Association of AMMONIA REFRIGERATION

AAR Web Series – III
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Low charge NH3 refrigeration systems

by

Mr. Pradip Wani

DCE REFRIGERATION PVT. LTD.
Trusted partner of Refrigeration systems and packages for
Brewery| Dairy| Food processing| Beverages| Cold storage| Pharmaceuticals| Chemical
Email: sales@dceref.com / dceref@gmail.com | Website: www.dceref.com

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Overview

We will cover following points in today's presentation

- What is low ammonia charge refrigeration?
- Why we need low ammonia charge refrigeration?
- Traditional ammonia refrigeration and ammonia charge required
- Low charge ammonia refrigeration and ammonia charge required
- Advantages of low ammonia charge refrigeration
- Why all systems are not made low ammonia charge?
- Examples of low ammonia charge refrigeration

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What is low charge ammonia refrigeration?

"Low charge" refers to the ratio of charge per unit of cooling capacity, with systems having no more than 1.3kg/kw-1, with some systems as low as 0.06 kg kW-1.[1]

Traditional ammonia plants containing large amounts of ammonia can now be replaced with modern, safer pre-packaged low charge ammonia units which are in turn able to reduce the refrigerant charge to a minimum.

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Ammonia as a refrigerant
Ammonia properties

Ozone depletion and global warming[2]

The Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) of various refrigerants are shown below.

Refrigerant	Refrigerant	ODP (1)	GWP
R717	Ammonia	0	<1
R744	Carbon dioxide	0	1.00
R290	Propane	0	0.30
R404A	R-125/143a/134a (44/52/4)	0	3920
R600a	2-methyl propane (isobutane)	0	~20
R1270	Propene (propylene)	0	1.80
R22	Chlorodifluoromethane	0.06	1810
R134a	1,1,1,2-tetrafluoroethane	0	1430
R410A	R-32/125 (50/50)	0	2090

(1) Adopted under the Montreal Protocol

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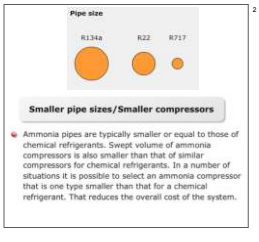
Ammonia as a refrigerant
Ammonia properties

AMMONIA C.O.P. (EFFICIENCY) COMPARISON WITH OTHER REFRIGERANTS FOR VARIOUS APPLICATIONS[3]

Refrigerant	Condensing Temperature +40°C			
	Evaporating Temperature 2°C	Evaporating Temperature -5°C	Evaporating Temperature -25°C	Evaporating Temperature -40°C
Ammonia-R717	6.2	4.965	2.91	2.06
R410A	5.43	4.8	2.5	1.75
R134a	5.88	4.67	2.7	Not used
R404A	5.18	4.07	2.26	1.52
R22*	5.93	4.74	2.79	1.98



[2]

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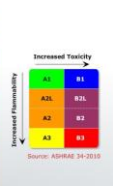
Ammonia as a refrigerant
Ammonia properties

Refrigerants - Safety groups[2]

Refrigerant type	Refrigerant	Name	Safety Groups
-	R717	Ammonia	B2L
-	R744	Carbon Dioxide	A1
HCFC	R22	Chlorodifluoromethane	A1
HFC	R134a	1,1,1,2-tetrafluoroethane	A1
HFC	R404A	R125/143a/134a (44/52/4)	A1
HFC	R407C	R32/125/134a (23/25/52)	A1
HFC	R410A	R32/125 (50/50)	A1
HFC	R507A	R125/143a (50/50)	A1
HFC	R152a	1,1-difluoroethane	A2
HC	R290	Propane	A3
HC	R600	Butane	A3
HC	R600a	Iso-butane	A3
HC	R1270	Propylene	A3



Most of the popular refrigerants including CO2 fall under the A1 safety group category. While Ammonia is categorized in the B2L safety group.

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Why we need low charge ammonia refrigeration?

- Low charge ammonia refrigeration system eliminates the health and safety risks associated with refrigerant leakage and flammability.
- Ammonia refrigeration offers a long term and readily available refrigeration solution. It has zero detrimental environmental effects on ozone and global warming.
- Ammonia refrigerant outlook is stable as cost is directly linked to agricultural industry.

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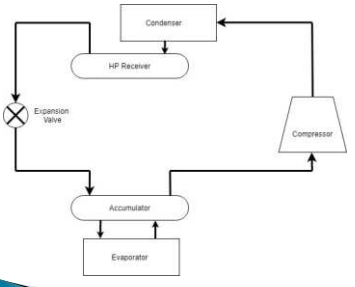
Traditional ammonia refrigeration - Gravity feed system



Gravity feed ammonia refrigeration system

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Traditional ammonia refrigeration - Gravity feed system

Typical traditional ammonia refrigeration setup

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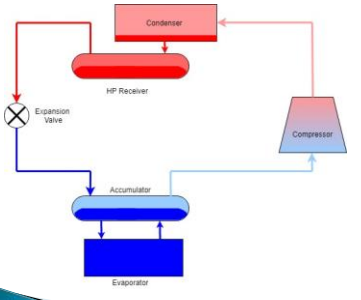
Traditional ammonia refrigeration - Gravity feed system



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Ammonia density[4]

Sr. No.	Phase	Temperature Deg C	Density Kg/m3
1	Ammonia vapor	-10	2.39
2	Ammonia liquid	-10	651.9
3	Ammonia vapor	0	3.46
4	Ammonia liquid	0	638.6
5	Ammonia vapor	40	12.05
6	Ammonia liquid	40	579.3

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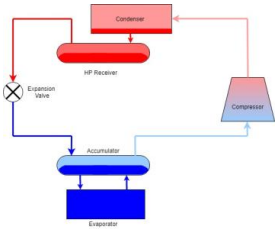
Traditional ammonia refrigeration - Gravity feed system



Ammonia charge for a 350 TR system

Sr No.	Equipment	Volume liters	Total NH3 Kg	% NH3 charge
1	Compressor	500.00	1.20	0.20%
2	Suction line	94.26	0.23	0.04%
3	Discharge line	60.33	0.73	0.12%
4	Liquid Line	61.94	35.86	6.09%
5	Surge Drum	1486.00	293.15	49.80%
6	Ammonia Receiver	967.00	176.16	29.92%
7	PHE Condenser	146.40	18.37	3.12%
8	PHE Chiller	96.60	62.98	10.70%
	TOTAL AMMONIA CHARGE		**588.67**	

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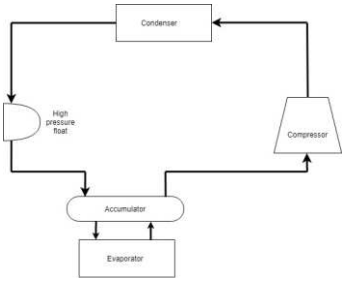
Low charge ammonia refrigeration - Gravity feed system



Gravity feed ammonia refrigeration system

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Low charge ammonia refrigeration - Gravity feed system

Gravity feed ammonia refrigeration system

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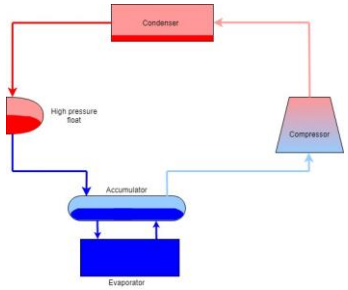
Low charge ammonia refrigeration - Gravity feed system



- HP Ammonia vapor
- LP Ammonia vapor
- HP Ammonia liquid
- LP Ammonia liquid

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Ammonia density[4]

Sr. No.	Phase	Temperature Deg C	Density Kg/m3
1	Ammonia vapor	-10	2.39
2	Ammonia liquid	-10	651.9
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5	Ammonia vapor	40	12.05
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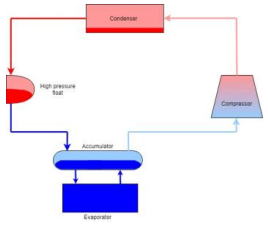
Low charge ammonia refrigeration - Gravity feed system



Ammonia charge for a 350 TR system

Sr No.	Equipment	Volume liters	Total NH3 Kg	% NH3 charge
1	Compressor	500	1.20	0.57%
2	Suction line	94.26	0.23	0.11%
3	Discharge line	60.33	0.73	0.35%
4	Liquid Line	29.87	17.29	8.28%
5	High Pressure Float	19	7.45	3.57%
6	Surge Drum	1486	102.22	48.92%
7	PHE Condenser	134.4	16.86	8.07%
8	PHE Chiller	96.6	62.98	30.14%
	TOTAL AMMONIA CHARGE		208.97	

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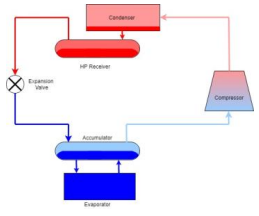
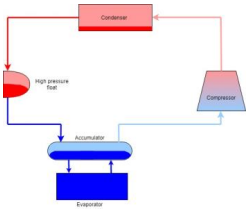
Comparison of Ammonia charge required for a 350 TR system

Traditional gravity feed system



Ammonia charge: 589 kg

Low charge gravity feed system



Ammonia charge: 209 kg

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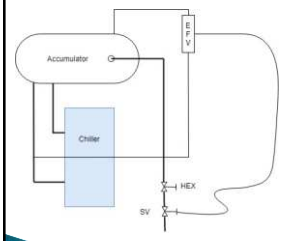
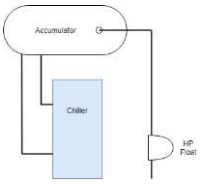
Difference between traditional and low charge ammonia systems

Traditional gravity feed system



Low charge gravity feed system



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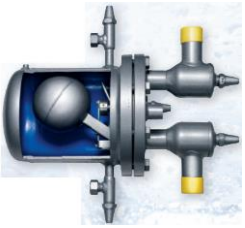
Construction of High-Pressure Float control device[5]



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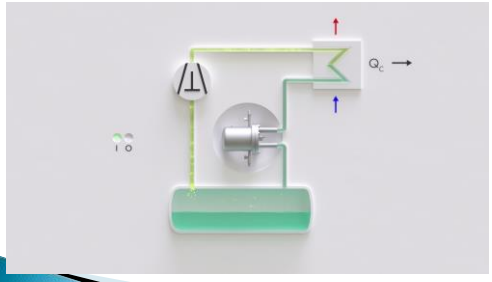
Construction of High-Pressure Float control device[5]



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Benefits of low charge ammonia refrigeration systems

- Fully automatic operation.
- No need to open/ close Ammonia valves during starting/ stopping.
- 100% Failsafe against Liquid stroke & subsequent compressor breakdowns.

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Why all ammonia refrigeration systems are not low charge?

- This system cannot be implemented for multiple evaporator setups.
- During major shutdown or evaporator maintenance, the ammonia needs to be transferred to empty cylinders/ portable ammonia receiver.
- Resistance from end user/ technicians due to absence of HP Receiver.

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Case study

Replacing traditional system with low charge ammonia refrigeration system

Low charge ammonia refrigeration package for Nestle FMCG plant in India

S & T CHILLER & CONDENSER CONVERTED TO PHE & HP FLOAT SYSTEM CHARGED REDUCED FROM 880 KG TO 143 KG.

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Case study

Replacing traditional system with low charge ammonia refrigeration system

	Old Plant	***Modified Plant***
Application	Water chilling plant	
Capacity	150 TR	
Refrigerant	Ammonia	
Condenser	S&T type	PHE
Evaporator	S&T type	PHE
HP Receiver	Horizontal Cylindrical	Not required
Accumulator	Horizontal Cylindrical	Horizontal Cylindrical
Evaporator Ammonia Controls	Electronic Float Valve, Solenoid Valve, Hand Expansion Valve	High Pressure Float
Plant operation	Manual	Fully Automatic
SCADA compatibility	No	Yes

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Case study

Replacing traditional system with low charge ammonia refrigeration system

Ammonia charge for old system

Sr No.	Equipment	Volume liters	Total NH3 Kg	% NH3 charge
1	Compressor	500	1.20	0.14%
2	Suction line	94.26	0.23	0.03%
3	Discharge line	60.33	0.73	0.08%
4	Liquid Line	28.00	16.21	1.84%
5	Surge Drum	458	30.85	3.50%
6	HP Receiver	1225	257.88	29.28%
7	S&T Condenser	622	42.03	4.77%
8	S&T Chiller	1019	531.51	60.36%
	TOTAL AMMONIA CHARGE		880.64	

Ammonia charge for modified system

Sr No.	Equipment	Volume liters	Total NH3 Kg	% NH3 charge
1	Compressor	500	1.20	0.84%
2	Suction line	94.26	0.23	0.16%
3	Discharge line	60.33	0.73	0.51%
4	Liquid Line	25	14.48	10.14%
5	High Pressure Float	19	7.45	5.22%
6	Surge Drum	350.84	46.50	32.59%
7	PHE Condenser	72.8	9.13	6.40%
8	PHE Chiller	96.6	62.98	44.14%
	TOTAL AMMONIA CHARGE		142.70	

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Examples of low charge ammonia refrigeration system

Low charge ammonia refrigeration package for Brewery application in India

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Examples of low charge ammonia refrigeration system

Low charge ammonia refrigeration package for Nestle FMCG plant in India

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Examples of low charge ammonia refrigeration system

Air cooled low charge ammonia refrigeration package for cold storage application[6] in Europe

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Examples of low charge ammonia refrigeration system

Low charge ammonia refrigeration package for industrial application[6] in Melbourne, Australia

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Examples of low charge ammonia refrigeration system

Low charge ammonia refrigeration package for Ice Rink application[6] in Canada

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References

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Thank You

Contact Details

Mr. Pradip Wani
pradipwani@gmail.com
Email ammoniaindia@gmail.com

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