Refrigeration Plant Maintenance

BY

Ramesh Paranjpey
Fellow Life member ASHRAE
Website: http://ramesh-paranjpey.com
Mail Id: ramesh.paranjpey@gmail.com
Cell : 98223 98220

1

Maintaining The Plant Well is More of an Attitude than the actual work involved

- 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+ 1+20+20+9+20+21+4+5= 100%
- It is therefore everybody's attitude, including the owner, is required towards proper maintenance

2

Visible Checks-Leaks



3

Poorly Maintained Plant



4

Poorly Maintained Plant



5

Poor Maintenance



6

Poor Maintenance-Rust Corrosion



7

Corrosion under Insulation

Corrosion under insulation (CUI) is a type of corrosion that occurs when moisture gets trapped under the insulation of a pipe or vessel, causing the metal to oxidize. CUI can lead to serious issues, including:

1. Catastrophic leaks or explosions: if left undetected, CUI can cause catastrophic leaks or explosions.
2. Equipment failure: cui can lead to equipment failure, which can cause prolonged downtime.
3. Safety and environmental concerns: cui can cause safety and environmental concerns

8

Corrosion under insulation



9

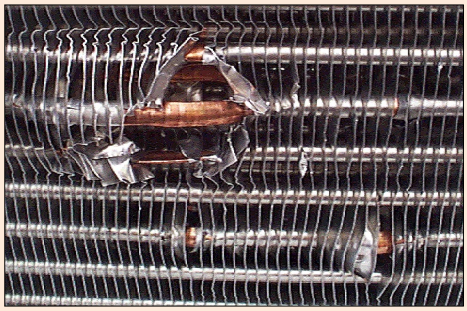
NO METAL CLADDING OVER INSULATION MAKING IT WET



Figure 8. The hot gas pipe with the wet insulation removed.

10

Damaged Fins



11

PREVENT RUSTING-BASINS/PIPING/VESSELS PAINT REGULARLY



12

AVOID WATER ACCUMULATION COLD ROOMS/TERRACES



13

Well Maintained Plant



14

Well Maintained Machine Room



15

The Maintenance of Equipment Categories

1. Inherent Maintenance-This responsibility lies with
1. Original equipment manufacturer
2. Application Engineer-proper machine room design
3. System Designer
4. System installer

2. Preventive Maintenance: This depends on
1. Scheduled maintenance
2. Conditions monitored/observed
3. Replacement or repair prior to failure

3. Corrective Maintenance- This is related to-
1. Breakdown leading to repair or replacement of part

4. Opportunity Maintenance- As & When-This depends on breakdown or shutdown of the plant.
1. One can do some preventive maintenance during this time, even though it is not scheduled.

16

Machine Room Design & Maintenance

1. Plan Proper Layout- Enough maintenance Space
2. Proper Ventilation
3. Doors for Quick Evacuation in Case of refrigerant Leaks
4. Plan Cable Trenches/Oil/water Drains
5. Provide Anti Skid Flooring
6. Provide Safety Equipment /First Aid Kits

17

Maintenance Guidelines for Machine Room

1. Sweep and mop engine room floor daily
2. Wipe compressors and other equipment daily
3. Perform machine room clean-up inspection for safety, & operational cleanliness to help extend the asset life

Things to adjust or eliminate may include

1. Oil on the floor
2. Brooms, mops, shovels, operator's cloths, jackets, belts, electrical cables, hoses etc. are hanging on valves, compressors, or panels
3. Boxes, garbage cans, empty cylinders stored next to compressors or other equipment in machine rooms should be removed

18

4. Ensure clearance in front of all electrical panels
5. Avoid Open or unlocked electrical panels
6. Avoid Hoses and electrical cables hanging or on lying on floor
7. Wipe Water on the floor from condensation from pipes, valves or equipment
8. Ensure burned out light bulbs are replaced

19

Proper trained maintenance Staff

- For proper maintenance associated materials and equipment should be available and technicians should be appropriately trained & equipped, so that they are able to maintain temperature-controlled systems in an operable and safe and efficient condition.
- The basic equipment needed for proper maintenance includes the following:

20

Maintenance Tools

1. Service manuals for each equipment
2. Digital thermometer
3. Cleaning material (non-solvent based) & Sponge and soapy water
4. Repair equipment for Insulated envelope,
5. Multimeter for electrical testing
6. Electronic leak detectors as also Hand-held leak detector
7. Manifold gauges-set and special refrigeration tools
8. Spare cylinders containing enough Refrigerant as well as Nitrogen in case pressure testing is required
9. Spare part kits-for compressors, evaporative condensers, pumps, air coolers etc.
10. Spare mercury in glass thermometer and pressure gauge
11. Refrigerant recovery equipment
12. Vacuum pump

21

Maintenance Tools

13. Weighing scales
14. Torch to enter dark areas
15. Thermography camera- (can be rented in case insulation leak is suspected)
16. All personal safety equipment such as goggles, non-slippery shoes with hard toe, hard hat, protective dress, gloves etc.
17. Ventilation fans in the plant room should be provided based on 2cfm/ft^2. running continuously. Such two fans should be provided and in case of accidental leaks both the fans should be activated so that the ammonia vapours are dispensed more effectively.
18. One bottle of boric acid and eye cup and one bottle of vinegar
19. A 100ft length of ½" diameter rope to tie a person entering in high refrigerant concentration area
20. Sulphur dioxide/hydrochloric acids to detect ammonia leaks
21. Emergency Alarm/Hooter to be provided in the plant room
22. Emergency eye wash basin and body shower facility readily accessible in the machine room must be provided.

22

Emergency Electrical Trip switch





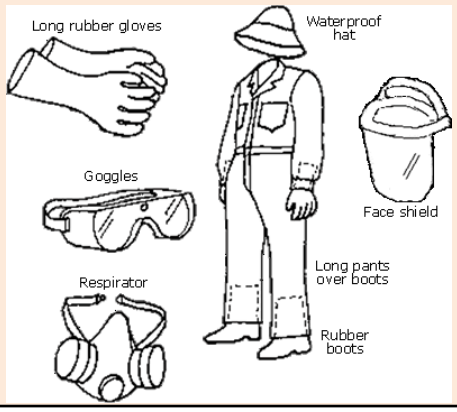
23

Eye Wash



24

Safety Accessories

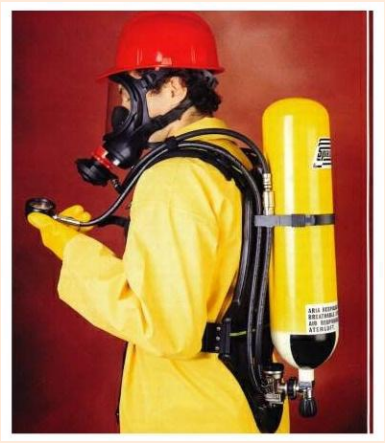


25



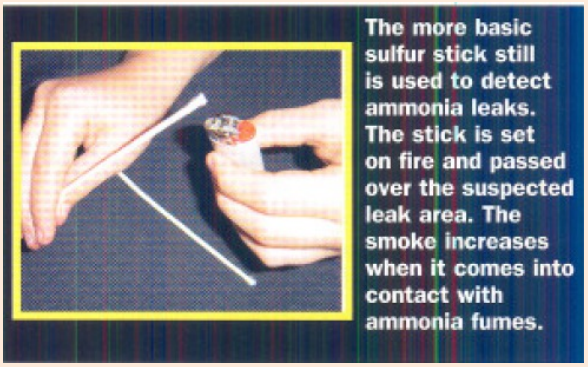
FACE MASK

26



AMMONIA SUIT

27



28

The Daily Maintenance Checks

1. All the compressors used should be checked for the oil leakage and proper oil level.
2. The refrigerant levels in the receiver/L. P. vessels, Interstage coolers should be checked as well.
3. The evaporators and drain pans in the cold room should be checked for ice formation.
4. The proper water/brine or cold room temperature and R.H. needs to be checked on a daily basis and maintenance of uniform temperature throughout the cold room should be ensured

29

Monthly Check Ups

1. Make sure that the fins of condenser coils are clean.
2. The evaporator and the fins of the cooler should be clean as well.
3. Make sure that the room is cooling perfectly when fully loaded.
4. Ensure that the levels of refrigerants are maintained properly.
5. The control valves are functioning efficiently.
6. The function of defrosting should work properly because defrosting is imperative to the efficiency of the negative temperature cold rooms.

30

Monthly Check ups

7. The evaporators should be clean and functioning efficiently to make sure that the temperature is maintained.

8. The casing of the evaporator should be cleaned along with the blower fans.

9. The temperature indicators should be calibrated.

10. Make sure there is no malfunctioning, perform a system functional test.

11. At least every month check, conditions of the belt, drive guards; abnormal vibrations, abnormal temperatures, smells, and leakage suspect points. The compressor inspection on the basis of hour runs, foundation bolts, shaft and floats should also be checked

31

Quarterly Check ups

- Perform all the monthly maintenance practices. They should not be ignored. If ignored they can lead to increase in the energy consumption and inefficient cooling.
- The overall functionality of the system should be tested & to make sure there are no leakages or damage to the cold room panels, doors etc.

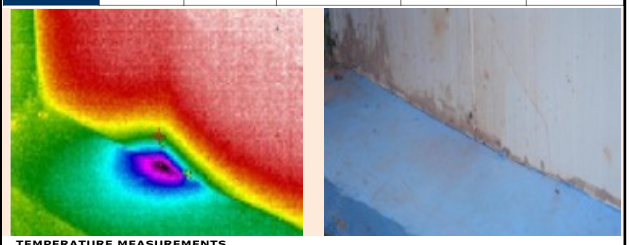
32

INSULATION LEAKAGE TEST-THRMOGRAPHY

33

SITE AND MEASURING PARAMETERS

OBJECT PARAMETER	LOCATION	DISTANCE	CONDITIONED PREMISE TEMP.	OUTSIDE AMBIENT TEMP.	EMISSIVITY
Value	Outdoor	05 FT	-21 C	23 C	0.95

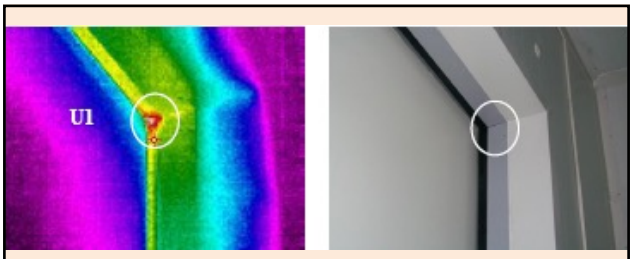


TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. DECREASED BY (AS PER MIN) (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	23	9.7	13.3	17.1	21.8

Recommended Action:
Temperature at highlighted area in the real image is 9 C less than the ambient outside temperature. A panel joint at bottom has not been done properly. By injecting silicon sealant at mentioned area will maintained the temperature.

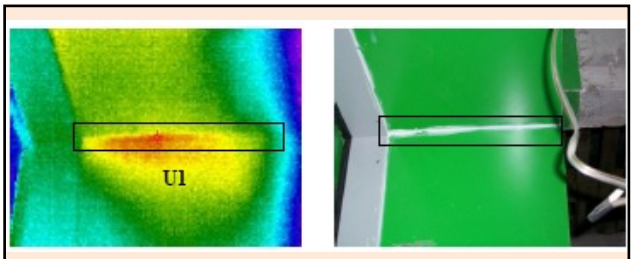
34



TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. INCREASED BY (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	0	10	2.2	5.8	10.0

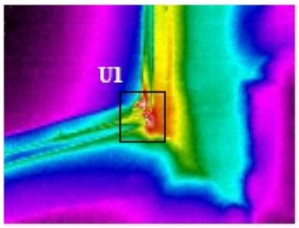
35



TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. INCREASED BY (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	5	7.9	8.8	11.4	12.9

36





TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE	TEMP. INCREASED BY	OUTLINED AREA TEMP.		
	(°C)	(°C)	MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	0	21.4	7.2	15.6	21.4

37

Annual Maintenance Practices

1. The daily, monthly and the quarterly maintenance checks should be carried out without any exception.

2. By carrying out all the maintenance steps mentioned above, the efficient functionality of the room can be ensured.

3. The heat exchangers should be washed chemically. This will help in removing any impurities which may become a hindrance in the efficient functionality of the room.

4. The reciprocating compressors should be opened one by one and clearances checked to ensure that they are within condemning limits. If not replace the part.

38

RECIPROCATING COMPRESSORS

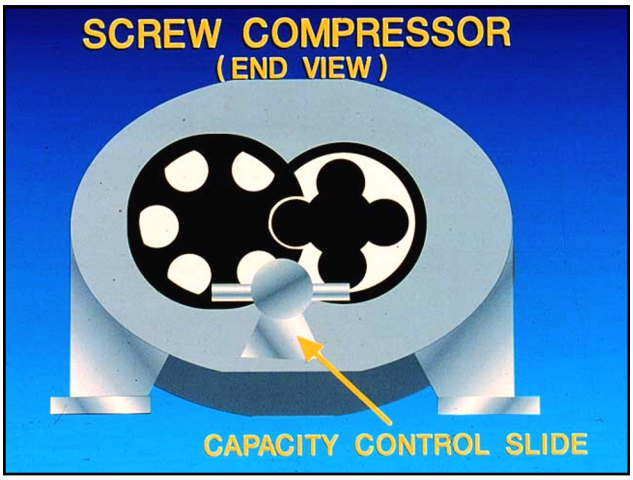


39

Reciprocating Compressor Maintenance

1. Visually check abnormal noise and vibrations
2. Perform oil analysis
3. Inspect refrigerant lines
4. Grease motor bearings
5. Keep terminal boxes free from moisture and dirt
6. Check and Calibrate pressure and temperature sensors
7. Inspect oil lines
8. Lubricate valve stems
9. Check tightness of foundation bolts for compressor and motor
10. Check 'V' belt tightness
11. Replace oil filters if necessary

40



41

Screw Compressor Maintenance

1. Visually check seal oil
2. Check oil levels in oil separators,
3. Adjust loading/unloading solenoid valve if necessary
4. Check oil pressure regulator
5. Perform vibration check and analysis if necessary
6. Perform oil analysis
7. Calibrate pressure and temperature sensors
8. Replace oil filters if necessary
9. Grease motor bearings
10. Clean oil pump suction strainer
11. Check operation of oil heaters if installed
12. Check tightness of motor anchor and compressor package foundation bolts
13. Check compressor –motor alignment if necessary
14. Replace/calibrate safety valves on a frequency as per good engineering practices

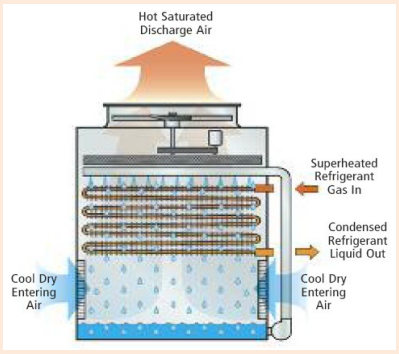
42

Pressure Vessel maintenance

1. While the system is operational external appearance of the surface of vessels or heat exchangers, insulation conditions shall be visually inspected weekly by staff for any abnormal observations. Liquid level gauges to be inspected & oil built up drained if necessary.
2. Oil addition / drained oil quantities to be recorded.
3. Quality of oil, for impurities, contamination & deterioration should be checked periodically which helps in a long way in troubleshooting & preventive maintenance analysis.
4. Cooling coils & defrost water drains should be examined weekly for excessive frost build up & defrosted as necessary. System should be purged for non-condensable if necessary.
5. Accumulation of water on the low side to be checked & water removed as required.
6. Finned heat exchangers should be inspected monthly for possible dirt or contamination on tubes & fins & cleaned as appropriate. Defrost elements should be tested electrically for correct operation.
7. Every six months the fan impeller should be checked for corrosion & cracks. Correct direction of airflow & rotation should be confirmed after every disconnection from power supply

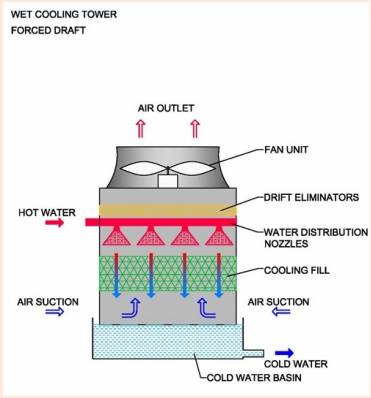
43

Evaporative Condensers



44

Cooling Tower



45

Cooling tower/Evaporative condenser Maintenance

1. Weekly, clean pan strainers & ensure adequate bleed off & proper operation of bleed off valve. The bleed should be equal to 0.03gpm per ton of refrigeration. This will vary depending on the quality of makeup water. Tank water concentration, should be checked
2. Check water distribution system, drift eliminators, float valve adjustment, fan belt tension, dirt & debris etc.
3. Clean all debris from the cooling tower every day.
4. The strainer on the pump suction line should be removed and cleaned every week or as often as necessary to keep it clean.
5. Before working on the unit, switch off and lock out the motor & pump.
6. The basin should be flushed out weekly or as often as necessary to prevent an accumulation of dirt and debris
7. The makeup valve must be checked every day to ensure the valve is functioning and set properly
8. The pump and pump motor should be lubricated monthly.
9. The water distribution system should be checked weekly for proper operation. Always check the water distribution system with the pump on and the fans off.

46

PHE Semi Welded Condenser



47

Plate heat Exchanger Maintenance

1. Back wash the PHE during defrosting or freezing for 30 minutes every day.
2. Cold store's PHE back washing to be done once a week.
3. Clean the Plate heat exchangers every quarterly by opening to clear fouling,
4. After opening, clean the plates with a soft brush and running water. Take care of gaskets to avoid any damages.
5. Clean with high pressure & then chemical cleaning using Sulfamic acid max 4% concentration at max 60^0C temperature. Do not use Hydrochloric acid with Stainless Steel plates.
6. Replace the damaged gaskets.

48

SHELL AND TUBE CONDENSER



49

Shell & Tube Condensers Maintenance

1. Quarterly clean the tubes of condenser by scrubbing.
2. Renew the gaskets.
3. Inspect for tube leakages and rectify

50

Ammonia Pump maintenance

1. Check for abnormal vibration or noise
2. Check pump oil level wherever applicable
3. Test and rotate standby pump
4. Check the operation of pump differential switch
5. Drain oil from pump low point
6. Examine pump exterior and adjacent lines for damage or corrosion
7. Verify minimum flow orifices and regulators are open and properly adjusted
8. Rotate working and standby pump one in six months to ensure equal number of hours running of each pump

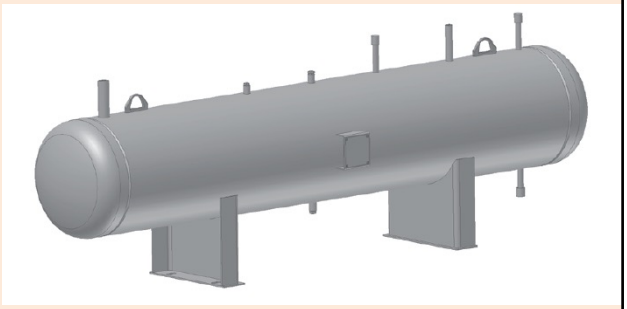
51

Water Pump Maintenance

1. Check daily the water pumps for any abnormal sound
2. Check for water leakages through glands. Tighten or renew the gland packing
3. Weekly measure the current (RYB) and report any abnormalities
4. Check water pump discharge pressure and clean water strainers

52

HIGH PRESSURE AMMONIA LIQUID STORAGE RECEIVERS



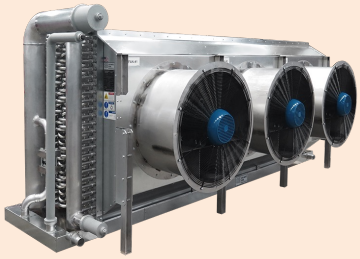
53

High pressure Receiver maintenance

1. Check the functioning of the pressure gauge every shift
2. Check and rectify leakages through the valves
3. Always cap the vent lines.
4. Check ammonia level and ensure that it is adequate-say 50 % minimum when plant is not operating and 20% minimum when plant is operating and 80% maximum when entire charge is pumped down in the receiver.

54

EVAPORATORS



55

Evaporator-Air Cooler Maintenance

1. Perform visual check of coil and fins and fans
2. Inspect evaporator outdoor piping and valve stations
3. Drain oil from evaporator wherever applicable
4. Periodically review defrost schedules to determine if the length of time between defrost can be increased to save energy
5. Check air temperature differential across coil
6. Check and clean coils and pans for excessive dirt
7. Check evaporator supports, motor mounts, fans and guards

56

Validation of Safety Interlocks

1. H.P. cut off While running the compressor, close the compressor discharge valve, and check the compressor is tripping at 16-17 bara, and record.
2. L.P. cut off While running the compressor, close the suction valve, check the compressor is tripping at – 0.3 bara, and record
3. Intermediate cut off While the compressor is running, close the intermediate discharge valve, check the compressor is tripped above 4 bara.
4. O.P. cut off Start the compressor with low oil level than required, the compressor should trip within a minute.
5. Interlock with cooling tower fan and pump – start up
   Start the compressor after starting the pump and cooling tower fan. The compressor should not start first.
6. Interlock with cooling tower fan and pump – while running, the compressor manually, stop the supply to the pump by switching off the MCB. The compressor should trip

57

General Maintenance Suggestions

1. Check regulating devices. Correct function and set points
2. Avoid water in the system. Max 1-2% in the ammonia is acceptable (per. 2% vol. water the suction pressure rises with approx. 0.5°C).
3. Avoid non-condensable gasses in the system (condenser and receiver). Prefer an automatic airpurger to manual purging
4. Regular oil draining from the system.
5. Keep a log book (operation conditions, maintenance, malfunctioning, operating hours for compressors, oil- and refrigerant account, etc.)
6. Provide automatic monitoring of operating conditions
7. Implement maintenance schedules
8. Keep documentation and item lists updated (year, maintenance intervals, last repaired, etc.)
9. Drain oil from the system on a regular basis and have the oil analyzed

58

Water Dehydrator



59

Air Purger



60

Piping Colour Code

61

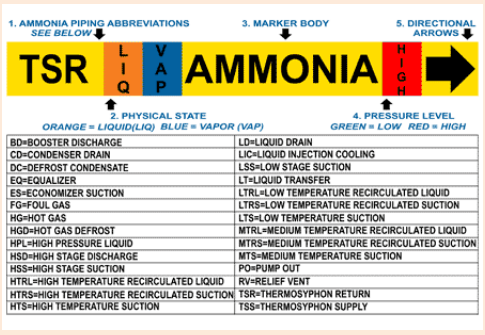
REFRIGERANT PIPING COLOR CODE

SR.NO.	DESCRIPTION	SCOPE	COLOUR CODE
1	HP Hot gas	High Stage Discharge	Red
		Booster Discharge	
2	HP liquid refrigerant	Receiver to Economizer	Orange
		Economizer to Intercooler	
3	LP liquid refrigerant	Intercooler to LP Vessel	Light green
4	LP refrigerant vapor	High Stage Suction	Dark green
		Booster Suction	
5	Liquid/vapor mixture of refrigerant		Purple
6	Oil Circuit	Both Booster & High Stage	Black

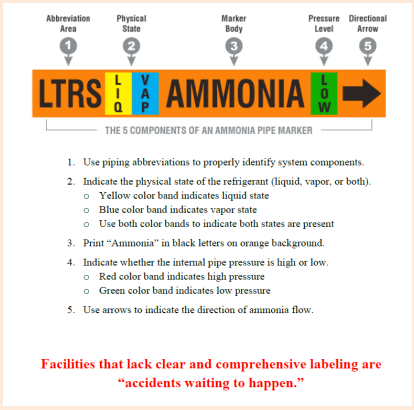
62



63



64



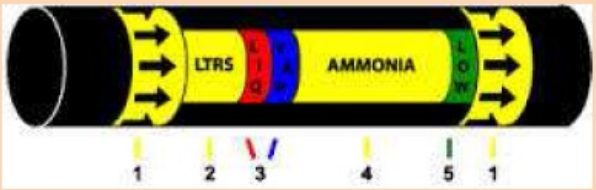
1. Use piping abbreviations to properly identify system components.
2. Indicate the physical state of the refrigerant (liquid, vapor, or both).
   - Yellow color band indicates liquid state
   - Blue color band indicates vapor state
   - Use both color bands to indicate both states are present
3. Print "Ammonia" in black letters on orange background.
4. Indicate whether the internal pipe pressure is high or low.
   - Red color band indicates high pressure
   - Green color band indicates low pressure
5. Use arrows to indicate the direction of ammonia flow.

Facilities that lack clear and comprehensive labeling are "accidents waiting to happen."

65



66



67

Log Book Maintenance

Date	
Ambient Temperature-^{0}C	
Time of starting of plant	
Total running hours of plant	
Total production if process plant-like blast freezers, IQF, Plate freezers etc.	
Compressor Discharge pressure-kg/cm2	
Compressor Discharge temperature-^{0}C	
Compressor suction pressure-kg/cm2	
Compressor suction temperature-^{0}C	
Compressor oil level	
Oil temperature in case screw compressor-^{0}C	
Compressor –Amps (current/power consumption)	
Cooling water temperature-condenser inlet	
Cooling water temperature-condenser outlet (Tank temperature -^{0}C, in case evaporative condenser)	

68

Log Book Maintenance

Make up water temperature-^{0}C in case evaporative condenser	
Ammonia temperature in LP vessel-^{0}C	
Ammonia temperature at air cooler /equipment inlet-^{0}C	
Room Temperature in case cold room, blast Freezers-^{0}C	
Defrost Frequency and defrosting time	
Brine inlet/outlet or chilled water inlet/outlet temperatures for process plants-^{0}C	
Quantity of oil removed/charged-CC	
Any abnormal observation-Noise, smell, oil patches etc.	

69

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

70

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 & Pressure Vessel Drawings with the Manager

71

Conclusion

A well maintained plant would lead to reduction of MTBF (Mean Time Between Failure)

& would give owner maximum output at minimum operating/maintaining cost

with at least 15 to 20% energy Saving.

72

THANK YOU
Questions?

Ramesh Paranjpey
Fellow Life member ASHRAE
ramesh.paranjpey@gmail.com
Cell No. 9822398220
Web: http://ramesh-paranjpey.com

73