AMMONIA PUMP CIRCULATION SYSTEMS

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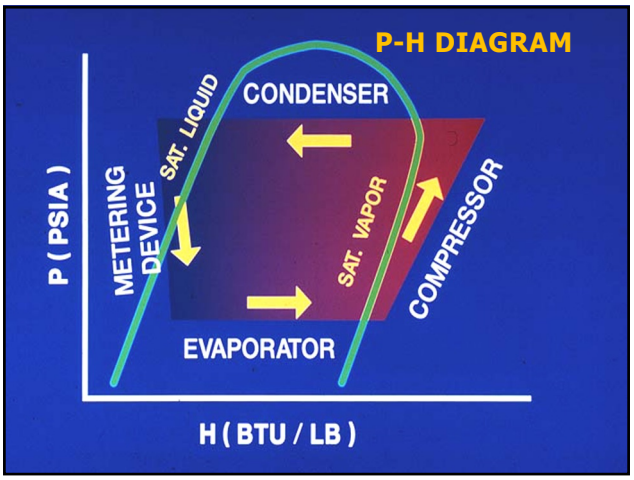
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Basic Components of A Refrigeration System

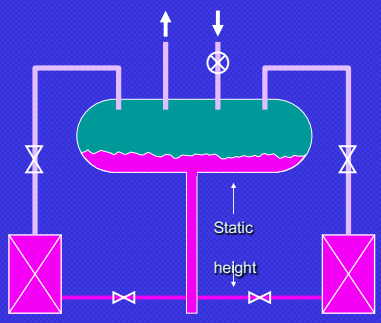
- Evaporator
- Condenser
- Compressor
- Liquid Expansion Device

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Gravity Flooded System



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Gravity Flooded System Characteristics

Mostly similar characteristics as pumped systems

No extra pump & pump energy necessary

Static pressure (liquid column) necessary to overcome the pressure drop in the coil, piping ,valves, controls

Normally flow rate is two times evaporation rate(Ref:W.F. Stoecker Book)

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Force Feed Pump Circulation Systems

1. In the pumped system the low temperature liquid Ammonia, instead of going to the evaporators, is stored in the Low Pressure Vessel (like a storage tank) and then it is circulated with the help of pump to various air coolers/freezers/evaporators
2. The excess unevaporated liquid and vapours formed due to the system load return to L.P. vessel instead going directly to the compressor.
3. So this becomes an additional component in the refrigeration system

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In pump circulation system design, the major advantage is one effectively decouples refrigeration system with load allowing more efficient operation and lot of flexibility for designer and the operator and for fault detection.

The compressor, condenser and liquid separator becomes one circuit and the second circuit is liquid separator, pumps and air coolers/evaporators.

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So long as there is enough liquid in the L.P. vessel and at the required temperature, it means refrigeration system design is doing correct job and if the problem still exists, then one can look at the pump circulation circuit alone.

Similar example is corporation overhead water tank. So long as the tank is having enough water and if we are not getting proper water supply in our house, that means there is something wrong in our piping system.

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The liquid- overfeed or also known as pump recirculation system designs are, more popular with ammonia refrigerant because in ammonia refrigerant system smaller mass flow rate is required to be handled as compared with R-22 refrigerant systems. A 100-TR plant with -25^0 C /+40^{0}C requires about 1193kg/hr. of saturated liquid ammonia to provide desired refrigeration effect.

If for same application R-22 is used then the liquid flow rate would be about 8317 kg/hr. This means a pump having circulation rate in ratio 4:1 would require 10 kW pump motor for R-22, whereas for ammonia it would be only 3 kW.

Since these pumps are running continuously so long as plant is in operation, it contributes substantial additional operating cost.

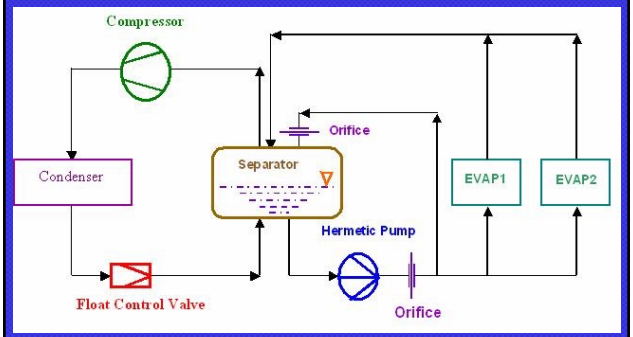
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When to use Overfeed?

1. More than 3 to 4 freezers or cold rooms
2. More suited for low temperature applications
3. Processing area away from machine room
4. Better efficiency
5. Dependability/Reliability

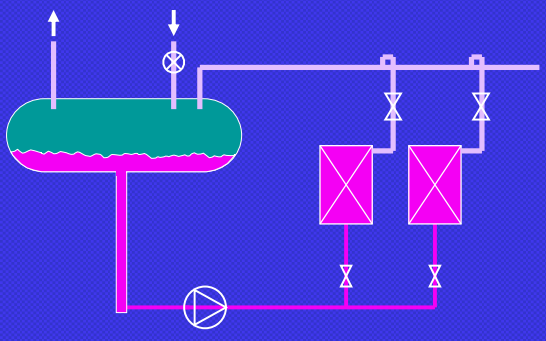
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System layout



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Pumped System-Overfeed Systems



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Difference Between Circulation rate & Over feed rate

Circulation rate 4:1 =

Supply to freezer (4kg) Liquid/ Evaporation of (1 kg) Liquid in to Gas equal to load

OR

Overfeed rate 3:1 =

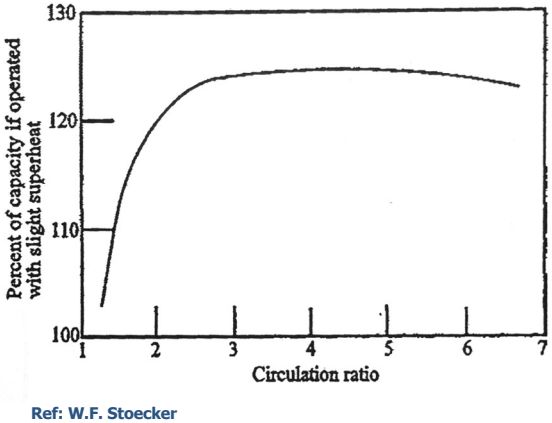
Liquid return (3 kg) / Evaporation (1 kg) Liquid into the Gas, means you have overfed evaporator with liquid 3 times more, circulation rate is one more than overfeed rate.

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The overfeed means excess liquid is fed to evaporator than the liquid actually vaporizes. Excess liquid is called overfeed, which returns to low pressure side accumulator or L.P. receiver.

Overfeeding also ensures that the vapours coming out of the evaporator are at close to saturated temperature condition without any substantial superheat thus lowering compressor inlet gas temperature, which also means corresponding lower discharge gas temperatures, which are critical factor for ammonia systems working at low temperature applications. Higher discharge temperatures pose many problems for the compressor & lubricating oil.

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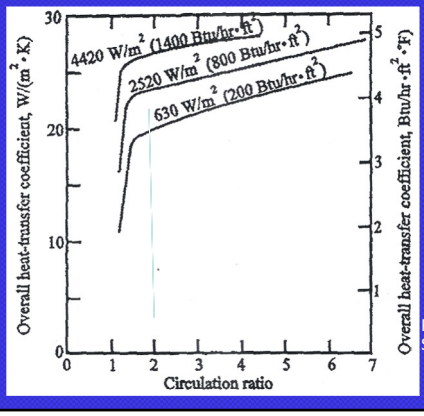


Ref: W.F. Stoecker

Effect of circulation ratio on the overall heat-transfer coefficient of an air-cooling coil[1].

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Optimum circulation rate



Ref: W.F. Stoecker

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Recommended Circulation Rates For Bottom Feed Evaporators

	CO2	AMMONIA	R22
Blast freezers/ Air Coolers	1.2-2	3-4	2-3
Plate Freezers	5-10	7-14	5-12
Liquid Chillers	1.2-1.5	1.2-1.5	1.2-1.5

Excess rate means you are wasting Pumping energy

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L.P. Receiver Package

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Low Pressure Vessel & piping

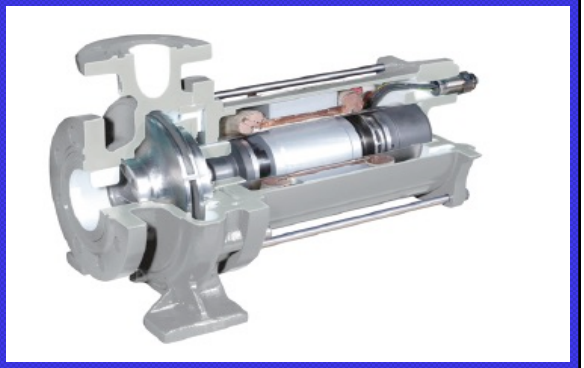


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L.P. Receiver Package



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Hermetic Ammonia pump

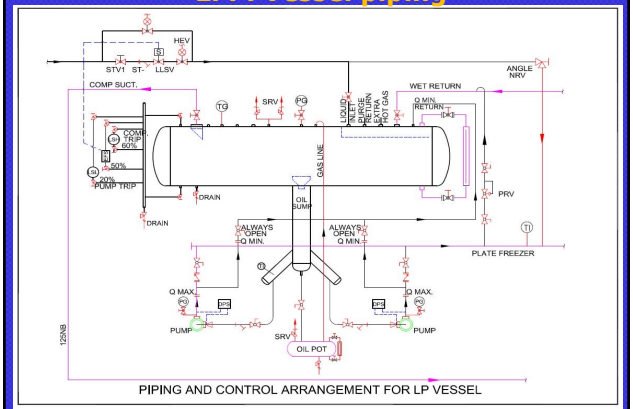
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L.P. Vessel Assembly



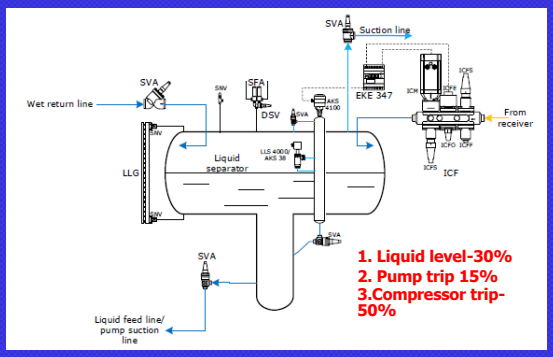
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L. P. Vessel piping

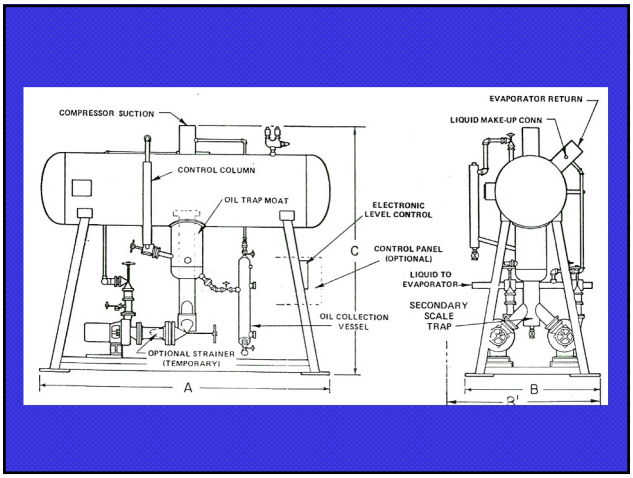


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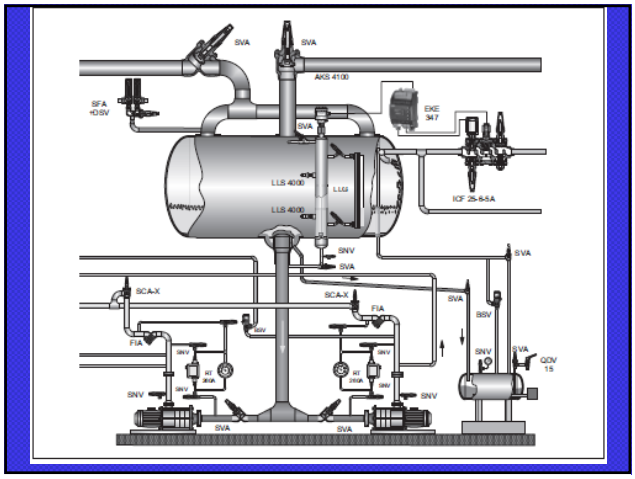
L.P. Vessel Piping



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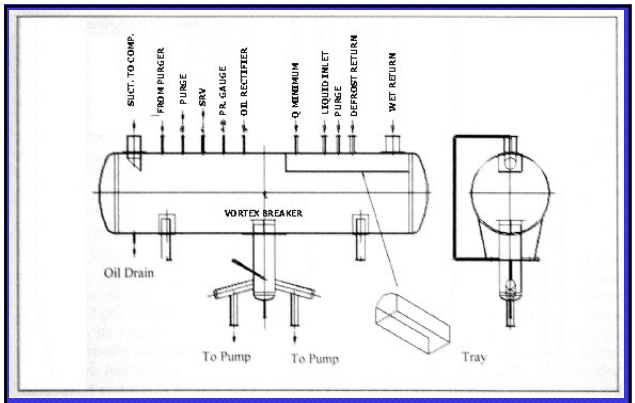
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Design Details of Low Pressure Receiver

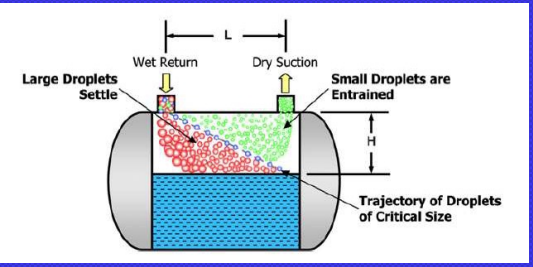
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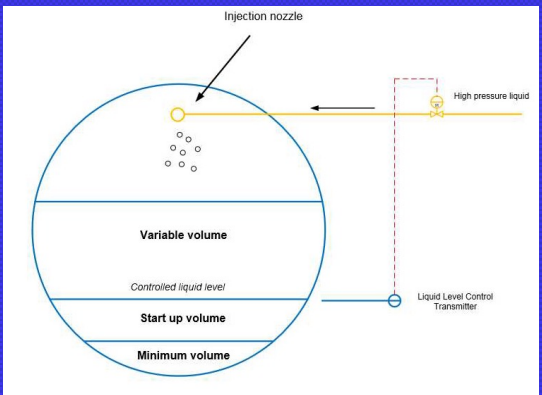
Low Pressure vessel details-Most Important Vessel

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Liquid Droplets & their flow pattern



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Optimum Liquid Levels To be maintained

1. Operating Level-25 to 30%
2. High level trip for compressor stop--50%
1. Low level trip for pump shut down-15 to 20%

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Surge volume

the volume above working liquid level provided in the vessel, is known as surge volume and serves the purpose of accommodating liquid that might be forced out of evaporators during defrosting of one or more evaporators.

Another aspect needs to be considered is the liquid in the wet return line from evaporators to L.P. vessel, which may drain in the L.P. vessel if power shut down takes place and the liquid refrigerant pump becomes inoperative.

In normal circumstances the amount of liquid + vapour returning is same as pump circulation feed to evaporators, but when pump is not working, the extra liquid quantity gets added to vessel from the wet suction line and vessel design needs to take this quantity into account in addition to defrost quantity.

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Ballast Volume

1. The other important level on the lower side of the operating liquid level is the liquid required either during start up after a pump-down cycle or if additional evaporators are taken on line for operation. During this period the liquid drawn from the vessel is at higher rate than it is returning to L.P. vessel.
2. The alarm indication for this minimum level should be provided making the operator aware about the falling liquid level.
3. The ballast volume is generally calculated for **5** minutes period meaning pump flow rate per minute multiplied by **5**.

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Liquid channel

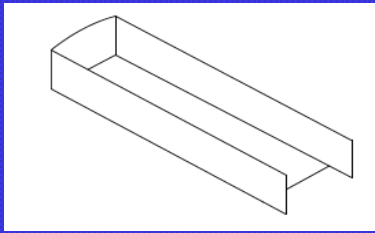
While constructing L.P. vessel, provide a liquid channel inside the L.P. vessel, which is fully welded from all sides except open on one side as shown

All liquid connections should be brought/taken to this channel so that there is no risk of liquid going to the compressor

Be careful of locating pump bypass return line at correct place otherwise there would be pump pressure development problem. I have experienced this and have learned the hard way. Connect this bypass line in wet return rather than in the Liquid Channel

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Liquid Channel Inside L.P. Vessel



Length-750-800mm Long

Height -150mm

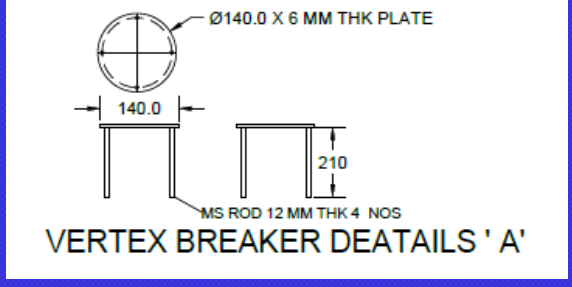
Width-200-250mm

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Vortex Breaker



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VERTEX BREAKER DEATAILS ' A'

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Vortex breaker



Cross Type Vortex Breaker installed at nozzles

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Recommended Sizes For Down Leg to Pump

Approx. Pump Flow Rate	5m³/hr	12m³/hr	15m³/hr	35m³/hr	70m³/hr
Pump Suction Size-mm	32	50	50	80	100
Down Leg Size-mm	80	100	125	150	250

Design Velocity Less than 0.3m/s

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Adjustment of flow rate and Pressure –most Important

Inlet / outlet temperature difference 1.5 ^{0}C to 2 ^{0}C max.

Inlet pressure: Just enough to overcome freezer + wet return pipe line pressure+ valves, controls

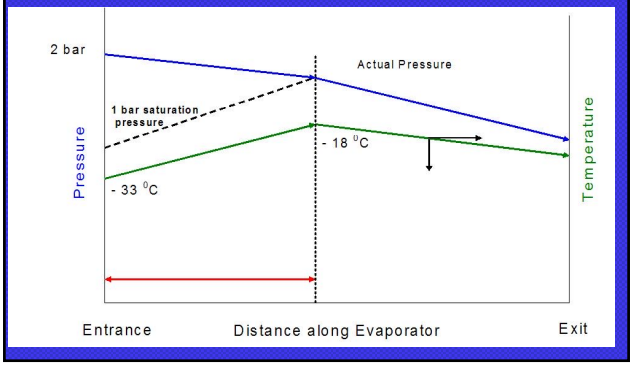
Higher temperature difference / Higher pressure means waste of evaporator area.

- 32 ^{0}C liquid / 1 bar$_a$ saturation
- 32 ^{0}C liquid / 2 bar$_a$ pr (- 18 ^{0}C saturation)

14 ^{0}C sub-cooling to overcome, Evaporator area wasted

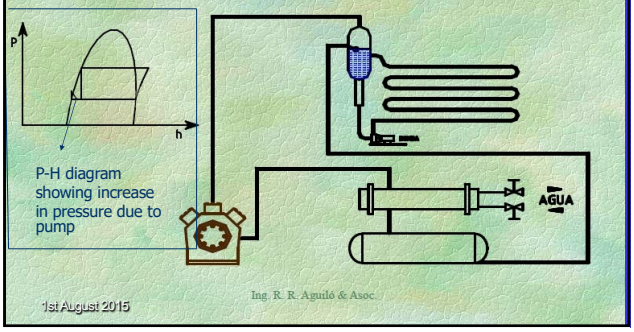
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Effect of higher than required pump pressure at inlet of evaporators



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Flow Control Methods Recirculated Systems



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Adjusting Pump Bypass PRV valve –Important

1. Normally the pump capcity is selected which is in excess of requirement especially on part load operation, such as say out of 4 coolers only two are operating and others are closed
2. The excess liquid is then bypassed from pump outlet back to L.P. vessel through PRV
3. Setting of PRV is important-
    1. When the plant is new , open all the valves , start the pump and record pump inlet and out let pressures
    2. This is maximum pressure drop of the system
    3. Adjust PRV to open at 1 kg/cm2 pressure , more than the total system pressure drop
    4. This will ensure that when some air coolers are not operating, the higher pressure developed by pump due to reduced pressure drop, is bypassed back to L.P. vessel

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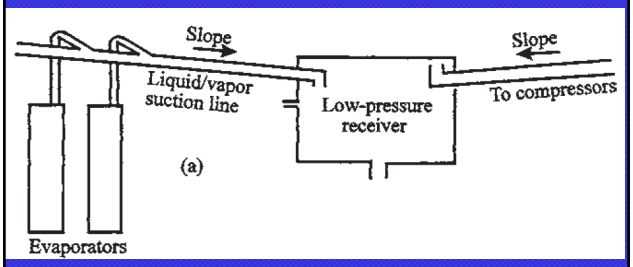
Ammonia Pump Protection

1. Q max-This orifice installed in the line ensures that pump motor does not get overloaded, due to higher flow which can happen when there is less pressure drop in the entire system, due to some freezers/coolers are not in operation

2. Q Min-This orifice installed in the pipe line ensures that the pump motor does not get overheated and the minimum flow is maintained to ensure pump motor winding e cooling

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L.P. Vessel Piping Arrangement



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WHY USE FLOW REGULATING VALVE?

The pump circulation system uses FRV (Flow regulating valve.). Liquid is already expanded before entering L.P. vessel-No additional expansion valve is needed

The advantage of flow regulating valve is it ensures uniform liquid supply, irrespective of load fluctuations.

The hand expansion valve used in Gravity flooded system, works opposite to load demand. When the load reduces, the pressure drop across the valve increases as the suction pressure drops while incoming pressure remains same as receiver outlet pressure and the valve supplies more liquid when in reality, we require less liquid.

Similarly, when load increases, the suction pressure increases, the liquid supply before the expansion valve having same pressure as receiver pressure, the pressure drop across the valve reduces and thus admitting less liquid when in reality we need more liquid. Hence use of FRV, in pump circulation system, ensures constant flow, irrespective of load fluctuations and when load reduces excess liquid is bypassed to the wet return line from pump discharge

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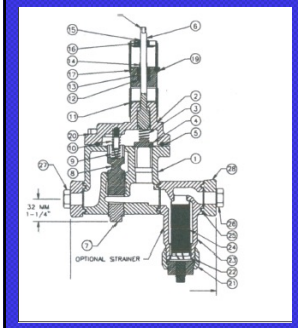
Automatic Liquid Flow Regulating Valve(FRV) V/S Hand Expansion valve





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Flow Regulating Valve



Hand operated expansion valve

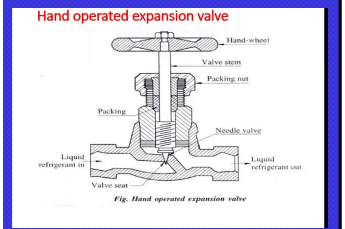


Fig. Hand operated expansion valve

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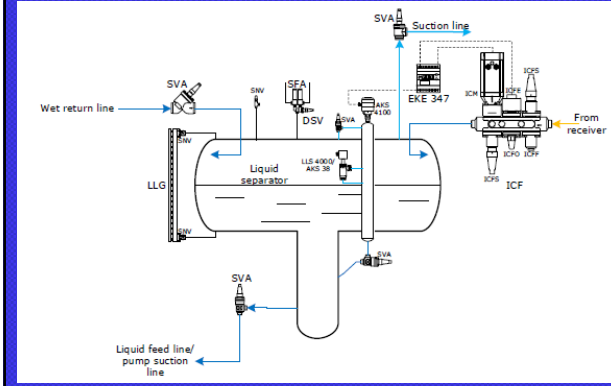
Flow Regulating Valve for Pump circulation systems

The precision built, Automatic flow regulator is used for Ammonia pump circulation overfeed systems.

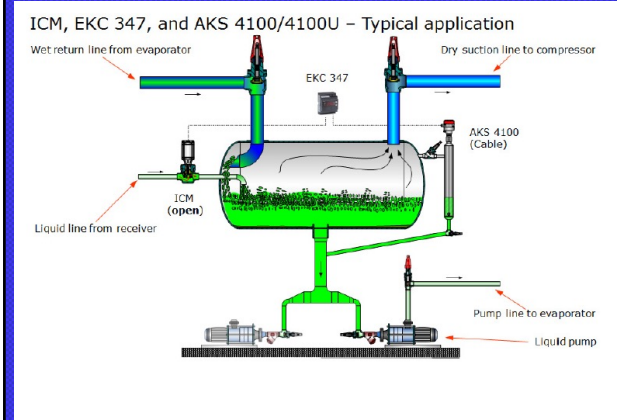
The flow regulator once set, by the adjusting stem which is marked for flow ratio, for particular flow ratio say 4:1, maintains constant flow rate of liquid to the evaporator despite fluctuations in the liquid inlet or evaporator pressures due to load fluctuations.

It also serves as non return valve to prevent back flow into the liquid line from the evaporator during pressure reversals which is required during hot gas defrost cycle.

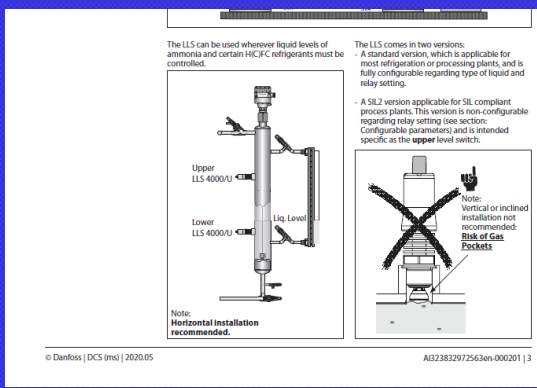
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Suggested Line Sizing Velocities

a) Suction line (NH3)	15.0-17.5m/sec
b) Discharge line (NH3)	17.5-20.00m/sec
c) Liquid line (NH3) condenser to receiver	0.5 - 0.6 m/sec
d) Liquid line (NH3) receiver to system	1.0 to 1.5 m/sec
e) Wet return line (NH3)	8 to 10 m/sec
f) Suction line (H20)	1.0 to 1.2 m/sec
g) discharge line (H20)	2.0-2.5 m/sec

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Piping valves

- Use ball valves
  1. Wet return line / suction line/Pump inlet line
  2. Keep Minimum pressure drop
  3. Higher operating compressor suction pressure
  4. Energy savings

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Wet Return Pipe sizing

Table 1-6A
Tons Capacity of Vapor Flow in Overfeed Return Lines

Service	Deg. F Temp	psig Press.	Deg. F/ft (Note 6)	NPS 1 Sch 80	1-1/4 80	1-1/2 80	2 40	2-1/2 40	3 40	4 40	5 40	6 40	8 40	10 40	12 Std	14 Std	16 Std	18 Std	20 Std	24 Std
Table 1-6A Overfeed Return Lines	40	58.4	0.03	5.35	9.90	13.91	27.48	40.03	63.39	113	181	267	487	768	1121	1380	1853	2412	3019	4483
	30	44.9	0.03	4.79	8.87	12.46	24.61	35.85	56.78	101	162	239	436	688	1004	1236	1660	2161	2704	4016
	20	33.4	0.03	4.22	7.81	10.98	21.69	31.60	50.04	88.85	143	211	384	606	885	1089	1463	1904	2383	3539
	10	23.7	0.03	3.73	6.91	9.71	19.18	27.94	44.25	78.56	127	186	340	536	782	963	1294	1684	2107	3129
	0	15.6	0.03	3.27	6.06	8.51	16.81	24.49	38.80	68.87	111	163	298	470	686	844	1134	1476	1848	2743
	-10	9.0	0.03	2.88	5.34	7.50	14.81	21.58	34.18	60.68	97.74	144	262	414	604	744	999	1301	1628	2417
	-20	3.5	0.04	2.49	4.60	6.47	12.78	18.62	29.49	52.36	84.33	124	226	357	521	642	862	1122	1404	2085
	-30	1.7"	0.05	2.13	3.94	5.54	10.93	15.93	25.22	44.78	72.13	106	194	305	446	549	737	960	1201	1784
	-40	8.8"	0.05	1.80	3.33	4.68	9.25	13.47	21.33	37.88	61.01	89.86	164	258	377	464	624	812	1016	1509
	-50	14.4"	0.06	1.53	2.83	3.98	7.86	11.45	18.13	32.19	51.85	76.37	139	220	321	395	530	690	864	1282
	-60	18.7"	0.07	1.27	2.35	3.31	6.53	9.51	15.07	26.75	43.08	63.46	116	182	266	328	440	573	718	1065

NOTES:

1. To adjust for pipe cost, power cost, hours of use, and years of life, see the equation in the text.
2. The capacities in the table are recommendations based on a circulating number (n) of 4, where n = 1/x, and x = exit vapor quality.

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Wet Return line Sizing

ASHRAE Refrigeration Volume Recommendations-Chapter 7

Use one pipe larger than calculated for vapour flow alone

Use a velocity selected for dry expansion reduced by the factor

V1/circulation rate

This method suggests that the wet return velocity for a circulating rate of 4 is v1/4=0.5

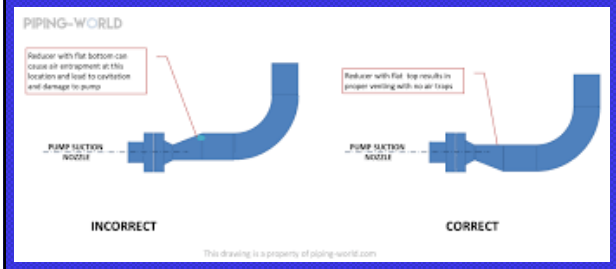
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Recommended Sizes For Down Leg to Pump

Approx. Pump Flow Rate	5m³/hr	12m³/hr	15m³/hr	35m³/hr	70m³/hr
Pump Suction Size-mm	32	50	50	80	100
Down Leg Size-mm	80	100	125	150	250

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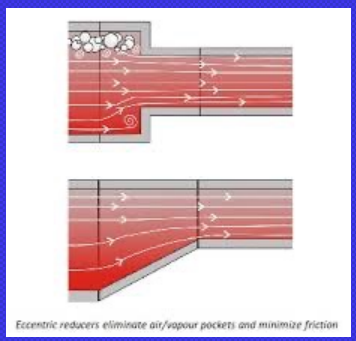
Reducer Installation



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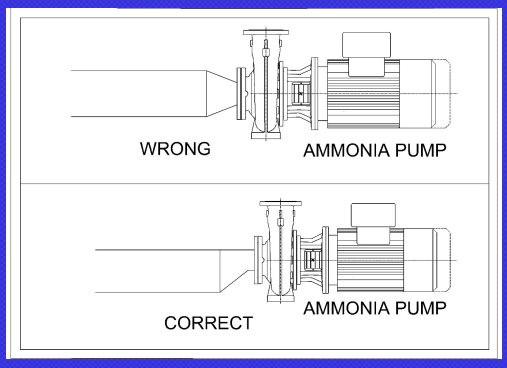
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Bubbles interfering the flow pattern

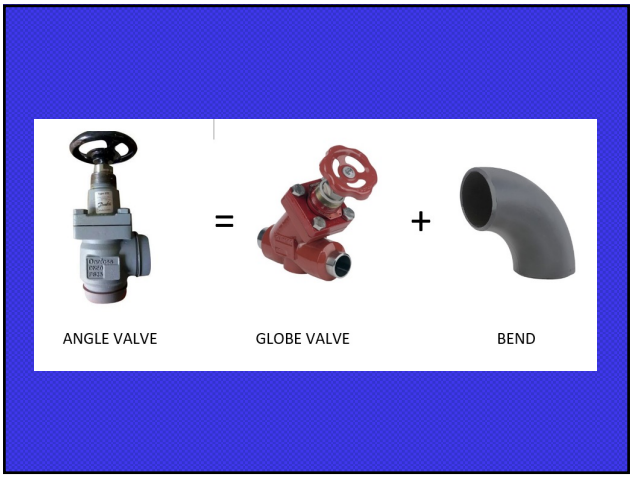


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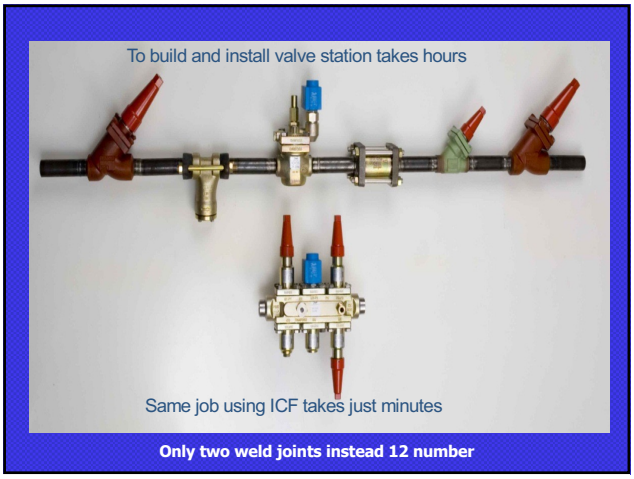
Ammonia Pump piping with Reducer



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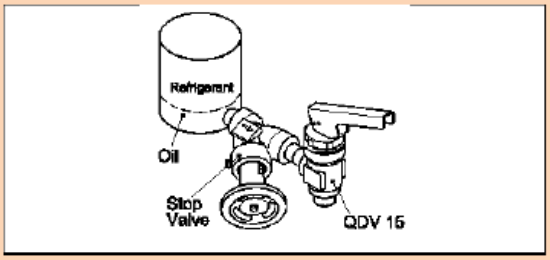


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QUICK CLOSING OIL DRAIN VALVE



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Important Considerations often overlooked

1. Cavitations to be avoided as it affects pump capacity & cause considerable damage to pump seals, impellers, motors, and casing and does not build pressure
2. Reverse rotation of pump to be avoided-Can be checked from pump discharge pressure & noise
3. NPSH should be considered from bottom of LP vessel to center line of pump
4. Pump head should be sufficient to overcome the required height lift, pressure drop in liquid lines,& valves, throttling devices & evaporators
5. Pump inlet filter may be removed after some time when system becomes clean
6. If there are more pumps, then each pump should be connected to the LP vessel independently to avoid interaction with other pumps

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Important Considerations often overlooked

7. Horizontal surge drum preferred over vertical to provide sufficient surface for settlement of oil & enable stable suction head conditions
8. Use of vortex breaker essential in down leg to avoid cavitations
9. Down leg should protrude 30 to 40 mm in the LP vessel to avoid oil and dirt in the pump suction
10. In pump inlet horizontal pipe lines should be avoided
11. Full bore valves are recommended in the pump inlet line
12. The down leg should be designed for velocity less than 0.3m/s
13. Pump venting line should be provided from top of pump to minimize possibility of vapor collecting in pumps

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Important Considerations often overlooked

14. Pump discharge pipe should be designed for velocity not exceeding 1.5m/s
15. Stop check valve in pump discharge essential when two or more pumps are connected to common discharge manifold to avoid reverse running of pumps not in use
16. At all times pump suction valve containing sub-cooled liquid should be kept open. Discharge valve can be closed
17. Pumps should be mounted on flexible mounts to avoid stresses on flanges due to expansion/contraction of pipes subjected to temperature fluctuations from ambient to minus 40 deg C
18. Pump operation should be rotated between working and standby pumps

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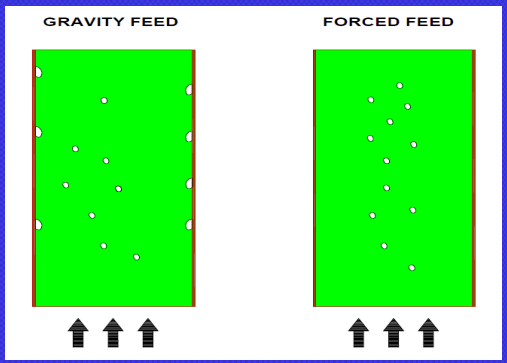
Important Considerations often overlooked

19. If more than one evaporators on working on common liquid header use two solenoid valves for each cooler inlet. Small solenoid to open first to equalize pressure. After time delay of 4 to5 minutes main solenoid to open to avoid liquid hammer and vibrations

20. Use FRV in evaporator inlet preferred instead hand expansion valve

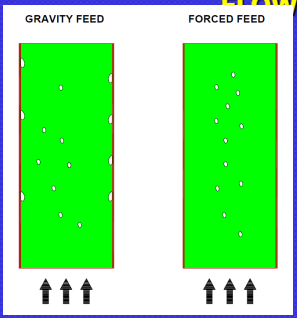
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Gravity Flow V/S Pumped Flow



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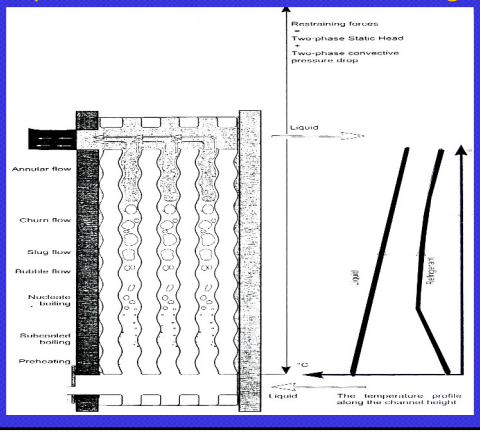
GRAVITY FLOW V/S PUMPED FLOW



IN PUMP CIRCULATONSYSTEM GAS BUBBLES ARE ENRAPPED IN EXCESS LIQUID FLOW, WALLS ARE ALWAYS IN CONTACT WITH LIQUID HENCE BETTER HEAT TRANSFER

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Liquid movement in a heat exchanger



70

The ammonia liquid density at minus 40^{0}C is 690.4kg/m3, whereas vapour density is only0.64kg/m3. This means the liquid when evaporates and the gas is formed; the gas tries to occupy maximum space thus depriving of effective evaporator surface deprived of wet refrigerant.
This can be explained in a better manner if we compare specific volumes of liquid and gas at -40^{0}C

The specific volume of ammonia liquid at -40^{0}C is 00.1449m3/kg whereas specific volume of ammonia gas is 1.5624m3/kg. The specific volume of gas being more, in gravity flooded systems, the substantial evaporator inner surface is covered with gas bubbles and liquid gets entrapped in the gas and thus reduces heat transfer.

71

Due to the high latent heat of ammonia, the quantity of liquid that enters an evaporator tube is very small, often occupying less than 2% of the cross-sectional area of the tube. For efficient heat transfer to result in optimum performance, excess liquid ammonia is therefore pumped into the evaporator tube.

This excess liquid "sloshes" around the inside perimeter of the tube ensuring a liquid ammonia film coats the inside of the tube completely to absorb external heat having higher temperature than liquid inside the evaporator tubes.

If there is no excess liquid, more areas of the at the tube surface would remain dry, & occupied with vapour bubbles, diminishing the performance of the evaporator which mostly happens in gravity flooded systems

72

- The publication by National Horticultural Board for Cold storages No. NHB-CS Type 01-2010 also suggests on page 57 that cooling coil surface area may be 5-10% lower if pump circulation force feed system is used.

73

Advantages with Overfeed

1. Higher circulation: Improved heat transfer by completely wetting internal tube surface
2. Compressors are protected from liquid slugs caused by fluctuating loads
3. Efficient freezer operation: Freezer operation de-coupled from main refrigeration system
4. Refrigerant feed independent of fluctuating condensing conditions due to ambient conditions variation

74

Advantages with Overfeed

Better Compressor operation

5. Minimum superheat: Means Less discharge temperature-L.P. vessel is in the machine room

6. Oil recovery simple in L.P. vessel/oil drain pot

7. With simple controls, evaporators can be defrosted with hot gas with no disturbance to the system

8. Flash gas is removed in the LP vessel before the liquid enters the evaporators. This gas is directly drawn by compressor. It does not contribute additional pressure drop in liquid line

75

Advantages with Overfeed

9. Trouble shooting easier since L.P. vessel and evaporators are having independent circuits.

10. As long as L.P. vessel is having sufficient liquid and at required temperature, it means compressor side there is no system fault

11. One can then concentrate on L.P. circuit and evaporators if there is any malfunction

12. All major equipment is in the plant room including controls and L.P. vessel ,Pumps which is under operator's surveillance and has limited access to outsiders.

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Advantages with Overfeed

13. Ideal suction gas conditions entering compressor with minimum superheat

14. Compressor life is extended

15. Less maintenance-fewer breakdowns

16.Oil circulation rate at evaporators is reduced because of low compressor discharge superheat

17.Liquid feed to evaporators more reliable since liquid is sub-cooled(pressurized) hence no flashing in the liquid feed line

18. Automatic operation convenient

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Advantages with Overfeed

19. Oil does not accumulate in evaporators. Oil draining is convenient in the plant room from L.P. vessel

20.There is uniform liquid distribution in all evaporators.

21 Each evaporator does not require independent accumulator, and level controller

22. More suitable for low temperature applications since flash gas is removed in LP vessel & only low temperature liquid goes to the evaporators

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Possible Disadvantages

1. Total refrigerant charge in system is higher
2. Due to higher flow rates of liquid to evaporator liquid line and wet return line sizes are of larger diameter
3. Insulation cost is more due to larger pipes
4. liquid supply lines also need to be insulated as they are conveying low temperature liquid
5. Installed cost is higher
6. Pumps consume extra energy but is usually compensated due to higher efficiency

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Possible Disadvantages

7. Pumping units require maintenance

8. Mechanical pumps subjected to cavitation if proper precautions not taken in providing sufficient net positive suction pressure

9. Problems of liquid hammer during defrosting need to be taken care by proper piping design and defrosting sequences

10. Automatic defrost independent to each cooler essential to avoid liquid accumulation

11. Liquid traps to be avoided-safety valve may be essential in liquid line

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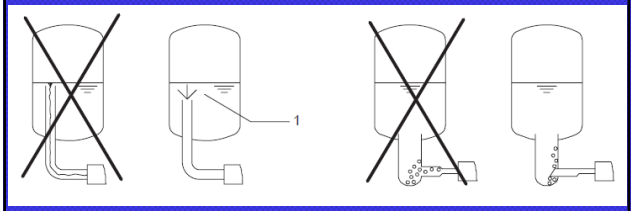
Cavitation-Problem No.1

Many forced circulation Ammonia pump system designers face this problem some day or the other in one of their plants
The reasons could be many

1. Undersized liquid leg
2. Connections to pump not proper
3. Incorrect connection of reducers
4. No vortex breaker
5. And many more

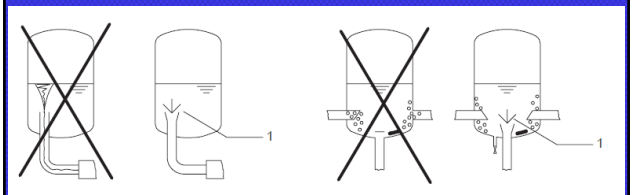
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Avoid Cavitation



82

Avoid Cavitation



83

Avoid Cavitation

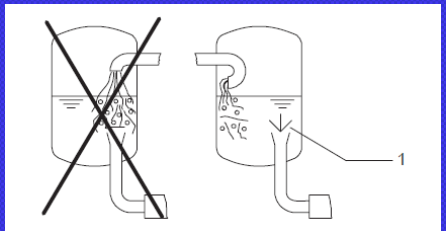


Fig. 9 Vessel inlet/vessel outlet arrangement

1 Vortex breaker

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AVOID CAVITATION

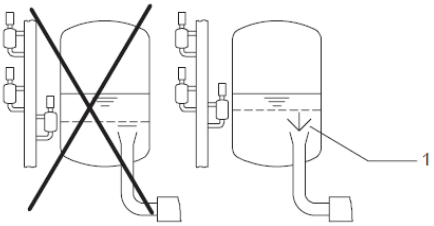


Fig. 10 Level monitor arrangement

1 Vortex breaker

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Avoid Cavitation

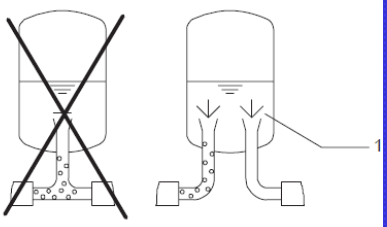


Fig. 11 Parallel operation arrangement

1 Vortex breaker

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Problem No -2

Hydraulic shock or water hammer

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Possibilities of Hydraulic shock

Trapped Liquid is the complete filling of the internal volume of a containment, such as a pressure vessel or pipe, with liquid refrigerant. This is also referred to as hydrostatic lockup.

Sudden Liquid Deceleration is the rapid decrease of liquid flow in a line or pipe, as a result of the sudden closing of a valve. This is also referred to as hydraulic shock or liquid hammer.

Vapor Propelled Liquid is the movement of liquid refrigerant propelled at high velocity by high pressure vapor in hot gas and suction lines. This is also referred to as hydraulic shock, liquid hammer or surge.

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Liquid hammer or hydraulic shock

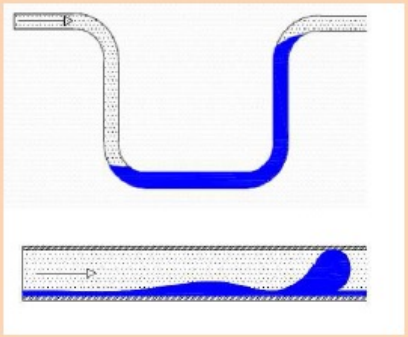
1. Hydraulic shock is a sudden localized spike in pressure that can occur in piping or equipment when there is rapid change in the velocity of a flowing liquid. Often referred to as “water hammer”, hydraulic shock is well understood phenomenon that has occurred in water and steam systems found in both domestic and industrial settings.

2. In ammonia refrigeration, hydraulic shock events can generate extremely high pressures with the potential of failure of piping, valves, and other equipment. The highest pressure often occur when vapour or liquid ammonia are present in a single line and are disturbed by a sudden change in volume.”

3. Moderate hydraulic shocks lead to vibrations and a knocking sound emanating from piping or valves.

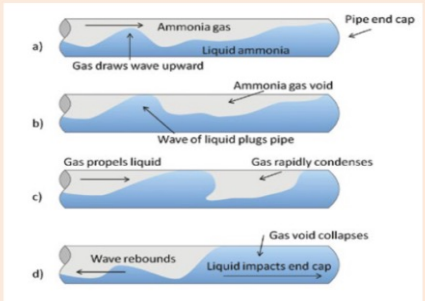
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Liquid Hammer-Liquid Trap



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HYDRAULIC SHOCK



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A Pipe ruptured due to liquid Stroke



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A Pipe ruptured due to liquid hammer



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Key Lessons summarized to avoid liquid stroke/liquid hammer:

1. For the design of ammonia system, avoid grouping multiple, large capcity evaporators to a single set of controls, provide separate controls to each evaporator
2. Program the defrost control sequence to automatically depressurize or empty the coil after defrosting, prior to opening the suction stop valve to restart cooling cycle
3. Avoid manual interruption of evaporators while in defrost mode and equip controls to ensure only authorized and trained personnel are present.
4. Before staring hot gas defrost, ensure that entire quantity of liquid refrigerant has ben pumped out from the evaporator coil before admitting hot gas, especially after low load period or after power outages.
5. Connect all outlet pipes from evaporator coils to wet return with reverse 'U' connection, like gent's umbrella handle , to ensure liquid is not entering the from the wet return line into the evaporator which is getting defrosted.

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Piping Practices To Decrease Hydraulic Shocks

1. Hot gas piping-No traps, if traps unavoidable then provide liquid drains
2. The evaporator must be fully drained before admitting hot gas, not giving any liquid slugs, free flow for hot gas through evaporator to suction piping
3. Especially important for evaporators with vertical suction header and bottom feed
4. Evaporator shut off valves with stem horizontal
5. Wet suction should contain no traps
6. Evaporator outlet connection from top of wet return header
7. Wet suction and branches-No dead end or closed valves
8. Do not overcharge or undercharge LP vessel
9. Use soft gas defrost with smaller solenoid in parallel to equalize pressures for larger plants both in liquid and hot gas defrost lines to evaporator

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CONCLUSIONS

1. L.P. vessel should be designed for 300 psi since long/accidental shut down may lead to increase in pressure.

2. High level alarm should be set at 30 % level and shut down at 50 % level Suction pipe to pump should be sized for 3 fps velocity. Ball valves are best in pump suction to give full flow.

3. Pump should be at least 6 pipe diameters away from elbow and eccentric reducers at the pump flange are recommended, when direct vertical inlet to pump is not possible. Preferred piping is always vertical direct inlet to pump suction.

4.Pump mounting plates may be supported on flexible mounts to accommodate piping length variation due to temperature variation.

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CONCLUSIONS-CONTINUED

5. Oil drain pot should not be insulated and a pressure relief valve must be provided for the drain pot.

6. The mouth of drop leg should protrude about 2inch into LP receiver to prevent any oil collecting from being ingested by pump.

7. Minimum 4 feet distance between vessel bottom to pump inlet to ensure enough NPSH requirements.

8.Vortex breaker in the inlet line of liquid to pump in the LP receiver should be provided.

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CONCLUSIONS-CONTINUED

9.Pumps should be selected for low NPSH (1.5 to 2.5 ft head). The liquid level from centre line of pump suction to ammonia operating level should be twice the pump NPSH.

10.Provide independent suction pipe to each pump and not from common drop leg, if possible, to ensure that vapour bubbles caused by heat transfer from standby idle pump into suction of operating pump are avoided.

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5. Hermetic Pumpen-Germany
6. W.F. Stoecker-Industrial Refrigeration handbook
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Any Questions????

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