Ammonia Refrigeration Piping
Good Engineering Practices

BY

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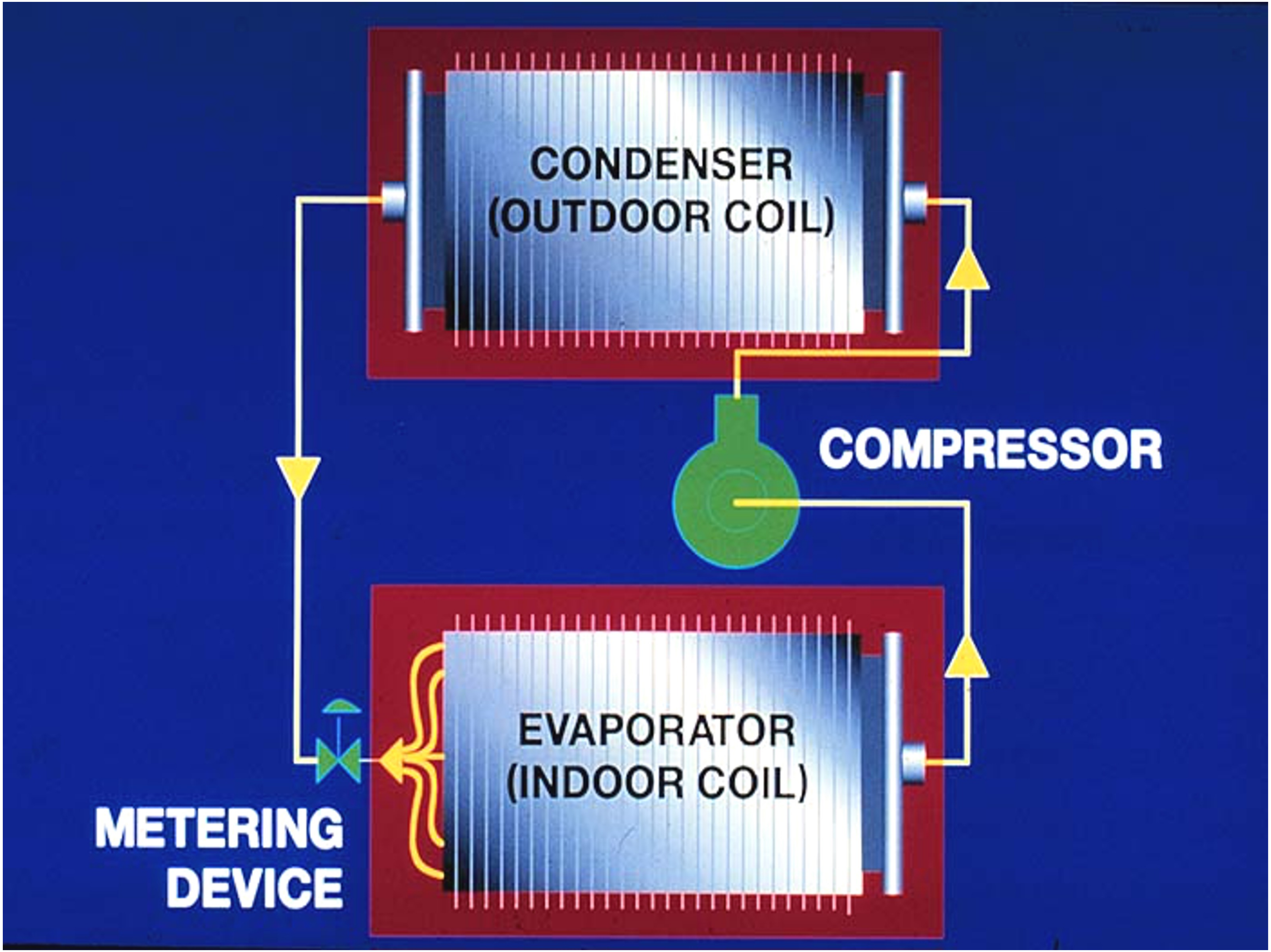

CONDENSER
(OUTDOOR COIL)
COMPRESSOR
EVAPORATOR
(INDOOR COIL)
METERING
DEVICE

Refrigerant Piping Required

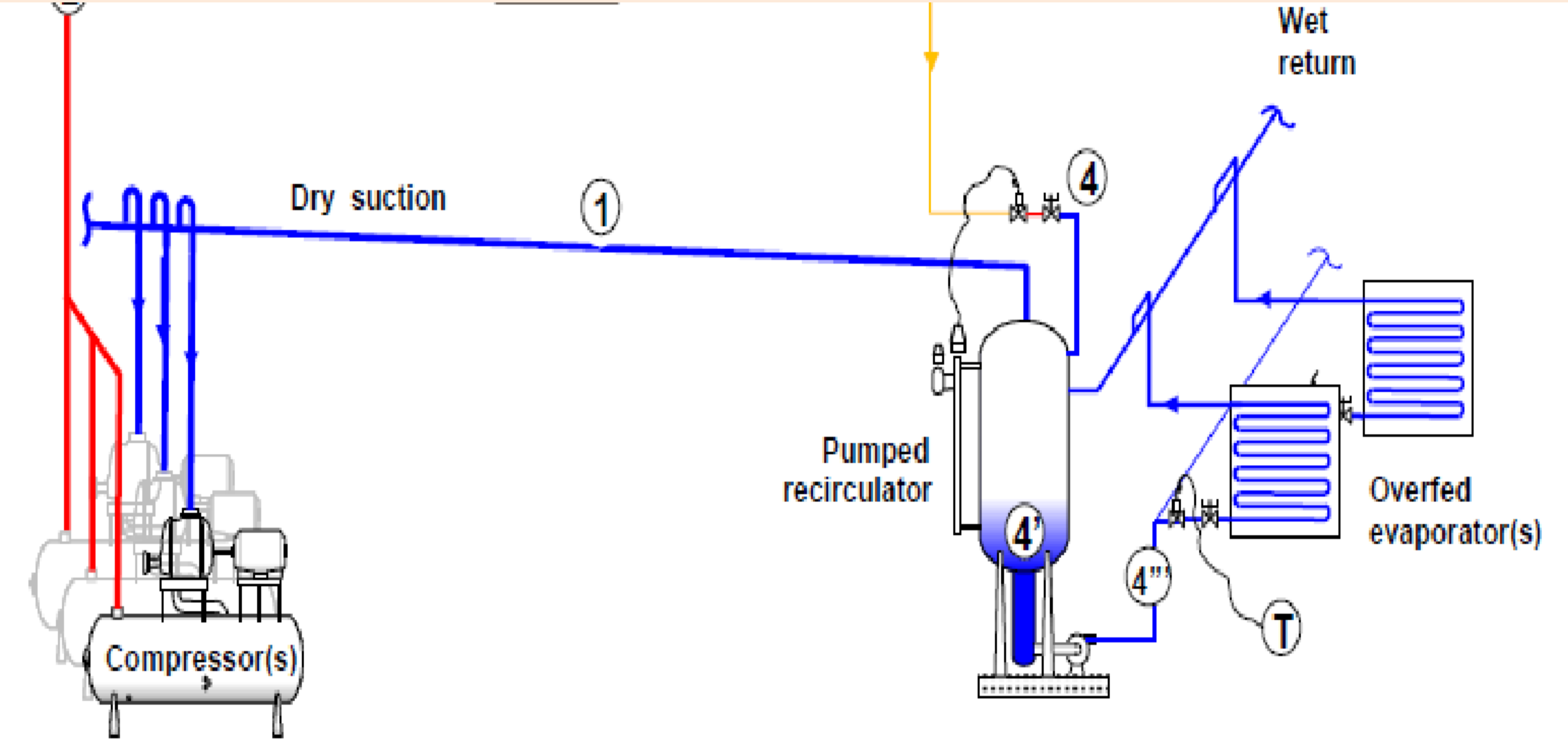
1. From compressor to oil separator-gas line
2. From Oil separator to condenser-Gas line
3. From Condenser to Receiver-liquid line
4. From receiver to expansion Device-liquid line
5. From expansion device to evaporator- liquid+ gas mixture
6. From evaporator to compressor-Gas line

Refrigerant Piping Sizing Priorities In Descending Order

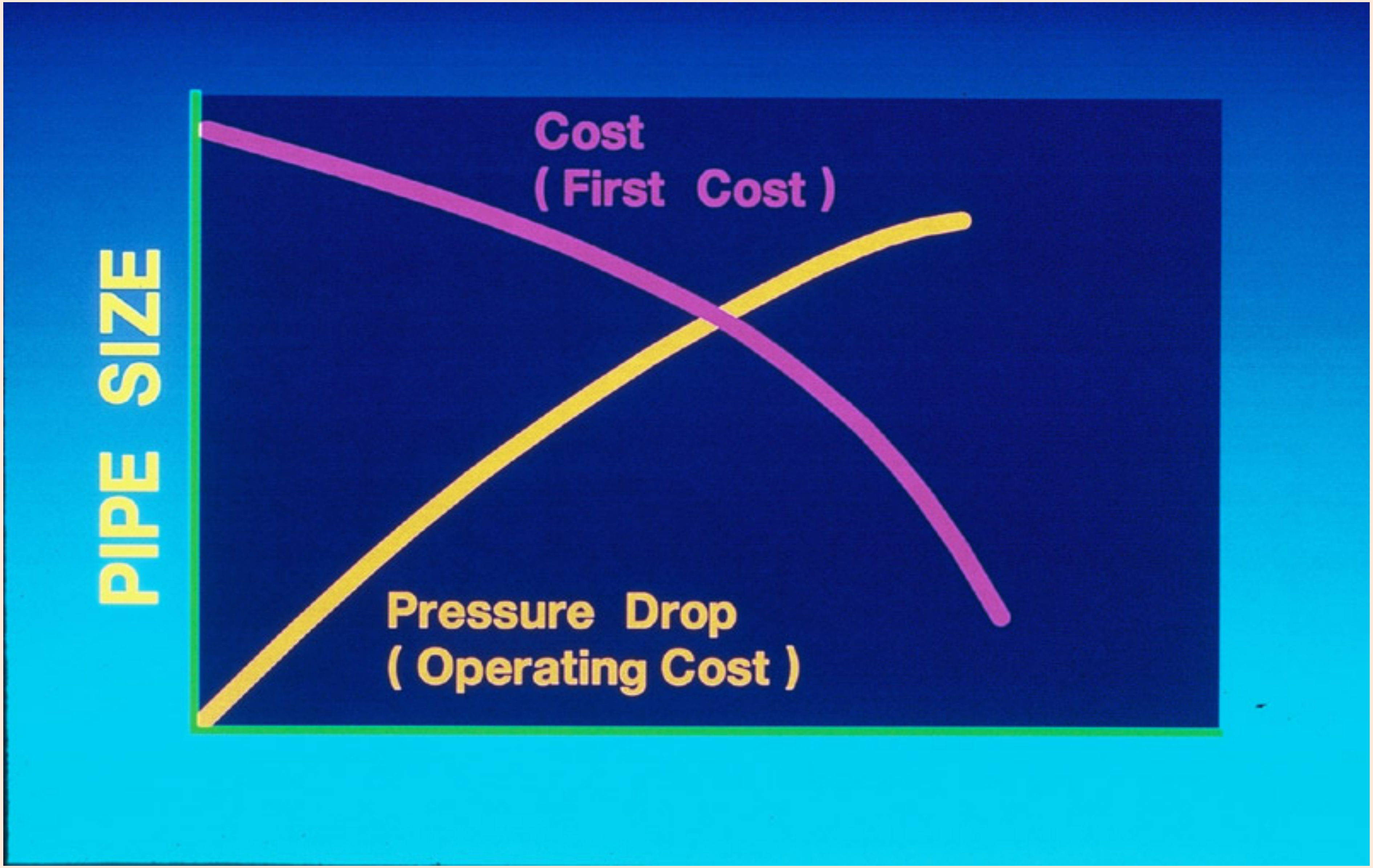
1. Suction Line sizing most important
2. Ammonia Pump inlet Line from LP vessel
3. Wet Return Line to LP vessel
4. High pressure liquid line
5. Condenser to Receiver Liquid line
6. High Pressure Discharge line

CAN YOU IDENTIFY ?-Which pipe is going where?

The piping should be done in accordance with refrigerant flow requirements and not necessarily from the point of aesthetics.



Systems Using Ammonia (R – 717) and Other Immiscible Refrigerants Rely on Gravity, Rather than Velocity for Oil Return.
Generous Sizing Saves Operating Costs for Such Systems.



Optimum pipe sizing –compromise between first cost and pressure drop, lower pressure drop , bigger pipe size, more cost, or the opposite

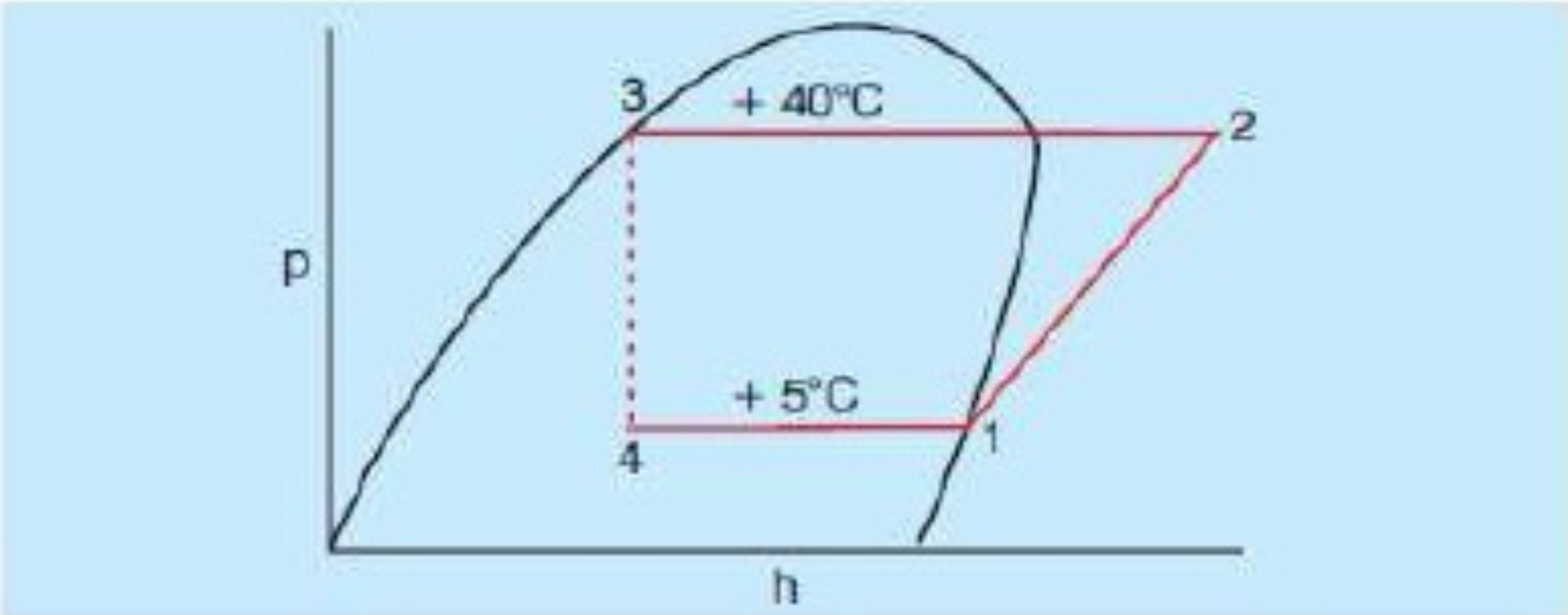
Recommended Velocities For Line Sizing

	From 25mm	To 300 mm
Compressor Suction Line	15m/s	18m/s
Wet Return To LP Vessel	12m/s	15m/s
Ammonia Pump Suction Line	0.3m/s	0.5m/s
Ammonia Pump Discharge Line	1.0 m/s	1.0m/s
Condenser to Receiver Line	0.3m/s	0.5m/s
Liquid Feed from main receiver	1m/s	1.5m/s
Compressor Discharge Line	18m/s	20m/s

Wet Return-One Size larger than calculated Suction Line or velocity reduced by √1/(circulation rate). It means ½ the velocity selected for dry suction

1. Gas Line Velocity is higher than Liquid line as Density of liquid is higher hence more friction and gas density is lower hence less pressure drop
2. Smaller Diameters have low velocity, larger diameters have high velocity

Pipe Line Sizing With P/H diagram Study-Mass Flow Calculations



Mass Flow & Pipe Size Calculations

Basic Data

1. Capacity 100 kW(28.43 TR)
2. Condensing Temperature: +40^{0}C
3. Evaporating Temperature: +5^{0}C
4. No superheat or sub-cooling: 0^{0}C

Calculation for Pipe Diameter Selection:

1. From Ammonia Table properties: vapour enthalpy at compressor suction h_1= 1467.385 kJ/kg
2. Liquid Enthalpy at h_3=h_4=390.64 kJ/kg
3. Refrigerating Effect: h_1-h_3=1467.385-390.64=1076.745 kJ/kg
4. For 100 kW mass flow : 100/1076.745= 0.09287 kg/s
5. Specific volume of gas at point 1: 0.24321 m^3/kg
6. Volume flow rate required at compressor suction:0.09287x0.24321=0.022586m^3/s=81.31m^3/hr
7. Assuming suction line velocity as 12m/s, the pipe cross sectional area would be 0.001882m^2 or 1882 mm^2
8. Diameter of pipe would be:√1882 =43.38mm
9. Select nearest size as 50 NB

Pipe Sizing –
ASHRAE handbook Refrigeration

Table 2 Suction, Discharge Line, and Liquid Capacities in Kilowatts for Ammonia (Single- or High-Stage Applications)

Steel Nominal Line Size, mm	Suction Lines (Δt = 0.02 K/m), Saturated Suction Temperature, °C: –40, Δp = 76.9	–30, Δp = 116.3	–20, Δp = 168.8	–5, Δp = 276.6	+5, Δp = 370.5	Discharge Lines Δt = 0.02 K/m, Δp = 684.0 Pa/m, Saturated Suction Temp., °C: –40	–20	+5	Steel Nominal Line Size, mm	Liquid Lines: Velocity = 0.5 m/s	Δp = 450.0
10	0.8	1.2	1.9	3.5	4.9	8.0	8.3	8.5	10	3.9	63.8
15	1.4	2.3	3.6	6.5	9.1	14.9	15.3	15.7	15	63.2	118.4
20	3.0	4.9	7.7	13.7	19.3	31.4	32.3	33.2	20	110.9	250.2
25	5.8	9.4	14.6	25.9	36.4	59.4	61.0	62.6	25	179.4	473.4
32	12.1	19.6	30.2	53.7	75.4	122.7	126.0	129.4	32	311.0	978.0
40	18.2	29.5	45.5	80.6	113.3	184.4	189.4	194.5	40	423.4	1469.4
50	35.4	57.2	88.1	155.7	218.6	355.2	364.9	374.7	50	697.8	2840.5
65	56.7	91.6	140.6	248.6	348.9	565.9	581.4	597.0	65	994.8	4524.8
80	101.0	162.4	249.0	439.8	616.9	1001.9	1029.3	1056.9	80	1536.3	8008.8
100	206.9	332.6	509.2	897.8	1258.6	2042.2	2098.2	2154.3	—	—	—
125	375.2	601.8	902.6	1622.0	2271.4	3682.1	3783.0	3884.2	—	—	—
150	608.7	975.6	1491.4	2625.4	3672.5	5954.2	6117.4	6281.0	—	—	—
200	1252.3	2003.3	3056.0	5382.5	7530.4	12 195.3	12 529.7	12 864.8	—	—	—
250	2271.0	3625.9	5539.9	9733.7	13619.6	22 028.2	22 632.2	23 237.5	—	—	—
300	3640.5	5813.5	8873.4	15568.9	21787.1	35 239.7	36 206.0	37 174.3	—	—	—

Suction Line Selection Medium & High Temperature -

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Steel Nominal Line Size, mm	Saturated Suction Temperature, °C					
	−20		−5		+5	
	Δt = 0.005 K/m Δp = 42.2 Pa/m	Δt = 0.01 K/m Δp = 84.4 Pa/m	Δt = 0.005 K/m Δp = 69.2 Pa/m	Δt = 0.01 K/m Δp = 138.3 Pa/m	Δt = 0.005 K/m Δp = 92.6 Pa/m	Δt = 0.01 K/m Δp = 185.3 Pa/m
10	0.91	1.33	1.66	2.41	2.37	3.42
15	1.72	2.50	3.11	4.50	4.42	6.37
20	3.66	5.31	6.61	9.53	9.38	13.46
25	6.98	10.10	12.58	18.09	17.79	25.48
32	14.58	21.04	26.17	37.56	36.94	52.86
40	21.99	31.73	39.40	56.39	55.53	79.38
50	42.72	61.51	76.29	109.28	107.61	153.66
65	68.42	98.23	122.06	174.30	171.62	245.00
80	121.52	174.28	216.15	308.91	304.12	433.79
100	249.45	356.87	442.76	631.24	621.94	885.81
125	452.08	646.25	800.19	1139.74	1124.47	1598.31
150	733.59	1046.77	1296.07	1846.63	1819.59	2590.21
200	1506.11	2149.60	2662.02	3784.58	3735.65	5303.12
250	2731.90	3895.57	4818.22	6851.91	6759.98	9589.56
300	4378.87	6237.23	7714.93	10973.55	10 810.65	15 360.20

Note: Capacities are in kilowatts of refrigeration resulting in a line friction loss per unit equivalent pipe length (Δp in Pa/m), with corresponding change in saturation temperature per unit length (Δt in K/m).

Suction line Selection –Low Temperature

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Table 1 Suction Line Capacities in Kilowatts for Ammonia with Pressure Drops of 0.005 and 0.01 K/m Equivalent

Steel Nominal Line Size, mm	Saturated Suction Temperature, °C					
	–50		–40		–30	
	Δt = 0.005 K/m Δp = 12.1 Pa/m	Δt = 0.01 K/m Δp = 24.2 Pa/m	Δt = 0.005 K/m Δp = 19.2 Pa/m	Δt = 0.01 K/m Δp = 38.4 Pa/m	Δt = 0.005 K/m Δp = 29.1 Pa/m	Δt = 0.01 K/m Δp = 58.2 Pa/m
10	0.19	0.29	0.35	0.51	0.58	0.85
15	0.37	0.55	0.65	0.97	1.09	1.60
20	0.80	1.18	1.41	2.08	2.34	3.41
25	1.55	2.28	2.72	3.97	4.48	6.51
32	3.27	4.80	5.71	8.32	9.36	13.58
40	4.97	7.27	8.64	12.57	14.15	20.49
50	9.74	14.22	16.89	24.50	27.57	39.82
65	15.67	22.83	27.13	39.27	44.17	63.77
80	28.08	40.81	48.36	69.99	78.68	113.30
100	57.95	84.10	99.50	143.84	161.77	232.26
125	105.71	153.05	181.16	261.22	293.12	420.83
150	172.28	248.91	294.74	424.51	476.47	683.18
200	356.67	514.55	609.20	874.62	981.85	1402.03
250	649.99	937.58	1107.64	1589.51	1782.31	2545.46
300	1045.27	1504.96	1777.96	2550.49	2859.98	4081.54

Liquid Line Selection-Pump Circulation Systems

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Table 3 Liquid Ammonia Line Capacities in Kilowatts

Nominal Size, mm	Pumped Liquid Overfeed Ratio			High-Pressure Liquid at 21 kPa[a]	Hot-Gas Defrost[a]	Equalizer High Side[b]	Thermosiphon Lubricant Cooling Lines Gravity Flow[c]		
	3:1	4:1	5:1				Supply	Return	Vent
40	513	387	308	1544	106	791	59	35	60
50	1175	879	703	3573	176	1055	138	88	106
65	1875	1407	1125	5683	324	1759	249	155	187
80	2700	2026	1620	10 150	570	3517	385	255	323
100	4800	3600	2880	—	1154	7034	663	413	586
125	—	—	—	—	2089	—	1041	649	1062
150	—	—	—	—	3411	—	1504	938	1869
200	—	—	—	—	—	—	2600	1622	3400

Source: Wile (1977).

[a]Rating for hot-gas branch lines under 30 m with minimum inlet pressure of 724 kPa (gage), defrost pressure of 483 kPa (gage), and –29°C evaporators designed for a 5.6 K temperature differential

[b]Line sizes based on experience using total system evaporator kilowatts.

[c]From Frick Co. (1995). Values for line sizes above 100 mm are extrapolated.

Piping material & thickness

1. Piping/fittings as per ANSI B31.5-2013
2. Carbon Steel A53 Grade A or B, ERW or A106 grade A/B seamless
3. Do not Use Galvanized Piping(Low Grade)
4. 1 ½” and smaller –Sch. 80
5. 2” to 6’ Sch. 40
6. 8” to 12” sch 20
7. Sch 80 ≥ Sch 40 ≥ sch20
8. All Weld Fittings-Avoid Threads/Flanges

Pipe Specifications

1. Carbon Steel ASTM A53 Grade a or B, Type E or S-Welded

2. Carbon Steel ASTM A106 Gr A or B –Seamless

3. Stainless Steel ASTM A312 Type 304,304L,316, 316L Type E or S

4. Carbon Steel (below -20Deg F) ASTM A333 Gr 1 or 6 Type E or S

Note-**E** means electric resistance welded, **S** means seamless

Pipe Material-Low Temperature

1. Carbon Steel(Low Temperature):ASTM A333-Grade 1
2. Carbon Steel Pipe, ASTM A53 or A106 may be used below -20^{0}F(-28.9^{0}C) if it meets ASME B31.5-2013 Refrigeration Piping and Heat Transfer component requirements
3. ASME B31.5 allows use of carbon steel pipe material for use between -28.9^{0}C to -101.1^{0}C provided the most severe conditions are multiplied by 2.5 times in determining the thickness

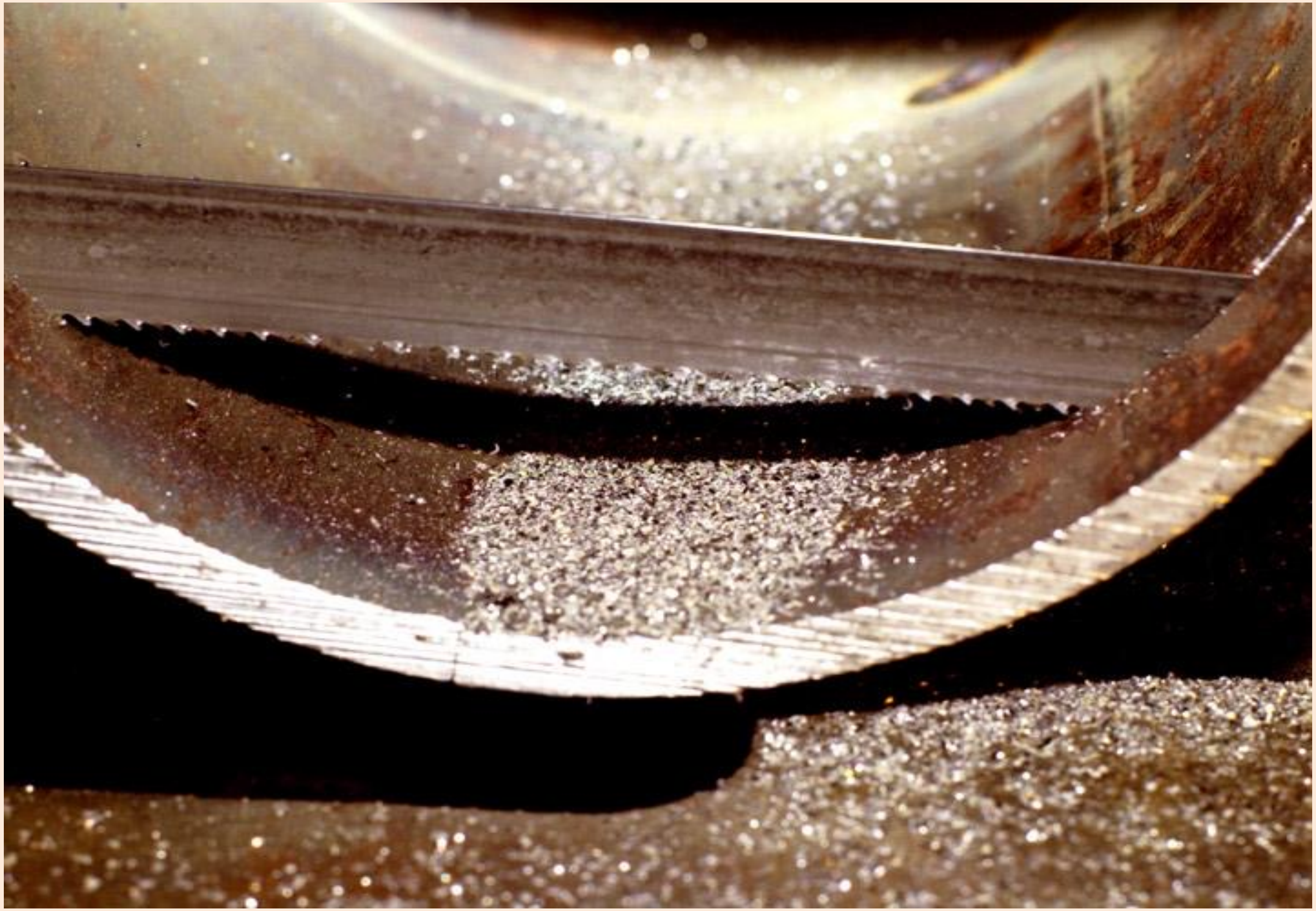
Example Calculations

- A53-GrA to be used for low temperature below -29^{0}C
- Design pressure -19.8 kg/cm^2
- Design Temperature –Minus 50^{0}C
- Liquid line -10” NB-OD 10.75” Sch. 20- Thickness 0.365”
- T=2.5xPD$_0$/2xSE=(2.5x19.8x14.22x10.75/2x13600)+ corrosion allowance
- T= 0.278+0.06=0.338”-required thickness
- Actual Thickness of Sch20 =0.365”- Hence Safe

Piping Accessories Material

- Fittings
- Carbon Steel ASTM A105
- Carbon Steel ASTM A234
- Carbon Steel(Low Temperature) ASTM A420
- Flanges
- Carbon Steel ASTM A105
- Carbon Steel ASTM A181
- Carbon Steel (Low Temperature) ASTM A707
- Bolting
- Cast Iron Flanges when used with ring gaskets, or when coupled to a raised face flange: ASTM A307 Grade B
- Carbon or Stainless steel Flanges down to -55^{0}F –ASTM A193 Grade B7
- Low Temperature applications(-55^{0}F to -150^{0}F): ASTM A320 Grade L7
- Nuts: for above materials: ASTM A194

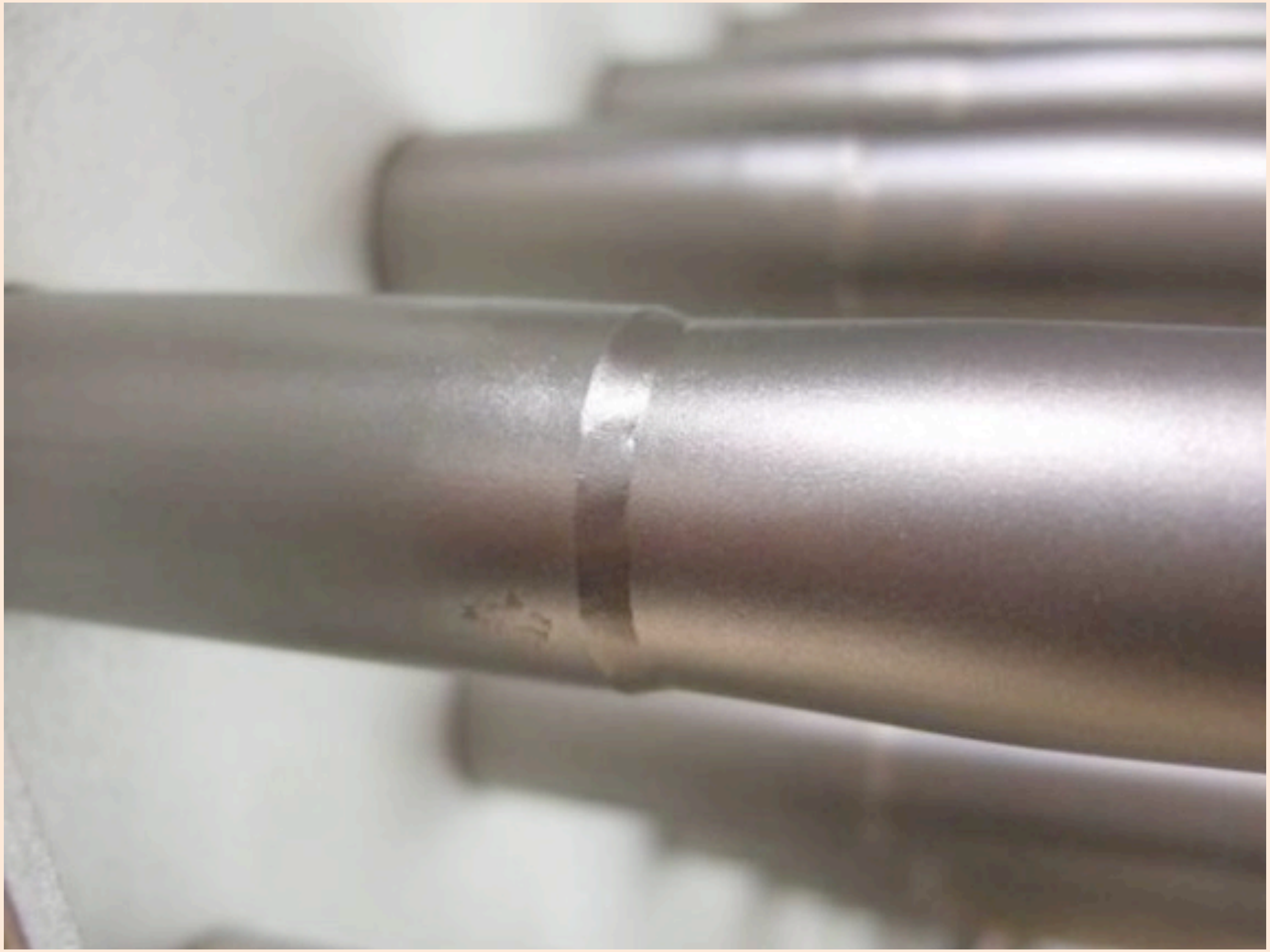
Piping material lying at site should be internally and externally cleaned thoroughly to make them free of rust scale, sand or dirt prior to installation



Welding Practices

1. Root run with TIG-Tungsten Inert Gas(Argon) for piping
2. Root run with TIG(Argon) or MIG (Metal inert Gas)for vessels
3. Welding by qualified welder certification level 3
4. Welding rods- Argon- High side-AWS-A5.18 ER70S-G, Low side –AWS –A5.28 ER70S-G
5. Electric Welding – AWS –A5.1 E7016, Do not use structural welding rods 6013
6. Remove valve internals & controls, strainers Solenoid coils etc. before welding

Good Welding Joint



IMPORTANT TIPS WHILE DOING THE PIPING TO AVOID AMMONIA ACCIDENTS:

1. Do not use flanged joints in piping wherever possible, use welded joints
2. Use proper slopes in the direction of flow, so that oil accumulates at desired places, except in pump circulation systems where piping to slope towards LP vessel.
3. Use safety relief valves of proper capacity and outlet piping to be taken above15ft. and 20 ft. Above human occupied areas
4. Ensure liquid traps are avoided in piping, since liquid is non-compressible, the piping would burst when ambient temperature rises
5. Avoid hydraulic shocks and vibrations in piping, wet rerun lines, during defrosting by proper designing
6. Provide bends, loops in long lines to take care of expansion/contraction due to temperature changes.
7. Use quick drain shutoff valves for oil draining. Consider using a spring-loaded ball valve (dead-man valve) in conjunction with the oil drain valve on all oil out pots (used to collect oil that migrates into system components) as an emergency stop valve.
8. Provide air purgers, especially in plants operating in negative pressures
9. Remove water from the system periodically

IMPORTANT TIPS WHILE DOING THE PIPING TO AVOID AMMONIA ACCIDENTS

10. Operate equipment within the design parameters as recommended by manufacturer.

11. Provide regular maintenace practice and prepare schedule for each item including valves, pumps safety relief valves etc.

12. Provide sufficient training to operators and make them familiar with oerating and maintenace procedures

13. Provide safe access to all operating valves and controls in addition to all equipment

14.Provide valve numbering so as convey information by plant operator to procurment agency as to which valve has gone defective and needs replacement

15. Cap all valves whch do not need daily opening/closing.

16. Use proper supports to all piping with L-bracket, U channel, and hangers are typical .Ensure supporting structure like roofs are capable of supporting loads of filled pipes

Compressor Piping-ASHRAE Handbook

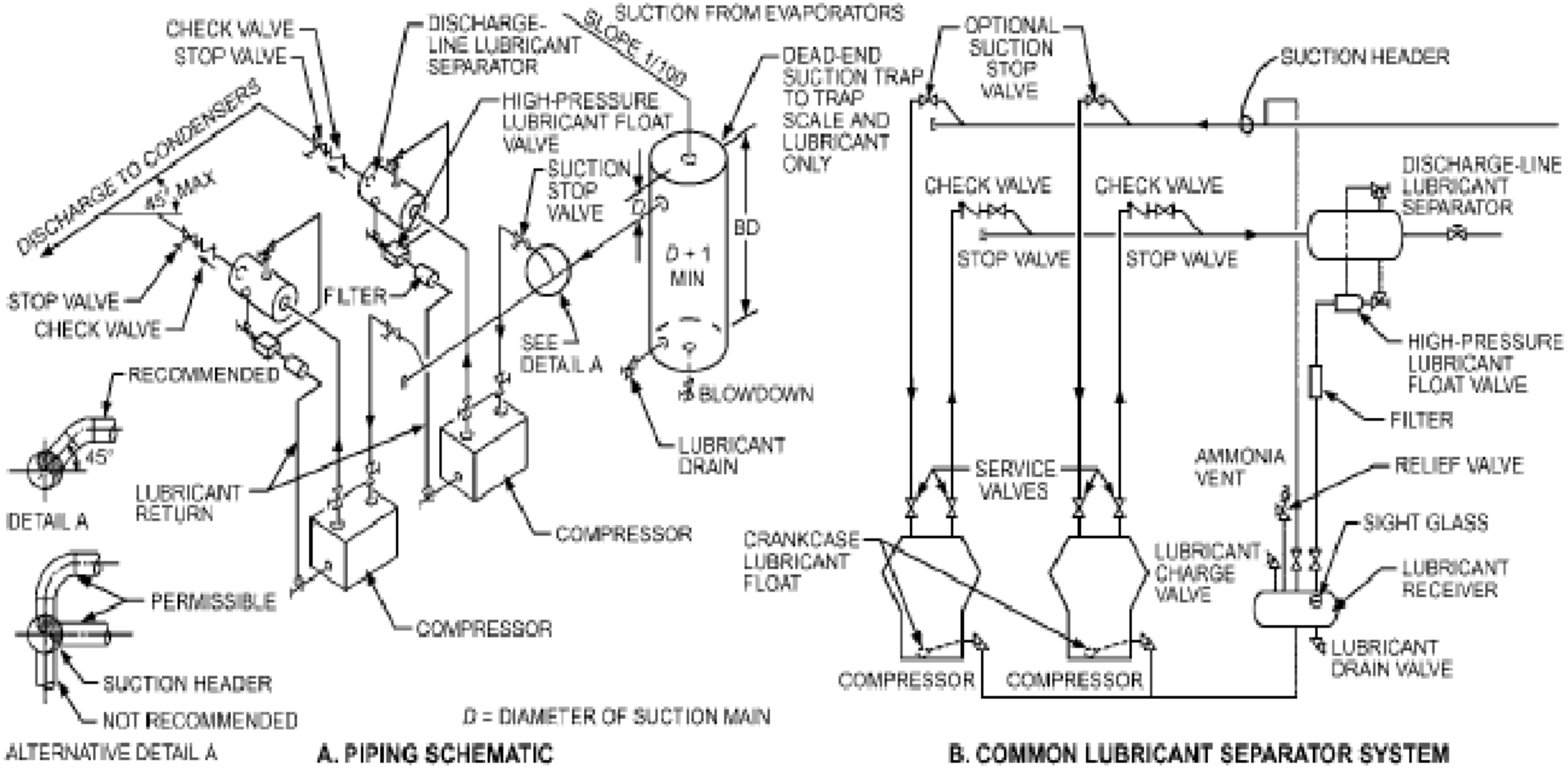


Fig. 1 Schematic of Reciprocating Compressors Operating in Parallel

Compressor Piping

Important points to note:

1. The NRV should be after oil separator and not after compressor-The reason being, the reciprocating compressor discharge gas pulsations are dampened in the oil separator, if the NRV is placed between the compressor and oil separator the NRV is subjected to these pulsations and it many times chatters, or likely to get damaged earlier than expected. Many people argue that placing it immediately after compressor prevents liquid condensation during standstill state. This argument is incorrect as there is no liquid in the discharge side and the density of Ammonia refrigerant is so high that when converted to the liquid the quantity is insignificant and it would accumulate in the oil separator and not on the compressor top. The discharge line from compressor to oil separator is also very short.

2. Depending on NRV design, keep NRV in horizontal line-The reason being in a horizontal position, the gravity is not acting on NRV parts, if in a vertical location, the parts are acted on by two forces, one is gravity and the other is discharge gas, both are opposite to each other and can lead to vibrations, noise, damage to parts.

3. Provide independent oil separator for each compressor-many installations I have observed where there is a single common oil separator and the combined discharge header is connected to this oil separator. This is not a good practice; each compressor has its own characteristic and quantity of oil migration along with discharge gas varies for each machine. It is always a good practice to have independent oil separator for each compressor.

Compressor Piping

4. Oil separator oil drain should be above oil return level of compressor- The pressure in the oils separator and the compressor is many times same, the oil returns by gravity and hence there should be sufficient head available between oil return point of oil separator and the incoming point of oil return on the compressor crankcase. Also, it is a god practice to drain oil manually when the installation is new and check the oil quality instead of automatically returning to the compressor crank case. The oil is normally not clean in the initial stages and till such time that one is fully convinced that the oil getting accumulated in the separator is clean, the automatic oil return should not be connected and used., as otherwise the contaminants would enter the compressor and may create problems.

5. Connect individual discharge and suction pipe to the header from the in a sloping manner, the slope being in the direction of flow , or easier is to connect from the top in a reverse 'J' pipe like gent's umbrella handle

6. Check alignment of motor with compressor in all 3 arises

7. Hook up suction and discharge piping without any force needed while

inserting bolts in the flanges- I have observed in many installations that when bolts joining the flanges of compressor and the discharge pipe are loosened, the alignment is not perfect, this happens due to the fact that during welding there is a shrinkage and the alignment gets disturbed. The normal practice is pulling the with force and then inserting the bolts, this should be avoided as it imposes undue forces on compressor and may lead to additional vibrations.

Compressor Piping

8. Aways use a stop valve after the NRV in the discharge pipe leading to the common header. This is required because if NRV gets stuck, one should be able to attend the same without stopping the entire plant. The stop valve of the particular compressor can be closed and the NRV can then be attended.

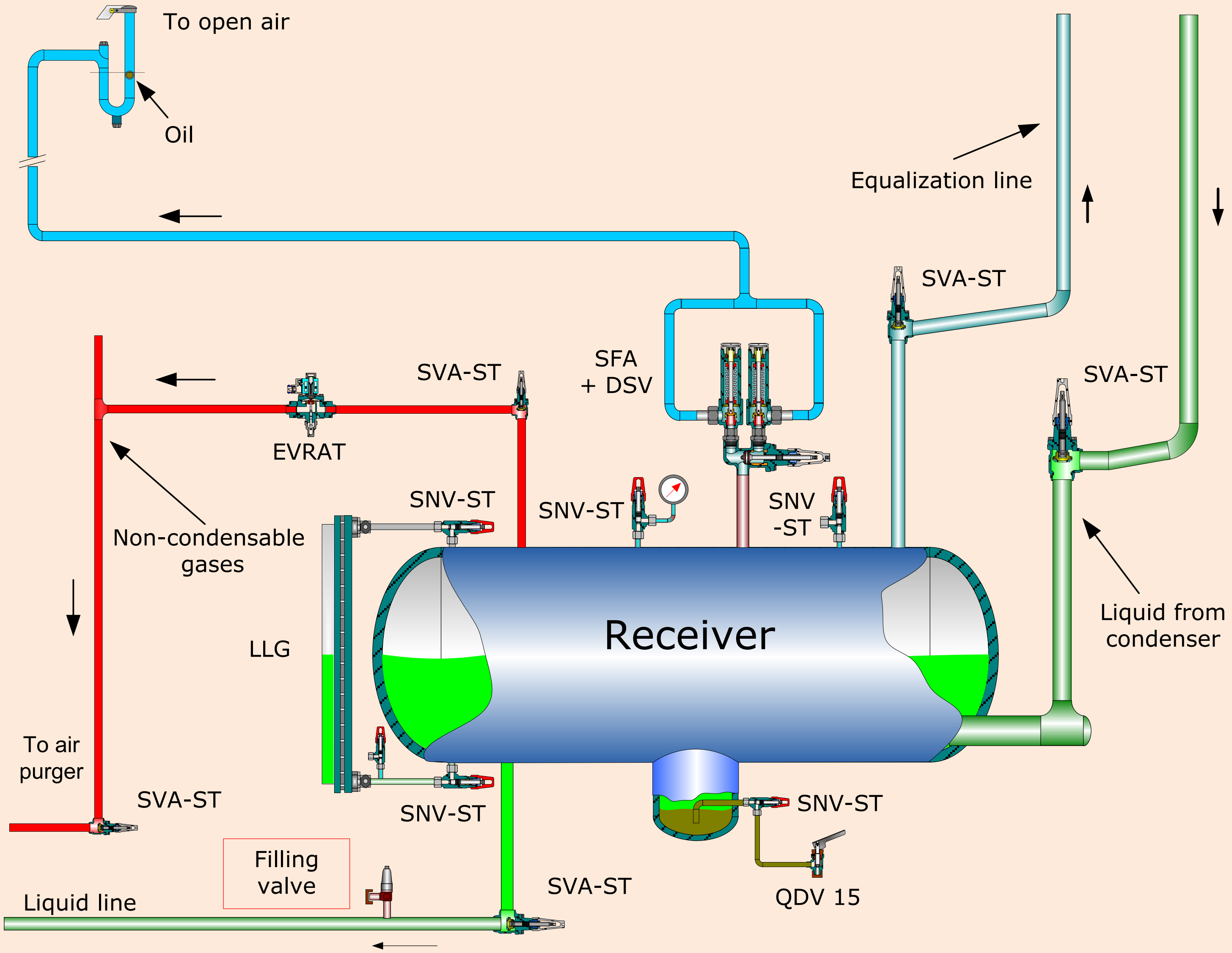
Vibration free operation

Vibration free operation

Receiver Mounted in the machine room

Liquid outlet pipe from the top with a tube immersed in the liquid, If receiver is mounted near evaporative condenser on roof top, the liquid should be taken from bottom

Receiver system – pipingg principle



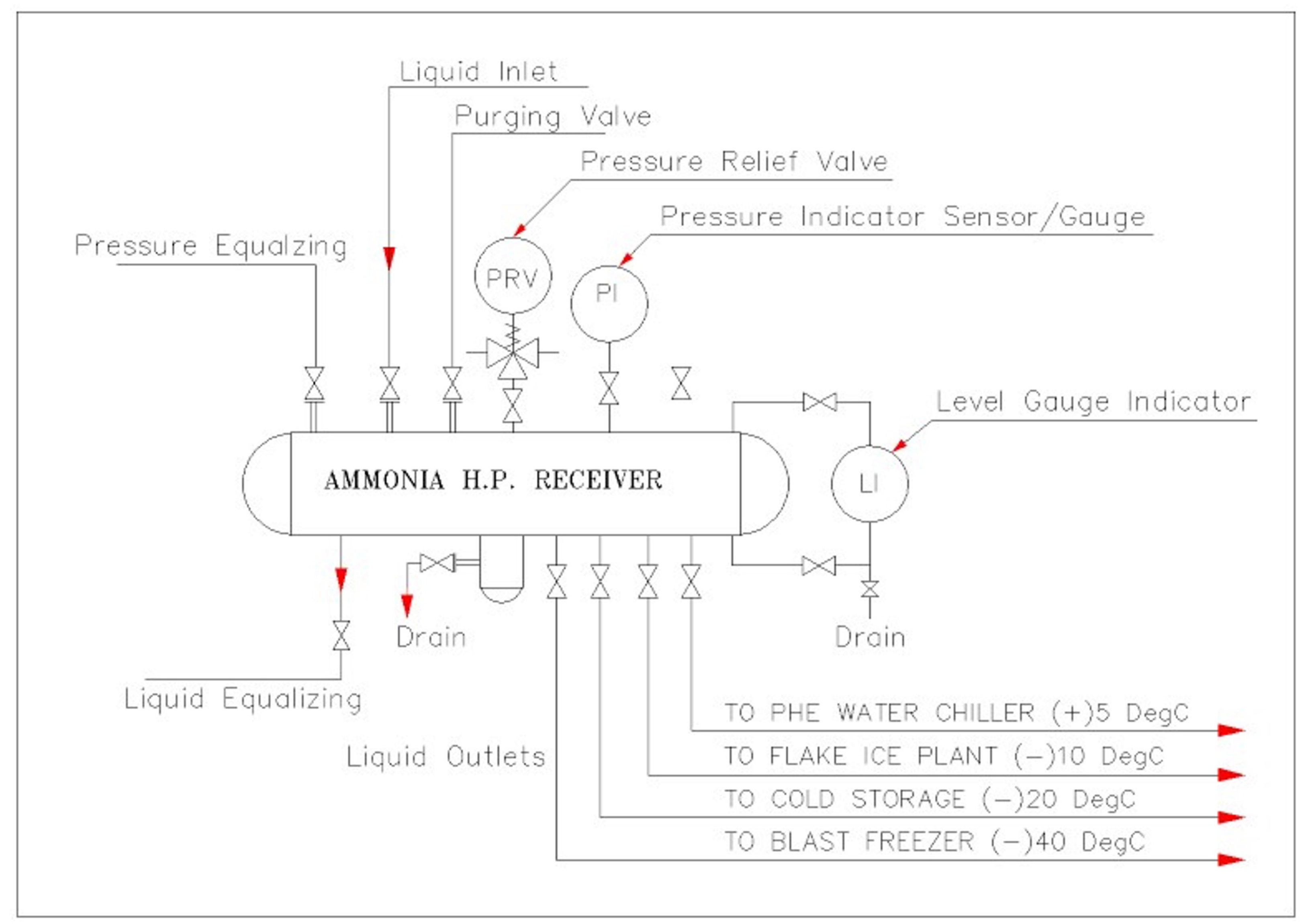
Receiver Piping better method

Normally it is a practice to take a common liquid header from the receiver with single outlet and then take different tapings from this common header to the various utilities for expansion at required temperatures.

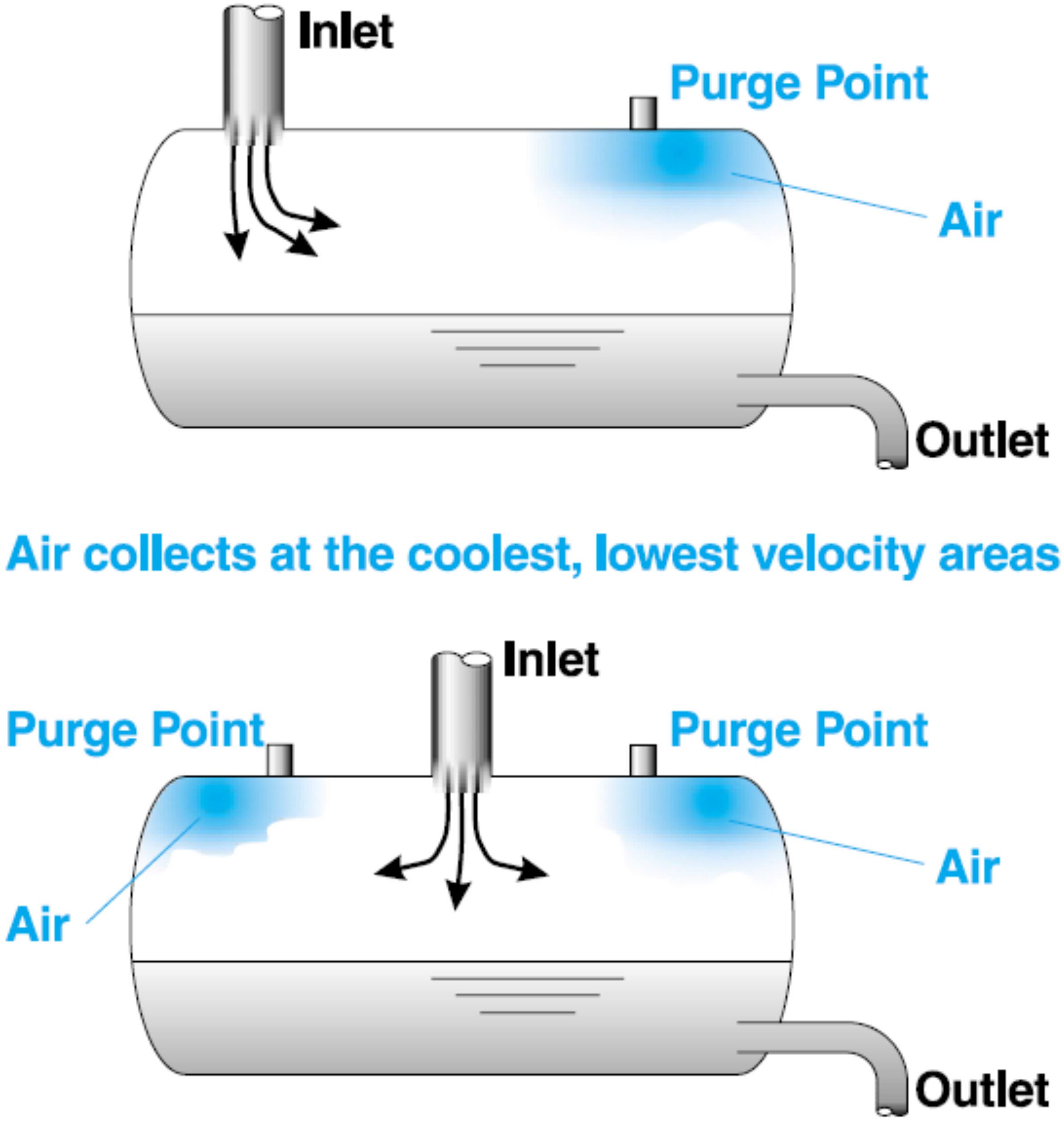
It is observed in may plants, that when you take certain utility, on line, let us say you start the freezing operation when other systems like ice plant, cold storages are operating, due to sudden increase in demand of the blast freezer, the major part of liquid gets diverted temporarily to this freezer and the working other working utilities are starved o liquid.

The more useful way is to take as may outlets as required by the various utilities and size these liquid lines to meet the refrigeration load of each utility so that the each line is smaller, ammonia quantity is reduced and fear of one utility starving temporarily is avoided.

Receiver piping



Receiver Purge Points



Purge point locations for horizontal receivers.

Receiver spray header

Evaporative condenser piping

Evaporative condenser piping

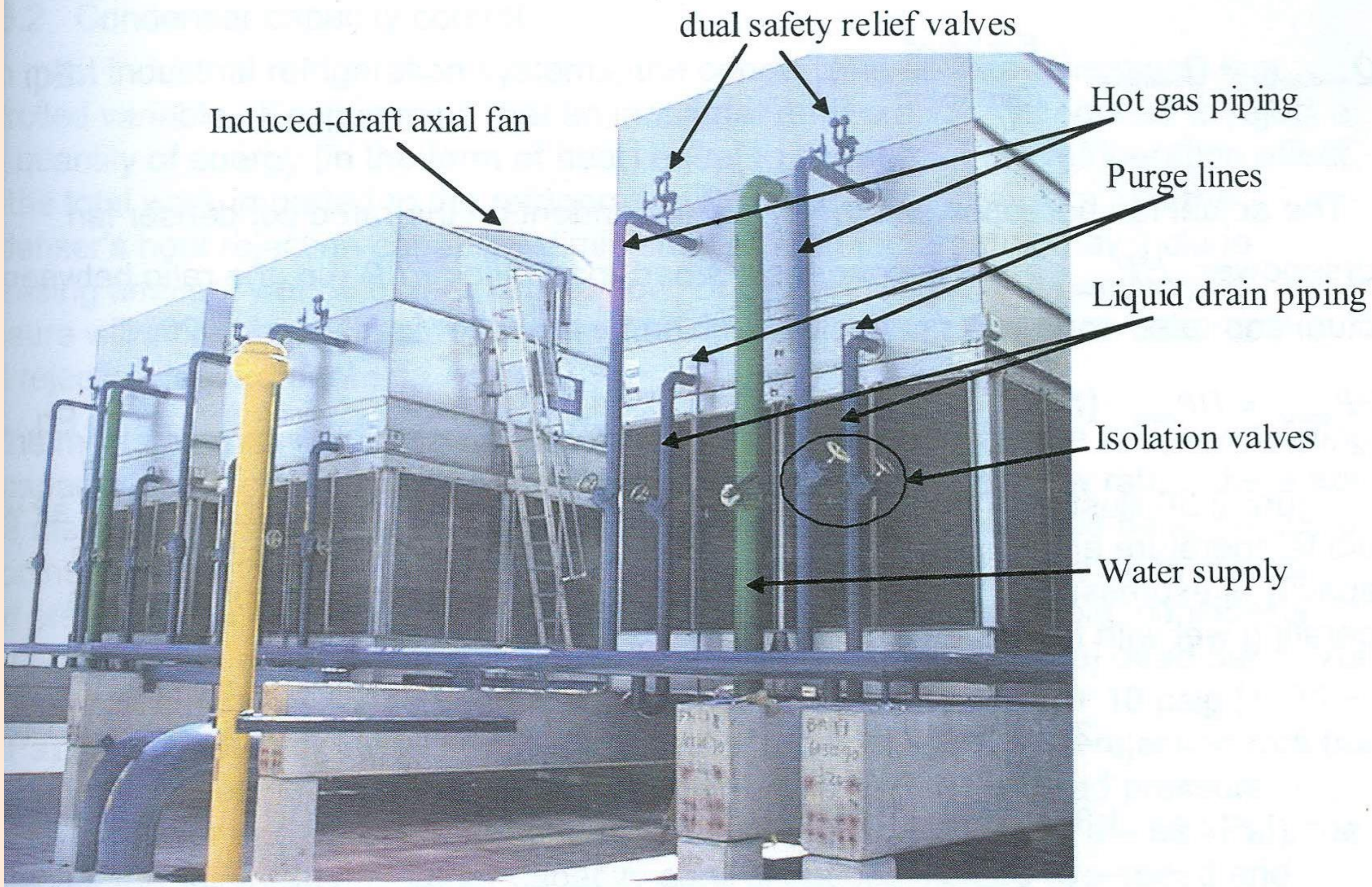


Figure 2-29: Field installation of an induced-draft evaporative condenser.

Evaporative Condenser Piping with Top inlet Receiver

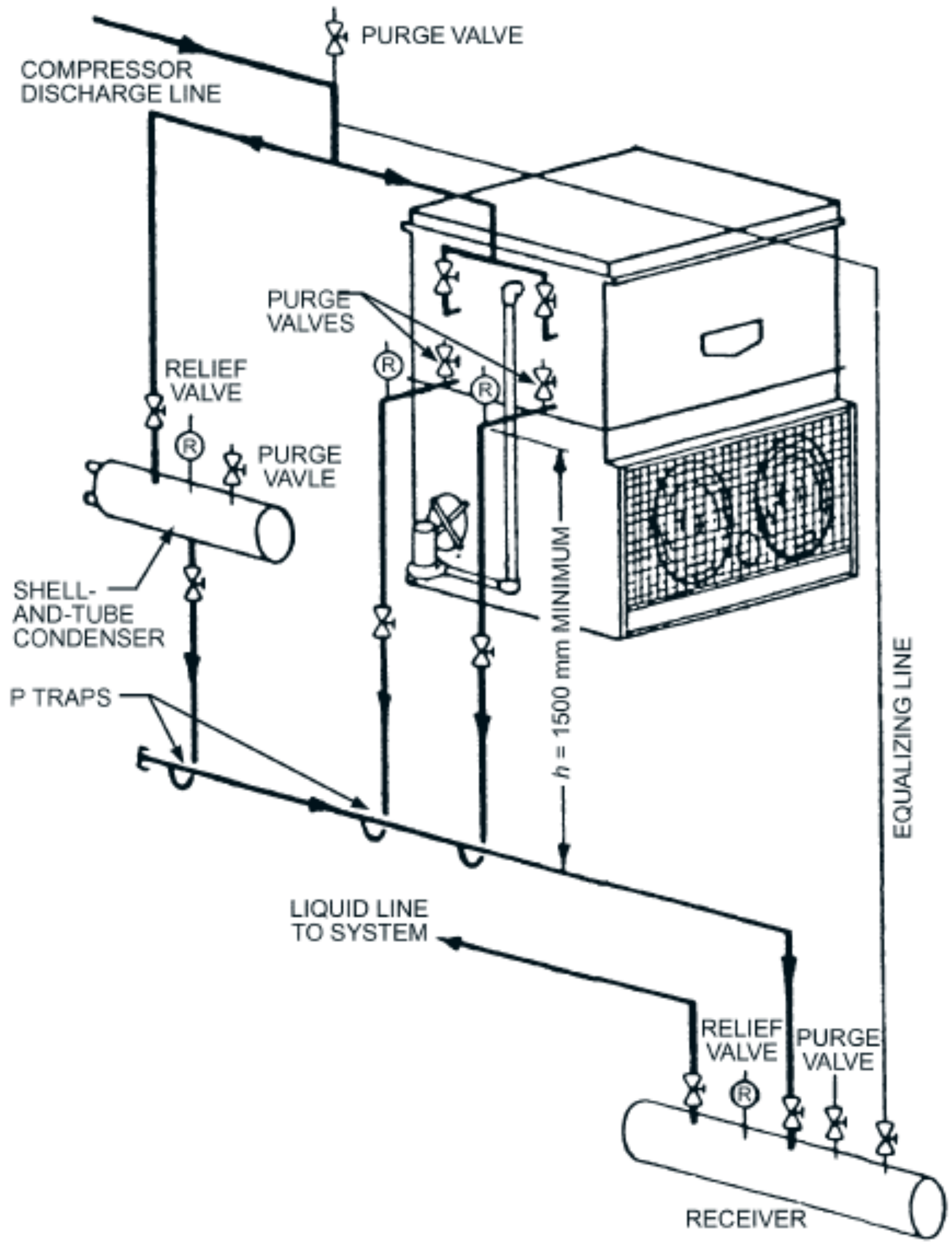


Fig. 33 Piping for Shell-and-Tube and Evaporative Condensers with Top Inlet Receiver

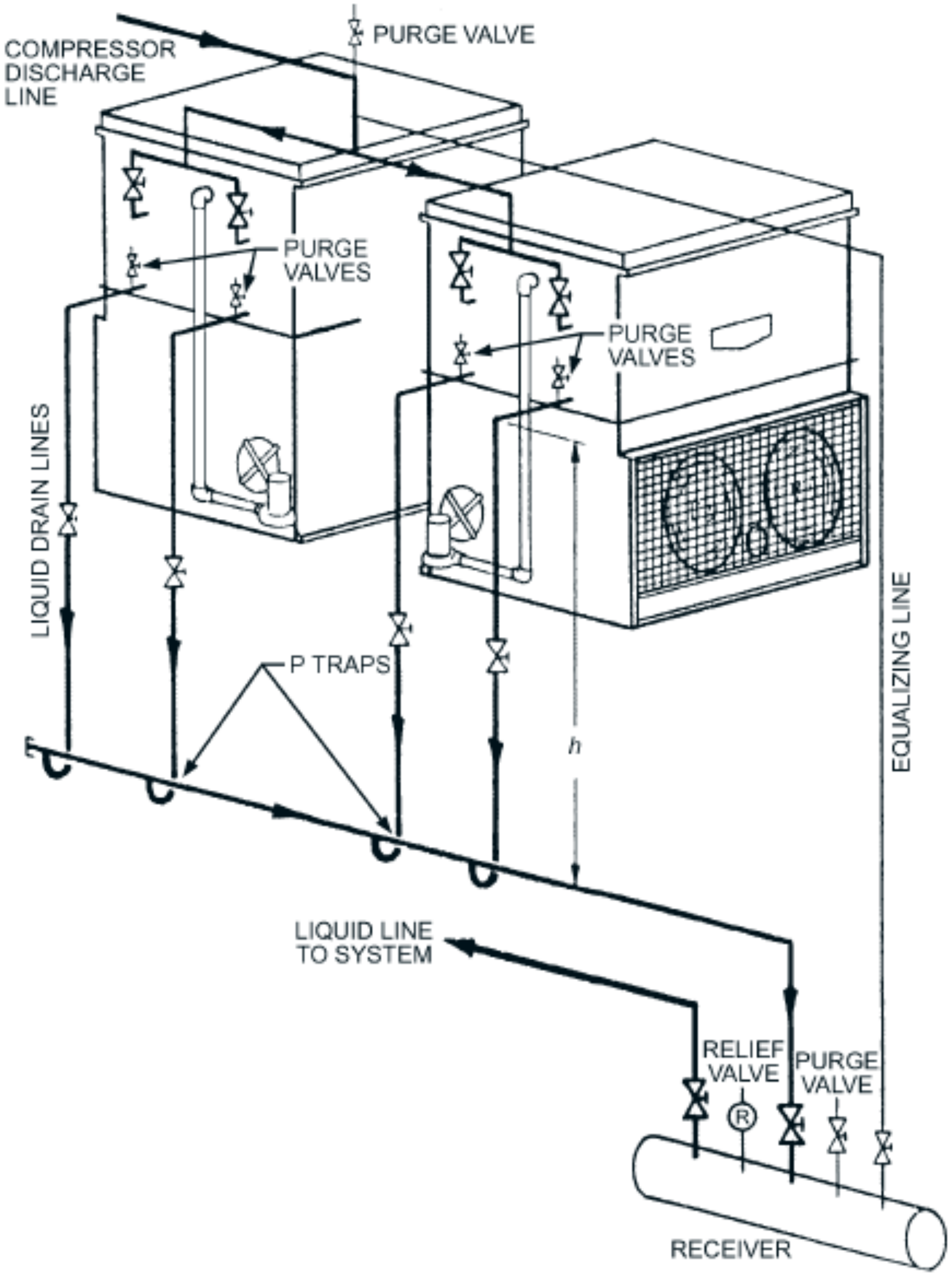
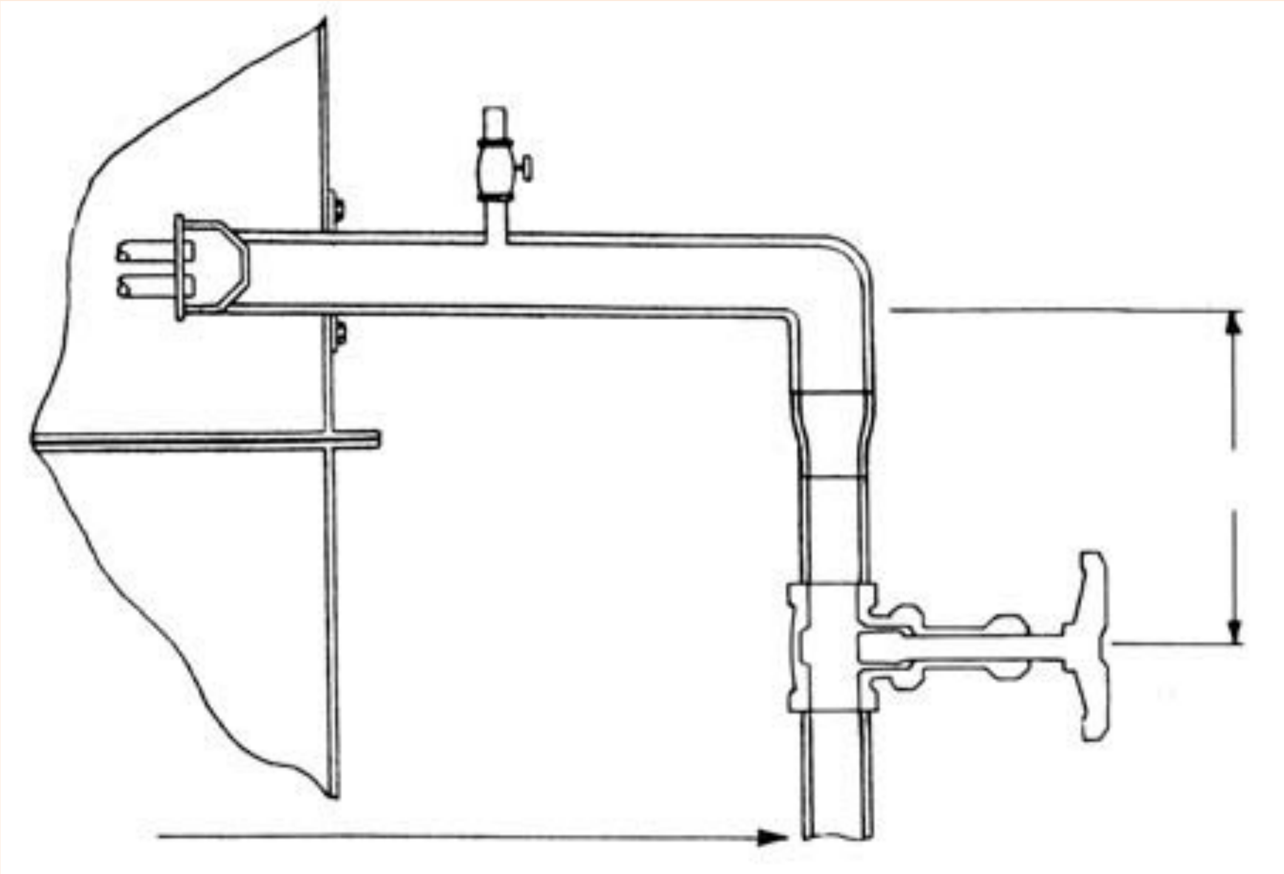


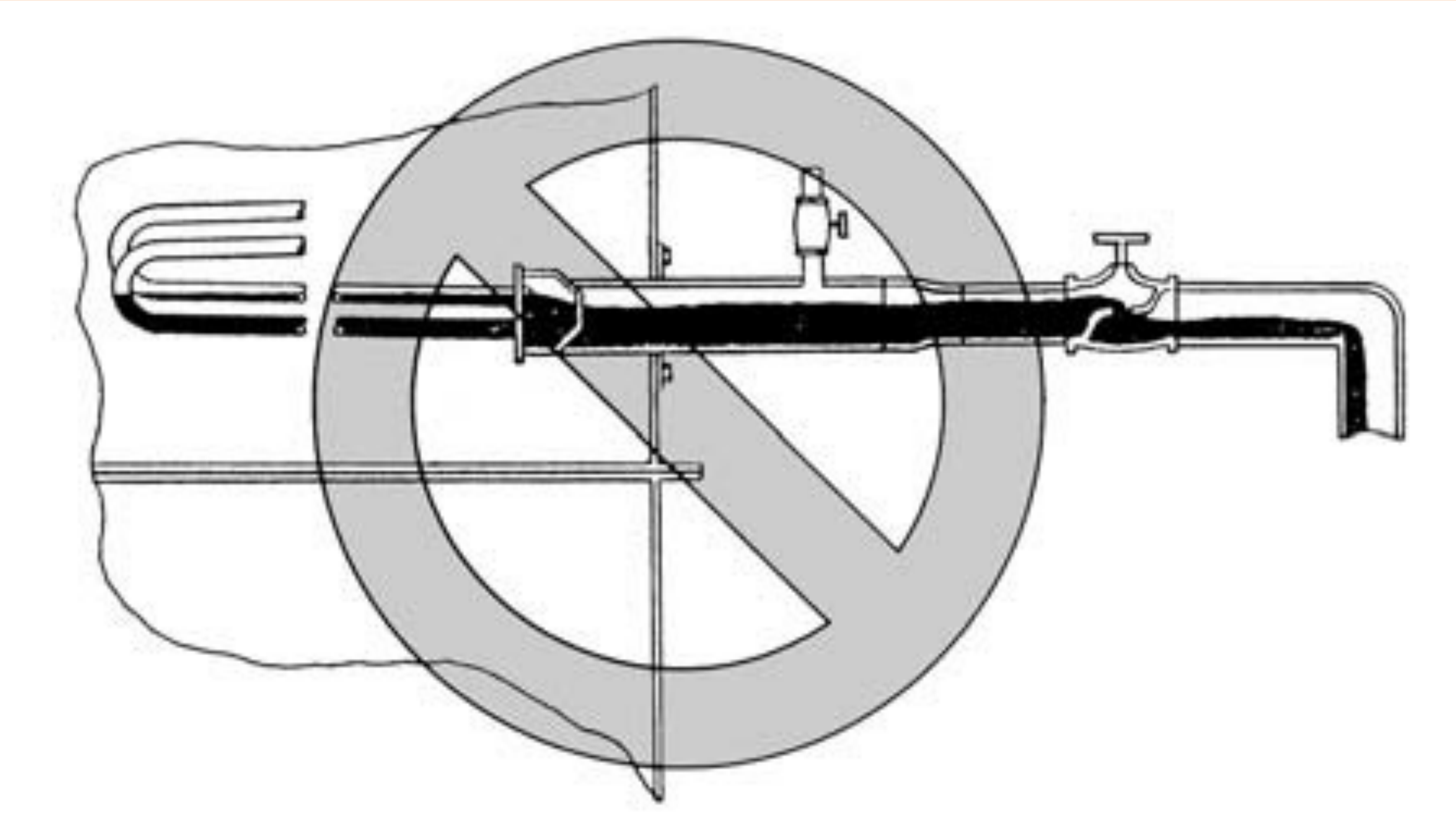
Fig. 35 Piping for Parallel Condensers with Top Inlet Receiver

Piping for Parallel running of evaporative condensers

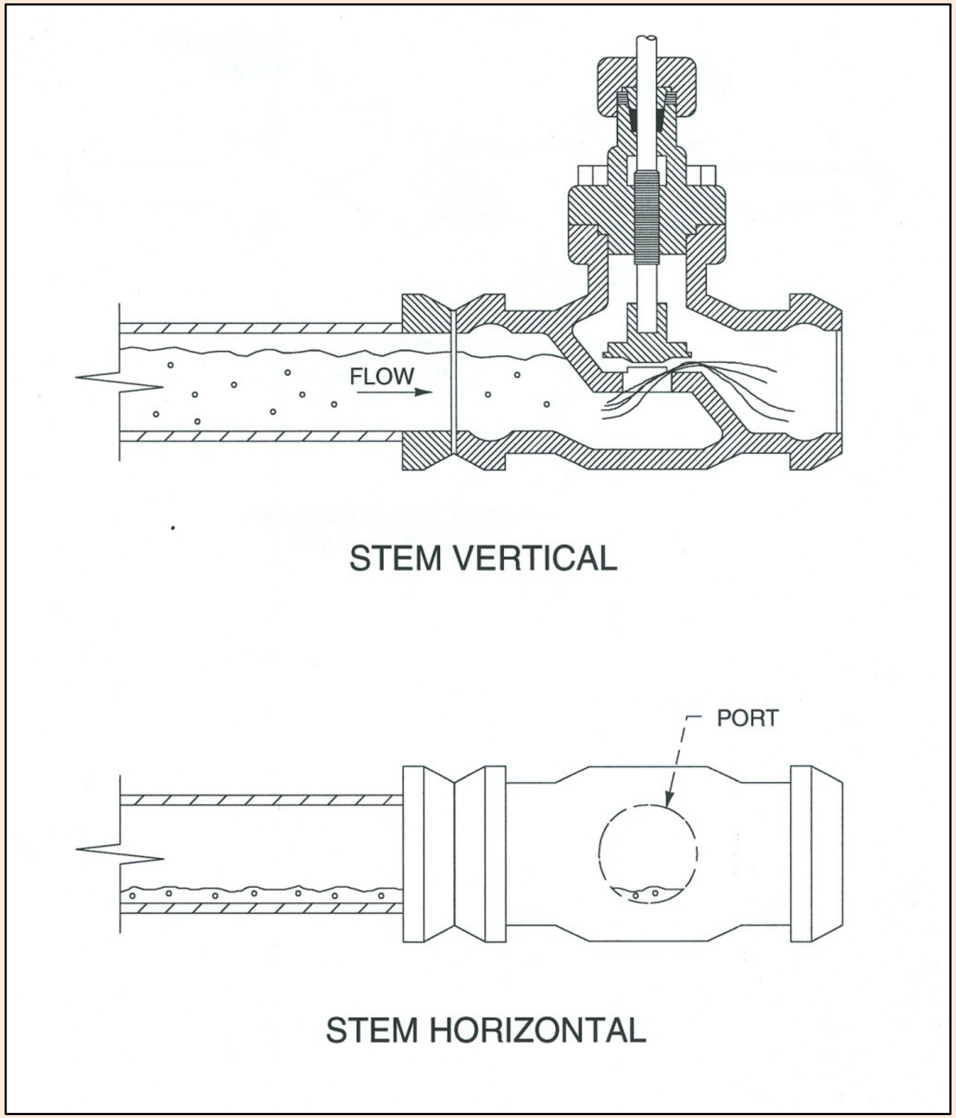
Install liquid line Valves in Vertical Line



Incorrect Valve Installation for Liquid Lines



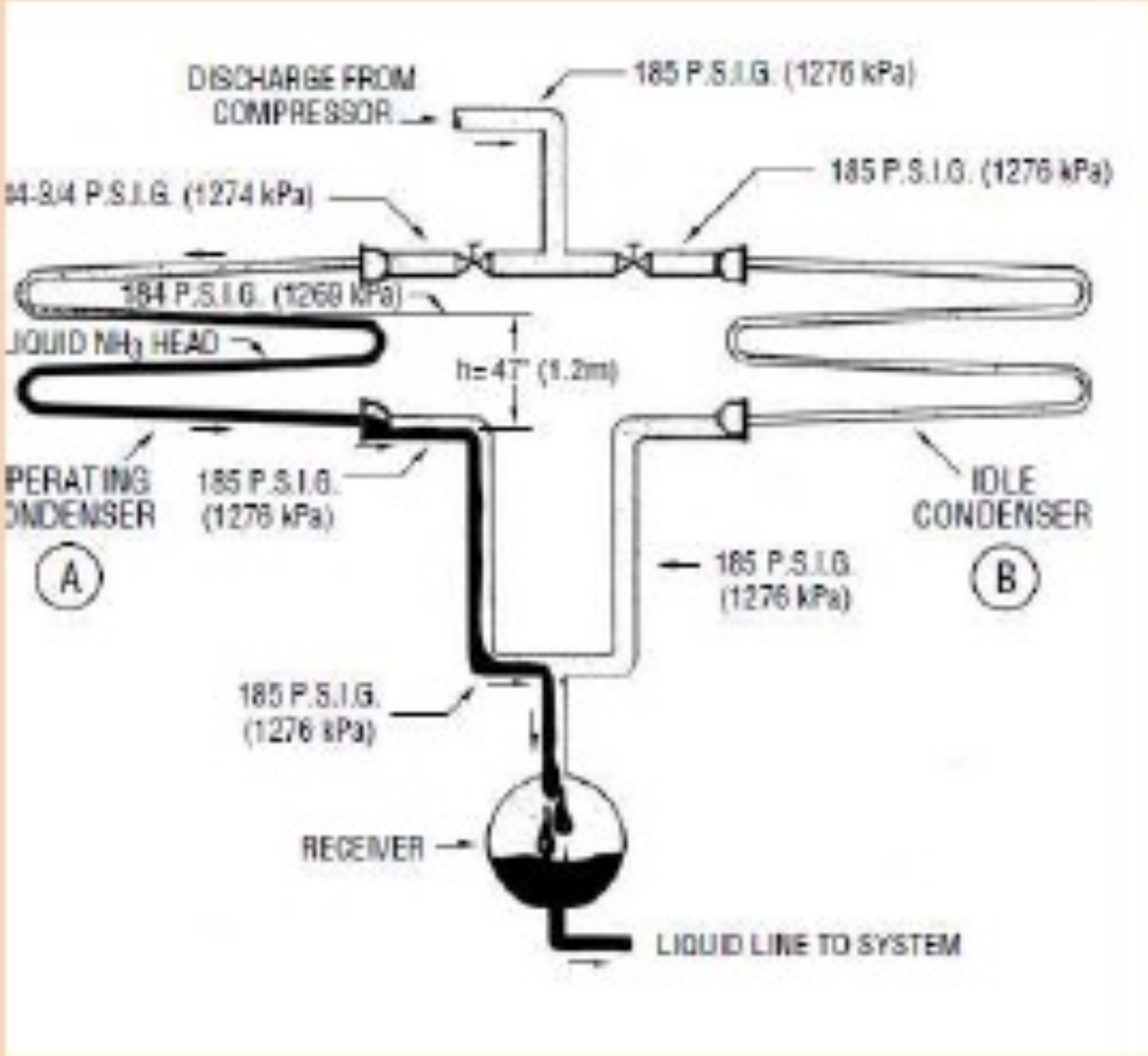
Liquid Hold-up Valve Position



INCORRECT

CORRECT

Evap. Cond.-Incorrect Piping Arrangement



Correct Piping with Gas Equalizer pipe

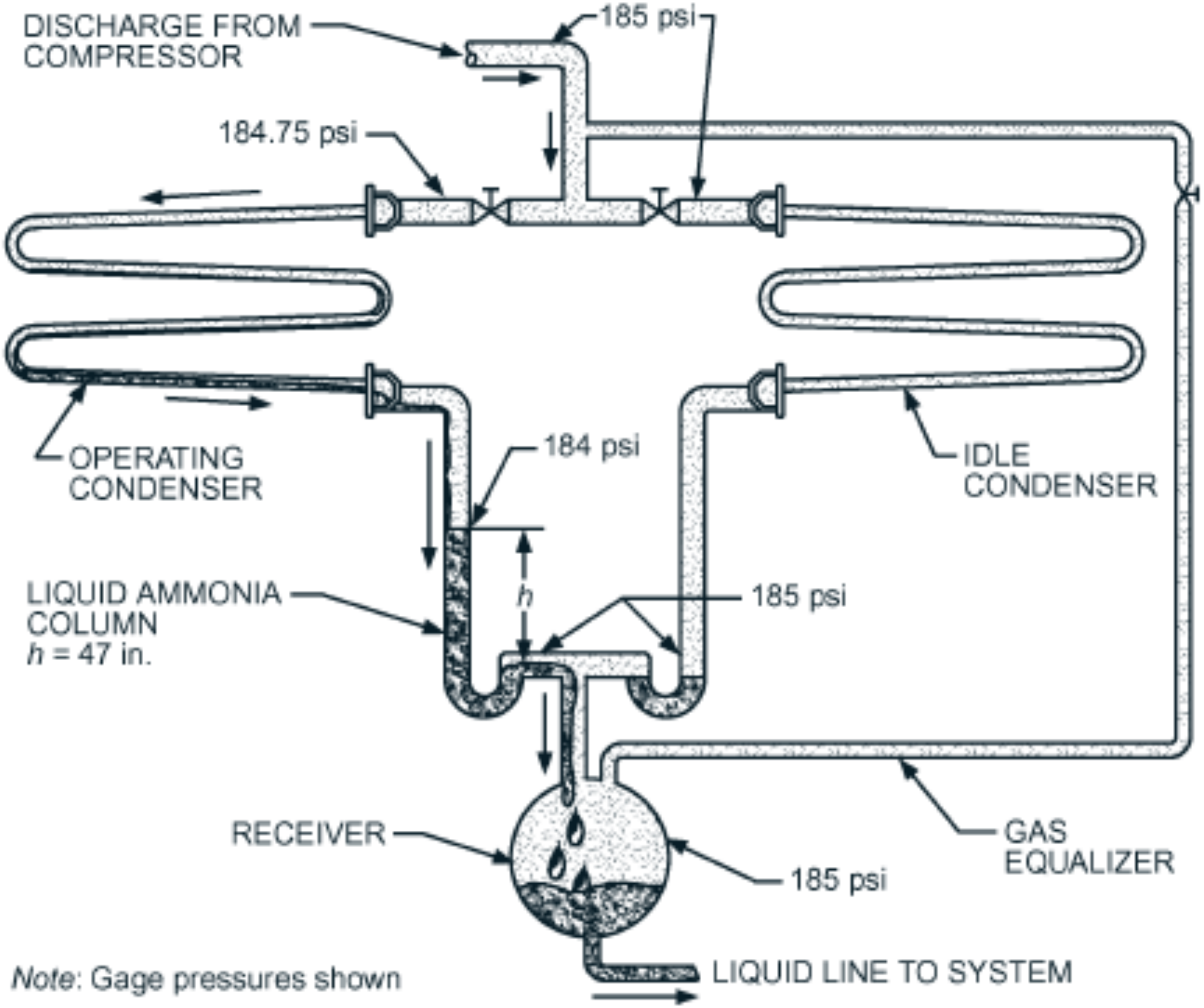


Fig. 31 Two Evaporative Condensers with Trapped Piping to Receiver

Correct Piping with Gas Equalizer pipe

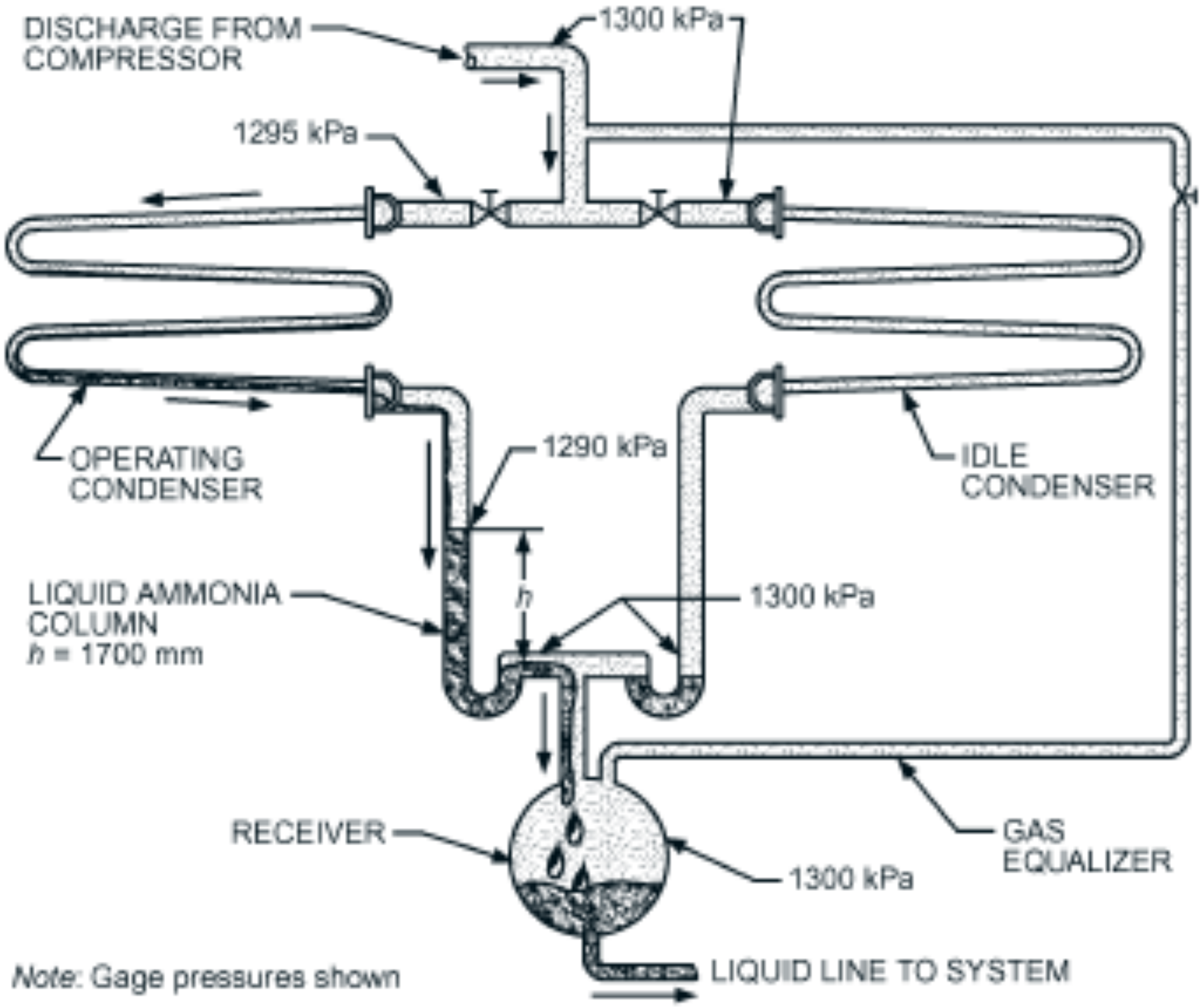
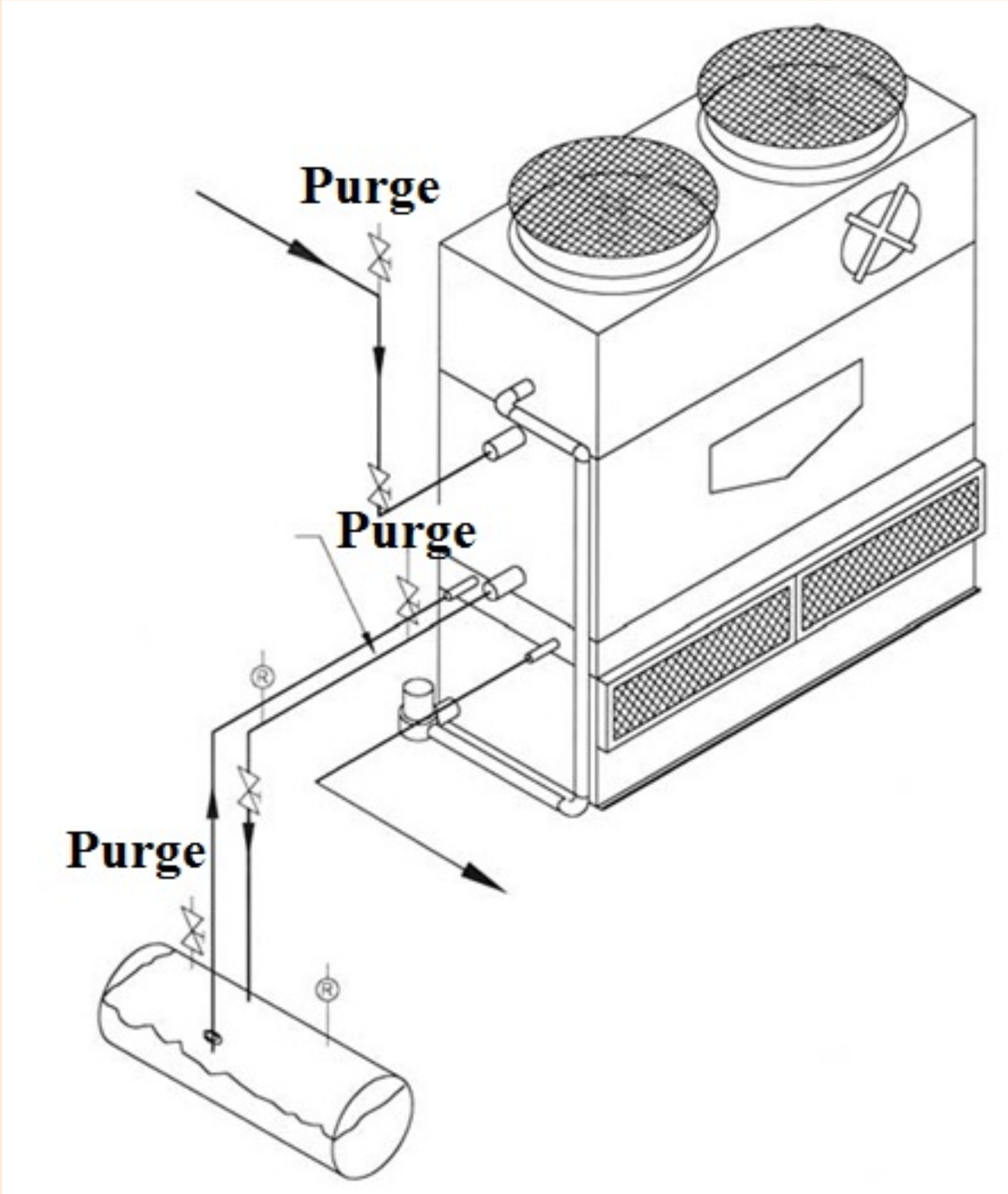
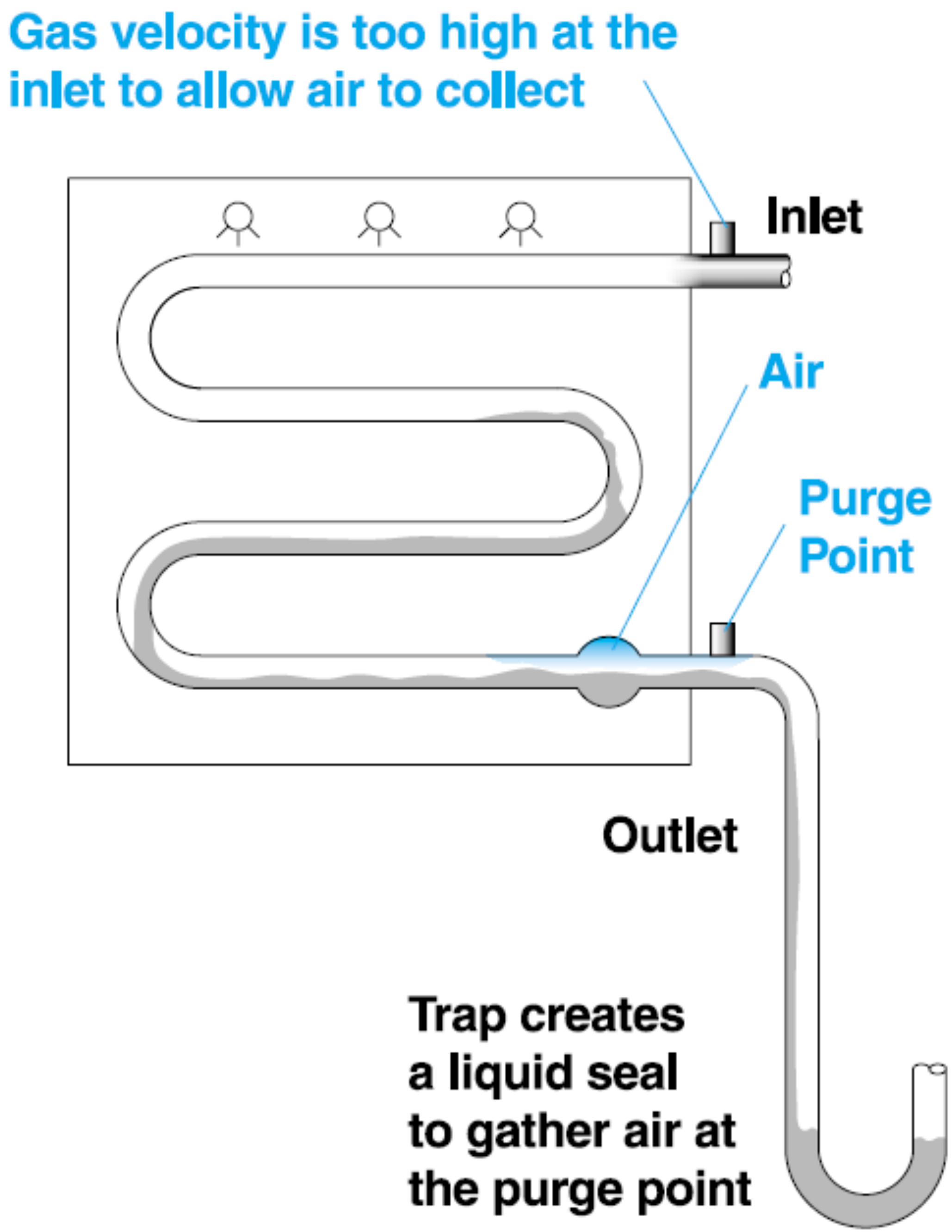


Fig. 31 Two Evaporative Condensers with Trapped Piping to Receiver

Purge Points Evaporative condensers

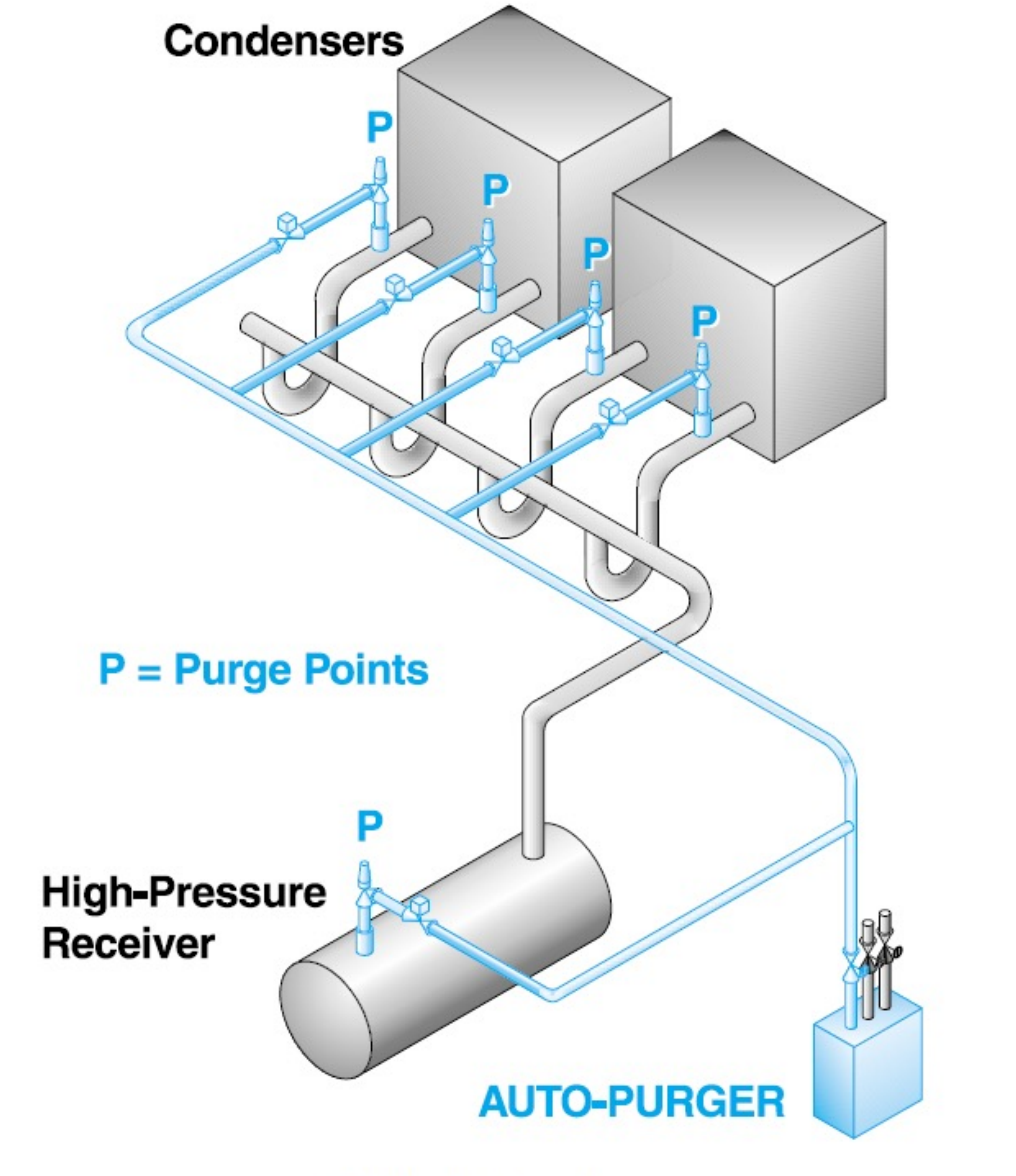




Purge point location for an evaporative condenser.

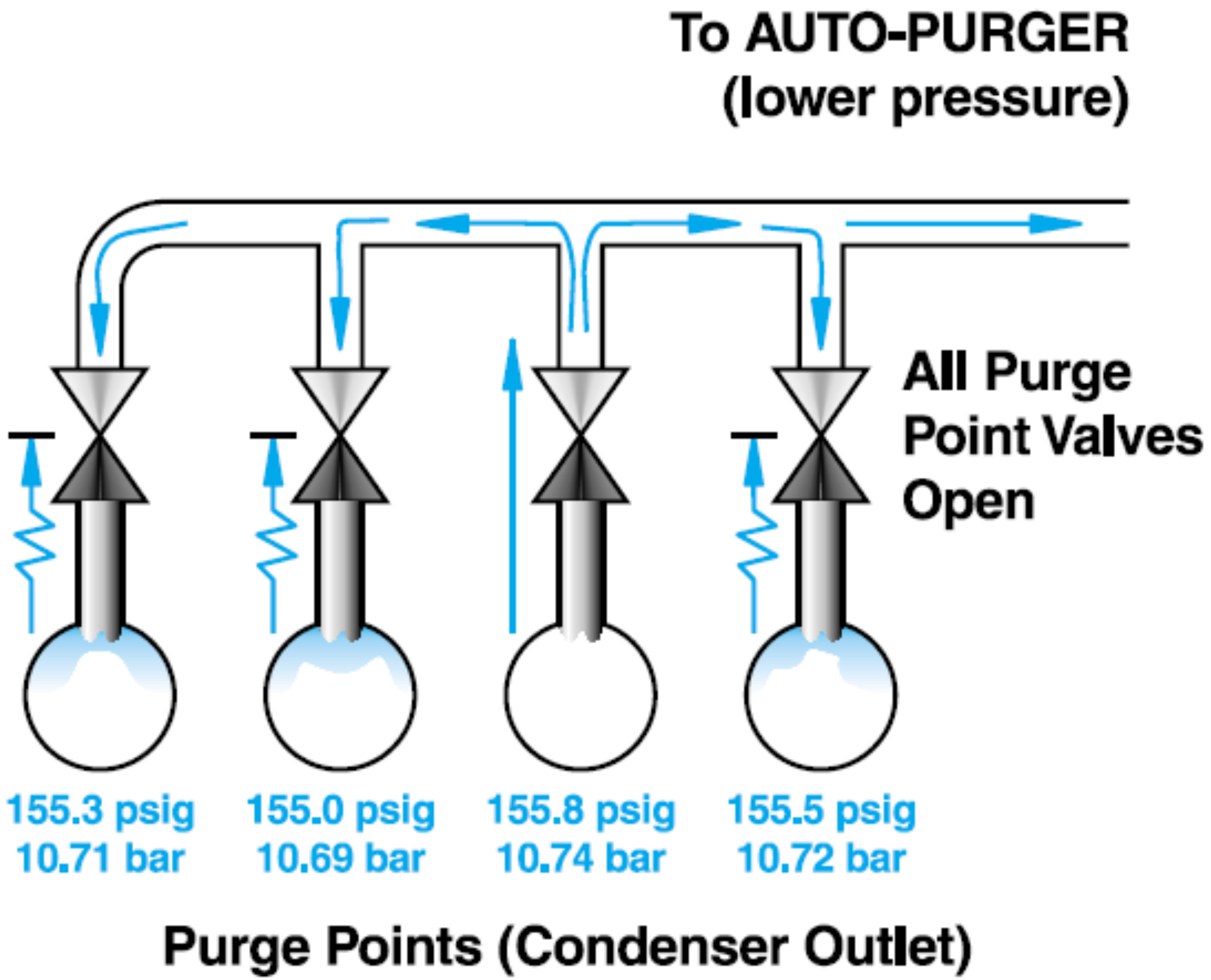
Evaporative Condenser Purge Piping Always on outlet pipe

Multiple Condenser Purge Piping



Multipoint purging.

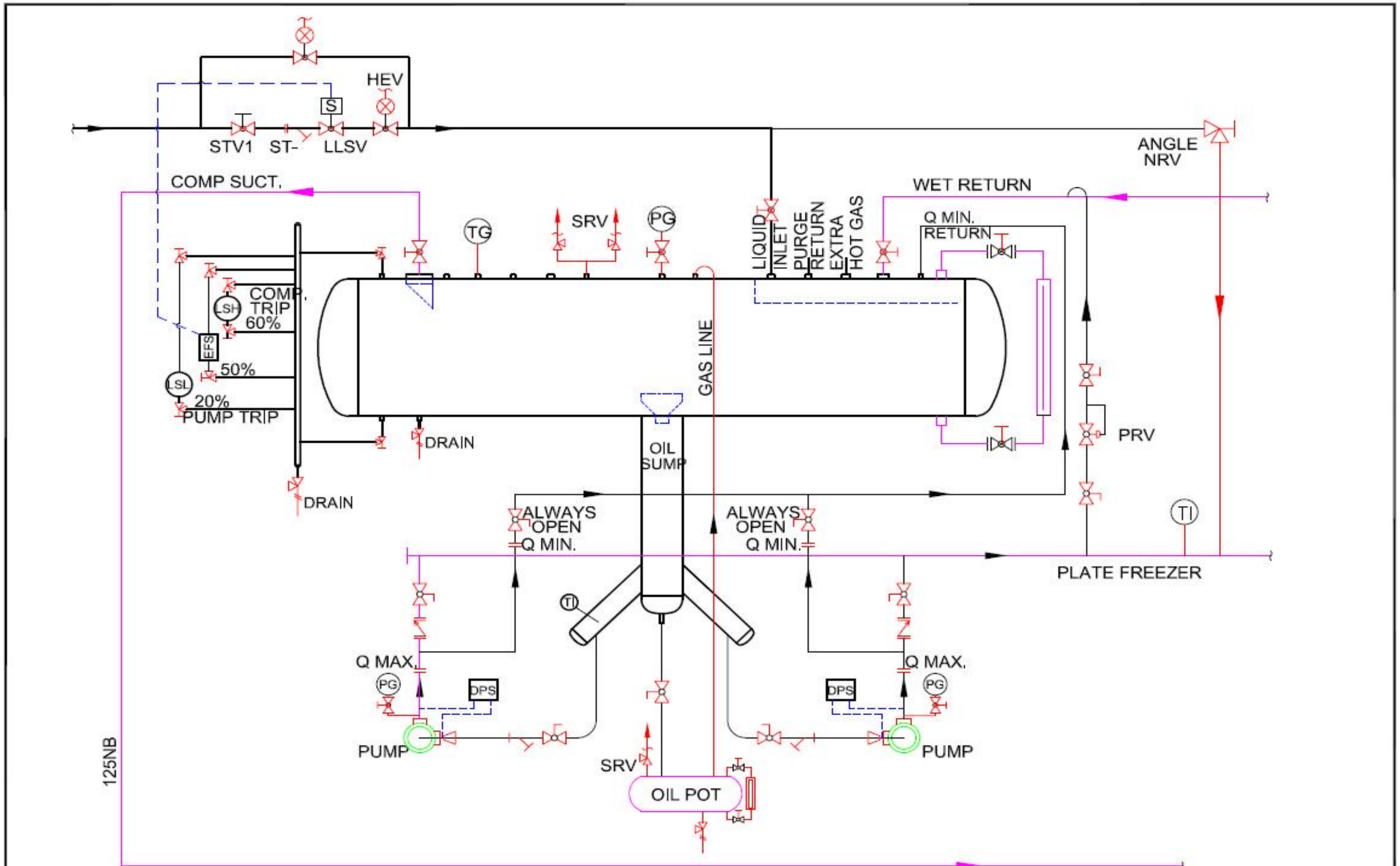
Multiple Condensers –Purge one at a time



When multiple purge points are open simultaneously, air is purged from only the point with the highest pressure.

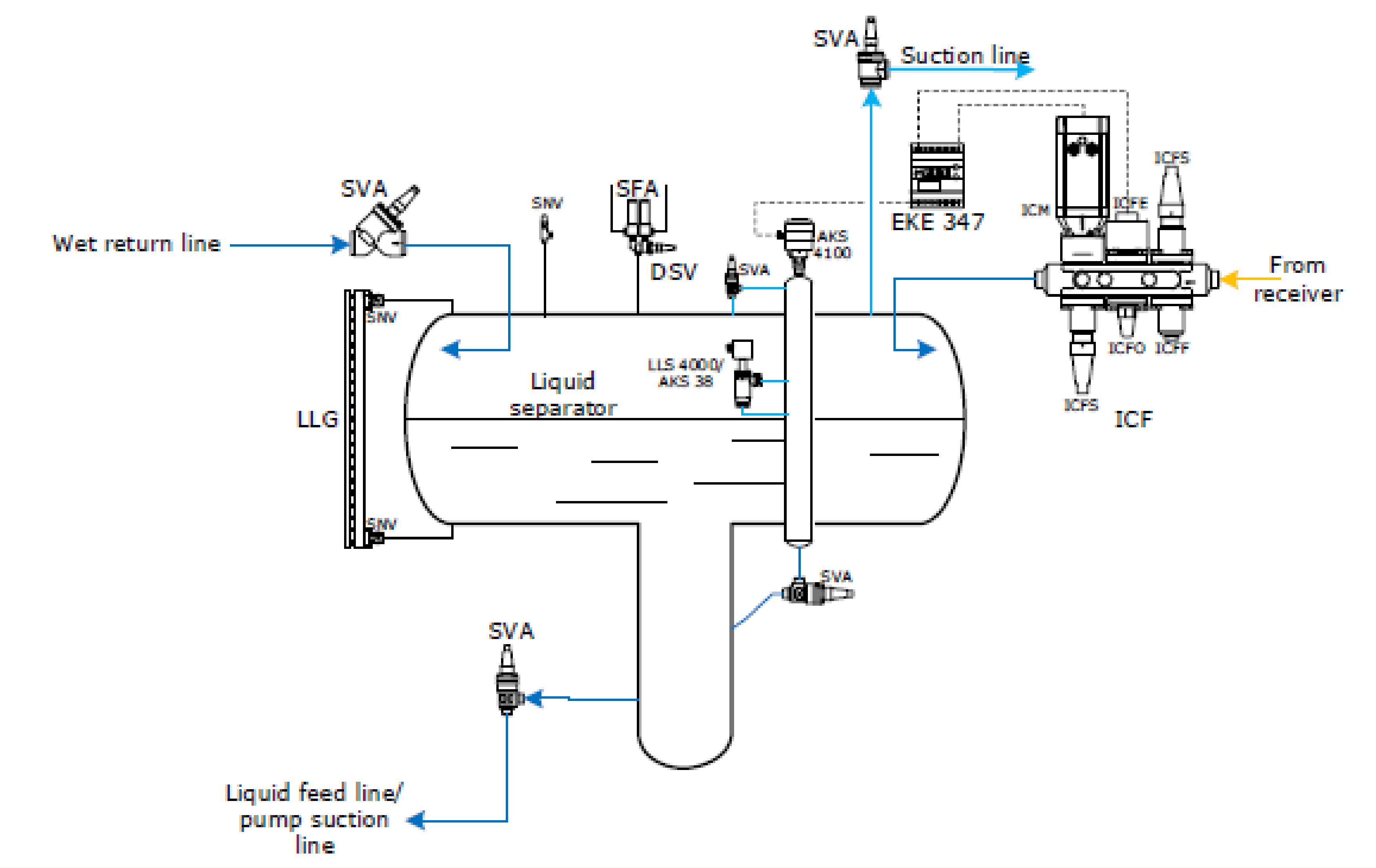
Low Pressure Vessel & piping

L. P. Vessel piping

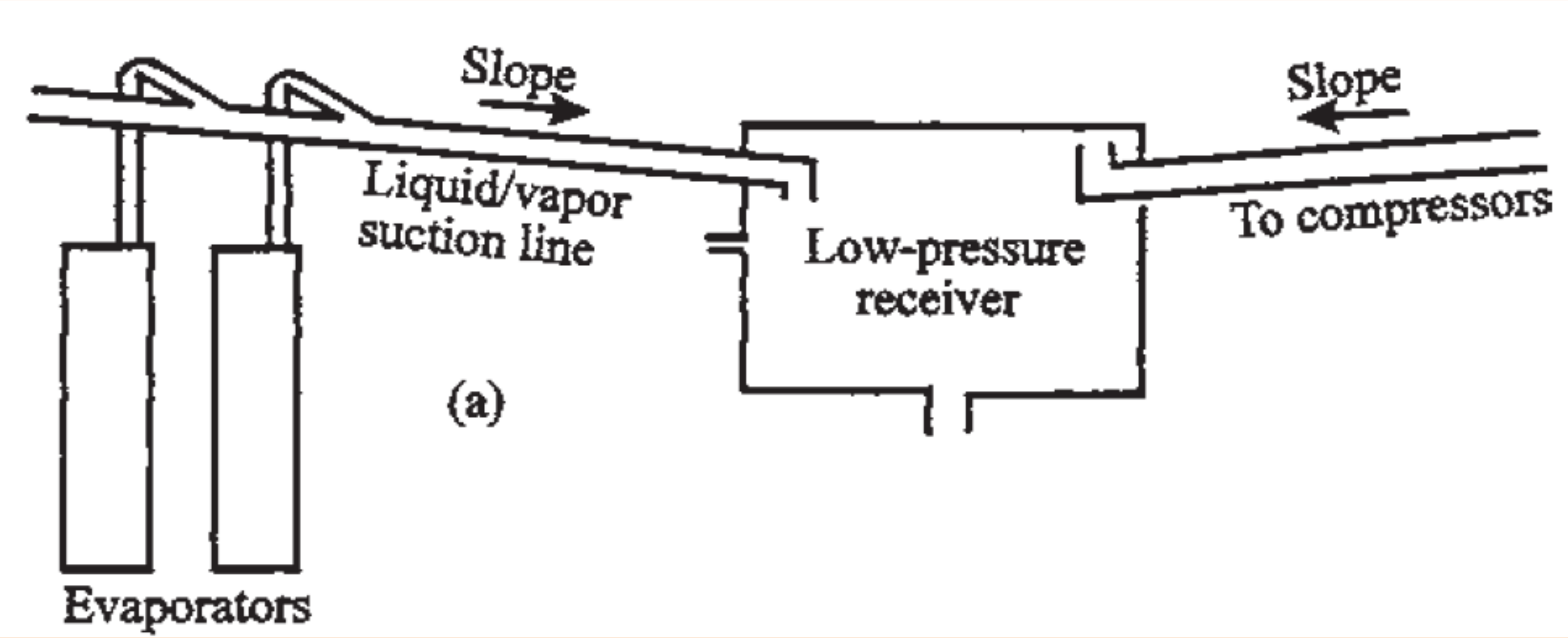


PIPING AND CONTROL ARRANGEMENT FOR LP VESSEL

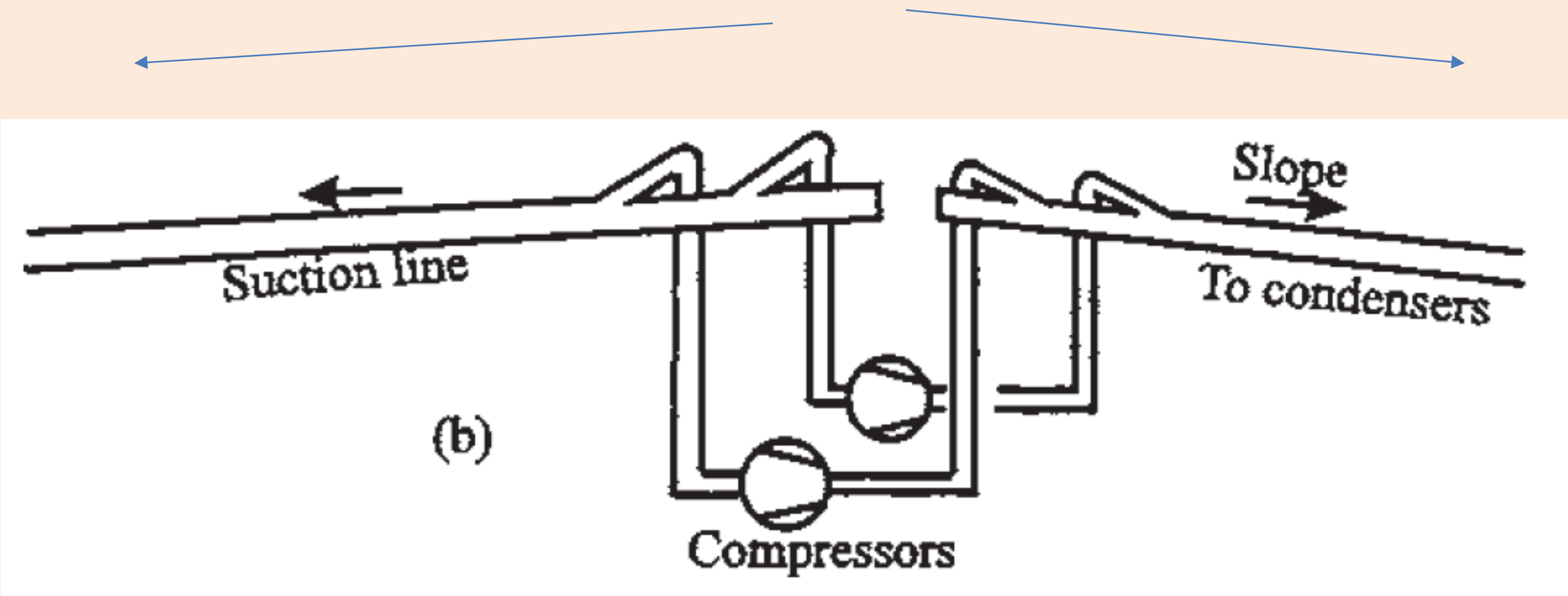
L.P. Vessel Piping



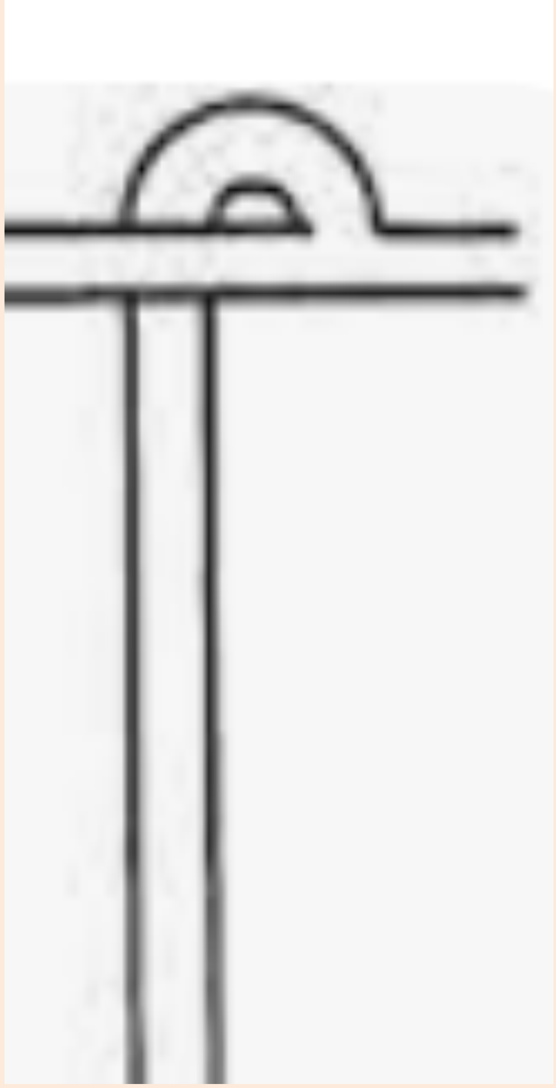
L.P. Vessel piping arrangement



Compressor Suction Piping



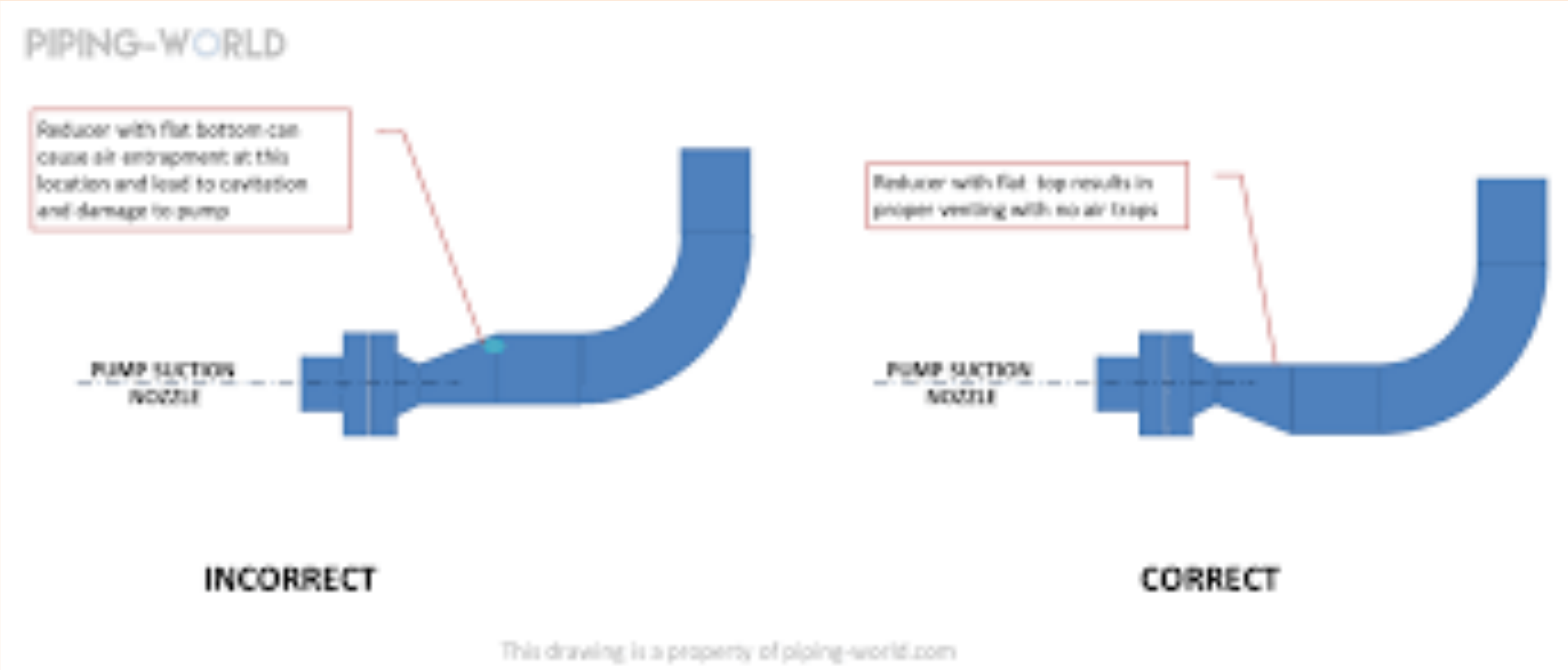
Compressor piping from Suction header



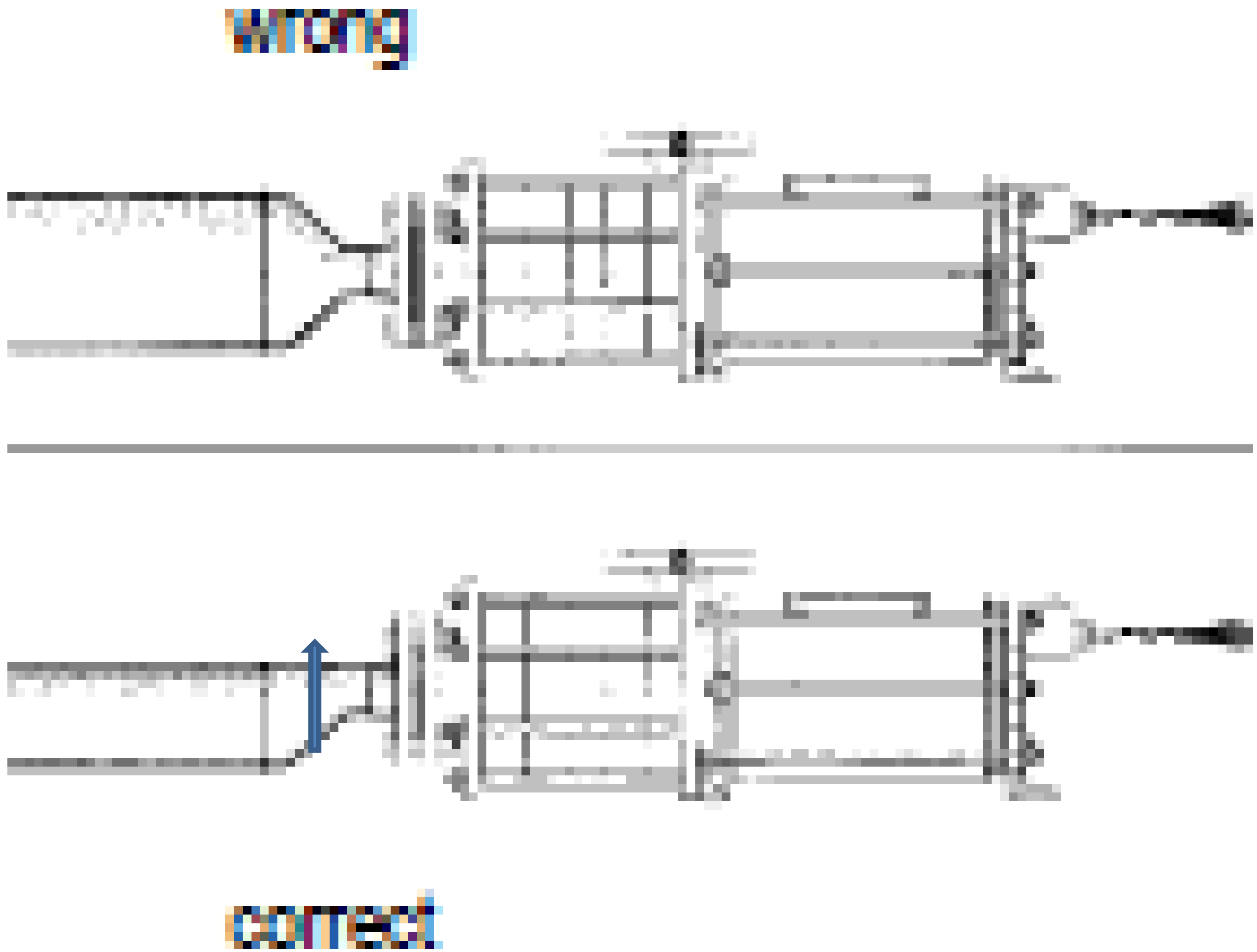
Recommended Sizes For Down Leg to Pump

Approx. Pump Flow Rate	$5m^3/hr$	$12m^3/hr$	$15m^3/hr$	$35m^3/hr$	$70m^3/hr$
Pump Suction Size-mm	**32**	**50**	**50**	**80**	**100**
Down Leg Size-mm	**80**	**100**	**125**	**150**	**250**

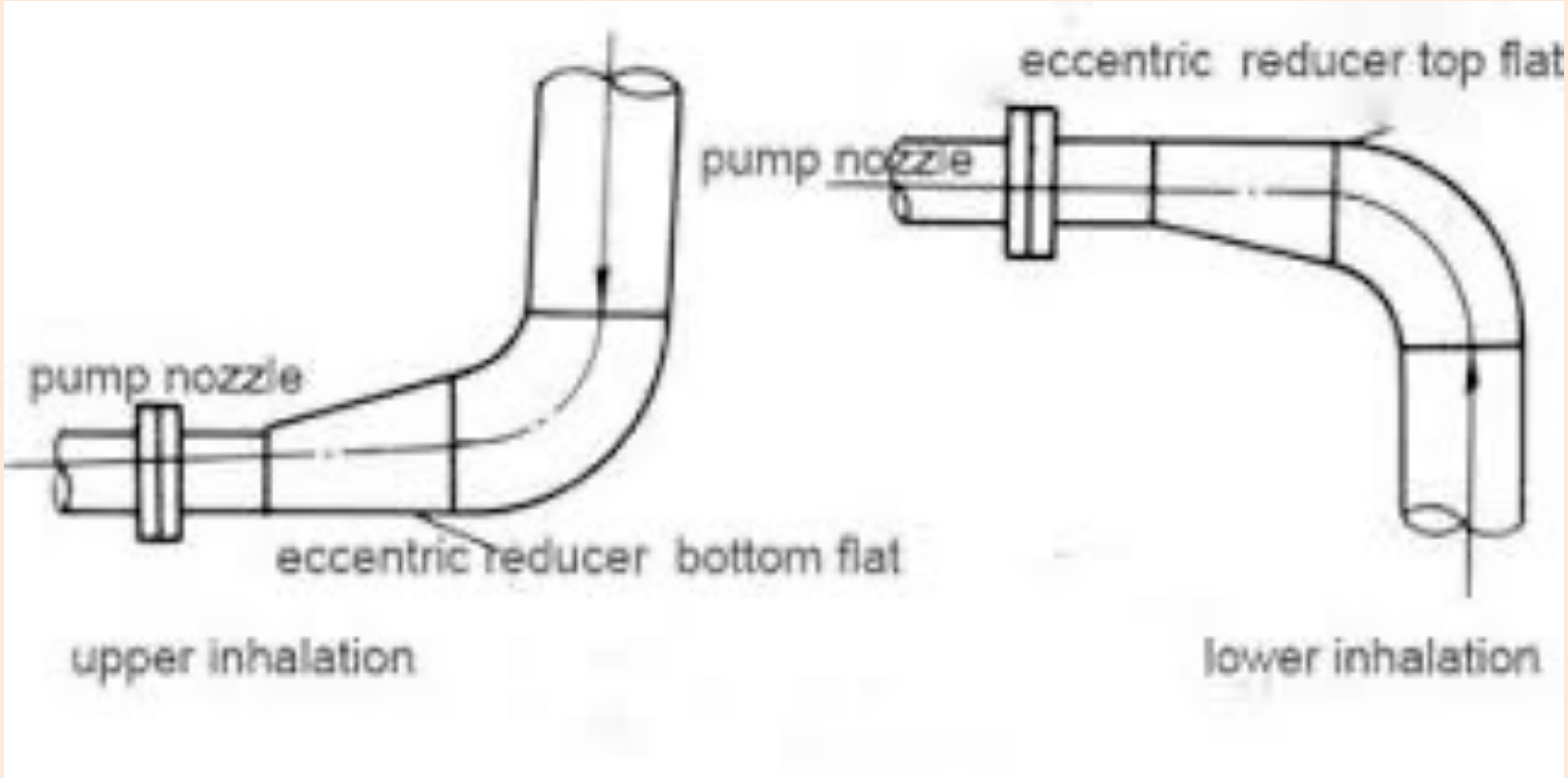
Reducer Installation



Reducer At Ammonia Pump Inlet



Ammonia Pump inlet connection

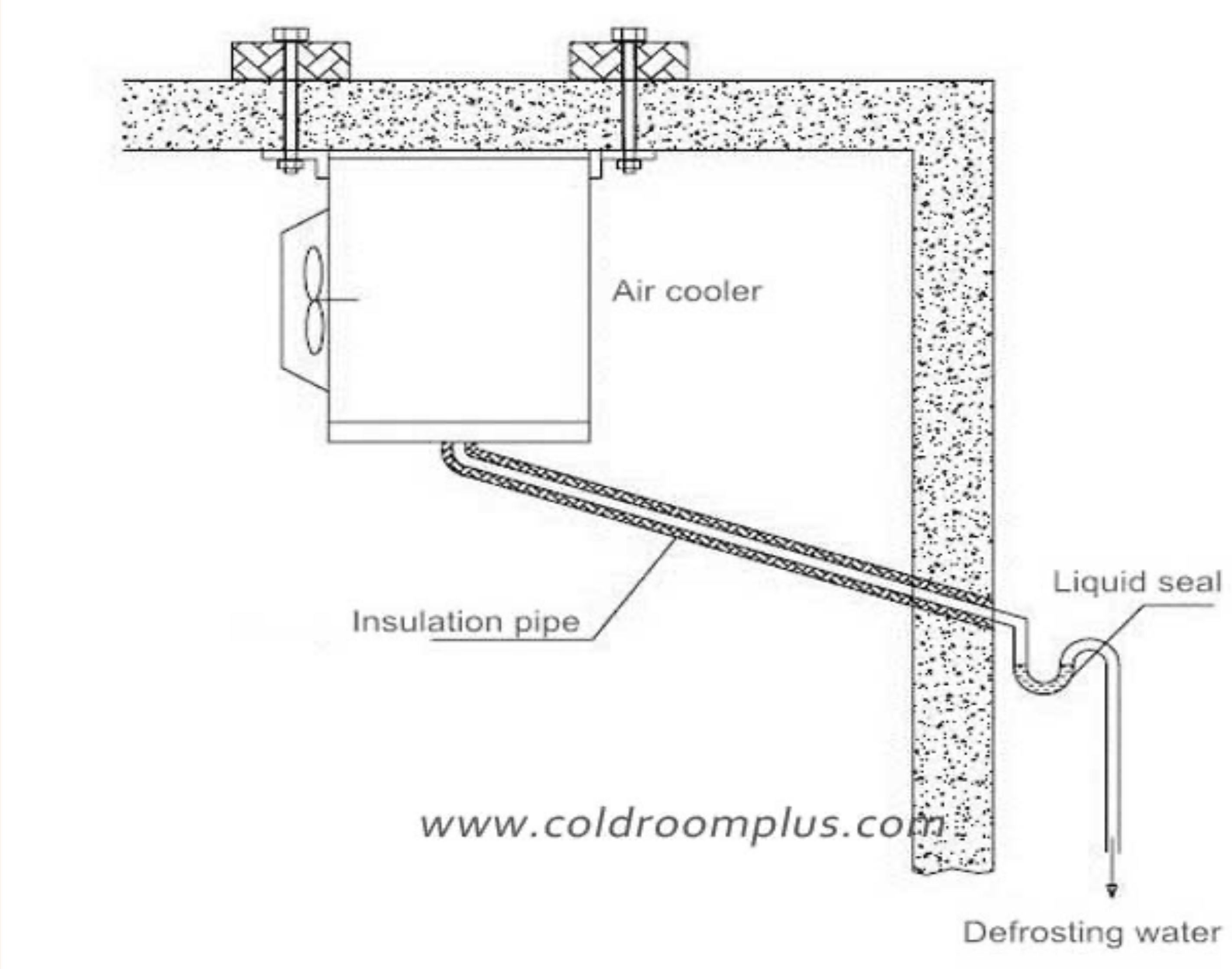


Piping valves

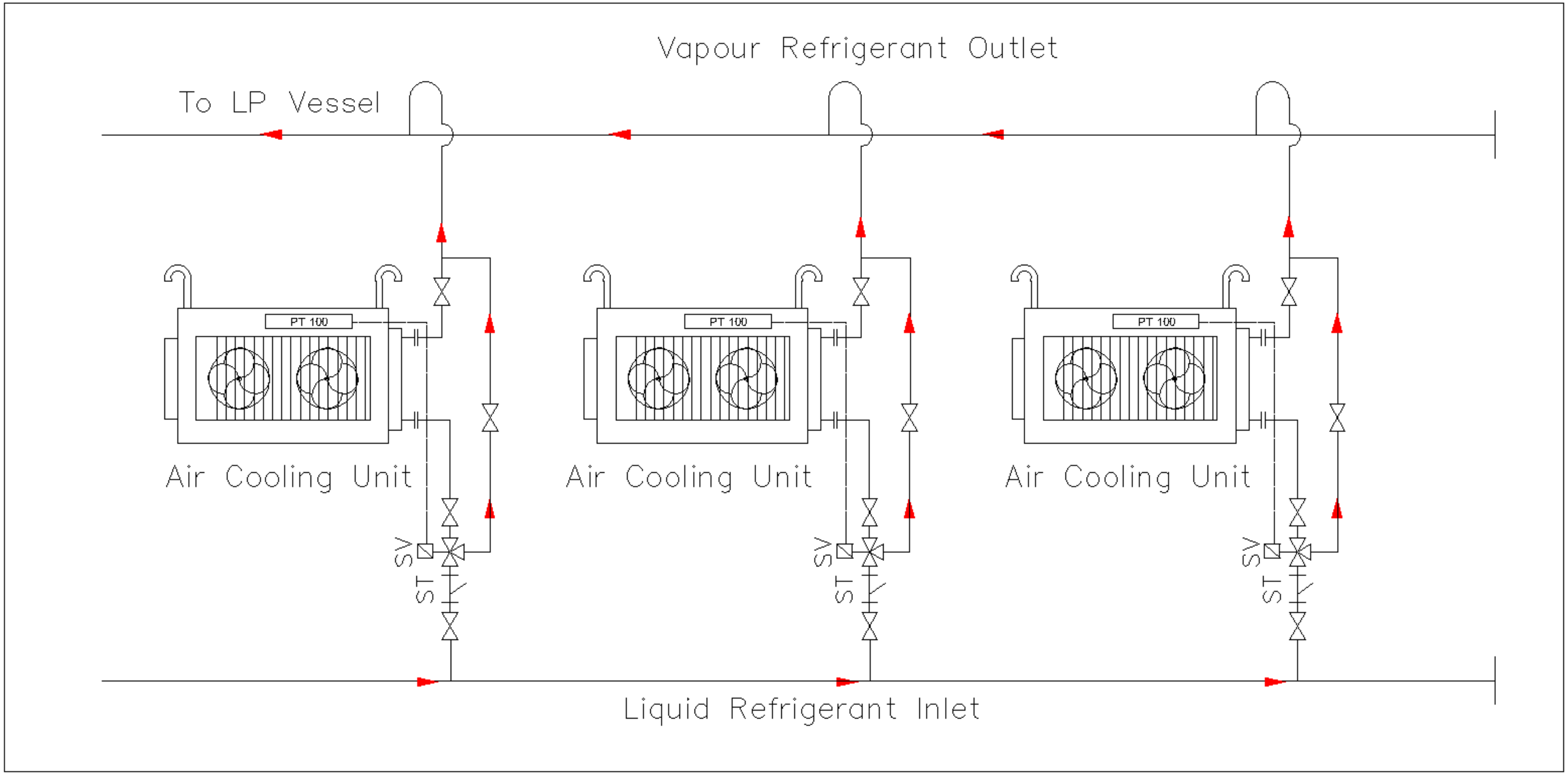
- Use ball valves

  1. Wet return line / suction line/Pump inlet line
  2. Keep minimum pressure drop
  3. Ensures higher operating compressor suction pressure
  4. Energy savings

Air cooler drain piping with liquid seal



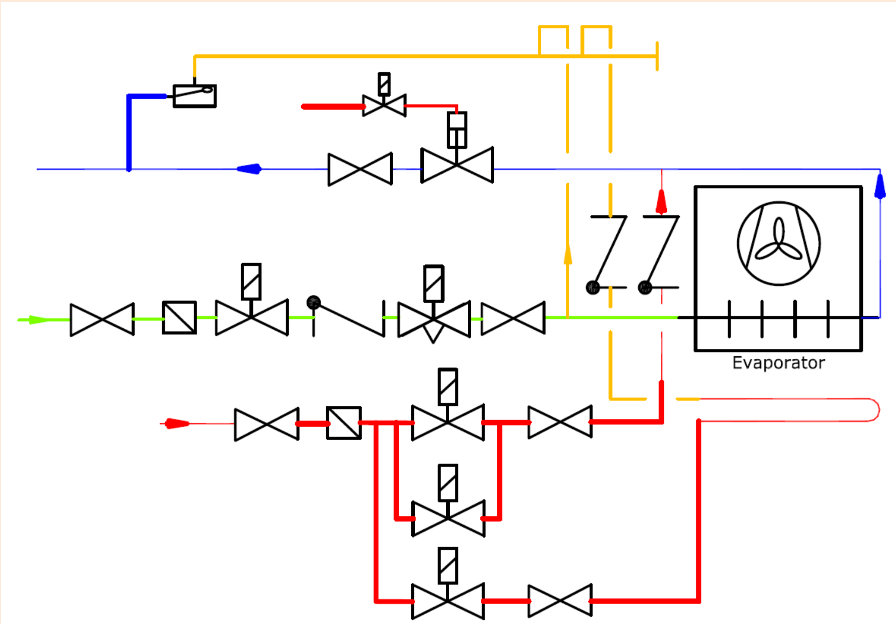
Multiple Air Cooler piping & Controls



Air cooler piping outside the building on terrace

Hot Gas Defrost Arrangement and piping

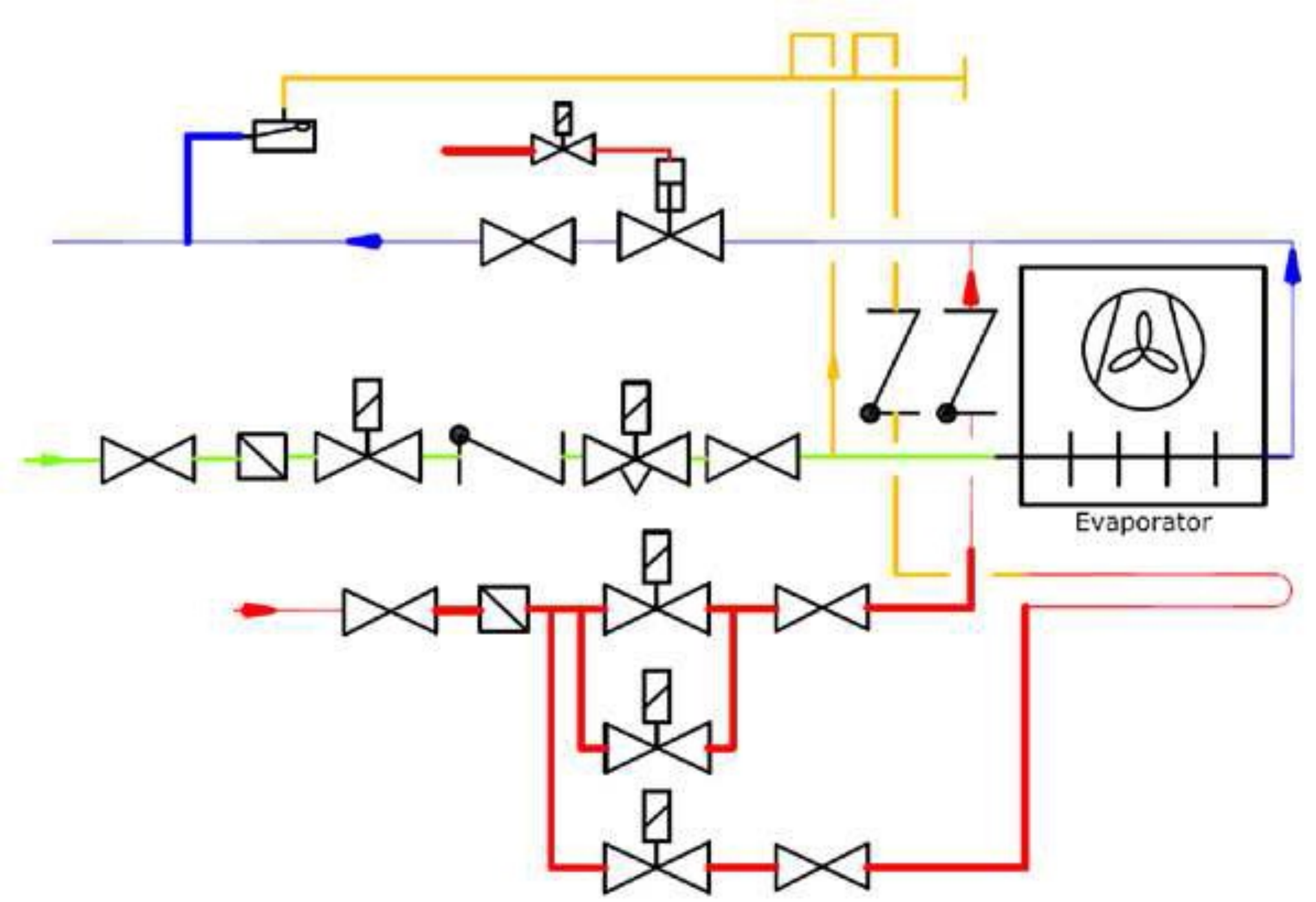
Separate hot gas defrost line for defrost pans



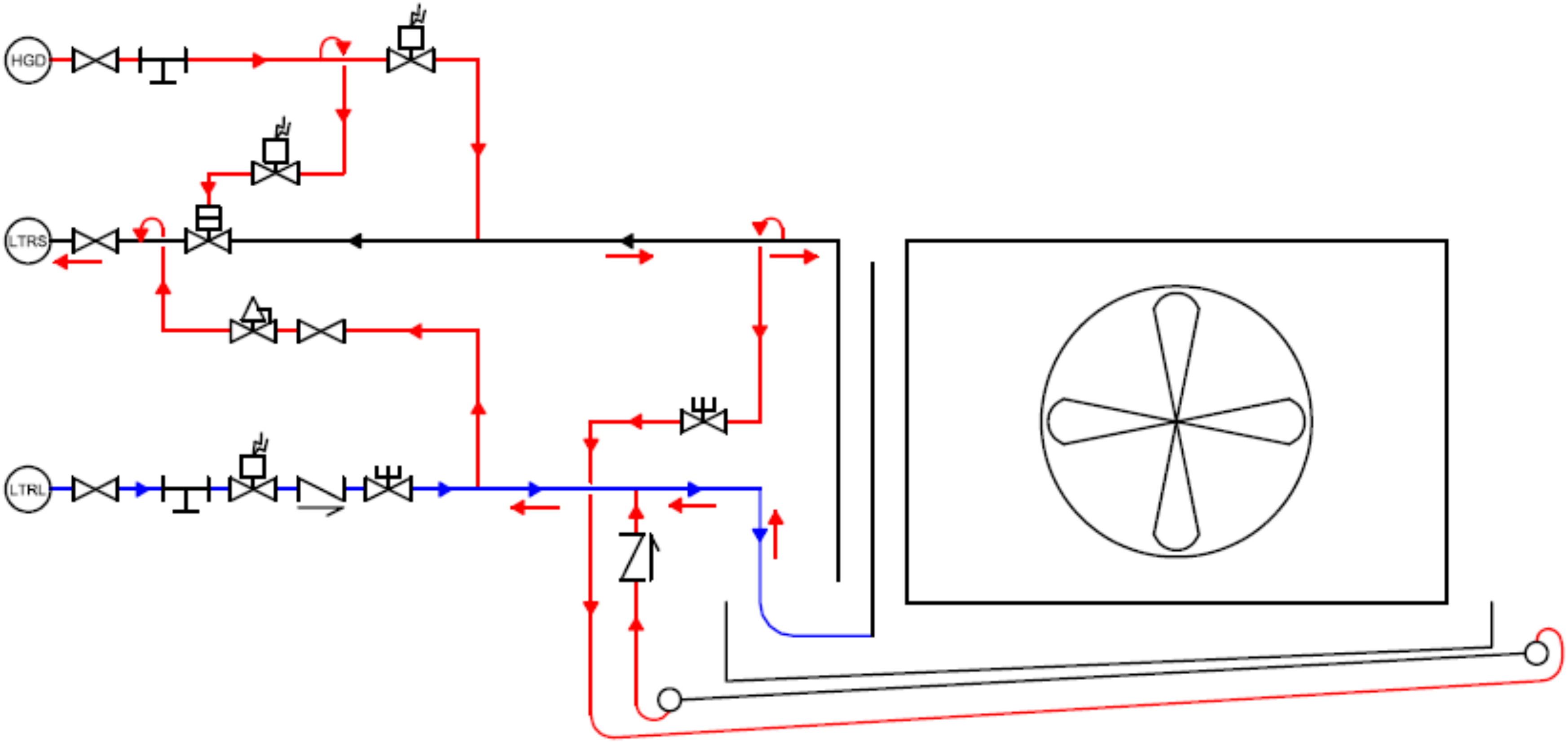
Having a separate valve station for the defrost pan:

- Reduces the energy consumption since a smaller solenoid valve is necessary to heat the pan during the length of the defrost sequence
- Main hot gas solenoid valve will only be active for 10 minutes reducing the amount of heat added to the refrigerated space.

Optimized hot gas defrost



RECIRCULATED BOTTOM FEED
2-PIPE HOT GAS DEFROST
VERTICAL HEADERS
1-PASS PAN LOOP



OPTIMIZED HOT GAS DEFROST WITH SEPARATE FOR DRAIN PAN

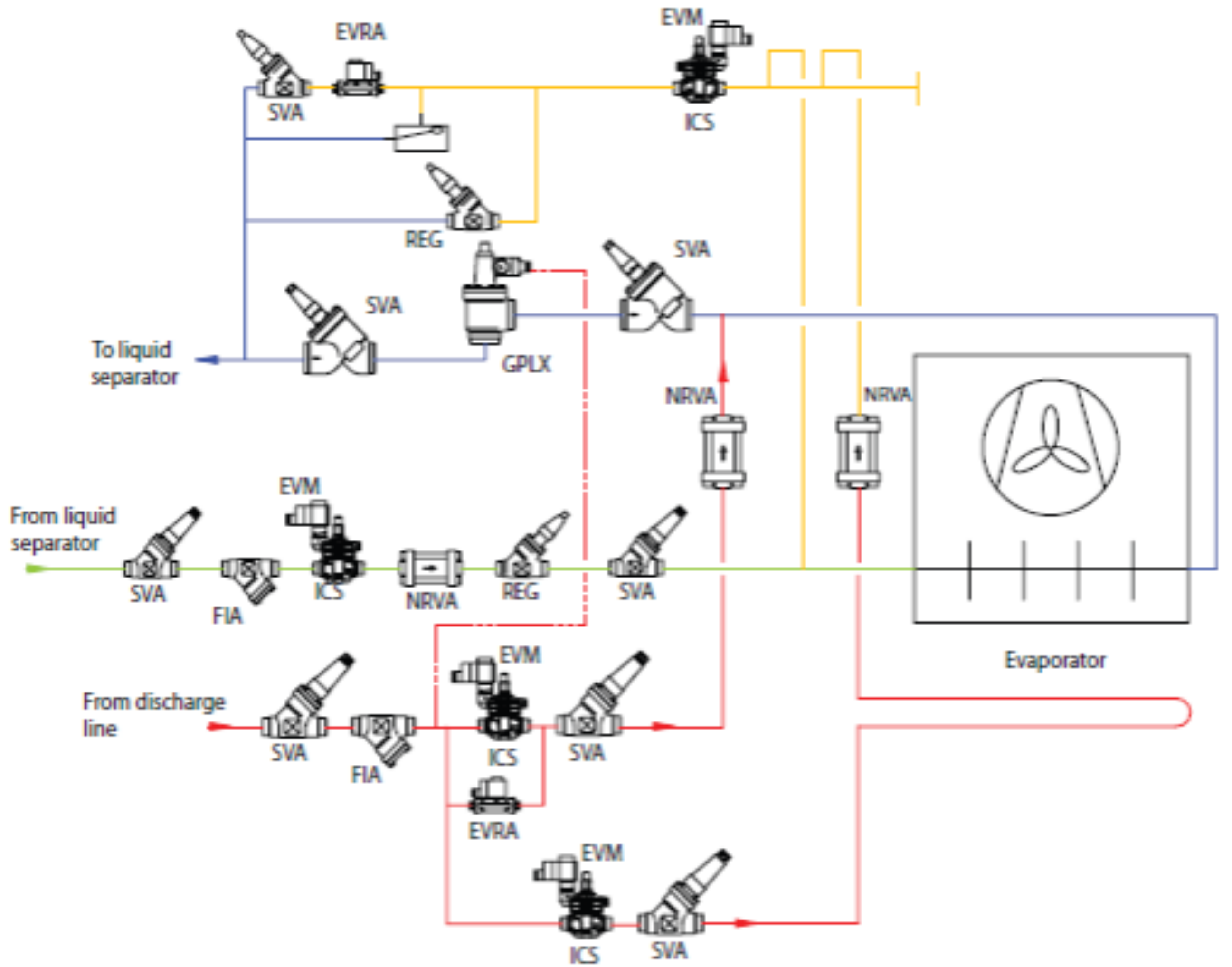
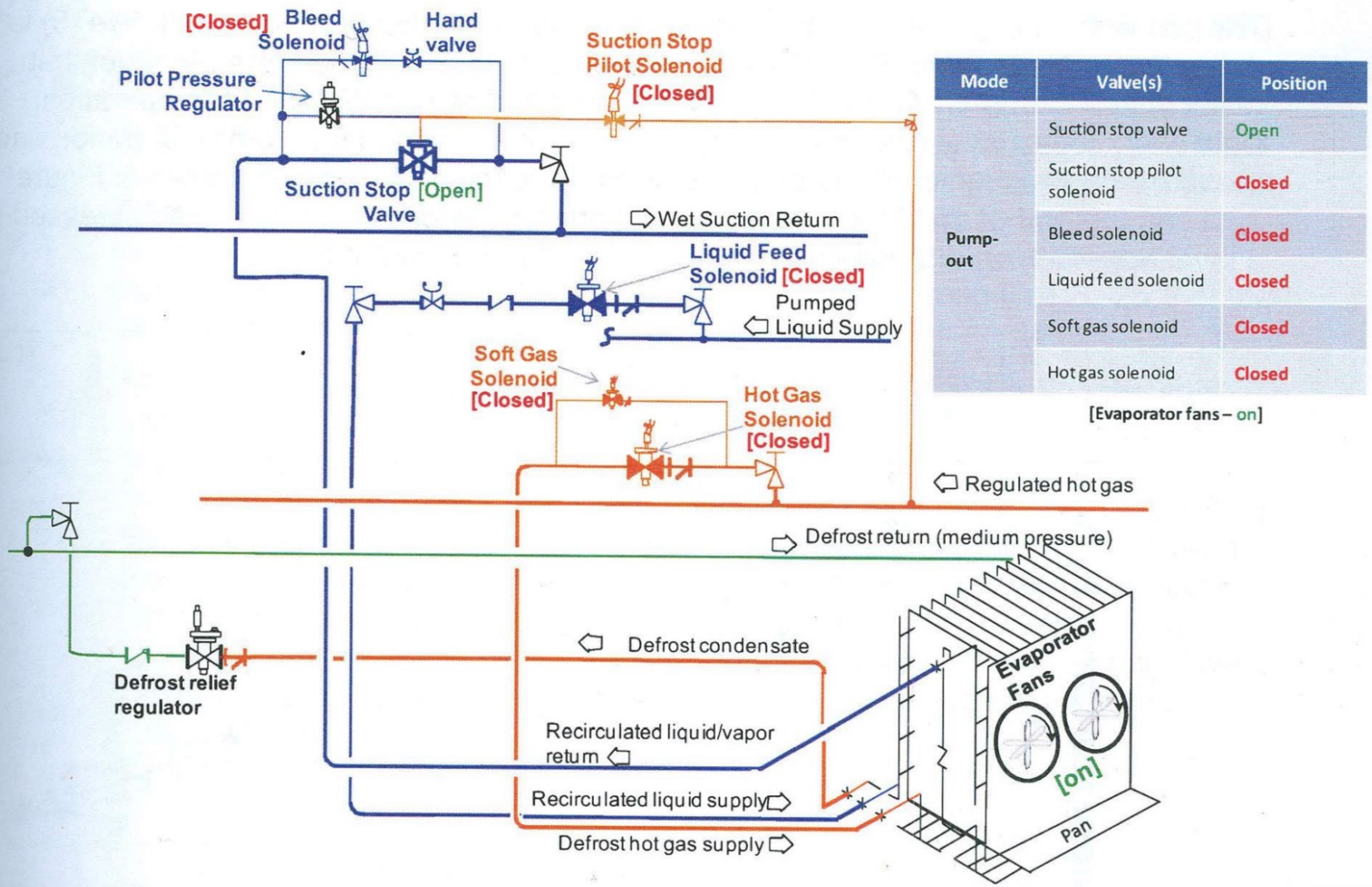


Figure 5. Optimized defrost system configuration

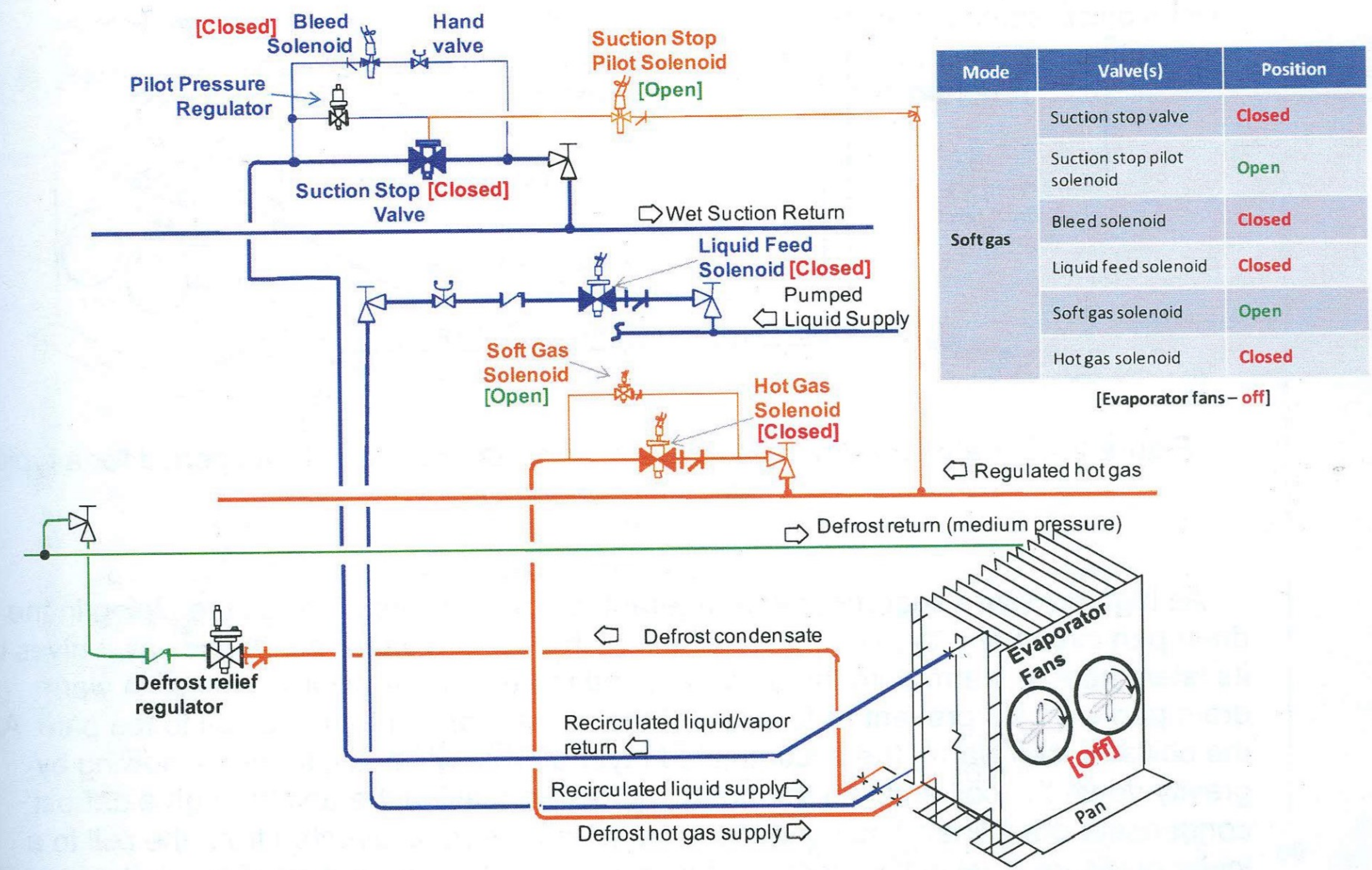
Hot Gas Defrost-Pump Out Phase



Mode	Valve(s)	Position
Pump-out	Suction stop valve	Open
	Suction stop pilot solenoid	Closed
	Bleed solenoid	Closed
	Liquid feed solenoid	Closed
	Soft gas solenoid	Closed
	Hot gas solenoid	Closed

Figure 2-40: Valve positions and fan operation during pump-out for a typical liquid overfed coil.

Hot Gas Defrost-Soft Gas Phase

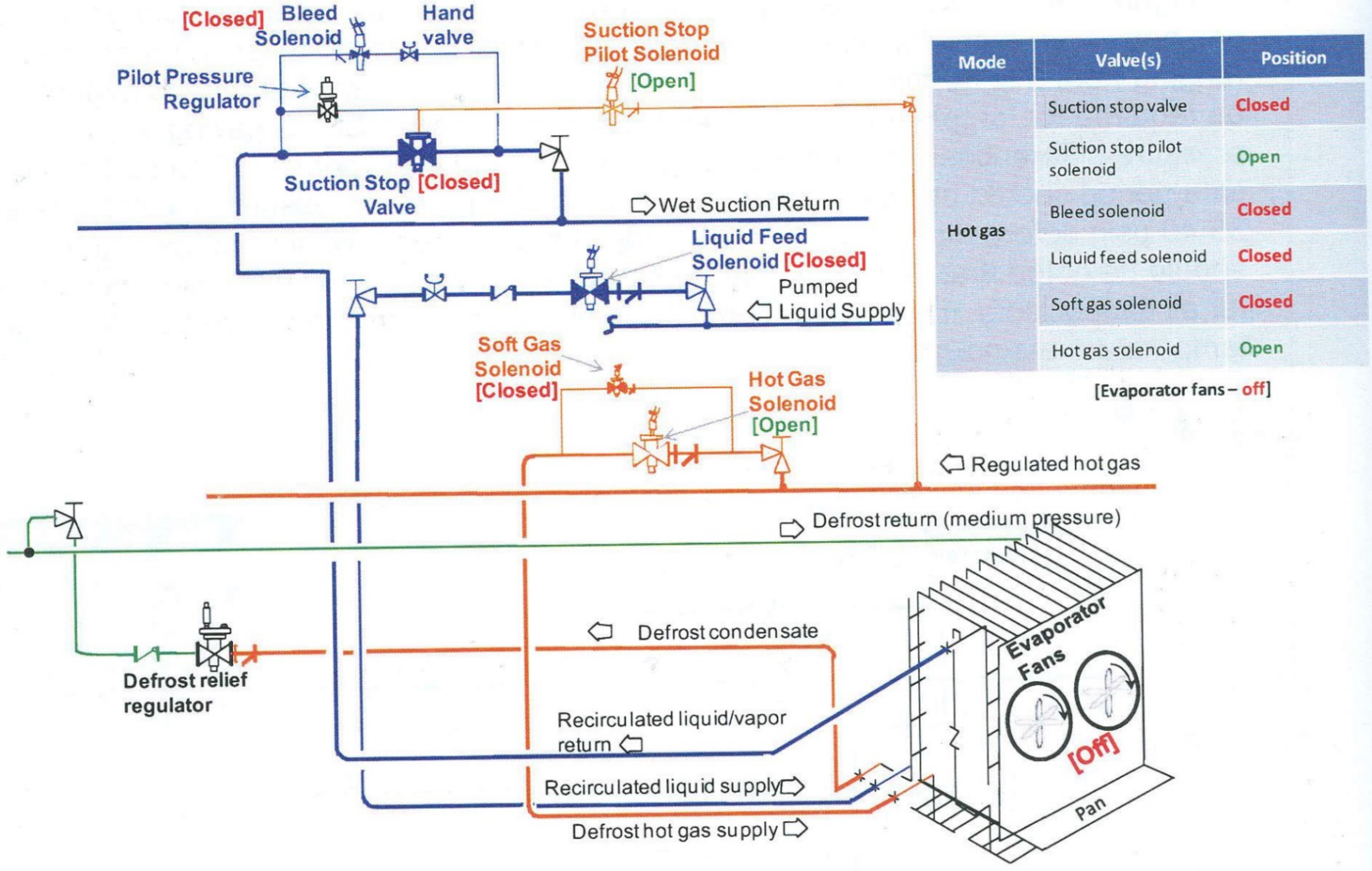


Mode	Valve(s)	Position
Soft gas	Suction stop valve	Closed
Soft gas	Suction stop pilot solenoid	Open
Soft gas	Bleed solenoid	Closed
Soft gas	Liquid feed solenoid	Closed
Soft gas	Soft gas solenoid	Open
Soft gas	Hot gas solenoid	Closed

[Evaporator fans – off]

Figure 2-42: Valve positions and fan operation during the soft-gas period for a typical liquid overfed coil.

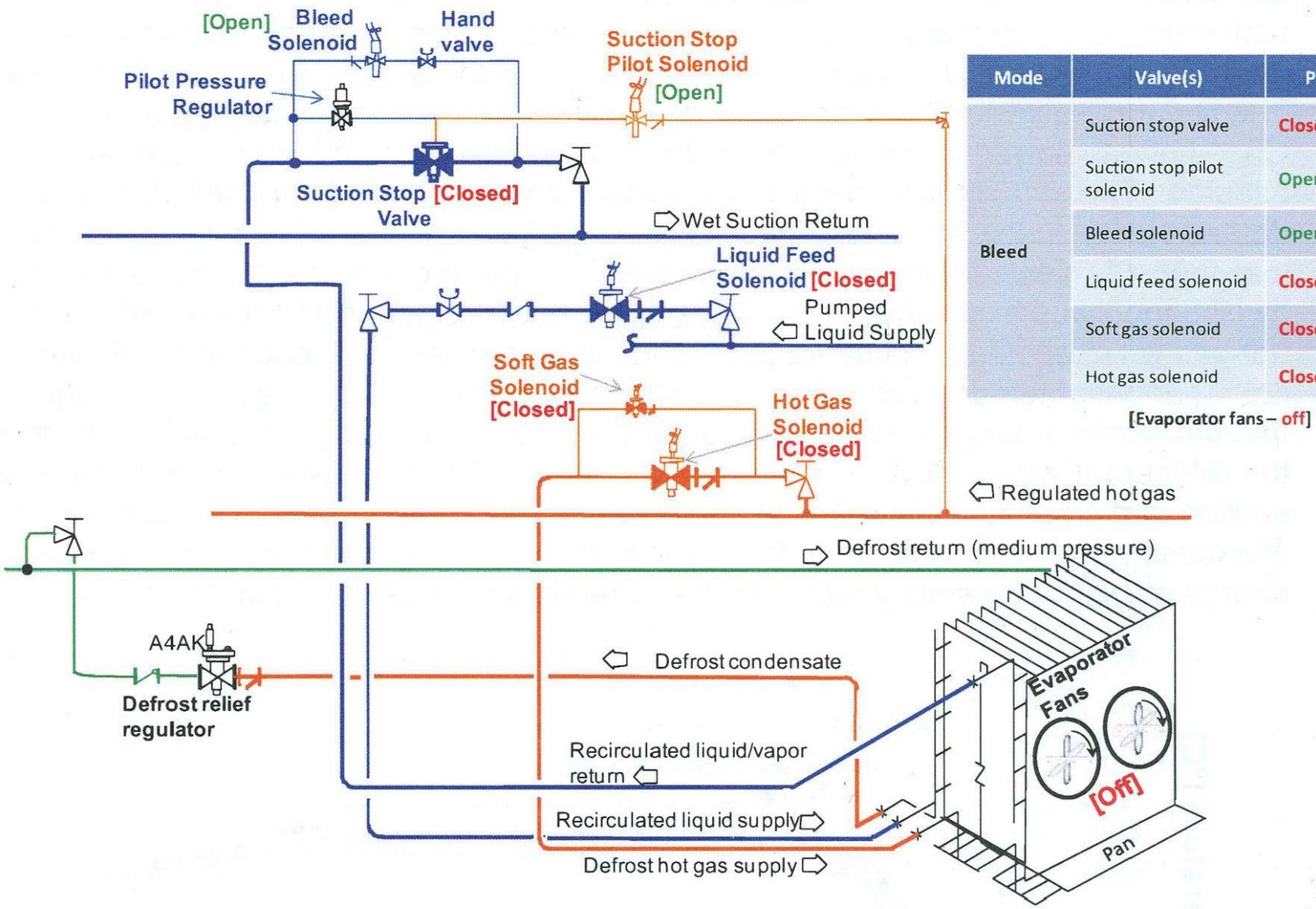
Hot Gas Defrost Phase



Mode	Valve(s)	Position
Hot gas	Suction stop valve	Closed
	Suction stop pilot solenoid	Open
	Bleed solenoid	Closed
	Liquid feed solenoid	Closed
	Soft gas solenoid	Closed
	Hot gas solenoid	Open

Figure 2-43: Valve positions and fan operation during the hot-gas period for a typical liquid overfed coil.

End of Defrost- Condensate Bleed Phase

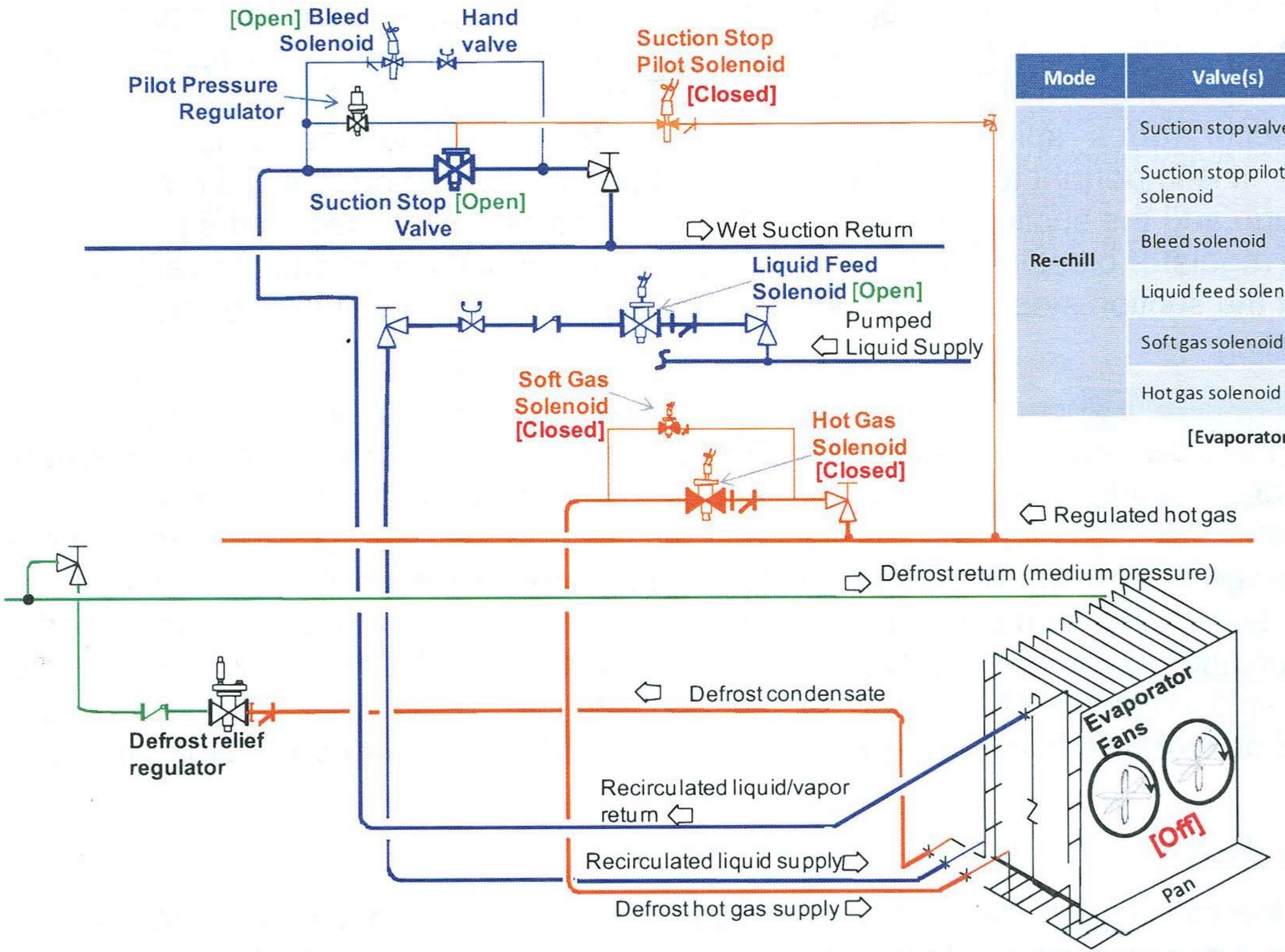


Mode	Valve(s)	Position
Bleed	Suction stop valve	Closed
	Suction stop pilot solenoid	Open
	Bleed solenoid	Open
	Liquid feed solenoid	Closed
	Soft gas solenoid	Closed
	Hot gas solenoid	Closed

[Evaporator fans – off]

Figure 2-45: Valve positions and fan operation during the bleed period for a typical liquid overfed coil.

Defrost Ends-Re chill Phase



Mode	Valve(s)	Position
Re-chill	Suction stop valve	Open
	Suction stop pilot solenoid	Closed
	Bleed solenoid	Open
	Liquid feed solenoid	Open
	Soft gas solenoid	Closed
	Hot gas solenoid	Closed

[Evaporator fans – Off]

Figure 2-46: Valve positions and fan operation during the re-chill period for a typical liquid overfed coil.

Time Dependant Energy Flow During Defrost

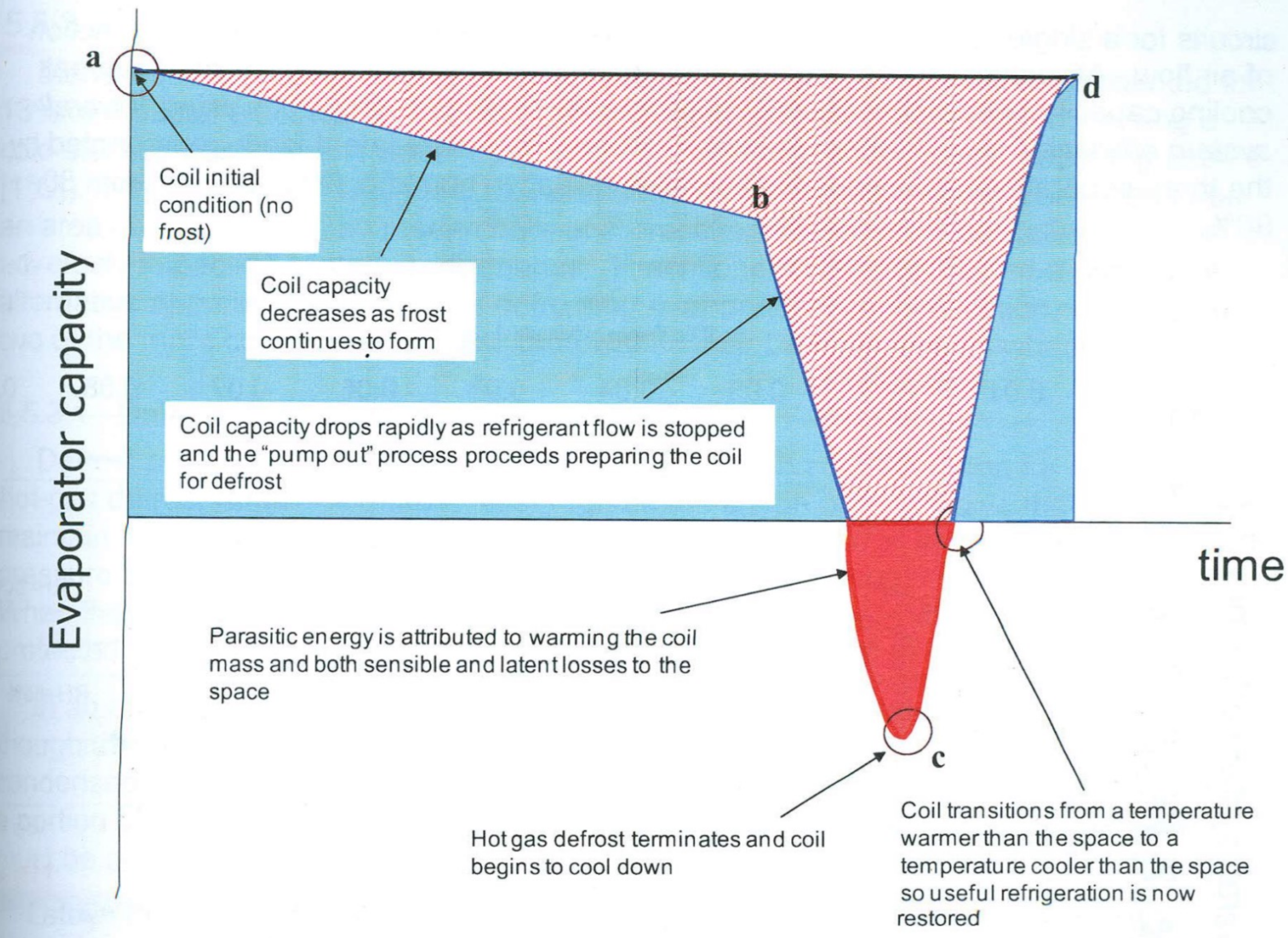
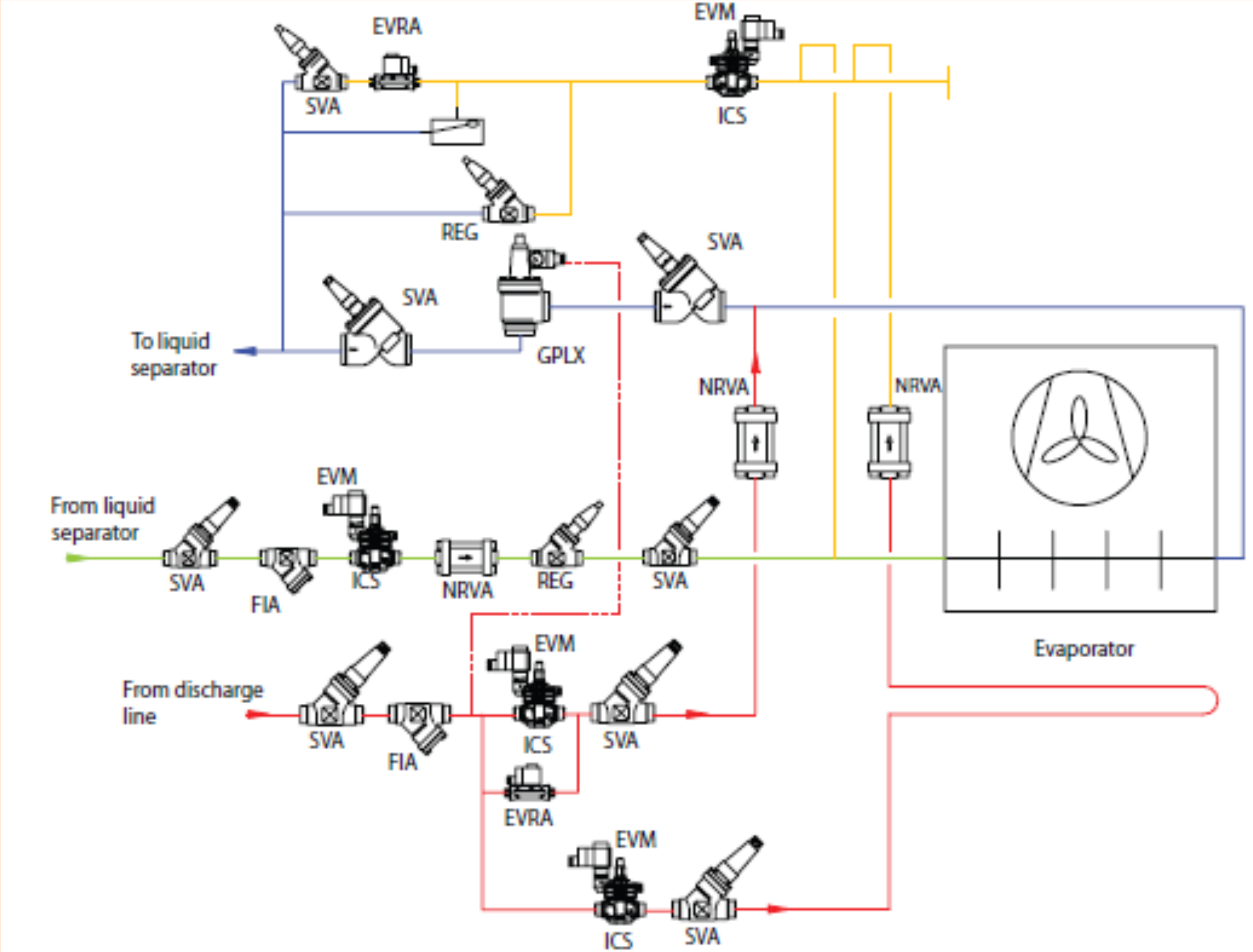


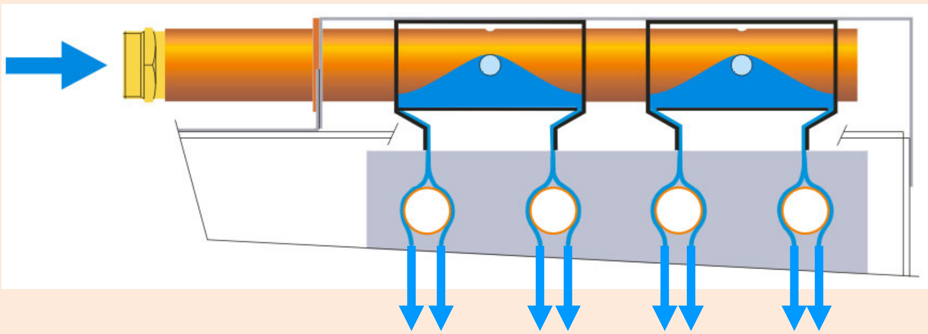
Figure 5-7: An illustration of the time-dependent energy flows for cooling mode and defrost mode of operation (Note: this graphic is not to scale in either capacity or time) [adapted from Aljuwayhel 2006b].

Hot gas for Drain Pan

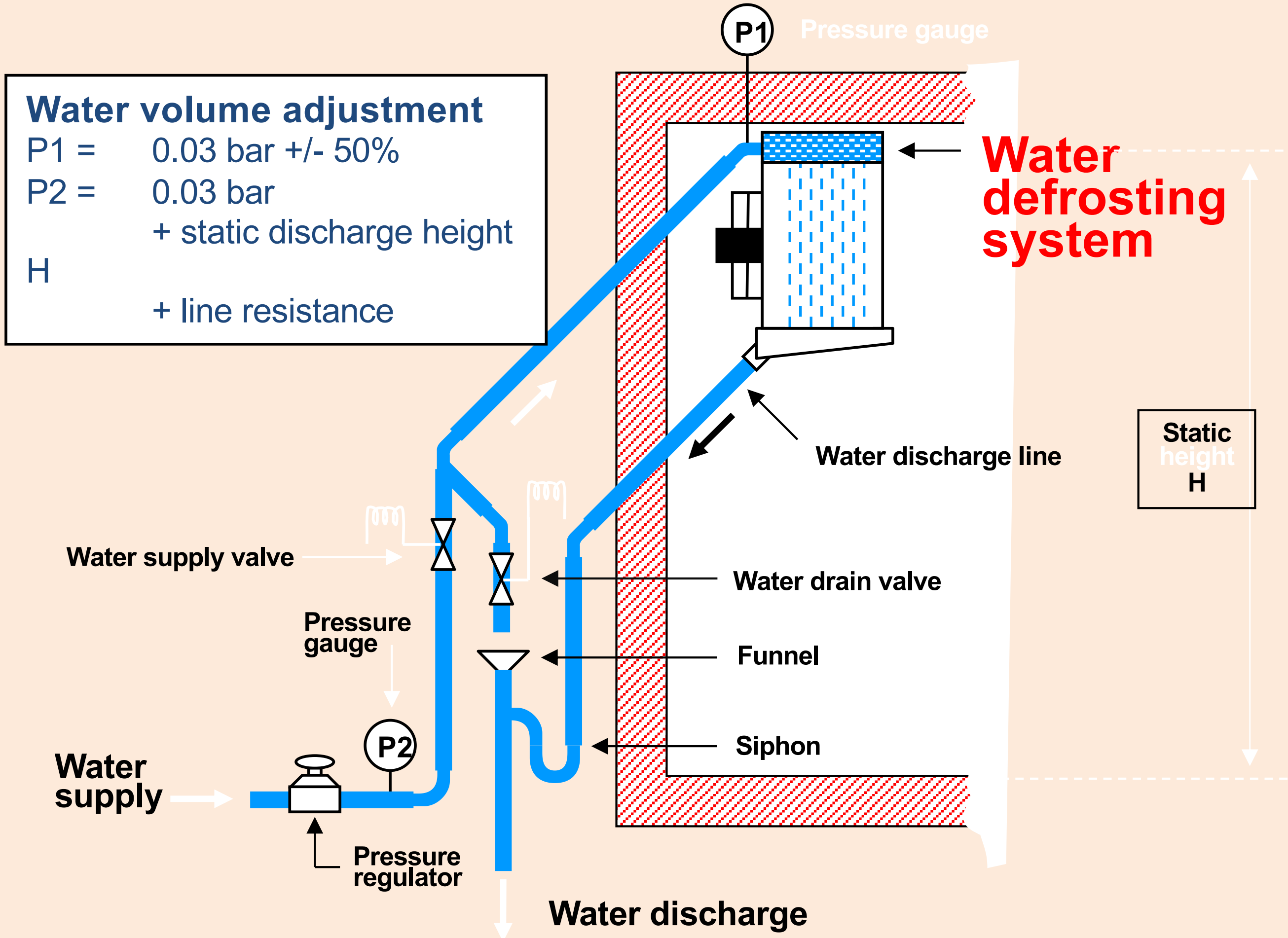


Water defrost

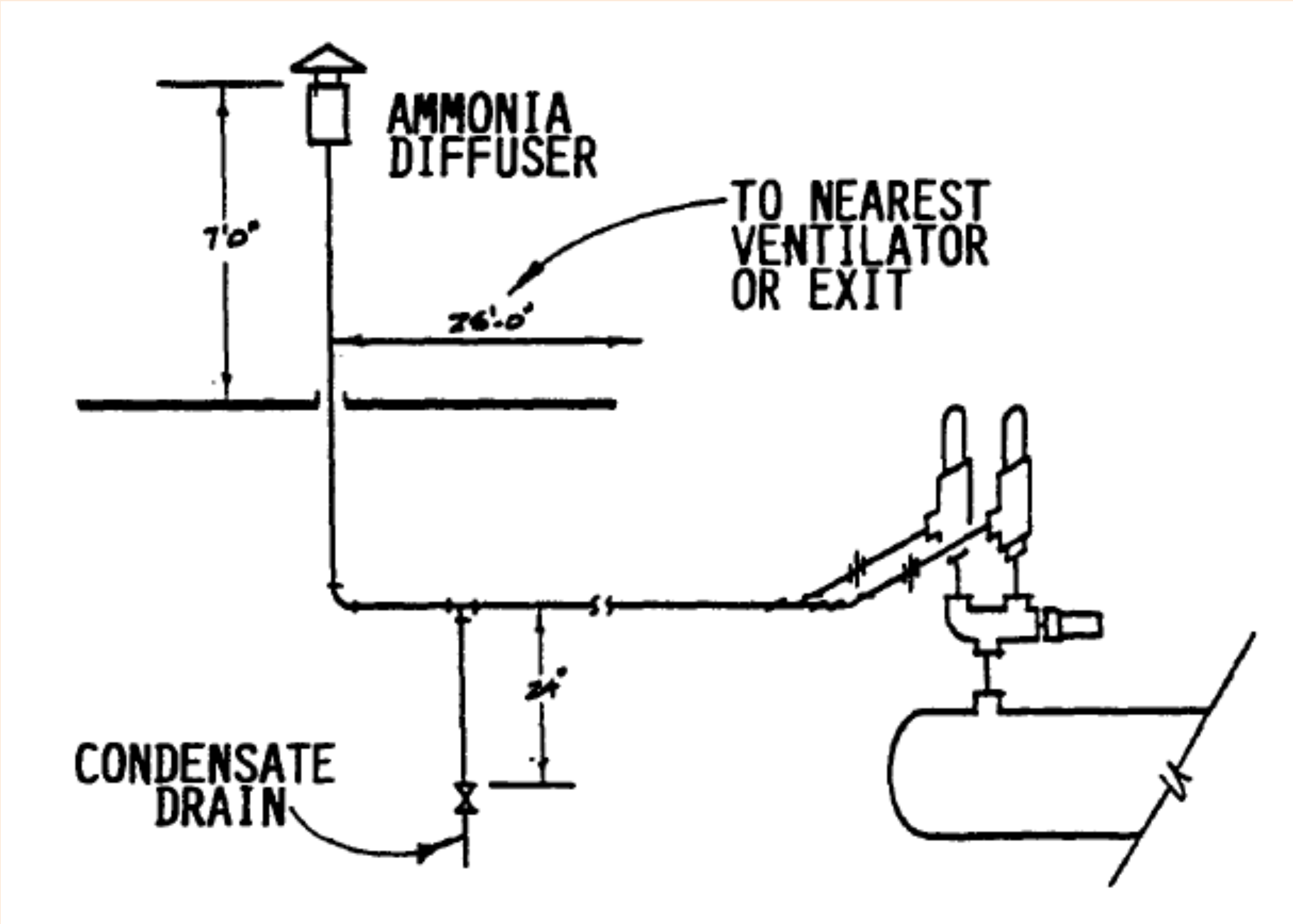
- Water is lead to gutters, located lengthwise above the cooler coil. One gutter per two tube rows.
- Water distribution openings in the gutter bottom plate ensure an even water distribution over the cooler tubes.



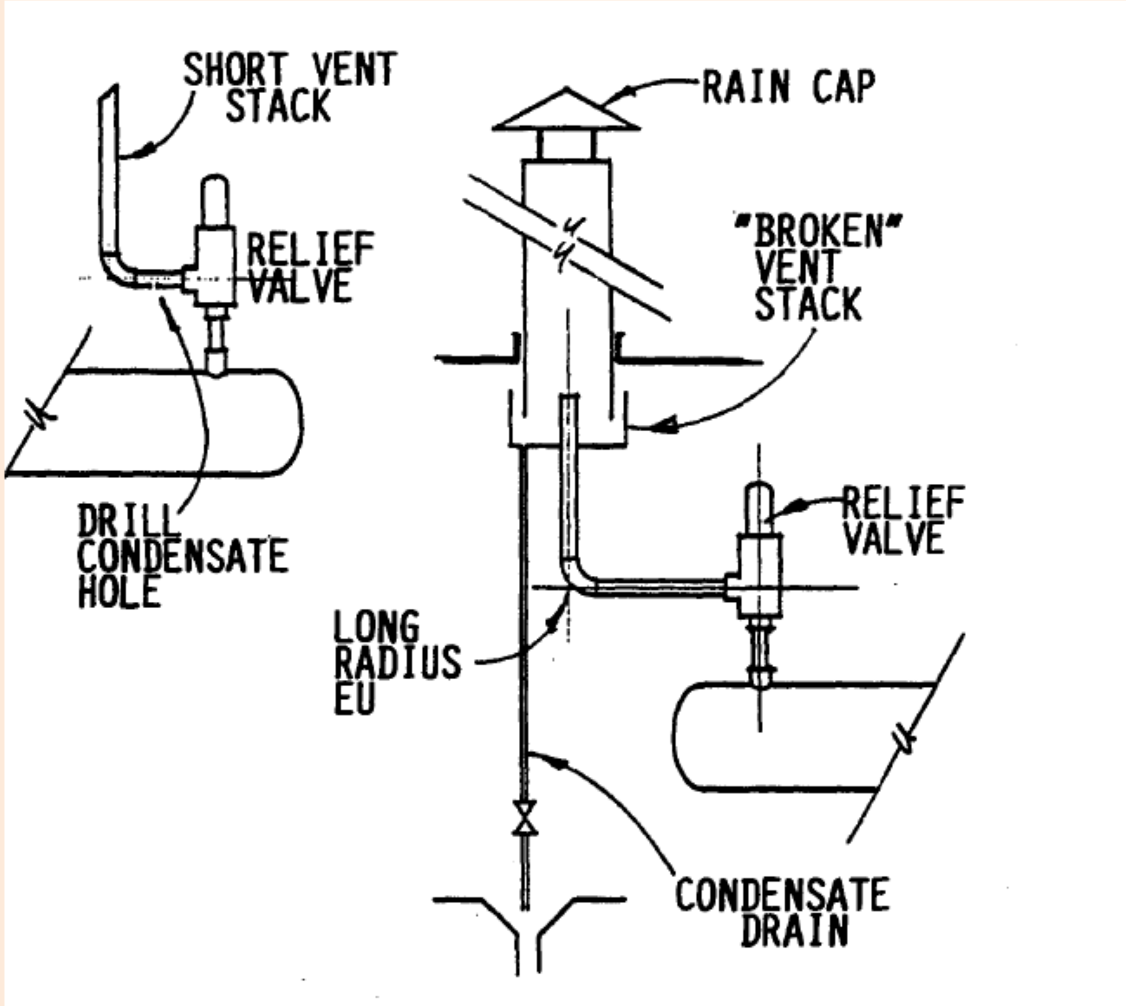
Bottom feed water supply



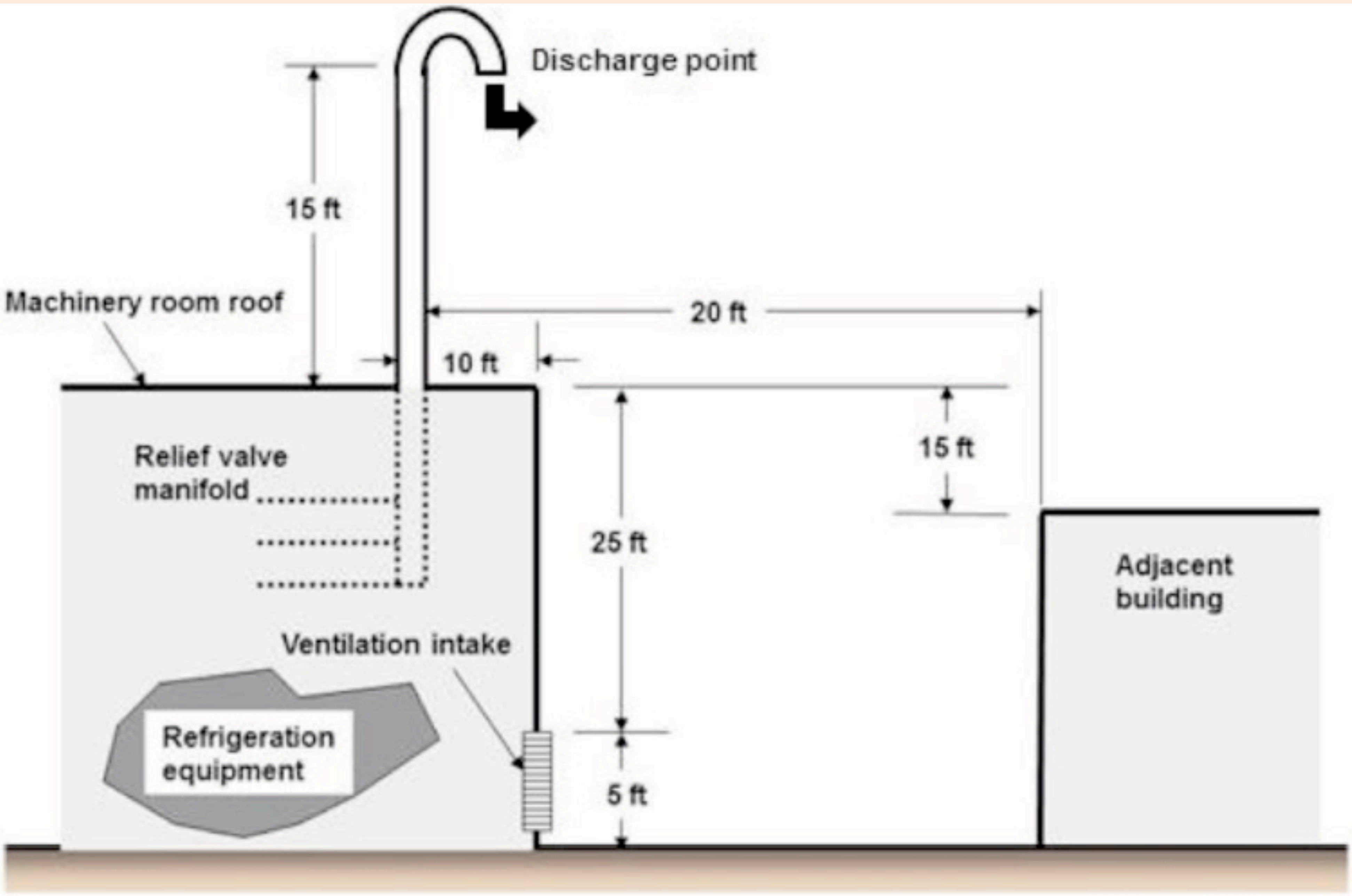
Safety Valve Piping Arrangement

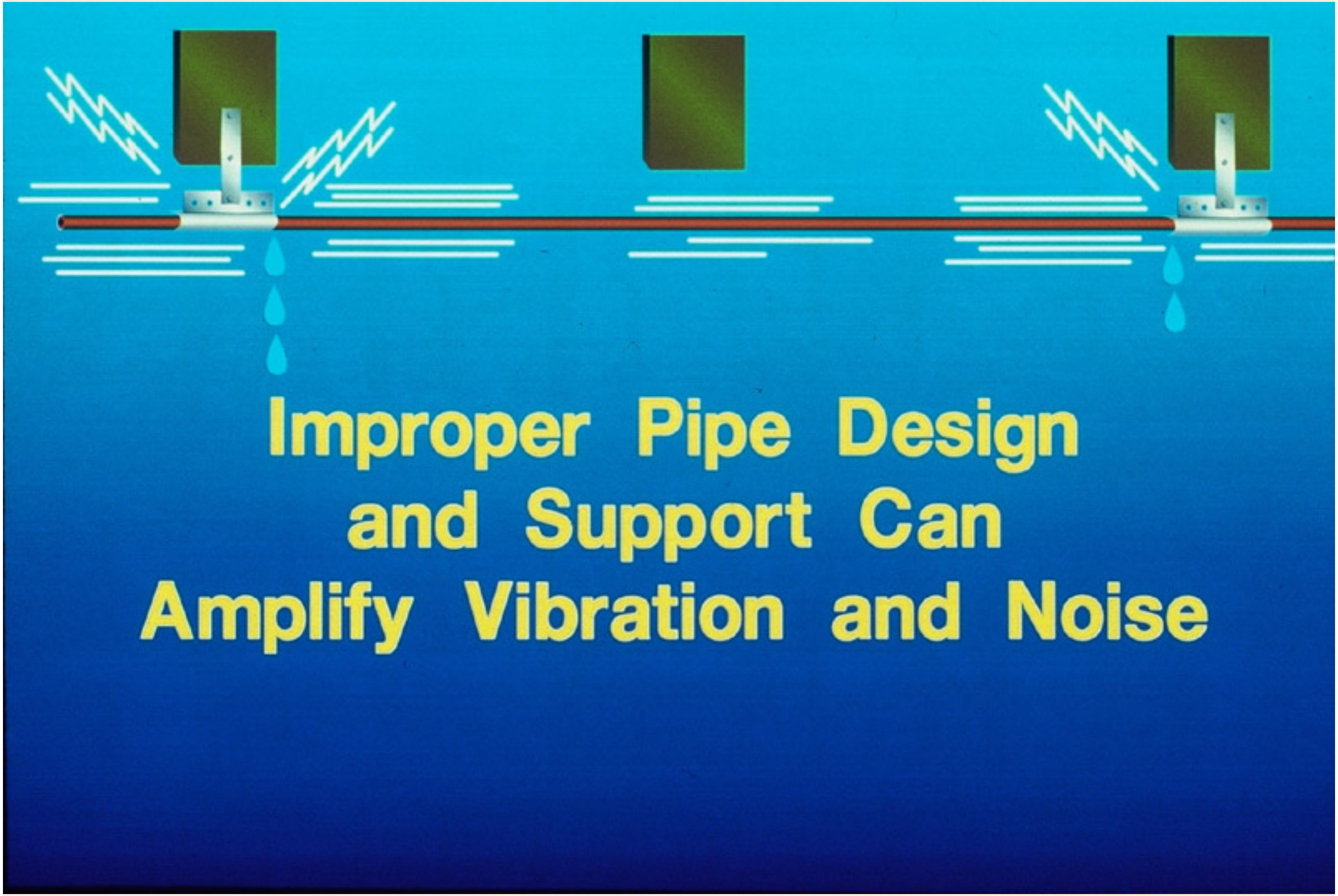


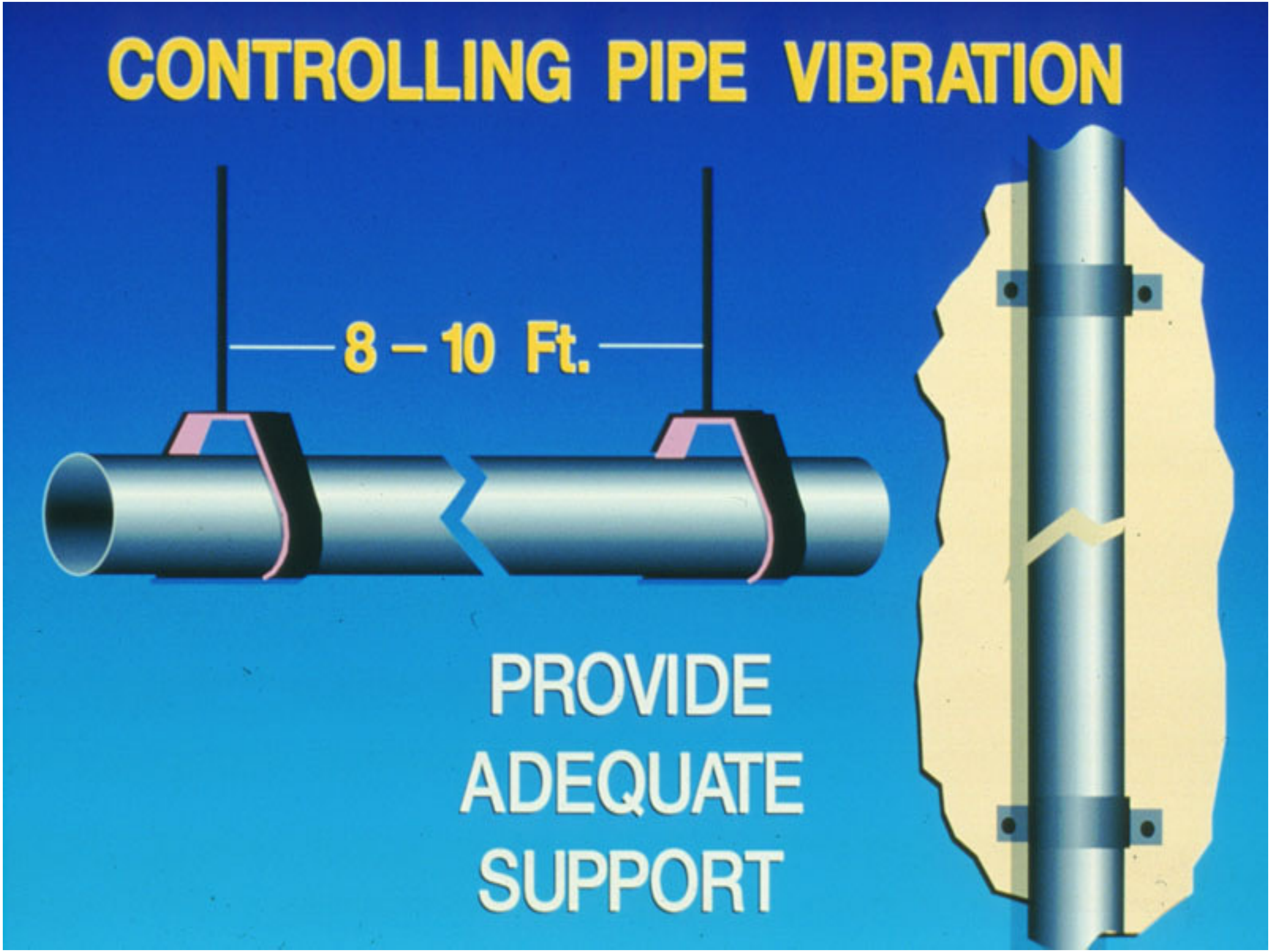
Safety Valve Piping Arrangement



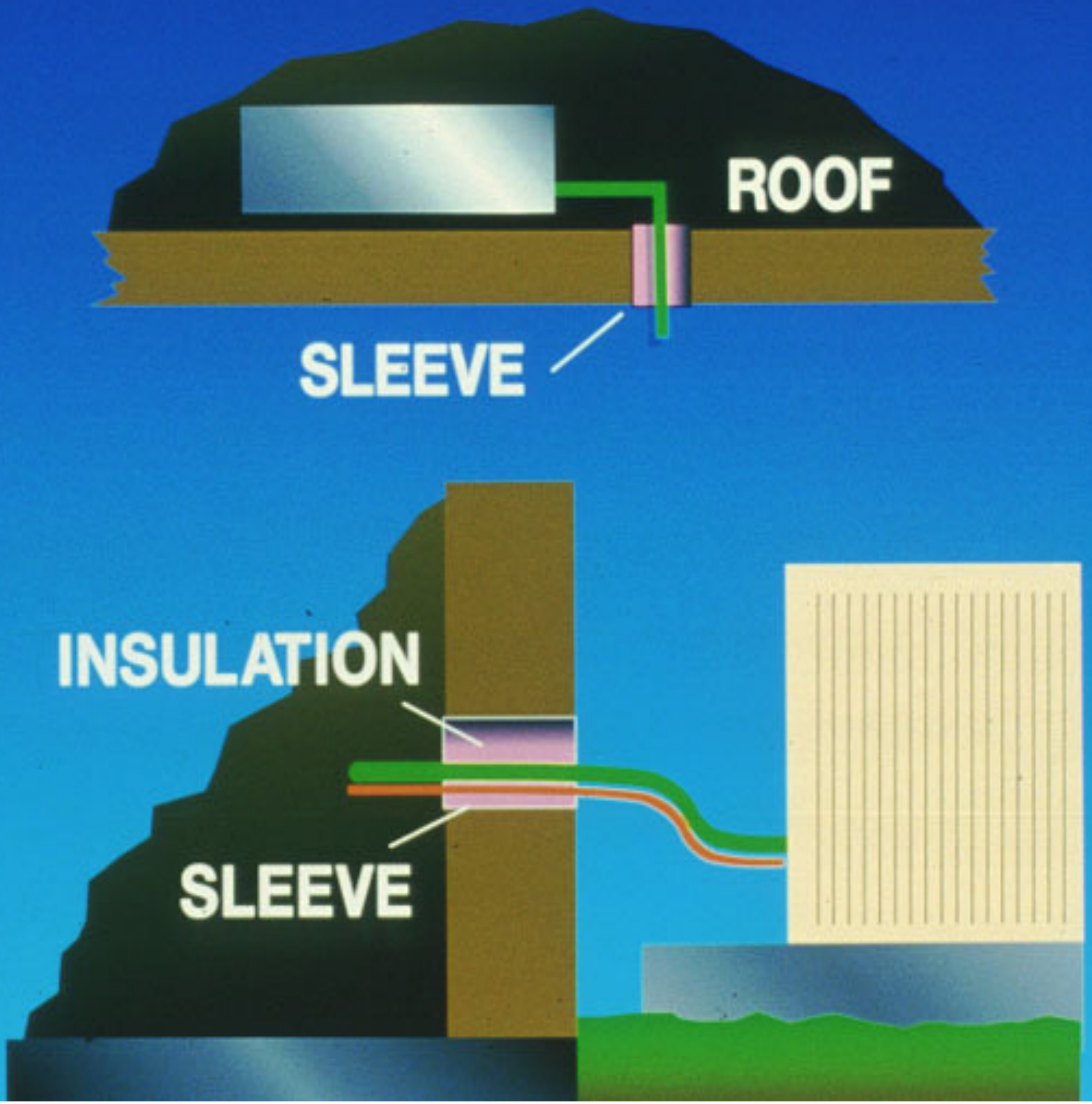
Safety Valve Piping out lets

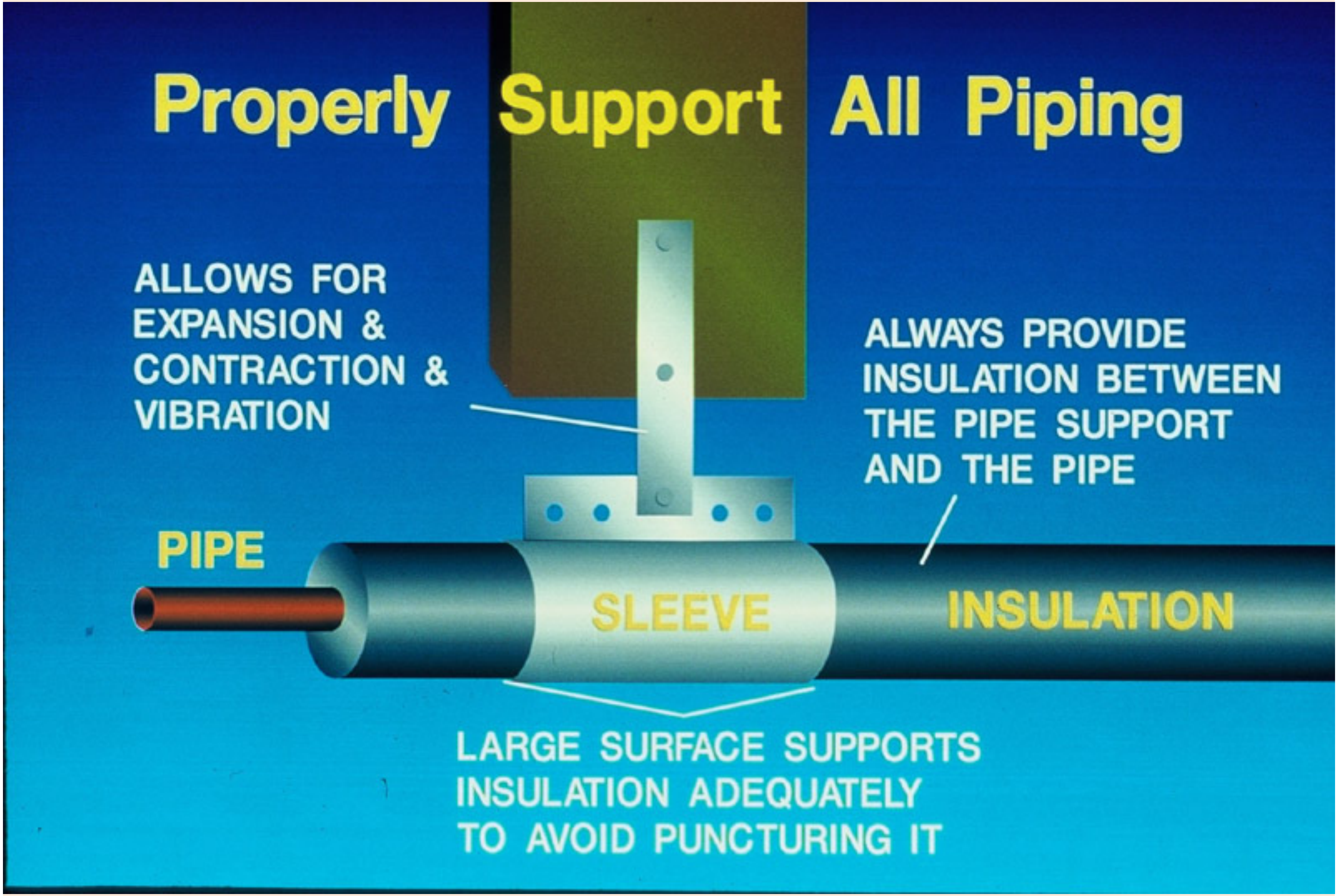

Discharge point
15 ft
Machinery room roof
20 ft
10 ft
Relief valve
manifold
15 ft
25 ft
Adjacent
building
Ventilation intake
Refrigeration
equipment
5 ft


Improper Pipe Design
and Support Can
Amplify Vibration and Noise


CONTROLLING PIPE VIBRATION
8 – 10 Ft.
PROVIDE
ADEQUATE
SUPPORT

CONTROLLING PIPE VIBRATION




Properly Support All Piping
ALLOWS FOR EXPANSION & CONTRACTION & VIBRATION
ALWAYS PROVIDE INSULATION BETWEEN THE PIPE SUPPORT AND THE PIPE
PIPE
SLEEVE
INSULATION
LARGE SURFACE SUPPORTS INSULATION ADEQUATELY TO AVOID PUNCTURING IT

Pipe Support Spacing

Pipe Diameter-inch	Maximum Span-ft	Minimum rod Diameter-Inch
Up to 1	7	3/8
1 ¼	9	3/8
2	10	3/8
2 ½	11	½
3	12	½
4	14	5/8
5	16	5/8
6	17	¾
8	19	7/8
10	22	7/8
12	23	7/8
14	25	1
16	27	1
18	28	1 ¼
20	30	1 1/4

THERMAL LINEAR EXPANSION OF COPPER TUBING AND STEEL PIPE (inches per 100 feet)

Temperature Range (F)	Copper Tubing	Steel Pipe
50	.56	.37
100	1.12	.76
150	1.69	1.15
200	2.27	1.55
250	2.85	1.96
300	3.45	2.38
350	4.05	2.81
400	4.65	3.25
450	5.27	3.70
500	5.89	4.15

Stop Valves: STC/SVA

1. Weld able-must show Flow Direction and Size
2. A420 material For Low Temperature
3. Forged Steel or Wrought Iron Steel for High Temperature

Dimension: DN 15 - DN 150

Pressure: PS 25 bar

Connection: DIN, ANSI, Metric

Types: Cap / Hand wheel
Angel / Straight

Material: Steel

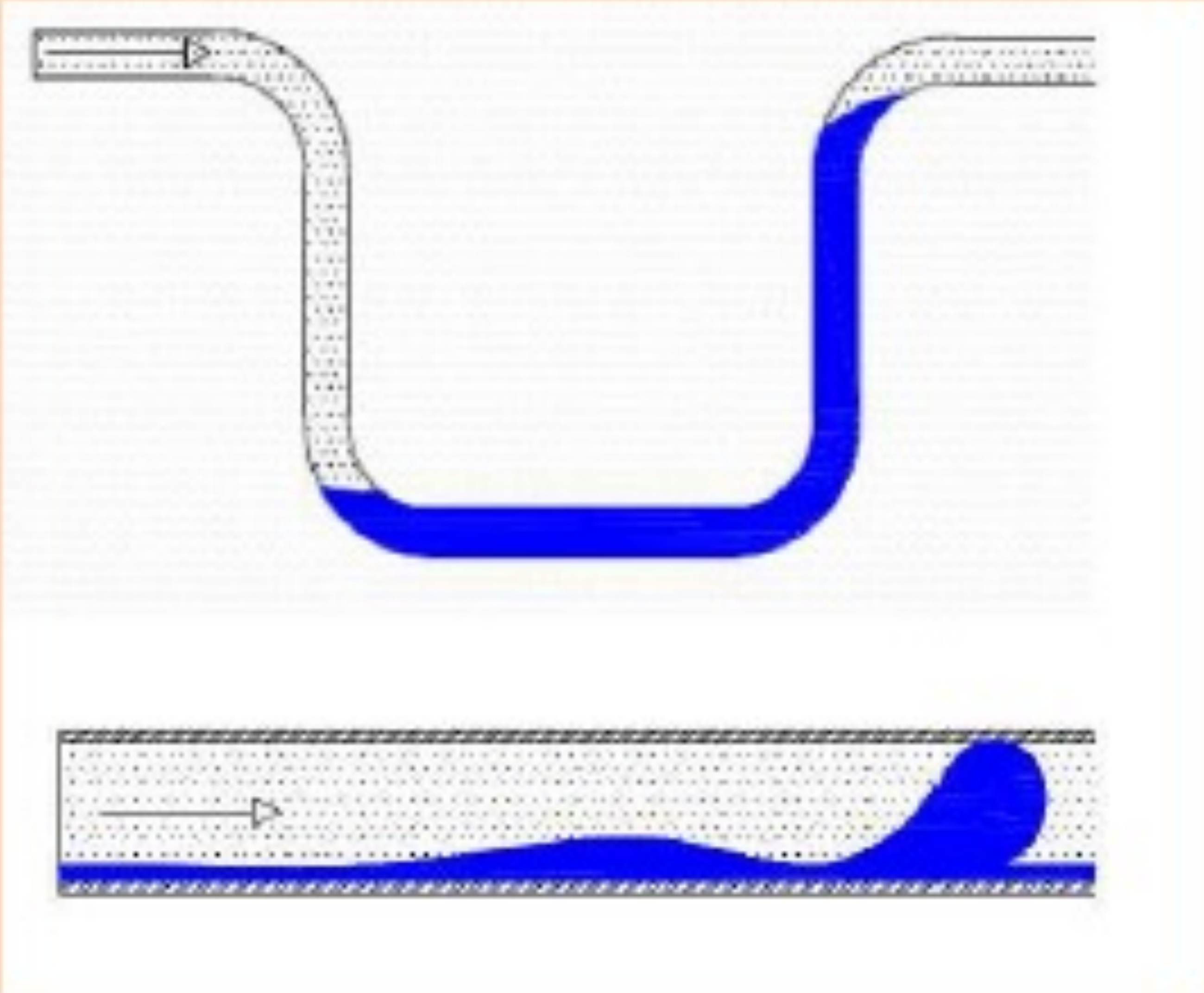
STC full fill the same high quality and safety requirements as all other Danfoss products. The test procedures for strength pressure test and internal / external leakage tests are identical for SVA and STC valves.

Use Angle Valve instead Globe valve plus bend-Reduced pressure drop, less welding

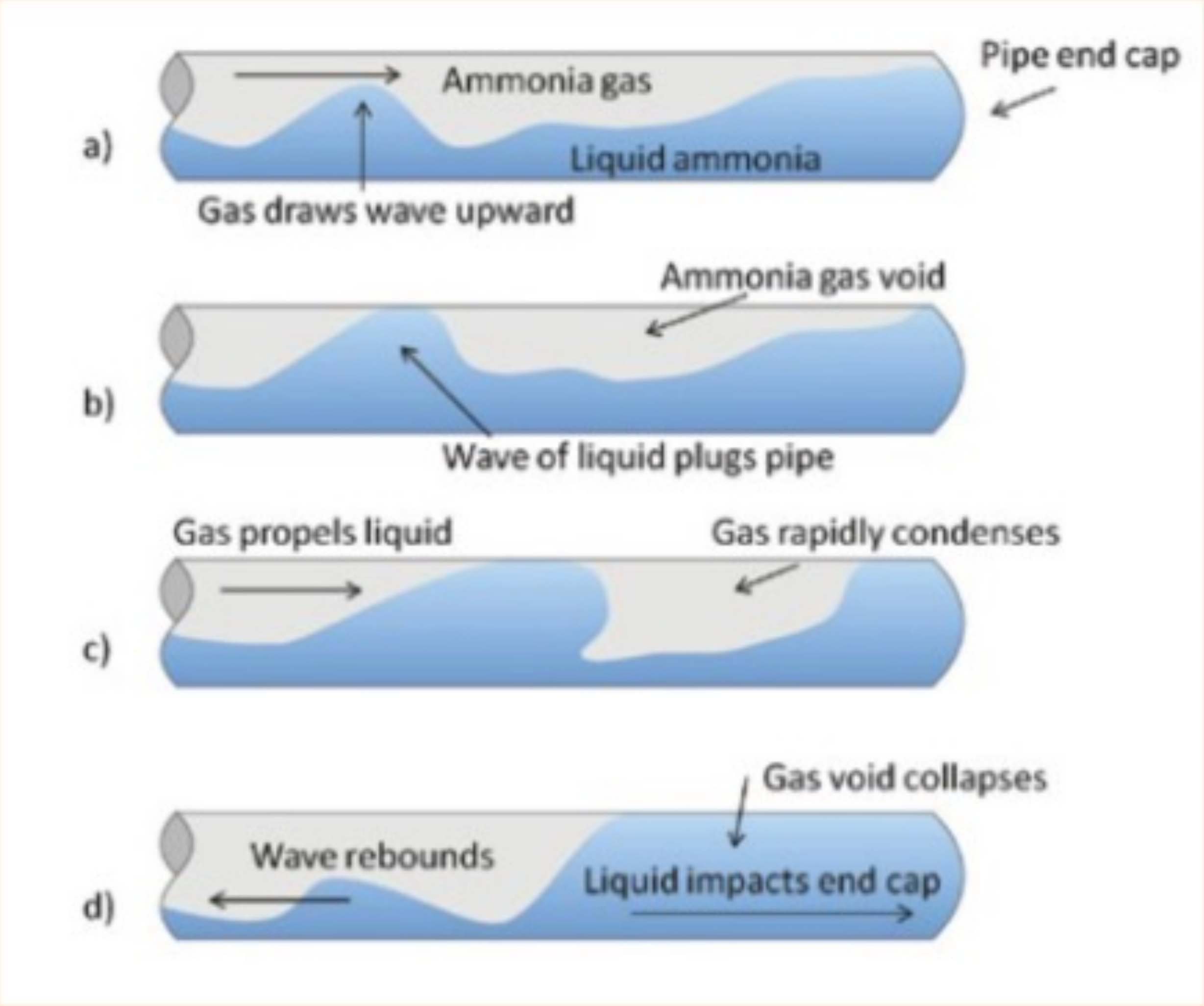
Hydraulic Shock/water Hammer-Why?

1. **Damaging Hydraulic Shocks are often Condensation induced**
2. **Occur in low temperature applications during onset or termination of defrost**
3. **Normally occur in two phase suction line-wet return line-due to liquid slugs**
4. **During initiation of defrost hot gas rushes in low side and relieved at termination**
5. **When gas flow is large it scoops up liquid from wet return line**
6. **Wet return header closed without exit gas gets compressed even more**
7. **When pressure rises the gas gets condensed and draws liquid in to the suction behind it and the liquid hits the close end cap**
8. **The slugs then develop pressures of even up to 52 bar and damage seamless pipes even up to 400 mm diameter.**

Liquid Hammer-Liquid Trap



HYDRAULIC SHOCK

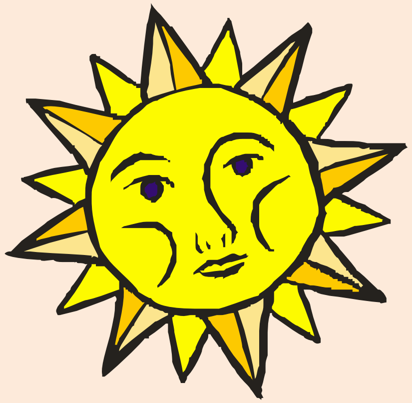


26th June 2020


#1
THIELSCH ENGINEERING, INC.
24 HOUR EMERGENCY SERVICE

A Pipe ruptured due to liquid hammer

Avoid Locked refrigerant



EVR/A

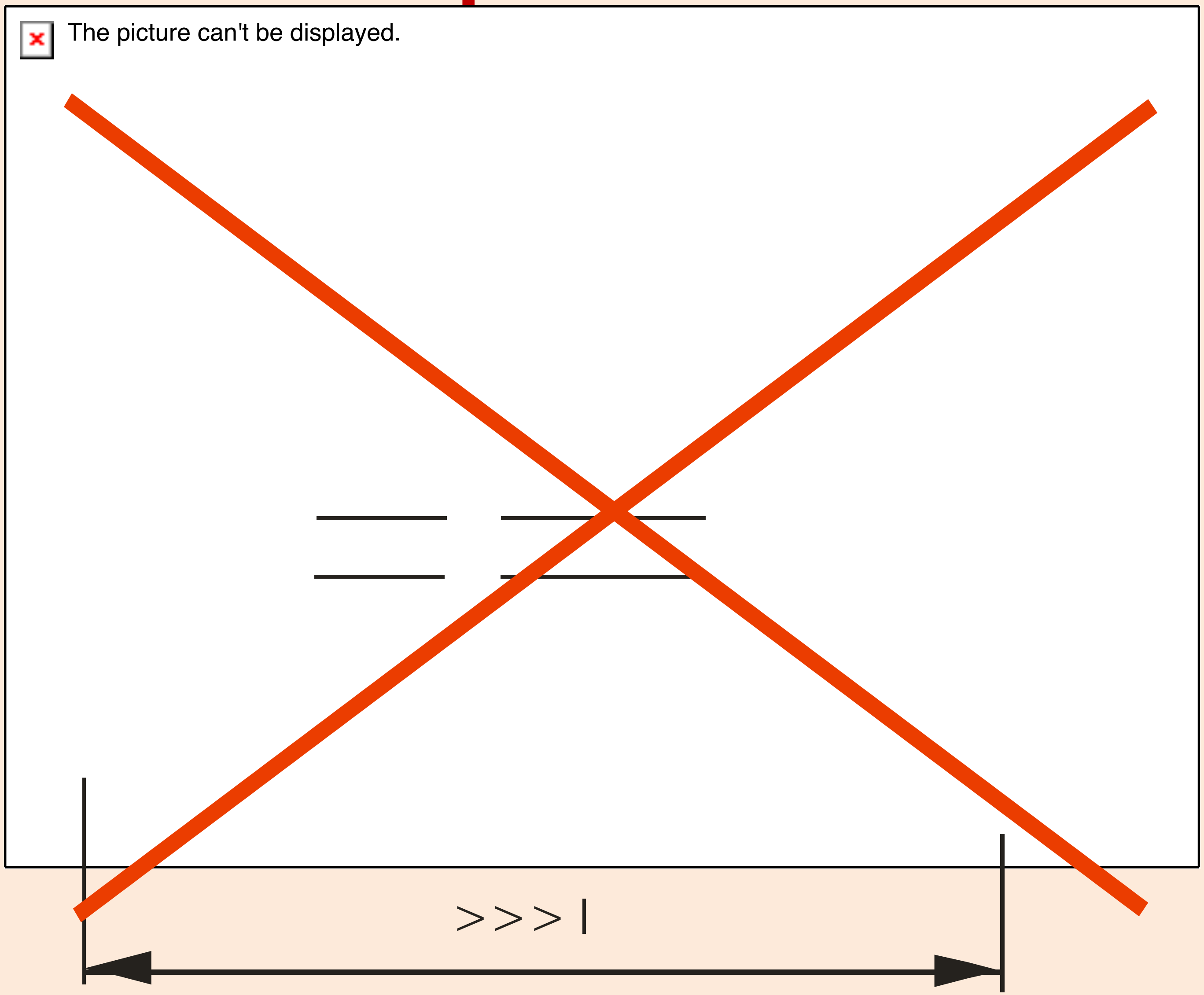
NRV/A

How to place solenoid and check valve

EVR/A

NRV/A

Long distance between solenoid and expansion valve



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, giving any liquid slugs free flow 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. **Draining a vessel puts gas in liquid line**
10. **Overfilling puts liquid in gas lines**
11. **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**

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.

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
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5. Wet suction should contain no traps
6. Evaporator outlet connection from top of wet return header
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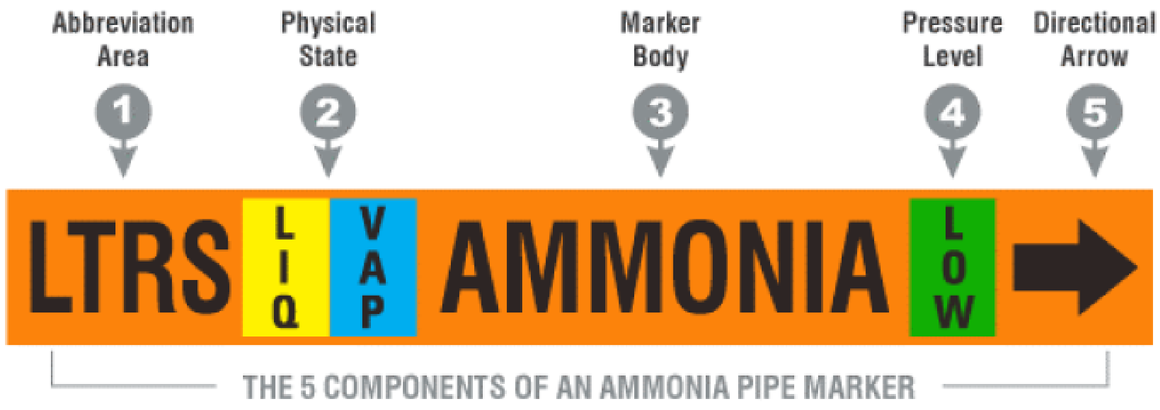
8. Do not overcharge or undercharge LP vessel
9. Use soft gas defrost with smaller solenoid in parallel to equalize pressures for larger plants both in liquid and hot gas defrost lines to evaporator

REFRIGERANT PIPING COLOR CODE

SR.NO.	DESCRIPTION	SCOPE	COLOUR CODE
1	HP Hot gas	High Stage Discharge Booster Discharge	Red
2	HP liquid refrigerant	Receiver to Economizer Economizer to Intercooler	Orange
3	LP liquid refrigerant	Intercooler to LP Vessel	Light green
4	LP refrigerant vapor	High Stage Suction Booster Suction	Dark green
5	Liquid/vapor mixture of refrigerant		Purple
6	Oil Circuit	Both Booster & High Stage	Black


AMMONIA
AMMONIA
021

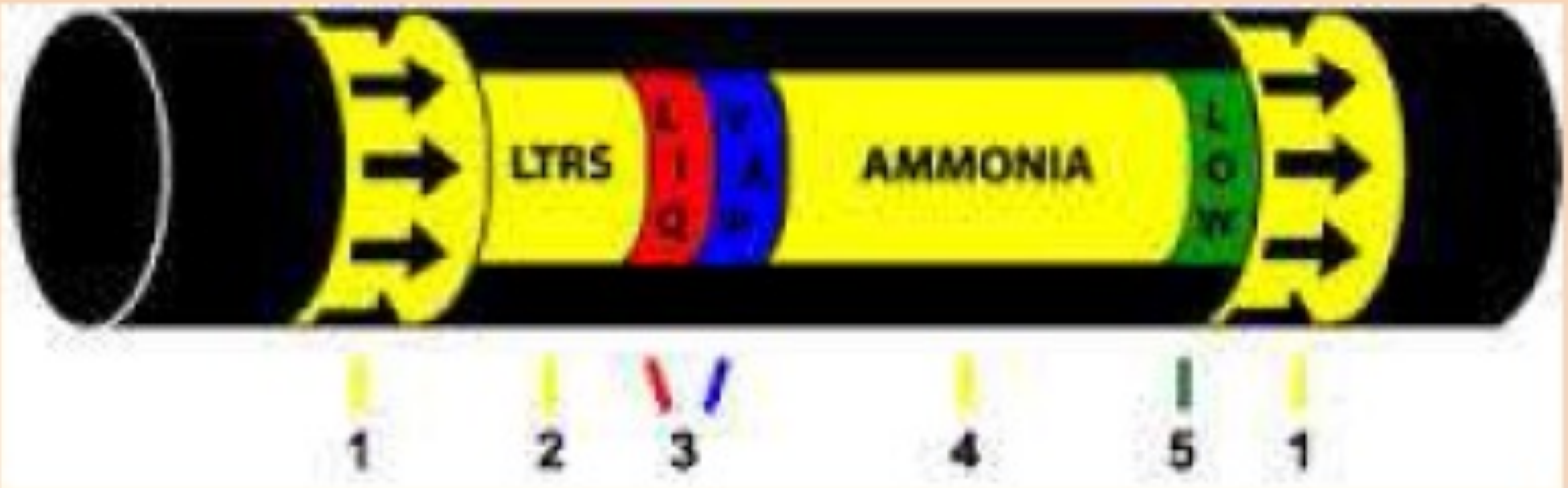
BD=BOOSTER DISCHARGE	LD=LIQUID DRAIN
CD=CONDENSER DRAIN	LIC=LIQUID INJECTION COOLING
DC=DEFROST CONDENSATE	LSS=LOW STAGE SUCTION
EQ=EQUALIZER	LT=LIQUID TRANSFER
ES=ECONOMIZER SUCTION	LTRL=LOW TEMPERATURE RECIRCULATED LIQUID
FG=FOUL GAS	LTRS=LOW TEMPERATURE RECIRCULATED SUCTION
HG=HOT GAS	LTS=LOW TEMPERATURE SUCTION
HGD=HOT GAS DEFROST	MTRL=MEDIUM TEMPERATURE RECIRCULATED LIQUID
HPL=HIGH PRESSURE LIQUID	MTRS=MEDIUM TEMPERATURE RECIRCULATED SUCTION
HSD=HIGH STAGE DISCHARGE	MTS=MEDIUM TEMPERATURE SUCTION
HSS=HIGH STAGE SUCTION	PO=PUMP OUT
HTRL=HIGH TEMPERATURE RECIRCULATED LIQUID	RV=RELIEF VENT
HTRS=HIGH TEMPERATURE RECIRCULATED SUCTION	TSR=THERMOSYPHON RETURN
HTS=HIGH TEMPERATURE SUCTION	TSS=THERMOSYPHON SUPPLY



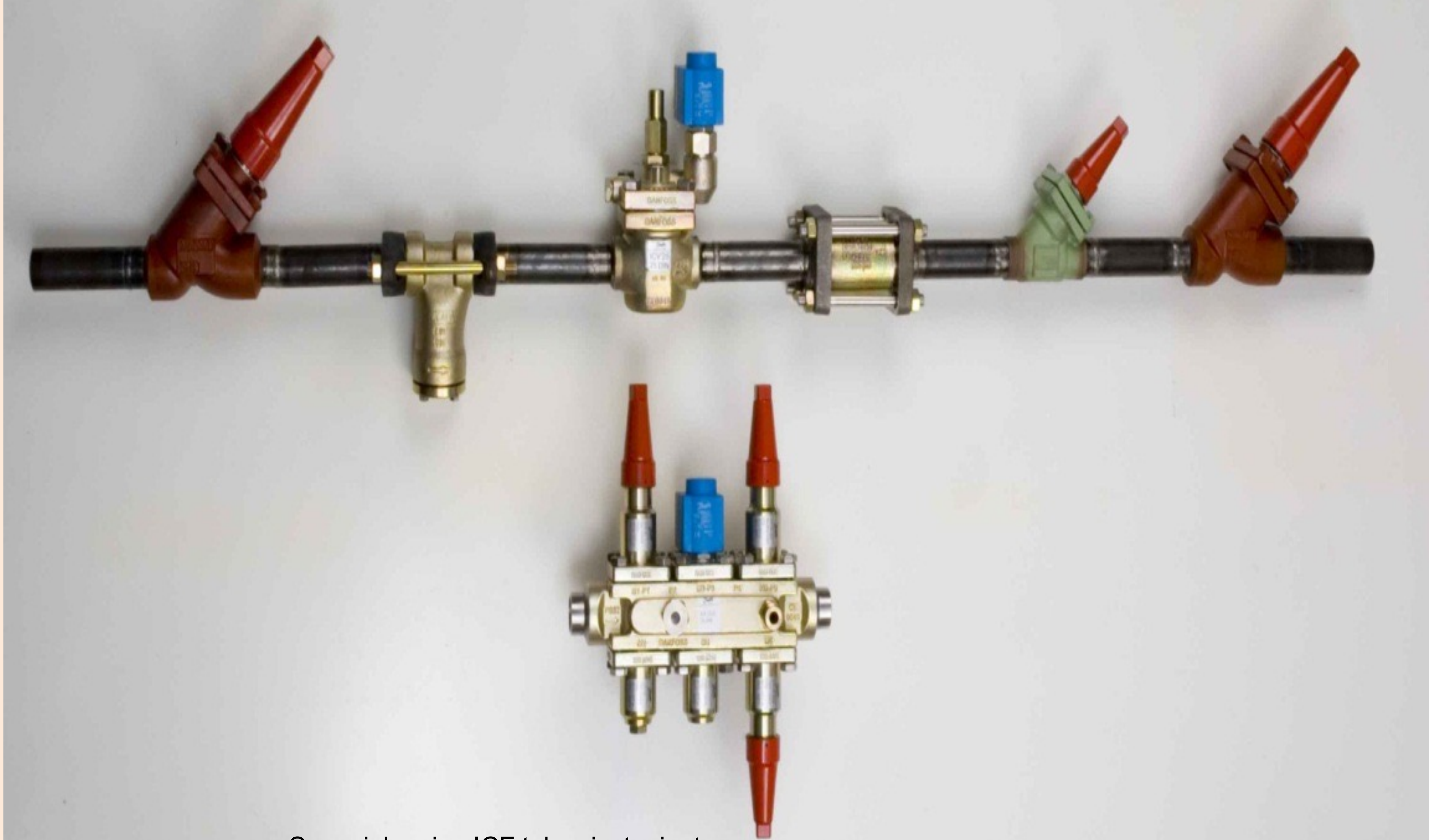
1. Use piping abbreviations to properly identify system components.
2. Indicate the physical state of the refrigerant (liquid, vapor, or both).
   - Yellow color band indicates liquid state
   - Blue color band indicates vapor state
   - Use both color bands to indicate both states are present
3. Print "Ammonia" in black letters on orange background.
4. Indicate whether the internal pipe pressure is high or low.
   - Red color band indicates high pressure
   - Green color band indicates low pressure
5. Use arrows to indicate the direction of ammonia flow.

Facilities that lack clear and comprehensive labeling are "accidents waiting to happen."


MTRS
AMMONIA
MTRL
AMMONIA
HTRS
AMMONIA
HTRL
AMMONIA

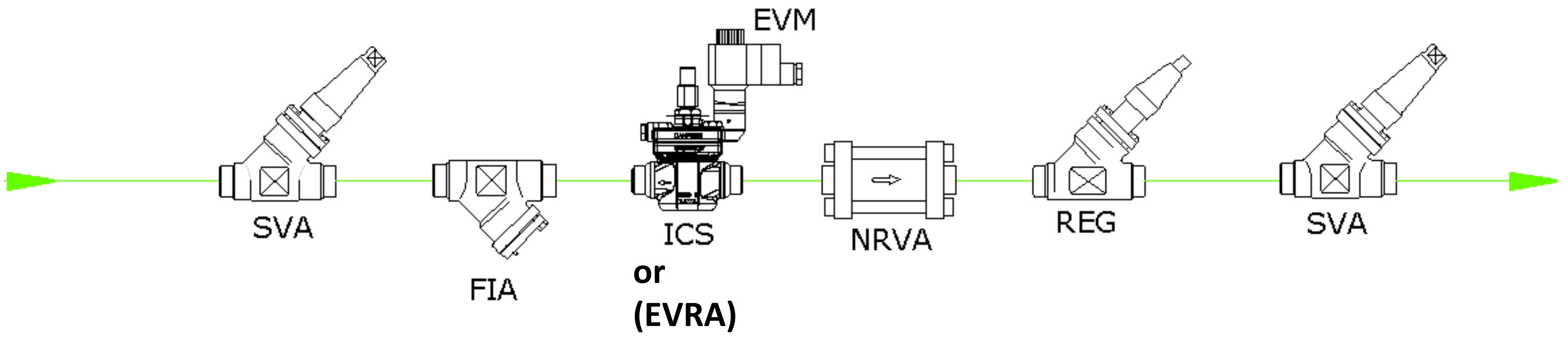

LTRS
AMMONIA
1
2
3
4
5
1

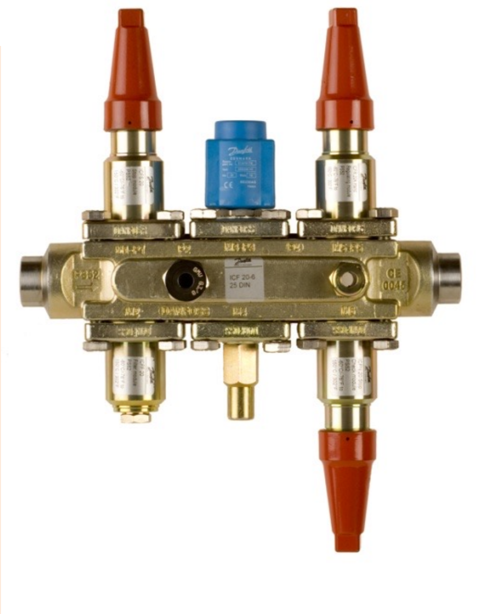
To build and install valve station takes hours

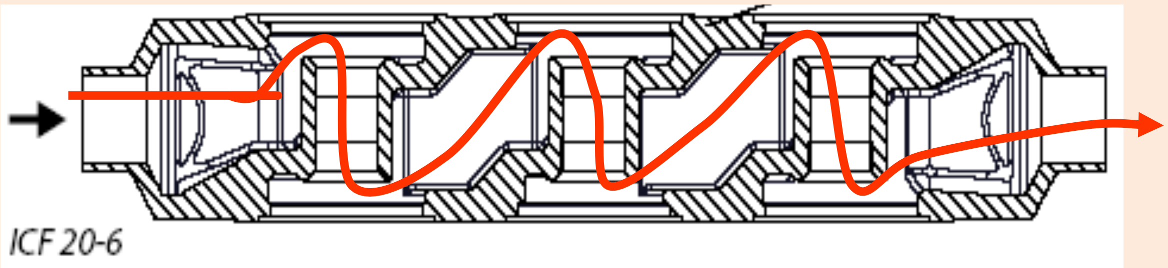


Same job using ICF takes just minutes

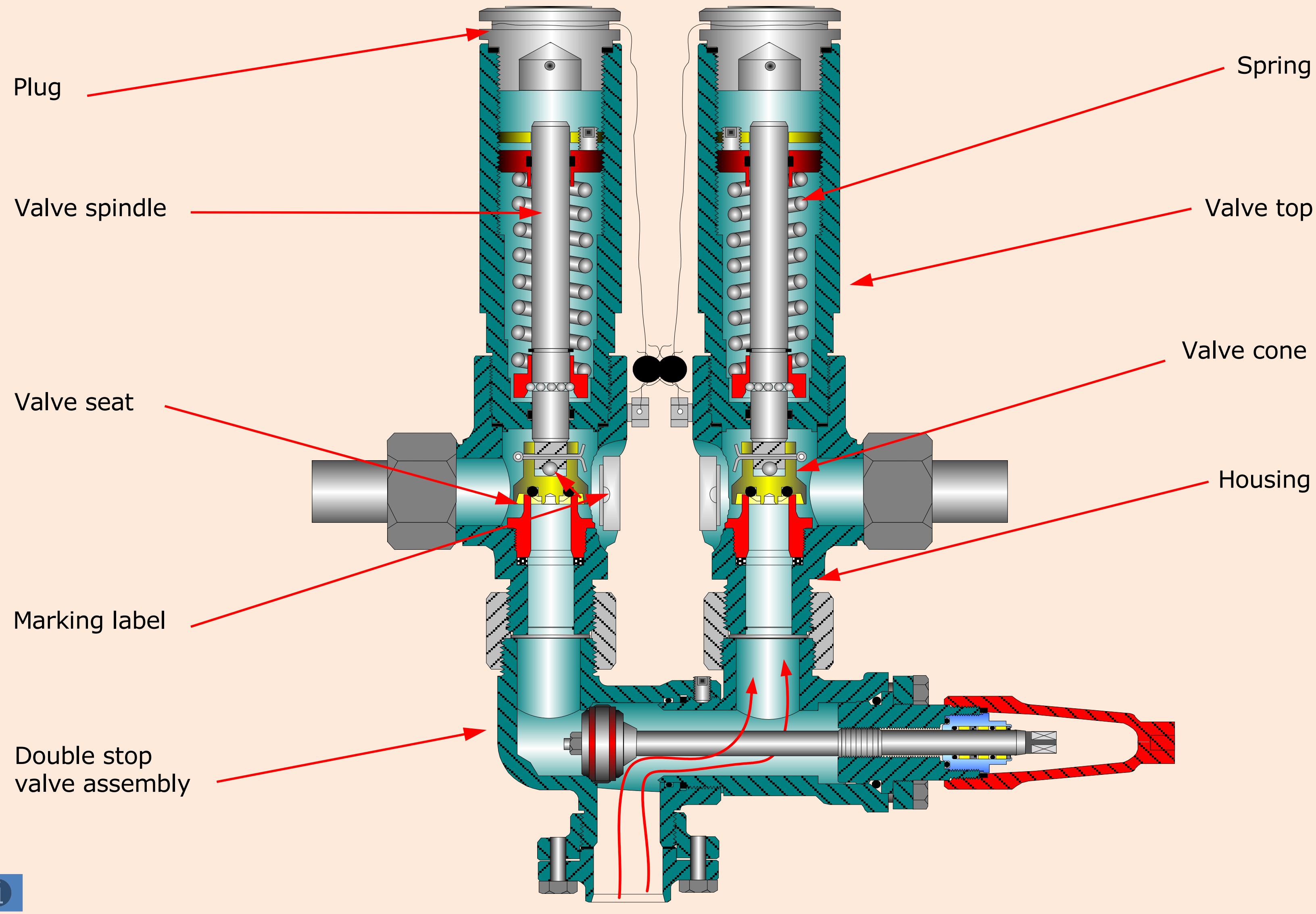
USE COMPOSITE VALVES





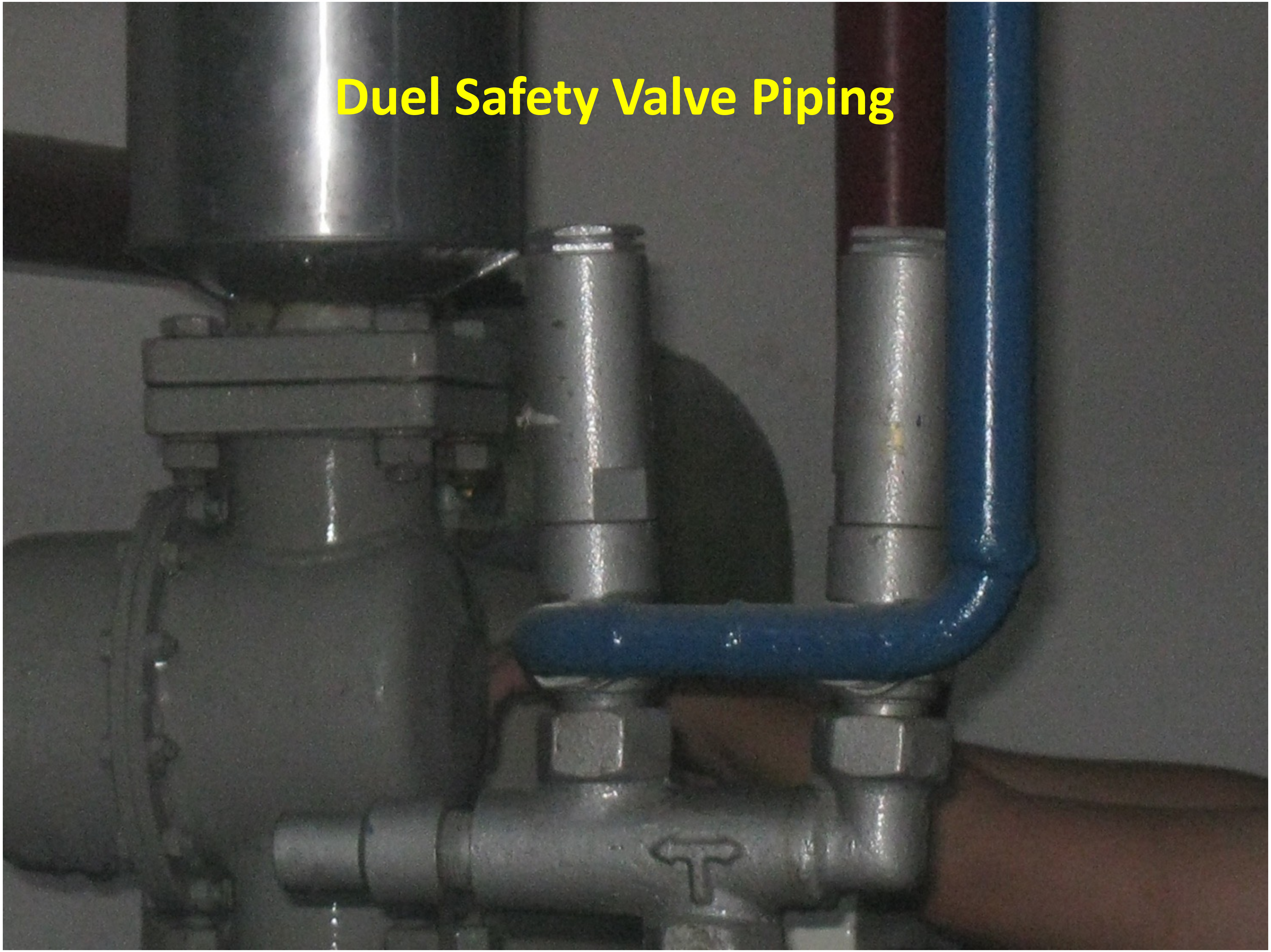


Double Stop Valve - type DSV and Double Safety Valve - type SFV

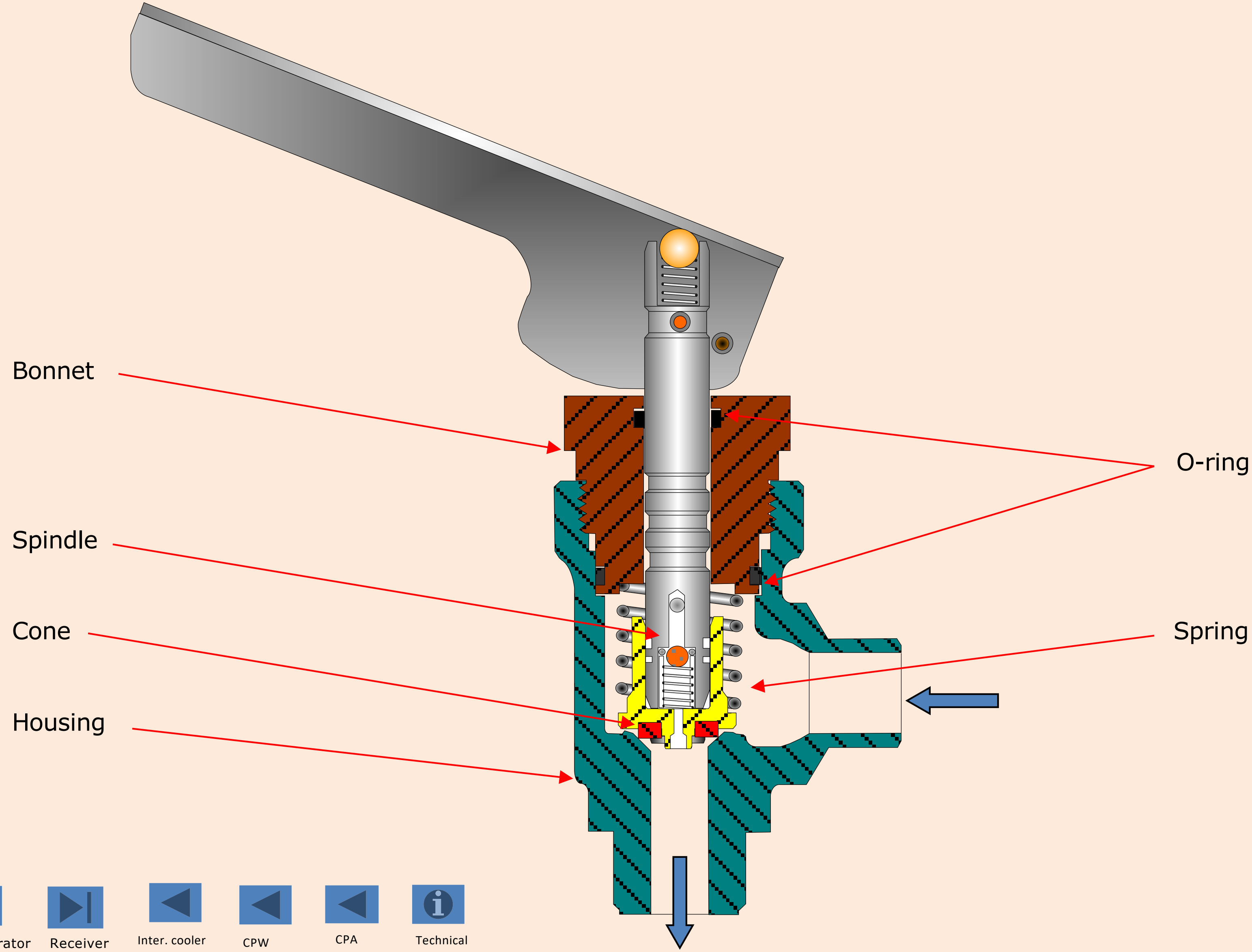


Technical brochure

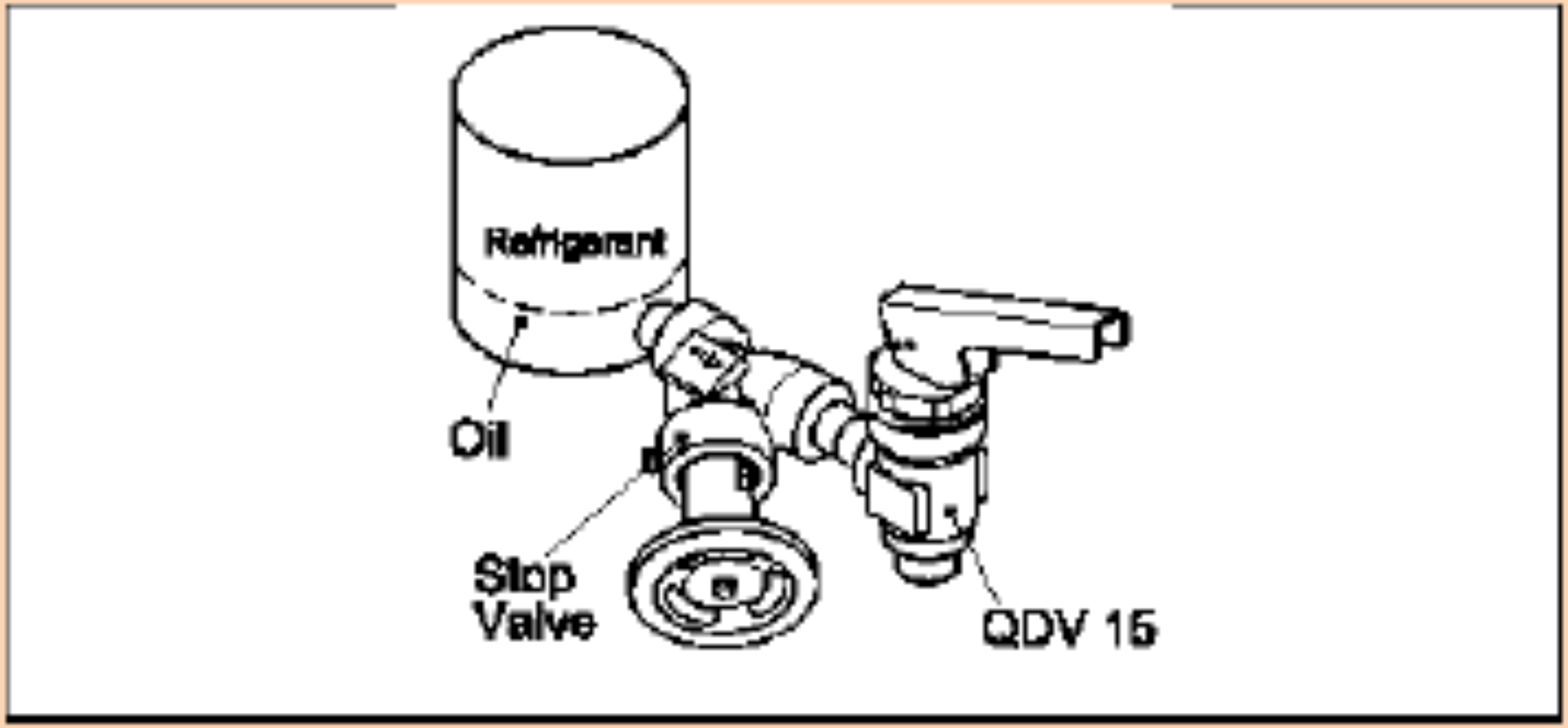
Duel Safety Valve Piping



Quick closing oil drain valve – type QDV 15



QUICK CLOSING OIL DRAIN VALVE



CONCLUSION

GOOD PIPING PRACTICES

1. PIPING TO SLOPE IN DIRECTION OF FLOW
2. PROVIDE LOOPS –THERMAL CONTRACTION/EXPANSION
3. VIBRATION ELIMINATORS-PROPER PENETRATION
4. PIPING INSULATION SLEEVES
5. OIL SEPARATOR ABOVE CRANKCASE LEVEL
6. ALL HIGH POINTS-VENT VALVES-PURGING
7. LIQUID LINE-VALVES IN VERTICAL LINES-
8. ECCENTRIC REDUCERS
9. BACKSEATING TYPE VALVES
10. GLOBE VALVES STEMS HORIZONTAL
11. VALVES INSTALLED TO CLOSE AGAINST FLOW OR PRESSURE
12. LONG STEM VALVES- FOR INSULATED LINES

GOOD PIPING PRACTICES

13. SUCTION BRANCHES FROM TOP
14. LIQUID BRANCHES FROM BOTTOM
14. HOT GAS BRANCHES FROM TOP
16. SEAL CAPS NOT IN USE-
    DRAIN/PURGE/CHARGING
17. SAFETY VALVE DISCHARGE –15 FT. ABOVE
    GROUND
18. DRAIN/VENT CAPS WITH SMALL DRILLED HOLE
19. NO SHUFF OF VALVE BEFORE SAFETY VALVE
    IF PROVIDED IN LOCKED OPEN POSITION
20. VALVES APPROACHABLE FROM FLR/FIXED
    PLATFORM
21. WATER TANK /SPRAY IN PLANT ROOM-
    AMMONIA
22. TREATMENT OF PIPING BEFORE INSULATION

Thank you

Any Questions ??

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