Association of AMMONIA REFRIGERATION

Advantage Ammonia

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Refrigeration Controls Selections and Applications

by
Anand Joshi
President AAR
BOG Member RATA
Past President ISHRAE Pune
Member IIAR (USA), ASHRAE (USA), IDA, IETE, IGCC

Definition of Automation

The use of sensors, actuators, and other equipment to achieve a safe level of performance from a system or subsystem without the aid of human interaction. –

ASHRAE Standard 15-2013

Why Automation ?

Observation

- Practically impossible to load unload, start stop compressor manually depending on load variation.
- Operator frequently throttle valves installed at liquid Header (going to cold room) from plant room to avoid liquid stroke to compressor.
- Manually Difficult, every hour to measure and log each room temperature.
- Manually Difficult to close / open each cold room liquid header isolation valve when room temperature is achieved and to reduce load on compressor.
- Measuring and recording energy

Why Automation ?

Human errors and inefficiency

a. Operating plant at designed conditions

b. Safety

c. Energy efficiency

d. Parameters recording

Standards for Plant Design and Safety

1. ASHRAE Standard 15 -2013
2. IIAR Standard 2-2014
3. IIAR Standard 3-2012
4. EN/BS 378
5. AAR Standard AAR-01
6. ASME B16.34-2013
7. ASME B31.5-2013

k_v Factor

What?

The k_v - factor for a given valve is a constant which in a simple way states the valve capacity. The k v - factor is determined by the valve manufacturer by experiments.

"The k_v value is the flow of water in m^3 /hr at a pressure drop across valve of 1 bar, $\rho = 1000 kg/m^3$"

Why?

The k_v - factor is an exact and easily applicable value for use when calculating pressure drops, sizing, and ordering valves.

Use K_v Factor

$$Q = K_v \sqrt{\Delta p / \rho}$$

Q flow in m^3/hr

Δp pressure drop across the valve in bar

ρ density of fluid in kg/m^3

K_v flow factor of Valve in m^3/hr

Data Required for Selection of Controls

- Refrigerant used : Ammonia,
- Type of system i. Gravity feed ii. DX or iii. Pump Recirculation
- Circulation ratio in case of Pump recirculation system
- Evaporating temperature or pressure
- Refrigerant liquid inlet temperature or pressure
- Refrigeration capacity of evaporator
- Condensing temperature or pressure
- Location of the valve i.e. wet suction, dry suction, liquid, discharge, hot gas, condensate return etc.
- Line Size

Various Controls for Refrigeration

- Liquid Level Controllers, Level Transmitters & Float Switches
- Solenoid Valves, Gas Operated Solenoid Valves Single and Two Stage
- Safety Controls Safety valves, Dual Manifold for Safety Valves, Dead Man's Valve
- Automatic Air Purger, Ammonia Purifier
- In Line components Non Return valves, Strainers,
- Controls Valves Flow Regulating Valves, Over Flow Valves, Pressure & Temperature Regulating Valves, Crank case Pressure Regulators

Various Controls for Refrigeration

- Compressor Capacity Controllers, PLCs for Piston and Screw Compressors
- Data Loggers, Temperature, Pressure, Humidity and Gas Indicators / Indicating controllers
- Alarm Annunciators, Defrost Controllers, Ice thickness Controllers
- Ammonia Leak Detectors
- Sensors & Transmitter for temperature, pressure, humidity, CO2, ethylene, Oxygen etc.
- Web-base Monitoring & Control Systems
- Mobile Applications to Monitor plant

Which Parameters ? Why ?

Level : Safety & Efficiency

Temperature : Product storage life

Pressure : Efficiency

Carbon Dioxide CO_2 : Product storage life

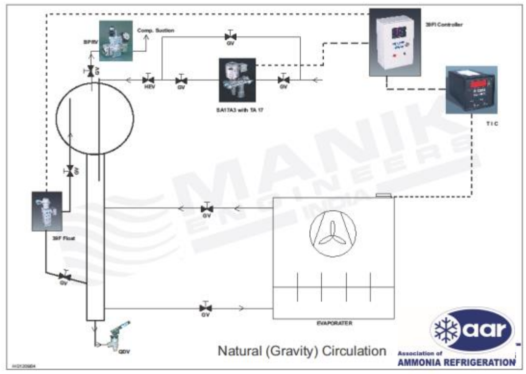
Relative Humidity : Weight Loss

Sensor & Transmitters for Temperature, Humidity, Pressure, Ethaline, CO_2 & O_2

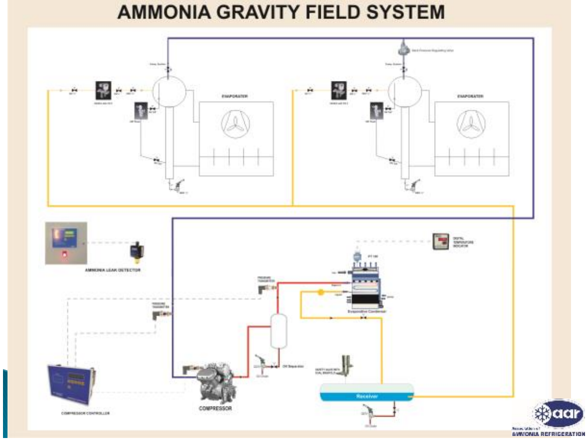
Why to Control Level in flooded system ?

- Liquid Level Controllers along with Solenoid Valve maintains evaporator flooded
- Prevents Liquid Stroke to the compressor
- Appropriate flooding of evaporator
- Better heat transfer efficiency of the evaporator
- Less wear & tear of compressor
- Running hours of compressor are reduced
- This all generates energy saving
- Bar graph display continuously display the rising & falling of liquid level inside the float chamber

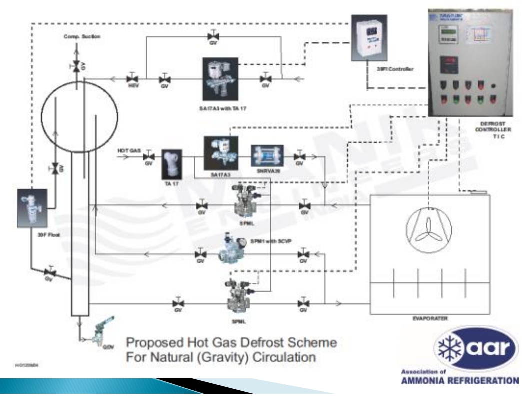
TYPICAL INSTALLATION FLOODED AIR COIL UNIT



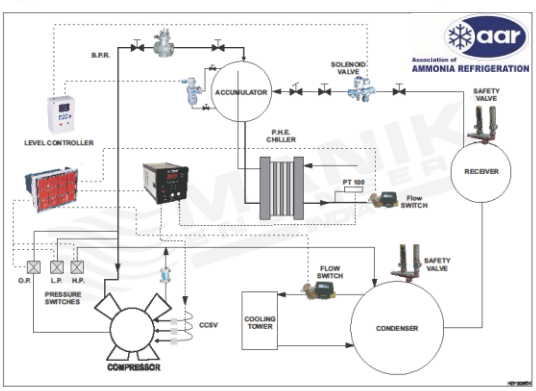
AMMONIA GRAVITY FIELD SYSTEM



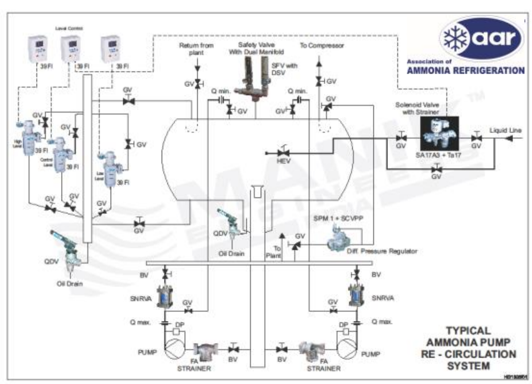
Flooded System with Hot Gas Defrost



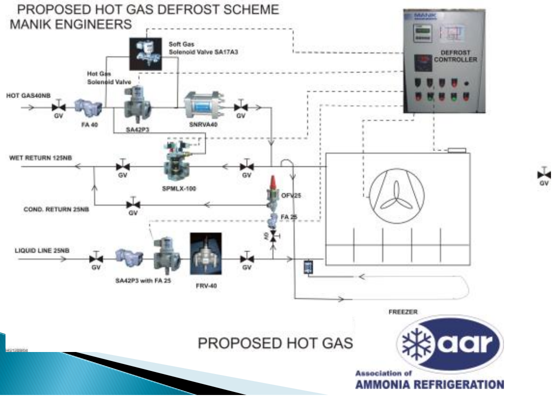
Typical Controls for Flooded PHE System



TYPICAL OVER FEED SYSTEM VESSEL

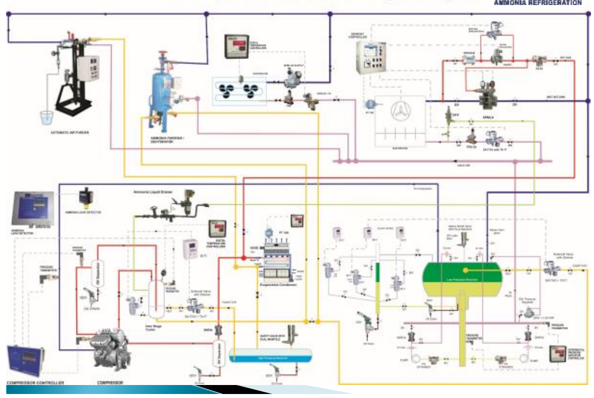


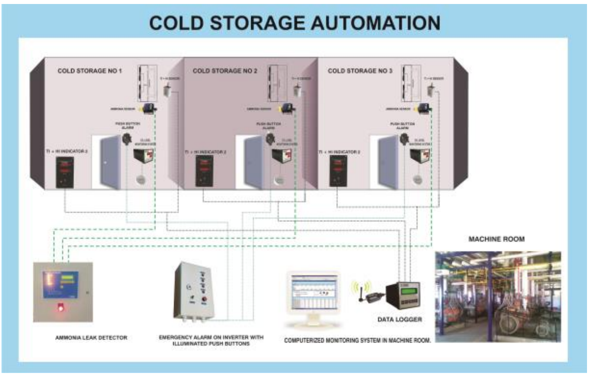
Hot Gas Defrost for Over feed System



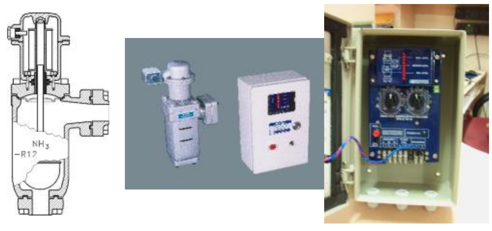
PROPOSED HOT GAS

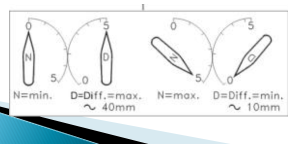
Ammonia Liquid Overfeed Industrial Refrigeration System





Liquid Level Controller





Float Switch

FUNCTION:-
1 Internal float assembly
2 Switch box
3 M4x8pinol tail stock screw
4 Top cover
5 4 pcs.M12x35 stainless steel bolt
6 FKS 39 housing
7 Pressure tube
8 Top cover gasket
9 'O'- ring for pressure tube
10 DIN plug for electrical connection
11 Aluminum gasket
12 Locking ring for internal float
13 Stainless steel bolts
14 Flanges
15 Flanges gaskets

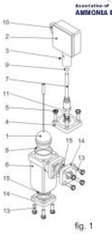


fig. 1

- An electro -mechanical float switch
- Adjustable liquid level differential switch point
- The complete switch box can easily be replaced without any interference with the refrigeration system.

Solenoid Valves

Type Solenoid Valves
- Direct Acting
- Pilot Operating
  - Piston Type
  - Diaphragm Type

Selection Chart for Solenoid Valve

Type	FLANGED CONNECTIONS Inches (Sizes Underlined will be furnished unless otherwise specified)	PORT SIZE Inches / mm	MOPD SIZE psi AC	NOMINAL LIQUID CAPACITIES Tones of Refrigeration / kW — AMMONIA — Pressure Drop - psi: 1	2	3	4	5	STANDARD COIL RATINGS Volts / Cycles	Watts
SA5A3	¼, ⅜ or ½" Weld	5/32	250	8.0	11.3	13.7	16	17.8	230/50 110/50	18
		4		28.2	40	48.7	56.3	62.66		
SA17A3	½, 1 or ¾" Weld	17/32	275	73	95	122	143	160		
		13.5		257	334.4	429	503	563		
SA32P3	1¼" Weld	1	250	125	176	225	250	280		
		25		440	619.5	792	880	985.6		
SA42P3	1½" Weld	1 5/16	300	275	390	500	550	625		
		33		968	1372.8	1760	1936	2200		
SA50P3	2" Weld	1 9/16	300	500	725	875	1000	1110		
		39.6		1760	2552	3080	3520	3907		

Selection Chart for Solenoid Valve

Liquid capacity Q_L kW

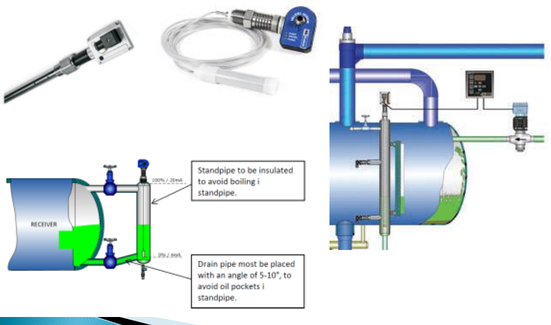
Type	Liquid capacity Q_e kW at pressure drop across valve Δp bar: 0.1	0.2	0.3	0.4	0.5
R 717 (NH_3)					
SVRA 3	17.8	25.1	30.8	35.6	39.8
SVRA/T 10	116.0	164.0	201.0	232.0	259.0
SVRA/T 15	209.0	295.0	362.0	418.0	467.0
SVRA/T 20	348.0	492.0	603.0	696.0	778.0
SVRA 25	773.0	1093.0	1340.0	1547.0	1729.0
SVRA 32	1237.0	1749.0	2144.0	2475.0	2766.0
SVRA 40	1933.0	2734.0	3349.0	3867.0	4322.0
R 22					
SVRA 3	3.8	5.3	6.6	7.6	8.5
SVRA/T 10	24.7	34.9	42.7	49.3	55.1
SVRA/T 15	44.4	62.8	76.9	88.8	99.2
SVRA/T 20	73.9	105.0	128.0	148.0	165.0
SVRA 25	165.0	232.0	285.0	329.0	368.0
SVRA 32	263.0	372.0	455.0	526.0	588.0
SVRA 40	411.0	581.0	712.0	822.0	919.0

Capacities are based on liquid temperature t_l = +25°C ahead of valve, evaporating temperature t_e = -10°C, and superheat 0 K.

Correction factors
When sizing valves, the plant capacity must be multiplied by a correction factor depending on liquid temperature t_l ahead of valve/evaporator. When the corrected capacity is known, the selection can be made from the table.

t_l°C	-10	0	+10	+20	+25	+30	+40	+50
R 717 (NH_3)	0.84	0.88	0.92	0.97	1.0	1.03	1.09	1.16
R 22, R134a	0.76	0.81	0.88	0.96	1.0	1.05	1.16	1.31
R 404A	0.70	0.76	0.84	0.94	1.0	1.07	1.24	1.47

LIQUID LEVEL TRANSMITTERS



Modulating Valves

Type summary

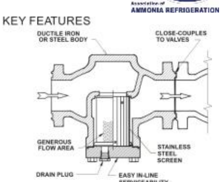
The refrigeration capacity refers to applications using ammonia.

Product number	DN	k_{vs} [m³/h]	k_{vs} reduced [m³/h]	Δp_{max} [MPa]	Q_0 E [kW]	Q_0 H [kW]	Q_0 D [kW]	S_{NA} [VA]	P_{med} [W]
MVS661.25-016N	25	0.16	0.10	2.5	95	10	2	22	12
MVS661.25-0.4N	25	0.40	0.25		245	26	5		
MVS661.25-1.0N	25	1.0	0.63		610	64	12		
MVS661.25-2.5N	25	2.5	1.6		1530	159	29		
MVS661.25-6.3N	25	6.3	4.0		3850	402	74		

k_{vs} = Nominal flow rate of refrigerant through the fully open valve (H_{100}) at a differential pressure of 100 kPa (1 bar) to VDI 2173
If required k_{vs}-value and refrigeration capacity Q_0 can be reduced to 63 %, refer to «k_{vs} reduction» on page 3
Δp_{max} = Maximum permissible differential pressure across the control path A → AB of the valve, valid for the entire actuating range of the motorized valve
Q_0 E = Refrigeration capacity in expansion applications
Q_0 H = Refrigeration capacity in hot-gas bypass applications
Q_0 D = Refrigeration capacity in suction throttle applications and Δp = 0.5 bar
S_{NA} = nominal apparent power for selecting the transformer
P_{med} = typical power consumption

The pressure drop across evaporator and condenser is assumed to be 0.3 bar each, and 1.6 bar upstream of the evaporator (e.g. spider).
The capacities specified are based on superheating by 6 K and subcooling by 2 K.

STRAINERS



- Strainer are with interchangeable filter insert
- Suitable for all common nonflammable refrigerants, including R 717
- Pleated filter net of stainless steel with a very large net surface ensures long intervals between cleaning and low-pressure loss.
- Retains contaminants, e.g. slag, and weld beads and swart.
- Pressure drop insignificant.
- Filter insert Stainless steel weave, mesh size

STRAINERS

Selection of Strainer
1. **Line Size by flow Rate**
2. **Mesh Size**

Flow Rate
The kv value is the flow of water in m3/h at a pressure drop in the strainer of 1 bar, p=1000kg/m3.

What is mesh ?
Mesh is the number of threads per inch.
µ[microns] is the distance between two threads (1µ = 1/1000 mm)

LIQUID LINES:
Before pumps: 500µ [38 mesh]
After pumps : 150µ [100 mesh) / 250µ [72 mesh]
Protection of automatic regulation equipment
Generally: 150µ [100 mesh) / 250µ [72 mesh]
Sensitive equipment, e.g.
Suction regulators with low temperature : 250µ[72 mesh]
Suction Lines
Before screw compressor 250µ [72 mesh]
Before piston compressor:150µ [100 mesh]

MULTI FUNCTION PRESSURE & TEMPERATURE REGULATORS

- Pilot operated main valve
- Screwed-in pilot valves or pilot valves mounted in an external pilot line.
- Two Variants
  One screwed-in pilot valve
  Three screwed-in pilot valves

- Used in refrigeration plant with
  Dry evaporation
  Pump circulation
  Natural circulation

MULTI FUNCTION PRESSURE & TEMPERATURE REGULATORS

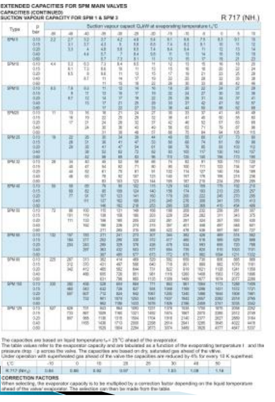
- In 3 Pilot port module valve pressure and temperature regulation can be combined with
  - Electric controlled forced closing (override)
  - Electric controlled forced opening (override)
  - Electric controlled forced closing and opening (override)
- Electric controlled changeover between two pressure or temperature settings
- Minimum pressure or temperature settings
- Maximum pressure limitation or relief
- Pilot valves can be mounted in external lines by using the pilot valve housing type SCVH.
- Opening without pressure drop in suction lines (with external pilot pressure)
- Pneumatically controlled reference change

PILOT CONTROL MODULES

- Pressure controlled pilot valve low pressure from vacuum (-0.6 bar) up to 7 bar
- High pressure from 4 to 28 bar
- Differential pressure control
- Solenoid pilot valve normally closed and normally open
- Out Let Pressure Regulator
- Crank case Pressure regulation

The pilot valves can perform the following functions:
- Constant pressure regulation
- Capacity regulation
- Crank case pressure regulation
- Refrigerant pressure regulation
- Normally Open / Normally Close Solenoid

Selection Chart for Back Pressure Valve


EXTENDED CAPACITIES FOR SPM MAIN VALVES
CAPACITIES (CONTINUED)
SUCTION VAPOUR CAPACITY FOR SPM 1 & SPM 3
R 717 (NH$_3$)

Solenoid Valves: External Pressure Operated
TWO STAGE OPERATION

- 2-step servo-controlled main valves with screwed-on pilot solenoid valves.
- Uses an external pressure source
- No differential pressure across the valve is required
- Replaces SPML with bypass solenoid valve, 2 signals and one timer
- Screw thread pilot valve fitting

- Two steps Operation
  Step one opens to 10% of the capacity,
  Step two opens automatically after the pressure differential across the valve reaches approximately 1.5 bar.
- Only one signal required for both pilot solenoid valves
- Provides safety against pressure "shocks" as the valve can only open fully when D p < 1.5 bar

Selection Chart

Capacities (Continued) — kW

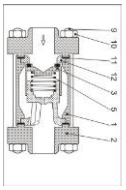
Type	Press.drop across valve △p bar	Capacities in kW circulation rate of 4 at evaporating temperature t_o °C -50	-40	-30	-20	-10	0	+10
FLOODED SYSTEMS, "WET" SUCTION LINE CAPACITIES								R 717 (NH$_3$)
SPMLX 32	0.02	15	19	24	29	33	39	44
	0.06	26	33	41	49	58	68	76
	0.1	33	43	53	64	76	87	98
	0.14	40	51	62	76	89	103	117
SPMLX 40	0.02	20	25	31	38	44	51	58
	0.06	34	44	54	65	76	89	100
	0.1	45	56	69	84	99	114	130
	0.14	53	67	82	99	117	135	154
SPMLX 50	0.02	33	41	51	61	72	83	95
	0.06	55	71	88	105	124	144	163
	0.1	72	92	113	136	161	185	210
	0.14	85	108	134	162	190	220	250
SPMLX 65	0.02	55	68	85	102	121	140	159
	0.06	94	119	147	177	209	242	275
	0.1	121	154	189	229	270	312	354
	0.14	143	181	224	271	319	369	418
SPMLX 80	0.02	115	146	180	217	256	296	335
	0.06	198	251	311	375	443	512	581
	0.1	256	325	401	485	517	661	750
	0.14	303	384	475	573	676	781	886
SPMLX 100	0.02	163	207	255	309	363	421	477
	0.06	282	358	443	534	630	729	826
	0.1	364	462	571	689	813	940	1067
	0.14	431	548	677	816	963	1113	1262
SPMLX125	0.02	260	329	407	490	579	669	759
	0.06	449	570	704	849	1003	1159	1315
	0.1	580	736	910	1097	1295	1496	1697
	0.14	689	871	1076	1298	1532	1770	2008

CORRECTION FACTOR FOR CIRCULATION RATE

Refrigerant	circulation rate 2	4	6	8	10
R 717 (NH$_3$)	1.25	1	0.88	0.80	0.73

The evaporator capacity is to be multiplied by a correction factor.

IN LINE NON RETURN VALVES / CHECK VALVES



No.	Parts
1	Housing
2	Flanges
3	Valve Cone
5	Spring
9	Bolts
10	Nut
11	Gasket
12	Valve Seat

- Ensures correct direction of flow.
- Fitted with damping piston that makes the valves suitable for installation in lines where pulsation can occur, e.g. in the discharge line from the compressor.
- Teflon tightening ring on valve cone ensures perfect sealing
- Minimal Pressure Drop
- Range 20 NB to 100 NB

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SELECTION OF IN LINE NON RETURN VALVES / CHECK VALVES

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Type	Rated Liquid Capacity kW		Rated Suction Vapour Capacity kW		Rated Hot-gas Capacity Kg/s		Rated Hot-gas Capacity m³/hr	
	R717	R22	R717	R22	R717	R22	R717	R22
SNRVA 15	454	96	26.9	10.0	0.046	0.104	27.5	10.0
SNRVA 20	545	117	32.2	11.9	0.056	0.124	33.0	12.0
SNRVA 25	1729	371	102.0	37.7	0.176	0.395	104.0	38.1
SNRVA 32	1817	391	108.0	39.7	0.185	0416	110.0	40.1
SNRVA 40/50	3991	859	236	87	0.407	0.912	242	88
SNRVA 65/80	6805	1468	402	149	0.694	1.555	412	150

FLOW REGULATING / METERING VALVE

Automatic Flow Regulator, once set, maintains a constant flow rate of liquid to the evaporator.

It also serves as a check valve to prevent back flow into the liquid line from the evaporator during pressure reversals which occur during hot gas defrost.

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OVER FLOW VALVE

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- OFV is angle-way over flow valve, which have adjustable opening pressure
- Cover the differential pressure range (ΔP): 2 - 8 bar (29 - 116 psi).
- The valve can be closed manually, e.g. during plant service and have back seating, enabling the spindle seal to be replaced with the valve still under pressure.
- The OFV valve is back pressure dependent

SAFETY VALVES AND DUAL MANIFOLD

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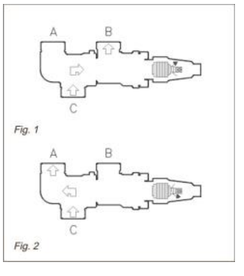
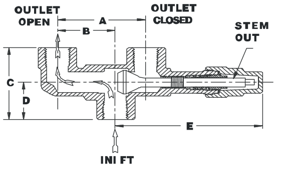
THREE WAY VALVE / DUAL MANIFOLD





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SAFETY VALVES AND DUAL MANIFOLD

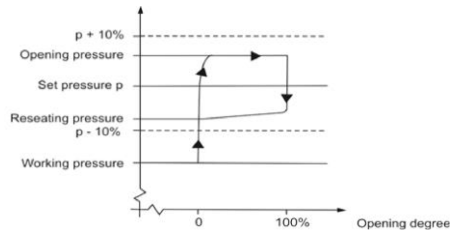
- Single Safety Valve
- Dual Manifold for Safety Valve
- Various Sizes of Safety valves

Single Safety Valve or Dual Manifold ?

- Single Pressure Relief Valve for Vessel of internal gross volume more than 3 cu. ft or less than 10 cu. Ft

- Dual Manifold for all pressure vessels with internal gross volume more than 10 cu. Ft.

SAFETY VALVE RELIEF SETTING



SIZING OF SAFETY VALVE

The minimum required rated discharge capacity for a vessel shall be:

C = F x D x L

C = Discharge capacity of the relief device
D = Outside diameter of the vessel
L = Outside length of the vessel

Refrigerant	Value of F
R-717	0.5 [0.041]
R-22, R-134a,R-401A, R-407c	1.6 [0.131]
R-404a, R-410a, R-502, R-507a	2.5 [0.203]

See Table 2/ASHRAE 15.
When combustible materials are used within 20 ft (6.1m) of a pressure vessel, multiply the value of F by 2.5.

SIZING OF SAFETY VALVE

Ammonia Pressure Vessel	IP	SI
General	C = 0.5DL	C = 0.04DL
If combustible materials are used within 20 ft (6.1 m)	C = 1.25DL	C = 0.1DL
For plate heat exchanger or double-pipe condenser	C = 0.5(A/2)	C = 0.04(A/2)

where
C = required discharge capacity , lb(air)/min [kg/s]
D = OD of vessel, ft [m]
L = length of vessel, ft [m]
A = Overall external surface, ft2 [m2]

SIZING EXAMPLE

1. Select a relief valve for an ammonia vessel 6 feet diameter by 16 feet long.

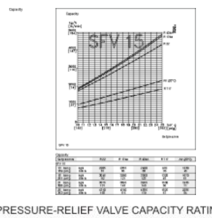
C = f D L = 0.5 x 6 x 16 = 48 lb-air/min

2. Select the desired pressure setting of 225 psig.

3. Refer to the capacity table / Use Discharge Capacity Graph Provided by Manufacturer.

4. select model.

SIZING OF SAFETY VALVE

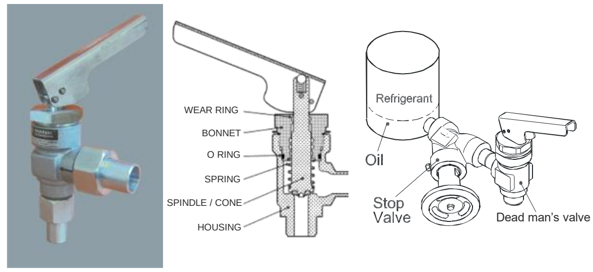


PRESSURE-RELIEF VALVE CAPACITY RATINGS

Cat. No.	Air Capacity	Standard Pressure Settings (psig)									
		150	175	200	225	250	275	300	325	350	400
SH5600R	lb/min.	10.6	6.12	13.9	15.6	17.2	18.9	20.5	22.1	23.8	27.1
SH5602R	scfm	141	166	185	207	229	251	273	294	317	360
SH5600A	lb/min.	31.3	36.1	40.9	45.7	50.5	55.3	60.1	64.9	69.7	74.5
	scfm	417	480	544	608	672	736	799	863	927	992
SH5601	lb/min.	35.8	41.3	46.8	52.2	57.7	63.2	68.6	74.1	79.6	
SH5602	scfm	476	549	622	695	768	841	913	986	1059	

SAFETY VALVES AND DUAL MANIFOLD

DEAD MAN'S VALVE



DEAD MAN'S VALVE

AMMONIA LEAK DETECTOR & ALARM

Limits of Toxicity of Ammonia	
Minimum Detectable Concentration	10 ppmv
TWA Value	30 ppmv
Serious Irritation Level	250 ppmv
Limit to Tolerable Breathing	500 ppmv

AMMONIA LEAK DETECTOR & ALARM

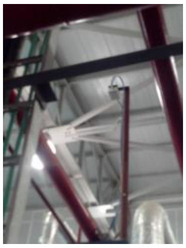
Ammonia Leak Detector Setting		
Alarm	Setting PPM	
	Manned Area	Unmanned Area
First	50	30
Second	150	70
Third	250	100

AMMONIA LEAK DETECTOR & ALARM

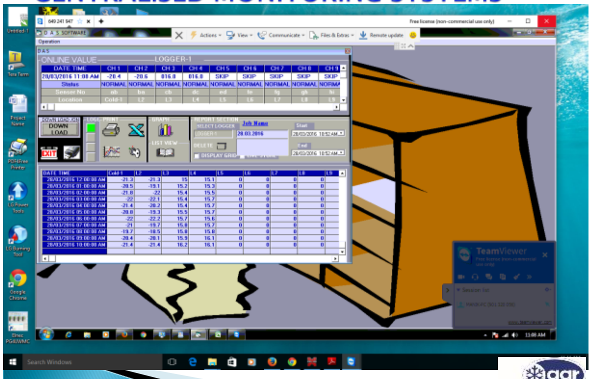
Location of Ammonia Sensors

- The Gas Detectors must be installed at High Level
- At least 1 detector at ceiling level on a grid of 10m to 20m intervals
- Above or to both sides of compressors
- Above Pressure vessels like H P / LP receivers
- Emergency power supply, e.g. battery or UPS for the detection system

AMMONIA LEAK DETECTOR & ALARM



CENTRALISED MONITORING SYSTEMS



COMPRESSOR CONTROLLERS

CAPACITY CONTROL DIAGRAM

Compressor KC-21

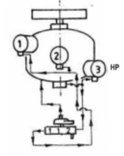


Figure 15

	Cyl. Block. No.			Capacity	Ø
	1	2	3	%	-
Direct Connection	-	-	✔	50	-
Solenoid Valve ON	✔	✔	✔	100	2

Compressor KC-51

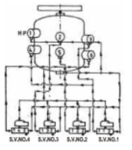
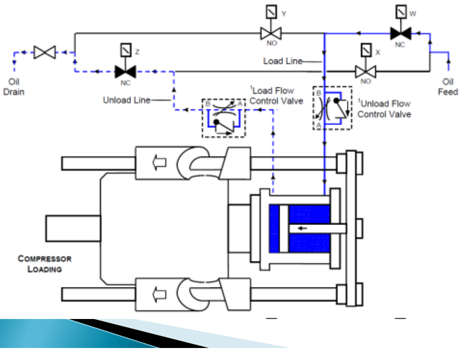


Figure 18

	Cyl. Block. No.						Capacity	Ø
	1	2	3	4	5	6	%	-
Direct Connection	✔	-	-	-	-	-	-	-
Solenoid Valve 1 ON	✔	-	✔	✔	-	-	40	2
Solenoid Valve 2 ON	✔	-	✔	✔	✔	-	60	3
Solenoid Valve 3 ON	✔	✔	✔	✔	✔	-	80	4
Solenoid Valve 4 ON	✔	✔	✔	✔	✔	✔	100	5

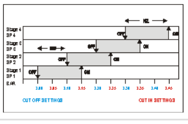
COMPRESSOR CONTROLLERS

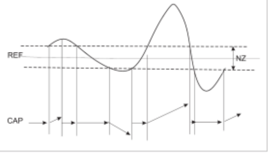


COMPRESSOR CONTROLLERS


Typical application

PRCC-04 unit stage control:
Set Point 2.00 bar
Neutral Zone 0.15 bar
Inter-Stage Differential 0.10 bar





COMPRESSOR CONTROLLERS




COMPRESSOR CONTROLLERS

COLD ROOM ALARM

- ❑ The COLD ROOM ALARM kit allows a person trapped in inside the cold room to activate an acoustic-luminous alarm installed outside the room and so call for help.
- ❑ The system will work even in the event of a temporary power cut thanks to the buffer battery on the external unit.
- ❑ The Cold Room Alarm Unit is available in 3 different models 4, 8 or 16 Input.
- ❑ The 4 input unit can be used for 4 cold rooms.

ICE THICKNESS CONTROLLER

- Automatically controlling the thickness of ice around the chilling tubes in ice bank systems.
- When the ice has formed around the chilling tube to the required thickness it automatically cuts off the electric supply to the compressor or refrigerant supply to ice bank coils.
- The compressor is automatically cut-in at a certain amount (6mm) of melt down of ice.
- The electronic controller along with a sensor probe assembly forms the complete unit.

ICE THICKNESS CONTROLLER

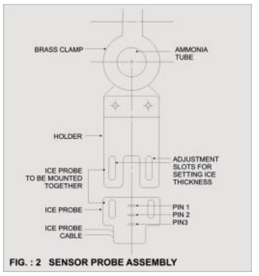


FIG. : 2 SENSOR PROBE ASSEMBLY

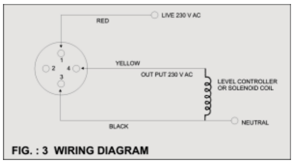


FIG. : 3 WIRING DIAGRAM

Example

Anhydrous Ammonia Gas will change phase from gas to liquid if heat is removed at temperature 35°C and pressure 13.5 kg/cm^2

At same pressure any Nitrogen present would have be cooled to -164°C to liquefy.

Hence any nitrogen present in always remain in gaseous state

VARIOUS WAYS IN WHICH NON-CONDENSABLES ENTER THE SYSTEM:

1. The refrigerant, when delivered, may contain non-condensable gases upto 15%.
2. Inadequate evacuation before commissioning the refrigeration plant
3. For service and maintenance certain parts of the refrigeration plant are frequently opened, causing air to penetrate into the system.
4. Oil changing and recharging with refrigerant have the same effect.

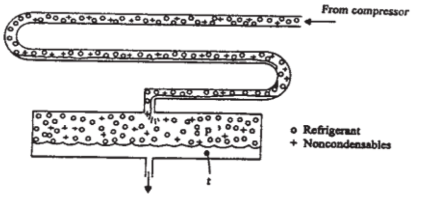
VARIOUS WAYS IN WHICH NON-CONDENSABLES ENTER THE SYSTEM:

5. Leakage: Systems operating with suction pressure below atmospheric pressure (i.e., working temperatures below -33°C for ammonia system) can have small leaks (from system piping, valves, vessels valve stem packing, bonnet gaskets, compressor shaft seals, non-welded connections, and control transducers etc.) allowing air to penetrate into the system.

6. Decomposition of the refrigerant or the lubricating oil can occur due to catalytic action of the various metals in the installation and due to high discharge temperatures. Ammonia for instance decomposes into Nitrogen and Hydrogen.

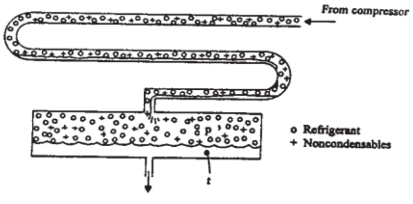
Air and other non-condensables

$P_{actual} = P_{refrigerant} + P_{noncond}$



Air and other non-condensables

When to Purge ?
If $P > P_t$
Where,
P is actual Pressure in receiver
P_t is saturation pressure corresponding to temperature t



The presence of non-condensable gases

- Increases electrical power demand
- Decreases Refrigeration system capacity
- Decreases system efficiency
- Excess head pressure puts more strain on bearing and drive motors. Belt life is shortened and gasket seals are ruptured.

The presence of non-condensable gases

- Increased pressure leads to increased temperature, which shortens the life of compressor valves and promotes the breakdown of lubricating oil.
- Increases condenser scaling which increases maintenance cost and reduces life of condenser
- Increase in discharge temperature leads to "Ammonia explosions" and it breaks down into Nitrogen and Hydrogen. Which means further addition to non-condensable gases.

AIR VS. POWER LOSS

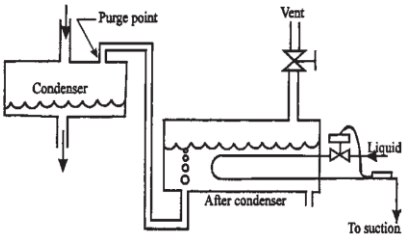
% of Air by weight	0.5	1.0	2.0	4.0
Air Pressure in PSI	0.7	1.3	2.7	5.5
Power %	0.6	1.2	2.5	5

for -15°C Evaporating and 30°C Condensing Ref. IIAR Paper TP-22

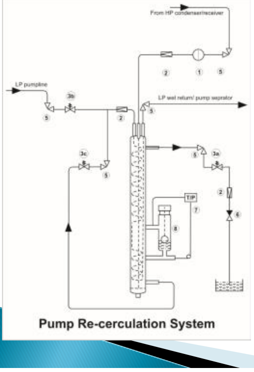
Calculation of increased power cost

Plan Condition :
Evaporation Pressure for -40°C,
Condensing Pressure for 38°C, 13.7 kg/cm^2
Refrigeration Capacity 500kW
Power required by compressor 281kW*
If our actual pressure is 0.5 Kg/cm^2 higher i.e. 14.2 kg/cm^2
Then power required would be 285kW
The 4 kW per hour for 6000 hours of operation is 24000kW
If Electricity Cost is Rs. 8/- per kW
The total increase in electricity bill is **Rs. 1,92,000/-**

Condensation of refrigerant using a small evaporator



Automatic Purger



Advantages and Disadvantages of Automatic Air Purger

Advantages	Disadvantages
Safety: Automatic Purgers eliminate the need for refrigeration staff to manually “open the system” on frequent basis	**Capital cost:** The cost is high because of purger unit, piping, solenoid valves and other controls
Effectiveness: A properly installed and operated multipoint purger can continually function to scavenge and remove NCG from System	**Maintenance Cost:** For the purger unit, accompanying solenoid valves and transducers required for purge control
Labour: Eliminates the labour associated with personnel regularly removing NCG by manual operation	

Where to Purge air ?

- Purge point connections must be at places where air will collect.
- Refrigerant gas enters a condenser at high velocity. By the time the gas reaches the far (and cool) end of the condenser, its velocity is practically zero.
- This is where the air accumulates and where the purge point connection should be made.
- Similarly, the purge point connection at the receiver should be made at a point furthest from the liquid inlet.

Purge Points

Evaporative Condenser

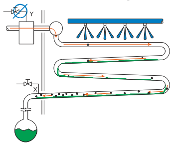


Fig. 1.(left) High velocity of entering refrigerant gas prevents any significant air accumulation upstream from point X. High velocity past point X is impossible because receiver pressure is substantially the same as pressure at point X.**Purge from point X.** Do not try to purge from point Y at the top of the oil separator because no air can accumulate here when the compressor is running.

Purge Points

Purge Connection for Receiver

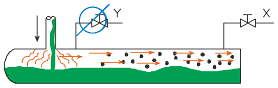
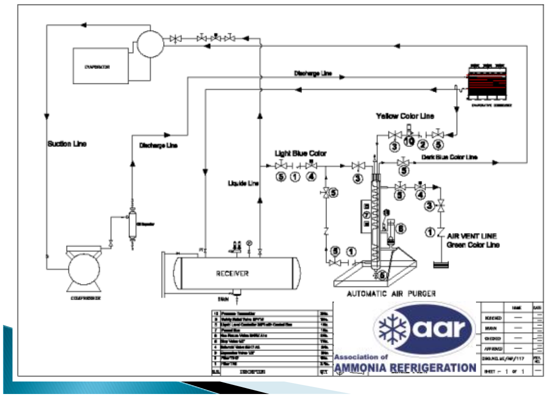


Fig. 5. Purge from Point X farthest away from liquid inlet. "Cloud" of pure gas at inlet will keep air away from point Y.

Automatic Purger



Water Contamination and Removal in Ammonia Refrigeration Systems

Water Contamination is very Commonly observed due to Solubility of Ammonia in Water

Ammonia-water Relationship

- Ammonia and water have a great affinity for each other.
- For example, at atmospheric pressure and a temperature of 30°C., a saturated solution of ammonia and water will contain approximately 30 percent ammonia by weight. As the temperature of the solution is lowered, the ability to absorb ammonia increases.
- At 0° C. the wt. percentage increases to 46.5 percent;
- At -33°C. the percentage increases to 100 percent ammonia by wt.

Ammonia-water Relationship
Solubility Of Ammonia With Water

% Dilution	Saturated Suction Temperature at		
	-0.3 Kg/ cm^2 g	0 Kg/ cm^2 g	2.0 Kg/ cm^2 g
0	-40.2°C	-33.3°C	-8.9°C
10	-38.6°C	-31.6°C	-7°C
20	-36.4°C	-28.9°C	-3.9°C
30	-32.2°C	-24.4°C	2.3°C

Water Contamination and Removal in Ammonia Refrigeration Systems

Two Sources of Water contamination

1. The contamination sources in the construction and initial start up phase
2. The contamination sources after the system has been put into normal operation.

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination During construction and at initial start up

- Water remaining in new vessels, which are not properly drained after Hydro pressure test.
- During construction, water may enter through open piping or weld joints, which are only tacked in place when either are exposed to the elements.
- Condensation, which may occur in the piping during construction.
- Condensation, which may occur when air has been used as the medium for the final system pressure testing.
- Water, which remains in the system as a result of inadequate evacuation procedures on start up.
- The use of non-anhydrous ammonia when charging the system.

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- Rupture of tubes on the low-pressure side of the system, especially in Shell & Tube Heat Exchangers such as chillers or oil coolers
- Improper procedures, when draining oil or refrigerant from vessels or pipes in vacuum range into water filled containers.
- In systems, which are operating below atmospheric pressure or which are making pump down so the pressure goes into a vacuum range: Leaks in valve stem packing, flexible hoses, screwed and flanged piping joints, threaded and cutting ring connections, pump and compressor seals, and leaks in the coils of evaporator units.

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- Improper procedures when evacuating the system or parts of the system, while service and maintenance work is carried out.
- Complex chemical reactions in the system between the ammonia, oxygen, water, oils and sludge's can create more "free" water in the system.
- Lack of adequate or no purging

Water Contamination and Removal in Ammonia Refrigeration Systems

Contamination after the system has been put into normal operation

- Lack of adequate or no purging

Example

Air Purger in a plant removes 5 Ltr of air per min

The ambient temperature is 35°C, with 75% RH

Hence water contain is 25 g/kg

5 Ltr x 1/1000 ltr X 25.5 g X 60 min = 7.65 grams of Water per hour

That is 45.9 Ltr per year considering 6000 hrs per year plant operation

In 10 years we will have 459 Ltrs of water in our plant

Effects Of Water Contamination

- Water contamination lowers system efficiency
- Increases the electrical costs
- In addition, water also causes corrosion in the refrigerant cycle and
- accelerates the aging process in oil
- Increased wear and more frequent oil changes generate lower plant availability and increase service costs.

Areas Of Highest Water Content

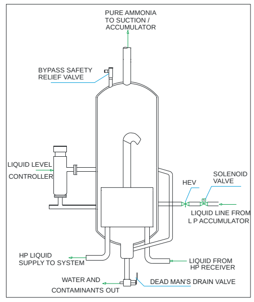
- Recirculation Sysetms :Pump receiver (LPR)
- Flooded systems: evaporator and surge drum.
- DX systems suction accumulator.
- Two-stage systems vessels and evaporators of the low stage portion of the system.

Areas Of Highest Water Content

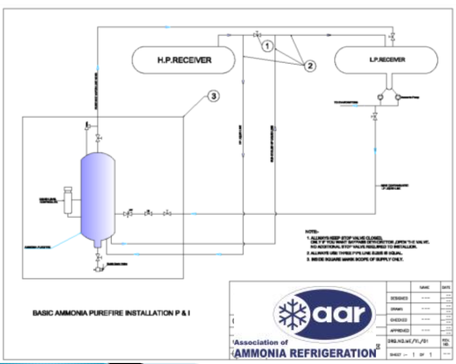
Reasons :

- Large difference in Vapour Pressure between water and ammonia.
- For example, at 2°C, the vapor pressure of ammonia is 3.6 Kg/cm^2 as compared to 0.007 Kg/cm^2 for water.
- Since the liquid with the higher vapor pressure will evaporate in greater proportion than the liquid with the lower vapor pressure, a residue is left containing more and more of the lower vapor pressure liquid if infiltration is not corrected.

Ammonia Purifier



Ammonia Purifier



Thank You

Association of
AMMONIA REFRIGERATION