AMMONIA REFRIGERATION SYSTEM OPERATION AND MAINTENANCE

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BRIEF ON OPERATION

- Operation of the plant in Refrigeration system play very **Important Role** on the performance of the refrigeration system.
- There are many factors which affect the performance of vapour compression refrigeration system such as :
  Ambient temp.,
  Dry bulb Temp.
  Various pressures and temperatures,
  Super heating
  Presence of non condensable gases,
  Presence of moisture/water
- It is necessary that to know the effect of the variations to enable to **protect and operate** the refrigeration system efficiently.

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EFFICIENT PLANT OPERATION

- Maintaining Proper system pressures are important for efficient plant operation
- Try to keep **discharge pressure as low as possible** .
- Do operate the compressor at **highest possible suction pressure**.
- Maintain **Superheat** and **TD as per design .**
- **Capacity control to match load at** various conditions such as loading, pull down, holding, ambient temperature etc. can be connected to suction pressure control.

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

°C	Bar g	PSI g	°C	Bar g	PSI g
-50	-0.59	-8.41	2	3.62	51.55
-40	-0.28	-4.03	4	3.97	56.53
-38	-0.20	-2.89	6	4.35	61.80
-36	-0.12	-1.64	8	4.74	67.38
-34	-0.02	-0.29	10	5.15	73.26
-33.33b	0.01	0.19	12	5.59	79.46
-32	0.08	1.17	14	6.05	86.00
-30	0.19	2.76	16	6.53	92.88
-28	0.32	4.48	18	7.04	100.12
-26	0.45	6.34	20	7.57	107.74
-24	0.59	8.34	22	8.14	115.73
-22	0.74	10.50	24	8.73	124.12
-20	0.90	12.81	26	9.35	132.92
-18	1.08	15.30	28	9.99	142.13
-16	1.26	17.96	30	10.67	151.79
-14	1.46	20.82	32	11.38	161.89
-12	1.68	23.87	34	12.12	172.44
-10	1.91	27.13	36	12.90	183.48
-8	2.15	30.60	38	13.71	194.99
-6	2.41	34.30	40	14.55	207.01
-4	2.69	38.23	42	15.44	219.54
-2	2.98	42.41	44	16.35	232.59
0	3.29	46.85	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*

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EFFICIENT PLANT OPERATION

General guidelines to record maintain log book

*** Compressors**

Date	Time	Parameter	Comp.1	Comp.2	Comp.3	Signature
		Suction Pressure				
		Discharge Pressure				
		Oil Pressure.				
		Intermediate Pressure.				
		Oil Level				
		Amount of oil added/removed				
		Motor Amps				
		Running Hours				
		Remarks				

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EFFICIENT PLANT OPERATION

General guidelines to record maintain log book

*** Cooling Towers / Shell and Tube Condensers & Water pumps**

Date	Time	Parameter	Pump1	Pump2	Cooling Tower 1	Cooling Tower 2
		Water inlet Pressure.				
		Water outlet Pressure.				
		Water inlet temperature.				
		Water outlet temperature.				
		Pump out let Pressure.				
		Pump Amps.				
		CT Fan Amps				

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EFFICIENT PLANT OPERATION

General guidelines to record maintain log book

Evaporative Condensers

Date	Time	Parameter	EC1	EC2
		Ammonia inlet Pressure.		
		Liquid Outlet Temperature.		
		Fan Amps		

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EFFICIENT PLANT OPERATION

General guidelines to record maintain log book

*** Receivers**

Date	Parameter	Receiver 1	Receiver2
	Liquid Level		
	Oil drain-Quantity		
	Receiver Pressure		

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EFFICIENT PLANT OPERATION

General guidelines to record maintain log book

*** Air Cooling Units/Plate Freezers/IQF**

Date	Time	Parameter	Freezer1	Freezer2	Plate F1	Plate F2	IQF
		Ammonia Inlet Pr.					
		Inlet temp.					
		Ammonia Out let pr.					
		Outlet temp.					
		Fan Amps					
		Product loading temp.					
		Product weight/batch- kg					
		No of batches per day					
		Production/day					
		Defrost time at end of freezing cycle					

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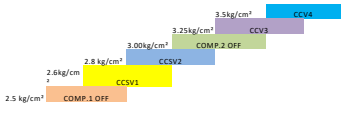
EFFICIENT PLANT OPERATION

- **Cylinders unloading :**

  Reciprocating compressors: step-by-step through cylinder unloading .

  This can be achieved by **Suction Pressure control** with automatic comp. capacity controller.

  Needs study of cooling load pattern during pull down, maintaining the room temp., loading and unloading of (Product) , Ambient temp., etc.



- **Speed control:**

  By providing Variable Frequency Drive (VFD) compressor can run within allowable speed limits at 100% load. Ensure that lubrication system is not affected .

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AUTOMIZATION OF AMMONIA REF. PLANTS

- Compressor Controllers / RMS
- Automatic Temp. Recorders
- Automatic Hot Gas Defrost
- SCADA
- **5 % to 25%** Savings in power depending upon the application.

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CASE STUDY – ENERGY SAVINGS BY CONTROLING OPERATION ACCORDING TO LOAD REQUIREMENT

	CCSV	AMPS	RUNNING HRS	Total AMPS	CCSV saving hrs	AMP saving
Direct	Direct	65	21	1365	NIL	NIL
50%	CCSV1	70	21	1470	NIL	NIL
75%	CCSV2	75	21	1575	NIL	NIL
100%	CCSV3	**95**	**16**	1520	**5**	**100**
POWER CONSUMPTION (watts)	57436	POWER (KW)	57.436	TARIFF (8.5rs /KW)	488.206	
Monthly saving (Rs)	14646.18	Annual savings (Rs)	175754.16			

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PRECAUTIONS : OIL

- Periodically checking of **Oil for its properties** as per Manufacturer' recommendations.
- Use **Demister Pad** type oil separators to prevent higher oil throw .
- Using **wrong grade** of lube oil will **cause failure** of Compressor.
- **Mixing of different brands of oil** will cause failure of compressor.
- **Foreign particle** containment will damage Compressor.
- **Reuse** of drained oil to be **avoided** totally.
- **Oil must be replaced completely** on getting **Ammonia Liquid** in the compressor crankcase

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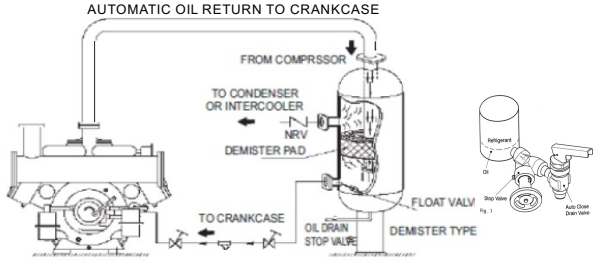
PRECAUTIONS : OIL

AUTOMATIC OIL RETURN TO CRANKCASE



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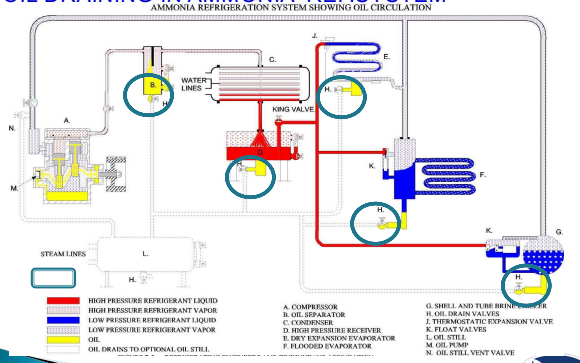
OIL DRAINING IN AMMONIA REF.SYSTEM

AMMONIA REFRIGERATION SYSTEM SHOWING OIL CIRCULATION



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PRECAUTIONS : WATER

Permissible Values of Water Analysis

Note : Follow Manufacturers Guidelines

Parameter	Make-up water	Circulating water
PH (25°C)	6 to 8	6 to 8
Total hardness ($CaCO_3$) ppm	50 below	200 below
M alkalinity ($CaCO_3$) ppm	50 below	100 below
Chlorine ion (Cl) ppm	50 below	200 below
Sulphuric acid ion (SO_4) ppm	50 below	200 below
Silicic acid (SiO_2) ppm	30 below	50 below
Ferric (Fe) ppm	0.3 below	1.0 below

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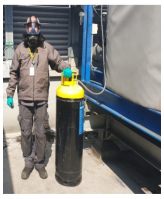
CARE DURING AMMONIA CHARGING

- **PPE** ,Hand Gloves, Safety Goggles, Safety shoes and Water Source Handy.
- Cylinder Should be properly **supported** .
- Ensure Liquid Ammonia is not **trapped** between Isolating valves
- Ensure No leakage at Charging Hose or its **connections/fittings.**
- Ammonia Level in working condition Receiver : Min 20% should not exceed 80-85% when stopped.
- Do not Open Low pressure valve when the system is being charged with **Liquid Refrigerant**



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AMMONIA PURITY REQUIREMENT

Specification

Allowable water content for closed loop ammonia refrigeration systems is
*"**Refrigerant-grade anhydrous ammonia**"*

Purity Requirement	
Grade	Refrigerant-Grade
Ammonia content	**99.95%** *Minimum*
Water	**33 PPM** *Maximum*

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EFFICIENT PLANT OPERATION

Effect of lower Evaporating Temp.

Evaporator Temperature (°C)	Corresponding Ammonia Pressure kg/cm² g	Refrigeration Capacity TR (kW)	bkW (Power Consumption)	Specific Power Consumption (kW/TR)	Increase in kW/TR (%)
5.0	4.23	90.55 (318.46)	51.38	0.56	-
0.0	3.35	73.86 (259.76)	49.95	0.68	**17.64**
-5.0	2.59	59.62(209.68)	47.68	0.80	**30.00**
-10.0	1.94	42.25(148.59)	44.70	1.06	**47.16**

***Reciprocating compressor using Ammonia refrigerant. Condensing temperature.+35 °C**

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REASON/S FOR LOW SUCTION PRESSURE

- Suction Stop Valve **Not open** enough
- **Low Airflow** across ACU/Low Water /brine flow across Evaporator / Chiller .
- Restriction in **Liquid Line.**
- Expansion Valve **Not Opened** wide Enough.
- **Oil Accumulated** in Evaporator.
- **Less** Refrigerant Charge.
- Suction Strainer Of Compressor **Chocked.**

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EFFICIENT PLANT OPERATION

Effect of higher condensation pressure

Condensing Temperature (°C)	Corresponding Ammonia Pressure kg/cm²	Refrigeration Capacity TR (kW)	bkW (Power Consumption) kW	Specific Power Consumption (kW /TR)	Increase kW/TR (%)
25	09.19	65.10 (228.9)	38.48	0.59	-
30	10.86	62.43 (219.57)	43.20	0.69	14.49
35	12.73	59.62 (209.68)	47.78	0.80	26.25
40	14.82	56.72 (199.48)	52.20	0.92	35.87

***Reciprocating compressor using Ammonia refrigerant. Evaporator temperature. - 5° C**

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REASON/S FOR HIGH DISCHARGE PRESSURE

- Delivery Stop Valve Not Opened Enough
- Low Water Flow Through Condenser
- Cooling Tower Fan Not Working.
- Overcharging
- Condenser Tubes Blocked or Dirty.
- Air/ Non Condensable in the system.

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EFFICIENT PLANT OPERATION

Effect of Excessive Superheat on Refrigeration Capacity

Superheat K	Capacity TR	% in Reduction in capacity
0	118.88	-
5	115.97	2.36%
10	113.29	4.9 %

Compressor +40 °C Condensing/+5°C Evaporating Ammonia Refrigerant

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BASIC SYMPTOM ANALYSIS

System Problem	Discharge Pressure	Suction Pressure	Super Heat	Sub Cooling	AMPS
Overcharge	▲	▲	▼	▲	▲
Undercharge	▼	▼	▲	▼	▼
Liquid Restriction	▼	▼	▲	▲	▼
Low Evaporator Airflow	▼	▼	▼	▲	▼
Dirty Condenser	▲	▲	▼	▼	▲
Low Outside Ambient Temp.	▼	▼	▲	▲	▼
Inefficient Compressor	▼	▲	▲	▲	▼

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ROUTINE MAINTENANCE

Many things occur in a plant that appear to be **small and insignificant**, yet soon grow into serious troubles, resulting in expenditure, loss of time, dislocation and lots of extra work usually at **most inconvenient time**.

Periodical checking and servicing helps in anticipating troubles and taking corrective action.

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EFFICIENT PLANT MAINTENANCE

Preventive Maintenance :

- Prepare **Annual Maintenance Schedule** and Strictly follow.
- Maintain **History** of **Parts replaced** with dates and reason for replacem
- Keep record of oil **topping up** and oil **replacement** into compressor/s
- Check **alignment** of compressor and motor.
- Maintain Correct **Belt Tension**.
- **Drain oil** from evaporators / accumulators/Receivers etc..
- Keep all valve stems **clean and oiled**.
- Periodically check the Tightness of the **Foundation Bolts.**
- Monitor **Vibrations** of the Compressor and Motor.

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EFFICIENT PLANT MAINTENANCE

Preventive Maintenance Practices Continued :

- System should be **purged** for non condensable if present in system.
- Any **pipe or shell vessel** showing **rust** should be cleaned & **painted.**
- Repair **insulation** as required.
- **Defrost** before excessive accumulation & do not remove frost by hammering.
- **Bleed off** continuously from cooling water tank at **least equal to evaporation rate.**
- **Colour coding** of pipes, **flow direction** arrows & **valve position** indication (either open or close) is desirable

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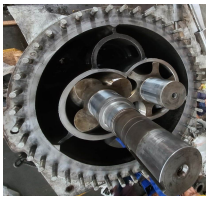
ROUTINE MAINTENANCE - SCREW COMPRESSORS

- Check and Maintain the oil level in the **Oil Tank Separator** as per set point.
- Ensure safety of **pressure drop across the oil Filters** working.
- Check **Oil Filters Condition.**
- Inspect **Shaft seal** for Oil Leakage .
- **Annual Inspection**
- **Vibrations** to be monitored
- **Alignmen**t to be checked .

As per Manufacturer's Guidelines.



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USE ONLY GENIUNE PARTS

- To increase the life of the compressor.
- To get the desired capacity.
- To reduce power consumption.
- To reduce down time.
- To save the cost on repetitive labor and spare parts.
- To avoid damage to compressor or other components.
- Easy and Accurate Fittings and Avoiding Hassles.
- Overall to have peace of mind in life.

Genuine

Non Genuine

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ROUTINE MAINTENANCE - MOTORS

- Motor should be kept **clean & free from Oil, dust & moisture**.
- Care should be taken to see the **ventilation passages** are not blocked.
- The **earthing conductor** should be checked **weekly** for continuity.
- The **insulation** resistance of stator & rotor windings should be checked regularly between respective terminal & the frame.
- **Lubrication** shall be done regularly as per lubrication schedule.
- **Vibrations** Monitoring .
- **Bearing temp**. Monitoring.
- **Winding temp**. Monitoring

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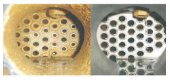
ROUTINE MAINTENANCE -Condensers

ATMOSPHERIC CONDENSER CLEANING:

- Stop the plant and then Water Pump.
- Remove algae formed over condenser pipes .
- Clean the pipes O.D. by Hand brushing the outside surface.
- Flush water over the pipes to remove the residues removed by brushing.

- For Shell and Tube Condensers, Normally dilute **Sulphuric Acid (5 to 7 % solutions)** at 55 to 60 Deg C is circulated on the tube side of condenser for two hours followed by circulation of Caustic for neutralizing the effect of Acid.



- Note : **0.55°C** reduction in returning water from cooling tower means **3.0 %** reduced power

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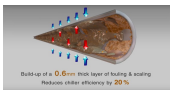
ROUTINE MAINTENANCE - S&T CONDENSERS AND CHILLERS

AUTOMATIC TUBE CLEANING SYSTEMS

- The sponge balls are injected into the cooling water inlet line and are circulated through the condenser tubes by the cooling water flow.
- **Accumulation of deposits in the condenser tube** is prevented by shear forces between the ball and tube wall and the **wiping action** of the cleaning balls.



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ROUTINE MAINTENANCE -PHEs

- **Back wash** the PHE during defrosting of freezing for 30 minutes every day.
- **Clean** the Plate heat exchangers **quarterly** by opening to clear fouling,
- After opening, **clean** the plates with **soft brush** and running water. Take care of gaskets to avoid any damages.
- **Clean** with **high pressure** &Then chemical cleaning using **Sulfamic acid max 4%** concentration at max 60 Deg C temp.
- Replace the **damaged gaskets**.

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ROUTINE MAINTENANCE - ACUS/FCUS

- **Oil to be drained** from Accumulators on regular intervals and recorded in logbook.
- **Finned heat exchang**ers should be inspected monthly for possible dirt or contamination on tubes and fins.
- **Fan impeller** should be checked for corrosion and cracks.

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PREVENTIVE CARE - REFRIGERANT PIPING

- Ensure **Supports** be provided for piping to avoid vibrations and in turn leakages,
- Inspection of pipes for **corrosio**n needs to be carried out to avoid leakage/accident.
- Never **Stand** on the Pipes .
- Mark Flow directional **Arrows** .

- Rust on Pipes must be cleaned and pipe should be **painted .**

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ROUTINE MAINTENANCE – Safety switches and Interlocks

- **Validation of Safety interlocks – Fortnightly** in presence of concerned Officer/Manager
- 1. **HP** cut off
- 2. **LP** cut off
- 3. **Intermediate** cut off
- 4. **OP** cut off
- 5. **Interlock** with cooling tower fan and pump – start up
- 6. **Interlock** with cooling tower fan and pump – while running

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EFFECT OF POOR MAINTENANCE PRACTICES

- Effect on down time cost.
- Reduction in overall plant efficiency.
- Safety of operator & machineries will be at risk.
- Higher power consumption.
- Reduction in life of machineries/equipments.
- Unstable System operation.

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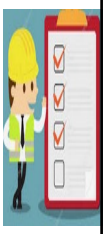
DO AND DON'T

Do

- **Do STUDY** the equipment **manuals** in detail.
- **Do ASCERTAIN** what **tools & equipments** are required to carry out the job.
- **Do USE proper tools** to suit the job. Avoid unnecessary Dismantling.
- **Do ENSURE** that all nuts, screws, pipe connections, electrical cable connections & covers are properly tightened.
- **DO inspect all filters** on pumps. Replace if dirty or clogged.
- **Do ENSURE** sufficient & recommended grade of **lube oil** for compressor.
- **Do DRAIN condensates** from all manual drain points.



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DO AND DON'TS

Do (Continue....)

- **DO keep** other people clear of the compressor before starting it and during operation.
- **DO ensure** all equipment **drains** are properly closed
- **Do check** the **vibration** levels and reduce it to minimum possible.
- **Do check** the **Ammonia leakage** in the plant with the help of leak detector or by sulphur stick.

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DO AND DON'TS

Don't

- **Do NOT ATTEND** the unit when the unit is in operation.
- **Do NOT ATTEMPT** to start the unit unless fault is rectified.
- **Do NOT CHANGE** the settings of any for the instruments.
- **Do NOT ATTEMPT** to carry out maintenance/service operation on the equipments unless the system is depressurised.
- **DON'T smoke** or have an open flame in the area when charging refrigerant.
- **Do NOT FLARE** Ammonia in open air.
- **Do NOT DRAIN & DISPOSE** oil in open space.

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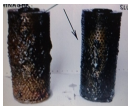
TROUBLE SHOOTING

- Majority of Compressor Failures were analysed and noted that most of the complaints are related to following :
- Liquid Flood Back - Abnormal Noise, Low Oil pressure, Loading Unloading.
- Contamination - Low Oil Pressure, Shaft Seal Leakage.
- Overheating - Abnormal sound , Low Oil Pressure ,Higher Cylinder Temperature.



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FEW ENERGY SAVINGS TIPS

- Reduce the air infiltration by using **automatic doors, air curtains, strip curtains, fast closing doors etc.**
- Use Evaporators and Condensers with **Larger heat transfer area** to reduce specific power consumption.
- Operate at **Highest acceptable** temperature.
- Check whether the **Refrigeration capacity** matches the load. Larger capacity machine will not operate as efficiently as properly loaded.
- Explore **Variable Speed** operation of Compressor and other motors.

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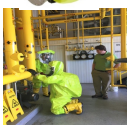
SAFETY

- Conduct Mock Drill.
- Easily accessible shower .
- Refrigeration plant room should have safety instruments.
- **PPE ,Mask, Hand gloves, Safety Goggles, Safety Shoes/Gumboots** must be used while doing maintenance as well as while attending leaks.
- Use aeration & washing with water for removing Ammonia fumes.
- Keep **all equipment clean** & machinery room clean, putting oily rags in fire proof containers



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Association of AMMONIA REFRIGERATION

THANK YOU

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