Safety in Design, Installation, Operation & Maintenance of Refrigeration Plant

BY

- Ramesh Paranjpey
- Fellow Life Member ASHRAE
- ASHRAE 50-year Distinguished Service Award 2021
- Ramesh.paranjpey@gmail.com
- Website: http://ramesh-paranjpey.com
- Cell No. +919822398220

1

Safety

SAFETY IS AN ATTITUDE

1. It is everybody's Responsibility
2. Safety is built while Plant Designing, construction, installation, operation & maintenance
1. Safety cannot be added later on as an accessory

2

Safety is an attitude, Attitude scores 100% marks

- A=1, b=2,C=3, D=4,E=5, F=6,g=7,h=8,I=9,J=10,k=11< L=12, M=13, N=14, O=15,P=16, Q=17,R=18, S=19,T=20, U=21,V=22, W=23, X=24, Y=25, Z=26
- Luck=12+21+3+11=47%
- Knowledge=11+14+15+23+12+5+4+7+5=96%
- Hard work= 8+1+18+4+23+15+18+11=98%
- ATTITUDE= Scores 100% Marks= 1+20+20+9+20+21+4+5= 100%
- It is therefore everybody's attitude towards Safety is essential to make the plant 100% safe

3

Good judgement comes from experience and experience comes from bad judgement

4

Why Ammonia Refrigeration Safety ?



Ammonia Refrigerant Leaks – Issues

1. **Toxicity- Above 50-100 PPM for long Duration**
2. **Up to 400 PPM for short duration acceptable**

2. Flammability- above 16% concentration by volume.- Ignition point 650^{0}C

5

Standards

1. **AAR-1 Ammonia Safety Standard**
2. **STANDARD-IIAR-2**
3. **ANSI/ASHRAE-15 2013**
4. **ASME B31.5 -2013**
5. **ASME Sect V III Div. 1**
6. **TEMA**
7. **ISO-5149**
8. **EN 378**
9. **IS 665- latest**
10. **OSHA**

6

Following Standards/Documents give detailed information safety aspects

1.OSHA (**O**ccupational **S**afety and **H**ealth **A**dministration)

2. EPA (**E**nvironmental **P**rotection **A**gency) Compliance

3. The IIAR (**I**nternational **I**nstitute of **A**mmonia **R**efrigeration) standards and bulletins on the design, installation, maintenance and operation of closed-loop mechanical refrigeration systems is also

4. RAGAGEP (**R**ecognized **a**nd **G**enerally **A**ccepted **G**ood **E**ngineering **P**ractices) and should be available for any

5. PSM (IIAR's **P**rocess **S**afety **M**anagement Guidelines for Ammonia Refrigeration practitioner.)

6. RMP (**R**isk **M**anagement **P**rogram Guidelines for Ammonia Refrigeration.)

7

7. PHA-**P**rocess **H**azard **A**nalysis of Ammonia System using Bow--Tie approach in process safety is a visual representation of potential hazards

8. EP&R- -**E**mergency **P**lanning and **R**esponse- EP&R is a critical element for emergency pre-planning and training to make personnel aware of, and able to execute, proper actions in the case of an unplanned incident.

9. LOTO Program: - lockout/tagout or LOTO programs. Historically, LOTO programs have appropriately focused on removing the threat of electrical and mechanical hazards when systems are being maintained or modified.

8

Safety

This presentation is divided in 5 parts

1. Safety precautions during designing the plant
2. Safety precautions during selection of equipment, it's vendors who have knowledge of end use & construction practices
3. Safety precautions during erection
4. Safety precautions to protect equipment
5. Safety precautions during operation & maintenance

9

Part-1

what are likely to be the deficiencies & Safety precautions to be considered while Designing the plant

10

Design Deficiencies leading to unsafe plant

1. Failure to understand customer's process requirements
2. Omission of an important component, accessory, controls
3. Failure to follow good engineering practices
4. Failure to comply with the requirements of codes or standards
5. Failure to use proper type of controls
6. Failure to recognize changes needed, if alternate equipment accepted or plant is expanded by adding new equipment
7. Failure to provide proper piping design & drawings to avoid liquid traps & oil accumulation, vibrations etc.

11

Design's responsibility

1. Understand Working of the Process and then design matching Refrigeration System
2. Prepare proper P & ID diagram for the system & isometric piping drawing for the guidance of erection team
3. Select Energy Efficient Equipment
4. Guide end user to Procure equipment From authorized and qualified Suppliers
5. Prepare comprehensive BOM including valves, controls & piping
6. Ensure that correct manufacturing /Design Standards are followed
7. Supervise and Ensure Quality Installation
8. Train operators for proper Maintenance of the plant

12

Designer's Responsibility -Machine Room

9. Plan Proper equipment Layout with adequate maintenance Space
10. Proper Ventilation as per standards
11. Doors for Quick Evacuation in Case of refrigerant Leaks
12. Plan Cable Trenches/Oil/water Drains
13. Provide Design for Anti Skid Flooring
14. Instruct client to procure Safety Equipment and First Aid Kits and make them readily available in machine room

13

Designer' s responsibility-Electricals

1. No other Electricals in Machine Room other than MCC & Control Panel
2. MCC to have proper forced ventilation
3. Provide Energy meter to record entire power consumption of Refrigeration system
4. Enough Distance between compressors and MCC
5. Provide Cable trays & Entry from Top of panel preferred
6. Proper Earthing for PLC/Electronic items
7. Cable trenches to be designed so that no water seepage/accumulation occurs
8. Fire Protection device near panels
9. Electronic items through UPS & protection against surge, high low voltage, earthing fault etc.

14

Designer's Responsibility -Electricals

10. Compressor panel to receive supply after all safeties are satisfied- no bypass
11. Extra contacts & I/O' s for PLC to be planned and provided.
12 . Emergency stop outside machine room to shut off all electricals in case of emergency & ammonia leaks.
13. Electrical and control wiring Diagram in the machine room prominently displayed on wall besides P & ID

15

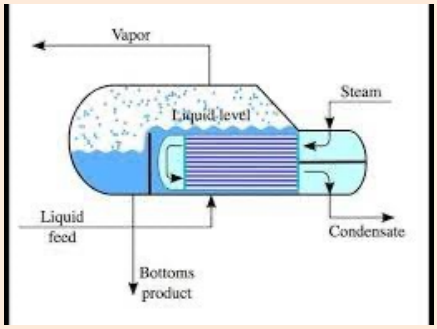
Emergency Electrical Trip Switch





16

Case Study 1-Kettle Type heat Exchanger instead shell & tube flooded chiller and surge drum



17

Surge Drum On top of Chiller



18

Case Study -2 Not Understanding specifications & Procurement

- Chemical plant using Ethylene Glycol brine Shell & Tube chiller in Mumbai-Thane
- Required concentration to achieve temperature of -20^{0}C was 45% and was ordered accordingly
- Customer did not make solution with 45% concentration and charged 100% Ethylene Glycol resulting in not able to lower brine temperature at all and getting liquid in compressor immediately on start up

19

Part-2
Safety precautions during selection of vendors with knowledge of end use application & Manufacturing practices

20

Precautions during Design & Manufacture of Pressure Vessels & Heat Exchangers

1. Design Pressure-17^{0}C above wet Bulb for Water Cooled minimum - EN/ISO standard
2. 17^{0}C above Dry Bulb for Air Cooled Minimum
3. 21 kg/cm^{2} g for water cooled Applications-AAR standard
4. 27kg/cm^{2} g for air cooled-AAR standard
5. Prefer Design for both High and low stage Vessels for above pressures to Reduce Ammonia Charge. Ammonia can be then stored in LP vessel instead pumping down in main receiver.

21

Design Precautions-Pressure Vessels

1. Use Boiler Quality plates for Receiver Fabrication- IS2002 Gr 2A –IS2041 GrR260 or SA516/Gr.70 plates & not Structural steel IS-2062-prefer SA516/Gr60/70
2. Use proper Thickness of plate as per TEMA standards
3. Consider joint efficiency as 0.7 if no radiography
4. Add corrosion allowance 0f 1.6mm in calculated thickness
5. Fabrication as per IS 2825 or ASME sec. VIII-Div 1./ or 97/23/EC-Use E7017 Electrodes & not structural 6013

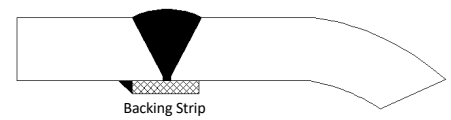
22

Pressure Vessels

6. Use backing strip for shell to end cap joints
7. Use minimum shell sections-Preferred up to 24" standard Sch. 20 pipes
8. Use Dual safety valve for vessels having 10 cu.ft. & above volume
9. Sight Glass shielded & with non return valves or level Sensors preferred in place of sight glass

23

Shell to Dish End Welding



POST WELD HEAT TREATMENT RECOMMENDED

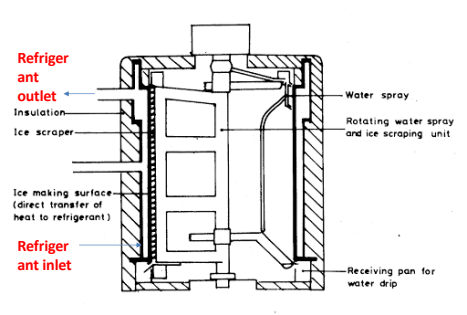
24

Pressure Vessels-Testing

11. Pressure Test-Hydraulic 1.5 Times Design pressure at factory
12. Leak Test -1.25 Times Design Pressure at site
13. Set Safety Relief valve 25% higher than max. operating pressure but never more than design pressure
14. Periodic pressure testing of receiver and thickness check & calibration of safety relief valve required once in a year

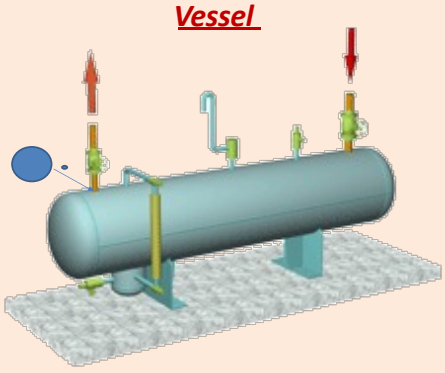
25

Case Studt-3 Flake ice Maker cross section Double wall construction with Flooded Ammonia refrigerant



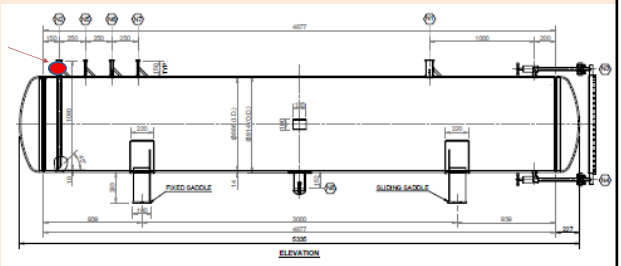
26

Case Study-4
High Pressure Receiver-*most Important Vessel*



27

High Pressure Receiver



28

Part-3
Safety precautions during erection

29

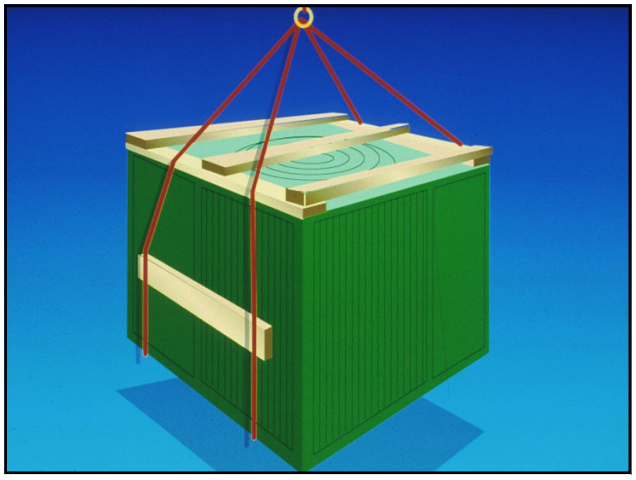
Possible Errors

1. Supervisor has little knowledge of the system or functioning of its components
1. Failure to install piping in accordance with good engineering piping practices
2. Failure to provide convenient access to important items
3. Failure to provide adequate instructions for the operator at startup
4. Failure to recognize or bring to owner's attention code violations contained in the system installed
5. Making unauthorized changes or additions to a system
6. Not Undergoing training on proper installation techniques and not using qualified welders, electricians

30

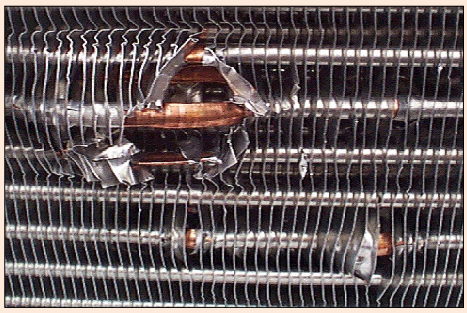
Refrigerant Piping Design & Installation

31



32

Inspect All Equipment for Transit Damage



33

Piping Material & Thickness

1. Piping/fittings as per ANSI B31.5
2. Carbon Steel A53 Grade A or B ERW or A106 grade A/B seamless or A333
3. Do not Use Galvanized Piping(Low Grade)
4. 1 ½" and smaller –Sch. 80
5. 2" to 6' Sch. 40
6. 8" to 12" sch 20
7. Sch 80 ≥ Sch 40 ≥ sch20
8. All Weld Fittings-Avoid Threads/Flanges

34

Contamination



Open System

- Oil Changed to Cleanse / Dilute Contaminants
- Contaminants Periodically Purged
- Lower Standard of Cleanliness

35

Whatever is Sealed In STAYS In



36

Used and new strainers



37



Contamination Found on valve Seats

38

How To Avoid likely Ammonia Leaks while doing piping

1. Use Welded Joints instead Flanged joints
2. Use Proper material for pipes
3. Correct Location of Valves
4. Avoid Liquid Ammonia Traps
5. Use Quick Drain Valves for oil Drain
6. Use Dual Safety Valves
7. Use long stem valves for insulated lines
8. Use angle valves instead (straight valve + bend) wherever possible
9. Reduce as many welding joints as possible
10. Use simple pipe routing and slopes as per requirement, it may not look aesthetically good but essential for proper functioning

39

LIKE THIS CONNECTIONS-?



X

40

FAILURE MODES

Piping & Vessels

1. Corrosion (Rust)
2. Internal Erosion (Rare)
3. Hydraulic Expansion
4. Hydraulic Shock
5. Impact
6. Loads
7. Vibration (Rare)

Buildings

1. Conflagration

41

1. CORROSION (RUST) UNDER INSULATION – Piping Under Different Conditions of Temp

Metal Temperature:

- Below Freezing (Safe)
  - ~ Corrosion begins
  - ~ Ice builds up
  - ~ Ice acts as insulator
  - ~ Further corrosion retarded

- Above Freezing
  - ~ Corrosion progresses unabated
  - ~ Elevated temperature/rapid drying accelerates corrosion

42

CORROSION (cont'd)

- Thermal Cycling above and below freezing
  - ~ Most severe corrosion
  - ~ Most rapid failure

43



FROZEN PIPE – ONLY SURFACE CORROSION
INSULATION SHOWS NO DAMMAGE

44



DAMAGED INSULATION – ONLY SURFACE CORROSION ON PIPE BELOW FREEZING

45



RUSTED PIPE ABOVE FREEZING TEMP.

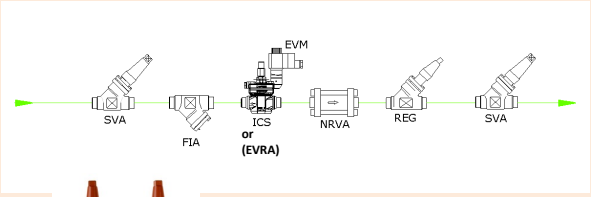
46

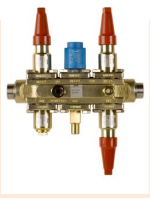
PREVENTION OF CORROSION (RUST)

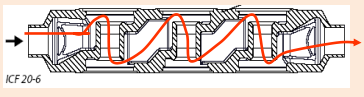
- COAT PIPE SURFACE WITH GREASE OR GREASE TAPE BEFORE INSULATION IS INSTALLED
- MODIFY PIPE SURFACE WITH SPECIAL REACTIVE COATING
- Vapour Barrier on Insulation (mostly inadequate)

47

USE COMPOSITE VALVES

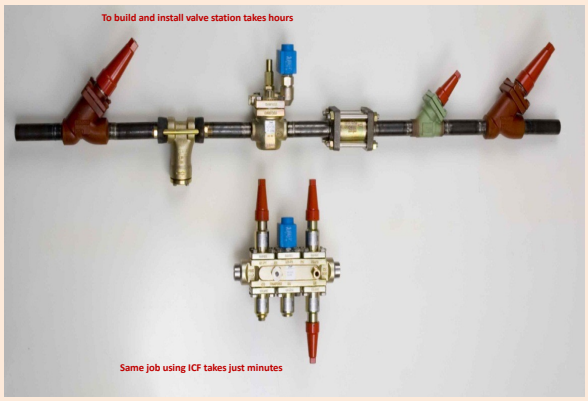






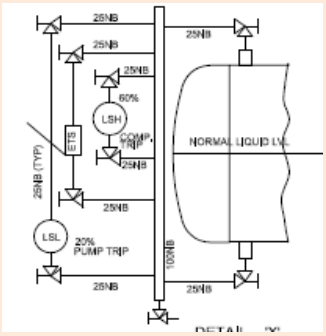
48

Two welding joints instead 12 welding Joints



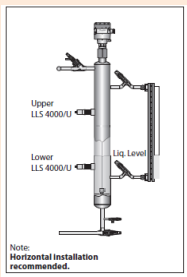
49

L.P. Vessel with Float Switches-3 Switches+6 angle valves+18 Weld Joints



50

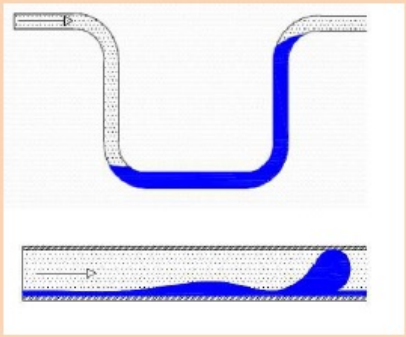




Electronic level switches

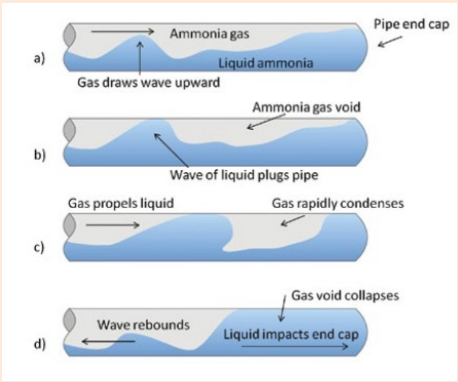
51

Liquid Hammer-Liquid Trap



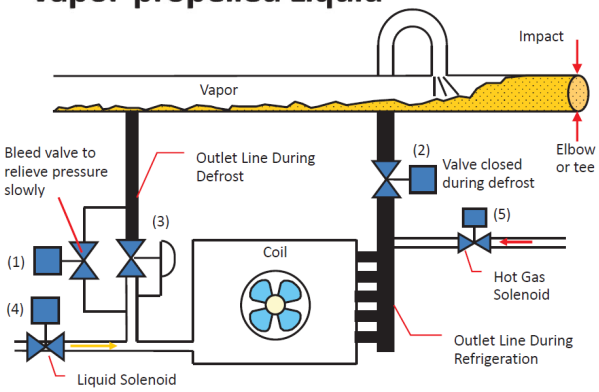
52

HYDRAULIC SHOCK



53

Vapor-propelled Liquid



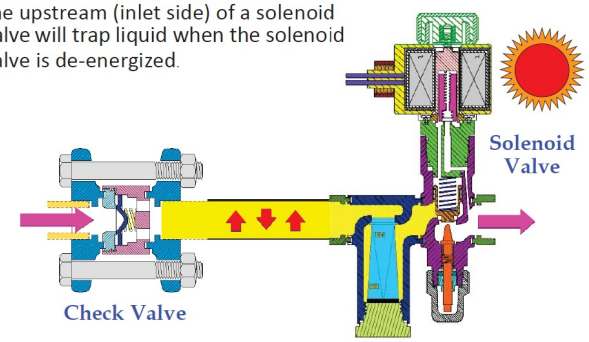
54



55

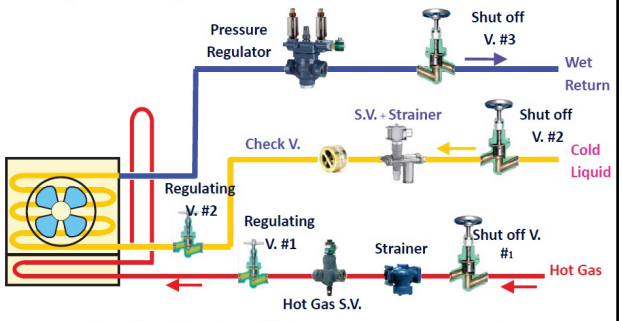
Liquid Expansion

Wrong Liquid line check valve installed at the upstream (inlet side) of a solenoid valve will trap liquid when the solenoid valve is de-energized.



56

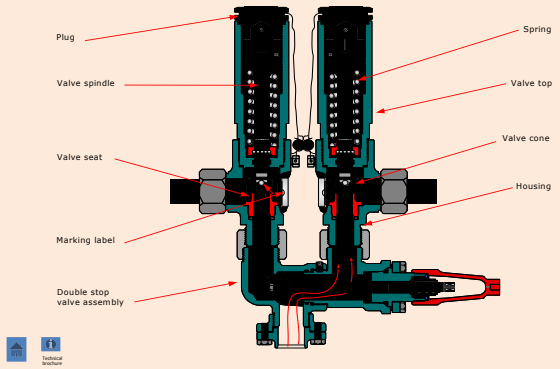
Liquid Expansion



Correct Install the liquid line check valve on the downstream (outlet side) of solenoid valve.

57

Double Stop Valve - type DSV and Double Safety Valve - type SFV



58



Safety Valve operation indicator

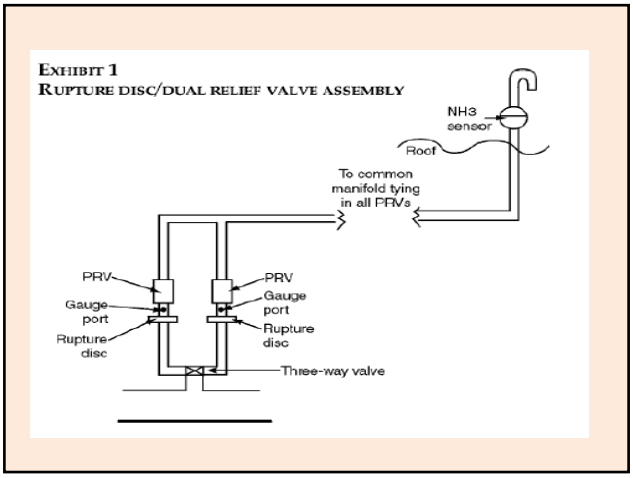
59

Rupture Members

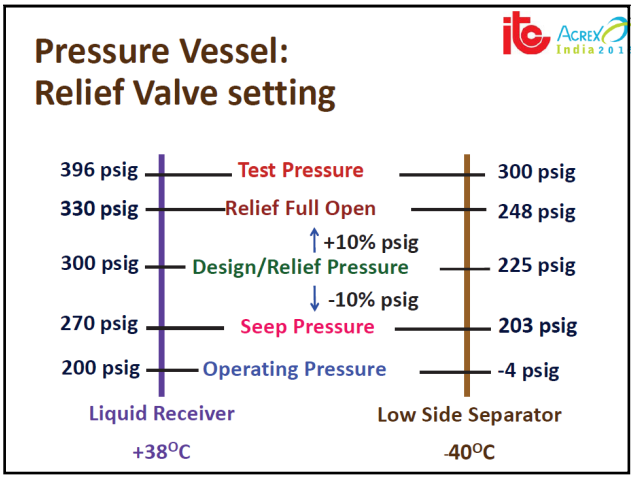
- Rupture members installed ahead of relief valves need not be larger but shall not be smaller than the relief valve inlet



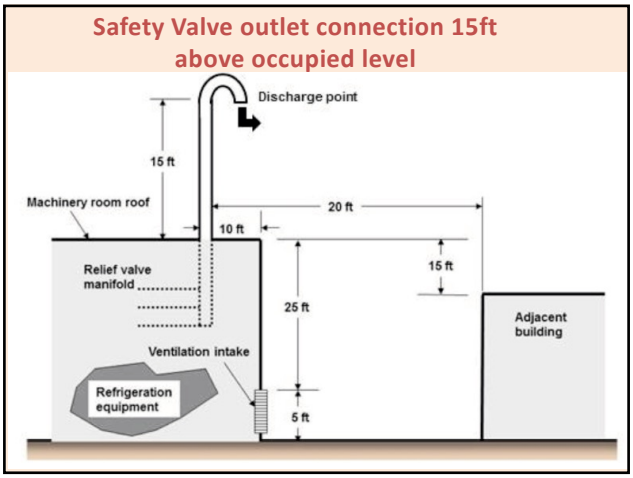
60


EXHIBIT 1
RUPTURE DISC/DUAL RELIEF VALVE ASSEMBLY
NH3 sensor
Roof
To common manifold tying in all PRVs
PRV
Gauge port
Rupture disc
PRV
Gauge port
Rupture disc
Three-way valve

61


Pressure Vessel:
Relief Valve setting
396 psig
Test Pressure
300 psig
330 psig
Relief Full Open
248 psig
+10% psig
300 psig
Design/Relief Pressure
225 psig
-10% psig
270 psig
Seep Pressure
203 psig
200 psig
Operating Pressure
-4 psig
Liquid Receiver
+38°C
Low Side Separator
-40°C

62


Safety Valve outlet connection 15ft above occupied level
Discharge point
15 ft
Machinery room roof
20 ft
10 ft
15 ft
Relief valve manifold
25 ft
Adjacent building
Ventilation intake
Refrigeration equipment
5 ft

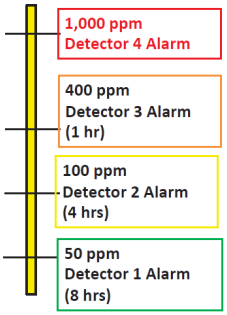
63


093

64

Machinery Room Design

- No open flames or apparatus producing open flames
- At least 2 ammonia detectors
- Air out > air in (negative pressure max. 0.25 in.wg.)



65



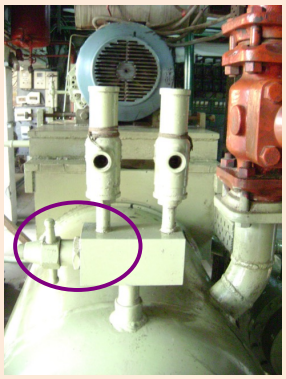
INCORRECT SAFETY VALVE OUTLET CONNECTION OUT LET SHOULD BE ON TOP (15 ft above occupied area) AS AMMNIA LIGHETER THAN AIR

66

Shut off Valve below Safety Valve-Incorrect Practice



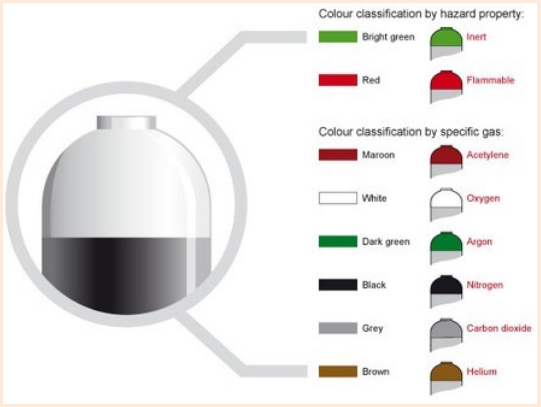
67



INCORRECT -NO SHUT OFF VALVE FOR DUAL SAFETY VALVE

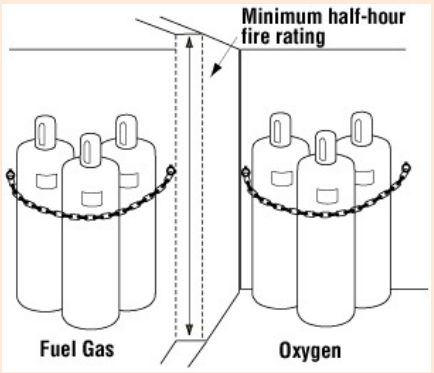
68

Pressure Testing with wrong gas



69

Nitrogen, Refrigerant cylinders must be chained to prevent accidents



70

- **Use proper Grade anhydrous Ammonia Refrigerant & Oil**
- **Less than 0.2% water to avoid stress corrosion**
- **Use synthetic oil for temperature for plant operation lower than minus 20^0C**

71

Part-4
Safety Precautions to protect Equipment & Building

72

COMPRESSOR -MOTOR BELT GUARD



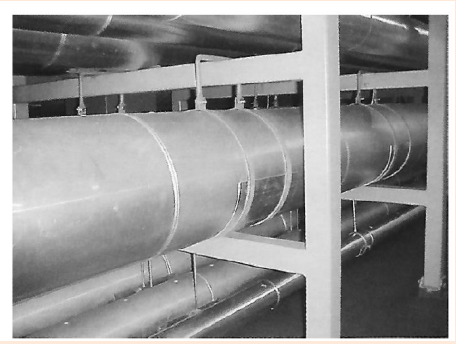
73



Evaporative Condensers-Walkway Guard

74

Pipe Support To Allow Expansion & Contraction



75

Insulated pipe supports and saddle supports







76

Piping Identification Labels/Painting



77

Pipe Insulation



New Pipe & corroded pipe

78

Rope wound around a small pipe



79

Equipment Protection



Air Coolers

Pressure Vessels



80



81

Receiver Spray Header



82

Building Protection



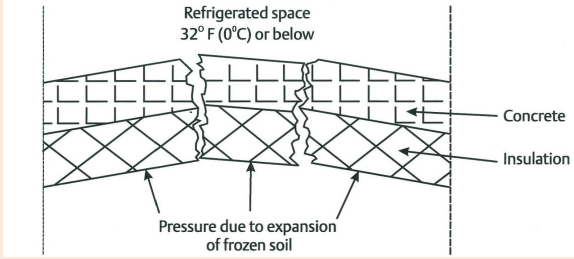
Wall Panel protection



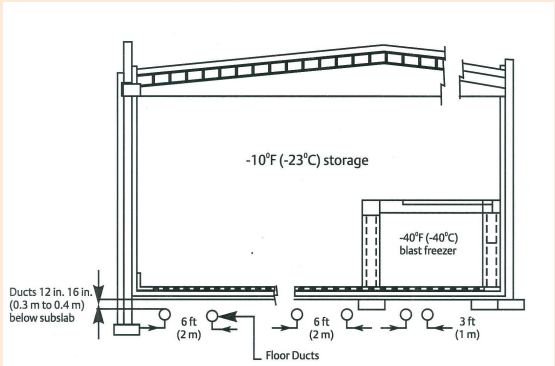
Door Protection

83

Frost heaving and its prevention

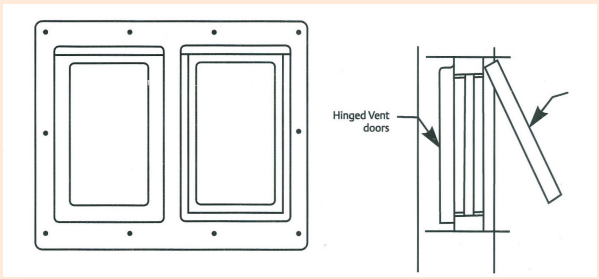


84



Ventilation Pipes to prevent frost heaving

85



Pressure Equalization Vents on Panel Walls

86

Wall Penetrations (Not Roof)



87

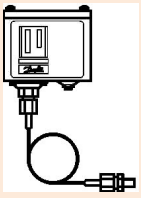


88

Safety and operating controls

89





KP switches

90



RT 107 Discharge Temperature Thermostat on compressor discharge

91



AKS 33 Pressure Transmitter

AKS 33, 4-20mA output signal
AKS 33 is a pressure transmitter that measures a pressure and converts the measured value to a 4-20 mA output signal. The output signal is adapted to the controls in the ADAP-KOOL® Refrigeration control system.

92

LLS electronic controls for Level on/off instead Float switches on stand pipe of LP vessel



93

SAFETY EQUIPMENT & ACCESSORIES

94

Leak Detector & Alarm



- Detects Leakage of Ammonia from 30 PPM
- Multi Level Alarm
- Single and Multi Channel Detection Unit
- 16 X 2 Line LCD display shows continuous ammonia level
- Inbuilt Hooter, And Relay to Operate Ventilation System
- Easy to Install
- Three Core Cable connection for Sensor
- Area Covered by one sensor is @ 2000 Sq. ft.

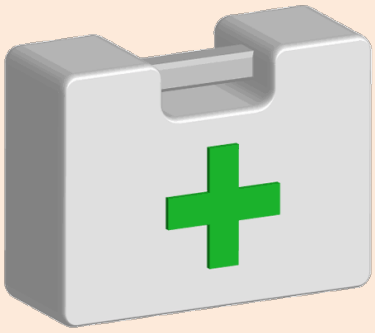
95

Leak Detectors-Ventilators

1. **One Detector should alarm activate normal Ventilation at 35 PPM to 50 PPM**
2. **Second Detector Should Alarm & Activate Emergency Ventilation below 1000 PPM**
3. **Should Discharge Up Vertically with Minimum Discharge velocity of 250 FPM(12.7m/s)**

96

First Aid kit in the machine Room



97

EYE WASH



98

EYE WASH SQUIRT (JET SPRAY)BOTTLE



99

Personal Safety Accessories



100

Hand Gloves to protect from hot surfaces



101

Goggles to protect eyes from Ammonia leaks



102

Ear mufflers to protect from noise above 90 Db



103

Hard hat to protect from falling heavy object or hitting from overhead trays, pipes etc.



104

Safety shoes with steel Toe



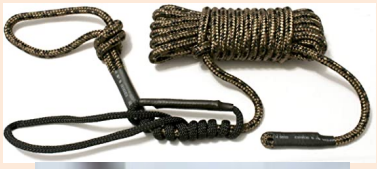
105

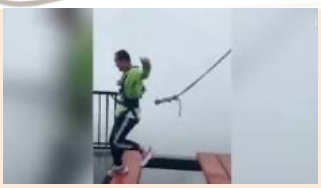
Torch to enter dark areas like cold storages



106

Rope to tie a person entering the cold rooms where leak is suspected



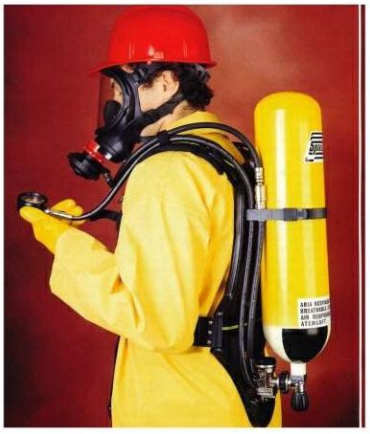


107



FACE MASK

108



AMMONIA SUIT

109



110

Ammonia Leaks

1. Ammonia Liquid Leaks-Density @40^{0}C- 579.4 kg/m^3
2. Ammonia Vapor Leaks-Density@ 40^{0}C- 12 kg/m^3
3. Liquid Density 48.22 Times more
4. Liquid Ammonia Leaks are More Dangerous Than Vapor-Never spray water on Ammonia Liquid

111

Possibilities of Ammonia Leaks

1. Accumulators/Receivers/LP vessels
2. Flanges –Joints-Use all welded joints
3. Stop Valves-Glands
4. Pressure Relief Valves
5. Piping-Charging methods
6. Manually operated valves-Oil drain
7. Oil Pots
8. Compressors/Pumps-Shaft Seals
9. Sight Glass

112



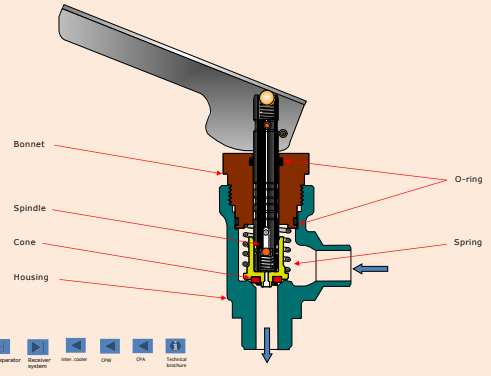
113



An oil recovery vat equipped with overfill prevention and a vent pipe leading outdoors.

114

Quick closing oil drain valve – type QDV 15



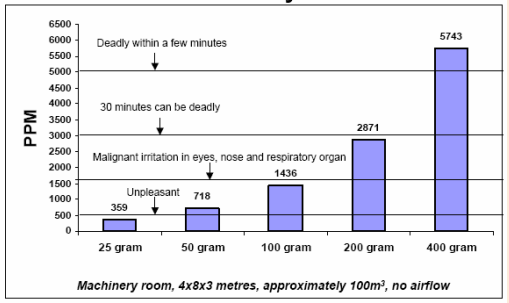
115

Where most leakages occur

Flanges/Joints	23%
Manual control/ stop valves	20%
Pumps	12%
Pressure Relief Valves	9%
Compressors	9%
Oil drains/pots	8%
Piping	7%
Charging	5%
Evaporators	4%
Sight Glass	2%

116

Ammonia leakage
In a machinery room

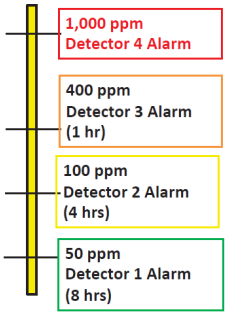


Machinery room, 4x8x3 metres, approximately 100m³, no airflow

117

Machinery Room Design

- No open flames or apparatus producing open flames
- At least 2 ammonia detectors
- Air out > air in (negative pressure max. 0.25 in.wg.)



118

LOSS OF WHOLE CHARGE OF AMMONIA

Refrigerant charge	Largest pipe diameter	Distance to leak	Leak time	Release	Distance to LC10 *1)
[kg]	[mm]	[m]	[min]	[kg]	[m]
8000	65	100	38	8000	252
8000	65	100	2	417	53
2 x 4000	50	100	72	8000	216
2 x 4000	50	100	2	223	34

*1) LC 10 (Lethal Concentration) This distance is calculated based on indoor release and no wind effect.

Table 1: Safety distance depended on leak time and refrigerant charge

119

Ventilation Requirements For Machine Room

1 . **Normal Mechanical Ventilation-IIAR 2- Enough to limit room dry bulb temperature to 40 deg C, when ambient temperature exceeds 38 deg C supplement with emergency ventilation.**

2. Emergency Ventilation- One air change per 2 minutes, or 30 air changes per hour

3. Ammonia concentration never to exceed 40000 PPM since 16% volume means 160000PPM LFL (Lower Flammability Limit) level and 25% of it is 40000 PPM

4. ANSI/ASHRAE 15 2013 Ventilation Air quantity $Q= 100xG^{0.5}$

Q= Air Flow CFm
G= Mass of Refrigerant in the largest component located in machine room

120

Leak Detectors-Ventilators

1. One Detector should alarm activate normal Ventilation at 35 PPM to 50 PPM
2. Second Detector Should Alarm & Activate Emergency Ventilation below 1000 PPM
3. Contaminated Air Should be Discharged Up Vertically with Minimum Discharge velocity of 250 FPM(12.7m/s)

121

AMMONIA LEAK-WHITE CLOUDS



122

AMMONIA LEAK-DETECTABLE- SMELL ABOVE 5PPM



123

Deficiencies leading to various type of Failures

124

DAMAGE –RECEIVER BURST-H. P. cutout Bypassed

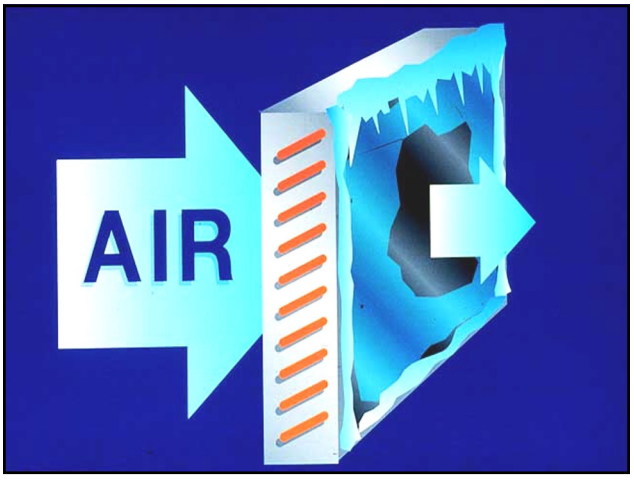


125

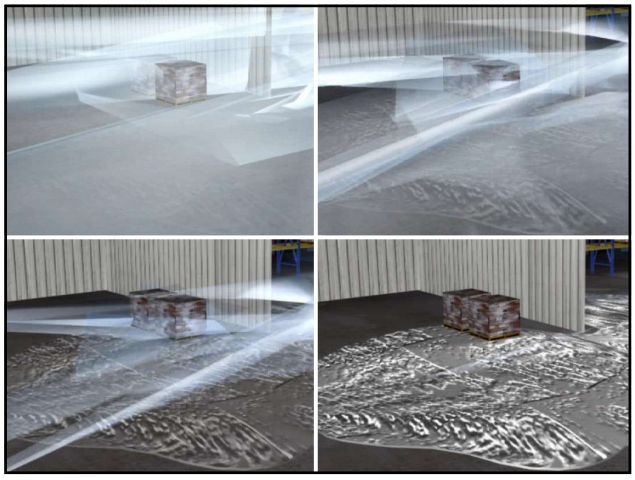
DAMAGE-STRESS CORROSION, MOISTURE INCORRECT MATERIAL ?



126



127



128

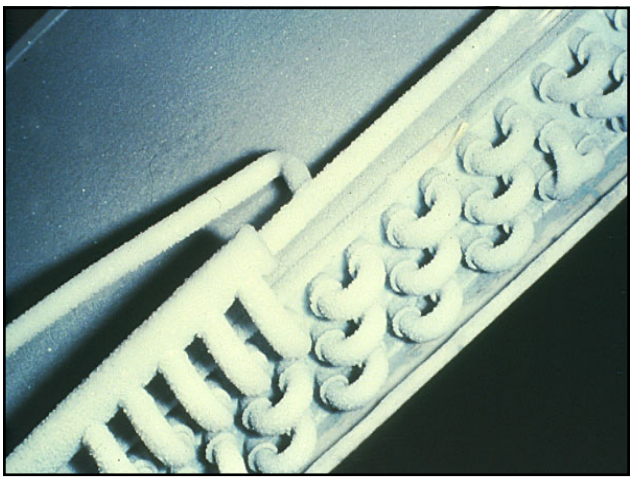


129

HEAVILY FROSTED COIL



130



131



132

PREVENT RUSTING-BASINS/PIPING/VESSELS PAINT REGULARLY



133

AVOID WATER ACCUMULATION COLD ROOMS/TERRACES



134



135

Operator's Fault

- May not be qualified for routine responsibilities
- May not completely understand the design & how the system is intended to operate
- May not realize when the equipment is not operating properly
- May not understand & analyze correctly as to what is causing unusual conditions in the system
- May not be aware of the consequences which could result from improper operation
- May not bring to the knowledge or attention of a Supervisor or management about abnormal operation

136

MAINTENANCE

Maintenance Team Should Develop

1. Standard Operating Procedure
2. Energy Saving Techniques Procedure
3. Process Hazard Analysis
4. Process & Implementation Diagram & Schedule
5. Log Book maintenance-Design V/S Actual

137

Maintenance

6. Piping & Instrumentation Diagram on The Wall
7. Electrical & Control Diagram on the Wall
8. Design Basis Parameters for each equipment Listed & Available in machine Room
9. Safety Instructions properly Displayed in machine Room
10. Maintenance Schedule properly Displayed in machine Room
11. Copy of maintenance manual & Pr. Vessel Drawings with Manager

138

IIAR BULLETINS
AAR STANDARD

1. Ammonia Machinery Room Design (Bulletin #112)
2. Suggested Safety and Op. Proc. Proc.–Tie In (#107)
3. Water Contamination in Ammonia Refrigerating Systems (#108)
4. IIAR Minimum Safety Criteria for Safe Ammonia Refrigeration (#109)
5. Start -Up, Inspection and Maintenance of Ammonia Refrigeration plant (#110)
6. Ammonia Machinery Room Ventilation (#111)
7. Identification of Ammonia Refrigeration Piping & Component (#114)
8. Avoiding Component Failure in Industrial Refrigeration
9. Systems Caused by Abnormal Pressure or Shock (#116)

139

SUMMARY OF SAFE PRACTICES

- Surface Protection for Pipe in wet region
- Use Low Velocities in Wet Suction Lines
- Avoid Liquid trapping between valves or provide pressure relief
- Provide Soft Valve Opening for Liquid Discharge into Suction or other piping (Hot Gas Defrost)
- Protect Piping and Vessels from impact (guards)
- Use Large (and heavy wall pipe for small piping) piping
- Use adequate support for piping
- Machinery Room Ventilation, Explosion Relief, No Boilers, Shut off of Elec. Power

140

HAZARD AND OPERABILITY STUDY(HAZOP)-is a hazard and operability to improve the safety aspects of design

A HAZOP study is a "what-if" safety study.
It requires, as a minimum following: -
P&ID,
FDS, (**F**unctional **D**esign **S**tudy Document describing operation of the refrigeration system and plant),
process design calculations,
Information on the specification of unit operations
Presence of professional engineers from a number of disciplines.
Test certificates for all equipment for testing carried out in the factory before dispatch

141

HAZOP STUDY-Hazards in Ammonia Refrigeration Systems-

- **HAZOP study (**Hazard and Operability Study)
- Hazards in Ammonia systems are associated with the chemical and physical characteristics of ammonia as well as temperature and pressures in the system, in general, hazards in ammonia refrigeration systems are classified as under-
-
  - Hazards from the effect of low temperature brittleness of materials at low temperatures, freezing of enclosed liquid, thermal stress, changes in volume due to changes in temperatures.
  - Hazards from excessive pressure caused by increase in condensation pressure of saturated vapour, Expansion of trapped liquid without presence of gas

142

- Hazards from direct effect of liquid phase due to excessive charge in the equipment, presence of liquid in the compressors, liquid hammer/hydraulic shock in piping and loss of lubrication due to emulsification of oil
- Hazards from escape of refrigerant, fire, toxicity, explosion, freezing of skin and asphyxiation
- Hazards from moving parts of the machinery, injuries, hearing loss from excessive noise, damage due to vibrations and ignition of materials due to broken parts
- Hazards from operation: excessive discharge temperature, liquid slugging, erroneous operation, reduction in mechanical strength due to corrosion, erosion thermal stress, liquid hammer and vibrations.

143

- **PSM/RSM Audits-**

- **PSM** (**P**rocess **S**afety **M**anagement) audits, as outlined by OSHA, are periodic assessments to evaluate the effectiveness of a PSM program and ensure regulatory compliance.
- Process Safety Management **(PSM)** in ammonia refrigeration is a comprehensive regulatory framework designed to prevent and minimize the consequences of catastrophic chemical releases. It's particularly important for facilities using ammonia refrigeration systems with 10,000 pounds or more of anhydrous ammonia. PSM ensures that systems are in place to manage risks associated with ammonia, including potential leaks, explosions, and other accidents.

144

• RSM (Risk Management) audits

- often conducted alongside PSM audits, assess the overall risk profile of a facility and identify areas for improvement. These audits are crucial for preventing accidents and ensuring the safety of workers and the public.
- The major differences between **PSM/RSM** are:
-
- a. **PSM** deals with potential hazard and protection for employees **inside** the regulated areas.
- b. **RSM** deals with potential incidents that may cause environmental and health hazards **outside** the facility boundary
-
- **RSM** helps identify the optimal settings for process variables to maximize ammonia recovery or efficiency, minimize waste, and ensure environmental compliance.
- By analysing the effects of different process parameters (e.g., temperature, pressure

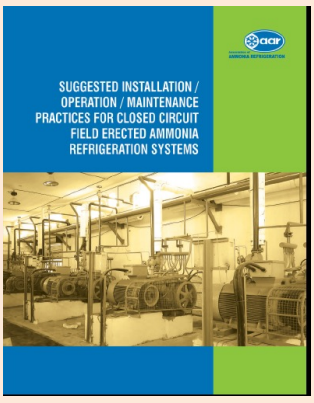
145

RMP (Risk Management Programs)

In ammonia refrigeration plants, the Risk Management Program (RMP) is a mandatory framework implemented by the Environmental Protection Agency (EPA). This program is designed to prevent and mitigate potential accidental releases of highly **hazardous** chemicals, & anhydrous ammonia, and their associated offsite consequences. Ammonia refrigeration systems with 10,000 pounds (4536 kg) or more of ammonia are subject to the EPA's RMP regulations.

146

AAR MANUAL



147

AMMONIA REFRIGERATION SAFETY STANDARD



148



149

Thank you
Any Questions ??

Ramesh.paranjpey@gmail.com
Cell no. +9120 9822398220

150