Installation and Commissioning

Student Resource Package No: NR 11

Nominal Student Hours: 18 Hours.

Delivery: Competence in this training program can be achieved through either a formal education setting or in the workplace environment.

Recognition of Prior Learning: The student/candidate may be granted recognition of prior learning if the evidence presented is authentic and valid which covers the content as laid out in this package.

Package Purpose: This package provides the student with the underpinning knowledge and skills to install commission and maintain either a refrigeration or air conditioning system.

Suggested Resources: Australian Refrigeration and Air Conditioning Vol 1&2.

Various Manufacturers Service and Installation Manuals.

Assessment Strategy: The assessment of this package is holistic in nature and requires the demonstration of the knowledge and skills identified in the student package content summary. To be successful in this package the student must show evidence of achievement in accordance with the package

Competence: This package should be supported by workplace exposure to the various applications under the guidance of a licensed mentor.

Assessment:

Grade Code: 72

GRADE	CLASS MARK (%)
DISTINCTION	>=83
CREDIT	>=70
PASS	>=50

Assessment Events:

1.	Theory Test:	30%
2.	Practical Project / Assignment:	70%
	Total Marks:	100%

Assignment:

Medium temperature coolroom assignment to include:

- Pump down cycle.
- Refrigeration piping and electrical and wiring diagrams
- Determine the rooms, transmission and product loads from specific product information.
- Select the required condensing unit and evaporator from calculated capacities.
- Determine the correct suction and liquid line sizes.
- List all safety and cycling control settings.

Practical:

Install medium temperature coolroom:

- Run refrigerant lines
- Install filter drier
- Connect electrical circuits
- Evacuate system and charge with refrigerant
- Commission system for trouble free operation.
- Construct a pressure enthalpy and compare actual capacity against the systems rated capacity.
- Measure air and compare to the rated air flow.

Content Summary:

Section No: 1
Dangers & Safe Working Practices

Purpose: The purpose of this section is to enable you to work safely within your work environment and at the same time ensuring safety for the general public.

As an apprentice, trainee or tradesperson working within a workshop or on site can be dangerous. If you take a positive approach to safety, health, and welfare, the number of accidents can be greatly reduced.

Note: accidents do not happen – they are caused.

Safety Issues:

1. **Body protection**
2. **Workshop / Site safety**
3. **Electrical safety**
4. **Fire safety**
5. **First aid.**

Body Protection:

The following protective equipment must be worn to comply with OH&S regulations for much of your work:

- Clothing: You need to wear protective clothing for much of your work.
- Footwear: Safety boots or shoes to protect your feet.
- Hearing: Protect your ears with ear muffs or ear plugs.
- Eyes: Wear eye protection when ever there is a risk of eye injury.
- Head: Wear a hard hat on building sites or when necessary.
- Breathing: In the event of a large gas leak wear suitable breathing apparatus.

Workshop / Site Safety Requirements:

- Behaviour: Pushing, shouting, or throwing things can cause accidents.
- Housekeeping: Good, clean working conditions lead to fewer accidents
- Tools: Always use the correct tool for the job and maintain in good working condition.
- Lifting: Use mechanical lifting gear where possible of use correct lifting techniques.
- Cylinders: Ensure that cylinders are not over filled, stored in a cool place and protected from physical damage.

- Welding: Use the correct safety equipment and procedures when welding or silver soldering.

- Ladders: Choose the correct ladder for the job. Ensure that the foot of the ladder away from the wall a distance equal to a quarter of the ladder's height.

- Guards: Dangerous machinery are to be fitted with safety guards.

Electrical Safety Requirements:

- Isolation: Ensure the correct disconnect and re-connect procedures are followed.

- Flexible cords: Extension cords should be maintained and tagged and used in accordance with all current regulations

- Power tools: Do not pick up or drop power tools by their electrical leads.

- Safety tags: Safety tags should be used when working on electrical machinery of the machine is faulty and cannot be used. These tags must only be removed by the person who placed it there or an authorised person.

Remember electricity can kill!

Fire Safety Requirements:

When welding, brazing, soldering or doing similar work.

1. Know your closet path of exit,
2. Have a fire extinguisher on hand and
3. Have enough fresh air – fumes can be dangerous.

First Aid

First aid by you has more chance of saving a life than second aid by the ambulance officer or third aid by the hospital. Time cost lives.

If you are first on the scene of an accident, what you do or do not do can make the difference between life and death.

Review Questions section No: 1

Q.1 What are the five main safety issues that you must consider in your working environment?

Q.2 List six types of body protection equipment used in the workplace:

Q.3 List and briefly describe eight requirements of workshop / safety:

Q.4 List and describe four important electrical safety requirements:

Q.5 What are three fire safety issues which you must consider when welding to ensure your personal and others safety:

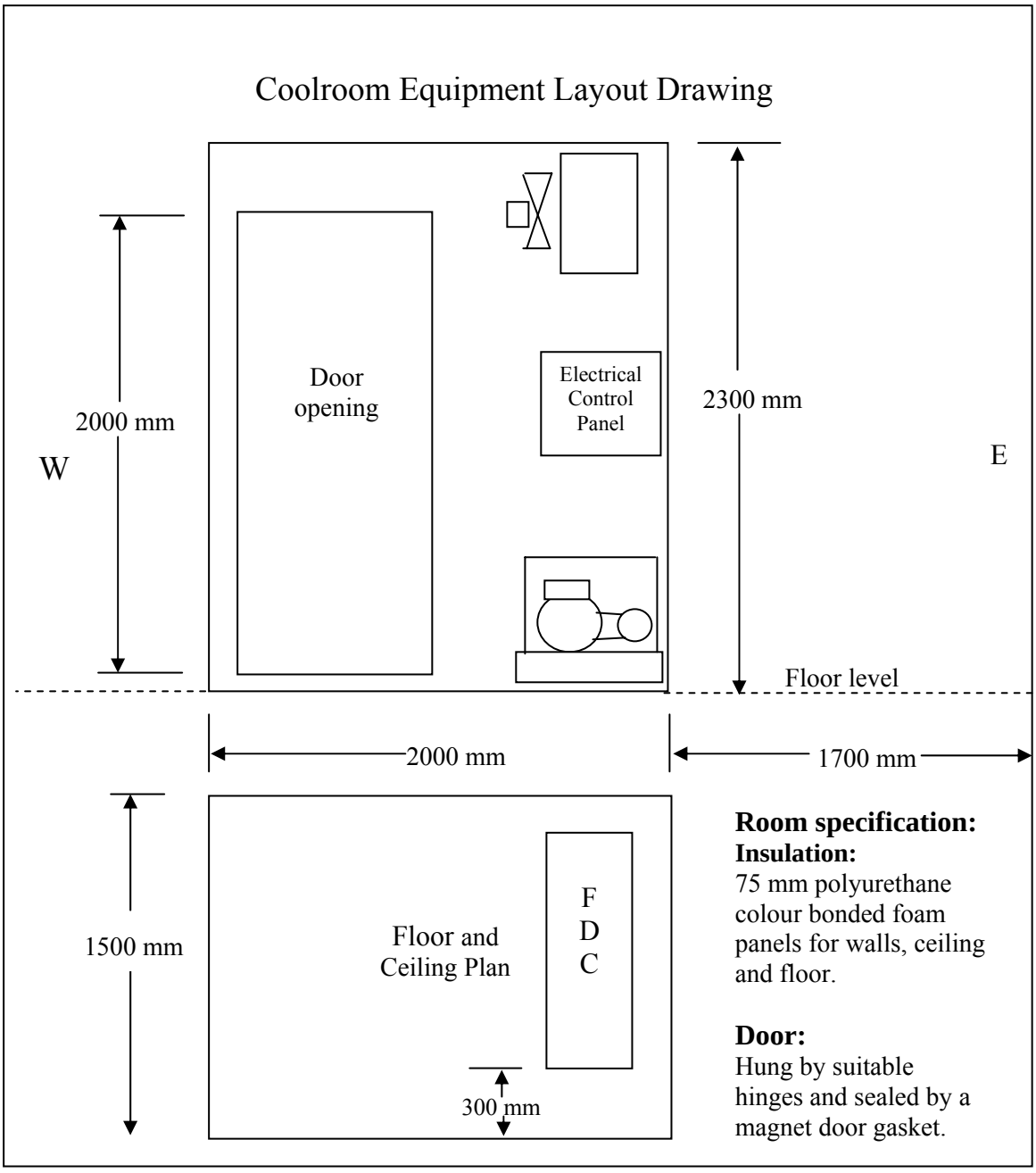
Section No: 2

Site Drawings and specifications

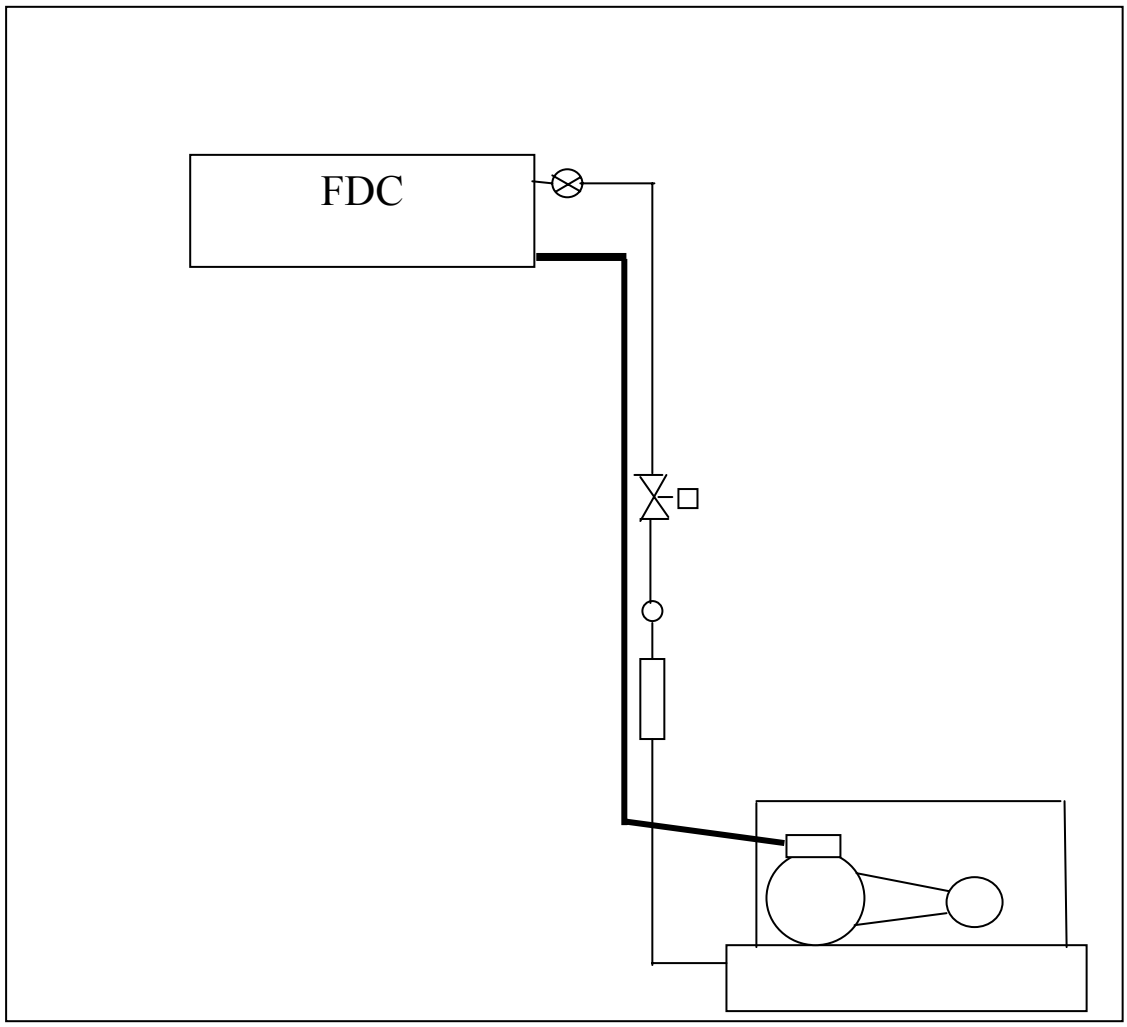
Purpose: The purpose of this section is to enable you to develop skills in the interpretation of plant and equipment layout drawings, piping / wiring diagrams and manufactures' specifications from standard symbols in accordance with the SAA Codes.

Site & Equipment Drawings:

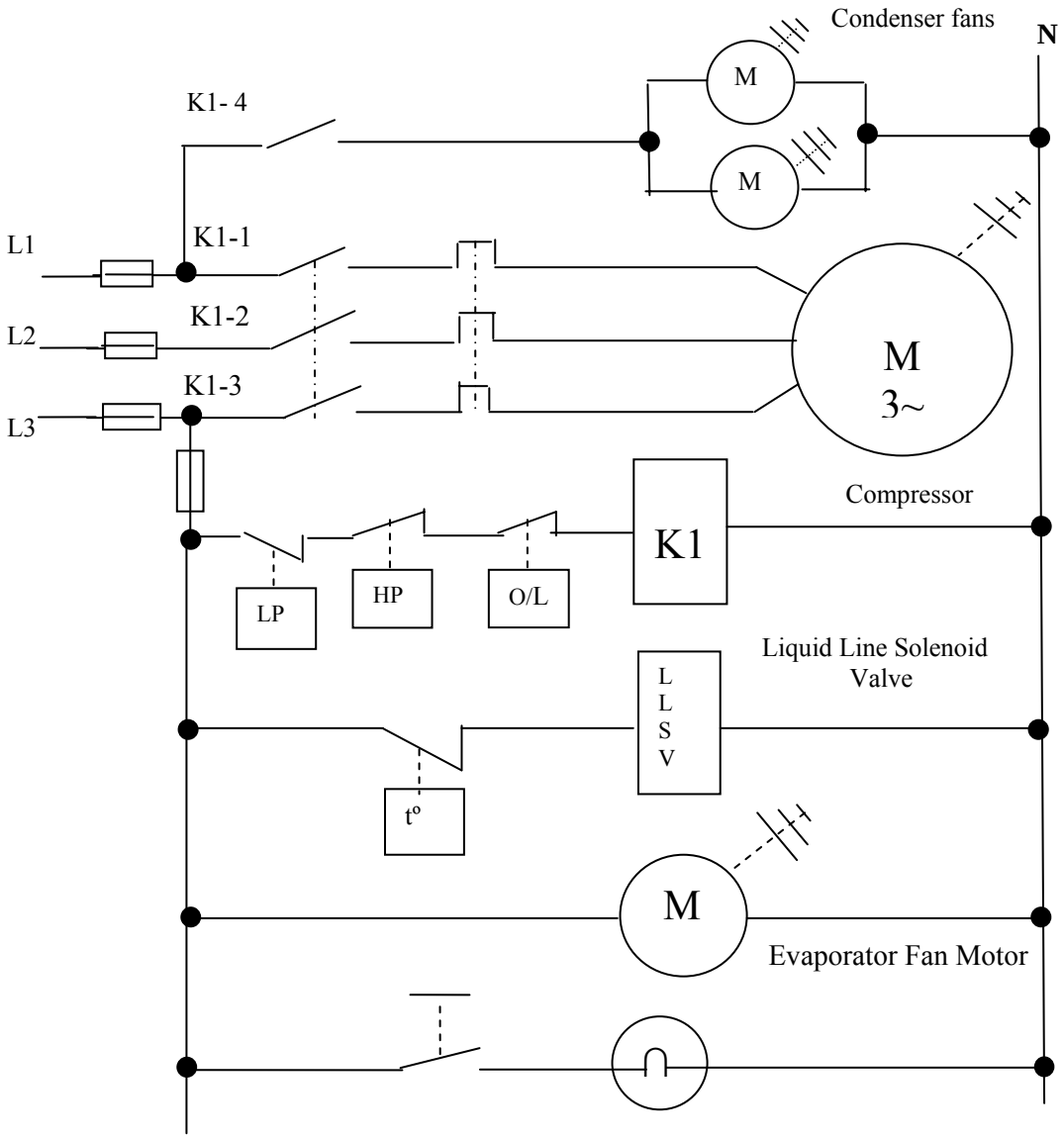
The following details and equipment layout drawing, piping and electrical for a typical medium temperature cool room installed in Room11 of the Refrigeration / Air Conditioning Section Ultimo.



Refrigeration Piping Diagram



Electrical Wiring Diagram Medium Temperature Coolroom



Section No: 3

Pipe Sizing & Installation

Purpose: The purpose of this section is to provide you with the underpinning knowledge and skills to correctly size and install refrigerant lines in accordance with the relevant codes and regulations.

Piping Installation: (ARAC 18.4)

Ideally piping should be easily installed and readily accessible for inspection and maintenance. Piping in all cases should present a neat and professional appearance. Lines should run straight and parallel to walls. Horizontal suction lines, condenser to receiver lines and discharge lines should be slightly pitched towards the direction of flow.

Piping should be well supported by suitable hangers or brackets and be spaced to prevent the pipe from sagging between each fixing.

Allowance should be made for the expansion and contraction of the pipe work and sheathed should be place in the openings where the pipe work passes through floors, ceilings or walls to prevent the possibility of refrigerant leakage.

Vibration:

Vibration and noise usually originates from the connected plant and equipment and is amplified by poorly designed / installed piping. Vibration is usually caused by rigid connections to the compressor, gas pulsations and turbulence of the refrigerant vapour due to a high velocity.

Vibration eliminators, vibration loops, well designed fixtures and installation will help eliminate excessive vibration and possible refrigerant leakage.

Suction Line Insulation:

In order to maintain minimum superheat in the suction line, Bradflex or Armaflex insulation can be used as insulation.

There are several points that should be considered when selecting the correct suction line insulation:

- Suction line length (longer the run the thicker the insulation).
- Suction line location (if the line is in the sun thicker insulation and a reflective shade may be required).
- Saturated suction temperature (SET). Low temperature freezer rooms will require thicker insulation to prevent moisture condensing due to low dew temperature on the outside of the insulation.

- Insulation requirements / specifications can be obtained by the manufactures, or plant and equipment wholesalers.

Pipe Sizing:

The proper sizing of refrigerant lines is just as important as heat load calculations, correct condensing unit and evaporator selection.

Excessive pressure drop in any line will appreciably reduce the refrigeration capacity of the system. Correct velocity will ensure adequate oil return. The suction / liquid line must be correctly sized as an excessive pressure drop in either of these lines will have a severe effect on the operating capacity on the refrigeration system as indicated by the following table below.

Pressure Drop & Condensing Unit Capacity Reduction.

Table No: 1

Evaporator Temperature	Suction Line Pressure Drop	Pressure At Compressor	Actual Suction Temperature	Condensing Unit Capacity in Watts	Capacity
-22°C	0 kPa	32 kPa	-22°C	10170	100%
-22°C	7 kPa	25 kPa	-23.2°C	9495	93.4%
-22°C	14 kPa	18 kPa	-24.5°C	8820	86.8%
-22°C	21 kPa	11 kPa	-26°C	8150	80.2%
-22°C	28 kPa	4 kPa	-28°C	7500	73.8%

Suction Line Sizing:

The following two steps are required to determine the suction line size:

- Determine the actual length of tubing required between the evaporator and compressor in metres.
- Add all the bends, valves and fittings as all these add to the pressure drop. This is referred as the **Equivalent Length** of straight tube of that size.
- Therefore the equivalent length of tube is the sum of the Actual Length and the Equivalent Length of fittings.

Equivalent Length = Actual length + Equivalent Length of fittings.

Note: The following table indicates the equivalent length of fittings in metres.

Equivalent Metres of Tube for Various Valves and Fittings

Table No: 2

Line Size mm OD	Globe Valve Open	Angle Valve Open	Gate Valve Open	90° Bend	Tee Standard
9	1.2	0.6	0.2	0.2	0.4
12	2.4	1.2	0.3	0.3	0.6
16	4.9	2.7	0.3	0.6	1.2
22	6.7	3.7	0.3	0.6	1.5
28	8.5	4.6	0.3	0.9	1.8
35	11	5.5	0.4	1.2	2.4
41	12.8	6.4	0.5	1.2	2.7
54	17.4	8.5	0.6	1.5	3.7
66	22	11	0.7	1.8	4.6
80	27	13.6	0.8	2.1	5.5

To Calculate Refrigerant Tube Size:

A freezer room operates with refrigerant R 404A. The condensing unit is located 12 metres from the evaporator, and the condensing unit refrigeration capacity is approximately 8700 watts at -30ºC (SET).

There are eight 90º bends, one angle valve and one globe valve.

Determine the suction line and liquid 0D sizes in mm.

Suction line:

1. An estimate must be made as to the probable suction line size to permit the equivalent lengths to be made. Reference table No: 4 for R 404A refrigerant with a capacity of 8700 watts at -30°C shows the size would be either 35mm or 41mm tube.

2. Working with 35 mm tube equivalent lengths from table No:2 listed are:

   - One 35mm globe valve = 11.0 metres.
   - One 35mm angle valve = 5.5 metres.
   - Eight 35mm 90° bends = 8 x 1.2 = 9,6 metres.
   - Straight tube = 12 metres.

   Total 38.1 metres

   Therefore the Equivalent Length equals 38.1 metres.

   Referring back to table No: 4 for R404A refrigerant
   Reading down from -30ºC suction temperature column; and down the 40 metre length then across from evaporator capacity of 8700 watts, the listed tube size equals 41mm.
   Cross – checking back down the -30ºC suction temperature column and down the 40 metre equivalent the listed size again equals 41mm.

Liquid line:

Since oil and liquid refrigerant mix readily, oil movement within the liquid line presents no problem. However, pressure drop does require some consideration.

Pressure drop in the liquid line is created by two main factors:

- Frictional loss through pipe and fittings
- Loss incurred by vertical riser due to the head on the liquid.

Note: The weight of 300mm column of R22 liquid exerts a pressure of 3.5kPa on the refrigerant below it.

Example: A 3m rise will create: $\frac{3000}{300} = 10$

Therefore: 3.5 x 10 = 35kPa.

Excessive pressure drop in the liquid line can cause the refrigerant to flash into vapour which reduces the evaporators' capacity and erodes the TX valves seat.

Liquid Line Sizes (Approx OD in mm)

Net Evap Cap Watts	R 404A & R22			
	Total equivalent length of liquid line in metres			
	7.5	**15**	**30**	**45**
900	6	6	6	9
1800	6	6	9	9
2700	6	9	9	9
3500	9	9	12	12
5000	9	9	12	12
7000	12	12	12	12
8700	12	12	12	16
10500	12	12	16	16
12200	12	16	16	16
14000	12	16	20	20
16000	12	16	20	20
17500	16	16	20	20
21000	16	16	20	20
26000	20	20	22	22
35000	29	22	28	28
44000	22	22	28	28
52500	22	22	28	28
61000	28	28	35	35
70000	28	28	35	35
87000	28	28	35	35

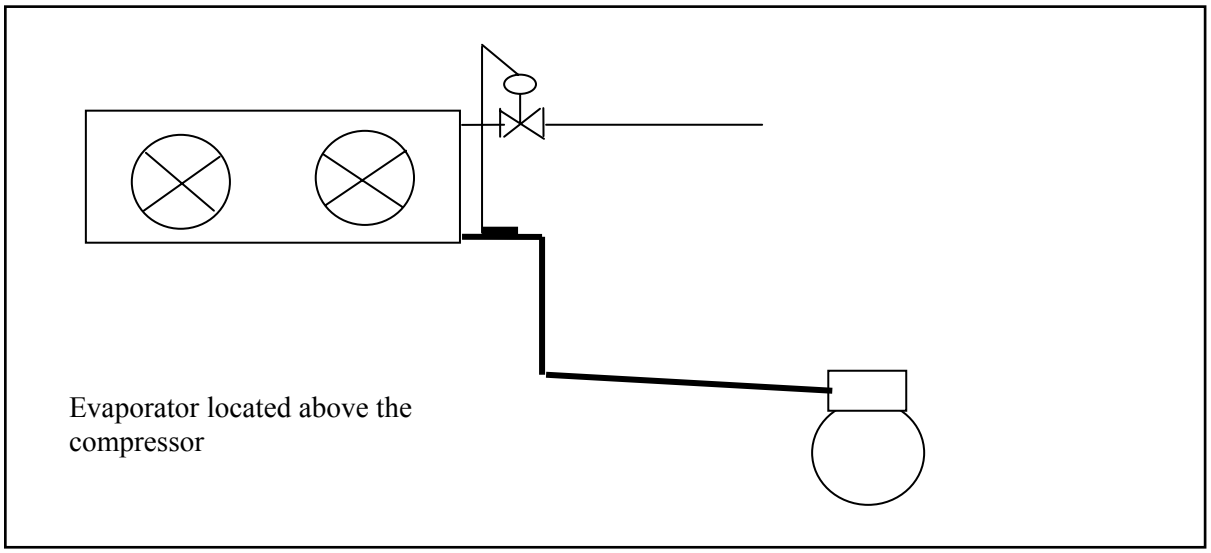
Suction Line Sizes for R404A & R22 (Approx OD in mm)

Table No: 4

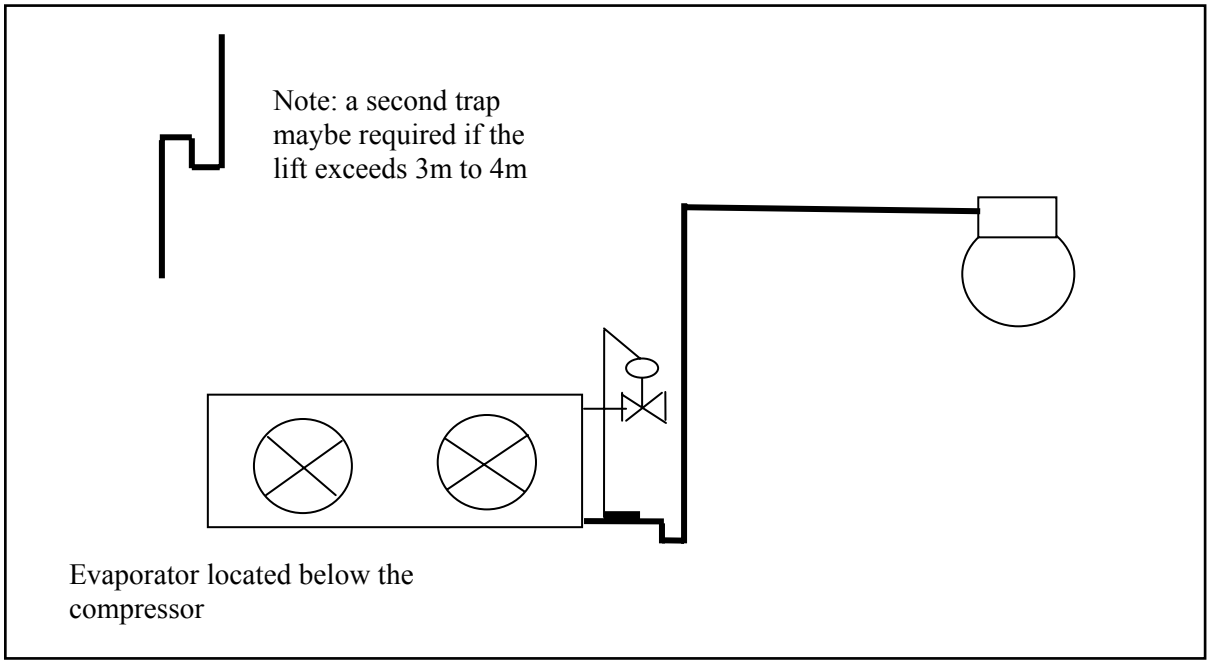
Evap Cap Watts	Saturated Suction Temperature ºC																			
	+4°C				-10ºC				-20°C				-30ºC				-40°C			
	Total equivalent of suction line, metres																			
	7.5	**15**	**30**	**45**	**7.5**	**15**	**30**	**40**	**7.5**	**15**	**30**	**40**	**7.5**	**15**	**30**	**40**	**7.5**	**15**	**30**	**40**
900	9	9	9	12	9	9	12	12	12	12	16	16	12	16	16	20	16	20	22	22
1800	9	12	12	16	12	12	16	16	16	16	20	22	16	20	22	22	20	22	28	28
2700	12	12	16	16	9	16	16	20	20	20	22	22	20	22	28	28	22	28	28	35
3500	12	16	20	20	16	16	20	20	22	22	28	28	22	22	28	28	28	28	35	35
5000	16	20	20	22	20	20	22	22	22	22	28	28	22	28	28	35	28	35	41	41
7000	20	20	22	22	20	22	28	28	22	28	28	35	28	28	35	35	35	35	41	41
8700	20	22	22	28	22	22	28	28	28	28	35	35	28	28	35	41	35	41	41	54
10500	20	22	28	28	22	28	28	28	28	28	35	41	28	35	41	41	35	41	54	54
12200	22	22	28	28	22	28	28	35	28	35	35	41	35	35	41	54	41	41	54	54
14000	22	28	28	28	28	28	35	35	35	35	35	41	35	41	41	54	41	54	54	54
16000	22	28	28	35	35	35	35	35	35	41	41	41	41	54	54	54	41	54	54	66
17500	22	28	28	35	35	35	35	35	35	35	41	54	41	41	54	54	41	54	54	66
21000	28	28	35	41	28	35	41	41	41	41	54	54	41	54	54	66	54	54	66	66
26000	28	28	35	41	28	35	41	41	41	41	54	54	41	54	54	66	54	66	66	80
35000	28	35	41	41	35	41	41	54	41	41	54	66	54	54	66	66	54	66	80	80
44000	35	35	41	54	35	41	54	54	4	54	54	66	54	54	66	66	66	66	80	80
52500	35	41	54	54	41	54	54	54	54	54	66	66	54	66	66	80	66	80	92	92
61000	35	41	54	54	41	54	54	66	54	54	66	66	66	66	80	80	66	80	92	92
70000	41	41	54	54	41	54	54	66	54	66	66	80	66	66	80	80	80	80	92	105
87000	41	54	54	66	54	54	66	66	54	66	80	80	66	80	80	92	80	92	105	130

Installation Considerations:

The following details the location of the evaporator and condenser in relation to the compressor within a refrigeration and or air conditioning system:



Evaporator located above the compressor

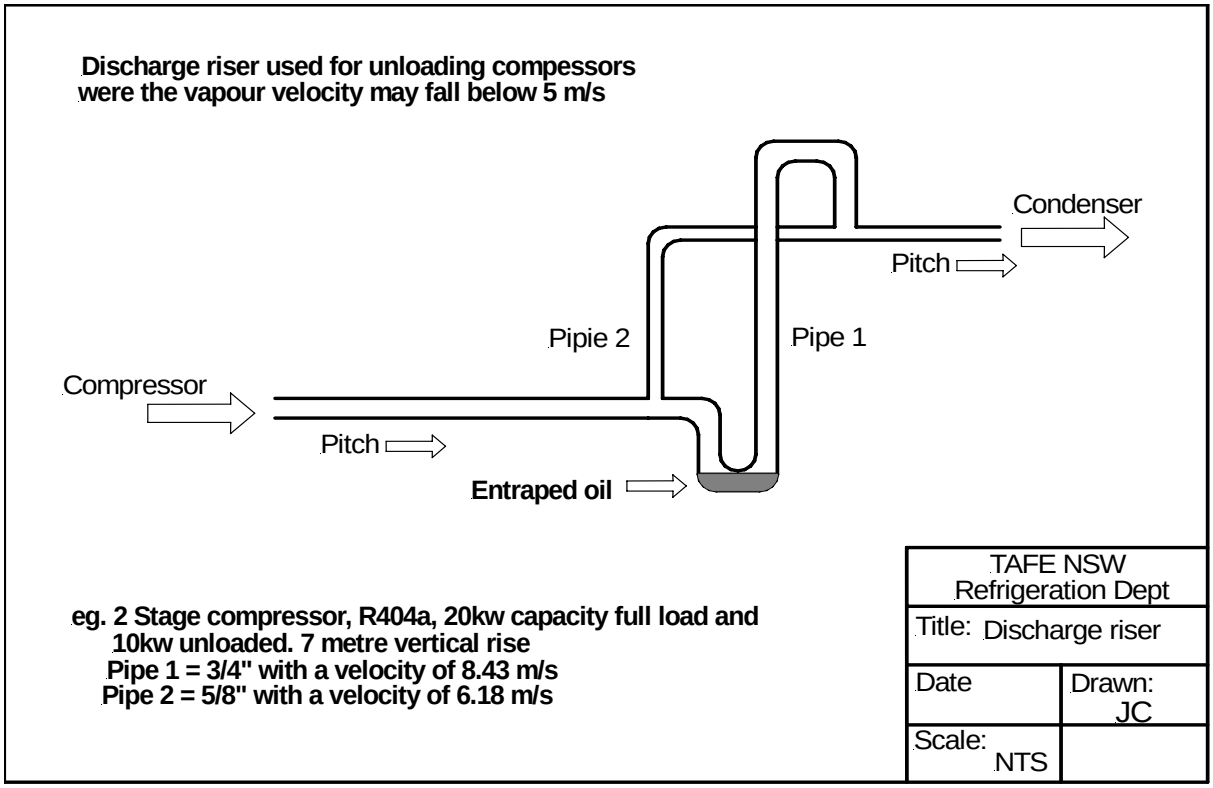


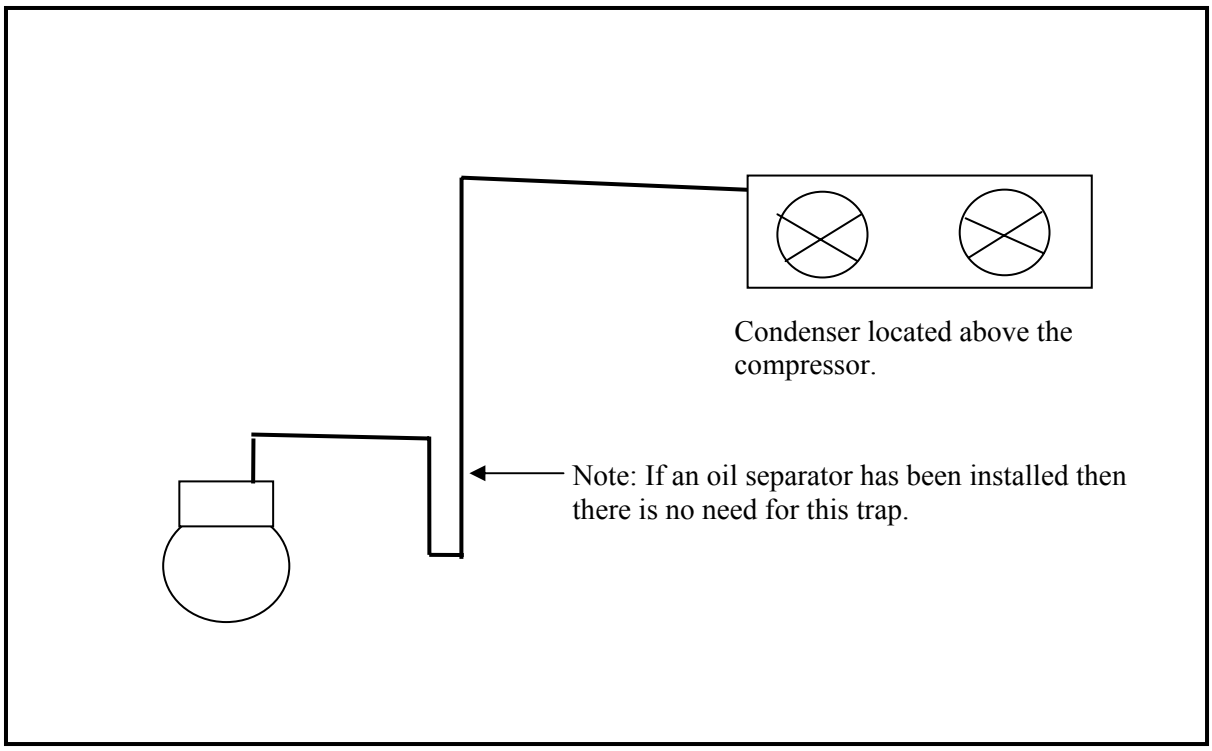
Evaporator located below the compressor

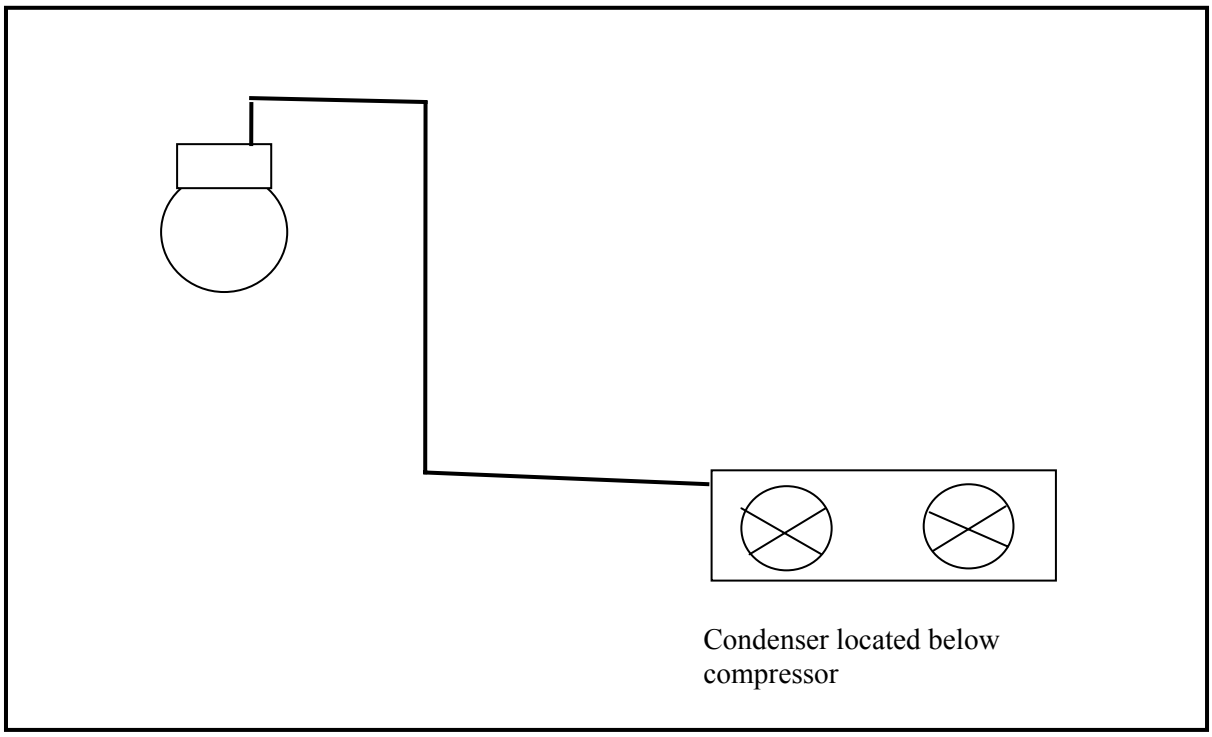
Double Pipe Riser:
It should be noted systems that are capable of varying their capacity unloading or loading up in response to changes in the product load may require a double pipe riser.

Construction:
The size of both risers should be large enough to ensure that the pressure drop and velocity of the suction vapour is maintained during 100% loading. The size of the smaller riser should be capable of handling the minimum load which could be around 25%.

Operation:
Suction vapour travels up the smaller riser during minimum capacity loading. The trap at the bottom of the riser will collect oil and block off the larger riser and thus the oil will be lifted out of the trap when the compressor returns to full load causing the suction vapour to flow up both risers.




Condenser located above the compressor.
Note: If an oil separator has been installed then there is no need for this trap.


Condenser located below compressor

Review Questions section No: 3

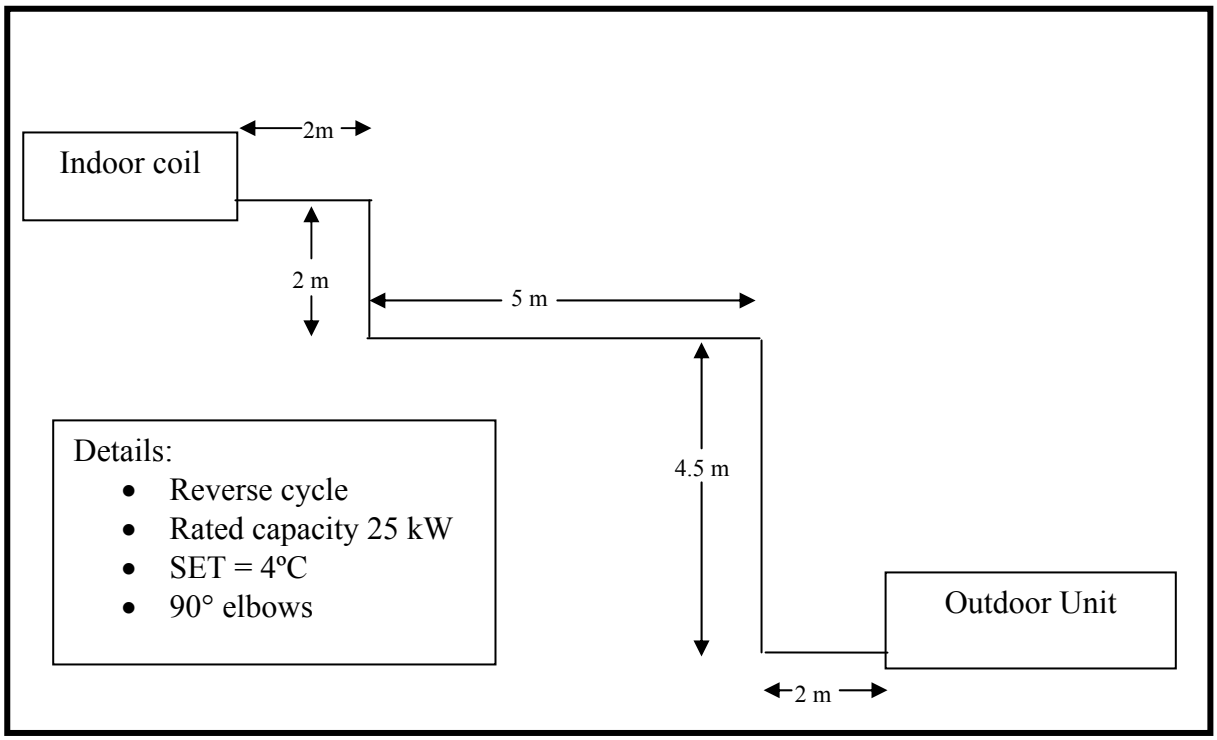
Q1. What is the main purpose of a double pipe riser?

Q2. Why is it important to ensure correct suction size and selection?

Q.3 In the space provided below sketch the refrigeration piping circuit for a medium temperature cool room, if the condensing unit is mounted 2 metres above the evaporator.

Q4. Describe the two main causes of pressure drop in the liquid line:

Q.5 An air conditioning system is to be installed in an office block with the refrigerant piping installed in accordance with the following drawing and details:



From the above drawing and details determine:

(a) Total equivalent length of suction and liquid refrigerant lines.

(b) Determine the actual suction and liquid line size in mm OD.

Section No: 4

Pressure & Leak Testing

Purpose: The purpose of this section is to provide you with the underpinning knowledge and skills in the correct procedures in regards to pressure testing and leak detection accordance with the relevant codes and regulations.

Pressure Testing:

Pressure testing is used on new installations to ensue there are no leaks and on existing plant that has developed a leak.

Pressure Testing Refrigeration / Air Conditioning Systems:

Note: always use eye protection!

- On existing plants look for of obvious signs of a leak (eg. oil or traces of oil around joints etc).
- Any control or relief valves should be removed and the connection points plugged as these could be damaged by the test pressure.
- On open drive compressors front seat the compressor service valves as the high test pressures may damage the shaft seal. The main purpose of the pressure test is to check pipe joints and fittings for leaks.
- Make sure all line valves, solenoid valves etc are open (manually or energising).
- Set the pressure regulator on a dry nitrogen cylinder at 1000 kPa or nominated pressure and charge the system until the required pressure has been achieved.
- Close both the cylinder shut off valve and the gauge manifold valve.
- Each joint and connection can now be leak tested using a soap solution and checking for bubbles. It is god practice to tap each brazed joint with a hide or rubber mallet which may disclose a leak.
- If any leaks are detected they should be repaired after the pressure has been released from the system.
- The system must be pressure tested again this time first charging with refrigerant up to 70kPa then add dry nitrogen until the systems pressure reaches 1000kPa.
- All joints in the system can now be checked with a halide or electronic leak detector.
- System should now be left for approximately 24 hours and checked for any noticeable drop in pressure.

- After pressure testing the system, reclaim any mixture of gases, reconnect any controls or fittings and open compressor service valves if fitted. A vacuum pump can now be fitted to the system for evacuation.

- The vacuum should be obtained by using a vac stat and obtaining at least 500 microns. The vacuum pump oil must be change before evacuation and may have to operate for 24 hours to reach the required vacuum..

Leak Testing Methods:

There are a number of methods used to detect refrigerant leaks. However the first step is to use your senses such as sight of fractured pipes and the presence of oil.

Refrigerant leaks can also be detected by listening and smelling as follows:

- A bad leak can often be detected by the noise generated by the refrigerant escaping.

- Ammonia refrigerant leaks can be detected because of its strong pungent odour.

The following details a number of leak testing methods:

Soap Bubbles:
The soap bubble method is the simplest way to test for refrigerant leaks in a positive pressure system. A soap solution is spread over the joint and the solution will bubble if a leak is present.

Chemical Leak Traces:
Chemical dyes are liquid charged into the refrigeration system and will produce a colouration at the point of a refrigerant leak.

Halide Torch:
A halide lamp is a torch that burns propane – butane fuel in the presence of a copper ring and is supplied with a rubber tube that is connected to the base of the burner. The other end is free to be moved about the various parts of the refrigerated system. The rubber tube draws air from the open end into the burner.
If the open end of the tube is brought near to a leaking refrigeration connection, some of the leaking refrigerant vapour will be drawn up the rubber tube into the burner. Immediately, the colour of the flame would change to green, indicating a leak.

Electronic Leak Detector:
This is often criticised for being too sensitive as it can sense fluorocarbons from refrigerant and other sources such as exhaust fumes.

Review Questions Section No: 4

Q.1 What are the first steps to be considered when a system is short of refrigerant or lost its charge? _____

Q,2 List four methods of leak detection: _____

Q.3 Describe how you would use the soap and bubbles leak detection method: _____

Q.4 At what pressure should the gauge on a dry nitrogen cylinder be set at when pressure testing a refrigeration / air conditioning system? _____

Q.5 Describe how you would pressure test a refrigeration system using a halide leak detector: _____

Section No: 5

Refrigerant Piping Accessories

Purpose: The purpose of this section is to provide you with the underpinning knowledge and skills to identify various accessories that are connected within a refrigeration and or air conditioning system.

Types of accessories:

- Liquid receiver
- Oil Separators
- Suction line accumulators
- Sight glass / moisture indicator
- Filter driers – liquid and suction
- Surge drum/tank
- Vibration eliminators
- Discharge mufflers
- Heat exchangers – suction to liquid line.

Liquid receiver: is a liquid / vapour refrigerant tank which stores refrigerant to provide a constant flow of liquid refrigerant to the metering device as it modulates. Note liquid receivers are not used on capillary systems.

Oil separator: an oil separator is installed when it is essential for all return to the compressor under all load conditions and where oil logging in the evaporator is likely.

Suction line accumulator: its function is to trap liquid refrigerant before it reaches the compressor. Any return liquid collects in the accumulator and boils off as a vapour as it returns to the compressor.

Sight glass / moisture indicator: indicates sub – cooled liquid refrigerant flow and bubbles will indicate a shortage of refrigerant. However, blended refrigerants may have an indication of bubbles when fully charged.

Filter drier is used to collect foreign particles and moisture within a refrigeration system. It may be necessary to install a suction line burn out filter drier when a hermetic or semi-hermetic compressor has burnt out to clean up the system.

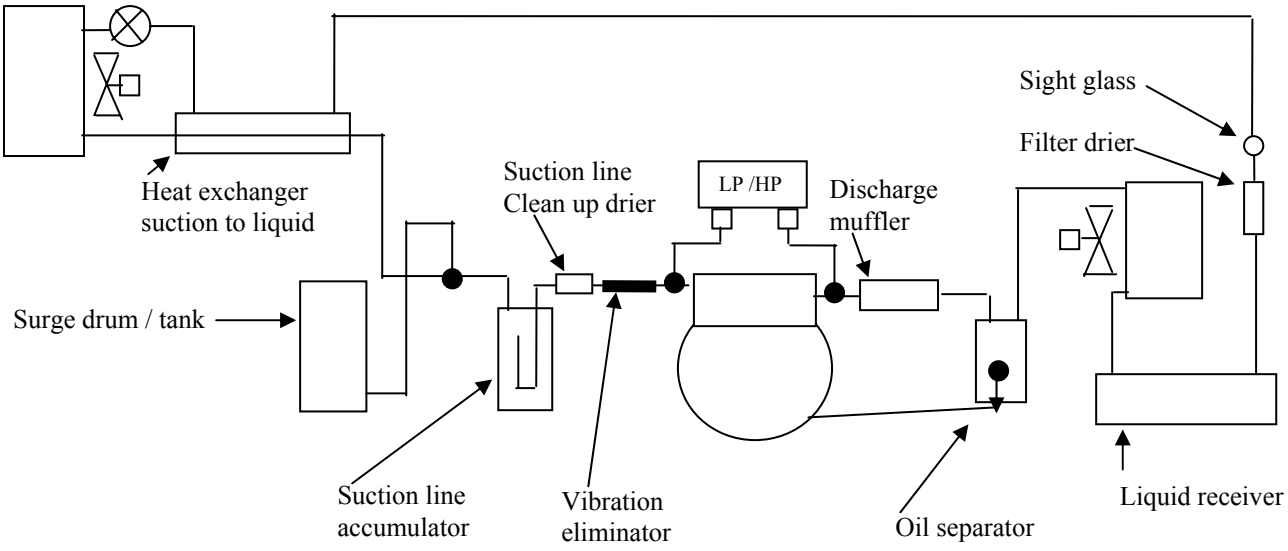
Surge tank is installed after the evaporator to increase the gas volume and reduce the rate of pressure change to eliminate short cycling of the compressor.

Vibration eliminators are installed to reduce the vibrations of the compressor to the pipe work.

Discharge mufflers are installed to absorb noise and gas pulsations emanating from the compressor

Heat exchangers – suction to liquid line are installed to cool liquid going to the evaporator to reduce the flash gas percentage.

The attached circuit diagram has all the listed accessories fitted. Some systems will require some of the accessories and others all, however depending on the applications and manufacturers recommendations will determine which one or ones of the accessories is to be installed.



Refrigeration piping circuit with various accessories

Review Questions Section No: 5

Q.1 What is the main purpose of an oil separator?_____

Q.2 What component is installed between the compressor and the connecting pipe work to reduce vibrations?_____

Q.3 What type of system doesn't require a liquid receiver?_____

Q.4 State the function of a liquid line filter drier:_____

Q.5 Describe the function of the liquid / suction line heat exchanger._____

Q.6 Which component can be installed to reduce gas pulsations?_____

Q.7 Liquid line sight glasses are installed for what purpose:_____

Q.8 Define the purpose of the oil separator:_____

Q.9 What component is installed to increase the gas volume and eliminate short cycling of the compressor?_____

Q.10 Describe the purpose of the suction line filter drier:_____

Practical Project

Installation of Medium Temperature Coolroom

Aim: To complete the total installation of a medium temperature coolroom in accordance with the following details:

Installation details:

- Refrigeration system to incorporate a pump down cycle.
- Determine the refrigerant tube size (Suction & Liquid).
- Complete a refrigeration circuit and components diagram.
- Develop an electrical circuit wiring diagram.
- Install the refrigerant tube and leak test with dry nitrogen to a pressure of 500 kPa (use soapy water).
- Install electrical interconnecting cables.
- Evacuate refrigeration system to a minimum of 500 microns.
- Check the electrical control circuit for compliance.
- Fully charge the system with refrigerant.
- Adjust all controls to maintain automatic operation and safety control.
- Room temperature to maintain an average temperature of 3ºC.
- Ensure the TX valve superheat is set to maintain 6K.
- Allow system to operate and complete a number of cycles.

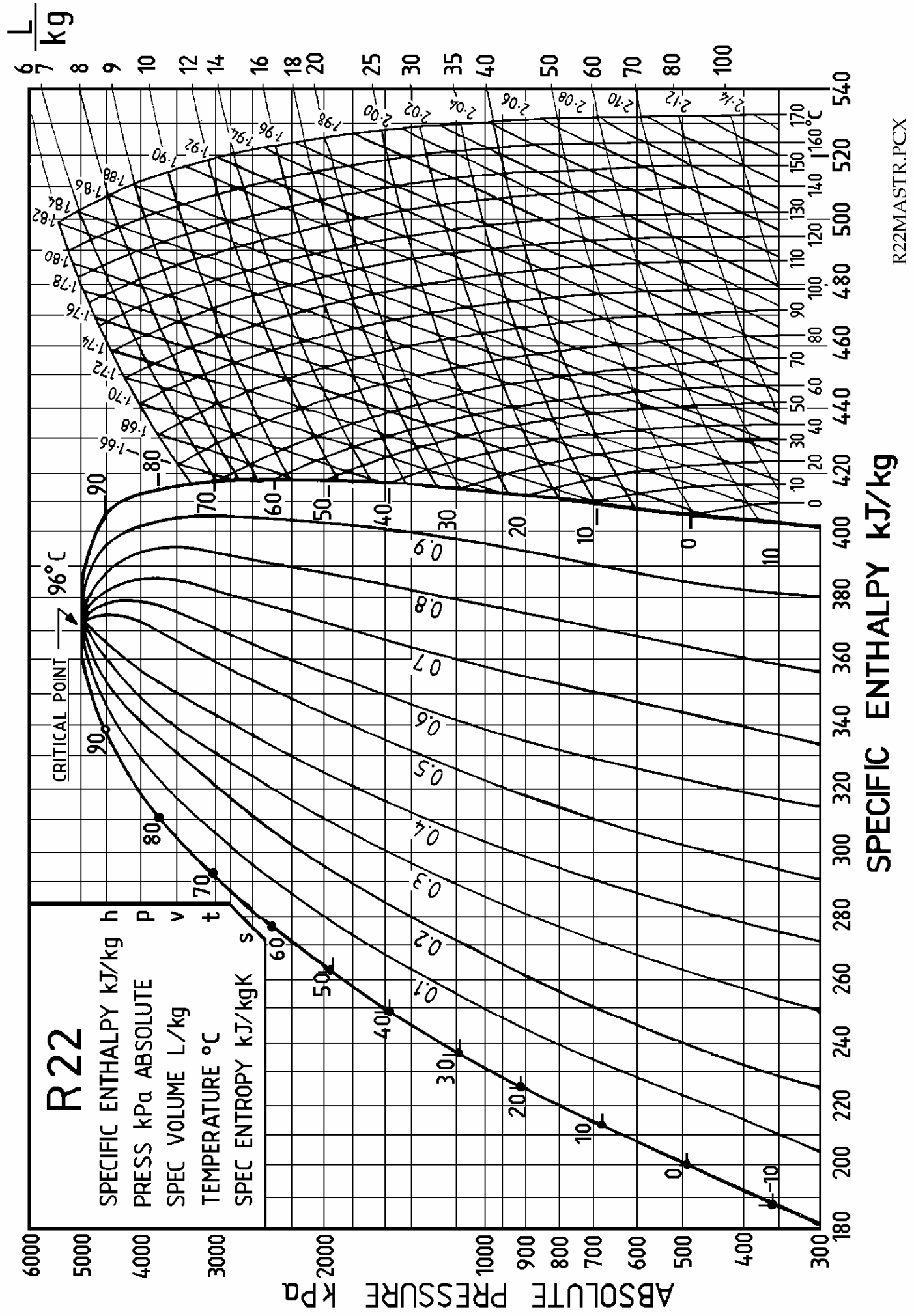
Note: The installation of refrigeration system and electrical wiring circuit must meet all the relevant standards, codes of good practice and legislative requirements.

Determine the Refrigeration Capacity:
Obtain the following details whilst the system is operating:

- Suction Saturated Evaporator pressure and temperature.
- Suction Saturated Condenser pressure and temperature.
- Liquid line temperature entering the refrigerant metering device.
- Suction line temperature entering the compressor.
- Drive motor speed.
- Drive motor pulley size.
- Compressor, fly wheel pulley size.

Pressure Enthalpy Chart:
Construct the refrigeration cycle on a pressure enthalpy chart and determine:

- Refrigeration effect: _____
- Percentage of flash gas: _____
- Total heat rejection: _____
- Specific volume of refrigerant entering the compressor: _____


R22
SPECIFIC ENTHALPY kJ/kg h
PRESS kPa ABSOLUTE p
SPEC VOLUME L/kg v
TEMPERATURE °C t
SPEC ENTROPY kJ/kgK s
CRITICAL POINT
96°C
ABSOLUTE PRESSURE kPa
SPECIFIC ENTHALPY kJ/kg
L/kg
°C
R22MASTR.PCX

Capacity Calculations:

Determine the following: **Note: Formula sheet to be provided**

Q.1 Compressor speed

Q.2 Compression ratio

Q.3 Volumetric efficiency

Q.4 Actual compressor displacement.

Q.5 Mass flow rate.

Q.6 Capacity.