Association of AMMONIA REFRIGERATION

Advantage Ammonia Webinar
8th July 2025

Harmful Effects Water, Oil & Dirt in Ammonia refrigeration system

by
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MANIK ENGINEERS INDIA

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Association of AMMONIA REFRIGERATION

ASSOCIATION OF AMMONIA REFRIGERATION
Presents
ADVANTAGE AMMONIA WEBINAR SERIES 1 : 2025-26

8th JULY 2025
Tuesday, 4 pm to 5 pm

Harmful effects of Water, Dirt and Oil in an Ammonia Refrigeration System

Speaker : Mr Anand Joshi Manik Engineers, India

Mr. Anand Joshi is an Engineer from Bharati Vidyapeeth - College of Engineering - Industrial Electronics Instrumentation. He is a Partner in Manik Engineers a Very Famous Brand in Refrigeration Controls. He is Pioneer in Many Cost Effective Refrigeration Plant Control Solutions. With his vast experience of 35 years, we have generated different products and solutions for energy optimization conservation.

He is Past President Association of Ammonia Refrigeration, Past President - ISHRAE Pune Chapter, He is also member of ASHRAE, Indo-German Chamber of Commerce, Indian Institute of Electronic and Telecommunication Engineers, Indian Dairy Association and RATA.

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For participation please contact:
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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

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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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What is contamination ?

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

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Contamination: which affect performance of refrigeration plant

1. Water
2. Oil
3. Dirt / Rust
4. Non-condensable gases (Air)

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Ammonia-water Relationship

- Ammonia and water have a great affinity for each other.
- Water Contamination is very Commonly observed due to Solubility of Ammonia in Water
- As the temperature of the solution is lowered, the ability to absorb ammonia increases.

Ammonia Temperature in Deg C	Maximum water absorption capacity % by weight
30	30
0	46.5
-33	100

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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

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Ammonia-water Relationship
Solubility Of Ammonia With Water

% Dilution	Saturated Suction Temperature at		
	-0.3 Kg/ cm^2 g	0 Kg/ cm^2 g	2.0 Kg/ cm^2 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

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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.

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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.

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Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- The use of non-anhydrous ammonia when charging the system.
- 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.

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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

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Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

Ammonia is Hygroscopic in Nature, hence it attracts moisture

Inadequate or no purging
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

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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.

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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

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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.

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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/cm² as compared to 0.007 Kg/cm² 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 (ºC)	Pressure (kPa)	
	Water	Ammonia
0	0.61	329
5	0.87	415
10	1.23	515
15	1.71	629

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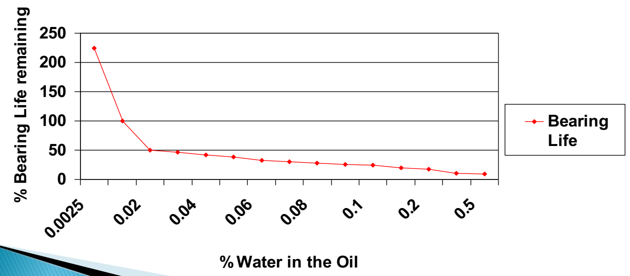
EFFECT OF WATER ON BEARING LIFE

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



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Effects of Water Contamination Compressor





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Effects of Water Contamination Compressor Oil

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Effects of Water Contamination valves chocking, slug in compressor

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

23

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

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

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

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

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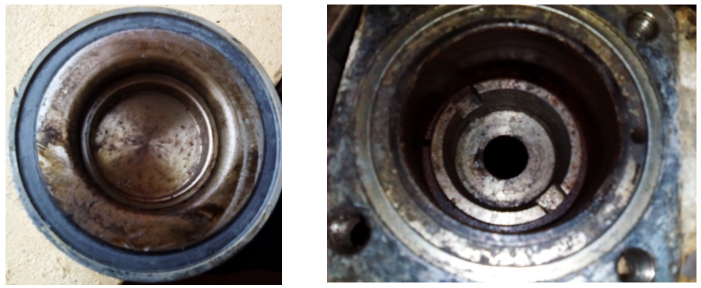
Effects of Water Contamination valves chocking, slug, rusting inside control valve



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Water in Plant

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Cost of Water

Parameters	Compressor Type	
	Booster	Two Stage
Compressor Capacity	300 kW	300 kW
Condensing Temperature	-7°C	40°C
Evaporating Temperature	-40°C	-40°C
Power required	80.1 kW	171 kW
Evaporting Temperaure for 10% Water contaimination	-42°C	-42°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 effects such as increased wear & tear of compressor parts, oil, decrease in refrigeration capacity are to be added

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Oil in Ammonia refrigeration plant

Oil is a viscous liquid derived from petroleum, especially for use as a fuel or lubricant

Types of Oil

1. Vegetable Oil
2. Mineral Oil
3. Synthetic Oil

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Oil in Ammonia refrigeration plant

Oil is used in refrigeration plant for

- Reducing friction
- Cooling
- Sealing of clearances
- Reducing noise level
- Damping of energies / forces
- Cleaning / washing out debris, gum, metal particles and so on
- Reduce corrosion by avoiding exposure to atmosphere

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Lack/loss of Lubrication

- Major cause of compressor failure could be Loss or lack of lubrication, especially if we include flood back and flooded starts. Other causes of lack of lubrication could be as simple as not enough oil in the crankcase.
- During operation, always oil level should be visible in the crankcase
- Separate oil from ammonia in oil separator and returning to the compressor at the same rate that it left the compressor.

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Reasons for lack / loss of Lubrication

- Adequate oil level are not maintained in the compressor sump or in oil separator in case of screw compressor.
- Reasons for oil carryover in the system is that the oil separator malfunctions, worn out piston rings.
- Oil pump failure or dirty oil filters in the compressor

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Lack/loss of Lubrication

Due to loss of the oil film from cylinder liner, rubbing happens between piston rings and cylinder liner and cylinder liner dimeter increases.

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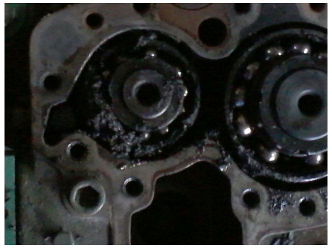
Lack/loss of Lubrication



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Over Heating

- If the heat Is high enough, the oil breaks down chemically.
- Compressors should operate within the safe limits of the discharge temperature.
- Oil and refrigerant break down In severe overheating and create CARBON and ACIDS, Which can cause harm throughout the entire system.

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Examples of Overheating

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Examples of Overheating

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Examples of Overheating

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PROBLEMS DUE TO OIL CARRYOVER

- Coats and congeals the exchanger surfaces leading to loss of capacity.
- Collects at lower points of vessels and heat exchangers
- Sticks to level indicators, instruments leads to malfunction and incorrect indication.
- Continuous oil monitoring and top-off
- Frequent oil draining
- Oil mixes with water and ammonia forms gums
- Loss of energy efficiency

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OIL CAN ACCUMULATE

- High Pressure Receivers
- Thermosyphon Receivers
- Intercoolers
- Pump Recirculator
- Float / Level Controller Column
- Strainers / Valves / Control Valves
- Level gauges

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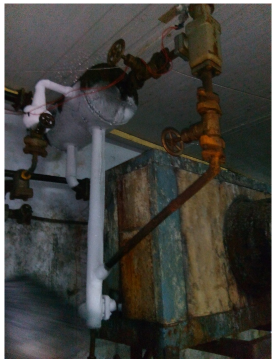
Oil Accumulation in Level / Float



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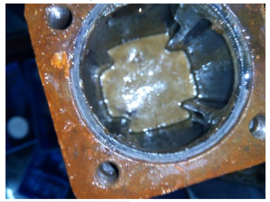
Oil Accumulation in Level / Float

- Plenty of oil was getting accumulated in ACU/ Freezer coils.
- Ammonia leakage during oil draining discouraging operators



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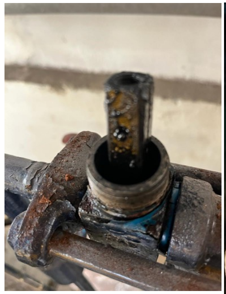
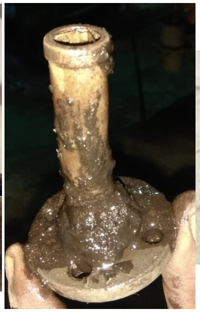
Oil Accumulation in Solenoid Valves & Filters with sludge





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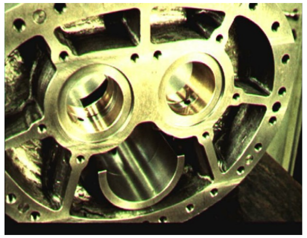
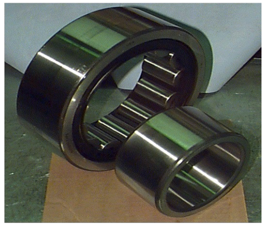
PROPERTIES OF LUBRICATING OIL

Bearing Life





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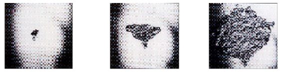
PROPERTIES OF LUBRICATING OIL

Bearing Life

- The life of a rolling bearing is defined as the number of operating hours which a bearing is capable of enduring before the first sign of fatigue, (flaking, spalling) occurs on one of its rings or rolling elements.
- First occurrence is defined as a 1mm square spall.



development of Fatigue Damage on a race

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PROPERTIES OF LUBRICATING OIL

Bearing Life

Surface fatigue failure

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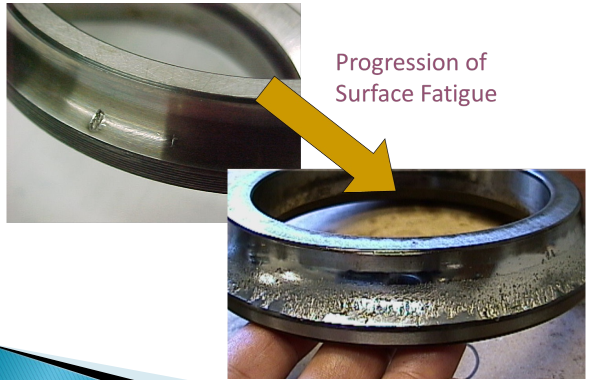
PROPERTIES OF LUBRICATING OIL

Bearing Life



Progression of Surface Fatigue

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MIXING OF OILS OF DIFFERENT GRADE

- Different manufacturers may use different additives for wear or anti-foam etc.
- These additives may not be compatible with the additives in the other oil.
- An example, One anti-wear additive may render another anti-foam additive useless.

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MIXING OF OILS OF DIFFERENT GRADE

Unusual failure mode caused by breakdown of oil additive reaction over time.

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MIXING OF OILS OF DIFFERENT GRADE

Don’t Mix Oils

Black deposits formed in oil system, wherever pressure drop occurred. Incompatible transformer oil from rotary vane compressor jacket mixed with ammonia. Resulted in compressor failures.

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Magic addivitives

Deposits on Coalescing Filters from
"Efficiency Improving Additives"

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Magic additives

Using "Magic Oil Additives" that promise great things is risky. Best oil in a refrigeration system is that recommended by the compressor manufacturer.

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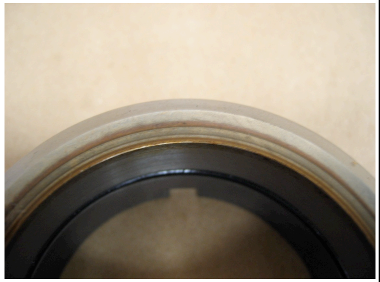
MIXING OF OILS OF DIFFERENT GRADE



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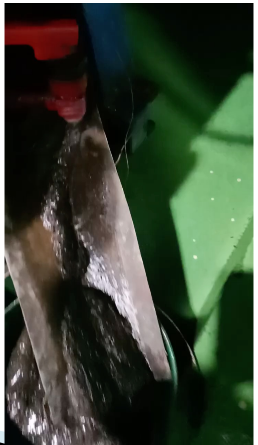
Oil + Sludge draining



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Oil in Ammonia refrigeration plant

The refrigeration oil, which is not miscible with NH_3, is transported back to the compressor or is drained off at the evaporator and other equipment.

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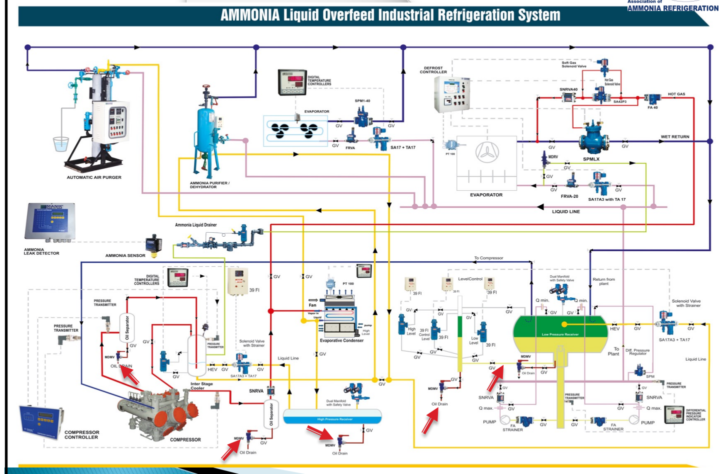
Oil Draining Guidelines



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Why oil draining is dangerous ?

- Oil that is collected at a drain point of an active system is under pressure by a pressure differential
- The oil has some liquid refrigerant suspended in it.
- The warmer the oil, the greater the amount of suspended ammonia will be in it. This also means that the starting pressure from where the oil is being drained is higher.
- When the oil is metered out from the starting pressure to the atmospheric pressure at the outlet of the oil drain valve, there is an expansion of the ammonia.
- When ammonia expands (pressure is reduced) that there is a corresponding reduction in temperature.
- The cold ammonia is causing the oil to congeal (thicken up). The oil can become as thick as a paste.

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Why oil draining is dangerous ?

- This causes the rate of flow to decrease through the oil drain valve.
- The impatient operator sees that the oil flow has slowed or stopped, so he opens the drain valve even more. This opening of the valve and stoppage of flow may be repeated a few times.
- Suddenly, there is no more oil coming from the oil drain valve. What is coming from the valve is a dangerous white aerosol cloud of liquid ammonia and gas.
- Unless the operator is very fortunate and can get the oil valve closed a very serious and possibly, lethal ammonia release has just been started.

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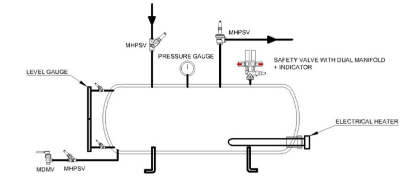
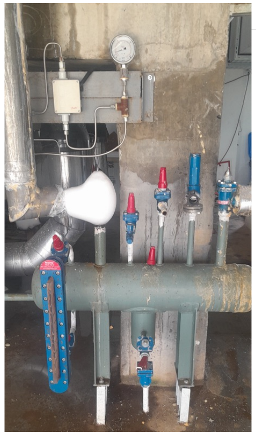
TYPICAL OVER FEED SYSTEM OIL RECTIFIER





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Typical Oil Drain Points

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Rust, Dust, sludge in Ammonia

1. Refrigeration system must be kept free of any foreign matters such as dirt, grit, rust, impure oil, wax, sludge, water, air etc.
2. Proper Strainer must be installed before the Solenoid Valves to keep dirt, weld debris and other foreign matter out of the valve which is a common cause for Solenoid Valves failure.
3. Due presence of air and water in ammonia the rust formation starts inside pressure vessels, pipes etc as these made from mild steel
4. During installation of maintenance welding burr may enter into systems
5. The pipes, vessel etc if not cleaned properly before installation the corrosion inside gets accumulated in filters and valves
6. Proper installation SOP must be followed to avoid rust, dust, sludge etc in system. Please refer to Ammonia installation and maintenance book by AAR.

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Rust, Dust, sludge in Ammonia

Valves was passing because of the heavy dust and debris found inside the valve which also damaged the cone.

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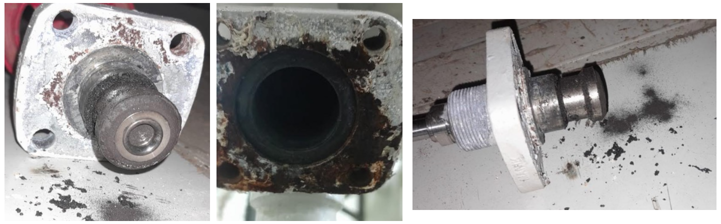
Rust, Dust, sludge in Ammonia

Photos of Dust and Debris found inside the valve.



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Rust, Dust, sludge in Ammonia

Photos of Dust and Debris found inside the valve.

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Rust, Dust, sludge in Ammonia

Defrost Relief Valves was passing because of the heavy dust and debris found inside the valve

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Rust, Dust, sludge in Ammonia

Filters clogging with rust and dust

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Rust, Dust, sludge in Ammonia

Filters clogging with rust and dust

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Rust, Dust, sludge in Ammonia

Filters clogging with rust and dust

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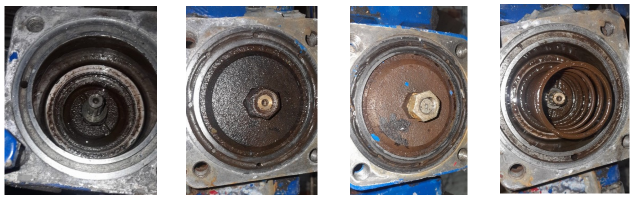
Rust, Dust, sludge in Ammonia

Found heavy dust & debris particles settled on the valve because of which the valve was passing.



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Rust, Dust, sludge in Ammonia

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Rust, Dust, sludge in Ammonia

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Rust, Dust, sludge in Ammonia

Dirt Accumulation in Level Gauge

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Rust, Dust, sludge in Ammonia

Safety Valve: Rust
Water damages
Safety valve seats
and fails to
operated

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Conclusion

- In a refrigeration system only, refrigerant should circulate not any other materials
- Ammonia has high affinity to water
- Oil is not miscible in ammonia and gets carried over with ammonia
- Oil should remain in compressor, oil cooler and oil separator
- Water in ammonia effects efficiency of system, helps corrosions , deteriorates oil life, filters and control devices
- Rust in system is catastrophic and chokes filters, damages controls, compressors

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We are thankful to
Dr. Ashish Kadam
Mr. Dhananajy Deshapande

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Thank You

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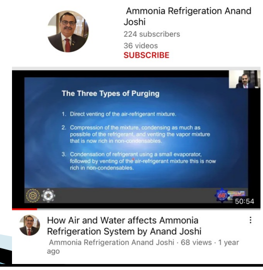

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