MASS. MARITIME ACADEMY

REFRIGERATION LAB OUTLINE

Rev.3 Fall 2015

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Tables and Figures

Massachusetts Maritime Academy

REFRIGERATION LAB #1

Objective:

To give the student a basic knowledge of the components of a refrigeration system.
To introduce the student to the operation of the Service Gauge Assembly.

1. Identify the major components of the refrigeration system.

- Compressor ______________________________

____

____

- Condenser ______________________________

____

____

- Flow Control Device ______________________________

____

____

- Evaporator ______________________________

____

____

2. Identify the proper names of the refrigerant lines.

- Compressor - Condenser ______________________________

____

- Condenser – Flow Control ______________________________

____

- Evaporator - Compressor ____

____

3. Become familiar with the Service Gauge Manifold.

Function of the Service Gage Assembly ________________________________

____

- How to Connect ____

____

- Compressor Service Valves ____

____

- Service Gauge Valves ____

____

- How to Operate ____

____

- How to Disconnect ____

____

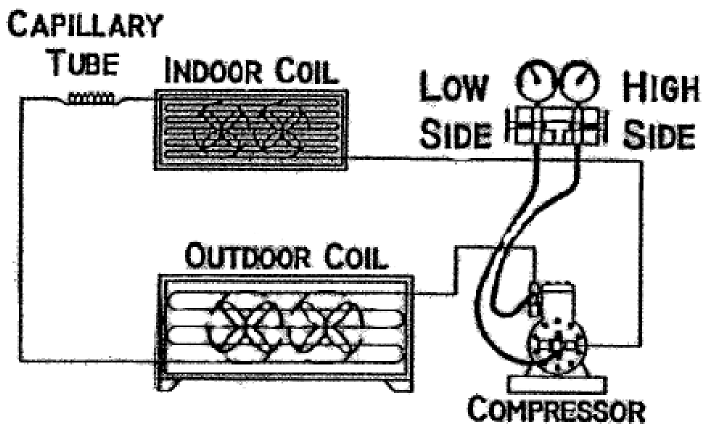
4. Review components of the Multi-evaporator Training Unit

SUMMARY:

The student should understand what items are required in a refrigeration system and how those items are arranged in the system. This exercise will be applicable to a wide variety of systems.

GAUGE MANIFOLD

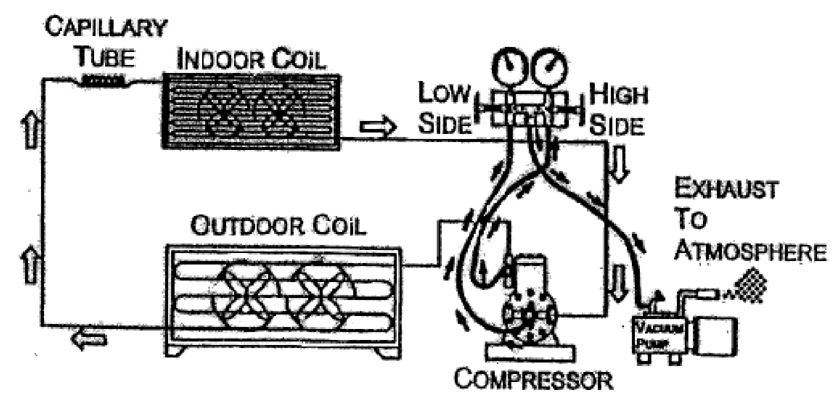
Reading High and Low Side Pressure While In Operation



Gauge Manifold (High and Low Pressure)

GAUGE MANIFOLD

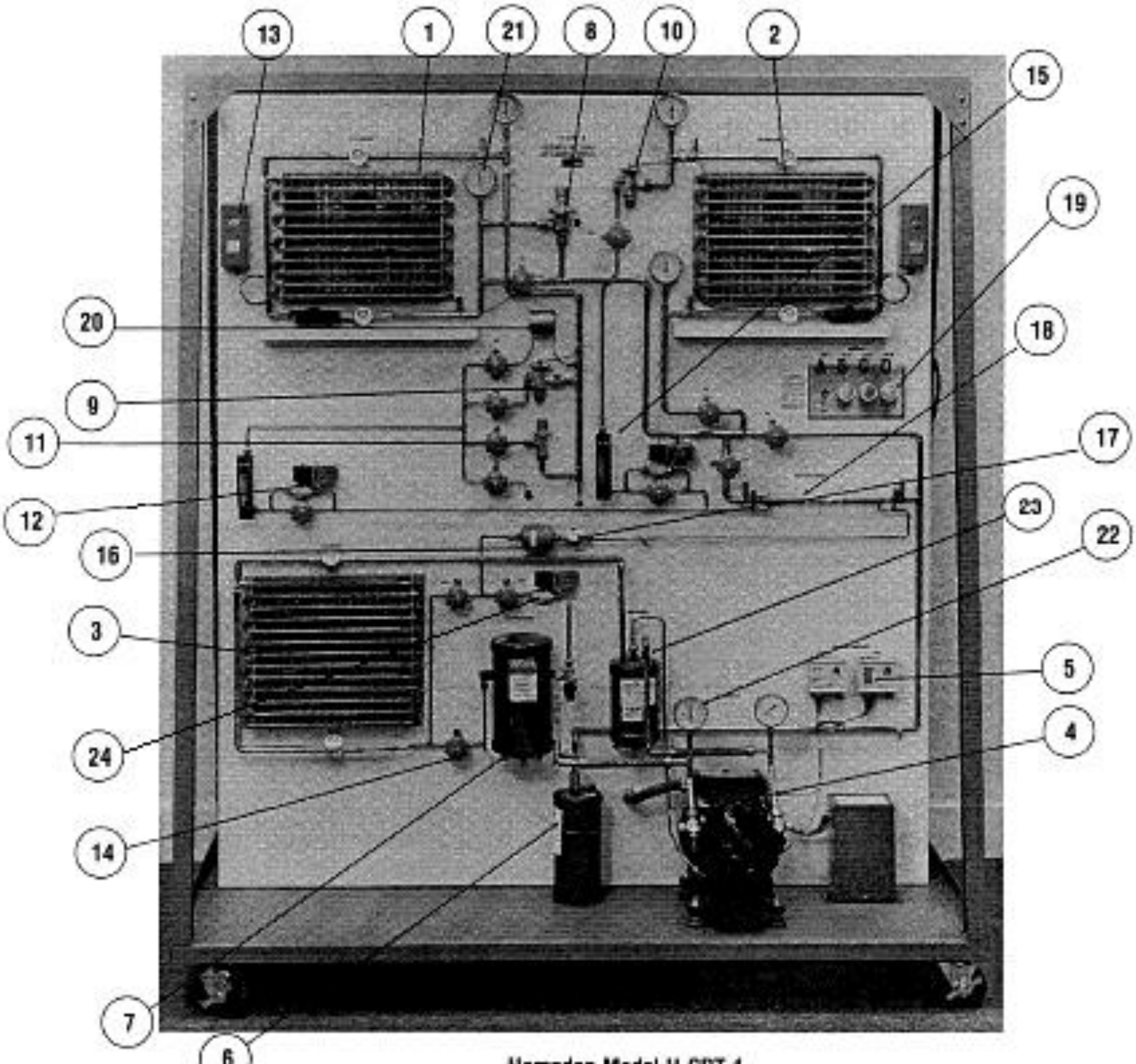
EVACUATING NON-CONDENSIBLES FROM A SYSTEM (UNIT NOT RUNNING)



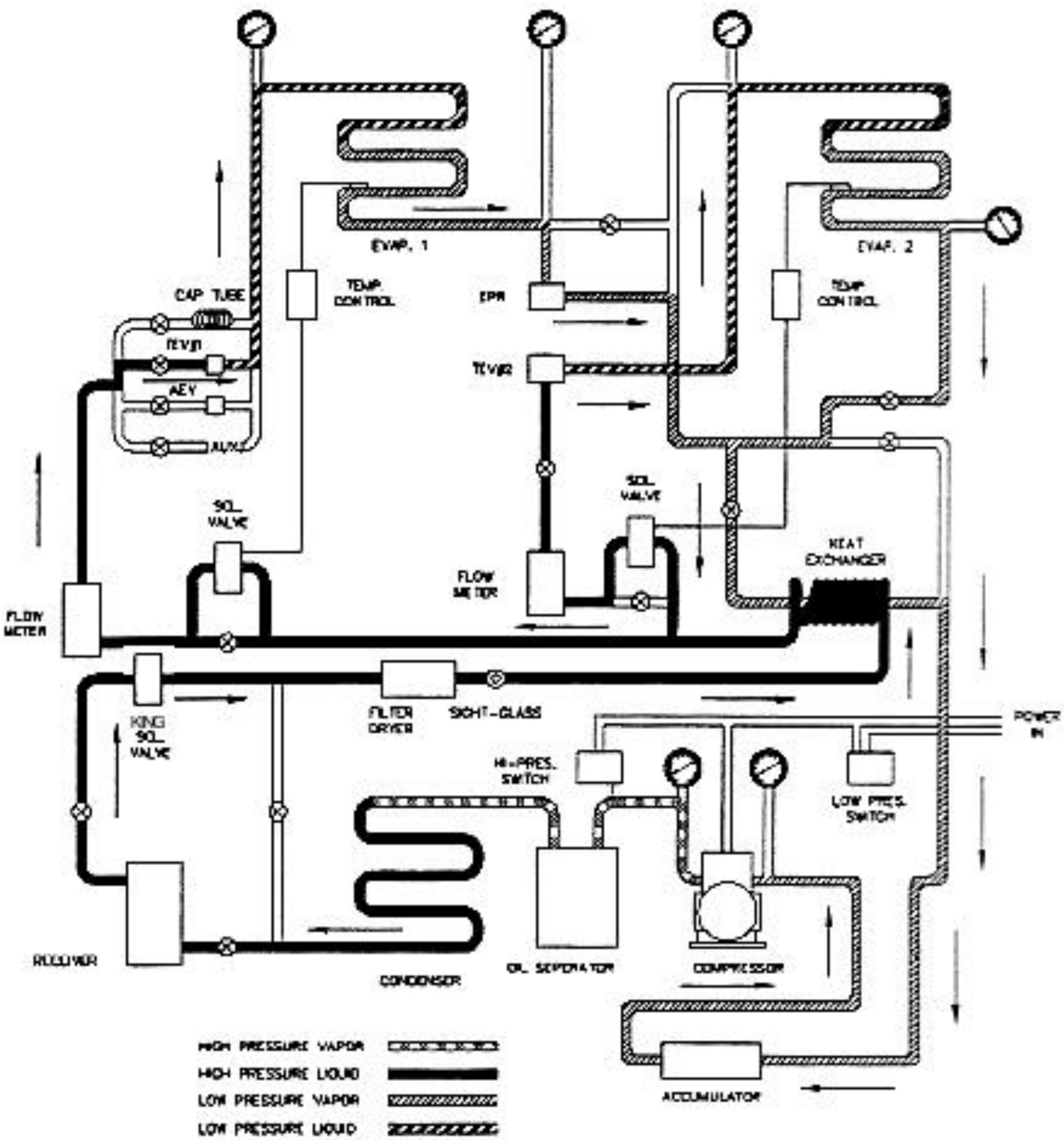
Gauge Manifold *(Evacuation)*

<u>**GAUGE MANIFOLD**</u>

TRAINER LAYOUT



Hampden Model H-CRT-1

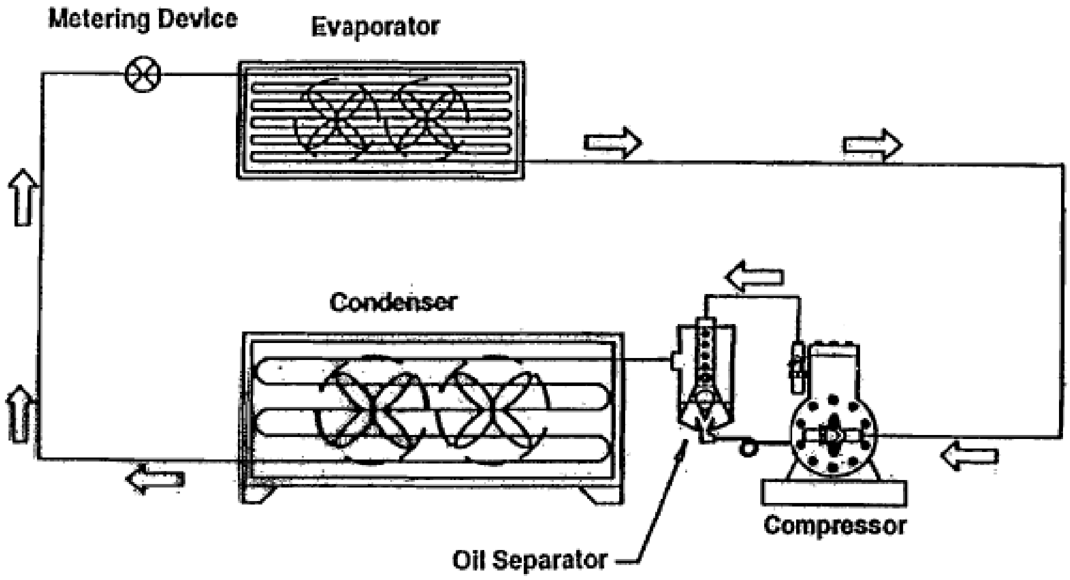


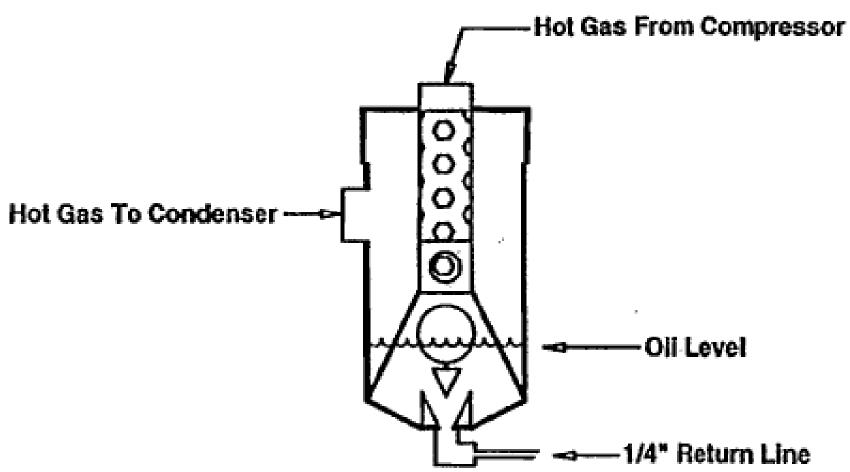
Flow Diagram of a Multiple Evaporator System

Oil Separator

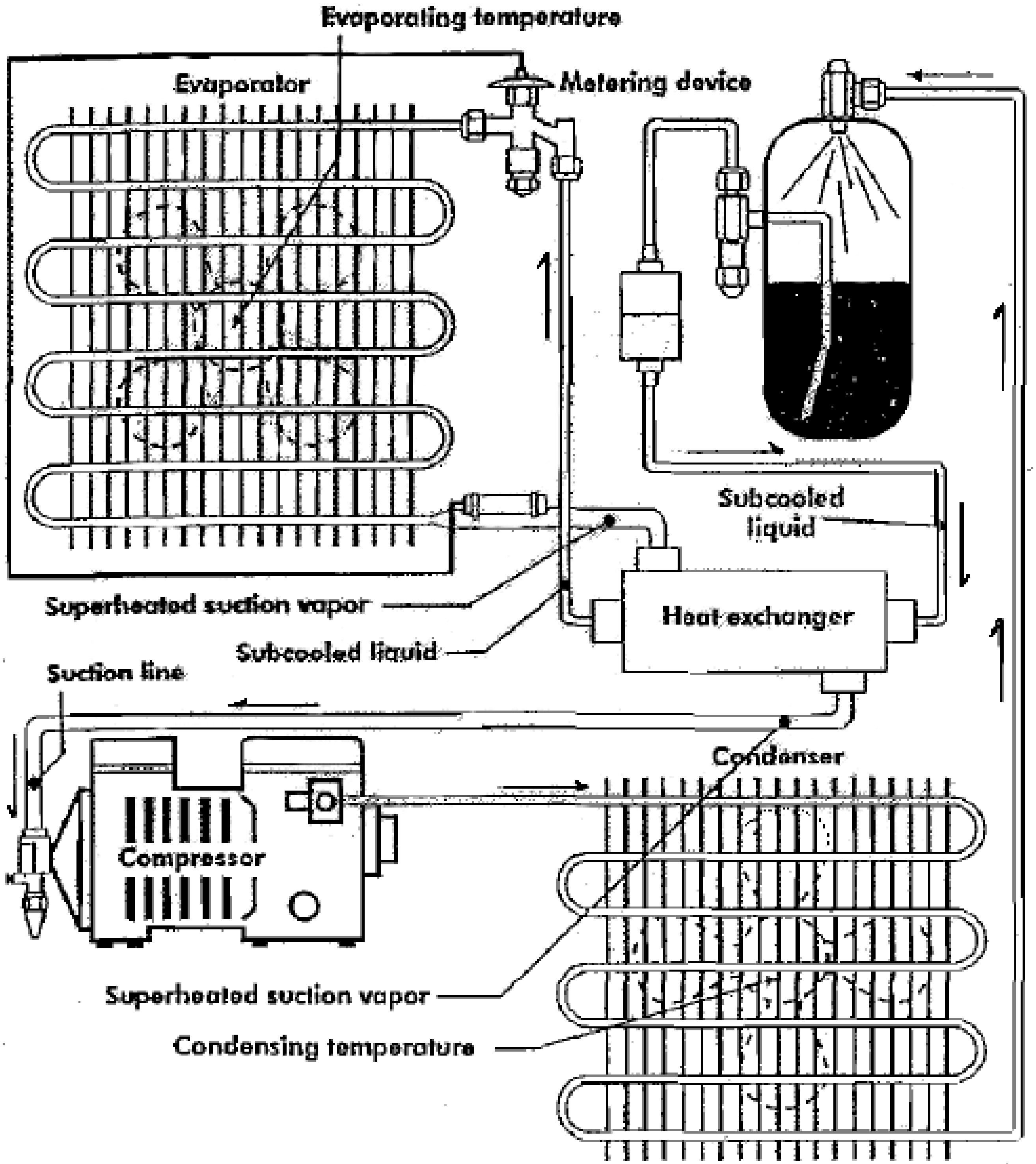
Installed In Hot Gas Line Between Compressor And Condenser

Purpose: To Prevent Excessive Oil From circulating Throughout The System And To Return Oil Back to Compressor Crankcase





OIL SEPARATOR

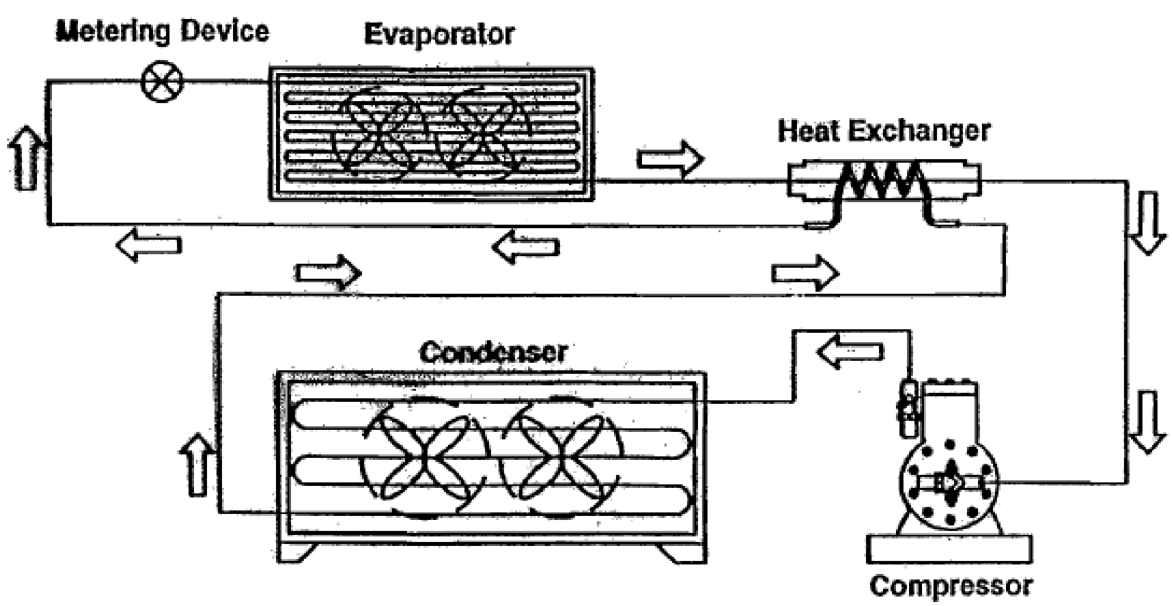


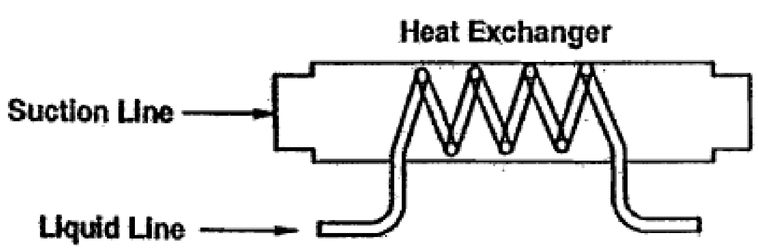
Refrigeration System with Heat Exchanger

Heat Exchanger

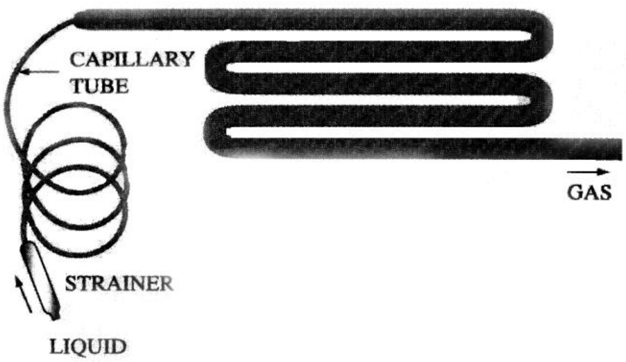
Installed Between Evaporator And Compressor When Using Capillary Tube System, The Capillary Tube Will Be Soldered Directly To The Suction Line

Purpose: To Subcool The Refrigerant In The Liquid Line And Superheat The Refrigerant In The Suction Line

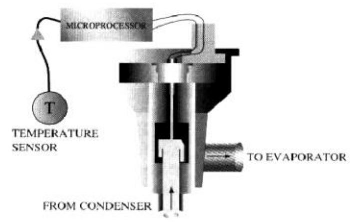




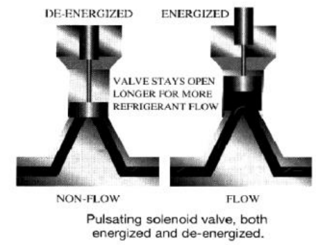
HEAT EXCHANGER



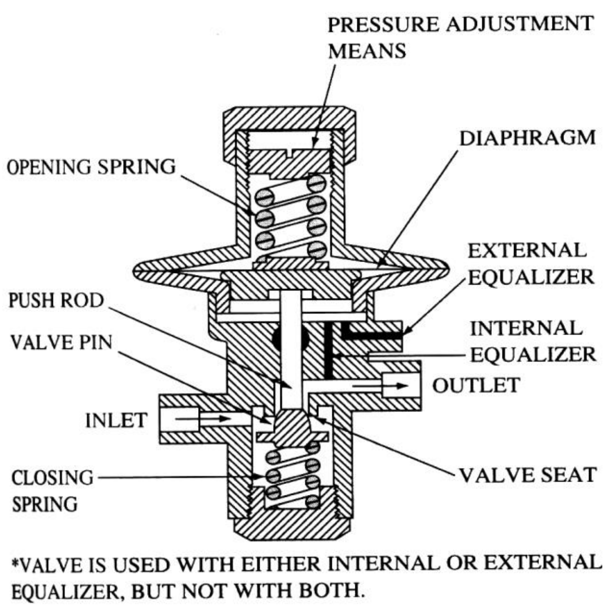
Capillary Tube



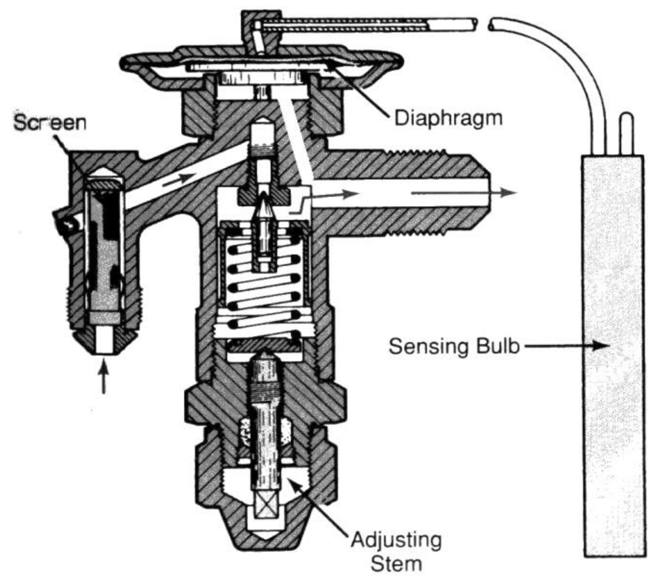
Electronic Expansion Valve



Electric Expansion Valve



Automatic Expansion Valve

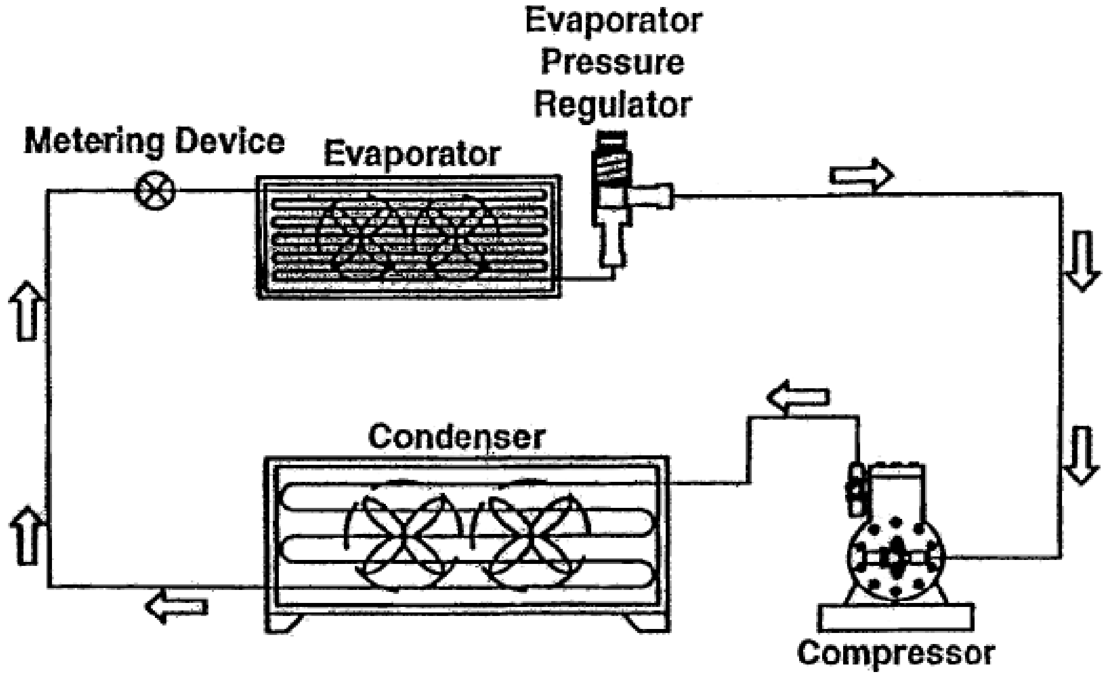


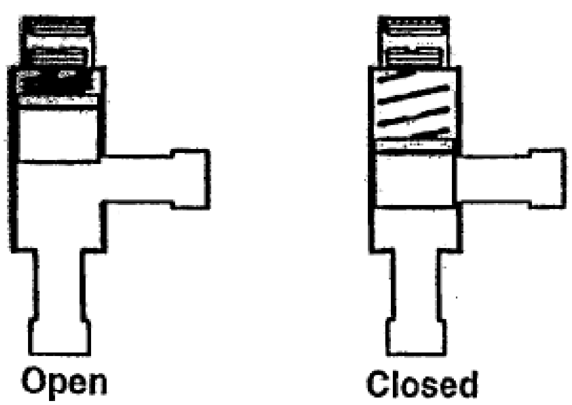
Thermostatic Expansion Valve

Evaporator Pressure Regulator (EPR)

Installed In Suction Line Between Evaporator and Compressor

Purpose: Throttles Closed When Evaporator Load Drops Preventing Evaporator Pressure From Dropping Below A Set Point.



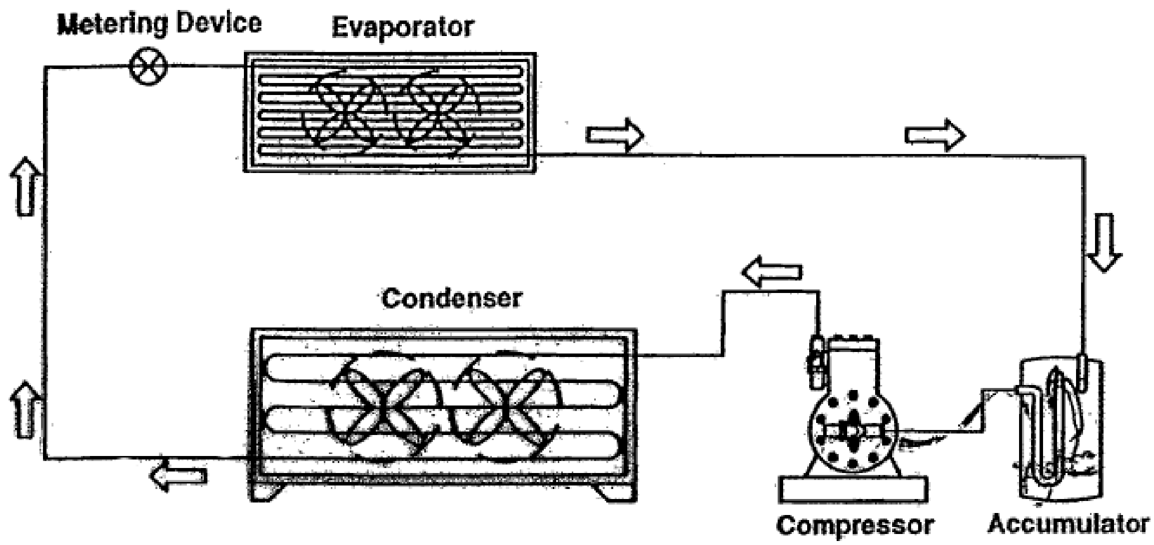


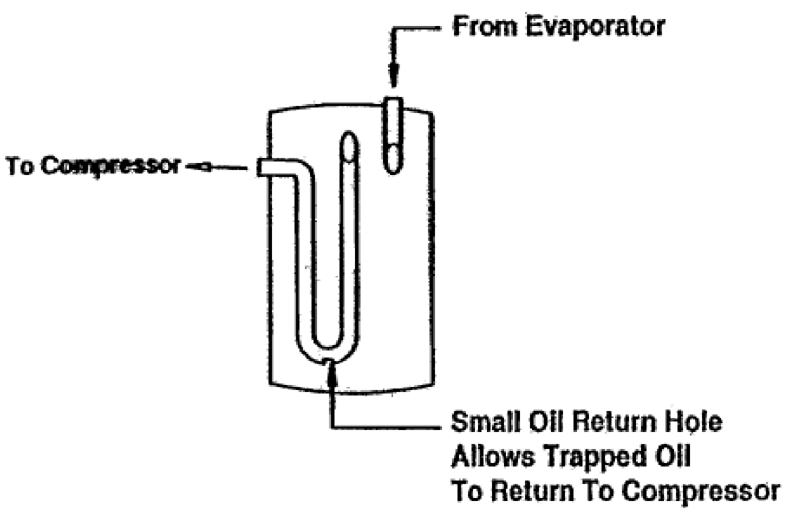
EVAPORATOR PRESSURE REGULATOR (EPR)

Suction Line Accumulator

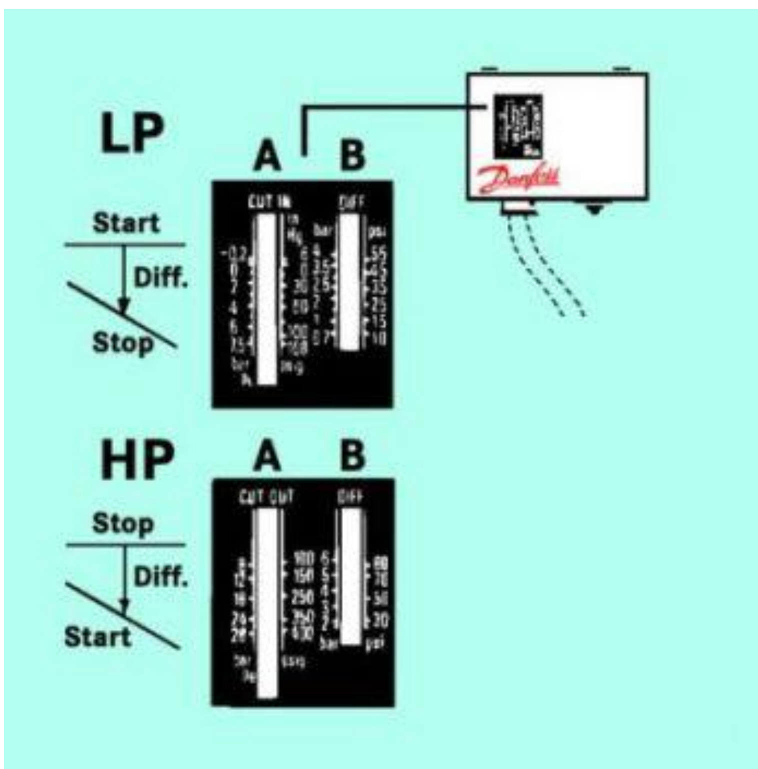
Installed Between Evaporator And Compressor

Purpose: To Prevent Surges Of Liquid Refrigerant From Reaching The Compressor





SUCTION LINE ACCUMULATOR



LP
A
B
Start
Diff.
Stop
CUT IN
DIFF
HP
A
B
Stop
Diff.
Start
CUT OUT
DIFF

REFRIGERATION LAB #2

Objective:

To strengthen the student's understanding of refrigerant system operation and calculation such as: system operating pressures, saturation temperature, superheat, subcooling, and refrigerating effect.

Procedure:

1) **Start the system :**

- Properly set all system valves. All valves should be BACK seated.
- Insure that the system is arranged for operation.
- Start the system. (First start the evaporator fan, then the compressor).
- Properly install the service gauges.
- Check oil pressure if available (larger systems).
- Observe the high and low side pressures
- Check sight glass-indicator.

2) **Trace out the system**: While tracing out the system, allow the system to operate for a sufficient time to stabilize. Identify all of the components in order of flow starting at the compressor. Also, identify the proper names of the lines connecting these components.

3) Have one teacher check your system set-up and knowledge. **Initial ________**

4) **Determine if the system pressures are correct**.

   a. Determine the temperature of the cooling air **entering** the condenser (if water cooled, use the water **outlet** temperature).

   b. Add 25 °F to this temperature (10 °F for water cooled condensers).

   c. Look up the corresponding pressures on the Refrigerant Properties Saturation Chart on p. 34. This is the proper operating pressure for the system. **$*P_{(h.s.\ design)}$=__________**

   d. To check low side pressure, use the same procedure using the actual **box temperature** and subtracting 10 °F. Look up the corresponding pressure. Since our evaporators are open to the room, use the temperature at the $evap._{out}$. This is NOT normal but will give you the best result. **$*P_{(l.s.\ design)}$=_______________**

   e. Compare your high and low side design pressures with your actual gauge pressures.

f. What would cause the high side pressure to be higher than this calculated pressure?

5) **Calculate Subcooling:** With the system in stable operation, determine the saturation temperature for the refrigerant on the high side.

a. Take the high side pressure, convert to PSIA and read the saturation temperature from the same attached chart for R-134a.

b. High side saturation temperature is: ___________________________________

c. Determine the actual high side liquid temperature at:

- The condenser out: ________________
- The TXV inlet (6" before): (Use the filter-drier outlet) ___________________

The difference between the high side saturation temperature and the actual liquid temperature at points b) & c) is equal to the "subcooling" at these points.

The degree of **subcooling** is: **at *condenser (outlet)**__________

at *flow control (inlet)__________

6) **Calculate Superheat:**

a. Determine the saturation temperature: Take low side pressure, convert to PSIA, read saturation temperature from the attached chart for R-134a. (p. 34)

b. Determine the actual refrigerant temperature at the location of the thermal expansion valve thermal sensing bulb. (Use mounted thermometer.)

c. **The actual temperature should be greater than the saturation temperature. The difference is equal to the "superheat."**

d. Superheat = T (evap. out) – T (saturation) **$*Superheat_{(evap.\ out)}$=**__________

b. Determine the superheat at the compressor suction.

a. **$*Superheat_{(comp.\ in)}$=**________________

7) **<u>Calculate Net Refrigerating Effect:</u>**

a. Using **temperature**, determine *h* of the vapor at the evaporator (out). __________

b. Using **temperature**, determine the *h* of the subcooled liquid (TXV in).__________

c. ***N.R.E. = a) – b) = ____________**

8) **<u>Calculate the Mass Flow per ton:</u>** *pounds of refrigerant that must be circulated each minute ((lb/min)* in order to produce a *ton of refrigerating effect (200 $_{Btu/min\text{-}ton}$=1 Ton R.E.)*?

$$\text{Mass Flow per ton} = \frac{\text{Ton Refrigeration Effect (Btu/min-ton)}}{\text{NRE (Btu/lb)}}$$

***Mass Flow =__________**

9) **<u>Calculate the Volume compressed:</u>** *cubic feet of vapor per minute (ft^3/min.)* are being handled by the compressor?

Measure the compressor **inlet** temperature and find its density.

$$\text{Volume compressed} = \frac{\text{Mass Flow rate (lb./min-ton)}}{\text{Density, lb./ft}^3\text{)}}$$

***Volume compressed = _______________**

10) **<u>Calculate the *Volumetric Efficiency*</u>** of the compressor (this is NOT true efficiency)?

$$\text{Volumetric Efficiency} = \frac{\text{Comp. discharge pressure (psia)}}{\text{Comp. suction pressure (psia)}}$$

***Volumetric Efficiency = __________**

11) What is the *Coefficient of Performance (COP)* of the compressor?

$$COP = \frac{NRE}{\text{Heat of Compression, (HOC)}}$$

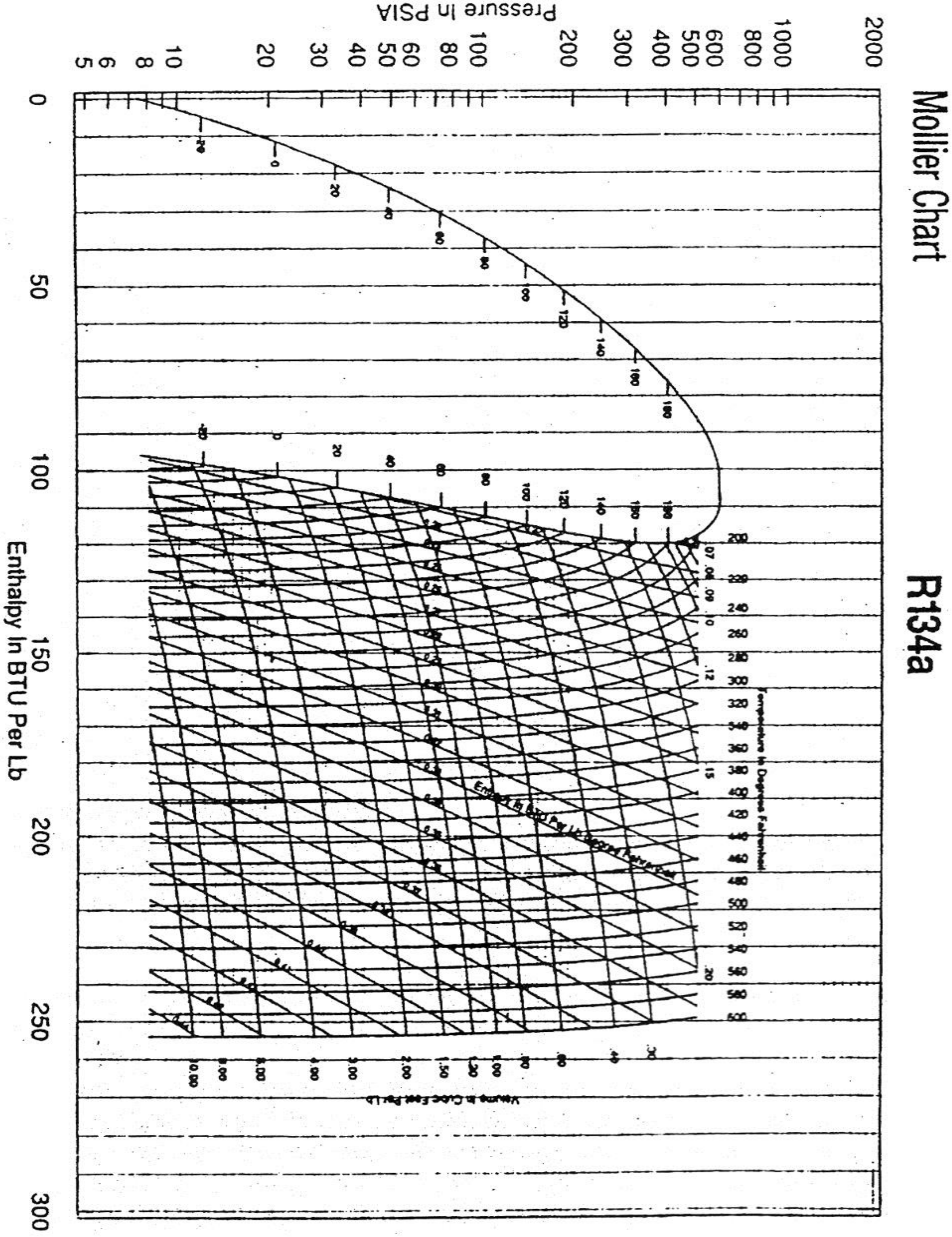
Where *HOC* = H compressor (out) – H compressor (in) ***COP = __________**

12) **Pump down** (forward seat the King valve to trap refrigerant in the receiver). While pumping down, back seat the high side service valve **or** close the high side low loss valve. Open both service manifold valves and remove refrigerant from the hose. Secure the system once the system stops, remove gauge manifolds, clean-up.

13) Plot the operation of your training unit on the *P-H* diagram on the next page.

CONCLUSION:

The student should be capable of determining the "superheat" in an operating refrigeration system, the degree of subcooling, net refrigerating effect and the proper operating pressure range. In doing these calculations, the student should be able to make a determination as to the proper operating conditions of an operating system.


Mollier Chart
R134a
Pressure In PSIA
2000
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
Enthalpy In BTU Per Lb
0
50
100
150
200
250
300

REFRIGERATION LAB #3

Objective:

To reinforce the use of service gauge manifolds and compressor service valves. To learn how to perform vapor recovery, leak detection, and charging.

a) The student will remove the charge of refrigerant from the system using the “system independent” recovery unit.

b) The student will perform leak detection using a "Trace Charge" of a refrigerant followed by a charge of dry nitrogen to 100 PSIG (No higher than the system’s Low Side Test Pressure per the manufacturer’s label)..

c) The student will pull a high vacuum on the system using the vacuum pump and a Micron vacuum gauge.

d) The student will charge the system.

Procedure:

1) Ensure that the compressor service valves are in their proper position for connecting your service gauge manifold. Do Not start the system.

2) Connect service gauge manifold to your system.

   a) *Is there is any air in your system*?.______________________

   b) *How can you tell?*___________________________________

3) Connect the service hose of the service manifold to the inlet of the recovery unit. (See diagram on page 35).

   a) Connect the outlet of the recovery unit to the recovery bottle (liquid valve).

4) ***Purge all*** hoses which may have been contaminated by air. This is done by loosening (NOT disconnecting) the “down stream” hose fitting and allowing an audible, free-flow of vapor from the hose for <u>2 seconds</u>. If a fog appears, secure immediately.

5) Place the recovery bottle on the scale. <u>Set to zero</u> with all hoses attached.

6) Ensure all valves are lined up, start the system evaporator fan, start the recovery unit.

7) Pull a *"**recovery**"* vacuum on the system using the *service* hose and recovery unit (see ***figure 2-1*** for chart and sub notes). Ensure all lines and system components are <u>not</u> cool.

Heat lines and components with a heat gun. (The compressor crankcase is important here). If possible, chill the recovery bottle using ice & water to reduce pressure.

a) When "***recovery***" vacuum is achieved, isolate the system with the service manifold and ***"purge"*** the recovery unit to remove the refrigerant from the unit (do not shut off the recovery unit). THIS IS NOT THE SAME AS PURGING THE LINES!

1) Close (slowly!) the recovery unit inlet,

2) Change center valve to "Purge" (slowly)

3) Allow the inlet gauge to go to a minimum of 10 "hg.

4) At this point, the weight on the scale should be stable and not gaining.

b) <u>Log amount removed on the Recovery log sheet.</u> **(Each different service done should be on a separate line in the log sheet).**

Required Levels of Recovery Efficiency

REQUIRED LEVELS FOR APPLIANCES EXCEPT FOR SMALL APPLIANCES, MVACS, AND MVAC-LIKE APPLIANCES

Type of Appliance	Inches of Mercury Vacuum* Using Equipment Manufactured:	
	Before Nov. 15, 1993	On or after Nov. 15, 1993
HCFC-22 appliance** normally containing less than 200 pounds of refrigerant	0	0
HCFC-22 appliance** normally containing 200 pounds or more of refrigerant	4	10
Other high-pressure appliance** normally containing less than 200 pounds of refrigerant (CFC-12, -500, -502, -114)	4	10
Other high-pressure appliance** normally containing 200 pounds or more of refrigerant (CFC-12, -500, -502, -114)	4	15
Very High Pressure Appliance (CFC-13, -503)	0	0
Low-Pressure Appliance (CFC-11, HCFC-123)	25	25 mm Hg absolute

* Relative to standard atmospheric pressure of 29.9" Hg
** Or isolated component of such an appliance

FIGURE 2-1

- Small appliance regulations - contains 5 lbs. or less of refrigerant.
- If manufactured before November 15, 1993 - 80% or achieve 4"Hg.
- If manufactured after November 15, 1993 - 90% if active, 80% if passive or achieve 4"Hg.
- Effective August 12, 1993 - persons must be certified.
- November 14, 1993 - sale of CFC and HCFC only to certified persons.
- EPA does not require leaks to repaired, but do so whenever possible.

8) Add a *"few"* ounces of a refrigerant (use R-22) to the unit as a vapor (using the manifold service hose). This is enough to raise the system pressure to 10 psig. **Do not add more than 10% of the system's full charge**.

9) Pressurize system to 100 PSIG, using nitrogen through a regulator.

   a) The **maximum pressure** you can pressurize any system would be the appliance manufacturer's tag **<u>low side test pressure</u>** (usually located on the compressor frame).

   b) What is the maximum leak test pressure for your system? Test Pressure=____________

10) Check system for leaks.

   a) Electronic leak detector
   b) Ultrasonic leak detector
   c) Soap bubbles (if you find a suspected leak)
   d) UV light (dyed oil in the system)
   e) Halide torch (displayed by instructor when everyone is evacuating their systems)

11) Purge the system to atmosphere by keeping the service hose close to the floor and opening all valves.

12) Evacuate the system to 500 microns using the vacuum pump and observe the vacuum using a micron gauge placed on to the liquid line charging valve.

   a) Move the high side service hose to the King service valve.
   b) Connect the larger vacuum hose to the vacuum pump.
   c) Connect the "normal" service hose to your recovery bottle liquid valve (normally this would be connected to a virgin refrigerant bottle). The recovery bottle valve should remain closed. All other manifold and low-loss valves should be open.
   d) Install all valve stem caps. Lightly tighten with a wrench.
   e) Follow the procedure above the chalk board for vacuum pump start-up
   f) **Check for air in your recovery bottle using a refrigerant leak detector**

13) When proper vacuum is achieved, charge 1.5 LB of liquid refrigerant into the receiver (**systems with EEV flow controls should only be liquid charged with 1 lb.)**

   a) Close micron gauge valve, low side manifold valve, manifold line vacuum valve.
   b) Open the charging bottle liquid valve.

14) Move your service hose to the vapor valve. Purge. Start the system and add an additional ½ lb. as a vapor to the low side. **Get virgin refrigerant from the instructor if your charge is not complete.** (Log total charge).

   a) *Which charging operation took longer?*

15) Pump down. While pumping down, remove refrigerant from:

a) the gauge manifold

b) the spare hose used for liquid charging. This can be done by attaching it to the liquid charging valve during pump down.

16) Secure the system, and clean-up.

CONCLUSION:

- The student should be capable of installing the service gauge manifold to the system.
- Connecting the service gauge manifold to perform various service evolutions to the system.
- Perform a vapor recovery.
- Perform a leak detection
- Perform an evacuation
- Perform a liquid and a vapor charge.

REFRIGERATION LAB #4

Objective:

To reinforce the use of service gauge manifolds and compressor service valves.
To learn how to perform liquid and vapor recovery.
To perform liquid and vapor charging.
To check charge level by superheat and subcooling.
To check for proper high side pressure

- The student will remove the charge of refrigerant from the system using a “push-pull” liquid recovery followed by a vapor recovery.
  - You will know when the liquid recovery is complete by watching the scale.
  - Rearrange the recovery device for vapor recovery and complete the recovery to 4"Hg. (small appliance requirement).
- The student will now perform a vapor charge and dynamic liquid charge.
  - The liquid charges will be made to the high side of the system.
  - The vapor charge will be made to the low side of the system.
  - Watch subcooling temperature for correct amount of charge.

Procedure:

1) Ensure that the compressor service valves are in their proper position for connecting your service gauge manifold.

2) Connect service gauge manifold.

   a) Position compressor service valves in their correct position to obtain a reading on the service gauge manifold.

3) Connect the service hose of the service gauge manifold and the recovery unit as per attached diagram (page 36) for a liquid recovery.

4) Connect a “free” hose from the receiver to the recovery bottle.

5) ***Purge all*** hoses that may have been contaminated by air.

6) Do a pump down

7) Weigh the recovery bottle with hoses connected. Determine safe fill weight.

Example: Calculating the capacity of a 125# recovery cylinder filled with R-134a

- At 125 ºF, the density of R-134a is 68.32 lb/ft^3. (125 ºF is the max. storage temp.).
- Take that factor 68.32 lb/ft^3 divided by water density 62.4 lb/ft^3 = 1.095.
- If the W.C. (water capacity) of a 125 lb. bottle is 121 lb., multiply 121 lb. x 1.095= 132.495 lbs.
- The tank total liquid capacity of R-134a @ 125 ºF. is = 132.495 x 80% = 106 lb. net refrigerant.
- Calculate the safe R-134a fill weight of your bottle. _____________ Lb.s
- Add the Tare Weight (TW) of the bottle for max. total scale weight.

8) Set scale to zero.

9) Ensure all valves are lined up for liquid recovery and start recovery unit.

10) Recover until the scale stops gaining weight (when scale slows down in incremental gain).

11) Rearrange the hoses for vapor recovery and pull a recovery vacuum (just switch the hoses at the recovery unit). (**Ensure all lines and system components** are <u>not</u> cool – they should be above room temperature).

12) Purge the recovery unit. Log recovery.

13) Disconnect the recovery machine and stow equipment on the lower tray.

    a) **At this point, repairs would be made followed by a leak detection and evacuation.**

14) Arrange the service gauges and bottle for a vapor charge.

    a) Add enough refrigerant vapor to raise the pressure to correspond to 36 ºF (minimum).

        i) This is done for all water heat exchangers in a vacuum to prevent freeze up.

15) We will now perform a "liquid charge" to a running system.

    a) Set bottle for liquid output.
    b) Remove the shraeder valve from the liquid charging connection (located downstream of the "king valve" and upstream of the filter-dryer) and connect the auxiliary hose.
    c) Front seat the king valve. As the refrigeration system "pumps down" you can charge liquid refrigerant into the system and have it vaporize in the evaporator before reaching the compressor. (Add a total of 2 lbs. -TXV systems / 1-1/2 lbs. - EEV systems)
    d) If you cannot complete your full charge, get virgin refrigerant from the instructor. If charging from a “virgin” bottle, check to see if the bottle needs to be flipped upside-down for liquid charge.
    e) Enter total charge in log sheet.

16) Set system valves to properly run for approximately 5 minutes to stabilize. Then determine the design operating pressures, superheat and subcooling. These and the sight glass condition provide a good indication for a correct charge in the system.

   a) How are the system pressures? (Compare with design values)
   b) What is the low side saturation temperature?
   c) What is the superheat at the sensing bulb?
   d) What is the superheat at the compressor inlet?
   e) What is the high side saturation temperature?
   f) What is the subcooling at the condenser outlet?
   g) What is the subcooling at the TXV (6” before)?
      - Proper superheat for a refrigeration system typically ranges between 4-8°
      - Proper superheat for an AC system typically ranges between 8-12°
      - Proper subcooling will vary depending on application and EER rating. Typical ranges may be between 10°-20° (10° for newer systems).

17) Remove your service manifold and connect the electronic service manifold. Check and compare subcooling and superheat at all 4 places.
   - What is the superheat at the sensing bulb?
   - What is the superheat at the compressor inlet?
   - What is the subcooling at the condenser outlet?
   - What is the subcooling at the TEV (sight glass/indicator outlet)?

18) Pump down and remove refrigerant from the aux. hose and manifold.

19) Replace the shraeder valve and remove the coring tool.

CONCLUSIONS:

The student should be capable of:

- Installing the service gauge manifold to the system.
- Connecting the service gauge manifold to perform various service evolutions to the system.
- Perform a liquid recovery and determine when this process is complete.
- Perform a vapor recovery and determine when *"recovery efficiency"* is attained.
- Perform both liquid or vapor charges.
- Determine the proper high side operating pressure.
- Determine proper charge using subcooling (or superheat).

"Freon" Refrigerants

TEMP	Refrigerant (pressure in psia) (Italics are "Hg gauge)											
F	R-11	R-12	R-13	R-22	R-113	R-114	R-123	R-124	R-134a	R-410a	R-500	R-502
-50	*28.90*	7.10	71.70	11.7	-	*27.10*	*29.2*	*24.8*	5.5	20.5	8.40	14.50
-40	*28.40*	9.30	87.40	15.3	-	*26.00*	*28.9*	3.80	7.40	25.60	11.00	18.70
-30	*27.80*	12.00	105.60	19.60	29.30	*24.60*	*28.5*	5.20	9.90	32.60	14.20	23.70
-20	*27.00*	15.20	126.40	24.90	29.10	*22.90*	1.00	6.80	12.90	41.10	18.00	29.80
-10	*26.00*	19.20	150.00	31.20	28.70	*20.60*	1.4	8.90	16.60	51.20	22.60	37.00
0	*24.70*	23.80	176.70	38.70	28.20	*17.80*	2.00	11.4	21.20	63.10	28.10	45.40
10	*23.10*	29.30	206.80	47.50	27.60	*14.40*	2.6	14.5	26.6	77.1	34.60	55.20
20	*21.10*	35.70	240.40	57.80	26.80	*10.20*	3.5	18.3	33.1	93.20	42.20	66.60
30	5.6	43.10	277.90	69.70	25.80	*5.20*	4.50	22.7	40.8	111.90	50.90	79.60
40	7.00	51.60	319.50	83.30	24.50	0.40	5.80	27.9	49.7	133.20	61.00	94.50
50	8.80	61.30	361.20	98.80	22.90	3.80	7.3	34	60.2	157.4	72.50	111.40
60	10.90	72.30	402.30	116.30	21.00	7.90	9.20	41	72.2	184.80	85.60	130.40
70	13.40	84.80	444.70	136.10	18.70	12.60	11.4	49.1	85.8	215.70	100.40	151.70
80	16.3	98.70	487.80	158.30	15.90	18.00	14.1	58.4	101.4	250.30	116.90	175.50
90	19.7	114.30	-	183.10	12.50	24.10	17.20	69	119	289	135.40	201.90
100	23.6	131.60	-	210.60	8.60	31.20	20.80	80.9	138.9	332.00	156.10	231.30
110	28.1	150.80	-	241.10	4.00	39.10	25	94.3	161.1	379.80	178.90	263.60
120	33.2	172.00	-	274.70	0.70	48.00	29.80	109.3	185.9	432.70	204.10	299.30
130	38.9	195.20	-	311.60	3.70	58.00	35.3	126	213.4	491.2	231.90	338.50
140	45.4	220.70	-	352.10	7.30	69.10	41.5	144.6	243.9	555.90	262.40	381.40
150	52.8	248.60	-	396.40	11.20	81.40	48.50	165.1	277.6	622.70	295.70	408.40

REFRIGERATION LAB #5

Objective:

To give the student a better understanding of the different type controls within a typical refrigeration system and how they interact.

Procedure:

1. The student is to first familiarize his/her-self with the system, its components, valves, controls, and operation. Start the refrigeration system (with evap. #1 Capillary tube on-line, evap. #2 on-line and by-pass the economizer). Allow time for the system to stabilize. (BPR on-line)

   A. Observe the system's suction pressure, discharge pressure, and evaporator pressure.

   - ***L.S. Pressure =________________**
   - ***H.S. Pressure =________________**
   - ***Evap 1 Pressure =______________**
   - ***Evap 2 Pressure =______________**

2. a. Set the LP control to cut out at .5 psi and to cut in at 6 psi
   Cut out = Cut in - Differential

   b. Set the HP cut-out to 20 psi higher than the operating pressure with a 40 psi differential.
   Cut in = Cut out - Differential

   Once this is set, secure the suction side valve (at the heat interchanger). Watch the pressure gauge and note the pressure at which the compressor shuts down.

   Cut out Pressure = ________

   Next, ***slowly*** open the suction side valve and observe the pressure at which the compressor restarts.

Cut in Pressure = ______________

3. For the high side, secure the condenser fan.
   Next, observe the pressure at which the compressor shuts down.

   Cut out Pressure = ________

   Restart the condenser fan and observe the pressure at which the compressor restarts.

   Cut in Pressure = ______________

4. For the next procedure, increase the temperature setting for Box 1 till the refrigerant solenoid valve closes.

   ***Temp.$_{(close)}$ = ____________**

   Reset the control to a lower temperature till the solenoid valve reopens.

   ***Temp.$_{(open)}$ = ____________**

   ***Temp. Diff. = ____________**

5. Calculate the superheat at the heat exchanger inlet and compressor inlet

   ***SH.$_{(Box1\ out)}$ = _____________**

   ***SH.$_{(Box2\ out)}$ = _____________**

   ***SH.$_{(HX\ in)}$ = _______________**

   ***SH.$_{(Comp.\ in)}$ = _____________**

   Calculate the subcooling at the heat exchanger inlet, heat exchanger outlet, and Flow control 1&2.
   ***SC.$_{(HX\ in)}$ = _______________**

   *** SC.$_{(HX\ out)}$ = ______________**

   *** SC.$_{(FC1)}$ = _______________**

   *** SC.$_{(FC2)}$ = _______________**

Put the economizer on-line. Recalculate the superheat and subcooling

$*SH._{(Box1\ out)}$ = ______________

$*SH._{(Box2\ out)}$ = ______________

$*SH._{(HX\ in)}$ = ________________

$*SH._{(Comp.\ in)}$ = ______________

$*SC._{(HX\ in)}$ = ________________

$*\ SC._{(HX\ out)}$ = _______________

$*\ SC._{(FC1)}$ = _________________

$*\ SC._{(FC2)}$ = _________________

Decrease the speed of the box 1 fan and recalculate the superheat at evap 1 out.

$*SH._{(Box1\ out)}$ = ______________

Decrease the speed of the condenser fan and recalculate the subcooling.

$*SC._{(HX\ in)}$ = ________________

$*\ SC._{(HX\ out)}$ = _______________

6. Switch over the flow control on the #1 evap. to the TXV and allow time for the system to stabilize. Adjust the TXV for 5ºF superheat. Once stable, by-pass the BPR and let the system stabilize. Measure the superheat.

7. Switch over the flow control on the #1 evap. To the AEV and allow time for the system to stabilize. Adjust the control for proper superheat. Once stable, place the BPR on line and let the system stabilize. Measure the superheat.

Conclusion:

You should have a better understanding of refrigeration controls. You should also be able to calculate the cut-out, cut-in and differential for these systems and also know how to make these adjustments.

Massachusetts Maritime Academy

Refrigeration STCW Practical

OBJECTIVE

To assess the student's ability to safely and properly start, operate, and secure a traditional refrigeration system. During this assessment, you should also be able to determine if the system is operating correctly. If the system is not operating correctly, be able to explain the potential problems. You will not be required to repair the system for proper operation.

RULES

1. Safety Glasses must be worn at all times during the exam
2. You may ask your examiner up to three (3) questions before the assessment begins but may not ask any questions during. Once you start, the examiner is only there to observe your progress. He/she may ask you questions.
3. Any time you make an error you will be given a "strike". Three strikes and you are out!
4. Any single error which may result in injury, failure of the system, or any damage to a component of the system will be an immediate failure.
5. All pressures and saturation temperatures will be taken from the manifold (No charts will be allowed).
6. **There is a 15 minute time limit. If you exceed this limit, you fail.**

PROCESS

1. Check the system over.
2. Connect service gauges
3. Start the refrigeration system
4. Determine whether the system is operating properly
5. Pump system down
6. Secure system
7. Remove and stow gauges and tools.

NATIONAL REFRIGERANTS

R-134a

Technical Guidelines

Physical Properties of Refrigerants	R-134a
Environmental Classification	HFC
Molecular Weight	102.3
Boiling Point (1 atm, F)	-14.9
Critical Pressure (psia)	588.3
Critical Temperature (F)	213.8
Critical Density (lb./ft^3)	32.0
Liquid Density (70 F, lb./ft^3)	76.2
Vapor Density (bp, lb./ft^3)	0.328
Heat of Vaporization (bp, BTU/lb.)	93.3
Specific Heat Liquid (70 F, BTU/lb. F)	0.3366
Specific Heat Vapor (1 atm, 70 F, BTU/lb. F)	0.2021
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO2 = 1.0)	1320
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes:

R-134a

012R134a 12 oz cans
30R134a 30 lb cylinder
A30R134a 30 lb auto AC
50R134a 50 lb cylinder
125R134a 125 lb cylinder*
1000R134a ½ ton cylinder*
2000R134a ton cylinder*

*Deposit Required

A long-term, HFC alternative with similar properties to R-12. It has become the new industry standard refrigerant for automotive air conditioning and refrigerator/freezer appliances.

R-134a refrigerating performance will suffer at lower temperatures (below –10 F). Some traditional R-12 applications have used alternatives other than 134a for lower temperatures.

R-134a requires polyol ester (POE) lubrincants. Traditional mineral oils and alkylbenzenes do not mix with HFC refrigerants and their use with 134a may cause operation problems or compressor failures. In addition, automotive AC systems may use polyalkaline glycols (PAGs), which are typically not seen in stationary equipment.

Both POEs and PAGs will absorb moisture, and hold onto it, to a much greater extent than traditional lubricants. The moisture will promote reactions in the lubricant as well as the usual problems associated with water (corrosion, acid formation). The best way to dry a wet HFC system is to rely on the filter drier. Deep vaccuum will remove "free" water, but not the water that has absorbed into the lubricant.

R-134a

Applications: Appliances, refrigeration (commercial and self-contained equipment), centrifugal chillers and automotive air conditioning.

Retrofitting: for R-12

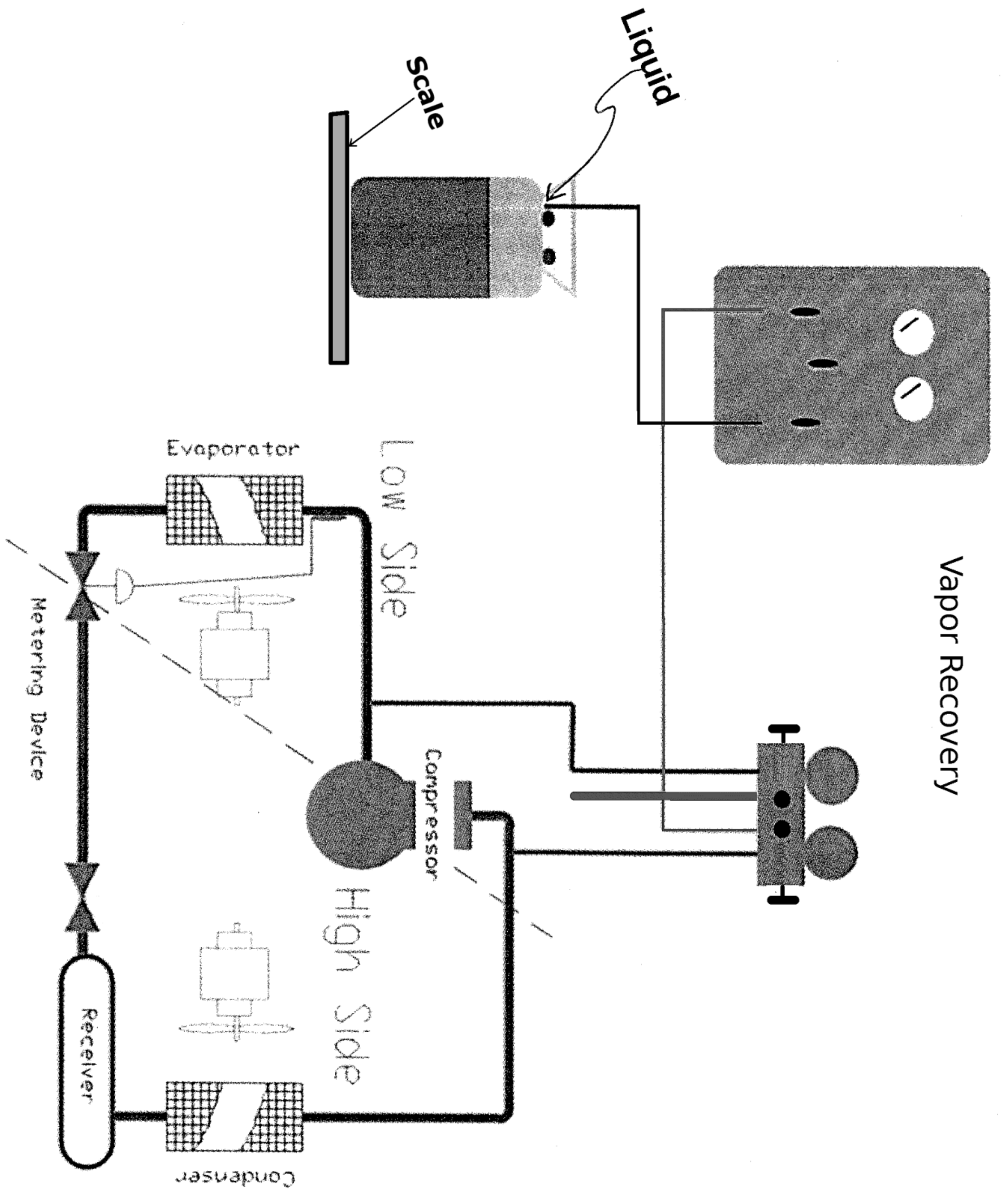
Pressure-Temp Chart

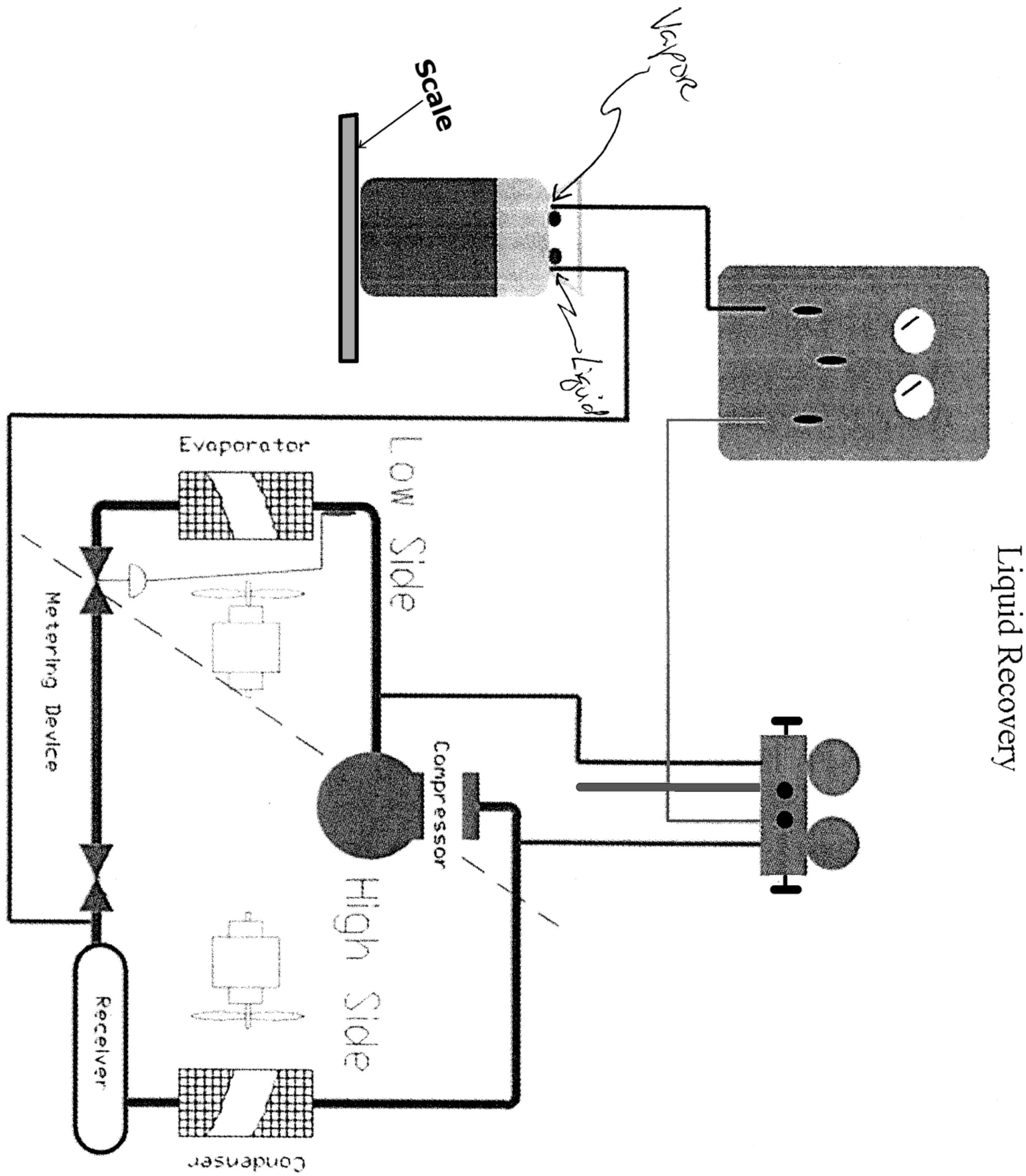
Temp (F)	R-134a (psig)
-40	14.8
-35	12.5
-30	9.9
-25	6.9
-20	3.7
-15	0.6
-10	1.9
-5	4.0
0	6.5
5	9.1
10	11.9
15	15.0
20	18.4
25	22.1
30	26.1
35	30.4
40	35.0
45	40.1
50	45.5
55	51.3
60	57.5
65	64.1
70	71.2
75	78.8
80	86.8
85	95.4
90	104
95	114
100	124
105	135
110	147
115	159
120	171
125	185
130	199
135	214
140	229
145	246
150	263

NATIONAL REFRIGERANTS

THERMODYNAMIC PROPERTIES OF R-134a

Temp [F]	Pressure [psia]	Density (L) [lb/ft^3]	Density (V) [lb/ft^3]	Enthalpy (L) [Btu/lb]	Enthalpy (V) [Btu/lb]	Entropy (L) [Btu/R-lb]	Entropy (V) [Btu/R-lb]
-60	4.0	90.49	0.09689	-5.957	94.13	-0.01452	0.2359
-55	4.7	90.00	0.1127	-4.476	94.89	-0.01085	0.2347
-50	5.5	89.50	0.1305	-2.989	95.65	-0.00720	0.2336
-45	6.4	89.00	0.1505	-1.498	96.41	-0.00358	0.2325
-40	7.4	88.50	0.1729	0.000	97.17	0.00000	0.2315
-35	8.6	88.00	0.1978	1.503	97.92	0.00356	0.2306
-30	9.9	87.49	0.2256	3.013	98.68	0.00708	0.2297
-25	11.3	86.98	0.2563	4.529	99.43	0.01058	0.2289
-20	12.9	86.47	0.2903	6.051	100.2	0.01406	0.2282
-15	15.3	85.95	0.3277	7.580	100.9	0.01751	0.2274
-10	16.6	85.43	0.3689	9.115	101.7	0.02093	0.2268
-5	18.8	84.90	0.4140	10.66	102.4	0.02433	0.2262
0	21.2	84.37	0.4634	12.21	103.2	0.02771	0.2256
5	23.8	83.83	0.5173	13.76	103.9	0.03107	0.2250
10	26.6	83.29	0.5761	15.33	104.6	0.03440	0.2245
15	29.7	82.74	0.6401	16.90	105.3	0.03772	0.2240
20	33.1	82.19	0.7095	18.48	106.1	0.04101	0.2236
25	36.8	81.63	0.7848	20.07	106.8	0.04429	0.2232
30	40.8	81.06	0.8663	21.67	107.5	0.04755	0.2228
35	45.1	80.49	0.9544	23.27	108.2	0.05079	0.2224
40	49.7	79.90	1.050	24.89	108.9	0.05402	0.2221
45	54.8	79.32	1.152	26.51	109.5	0.05724	0.2217
50	60.2	78.72	1.263	28.15	110.2	0.06044	0.2214
55	65.9	78.11	1.382	29.80	110.9	0.06362	0.2212
60	72.2	77.50	1.510	31.45	111.5	0.06680	0.2209
65	78.8	76.87	1.647	33.12	112.2	0.06996	0.2206
70	85.8	76.24	1.795	34.80	112.8	0.07311	0.2204
75	93.5	75.59	1.953	36.49	113.4	0.07626	0.2201
80	101.4	74.94	2.123	38.20	114.0	0.07939	0.2199
85	109.9	74.27	2.305	39.91	114.6	0.08252	0.2197
90	119.0	73.58	2.501	41.65	115.2	0.08565	0.2194
95	128.6	72.88	2.710	43.39	115.7	0.08877	0.2192
100	138.9	72.17	2.935	45.15	116.3	0.09188	0.2190
105	149.7	71.44	3.176	46.93	116.8	0.09500	0.2187
110	161.1	70.69	3.435	48.73	117.3	0.09811	0.2185
115	173.1	69.93	3.713	50.55	117.8	0.1012	0.2183
120	185.9	69.14	4.012	52.38	118.3	0.1044	0.2180
125	199.3	68.32	4.333	54.24	118.7	0.1075	0.2177
130	213.4	67.49	4.679	56.12	119.1	0.1106	0.2174
135	228.3	66.62	5.052	58.02	119.5	0.1138	0.2171
140	243.9	65.73	5.455	59.95	119.8	0.1169	0.2167
145	260.4	64.80	5.892	61.92	120.1	0.1201	0.2163
150	277.6	63.83	6.366	63.91	120.4	0.1233	0.2159
155	295.7	62.82	6.882	65.94	120.6	0.1265	0.2154
160	314.7	61.76	7.447	68.00	120.7	0.1298	0.2149


Liquid
Scale
Vapor Recovery
Evaporator
Low Side
Metering Device
Compressor
High Side
Receiver
Condenser


Liquid Recovery
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