLH
- 160,000 ppm (16%)
  - LFL in air

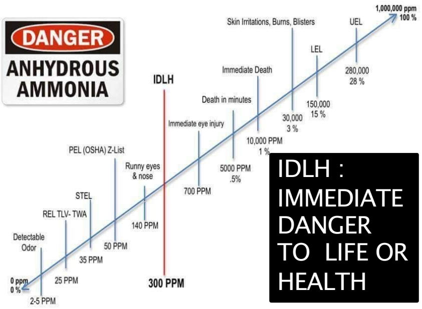
43

Ammonia Levels

Substance	Ammonia				
CAS no.:	7664-41-7				
	Limit value - eight-hour working day		Limit value – Short-Term Exposure Limit (STEL)		Comments to STEL values
	ppm	mg/m3	ppm	mg/m3	
Australia	25	17	35	24	
Austria	20	14	50	36	
Belgium	20	14	50	36	
Canada - Ontario	25		35		
Canada - Québec	25	17	35	24	
Denmark	20	14	40	28	
European Union	20	14	50	36	
Finland	20	14	50	36	15-minute average value
France	10	7	20	14	Restrictive statutory limit values
Germany (AGS)	20	14	40	28	15-minute average value
Germany (DFG)	20	14	40	28	STV 15-minute average value
Hungary		14		36	
Ireland	20	14	50	36	15-minute average value
Italy	20	14	50	36	
Latvia	20	14	50	36	15-minute average value
New Zealand	25	17	35	34	
People's Republic of China		20		30	15-minute average value
Poland		14		28	
Singapore	25	17	35	24	
South Korea	25	18	35	27	
Spain	20	14	50	36	
Sweden	20	14	50	36	Ceiling limit value refers to a 5-minute period
Switzerland	20	14	40	28	
The Netherlands		14		36	
USA NIOSH	50	18	35	27	
USA OSHA	25	35			
United Kingdom	25	18	35	25	

44

Ammonia Levels



45

Misconceptions: Toxicity Of Ammonia

Ammonia has a pungent odor and small leak as low as 5 ppm is detectable by smell
Continuous exposure to 30 ppm level is permitted for 8 hours per day per week.

How does ammonia affect the human body?

Gas concentration ppm	Effects on an unprotected human being	Time
20	The characteristic odour of ammonia can be detected. At low temperatures (below 0ºC), small concentrations of approximately 5 ppm can be detected.	Unlimited. Hygienic limit in Denmark.
50	The smell is pronounced.	Do not stay longer than necessary. This is the EU STEL value (Short-Time Exposure Limit)
100	No dangerous effects on healthy people. Uncomfortable. Inexperienced people will leave.	Leave the area as quickly as possible.
400-700	Immediate irritation of the eyes, nose and respiratory organs.	Under normal circumstances, no serious injuries.
1700	Coughing, convulsions and serious irritation of the nose, eyes and respiratory organs.	30 minutes can cause severe injuries.
2000-5000	Coughing, convulsions and serious irritation of the nose, eyes and respiratory organs	30 minutes, or even less, may cause death.
5000	Paralysis, suffocation	Lethal within a few minutes.

46

The following table shows the values for the max. permissible refrigerant content in air measured in volume %. Certain countries may, however, have official limits different from the ones stated

		Halogenated refrigerants						
		HFC				HCFC	Ammonia	CO_2
		R134a	R404A	R407C	R507	R22	R717	R744
TWA	Unit							
Time weighted average during a week	vol. %	0.1	0.1	0.1	0.1	0.1	0.005	0.5
Warning smell	vol. %	0.2					0.002	

Example :
Machine room of 20 m X 12 m X 6 m
Total Volume 1440 m^3
Ammonia Volume 7.2%
Ammonia Volume 4.97 kg

47

Ammonia Leak Detection & Alarm

Location of Ammonia Sensors

- The Gas Detectors must be installed at High Level
- At least 1 detector at ceiling level on a grid of 10m to 20m intervals
- Above or to both sides of compressors
- Above Pressure vessels like H P / LP receivers
- Above valve stations
- Emergency power supply, e.g. battery or UPS for the detection system

48

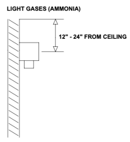
Location of Ammonia Sensors

Sensors should be located in an accessible area for maintenance and testing, but away from moving equipment that could accidentally come in contact with the sensor.
Avoid thermal extremes (close to heaters) and do not place unprotected in direct, strong drafts/ airflows, near exit doors, or areas where falling water or condensing moisture are present.
If high humidity is always present, power up the unit as soon as possible, as long term exposure can shorten the life of the gas sensing element. Select the unit for harsh environments where a condensing atmosphere may be present.
In blast freezers, mount the gas sensor below the coil to avoid high moisture and steam during defrost.

49

Location of Ammonia Sensors

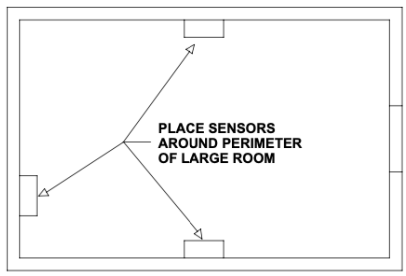
- The Gas Detectors must be installed at High Level
- At least 1 detector at ceiling level on a grid of 10m to 20m intervals
- Above or to both sides of compressors
- Above Pressure vessels like H P / LP receivers
- Above valve stations
- Emergency power supply, e.g. battery or UPS for the detection system



50

Location of Ammonia Sensors

"Perimeter" detection is where sensors completely surround the area in question.

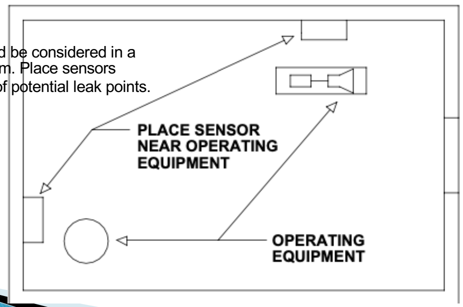


51

Location of Ammonia Sensors

"Point" detection is where sensors are located near the most likely sources of leakage.

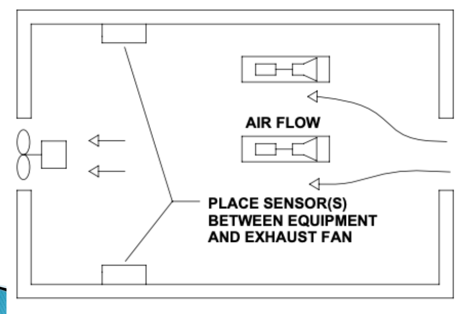
Air flow should be considered in a ventilated room. Place sensors downstream of potential leak points.



52

Location of Ammonia Sensors

Air flow should be considered in a ventilated room. Place sensors downstream of potential leak points.



53

Location of Ammonia Sensors

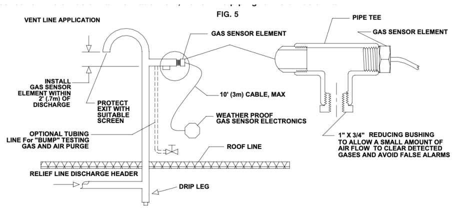
54

Location of Ammonia Sensors : Problems

55

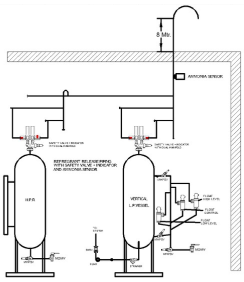
Location of Ammonia Sensors

Ammonia leak detector Safety Release System



56

Location of Ammonia Sensors : Safety Release System



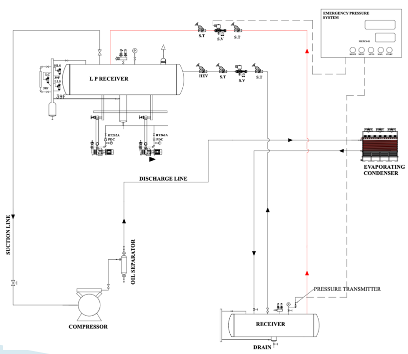
57

Portable Leak Detector

- Microprocessor controlled device
- Customized calibration optional possible
- Display of the calibrated gas concentration
- Various optional Accessories variable
- Values from 1 ppm up to 2000 ppm
- Optional 1 up to 1000 ppm
- Acoustic signal depending on concentration (can be switched off)
- Automatic measuring range charge over
- Automatic zero setting on air after switch on

58

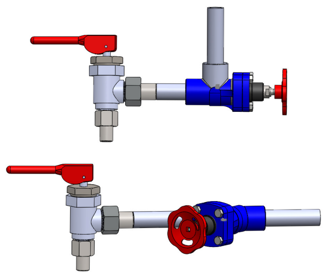
Safety Controls: Emergency Pressure Control System



59

59

DEAD MAN'S VALVE



60

DEAD MAN'S VALVE




61

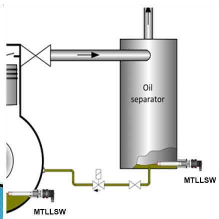
Level Glass or Level Gauge ?

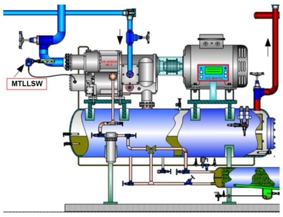

62

Electronic Level Switch

APPLICATION:

- Detect the presence of liquid in vessels, tanks, separators, compressors, standpipes and other applications.
- Detect level in all types of refrigerant media and oil
- Applicable for all types of cooling and heating systems (including heat pumps application)





63

Electronic Level Switch

Measuring principle

- Capacitance Measuring Principle

The capacitive measuring principle is based on the working principle of a capacitor. A capacitor creates an electric field between two conductive plates when the voltage is applied. The capacitance is calculated from the electric field and is than transform into a level.

The electric field is depending on 3 things:

- **Plate size** – Bigger plates can "hold" more charge.
- **Distance between plates** – Closer plates can "hold" more charge.
- **Material between the plates** – Different media have different dielectric constant (εr).

The distance of the conducting sheets (d) and the size (A) of the plates themselves are always kept constant to a capacitive sensor. Which means the only thing changing is the dielectric constants(εr) of the media.

Combined with

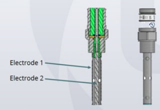
Medium	Dielectric Constant (εr, ~20-25 °C)
Ammonia (R717)	17
CO_2 (R744)	1.6
Propane (R290)	1.6 - 1.8
Propylene (R1270)	1.9
R134a (HFC)	13.6
R404A / R507A (HFC blends)	9 - 12
R1234yf (HFO)	9.5
Ethylene Glycol (30-50% aq.)	37 - 42
Propylene Glycol (30-50% aq.)	30 - 35
Brine (20-30% aq.)	70 - 80
Water	78.5
Ice (solid H_2O)	3.2
PAG Oil	5 - 7
POE Oil	4 - 6
PAO Oil	2.1 - 2.3
Air (gas)	1.0

- Conductance Measuring Principle

The conductance measuring consist of two electrodes and measure how well a material (media) can let electricity flow between the two electrodes.

How to use the conductance measuring principle:

- Detect level in tanks with conductive liquids
- Quality control (checking salt concentration in water).
- Leak detection (if a conductive liquid appears).



64

What is contamination ?

- A good Refrigeration system should contains only two things refrigerant and oil.
- Anything else is a contaminant!

65

65

Two Elements which affect performance of refrigeration plant

1. Water

2. Non-condensables gases

Common Non-condensables
Air
Nitrogen
Hydrogen
Hydrocarbons

66

Example

Anhydrous Ammonia Gas will change phase from gas to liquid if heat is removed at temperature 35°C and pressure 13.5 kg/cm^2

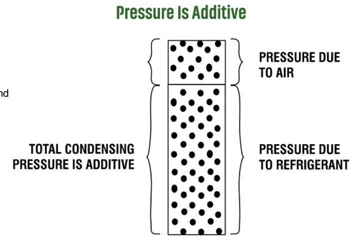
At same pressure any Nitrogen present would have be cooled to -164°C to liquefy.

Hence any nitrogen present in always remain in gaseous state

67

Presence of Air & Other Non-condensables Pressure is additive

$P_{actual} = P_{refrigerant} + P_{noncond}$



68

Presence of Air and Other Non-condensables

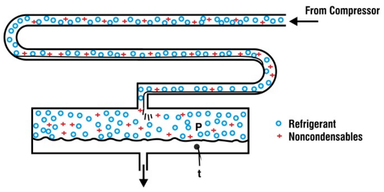
$P_{noncond} = P_{actual} - P_{refrigerant}$

When to Purge ?

If $P > P_t$

P is actual Pressure in receiver

P_t is saturation pressure corresponding to temperature



69

The Presence of Non-condensable Gases

- Increases electrical power demand
- Decreases Refrigeration system capacity
- Decreases system efficiency
- Excess head pressure puts more strain on bearing and drive motors. Belt life is shortened and gasket seals are ruptured.

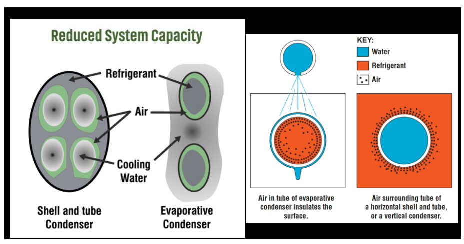
70

The Presence of Non-condensable Gases

- Increased pressure leads to increased temperature, which shortens the life of compressor valves and promotes the breakdown of lubricating oil.
- Increases condenser scaling which increases maintenance cost and reduces life of condenser
- Increase in discharge temperature leads to "Ammonia explosions" and it breaks down into Nitrogen and Hydrogen. Which means further addition to non-condensable gases.

71

The Presence of Non-condensable Gases



72

Air Vs. Power Loss

% of Air by weight	0.5	1.0	2.0	4.0
Air Pressure in PSI	1	1.6	3.2	7
Power %	0.8	1.4	2.8	6.5

for -15°C Evaporating and 38°C Condensing

73

VARIOUS WAYS IN WHICH NON-CONDENSABLES ENTER THE SYSTEM:

1. The refrigerant, when delivered, may contain non-condensable gases upto 15%.
2. Inadequate evacuation before commissioning the refrigeration plant
3. For service and maintenance certain parts of the refrigeration plant are frequently opened, causing air to penetrate into the system.
4. Oil changing and recharging with refrigerant have the same effect.

74

VARIOUS WAYS IN WHICH NON-CONDENSABLES ENTER THE SYSTEM:

5. Leakage: Systems operating with suction pressure below atmospheric pressure (i.e., working temperatures below -33°C for ammonia system) can have small leaks (from system piping, valves, vessels valve stem packing, bonnet gaskets, compressor shaft seals, non-welded connections, and control transducers etc.) allowing air to penetrate into the system.
6. Decomposition of the refrigerant or the lubricating oil can occur due to catalytic action of the various metals in the installation and due to high discharge temperatures. Ammonia for instance decomposes into Nitrogen and Hydrogen.

75

Remove Non-condensable Gases: Purging

Manual Purging

Automatic Purging

76

The Three Types of Purging

1. Direct venting of the air-refrigerant mixture
2. Compression of the mixture, condensing as much as possible of the refrigerant, and venting the vapor mixture that is now rich in non-condensables
3. Condensation of refrigerant using a small evaporator, followed by venting of the air-refrigerant mixture this is now rich in noncondensables

77

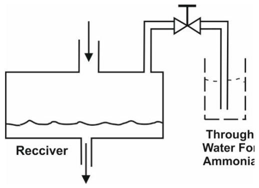
Direct Venting: Manual Purging

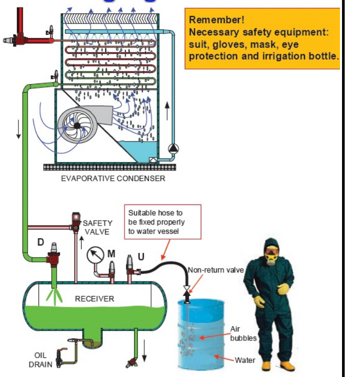
Manual purging at the condenser or receiver Procedure:

- Always use PPE kit (Mask, gloves, suite)
- Have valve with pipe connection on top of condenser and receiver
- Connect Hose to pipe connection for purge
- Connect weight to other end of hose & deep hose in water bucket
- Pump down refrigerant by shutting liquid valve at outlet liquid receiver, then stop refrigeration plant
- Keep condenser water / fans running for 1 hour
- Slowly open the purge valve
- Check ammonia smell, water colour / foam formation in water for ammonia release
- Close valve immediately if ammonia is released

78

Direct venting: Manual Purging





79

Direct Venting: Manual Purging

Manual purging at the condenser or receiver

Problems:

- Takes a lot of valuable time.
- Needs to shut down plant
- Does not totally eliminate air.
- Permits escape of refrigerant gas that may be dangerous and disagreeable to people and the environment, and may also be illegal.
- Is easily neglected until the presence of air in the system causes problems.

80

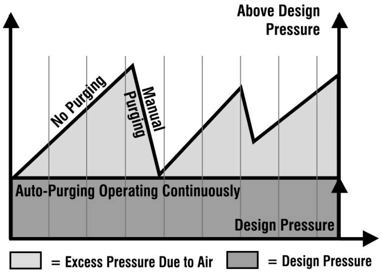
Advantages Automatic Purging System

Advantages	Disadvantages
Safety: Automatic Purgers eliminate the need for refrigeration staff to manually “open the system” on frequent basis	**Capital cost:** The cost is high because of purger unit, piping, solenoid valves and other controls
Effectiveness: A properly installed and operated multi-point purger can continuously function to scavenge and remove NCG from System	**Maintenance Cost:** For the purger unit, accompanying solenoid valves and transducers required for purge control
Labour: Eliminates the labour associated with personnel regularly removing NCG by manual operation	

81

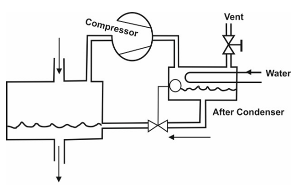
Advantages Automatic Purging System

No Purging Or Non working Purger



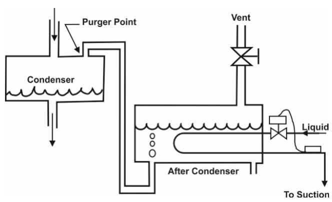
82

Compression of Mixture



83

Condensation of refrigerant using a small evaporator



84

Advantages refrigerant from plant

Feature	Plant refrigeration based purger	Benefit
No independent refrigeration circuit	Uses plant liquid ammonia as the cooling medium	Fewer components to maintain
Fewer moving parts	No compressor, condenser, expansion valve or refrigerant circuit	Higher mechanical simplicity and potentially higher reliability
No secondary refrigerant	No R290/R404A refrigeration circuit	Eliminates maintenance of another refrigeration system
Lower maintenance	Less equipment requiring servicing	Reduced maintenance cost
Long service life	Robust industrial design	Suitable for continuous industrial operation
No compressor failures	No miniature refrigeration compressor	Eliminates one common failure point
Lower electrical consumption	Only controller and solenoid valves consume power	Slightly lower operating power
Suitable for hazardous areas	Simpler construction may simplify installation in ammonia plants	Fewer electrical refrigeration components

85

Where To Purge Air ?

- Purge point connections must be at places where air will be collected.
- Refrigerant gas enters a condenser at high velocity. By the time the gas reaches the far (and cool) end of the condenser, its velocity is practically zero.
- This is where the air accumulates and the purge point connection should be made.
- Similarly, the purge point connection at the receiver should be made at a point farthest from the liquid inlet.

86

Where To Purge Air ? Receiver or Condenser ?

Air will remain in the condensers when the receiver liquid temperature is higher than condenser liquid temperature. This can happen when:

1. The receiver is in a warm place.
2. Cooling water temperature is falling.
3. Refrigerating load is decreasing.

Conversely, air will migrate to the receiver when the condenser liquid temperature is higher than the receiver temperature. This can happen when:

1. The receiver is in a cold place.
2. The cooling water temperature is rising.
3. The refrigeration load is increasing.

87

Purge Points

Evaporative Condenser

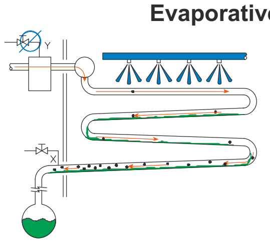
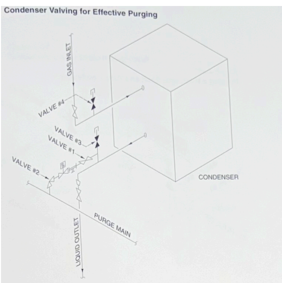
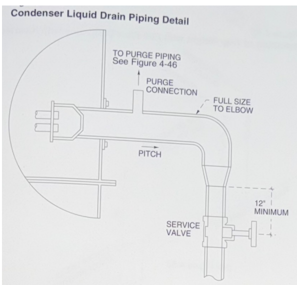


Fig. 1.(left) High velocity of entering refrigerant gas prevents any significant air accumulation upstream from point X. High velocity past point X is impossible because receiver pressure is substantially the same as pressure at point X.**Purge from point X.** Do not try to purge from point Y at the top of the oil separator because no air can accumulate here when the compressor is running.

88

Purge Points





89

Purge Points

Purge Connection for Receiver

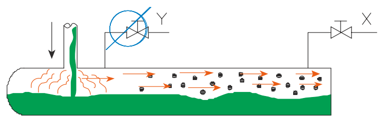


Fig. 5.Purge from Point X farthest away from liquid inlet. "Cloud" of pure gas at inlet will keep air away from point Y.

90

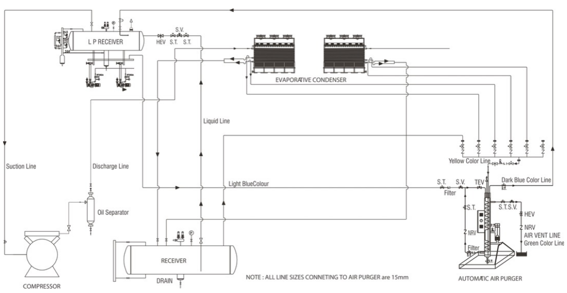
Purge Points

91

Purge Point solenoid valve connection

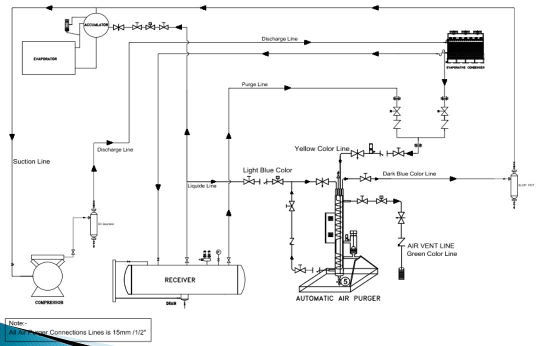
92

Automatic Purger Installation Liquid Over Feed



93

Automatic Purger Installation Gravity Feed



94

Automatic Purger

Electrical Power KW for different Condensing Pressure	12 kg/sq, cm	16 kg/sq, cm
KC51 2 No.	94	106
KC42 1 No.	45	51
Total Power	139	157
Extra Power	18	
Cost Rs./kW	7.5	
Running Hours in year	6000	
Total Saving due to air purger Rs.	8,10,000	

95

Calculation of Increased Power Cost

Plant Details	Freezing Plant	Potato Cold Storage 5000MT
Evaporation Pressure	-40°C	-10°C
Condensing Pressure for 38°C	13.7 kg/cm^2	13.7 kg/cm^2
Refrigeration Capacity	500kW	518kW
Power required by compressor	281kW	148kW
Actual pressure is 1.5 Kg/cm^2 higher	15.2 kg/cm^2	15.2 kg/cm^2
Power required due high pressure	300kW	165kW
Energy Saving	19kW	17 kW
Annual Running Ours	6000 hours	5000 hours
Electricity Cost	Rs. 8/-	Rs. 8/-
Total increase in electricity bill	Rs. 9,12,000/-	Rs. 6,80,000/-

*Other benefits such as reduction in wear & tear of compressor parts, condenser descaling, increase in refrigeration capacity are to be added

96

Water Contamination and Removal in Ammonia Refrigeration Systems

Water Contamination is very Commonly observed due to Solubility of Ammonia in Water

97

Water Contamination and Removal in Ammonia Refrigeration Systems

98

Ammonia-water Relationship

- Ammonia and water have a great affinity for each other.
- For example, at atmospheric pressure and a temperature of 30°C., a saturated solution of ammonia and water will contain approximately 30 percent ammonia by weight. As the temperature of the solution is lowered, the ability to absorb ammonia increases.
- At 0° C. the wt. percentage increases to 46.5 percent;
- At -33°C. the percentage increases to 100 percent ammonia by wt.

99

Ammonia-Water Reaction

- Ammonia Mixed with water produces Ammonium Hydroxide ($NH_3+H_2O=NH_4^++OH^-$)
- Ammonium & hydroxyl ions can cause galvanic corrosions
- Water mixed with compressor oil have chemical reactions that creates nitro compounds (sludge)
- These nitro compounds (sludge) clogs strainers and cause operation problems in valves

100

Ammonia-water Relationship

When water is added to anhydrous Ammonia, the saturation temperature at a given pressure increases

% Dilution	Saturated Suction Temperature at		
	-0.3 Kg/ cm² g	0 Kg/ cm² g	2.0 Kg/ cm² g
0	-40.2°C	-33.3°C	-8.9°C
10	-38.6°C	-31.6°C	-7°C
20	-36.4°C	-28.9°C	-3.9°C
30	-32.2°C	-24.4°C	2.3°C

101

Water Contamination and Removal In Ammonia Refrigeration Systems

Two Sources of Water contamination

1. The contaminated sources in the construction and initial start up phase
2. The contaminated sources after the system has been put into normal operation.

102

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination During construction and at initial start up

- Water remaining in new vessels, which are not properly drained after Hydro pressure test.
- During construction, water may enter through open piping or weld joints, which are only tacked in place when either are exposed to the elements.
- Condensation, which may occur in the piping during construction.
- Condensation, which may occur when air has been used as the medium for the final system pressure testing.
- while pressure testing with air using system Ammonia compressor
- Water, which remains in the system as a result of inadequate evacuation procedures on start up.
- The use of non-anhydrous ammonia when charging the system.

103

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- Rupture of tubes on the low-pressure side of the system, especially in Shell & Tube Heat Exchangers such as chillers or oil coolers
- Improper procedures, when draining oil or refrigerant from vessels or pipes in vacuum range into water filled containers.
- In systems, which are operating below atmospheric pressure or which are making pump down so that the pressure goes into a vacuum range: Leaks in valve stem packing, flexible hoses, screwed and flanged piping joints, threaded and cutting ring connections, pump and compressor seals, and leaks in the coils of evaporator units.

104

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- Improper procedures when evacuating the system or parts of the system, while service and maintenance work is carried out.
- Complex chemical reactions in the system between the ammonia, oxygen, water, oils and sludge can create more "free" water in the system.
- Inadequate or no purging

105

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

Moisture which enters with air on low side mixes with ammonia and remains their.

Example
Air Purger in a plant removes 5 lit of air per min
Ambient temperature is 35°C, & 75% RH
Hence, water contain is 25 g/kg
5 lit x 1/1000 lit X 25.5 g X 60 min = 7.65 grams of Water per hour
That is 45.9 lit per year considering 6000 hrs per year plant operation
In 10 years, we will have 459 Lit of water in our plant

106

Effects of Water Contamination

- Water causes corrosion in the refrigerant cycle
- Accelerates the aging process in oil
- The compressor oil begins forming organic acids and sludge from a complex chemical reaction
- Increased wear and tear of the compressor and frequent oil changes generate lower plant availability and increase service costs.

107

Effects of Water Contamination

- Pressure drops increase through piping
- Pump and evaporator performance are adversely affected
- The system must be operated at a lower suction pressure to maintain the desired temperatures
- Water contamination lowers system efficiency
- Increases electrical costs

108

Effects of Water Contamination Compressor

109

Effects of Water Contamination Compressor Oil

110

Effects of Water Contamination valves chocking, slug in compressor

111

Effects of Water Contamination valves chocking, slug, rusting inside control valve

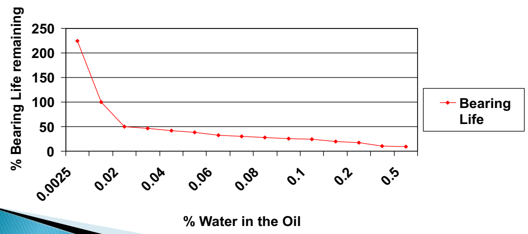
112

Effects of Water Contamination valves chocking, slug, rusting inside control valve

113

EFFECT OF WATER ON BEARING LIFE

- Water limits are dependent on the fluid's base stock.
- Parafinnic Mineral oils 100 ppm
- Napthenic Mineral oils 150 ppm
- POE's 1000 ppm
- PAG's 2-5%



114

Areas Of Highest Water Content

- Recirculation Systems :Pump receiver (LPR)
- Flooded systems: evaporator and surge drum.
- DX systems suction accumulator.
- Two-stage systems vessels and evaporators of the low stage portion of the system.

115

Areas of Highest Water Content

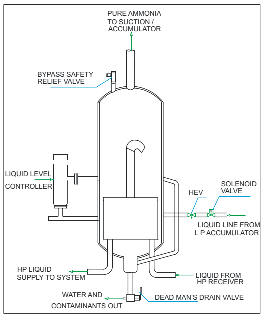
Reasons :

- Large difference in Vapour Pressure between water and ammonia.
- For example, at 2°C, the vapor pressure of ammonia is 3.6 Kg/cm^2 as compared to 0.007 Kg/cm^2 for water.
- Since the liquid with the higher vapor pressure evaporates in greater proportion than the liquid with the lower vapor pressure, a residue is left containing much more lower vapor pressure liquid when infiltration is not corrected.

Temperature (^{o}C)	Pressure (kPa)	
	Water	Ammonia
0	0.61	329
5	0.87	415
10	1.23	515
15	1.71	629

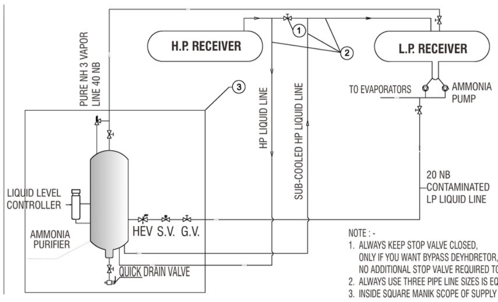
116

Ammonia Purifier / Dehydrator



117

Ammonia Dehydrator Installation



NOTE : -
1. ALWAYS KEEP STOP VALVE CLOSED, ONLY IF YOU WANT BYPASS DEYHDRETOR, OPEN THE VALVE. NO ADDITIONAL STOP VALVE REQUIRED TO INSTALLATION
2. ALWAYS USE THREE PIPE LINE SIZES IS EQUAL
3. INSIDE SQUARE MANIK SCOPE OF SUPPLY ONLY.

BASIC AMMONIA PUREFIER INSTALLATION P & I

118

Cost of Water

Parameters	Compressor Type	
	Booster	Two Stage
Compressor Capacity	300 kW	300 kW
Condensing Temperature	-7^{o}C	40^{o}C
Evaporating Temperature	-40^{o}C	-40^{o}C
Power required	80.1 kW	171 kW
Evaporting Temperaure for 10% Water containination	-42^{o}C	-42^{o}C
Corresponding Power required	87.9 kW	181 kW
Extra Power requred	7.8 kW	10 kW
Power Cost	Rs. 8/kW	Rs. 8/kW
Runnuing Hours per year	6000 hours	6000 hours
Total Cost of extra power	Rs. 7,74,400/-	Rs. 4,80,000/-

*Other benefits such as reduction in wear & tear of compressor parts, oil, increase in refrigeration capacity are to be added

119

Cost of Water & Air

Cost of Water & Air										
Potato Cold Storage 5000 MT										
							0.746			
						130	8		16	270
Suction Pressure PSI	Suction Temperaure Deg F	Discharge Pressure deg F	Discharge temp deg F	Refrigeration Effect Btu/lb	BHP/ton	Power Required for C/S HP	Electrical Cost Rs/kW	Extra cost per hour Rs.	cost per day Rs.	cost per year Rs.
38.87	25	186.95	97	466.78	0.83	107	641			
38.87	25	213	105	457.38	0.95	123	734	93	1486	401190
28.31	15	186.95	97	464.00	1.08	140	837	196	3132	845616
28.31	15	213	105	454.58	1.21	157	935	294	4707	1270938

120

Working Video

121

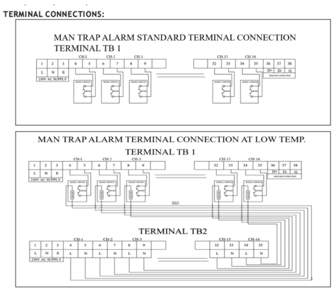
Man Trap Alarm

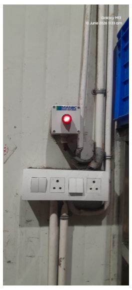
The chiller room alarm system was installed in machine room with self illuminated push button system near doors in chiller and freezer rooms for trapped loader. This unit was incorporated with inbuilt battery backup so that it can work independently in the event of power outage.

MAN TRAP ALARM : MTA

122

Man Trap Alarm





123

Corrosion , rusting and damages

124

Ultimate solution : Stainless Steel

SS 304 seamless pipe				Seam Less steel pipe		
DN/NB Size	Schedule No	Thickness in mm	weight kg/m	Schedule No	Thickness in mm	weight kg/m
15	40	2.77	1.29	80	3.73	1.50
20	40	2.87	1.71	80	3.91	2.19
25	40	3.38	2.54	80	4.55	3.23
32	40	3.56	3.44	80	4.85	4.46
40	40	3.68	4.11	80	5.08	5.44
50	10S	2.77	3.99	40	3.91	8.62
65	10S	3.05	5.34	40	5.16	11.28
80	10S	3.05	6.56	40	5.49	11.27
100	10S	3.05	8.5	40	6.02	16.06
125	10S	3.4	11.64	40	6.55	21.08
150	10S	3.4	14.04	40	7.11	28.23
200	10S	3.76	20.77	20	8.18	42.49
250	10S	4.19	28.2	20	9.27	60.24
300	10S	4.57	36.54	20	9.53	73.75

125

Ultimate solution : Stainless Steel

126

127

128

129

130

131

132

Ultimate solution : Stainless Steel

133

Ultimate solution : Stainless Steel

134

Ultimate solution : Stainless Steel

135

Association of AMMONIA REFRIGERATION

Thank You!!

MANIK ENGINEERS INDIA

136