AMMONIA REFRIGERATION SYSTEMS

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1

Refrigeration As a Utility

IT'S DIFFERENT

2

2

Basic Components of a Refrigeration System

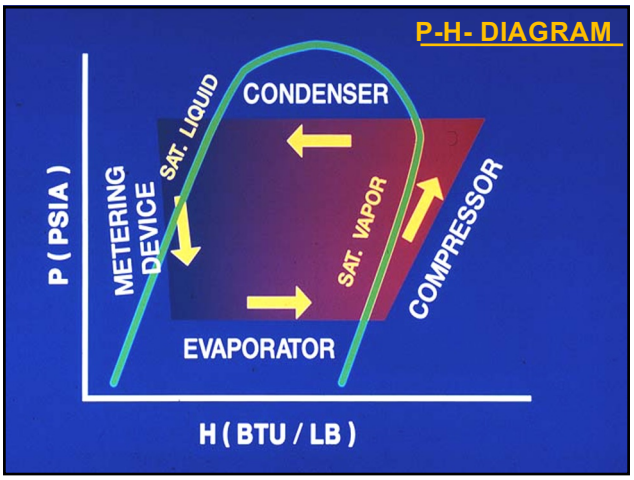
1. Compressors
2. Condensers
3. Evaporators
4. Liquid metering Devices/Expansion valve

3

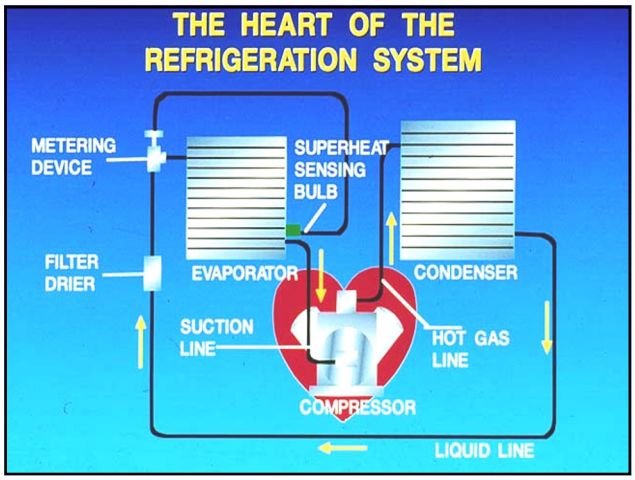
(There is separate Detailed presentation on P-H diagram study)

P - H DIAGRAM ALLOWS YOU TO "SEE THE INVISIBLE"

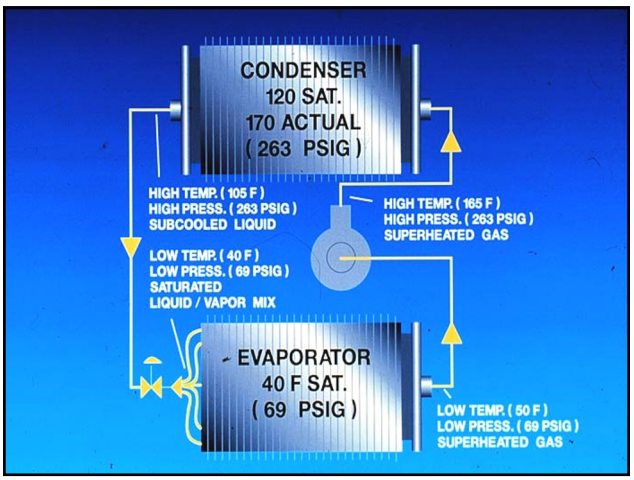
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P-H- DIAGRAM
P (PSIA)
METERING DEVICE
SAT. LIQUID
CONDENSER
SAT. VAPOR
COMPRESSOR
EVAPORATOR
H (BTU / LB)

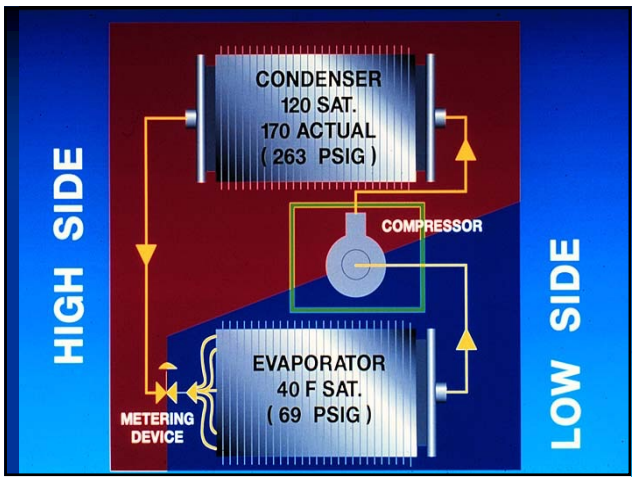
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THE HEART OF THE REFRIGERATION SYSTEM
METERING DEVICE
SUPERHEAT SENSING BULB
FILTER DRIER
EVAPORATOR
CONDENSER
SUCTION LINE
HOT GAS LINE
COMPRESSOR
LIQUID LINE

6

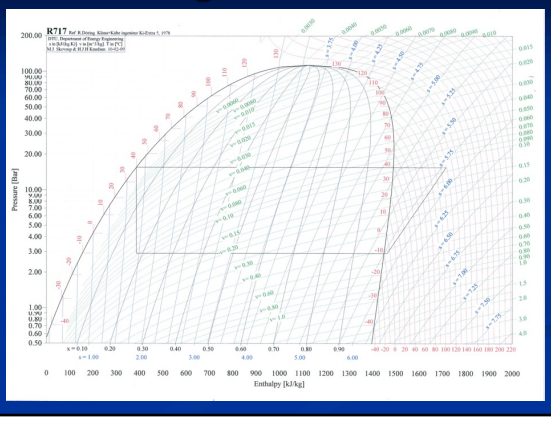

CONDENSER
120 SAT.
170 ACTUAL
(263 PSIG)
HIGH TEMP. (105 F)
HIGH PRESS. (263 PSIG)
SUBCOOLED LIQUID
HIGH TEMP. (165 F)
HIGH PRESS. (263 PSIG)
SUPERHEATED GAS
LOW TEMP. (40 F)
LOW PRESS. (69 PSIG)
SATURATED
LIQUID / VAPOR MIX
EVAPORATOR
40 F SAT.
(69 PSIG)
LOW TEMP. (50 F)
LOW PRESS. (69 PSIG)
SUPERHEATED GAS

7


HIGH SIDE
CONDENSER
120 SAT.
170 ACTUAL
(263 PSIG)
COMPRESSOR
LOW SIDE
METERING DEVICE
EVAPORATOR
40 F SAT.
(69 PSIG)

8

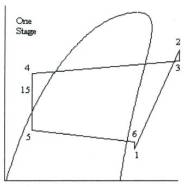
P-H Diagram for Ammonia



9

P-H diagram coordinates for Ammonia in operating plant

Refrigerant: R717
Values at points 1-6,15 for the selected one stage cycle



Point	T [°C]	P [bar]	v [m^3/kg]	h [kJ/kg]	s [kJ/(kg K)]
1	-5.000	2.908	0.427680	1461.848	5.7987
2	118.949	15.549	0.115999	1715.167	5.7987
3	118.949	15.549	0.115999	1715.167	5.7987
4	40.000	15.549	N/A	386.426	N/A
5	-10.000	2.908	N/A	386.426	N/A
6	-5.000	2.908	0.427673	1461.848	5.7987
15	N/A	15.549	N/A	386.426	N/A

10

OBJECTIVES OF DESIGNING DIFFERENT REFRIGERATION SYSTEMS

1. To have highest Efficiency
2. Simplicity for operation
3. Minimum refrigerant quantity
4. Value for money-i.e. minimum owning and operating cost
5. Easy and reduced Maintenance
6. Life of system
7. Safety-most important to ensure no ammonia leakage

11

Various Ammonia Refrigeration systems

1.Vapour Compression systems

a. Single stage systems for operation between +40^{0}C/-20^{0}C to -15^{0}C
b. Two stage systems for Temperatures up to -50^{0}C using same refrigerant-either single compound compressor or two independent compressors
c. Cascade systems using two different refrigerants –Ammonia for high stage and another refrigerant or fluid for low stage for temperatures up to -60^{0}C
d. Booster system using same refrigerant but two separate compressors

2.Different system Designs

a. Direct Expansion systems
b. Gravity Flooded systems
c. Force feed pump circulation systems
d. Low ammonia charge systems
e. LVS system-patented JBT
f. Neo Charge system-Danfoss

12

STANDARD COMPONENTS OF A SYSTEM

1. Compressor-Reciprocating or screw –open type
2. Condensers- Atmospheric, shell and tube, evaporative or PHE-mostly water cooled in India
3. Expansion devices-in the high pressure liquid line before evaporator-Low side Float valve, Hand expansion valve, Flow regulating valve, or motorized control valve
4. Evaporator-Application oriented, such as cold room air coolers, Shell &Tube or Plate Heat Exchanger chillers(PHE) for water or brine, ice makers, plate freezers, IQF or blast freezers, spiral Freezers etc.

13

Direct Expansion & Flooded Systems using Evaporators-either D-X or Flooded

1. **Direct expansion** -Refrigerant is a mixture of liquid and the gas at the start- gas at the outlet having Superheated vapours up to 5^0C

2. **Gravity Flooded** –Liquid from the inlet as well as to the outlet of evaporator-No superheat

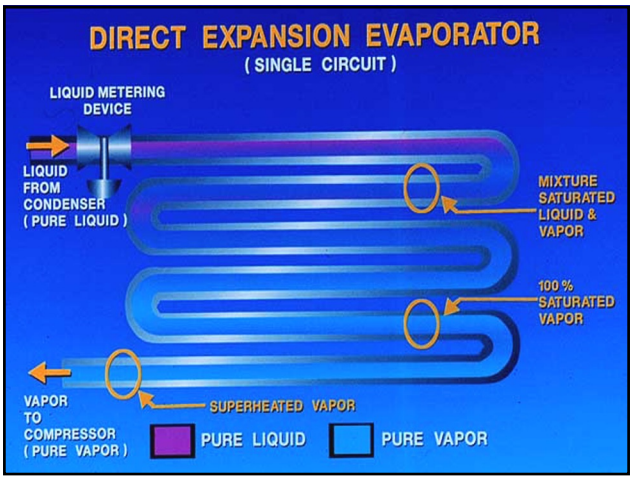
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DIRECT EXPANSION SYSTEMS

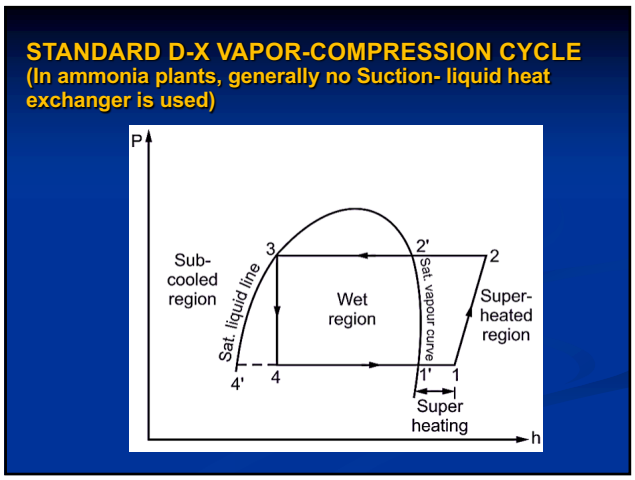
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Direct Expansion Air Coil

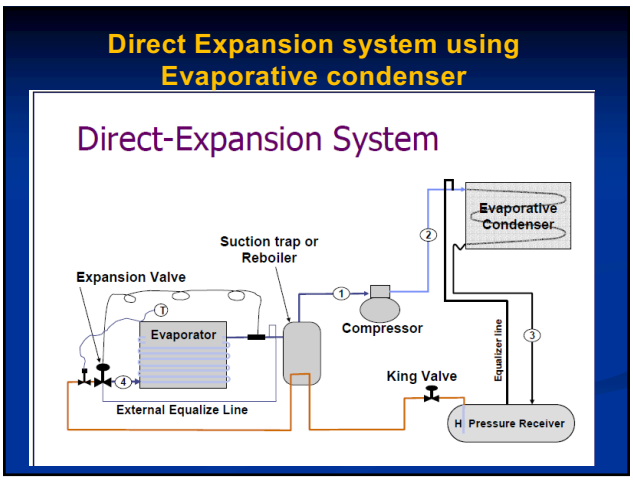
16


DIRECT EXPANSION EVAPORATOR
(SINGLE CIRCUIT)
LIQUID METERING DEVICE
LIQUID FROM CONDENSER (PURE LIQUID)
MIXTURE SATURATED LIQUID & VAPOR
100 % SATURATED VAPOR
VAPOR TO COMPRESSOR (PURE VAPOR)
SUPERHEATED VAPOR
PURE LIQUID
PURE VAPOR

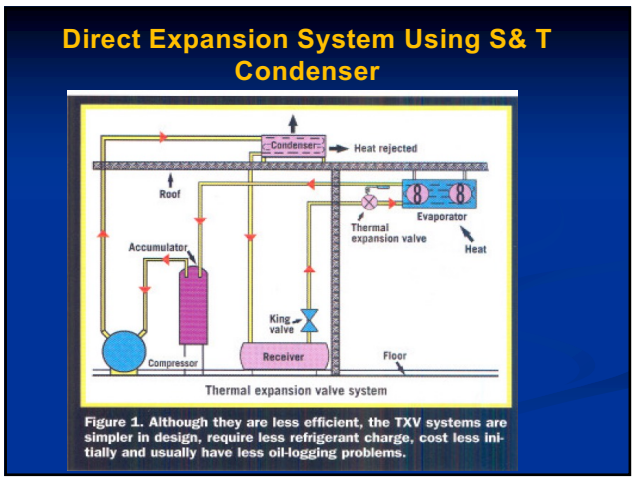
17


STANDARD D-X VAPOR-COMPRESSION CYCLE
(In ammonia plants, generally no Suction- liquid heat exchanger is used)
P
h
Sub-cooled region
Sat. liquid line
Wet region
Sat. vapour curve
Super-heated region
Super heating
3
2'
2
4'
4
1'
1

18


Direct Expansion system using Evaporative condenser
Direct-Expansion System
Evaporative Condenser
Suction trap or Reboiler
Expansion Valve
Compressor
Evaporator
King Valve
Equalizer line
External Equalize Line
H Pressure Receiver

19


Direct Expansion System Using S& T Condenser
Condenser
Heat rejected
Roof
Evaporator
Thermal expansion valve
Heat
Accumulator
King valve
Compressor
Receiver
Floor
Thermal expansion valve system
Figure 1. Although they are less efficient, the TXV systems are simpler in design, require less refrigerant charge, cost less initially and usually have less oil-logging problems.

20

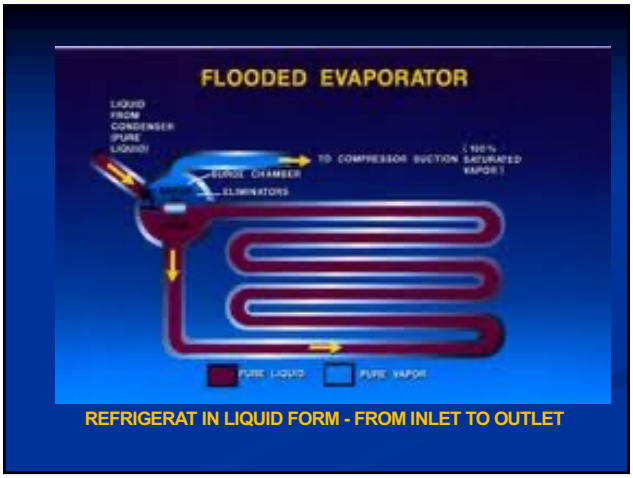
GRAVITY FLOODED SYSTEMS

21

Flooded Air Coil

Flooded coolers are more efficient than DX coolers

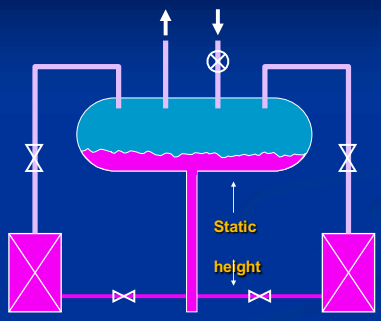
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REFRIGERAT IN LIQUID FORM - FROM INLET TO OUTLET

23

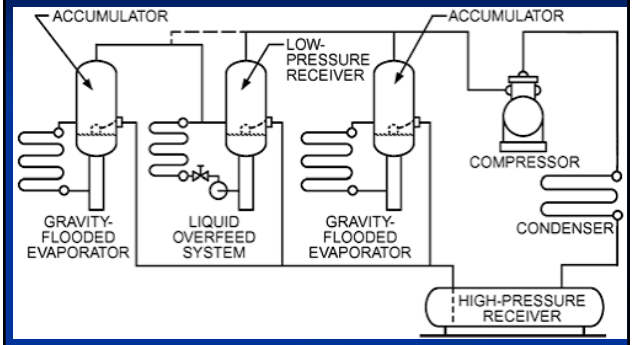
Gravity Flooded System



Circulation rate 1.5 to 2 Times depending on Evaporator design & pressure drop

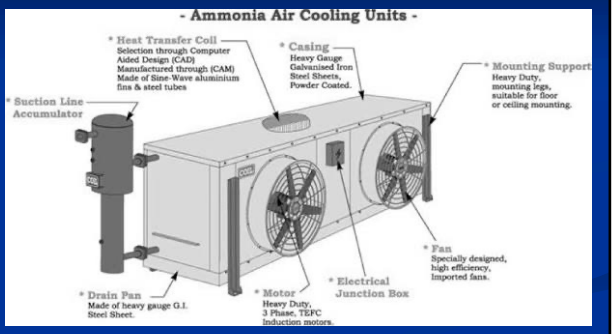
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Gravity Flooded Evaporator



25

Gravity Flooded Evaporator



26

Gravity Flooded Evaporator in Water Tank

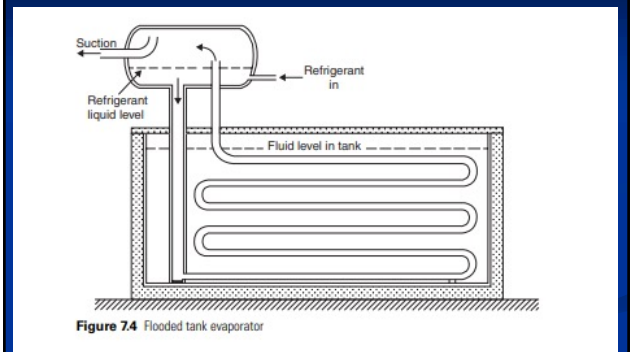
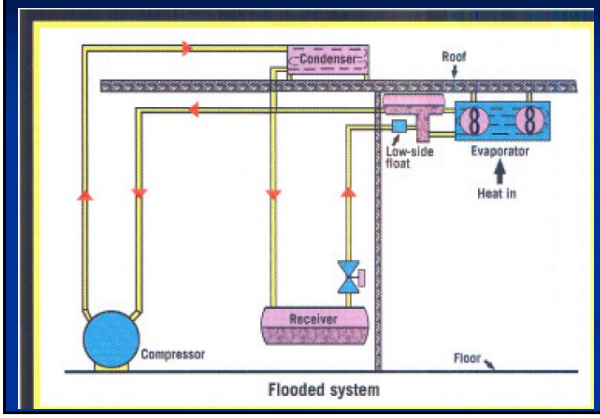


Figure 7.4 Flooded tank evaporator

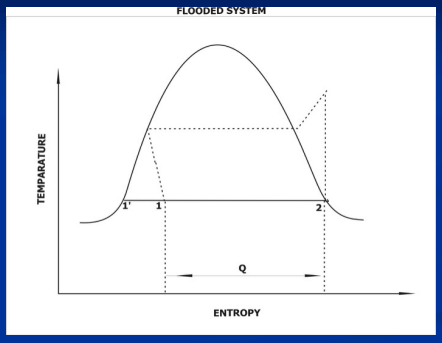
27

Gravity Flooded System



28

P-H DIAGRAM-FLOODED EXPANSION



Uses Accumulator to separate liquid and gas after expansion point 1 and allows only liquid at point1' to enter in the evaporator

29

WHY GRAVITY FLOODED SYSTEM IS BETTER THAN D-X SYSTEM

1. It is the latent heat of refrigerant which makes Refrigeration work
2. Higher the latent heat more efficient is the is the refrigerant
3. Ammonia has highest latent heat
4. More the liquid in the evaporator more is latent heat, more efficient is the system
5. The DX evaporator, the refrigerant is mixture at the entry, depending on evaporating temperature , the liquid can be 70 to 80% and remaining gas could be 20 to 30%
6. It is the liquid Refrigerant when It gets converted into vapour absorbs maximum heat, the gas or vapour does very little work(only sensible heat)
7. In Flooded system, it is liquid at the inlet as also liquid at the outlet and hence the flooded evaporators are more efficient

30

DIRECT EXPANSION OR FLOODED SYSYEM?

Advantages of Direct Expansion system

1. Quantity of refrigerant charge is low
2. Easier to operate and more compact
3. Can be used for smaller size system design
4. Air cooled condenser possible for small systems
5. Low initial cost

Drawbacks

1. Less efficient compared to flooded systems
2. Requires synthetic oils which are miscible with ammonia refrigerant
3. Control of moisture content in refrigerant essential to ensure proper operation of expansion valve

31

Flooded System Characteristics

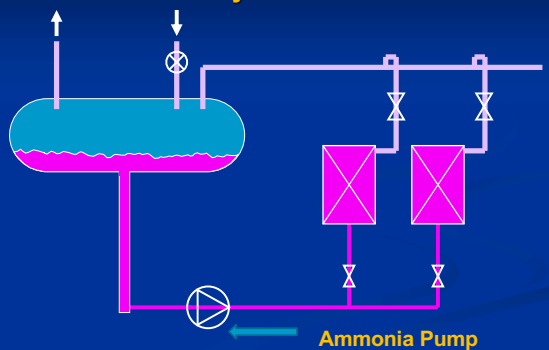
1. Similar characteristics as pumped systems
2. No extra pump & pump energy necessary
3. Static pressure (liquid column) necessary to compensate for pressure drop in coil
4. Used when a smaller number of evaporators in the system for proper liquid distribution
5. Air coolers need to be near to compressor room so that suction line superheat is not excessive

32

FORCED CIRCULATION PUMPING SYSTEM

33

Forced Circulation with Ammonia Pump System



34

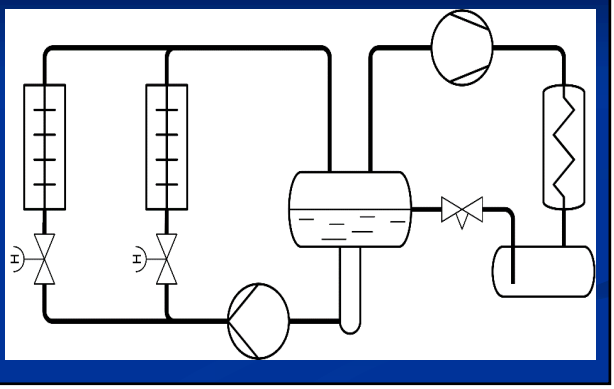
When To Use Overfeed System?

1. More than 3 to 4 air coolers or freezers
2. Processing area away from machine room
3. Low temperature applications

(THERE IS SEPARATE PRESENTATION FOR AMMONIA PUMPING SYSYEMS)

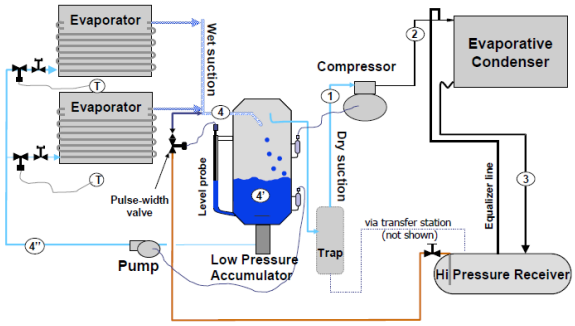
35

Pump Circulation system

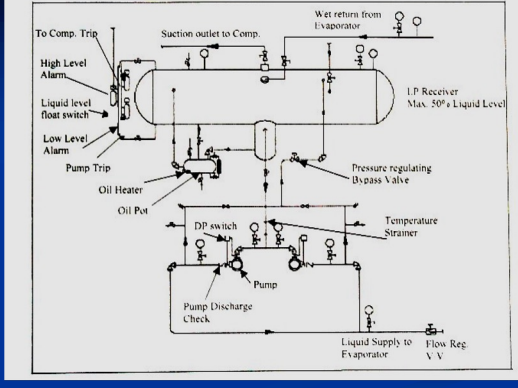


36

Overfeed System layout

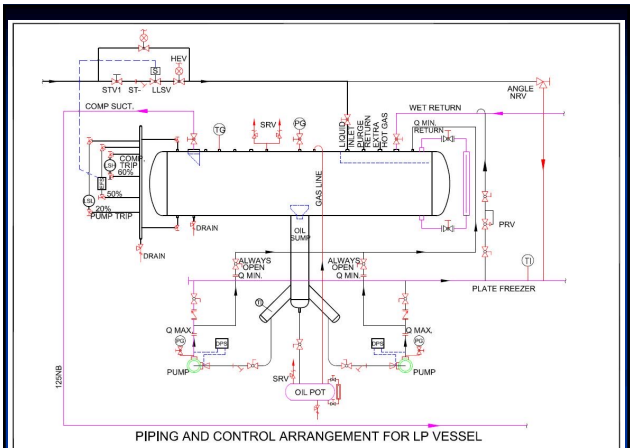


37



Piping and control arrangement

38



39

Circulation rate / Over feedrate

Circulation rate 4:1 =Total 4 Kg

Supply to freezer (4kg) Liquid/ Evaporation(1 kg) Liquid in to Gas, Liquid return(3kg)

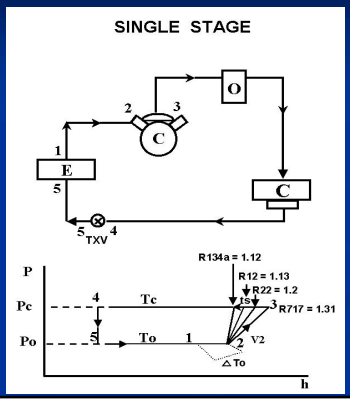
OR

Overfeed rate 3:1 = Total 4 kg

Evaporation (1 kg) Liquid into Gas/ Liquid return (3 kg)

40

Single stage system



41

Lower Temperature Means More Energy

Application	Energy Consumption	Temp.
An Air conditioning plant would consume	(0.2431 W/unit output) /4.1W out put/ unit W input	+10⁰C
Fruit & vegetable pre cooling would consume	(0.2635 W/W)/ 3.8 W/W	+5⁰C
Refrigerators	(0.3125 W/W)/ 3.2 W/W	0⁰C
Dairy & Milk products	(0.3866 W/W)/ 2.6 W/W	-5⁰C
Meat storage	(0.4348 W/W)/ 2.3 W/W	-15⁰C
Freezing plants	(0.6666 W/W) /1.5 W/W	-30⁰C
ICF cream freezers	(0.8333 W/W)/ 1.2 W/W	-40⁰C

42

42

CHANGING REFRIGERANT CHANGES CAPACITY

Refrigerant	Capacity kcal / hr - ton	Power Consumption kW	kW/Ton
AMMONIA	**118.8**	76.7	0.645
R12	**60.84**	53.0	0.871
R22	**101.32**	82.0	0.809
R502	**98.97**	105.3	1.0639

43

COMPRESSOR CAPACITY DROPS DRASTICALLY WHEN DISCHRAGE PRESSURE INCREASES

3 Cylinder Compressor

	Capacity - Ton	Power Consumption kW	kW / TON
25⁰C / +5⁰ C	**117.75**	**63.5**	**0.539**
+35⁰C / +5⁰ C	**106.91**	**75.5**	**0.706**
+45⁰C / +5⁰ C	**95.66**	**88.65**	**0.926**

44

44

COMPRESSOR CAPACITY DROPS DRASTICALLY & POWER CONSUMPTION/TON INCREASES WHEN EVAPORATING TEMPERATURE REDUCES

	Capacity Ton	Power Consumption kW	kW / TON
40^0 C / $+5^0$ C	101.32	82.0	0.809
$+40^0$C / -15^0 C	44.47	63.5	1.427
$+40^0$C / -30^0 C	19.21	40.2	2.092

45

45

COMPRESSOR CAPACITY DROPS DRASTICALLY WHEN SUCTION PRESSURE DROPS

	Capacity Ton	Power Consumption kW	kW / TON
40^0 C / $+5^0$ C	101.32	82.0	0.809
$+40^0$C / -15^0 C	44.47	63.5	1.427
$+40^0$C / -30^0 C	19.21	40.2	2.092

46

46

SUPERHEAT REDUCES CAPACITY

+ 40^0 C / $+5^0$ C , Ammonia

Superheat	CAPACITY kcal/hr
0 K	359400
5 K	350700
10 K	342600

47

SUBCOOLING INCREASES COMPRESSOR CAPACITY-

40^0C/-15^0C-R22 Refrigerant—Cool pack software

Sub cooling-^{0}C	Capacity -kJ/kg	Power consumption-kJ/kg	C.O.P
0^0C	149.879	41.812	3.58
5^0C	156.452	41.812	3.74
10^0C	162.902	41.812	3.90

48

TWOSTAGE/BOOSTER/CASCADE --WHEN?

1. Allowable pressure difference exceeds Manufacturer's recommendations
2. Allowable discharge temperature exceeds-120^{0}C to 140^{0}C
3. Sat. Condensing temp minus sat. Evaporating temp for Ammonia more than 50K & for R-22 and other HCFC/HFC refrigerants more than 70K
4. For same pressure range ammonia may require two stage and R-22 single stage
5. Cascade system may be used using same refrigerant but different high stage low stage refrigeration loads
6. Cascade when different refrigerants for high stage and low stage or low stage using secondary fluid

49

TWO STAGE SYSTEMS

- When the difference between Design condensing temperature and Design evaporating temperature exceeds 50K to 55K in case of ammonia refrigerant(40^{0}C condensing/-15^{0}Cevaporating Temperatures)-, it is recommended to use two stage systems, to limit compressor discharge temperatures and to improve efficiency & protect lubrication oil properties.

50

TWO STAGE SYSTEMS WITH SINGLE COMPOUND COMPRESSOR

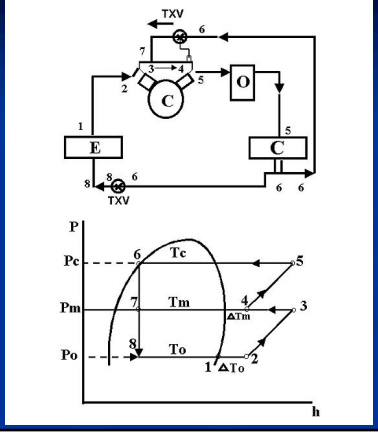
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Two Stage Systems variations

1. Liquid injection in inter-stage
2. Closed inter-stage cooler vessel with coil for sub-cooling liquid
3. Open inter-stage cooler flash vessel

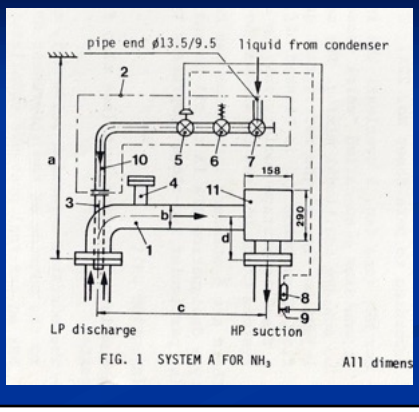
52

INJECTION INTERSTAGE GAS COOLING



53

DIRECT LIQUID INJECTION ARRANGEMENT



54

INJECTION INTER-STAGE COOLING

ADVANTAGES

1. Simple/inexpensive
2. No new additional –isolation valves/oil separator in L.P. discharge or strainer in hp suction
3. Saving in floor space
4. Easy to control
5. Suitable for all refrigerants
6. Low initial cost

DRAWBACKS

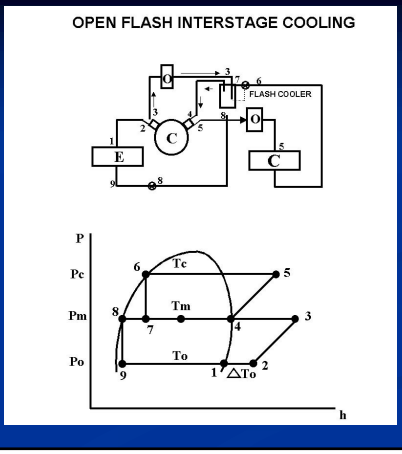
1. No subcooling-less refrigeration capacity
2. Higher specific power compared to other systems
3. Expensive compressor per unit capacity compared to other two systems
4. Operating cost higher compared to other systems
5. Hunting of expansion valve-at reduced capacity

6. APPLICATION-

SMALL/MEDIUM AMMONIA/R-22 INSTALLATIONS WITH LOW INITIAL COST,SIMPLE IN OPERATION

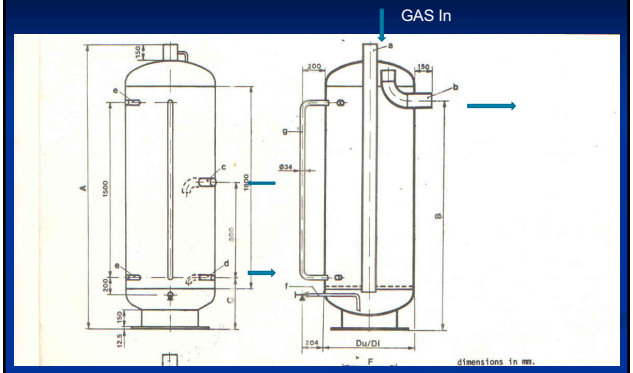
55

OPEN FLASH INTERSTAGE COOLING



56

OPEN INTER-STAGE COOLER



57

OPEN FLASH INTER-STAGE COOLER

ADVANTAGES

1. Maximum capacity for given compressor
2. Minimum power consumption
3. Maximum cop
4. Minimum operating cost per year

DRAWBACKS

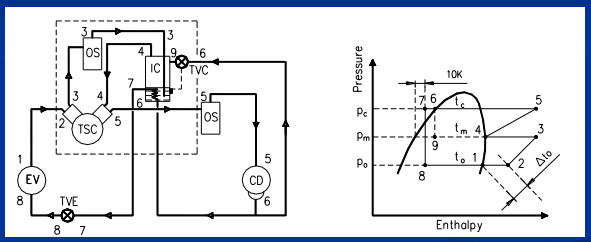
1. Inter-stage cooling section expensive
   Require- shut off valves/oil separator LP discharge, HP suction strainer
2. More floor space
3. Qualified operator necessary
4. Large refrigerant quantity
5. Oil trapping from L.P. discharge-less suitable for R-22
6. Low pressure difference across expansion Valve
7. Risk of flash gas in liquid line to evaporator.
8. Flash cooler in engine room above L.P. vessel With minimum height distance

Application

1. Optimized system
2. Medium/large plants where minimum running cost is important compared to initial cost

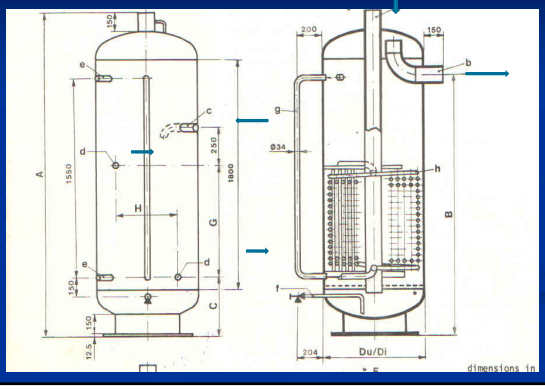
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Closed Inter-stage Cooler

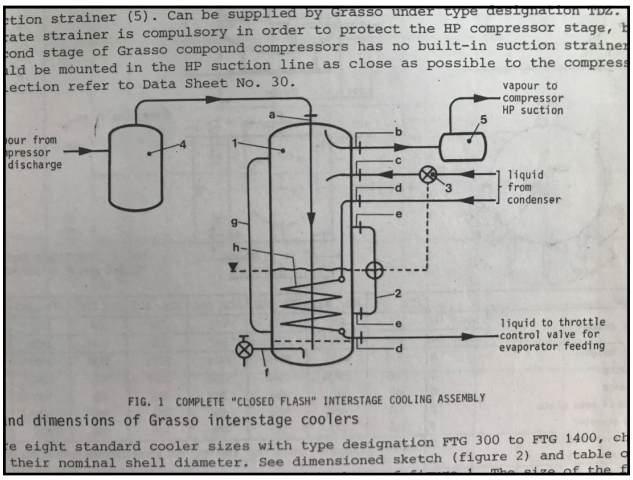


59

CLOSED INTER-STAGE COOLER WITH SUB COOLING COIL



60



tion strainer (5). Can be supplied by Grasso under type designation TDZ.
rate strainer is compulsory in order to protect the HP compressor stage, h
ond stage of Grasso compound compressors has no built-in suction strainer
ld be mounted in the HP suction line as close as possible to the compress
ection refer to Data Sheet No. 30.

FIG. 1 COMPLETE "CLOSED FLASH" INTERSTAGE COOLING ASSEMBLY

nd dimensions of Grasso interstage coolers

e eight standard cooler sizes with type designation FTG 300 to FTG 1400, ch
their nominal shell diameter. See dimensioned sketch (figure 2) and table c

61

CLOSED FLASH INTER-STAGE COOLER

ADVANTAGES

1. Alternate to open flash cooler excluding disadvantages
2. Full pressure drop across expansion Valve
3. No risk of flash gas in liquid line to evaporator
4. Interstge cooler can be located in machine room on the floor

DRAWBACKS

1. Capacity some what lower than open flash cooler(3-5%)
2. Specific power consumption somewhat higher
3. Compressor price per unit capacity –higher
4. Inter-stage cooling more expensive than open flash cooler due to built in coil
5. All drawbacks of open flash cooler like extra LP oil separator

APPLICATION

MEDIUM/LARGE AMMONIA INSTALLATIONS

62

Inter-stage Cooling Systems comparison

Method of Cooling	Capacity TR	Power kW	kW/TR
Liquid injection Inter-stage	51.22	95.1	1.856
Closed liquid sub-cooler	50.05	85.24	1.703
Open Flash Cooler	51.65	86.39	1.672

Savings - (1.856 - 1.672) x 100 TR x 16 hrs/day x 30 days x 8 months per annum = 70656 kWh@8Rs. Per kW=Rs.5.65.300

63

MULTI-STAGE VAPOUR COMPRESSION REFRIGERATION SYSTEM

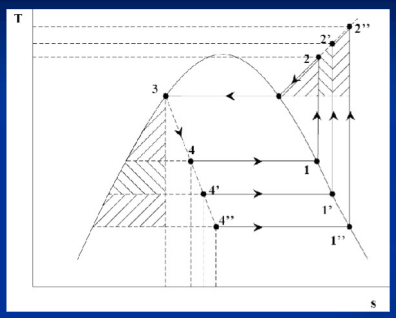


Fig. Effect of evaporator temperature on vapour compression cycle performance (T-s diagram)

64

MULTI-STAGE VAPOUR COMPRESSION REFRIGERATION SYSTEM

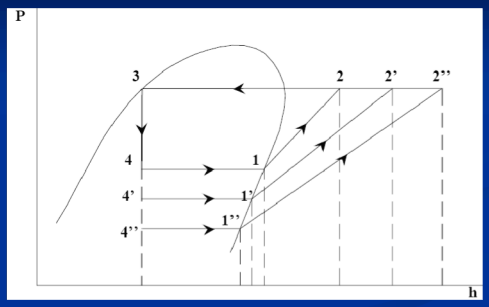


Fig. Effect of evaporator temperature on vapour compression cycle performance (P-h diagram)

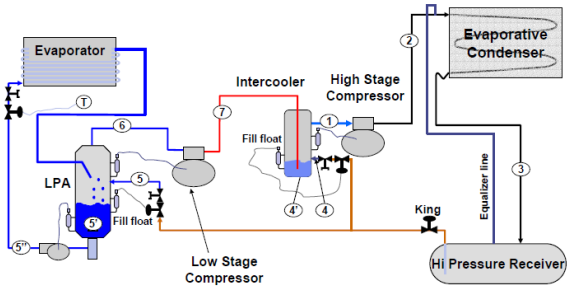
65

BOOSTER SYSTEMS USING TWO INDEPENDENT COMPRESSORS

66

Two Stage

(single temperature, two-stage compression, single stage liquid expansion)



67

COMPARISON BETWEEN SINGLE COMPOUND COMPRESSR AND BOOSTER SYSTEM USING TWO INDEPENDENT COMPRESSORS

In case of two stage we require-4Nos 12 cylinder compressors with 110kW motors- Total capacity of four compressors would be 602.24kW and total power consumption-351.68kW

In case of booster and high stage combination-require 8 compressors (4High+4 Low stage). The total capacity would be 592.12kW and total power consumed would be 150.48kW+225.0kW=375.48kW

68

COMPARISON BETWEEN SINGLE COMPOUND COMPRESSR AND BOOSTER SYSTEM USING TWO INDEPENDENT COMPRESSORS

SYSTEM	Two stage compressors	Booster-High stage combination
Compressors	KCX93	KCX9+KCX3
Quantity	4 Nos.	4+4=8Nos.
Total capacity	602.24kW	597.12kW
Total Power consumption	351.68kW	375.48kW

69

COMPARISON BETWEEN SINGLE COMPOUND COMPRESSR AND BOOSTER SYSTEM USING TWO INDEPENDENT COMPRESSORS

Conclusion-In case of two stage compressors, we require four KCX93 compressors with 602.24kW capacity & 351.68kW power consumption

whereas with booster system, we require-4 Nos KCX9 and 4 No KCX3 high stage compressors we get capacity of 592.12kW and power consumed as 375.48kW
Hence use of two stage KCX93 compressors is a better option, as cost would be much less as well as the power consumption would be less, & space required would be less.

70

TWOSTAGE/BOOSTER/CASCADE WHEN?

1. SWEPT VOLUME BOTH STAGES-LESS THAN SINGLE STAGE
2. COP HIGHER/SPECIFIC POWER CONSUMPTION LOWER
3. ALLOABLE PRESURE DIFFERENCE EXCEEDS MANUFACTURER'S RECOMMENDATIONS
4. ALLOWABLE DISCHARGE TEMPERATURE EXCEEDS-120^{0}C
5. SAT. CONDENSING TEMP-SAT. EVAPORATING TEMP
   AMMONIA MORE THAN 50K
   R-22 MORE THAN 70K
6. FOR SAME PRESSURE RANGE AMMONIA MAY REQUIRE TWO STAGE AND R-22 SINGLE STAGE

71

CASCADE & TWO STAGE COMPARISON

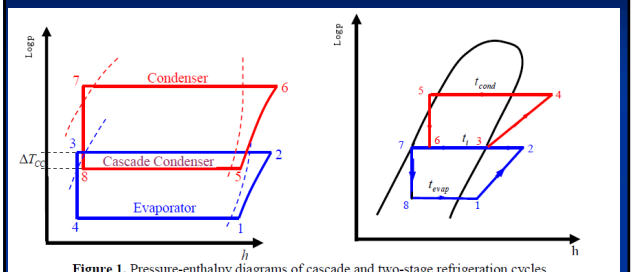


Figure 1. Pressure-enthalpy diagrams of cascade and two-stage refrigeration cycles

72

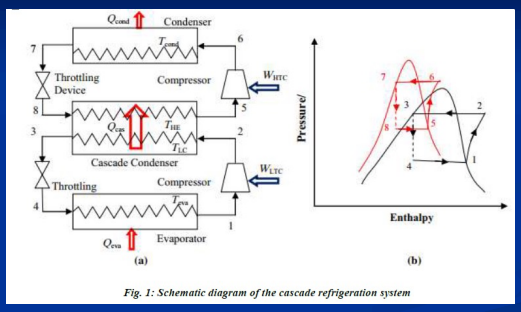
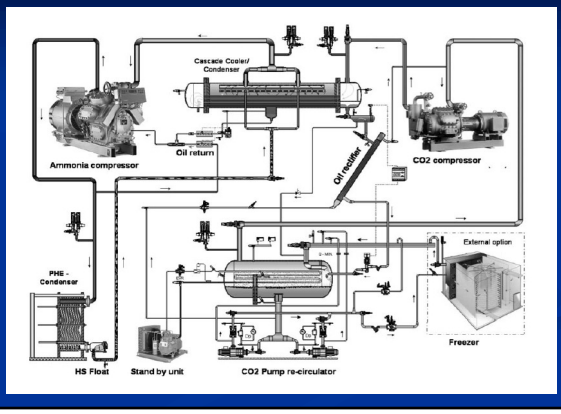


Fig. 1: Schematic diagram of the cascade refrigeration system

73

AMMONIA-CO2-CASCADE SYSTEM



74

CASCADE SYSTEMS

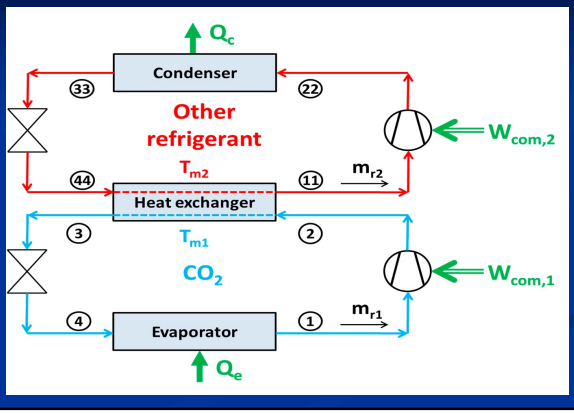
Generally uses two different refrigerants

Ammonia for high stage and

carbon dioxide for low stage

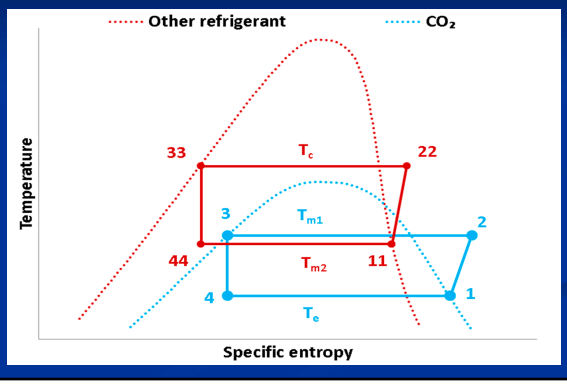
75

CASCADE SYSTEM



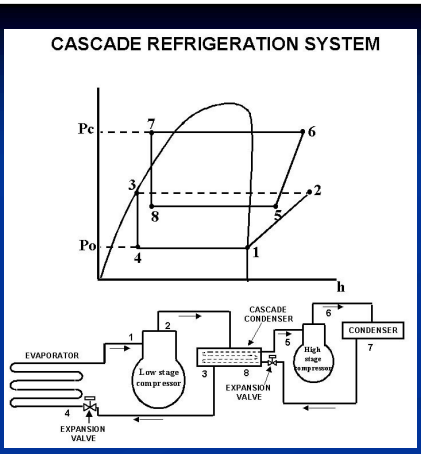
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CASCADE SYSTEM-NH3 & CO2



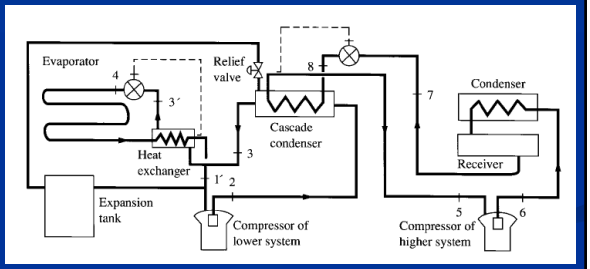
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CASCADE REFRIGERATION SYSTEM



78

Cascade system – different refrigerants, equipment, oils



79

CASCADE REFRIGERATION SYSTEMS

APPLICATION

1. Very low temperature applications
2. Different load patterns for high and low stage
3. Very high temperature difference between condensing/evaporating temperatures

ADVANTAGES

1. Simplicity of operation
2. Regular skills enough to operate the plant
3. No oil circulation/recovery problems
4. Different refrigerants can be used for High and low stages
5. Three stage cascade possible

DRAWBACKS

1. Cascade condenser-penalty heat transfer differential
2. First cost higher-two compressors/motors/condenser
3. Liquid subcooling limited
4. Expansion valve pressure drop less-valves bigger

80

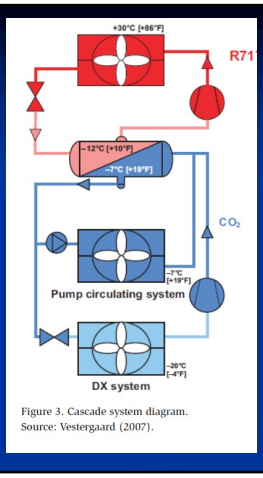


Figure 3. Cascade system diagram.
Source: Vestergaard (2007).

Ammonia –CO_2 Cascade

81

COMPARISON SINGLE STAGE/TWO STAGE/ CASCADE

R-22 REFRIGERANT, 105 DEG F CONDENSING/MINUS 40 F EVAPORATING CAPACITY 50 TON

TYPE	SINGLE STAGE	TWO STAGE			CASCADE		
		LP	HP	TOTAL	LP	HP	TOTAL
POWER REQD.	120.6	41.73	60.27	102.0	39.754	74.89	114.644
C.O.P	1.955	5.646	4.602		5.927	3.673	
COMPRESSOR DISPLACEMENT CU.M./ HR	1574.37	873.45	365.362	1238.81	855.66	485.74	1341.4
DISCHARGE TEMP. DEG F	190	71	141		70	155	

82

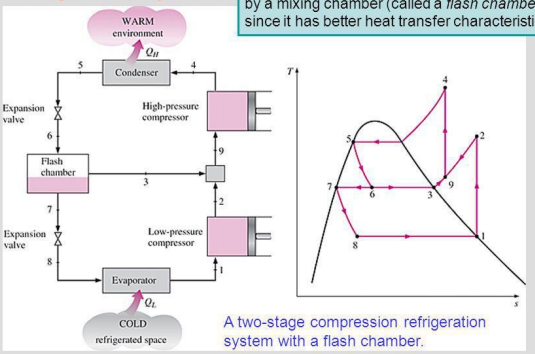
THANK YOU
Questions?

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Cell No. 9822398220
Web: http://Ramesh-paranjpey.com

83

Multistage Compression Refrigeration Systems

When the fluid used throughout the cascade refrigeration system is the same, the heat exchanger between the stages can be replaced by a mixing chamber (called a *flash chamber*) since it has better heat transfer characteristics.



A two-stage compression refrigeration system with a flash chamber.

12

84

CASCADE REFRIGERATION SYSTEMS

APPLICATION

1. VERY LOE TEMPERATURE APPLICATIONS
2. DIFFERENT LOAD PATTERN FOR HIGH AND LOW STAGE
3. VERY HIGH TEMP.DIFFERENCE BET, CONDENSING/EVAPORATING

ADVANTAGES

1. SIMPLICITY OF OPERATION
2. REGULAR SKILLS ENOUGH TO OPERATEPLANT
3. NO OIL CIRCULATION/RECOVERY PROBLEMS
4. DIFFERENT REFRIGERANTS CAN BE USED FOR STAGES
5. THREE STAGE CASCADE POSSIBLE

DRAWBACKS

1. CASCADE CONDENSER-PENALTY HEAT TRANSFER DIFFERENTIAL
2. FIRST COST HIGHER-TWO COMPS/MOTORS/CONDENSER
3. LIQUID SUBCOOLING LIMITED
4. EXPANSION VALVE PRESSURE DROP LESS-VALVES BIGGER

85

TYPE	SINGLE STAGE	TWO STAGE			CASCADE		
		LP	HP	TOTAL	LP	HP	TOTAL
POWER REQD.	120.6	41.73	60.27	102.0	39.754	74.89	114.644
C.O.P	1.955	5.646	4.602		5.927	3.673	
COMPRESSOR DISPLACEMENT CU.M./ HR	1574.37	873.45	365.362	1238.812	855.66	485.74	1341.4
DISCHARGE TEMP. DEG F	190	71	141		70	155	

COMPARISON SINGLE STAGE/TWO STAGE/ CASCADE
R-22 REFRIGERANT, 105 DEG F CONDENSING/MINUS 40 F EVAPORATING
CAPACITY 50 TON

86

TYPE	SINGLE STAGE	TWO STAGE			CASCADE		
		LP	HP	TOTAL	LP	HP	TOTAL
POWER REQD.	120.6	41.73	60.27	102.0	39.754	74.89	114.644
C.O.P	1.955	5.646	4.602		5.927	3.673	
COMPRESSOR DISPLACEMENT CU.M./ HR	1574.37	873.45	365.362	1238.812	855.66	485.74	1341.4
DISCHARGE TEMP. DEG F	190	71	141		70	155	

COMPARISON SINGLE STAGE/TWO STAGE/ CASCADE
R-22 REFRIGERANT, 105 DEG F CONDENSING/MINUS 40 F EVAPORATING
CAPACITY 50 TON

87

LOW CHARGE SYSTEMS

88

What is Low Charge Ammonia Systems

1. Low charge systems are defined as systems having less than 1.3kg of ammonia quantity per kW of Refrigeration
2. Low charge factory made packaged refrigeration systems of less than 0.3kg/ton are available using shell and plate heat exchangers. Use of High side float eliminates use of H.P. receiver.
3. Systems with as low as 0.06kg/kW charge are also available for some applications

Ref: ISHRAE JOURNAL JAN-March 2017-Star Refrigeration UK-R. Lamb

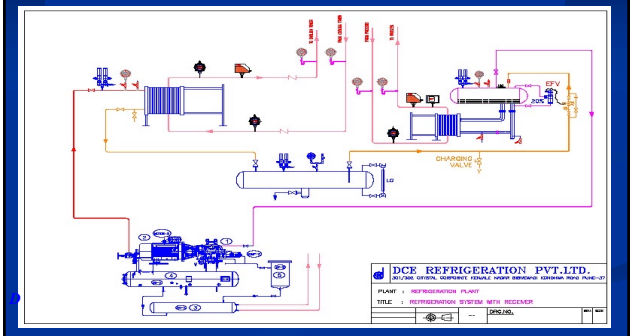
89

Various Design & Component options for Low charge systems

- 1. PHE condenser and chiller
- 2. High side float eliminating ammonia receiver
- 3. Micro channel heat exchangers –evaporators
- 4. DX evaporators and air cooled condensers
- 5. Aluminium air coolers and miscible oils
- 6. Cascade using high stage ammonia and low stage secondary fluids like brine, CO_2 etc.
- 7.One piece factory made unit for roof mounting
- 8. LVS systems-JBT patented
- 9. Neo Charge system-Danfoss patented

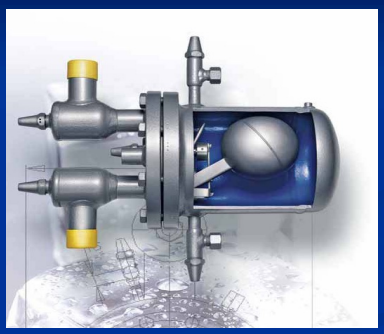
90

CONVENTIONAL AMMONIA REFRIGERATION LOW CHARGE SYSTEM USING PHE CONDENSER/CHILLER-



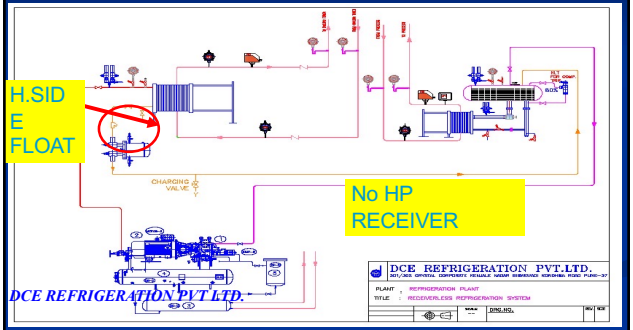
91

HIGH PRESSURE FLOAT – MAKE-WITT OR DANFOSS



92

LOW CHARGE AMMONIA REFRIGERATION SYSTEM WITH HIGH SIDE FLOAT & NO RECEIVER



93

CONVENTIONAL AMMONIA REFRIGERATION SYSTEM
- AMMONIA CHARGE CALCULATIONS FOR 350 TR CAPACITY

Sr No.	Equipment	Volume	Volume	Vapour	Liquid	Vapour NH3	Liquid NH3	Total NH3
		Liters	m3	%	%	Kg	Kg	Kg
1	Compressor	500.00	0.50000	100.00%	0.00%	1.730	0.000	1.730
2	Suction line	94.26	0.09426	100.00%	0.00%	0.326	0.000	0.326
3	Discharge line	60.33	0.06033	100.00%	0.00%	0.723	0.000	0.723
4	Liquid Line	61.94	0.06194	0.00%	100.00 %	0.000	35.891	35.891
5	Accumulator	1486.00	1.48600	70.00%	30.00%	3.599	284.692	288.292
6	Ammonia Receiver	967.00	0.96700	70.00%	30.00%	8.111	168.106	176.217
7	PHE Condenser 2.4 lit X 56 Cassetees	146.40	0.14640	80.00%	20.00%	1.403	16.967	18.371
8	PHE Chiller 1.4 lit X 69 Cassetees	96.60	0.09660	0.00%	100.00 %	0.000	61.690	61.690
	TOTAL AMMONIA CHARGE					15.89	567.35	583.24

94

LOW CHARGE AMMONIA REFRIGERATION SYSTEM
- AMMONIA CHARGE CALCULATIONS FOR 350 TR CAPACITY

Sr No.	Equipment	Volume	Volume	Vapour	Liquid	Vapour NH3	Liquid NH3	Total NH3
		Liters	m3	%	%	Kg	Kg	Kg
1	Compressor	500.00	0.50000	100.00%	0.00%	1.730	0.000	1.730
2	Suction line	94.26	0.09426	100.00%	0.00%	0.326	0.000	0.326
3	Discharge line	60.33	0.06033	100.00%	0.00%	0.723	0.000	0.723
4	Liquid Line	29.87	0.02987	0.00%	100.00 %	0.000	17.308	17.308
5	High Pressure Float	19.00	0.01900	40.00%	60.00%	0.026	7.280	7.306
6	Accumulator	1486.00	1.48600	90.00%	10.00%	4.628	94.897	99.525
7	PHE Condenser 2.4 lit X 56 Cassetees	134.40	0.13440	80.00%	20.00%	1.288	15.576	16.865
8	PHE Chiller 1.4 lit X 69 Cassetees	96.60	0.09660	30.00%	70.00%	0.000	43.183	43.183
	TOTAL AMMONIA CHARGE					8.72	178.24	186.97

DCE REFRIGERATION PVT LTD

95

COMPARISION

PARTICULAR	LOW CHARGE AMMONIA REFRIGERATION SYSTEM (RECEIVERLESS)	CONVENTIONAL AMMONIA REFRIGERATION SYSTEM (WITH RECEIVER)
COMPONENTS	COMPRESSOR + CONDENSER + EVAPORATOR	COMPRESSOR + CONDENSER +EVAPORATOR +RECEIVER
EXPANSION DEVICE	HP FLOAT	HAND EXPANSION VALVE
LEVEL CONTROL DEVICE	NOT REQUIRED	ELECTRONIC FLOAT / LEVEL CONTROLER & SOLENOID VALVE
REGRIGERANT CHARGE	186 Kg	583 Kg
ADDITIONAL CONTROL	HIGH LEVEL TRIP	MAY BE PROVIDED
PLANT CAPACITY	350 TR	350 TR

96

REFRIGERATION SYSTEM WITH RECEIVER



DCE REFRIGERATION PVT LTD.

97

REFRIGERATION SYSTEM WITHOUT RECEIVER



DCE REFRIGERATION PVT LTD.

98

Star Refrigeration U.K. Roof Top Units using Low charge Ammonia systems



99

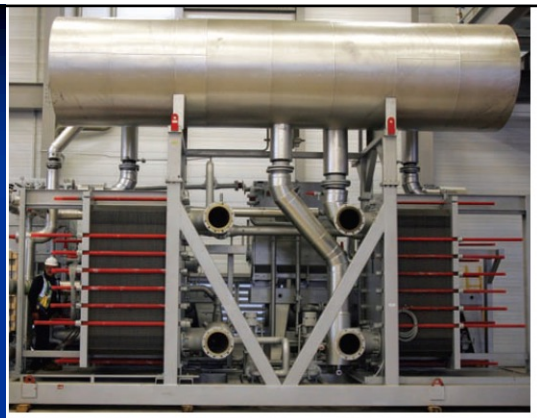


Photo 3: Ammonia chiller at Heathrow Airport (picture courtesy of JCI/Sabroe).

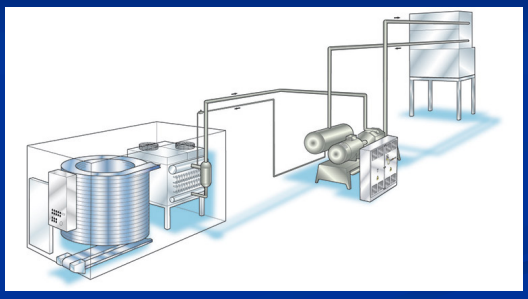
100

AIR COOLED AMMONIA PACKAGE CHILLER-Azane by Star Refrigeration UK-784kW-200kg (0.86kg/Ton)refrigerant charge



101

LVS (Low Volume System) SYSTEM BY JBT - FRIGOSCANDIA



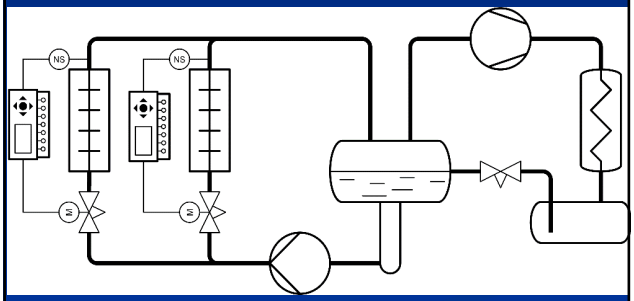
102

Advantages as indicated by JBT

- Can be installed in a few days and is easy to retrofit on all your freezers and chillers; also easy to relocate
- Fully automatic controls integrate with the freezer control panel;
- Compact design, with smaller pipe dimensions and no need for a large pressure vessel, resulting in lower refrigerant costs
- Requires little floor space and provides great location flexibility
- Fast temperature pull-down. Low-temperature freezing (down to -50˚C/-60˚F) provides increased freezer capacity and lower food product dehydration
- No refrigerant pumps means easier maintenance with longer service intervals

103

Danfoss Controlled Circulation Rate-Neo Charge system



104

Neo Charge System

Using Neo Charge means that the manual regulating valve at the evaporator inlet is replaced by an electronic valve and that a controller is used to control the valve opening based on the signal from the NeoCharge sensor (NS) as shown in the previous figure

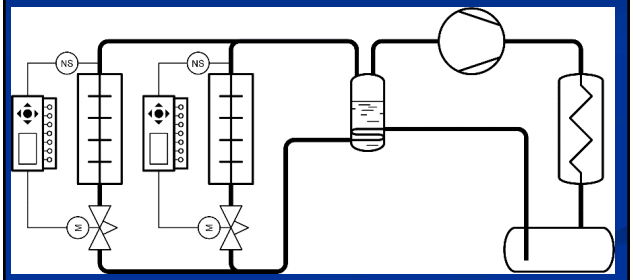
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Working of Neo Charge System

Controlling the circulation rate using NeoCharge has several advantages:
The refrigerant charge is minimized. This is increasingly important for especially ammonia refrigeration systems due to requirements to safety and documentation for systems with high ammonia charge.
The efficiency of the system is maintained because the evaporators are still operating (slightly) flooded. And in some situations, the efficiency is improved because the amount of liquid in especially the wet return line and risers is reduced.
NeoCharge addresses the increased energy consumption by allowing only a small amount of liquid out of the evaporator while keeping the superheat to zero. This means that the efficiency increases (no need to lower the evaporation temperature), but it also means that the systems needs to be built with a suction accumulator:

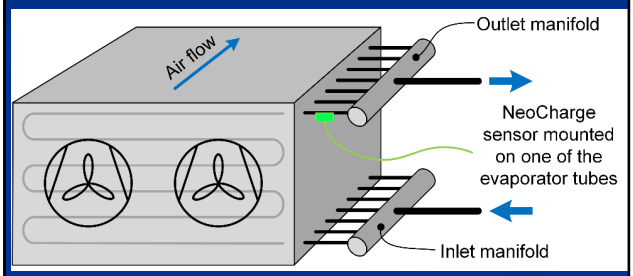
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Neo Charge System Requires Accumulator



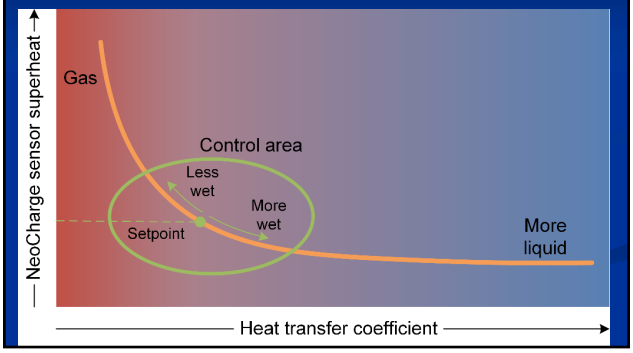
107

Neo Charge sensor mounted on one of the evaporator outlet tubes



108

Neo Charge sensor superheat signal depending on overall heat transfer coefficient



109



Thank you

110

AMMONIA REFRIGERATION SYSTEMS

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111