Chapter 1 – Basic Cooling and Air Conditioning Systems

EXPERIMENT 1.2 – PRESSURE/TEMPERATURE RELATION

Name	Class/Period	Date

1. Objectives:

At the end of this experiment session, you will be able to:

- Explain the pressure temperature relation.
- Explain the p h (Mollier) diagram.
- Explain the p h (Mollier) diagram terms.
- Explain the p h (Mollier) diagram process.
- Explain the Theoretical cooling cycle.
- Explain the Practical cooling cycle.
- Explain the Pressure losses in the evaporator and condenser.
- Explain the Enthalpy changes in the metering process.
- Explain the Enthalpy changes in the metering and compression process.
- Understand the pressure temperature relation graph.

2. Equipment Required:

- Main Platform Unit
- Professional Air Conditioning Panel

3. Discussion: Pressure/temperature relation

The air-conditioning system is a closed system composed as follows:

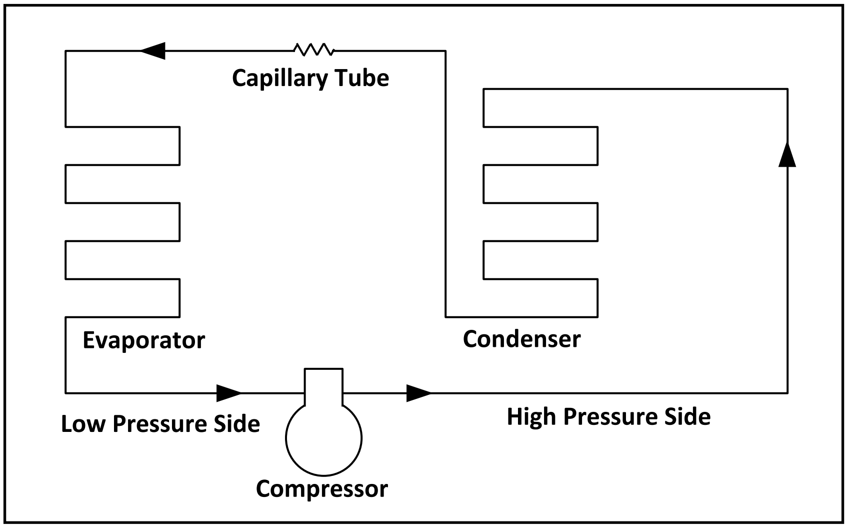


Figure 1-12

The cooling system contains coolant from the compressor under high pressure on one side of the system, which becomes low pressure while transferring to gas state on the other side of the system.

Compressing gas causes the pressure to rise and its temperature to rise at the same ratio.

The compressor in the system sucks the gas from the evaporator and compresses it in towards and inside the condenser. In the condenser, which is built as a radiator, a lot of heat is created and then dissipated by the fan that draws air from the surroundings through the condenser pipes.

The high-pressured gas causes another action. It raises the boiling temperature of the gas. The boiling temperature is the temperature where liquid turns to gas and vice versa.

Lowering the pressure and temperature of the gas in the condenser causes it to turn into liquid.

The compressed liquid is drawn by the compressor and flows through the Receiver/Drier (called also the Accumulator), which dries the water from the liquid. After the receiver/drier the gas keeps flowing to the evaporator through the evaporator fix orifice. The evaporator fix orifice is a narrow passage in the A/C pipes. It causes high gas and liquid pressure at one side (the condenser side of the system) and a very low pressure at the other side (the evaporator side).

The liquid flow pace through the evaporator fix orifice is limited and is determined by the pressure difference in the system.

The small amount of coolant passing through the evaporator fix orifice is drawn to the evaporator and from there diffuses at once.

The liquid diffusing causes a pressure descent of the liquid. This pressure descent causes a temperature a descent of the liquid to 0oC (32oF) of the evaporator pipes. The system is designed for this temperature in order to achieve maximal cooling efficiency. Lower temperatures will cause the water steam around the evaporator to freeze, which heats up the air flow through the cooling walls of the evaporator.

Pressure descent also causes the dropping of the boiling point of the coolant to 0oC (32oF). Transferring the air from the compressor through the evaporator pipes and from there to the passenger's compartment causes the air to cool and the coolant in the evaporator to get extra heat.

The extra heat for the coolant is not enough to change its temperature (which stays at 0oC (32oF)), but manages to turn it to gas.

In the gas state, it arrives to the compressor and compressed back towards the condenser.

As mentioned above, the A/C system is a closed system, where changes in the temperature are affected by pressure changes in two areas of the system.

As observed in the previous experiment, the system includes two pressure sensors, which stop the compressor operation (by disconnecting the clutch) in too high a pressure in the system or too low a pressure (which indicates among other things lower temperature).

The A/C system includes two connection points, where two pressure meters are connected. These connection points are located at the two sided of the compressor and allow the measuring of Discharge (compress pressure) and of Suction (suction pressure).

The pressures in the system are influenced by the air temperature transferred by the fan through the evaporator.

This air comes from outside the vehicle or from the passenger's compartment (in the recirculation state) to an area from which the compressor pulls the air. The pushed air temperature (called Shop Air) influences the A/C system's pressures is observed during the experiment.

4. Discussion: **Accumulation states**

Each substance existing in nature is composed of molecules that move constantly and are mutually connected by their gravitational force. The closer the molecules are to each other, their gravitational force is bigger.

Substances can appear in nature in three different states: solid, liquid, and gas.

In solids, the forces between the molecules are very great because the distance between them is very small. This is why solid substances maintain their solid form.

In liquids, the forces between the molecules are weaker because the distance between the molecules is relatively larger than in solid substances. This is the reason why liquid takes the shape of the container they are in.

In gases, the forces between the molecules are very weak because distances between them are very large. This is why gas spreads throughout the space it is in.

The substance state depends on the forces between the molecules, and in certain conditions, substances can be transferred from one state to another.

The following graph describes the three states over a pressure-temperature diagram:

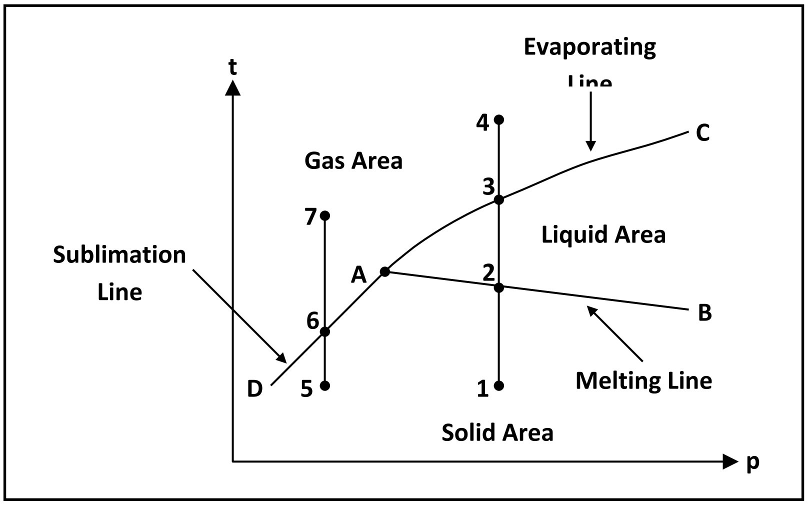


Figure 1-13

The diagram is divided into three areas defined by the lines: A-B, A-C, and A-D. Line 1-4 describes a process under a fixed pressure where solid substance turns first to liquid (by heating and temperature rising), and then to gas.

Along section 1-2 the substance is in a solid state.

At the melting point 2, substance can appear in two states: solid and liquid.

Along section 2-3 the substance is in a liquid state.

At the evaporating point 3, substance can appear in two states: liquid and gas.

Along section 3-4 the substance is in a gas state.

As we lower the pressure of the process, line 1-4 moves to the left and the distance between points 2 and 3 (the liquid area) gets smaller until at point A it disappears completely and turns into a point. This point is called "triple point" because at this point the substance can appear in one of the three states.

This point is defined for every substance in different temperatures and pressures. The "triple point" is also define as the temperature at which all three phases of a pure substance – solid, liquid and gas – are in equilibrium.

For example, the triple point for water is defined in a temperature of 0.01°C and in absolute pressure of 0.00623 technical atmospheres. Under these conditions, the substance (water in this case) will be in the three states of water: water vapors, water, and ice.

When the pressure is lowered further, the process moves to the left to point A on the line. This is defined by line 5-7. In this process there is no passage through the liquid state, and the substance transfers directly from solid state to gas state.

This direct transfer (from solid state to gas state) while skipping the liquid state is called "Sublimation". The sublimation process turns the dry ice (solid state of carbon dioxide) to gas.

5. Discussion: Basic cooling cycle in the Mollier (ph) diagram

Mollier Diagram – An enthalpy-entropy or enthalpy-pressure chart showing the thermodynamic properties of the refrigerant.

The Mollier diagram is the European version of the Anglo-American Psychrometric Chart. They are identical in content but not in appearance.

The cooling material thermodynamic condition at each point of the cooling cycle is described in the Mollier diagram. Each cooling material has its own Mollier diagram. The R134a Mollier diagram is described in section 1.2.7.

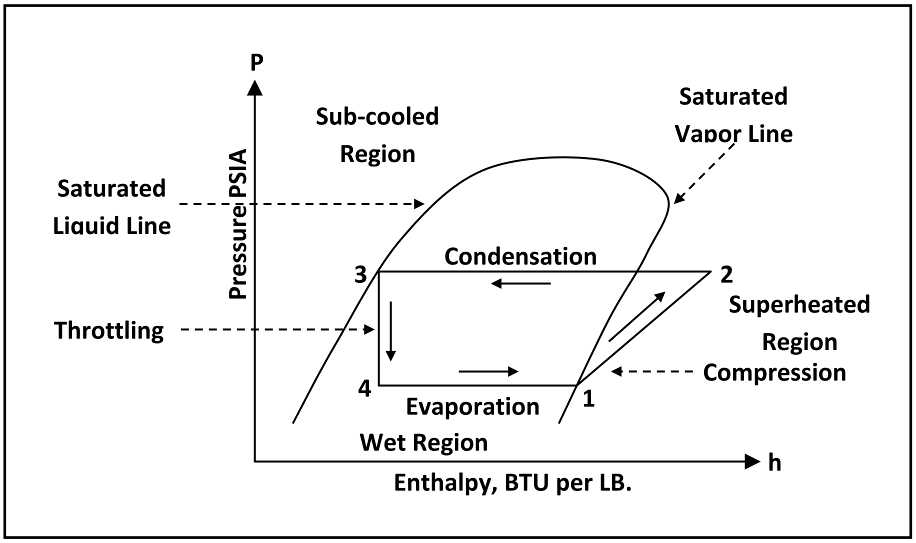


Figure 1-14

The diagram is constructed from three regions separated by a curved line shaped as a bell, thus the name.

1. The region where the refrigerant is in a liquid state is described on the bell's left side. This region in also called the Compressed Liquid Region or the Sub-Cooled Region.
2. The region where the refrigerant is in two states (liquid and gas) is described inside the bell. This region is called the Wet Region, and it describes the substance's evaporation or condensation processes under a given temperature and pressure. This is a saturated state.
3. The region where the cooling material is in a gas state is described on the bell's right side. This region is also called the Superheated Vapors Region or the Superheated Region.

5.1. The use of psychrometric Mollier diagram:

1. **Absolute Pressure (P)** – Choose an arbitrary point on the diagram, then move from this point to the right or to the left horizontally to the end, and read the absolute pressure in PSI units.

2. **Enthalpy (h)** – Choose an arbitrary point on the diagram, then move from this point up or down vertically to the end, and read the Enthalpy in BTU units per Libra.

   The Enthalpy is zeroed at -40°F temperature in the Mollier diagram when the substance on the bell's left line is in a liquid state. The Enthalpy change between two given points is important in the Mollier diagram in order to calculate the heat added or subtracted from the cooling material.

3. **Temperature (T)** – The temperature is a value read (in Fahrenheit) differently in each of the diagram's regions. The temperature's values surround the bell's line where the high value is at its vertex, and the low values are at its bottom (at each side).

   Reading the temperature in the liquid region is done by a vertical descent on the left side of the bell.

   Reading the temperature inside the bell is done by a horizontal movement (right or left) towards the bell's line.

   Reading the temperature at the gas region is done by moving on a very steep curved line (almost vertical) from an arbitrary point towards the right side of the bell.

4. **Specific Volume (V)** – Appears only in the gas region and is described by a moderate and very curved line. The specific volume units in the Mollier diagram are cubic feet per Libra.

5. **Entropy (S)** – Is a thermodynamic characteristic which presents the relation of Enthalpy to the absolute temperature of the substance in Kelvin or Rankin degrees. A more important function use is where the change in the Entropy presents the relationship between the amount of heat added or subtracted from the substance to the absolute temperature where the heat transfer occurs.

   The Entropy described in the Mollier diagram is specific Entropy, which means Entropy per mass unit.

The general Entropy units are:

- Joule per Kelvin degree (international system).
- Kilocalorie per Kelvin degree (technical system).
- BTU per Rankin degree (British system).

The specific Entropy units are:

- Joule per kilogram per Kelvin degree (international system).
- Kilocalorie per kilogram per Kelvin degree (technical system).
- BTU per Libra per Rankin degree (British system).

The Entropy appears only in the gas region, and it is described by curved lines. They are steeper than the specific volume lines but more moderate than the temperature line in this region.

6. **Dryness Coefficient (quality) (X)** – This thermodynamic characteristic exists only inside the bell when the substance changes its state, and is in both liquid and gas states. The dryness coefficient defines how much of the substance mass percentage is in gas state.

$$\mathbf{X} = \frac{\mathbf{M\ gas}}{\mathbf{M\ gas + M\ liquid}}$$

As the point moves horizontally towards the bell's right side, the dryness coefficient rises and aspires to the gas state. The substance on the right line is in a saturated vapor state, and its dryness coefficient is 1 (there is no substance percentage in liquid state). In this state, the substance finishes the evaporation process or starts the condensation process.

As the point moves horizontally towards the bell's left side, the dryness coefficient decreases and aspires to the liquid state. The substance on the left line is in a saturated liquid state, and its dryness coefficient is 0 (there is no substance percentage in gas state). In this state, the substance finishes the condensation process or starts the evaporation process.

The dryness coefficient in the Mollier diagram is given in percentages by nine steep lines inside the bell (10 to 90). The zero line is the bell's left line and the 100 line is the bell's right line.

5.2. Theoretical cooling cycle:

Point 1 describes the cooling material's condition at the compressor entrance. The cooling material is situated on the saturated vapor line at low temperature and at low pressure. The compressor raises the gas temperature and pressure, such that at point 2 (the compressor's output), the cooling material is in a gas state with high temperature and pressure.

The theoretical compression process is defined as a process where heat does not pass the system's boundaries, so there is no energy passage to the environment, therefore there is no change in the Entropy, and the process occurs along a unified Entropy line.

The electrical energy used by the compressor's operation is defined as an external operation, which must be invested in order to produce the cooling process. As a result of this operation there is change in the Enthalpy between points 1 and 2. The Enthalpy at point 2 is higher than the Enthalpy at point 1 and the difference between them is the energy needed for the compressor's operation.

$$\text{Compressor } h = h_2 - h_1$$

In the gas region, the substance is situated at point 2 (far from the bell), and in this state it enters the condenser. The compressor raises the substance's temperature, and it enters the condenser at a higher temperature than the environment temperature (outside the condenser).

The temperature difference between the cooling material and the environment causes heat transfer from the substance to the environment. Because the substance state is superheated gas (far from the bell), the heat reduced in it is expressed by temperature decrease (sensible heat), and moving closer to the bell.

The cooling material gradually loses temperature until it reaches the condensation temperature at its existing pressure (saturated vapor). This state is described by point 2'.

Additional heat loss puts the substance into the bell, and the condensation process starts with no change in the substance's temperature (latent heat). The cooling material delivers heat to the environment, and gradually turns from gas to liquid.

At point 3, the cooling material finishes its path in the bell in the only possible liquid state, at high temperature and pressure (saturated liquid).

In process 2-3 the substance loses energy to the environment and its Enthalpy drops. This loss value is calculated according to the Enthalpy differences between points 2 and 3.

$$\text{Condenser } h = h_2 - h_3$$

To recycle the process, the cooling material should be removed from point 3. The metering device installed between points 3 and 4 performs this function.

Explanation about metering devices appears in Experiment 1.3, Section 9.

Cooling material enters the metering device as hot liquid under high pressure, and exits at point 4 as a mixture of liquid and gas (relatively low dryness coefficient) at low temperature and under low pressure.

The theoretical metering process is defined as a process where there is no heat transfer to the environment, and no external work is invested in it, thus throughout the process the Enthalpy remains unchanged.

The temperature and pressure of the cooling material drops, and must transfer sensible heat to the environment, but however, it had already started its boiling process at the metering device where, a small part of it turned to gas (due to the temperature and pressure drop; it is also easy for the substance to expand and boil in low temperature). The cooling material boiling in the metering device is called Flash Gas. The required heat for the substance to boil is latent heat.

In a theoretical metering process, the sensible heat decrease equals the latent heat rise, thus there is no change in the substance's Enthalpy. This is why process 3-4 is described as a vertical line starting iat high pressure on the saturated liquid line, and finishing at low pressure inside the bell.

$$\mathbf{h_3 = h_4}$$

At point 4, the cooling material enters the evaporator as a mixture of liquid and a small amount of gas at both low temperature and pressure. The metering device is designed to lower the evaporation temperature below the environment temperature (outside the evaporator).

The temperature difference between the cooling material and the evaporator's environment causes heat transfer from the environment to the substance.

Because at point 4 the cooling material is inside the bell, all heat transferred to it accelerates the evaporation process, and the substance gradually turns from a mixture of liquid and a small amount of gas to gas only. The evaporation process (as does the condensation process) occurs with no change in the substance temperature and pressure.

At point 1, the cooling material finishes its path in the bell as a gas state only, at low temperature and under low pressure (saturated vapor).

In process 4-1, the substance absorbs energy from the environment and its Enthalpy rises. The value of this addition is calculated according to the Enthalpy differences between points 4 and 1.

$$\textbf{Evaporator h} = \mathbf{h_1 - h_4}$$

The cooling material exits the evaporator at point 1 and enters the compressor.

The above process is a cyclic process.

An important conclusion is derived from the closed cooling cycle described by the Mollier diagram. It is that the amount of heat expelled to the condenser's environment equals the heat received in the evaporator + the heat amount needed for the compressor's operation.

$$\boxed{\begin{array}{ccccc} \textbf{Evaporator h} & + & \textbf{Compressor h} & = & \textbf{Condenser h} \\ \mathbf{(h_1 - h_4)} & + & \mathbf{(h_2 - h_1)} & = & \mathbf{(h_2 - h_3)} \end{array}}$$

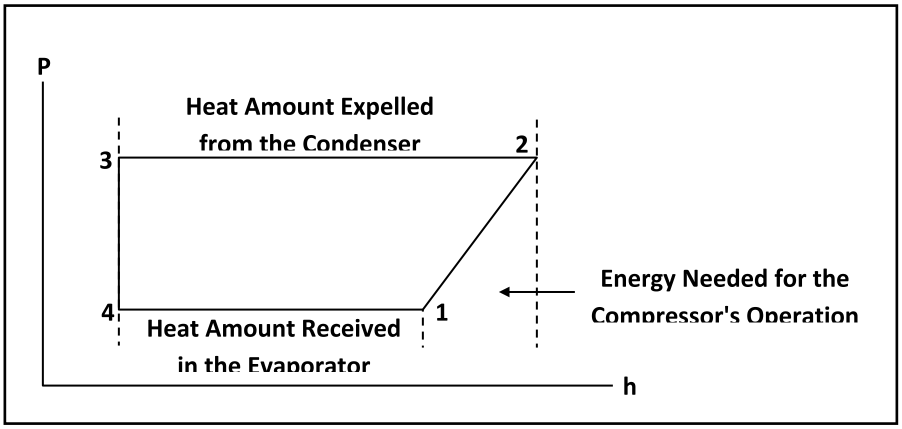


Figure 1-15

To sum up, it can be said that the cooling system is a unit, which transfers heat energy from the cooling area to the external environment through the cooling material and investing electric energy for operating the compressor.

5.3. Cooling production:

The Enthalpy differences between the evaporator's input and output points indicate the device's cooling production.

$$h_1 - h_4$$

The Mollier diagram is used to calculate a mass unit, so the specific change in the Enthalpy must be multiplied by the cooling material mass, which passes to the time unit in the evaporator.

The cooling production is measured in:

- The British system in BTU/H units.
- The technical system in Kcal/H units.
- The international system in J/H unit.

The Coefficient Of Performance (COP) is the ratio between the cooling production to the energy consumed by the compressor.

$$\mathrm{COP} = \frac{\text{Evaporator } \Delta h}{\text{Compressor } \Delta h} = \frac{h_1 - h_4}{h_2 - h_1}$$

The COP is the ratio between the Enthalpies, thus it does not have units.

The cooling cycle can be described by a T-S Entropy temperature diagram.

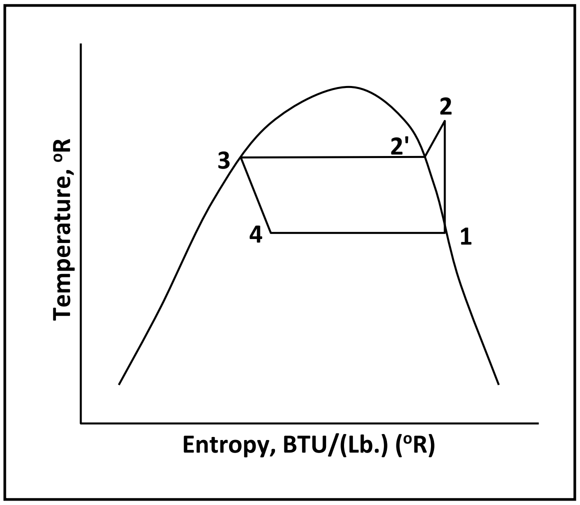


Figure 1-16

The compression process is described as a vertical line from point 1 to point 2 because there is no change in the Entropy along this process.

The condensation process begins as a curved line where the temperature drops until the cooling material reaches the bell, then the condensation process starts at point 2'.

The condensation process ends at point 3 where the cooling material enters the metering device.

In the 2-3 condensation process, the cooling material transfers heat to the environment, and so its Entropy drops.

The process in the metering device (from point 3 to point 4) is defined as a process of fixed Enthalpy, but the Entropy is this process rises.

This process occurs naturally due to the temperatures and pressures differences between the process' edges. This process cannot occur naturally in the reversed direction, that is why it is called 'irreversible process.'

In every irreversible process without heat transfer to the environment (as this process is defined), there is an increase in the Entropy.

The cooling material enters the evaporator at point 4, and finishes its evaporation process at point 1.

In the 4-1 evaporation process, the cooling material absorbs heat from the cooling center, and so its Entropy rises.

5.4. Practical cooling cycle:

The practical cooling system cannot perform the demands placed by the theoretical cooling cycle. Various constraints, which cannot be ignored, influence the cycle's nature.

a) Superheating:

The theoretical cycle determines that point 1 indicates the end of the cooling material's evaporation, and the end of its path in the evaporator. Sometimes, the evaporation process ends before the cooling material finishes its path in the evaporator. Each additional heat transfer from the cooling center to the cooling material (after it finishes its evaporation process) is expressed in the cooling material temperature rise, and turning it to a superheated vapor gradually moving away from the bell.

The cooling material leaving the evaporator is hotter than it was the moment it finished the evaporation process. This process is called Superheating.

Sometimes there is a concern that the cooling material will not finish its evaporation process in the evaporator and a certain percentage of liquid will enter the compressor. This situation occurs when the heat loads operating on the cooling center are low, the heat transfer to the cooling material is low, and the cooling material does not get enough heat in order to finish boiling. In this situation, point 1 will move to the left, into the bell.

The compressor is designed to work with a cooling material only in a gas state, and a liquid entering (even in small percentages) causes damage to the compressor's valves and jeopardizes its intact operation.

One of the methods employed to avoid the above problem is to increase the evaporator, thus the cooling material keeps flowing to the battery, absorbs additional heat from the cooling space, and finishes its evaporation process. In normal working conditions, point 1 moves to the right to the superheated vapor region.

b) Sub-cooling:

The theoretical cycle determines that point 3 indicates the end of the cooling material condensation, and the end of its path in the condenser. Sometimes, the condensation process ends before the cooling material finishes its path in the condenser. Each additional heat transfer from the cooling material to the environment (after it finishes its condensation process) is expressed in the cooling material temperature drop, and turning it to liquid gradually moving away from the bell.

The cooling material leaving the condenser is colder during the process, than it is the moment it finishes the condensation process. This process is called Sub-cooling.

Sometimes there is a concern that the cooling material will not finish its condensation process in the condenser and a certain percentage of gas will enter the metering device. This situation occurs when the external environment temperature rises and receives less of the heat. The cooling material is not able to transfer enough heat for it to finish its condensation process.

An effective condensation process is a process that enables any amount of substance to condensate, and by doing so, the maximum possible heat is transferred to the environment. It is not advisable that the cooling system should work with a condenser where a certain percentage of the cooling material will not be able to condensate. This phenomenon reduces the system's production and causes point 3 to move to the right, into the bell.

One of the methods employed to avoid the above problem is to increase the condenser, thus the cooling material keeps flowing to the battery, transfer additional heat to the external environment, and finishes its condensation process. In normal working conditions, point 3 moves to the right to the liquid region.

The superheating and sub-cooling processes increase the heat passage in the evaporator and condenser batteries contributing to the system's production increase.

A common method for achieving sub-cooling and superheating at the same time is using a heat exchanger in the evaporator and condenser outputs. The pipe coming out of the condenser can be wrapped around the pipe coming out of the evaporator, thus heat transfer from the cooling material at the condenser's output to the cooling material at the evaporator's output occurs.

The cooling material at the evaporator's output warms up and the cooling material at the condenser's output cools down.

In this case, the Enthalpy change in the 1'-1 superheating process equals the Enthalpy change in the 3'-3 sub-cooling process.

An additional assumption is that this heat exchanger is isolated from the environment in absolute isolation.

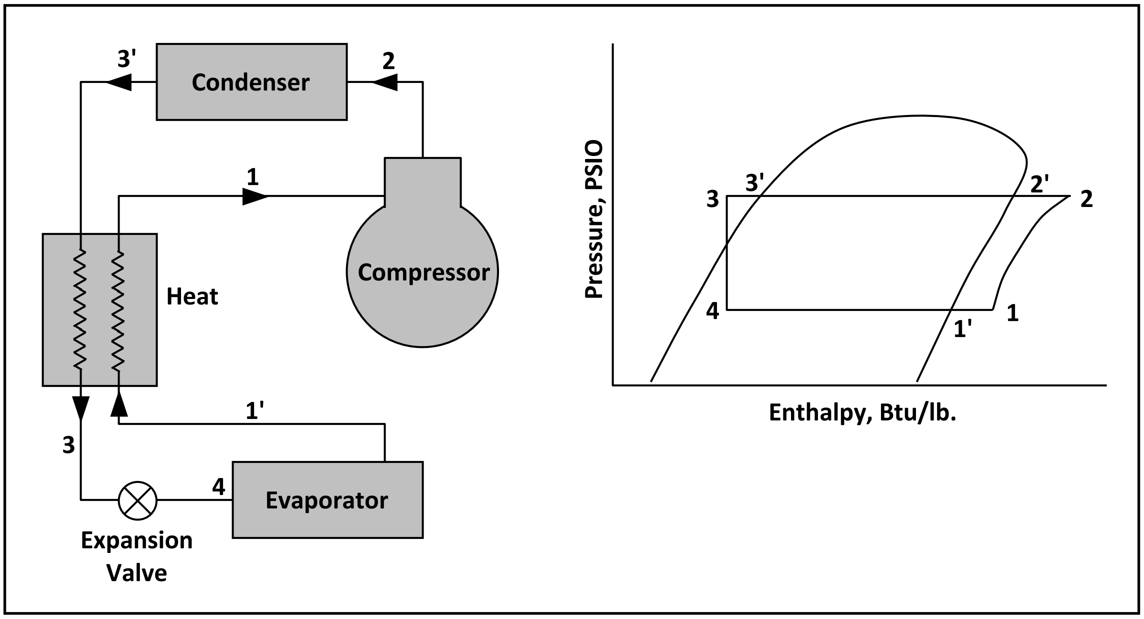


Figure 1-17

6. Discussion: **Pressure losses in the evaporator and condenser**

The theoretical cooling cycle enables the cooling material flowing in the evaporator and condenser batteries to flow without friction, such that there is no pressure drop during the cycle. In reality, there is no pipe existent, which enables flow without any friction.

The friction against the flow in the battery is caused by the substance's molecules bumping against each other, and the external substance layer friction against the pipe's internal side. The friction causes a drop in the cooling material pressure along its way through the battery.

The pressure at the battery output is always lower than the pressure at its input. The Mollier diagram expresses it by a moderate slope in the evaporator and condenser processes.

The pressure at point 3 is a bit lower than the pressure at point 2, and the pressure at point 1 is a bit lower than the pressure at point 4.

7. Discussion: **Enthalpy changes in the metering process**

The theoretical cycle requires no enthalpy change in the metering device so that no heat will be transferred to the environment. This requirement needs the heat drop to be equal to the additional latent heat in this process.

In reality, this requirement will not always be available. Due to changes in the working conditions (pressure, temperature, environment conditions, and cooling space), a lack of balance can occur between the additional latent heat to the sensible heat drop, and eventually a change in the general heat represented by the Enthalpy will occur.

This change can be negative or positive, such that the 3-4 process may receive a slight slope to either direction.

For this reason, the Enthalpy at point 4 in the practical process can be smaller, equal or bigger than the Enthalpy at point 3.

8. Discussion: **Entropy changes in the compression process**

The theoretical cycle requires no heat transfer from the condenser to the environment, only an electric energy investment for operating the condenser. For this reason, the Entropy in the theoretical compression process does not change.

In practice, the condenser is not isolated completely, and heat does pass to the condenser's environment.

The cooling material loses a certain amount of heat energy (which passes to the environment), and its Entropy does drop.

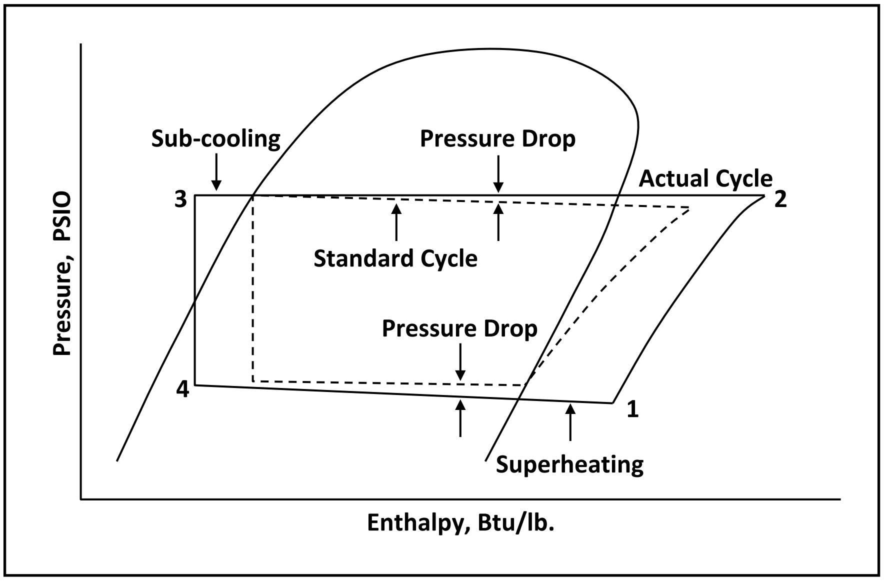


Figure 1-18 Practical Cooling Cycle in the Mollier Diagram

9. Discussion: **Pressure-enthalpy diagram for HFC-134a (SI units)**

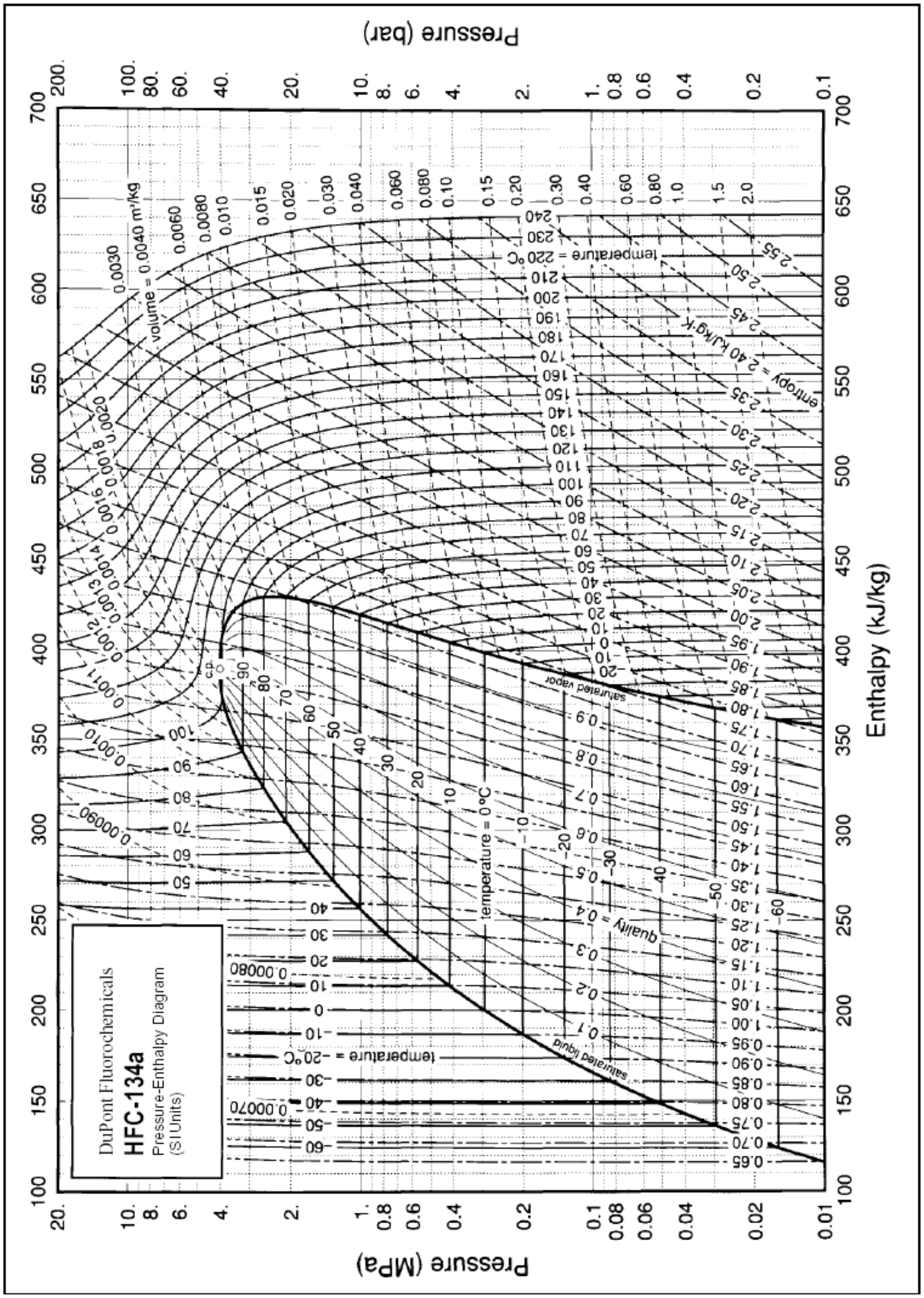


Figure 1-19

10. Procedure:

Step 1: Check that the PROFESSIONAL AIR CONDITIONING PANEL is properly installed on the refrigeration and air-conditioning general system MAIN PLATFORM UNIT according to the instructions described in the book's preface.

Step 2: Check that the MAIN PLATFORM UNIT MONITOR and PROGRAM switches are at OFF position.

A ground leakage relay, a semi-automatic switch, and a main power switch are installed in a main power box located on the rear panel.

Step 3: Connect the MAIN PLATFORM UNIT power supply cable to the Mains.

Step 4: Check that the high voltage ground leakage relay and the semi-automatic switch are ON.

Step 5: Set the Auto/Manual switch (located on the bottom left of the simulator) to the Manual position.

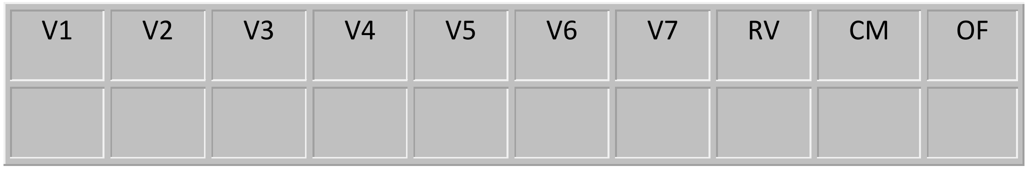
Step 6: Turn ON the main POWER switch located on the main power box on the rear panel.

Step 7: Turn ON the monitor power switch.

Step 8: The FAULT display should display the number 00. If not, use the keys above the FAULT display to display the number 00 (no fault condition) on the FAULT 7-segment display and press the ENTER key beneath this display.

Step 9: The STATE display should display the number 00 (no operation program).

Step 10: On the LCD display you should find the following table:



V1	V2	V3	V4	V5	V6	V7	RV	CM	OF

Check that the two taps on the flexible pipes (yellow and red) are open, and that the pipes are tightened to the module.

TEV mode:

Step 11: Changing the STATE number does not start the operating program (even after pressing the ENTER key).

Using the pushbuttons under each digit, press the number 11 on the STATE (each pushbutton changes the digit above it), and press ENTER.

The STATE number after pressing the ENTER key only displays the required operating program and state.

Step 12: Lower the PROGRAM switch and raise it.

The TEV mode states are 11-16.

Note: You can move from one TEV state to another without lowering and raising the PROGRAM switch. If you lower and raise the PROGRAM switch, the system will undergo a delay for safety operation.

The TEV programs are:

State 11 – TEV operation with °C display.

State 12 – TEV operation with °F display.

State 13 – TEV operation with graphic display.

State 14 – TEV operation with °C display and thermal load.

State 15 – TEV operation with °F display and thermal load.

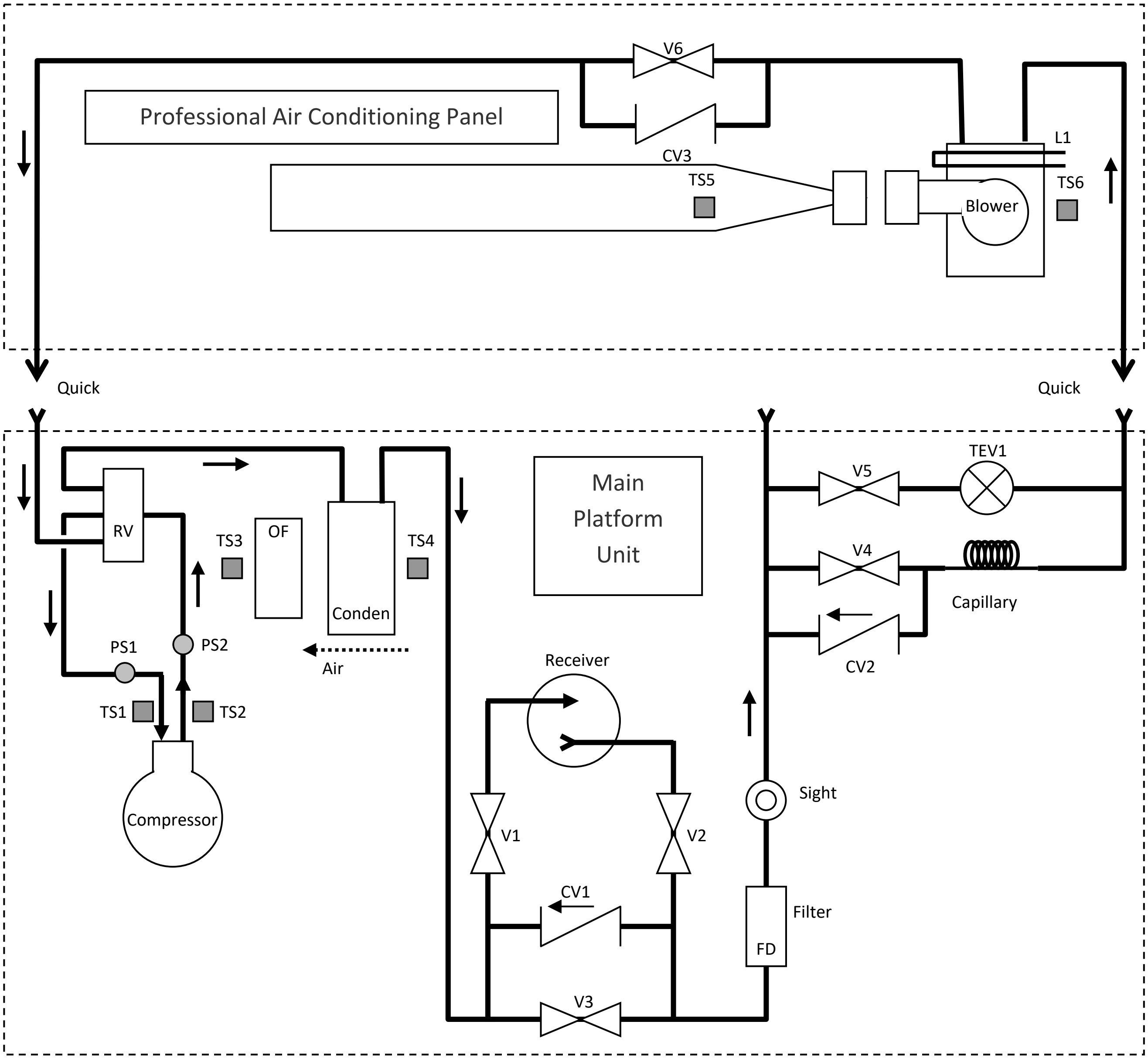
State 16 – TEV operation with graphic display and thermal load.

Step 13: On the LCD display you should find the following table:

V1	V2	V3	V4	V5	V6	V7	RV	CM	OF
ON	ON			ON	ON			ON	ON

If "on" (lowercase) appears on the CM and OF columns, it means that the compressor is in a 3 minutes delay state before it starts to work. This delay protects the compressor.

Step 14: The refrigerant path is marked on the following circuit.



Step 15: The LCD also displays the system pressures and temperature as follows:

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

LP – Low Pressure (the suction pressure measured by PS1)

HP – High Pressure (the compression pressure measured by PS2)

T1 – The compressor inlet temperature (measured by TS1)

T2 – The compressor outlet temperature (measured by TS2)

T3 – The condenser outlet air temperature (measured by TS3)

T4 – The condenser inlet air temperature (measured by TS4)

T5 – The evaporator outlet air temperature (measured by TS5)

T6 – The evaporator inlet air temperature (the cooling chamber temperature measured by TS6)

T7 – Not relevant to this panel

T8 – Not relevant to this panel

Identify the sensors in the drawing and in the system.

Step 16: Another table that appears on the LCD display is the control parameters:

S1	D1	S2	D2	SP	PD	E1	L1	E2	RT
20°C	5°C					LO			

S1 – Room temperature setup

D1 – Room temperature difference

The setup temperature is the required temperature. When the cooling chamber temperature goes below this temperature, the air-conditioning system should stop cooling and this is done by stopping the compressor.

The compressor turns ON when the cooling chamber temperature is above S1 + D1. D1 is determined in order to avoid system oscillation.

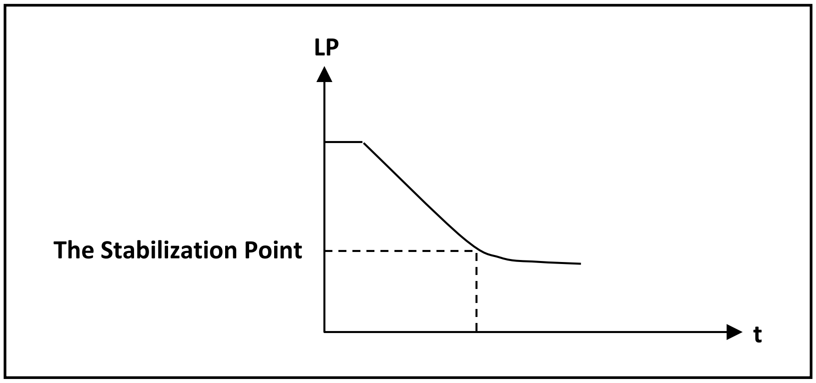
Note: Each time the compressor is turned OFF, a compressor's operation delay occurs.

There is a linear relationship between the temperature and pressure. This is why the cooling chamber temperature is controlled according to the system's low pressure or the system's high pressure. This subject will be described later.

The TEV mode is controlled by temperature and this is why a dash appears in the pressure squares.

Identify the system's default values of S1 and D1.

Step 17: Immediately after operating the air-conditioning, the suction pressure should be high and decreasing while the system is cooled according to the following graph.



Step 18: Change the STATE no. to 12 and press ENTER.

This state does not change the system's operation; it only changes the display from °C to °F.

Observe that.

Change the STATE no. to 11 and press ENTER.

Step 19: Observe the temperature and pressure values on the display and record them every one minute on the following table.

Min.	LP	HP	T1	T2	T3	T4	T5	T6
1								
5								
10								
15								
20								

25								
30								
35								

The stabilization point, which is the operation point, is the point where the pressures in the system are right for cooling and are appropriate for the system's devices, the refrigerant, the fan speed and the environment.

Observe the sight glass and check that there are no bubbles.

Step 20: When the LP is stable at the stabilized point, record the temperature and pressure values of this stabilization point.

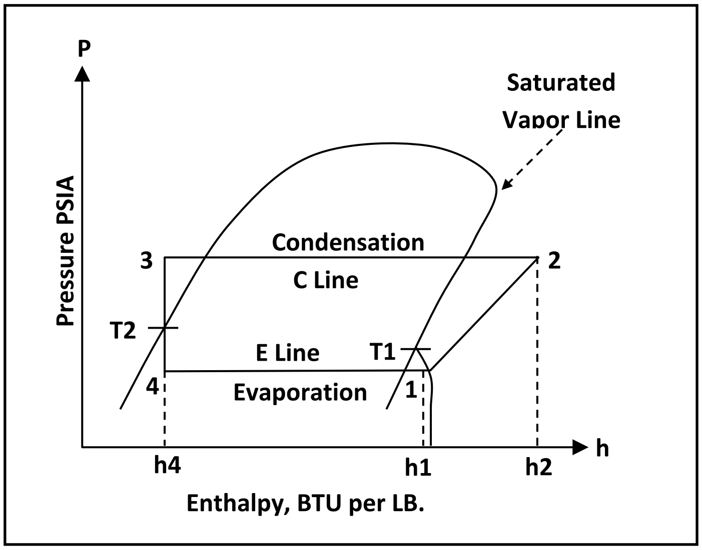
The cooling chamber temperature should continue to go down.

Step 21: Draw a graph LP against T1, which describes the relationship between the suction temperature and the suction pressure.

Step 22: The stabilization point values enable us to calculate the COP (Coefficient Of Performance) of the cooling system.

Use the Mollier diagram in Appendix A to find the value of h1, h2 and h4 in order to calculate the COP of the system as described in the following steps.

The cooling cycle is described in the following diagram



1. Draw the evaporation line (E line) according to the LP (the suction pressure measured by PS1) on the diagram.
2. Find a point on E line that meets a temperature line according to T1 (the suction temperature). This is point 1.
3. Find the enthalpy value of point 1 on the enthalpy line h. This is h1.
4. Draw the condensation line (C line) according to HP (the compression pressure measured by PS2) on the diagram.
5. Go up from point 1 using an entropy line on the Mollier diagram until it meets the C line. This is point 2.
6. Find the enthalpy value of point 2 on the enthalpy line h. This is h2.
7. On the left side of the bell, find the point with temperature equal to the compression temperature T2.
8. Draw vertical line up and down from this point until it meets C line (creating point 3) and E line (creating point 4).
9. Find the enthalpy value of point 4 on the enthalpy line h. This is h4.
10. Calculate the COP according to the following formula.

$$\mathbf{COP} = \frac{\mathbf{h_1 - h_4}}{\mathbf{h_2 - h_1}}$$

11. From point 3 and point 1 identify the type of cooling (sub-cooling, superheating etc.).

Step 23: The evaporator speed is changed by using the '*' key.

Press the '*' key and check that the evaporator fan (E1) changes to HI.

Step 24: Wait until the system reaches the stabilized point.

Record the stabilization values.

Step 25: Calculate the system COP at this point.

Step 26: Press the '*' key again and check that E1 is changed into 'LO'.

Step 27: Change the STATE no. to 16 and press ENTER.

This state operates the thermal load to the evaporator (1 minute ON and 2 minutes OFF alternately).

The suction pressure should go up slowly.

The compartment's temperature does rise, and that is dealt with later.

Step 28: Wait until the system is stable.

Identify the new stabilization point.

Step 29: Calculate the system COP at this point.

Step 30: Change the E1 speed to high and record the new stabilization point values.

Step 31: Change the E1 speed back to low.

Step 32: Change the STATE no. to 14 (°C) and press ENTER.

Record the stabilization values.

Step 33: Change the STATE no. to 15 (°F) and press ENTER.

Record the stabilization values.

Step 34: Calculate the system COP at this point.

Step 35: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it.

All the devices should shut OFF.