Chapter 1 – Basic Cooling and Air Conditioning Systems

EXPERIMENT 1.4 – COMPRESSORS TYPES

Name	Class/Period	Date

1. Objectives:

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

- Explain the compressor function.
- Explain the differences between the compressor types.
- Explain the need for oil in the cooling system.
- Explain the function of the crankcase heater.
- Explain the compressor system cycle.
- Explain the function of the compressor protection safety devices.

2. Equipment Required:

- Main Platform Unit
- Professional Air Conditioning Panel

3. Discussion: **The purpose of the Compressor**

The purpose of the Compressor is to:

- Circulate the refrigerant in the circuit.
- Compress the refrigerant that leaves the evaporator and thus raising its temperature in order to create a temperature difference that will enable heat transfer from the cooled area, toward the outside.

The pressure build-up in the system can only be accomplished by having a restriction in the high-pressure side of the system. This is a small valve located in the Expansion Valve. This metered orifice serves for that purpose in the system.

4. Discussion: **The hermetic, semi-hermetic, and open type compressors**

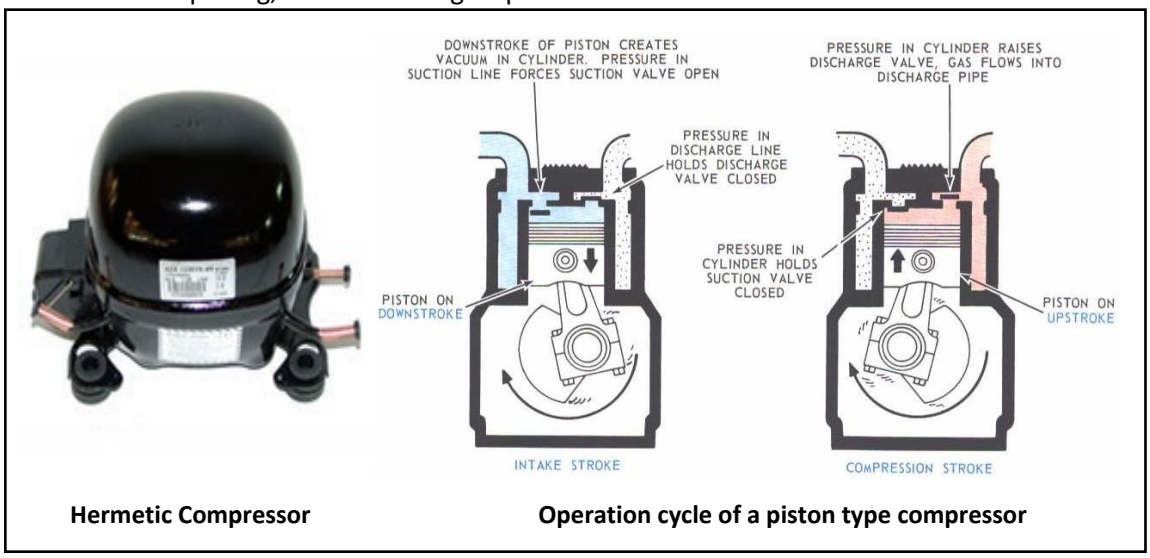
1. The most used compression methods today:

- **The Hermetic Compressor:** Compressor which has the driving motor sealed inside the compressor housing. The motor operates in an atmosphere of the refrigerant. This type is used in small and medium applications, and air-conditioners.
- **The Semi Hermetic Compressor:** the compressor itself and the drive motor are housed inside the housing; this housing can be opened for inspection and maintenance. This type is used in larger applications.

2. Rotary compressors, including circular compressors, vane and screw compressors (suitable for high capacity applications) and centrifugal compressors (used for applications that require higher capacities).
   - **Circular compressors**: features two involuted scrolls: one stationary, and one orbiting (not rotating) around the first. This motion causes the gas contained between the two elements to reach a very high pressure and is then discharged through a hole in the center.
   - **Stationary or rotary vane compressors** work due to the effect of the vanes located inside the cylinders. The vanes may rotate on a cam in the center of the cylinder (rotary), or be fixed to the walls of the cylinder (stationary). In both cases, the vanes are responsible for the movement of the gas, contributing fundamentally to the suction and compression phases.
   - **Screw compressors** are based on a mechanism made up of two threaded rotors (screws) that are coupled together.
     The gas is compressed due to the progressive overlapping of the lobes, causing a reduction in the volume occupied by the gas.

     There are also single-screw compressors that operate by the rotation of just one cylindrical screw with a helical thread, onto which two identical rotors are coupled.

   - **Centrifugal compressors** are made up of a rotor located inside a special chamber. The rotor is rotated at high speed, imparting high kinetic energy to the gas, which is forced through the narrow outlet opening, thus increasing its pressure.



Hermetic Compressor **Operation cycle of a piston type compressor**

- **Figure 1-21**

5. Discussion: **Oil in the cooling system**

The compressor is a dynamic component and there is constant movement of the metal parts (which move together) inside it. This movement creates friction between the metal parts, which in turn creates heat. Over-heating of the metal parts causes parts that were designed to work in a precise way (between them) to expand and be distorted, such as the piston and the cylinder.

The piston's heating causes it expansion, thus making its movement inside the cylinder difficult until (in extreme situations), the piston is stuck in the cylinder and can no longer move.

Decreasing friction is very important for avoiding compressor heating. Oiling the moving parts enable this decreased friction.

For every type of compressor, oil is added to every size of cooling or air-conditioning system. The oil dissolves with the cooling material and flows with it through the pipes and the devices. When the system is not working, most of the oil is gathered in a special concentration compartment (designed for it) in the compressor. This compartment is called the crankcase.

In compressors for medium and high production, a special control eyepiece is installed in the oil compartment. Through this eyepiece the oil level (in idle state) is seen, and oil is added as necessary. While the system is working, it is difficult to see the oil's level through the eyepiece because the cooling material sweeps the oil and foam is created, which fills the eyepiece, thus it is difficult to know if there is enough oil.

An oil pump is used in big compressors in order to contribute to the oil spin in the system. This pump works on the centrifugal power principle. The pump rotates with the compressor's axle, sucks oil from the oil crankcase, and squeezes it in the direction of the crankshaft, the connecting rod, the piston, and the cylinder.

The oil in the system helps to detect gas leakage. The gas evaporates in the air and does not leave any trace, while the oil accumulates around the leak source and creates a stain indicating the leak location. When the leakage is repaired, it is important to clean the leakage stain so there will not be a false report of a leak in the same location when checked again.

The oil's function is also to distribute temperature and to cool down the cylinder.

6. Discussion: **The Crankcase heater**

In large cooling and air-conditioning systems (in idle state,) a relatively large amount of gas accumulated in the compressor. When the system is activated, the liquid in the oil evaporates and it discharged from it, which creates oil bubbles, which reach the cylinder and destroy the valves. In addition to this problem, the oil's viscosity changes when the system stops its operation and cools down. This phenomenon is called "The Bubbles Phenomenon".

Viscosity is a substance's molecules ability to cling to each other. The oil's viscosity rises as long as it cools, and its ability to flow with the substance is decreased.

Even when the system is idle, these two problems are constantly treated and solved by the crankcase heater. The crankcase is continuously heated by a special heating body called crankcase heater. This body heats the oil in the crankcase in two common ways:

1. Heating body in the shape of a finger, which is entered to the crankcase.
2. Heating body in the shape of a circle, which surrounds the compressor from the outside in the crankcase area.

The crankcase heater receives control directly from the main electricity outlet with no switch. The heater works only when the compressor is idle.

When the system is idle, and the crankcase heater works, tiny bubbles rising upwards can sometimes be seen through the control eyepiece. The oil is kept in a diluted state and ready to flow constantly, and the cooling material boils and kept in a gas state.

Huge systems cannot be operated without checking and making sure that the crankcase heater has been working for a minimal number of hours required for heating the oil. Ignoring this is hazardous to the compressor.

In domestic cooling and air-conditioning systems, the amount of liquid is small and the above problem is not hazardous to the compressor, so they do not utilize crankcase heater.

7. Discussion: **Compressor protection safety devices**

Compressors may be damaged when cooling liquid flows to them from the suction line accidently. The refrigerant must be in a steam state, and the steam temperature must be higher than the temperature in the evaporator. A rise in temperature means that the evaporator is superheated.

There are many devices for preventing or minimizing the liquid flow from the suction line to the compressor:

- Drops separator – ensures that liquid will not go to the compressor.
- Warm gas bypass valve to remove the warm gas to the suction line.
- Temperature sensing device (OL – Over Load).
- Electrical heating for heating the liquid in the suction line.

8. Procedure:

Step 1: Check that the PROFESSIONAL AIR CONDITIONING PANEL 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-SEG. 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

In this experiment the compressor cycle is checked for time in thermostat control and in low pressure pressurestat control.

It will be checked in two speeds of the evaporator fan and with and without thermal load.

TEV mode:

Step 11: Change the STATE number to 11 (for °C) or 12 (for °F) and press ENTER.

Step 12: Lower the PROGRAM switch and raise it.

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

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

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

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

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.

Thermostat control:

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.

Observe this sight glass and check that there are no bubbles and the SP value reached the stabilization point.

Step 14: The cooling chamber temperature should continue to go down even after the SP is stable.

Observe that.

Step 15: The chamber temperature T6 goes down as long as the system is cooling (the compressor works).

The compressor should turn OFF when the chamber temperature reaches the S1 (Setup Point) and should turn ON when the chamber temperature goes over S1 + D1.

The default value of S1 is 20°C (68°F), the default value of D1 is 5°C (9°F).

Check that.

Step 16: See what happens when the cooling chamber temperature reaches the S1 point.

Step 17: Record the pressures and temperatures and measure the time.

Step 18: Wait until the compressor turns OFF.

Step 19: Record the pressures and temperatures and the compressor OFF time.

Step 20: Wait until the compressor turns ON.

Step 21: Record the pressures and temperatures and the compressor ON time.

Step 22: Press the '*' key and check that the evaporator fan (E1) changes to HI.

Step 23: Wait until the compressor turns OFF.

Step 24: Record the pressures and temperatures and the compressor OFF time.

Step 25: Wait until the compressor turns ON.

Step 26: Record the pressures and temperatures and the compressor ON time.

Step 27: Press the '*' key again and check that E1 is changed into 'LO'.

Step 28: Fill in the following table with the stabilization point's values of the two setup points.

No.	Comp.	E1	Time	S1	D1	LP	HP	T1	T2	T3	T4	T5	T6
1.	ON	LO											
2.	OFF	LO											
3.	ON	HI											
4.	OFF	HI											

Step 29: The system at 11-16 states allows you to change the S1 value in a certain range.

Key in the number 17 (if you are in °C) or 62 (if you are in °F) and key '#'.

Step 30: Change the state no. to 11 or 12 accordingly.

Step 31: Wait until the compressor stops working.

Step 32: Record the pressures and temperatures and the compressor OFF time.

Step 33: Wait until the compressor turns ON.

Step 34: Record the pressures and temperatures and the compressor ON time.

Step 35: Change the fan speed to High.

Step 36: Wait until the compressor turns OFF.

Step 37: Record the pressures and temperatures and the compressor OFF time.

Step 38: Wait until the compressor turns ON.

Step 39: Record the pressures and temperatures and the compressor ON time.

Step 40: Fill in the following table with the stabilization point's values of the two setup points:

No.	Comp.	E1	Time	S1	D1	LP	HP	T1	T2	T3	T4	T5	T6
1.	ON	LO											
2.	OFF	LO											
3.	ON	HI											
4.	OFF	HI											

Step 41: Change the STATE number to 14 (for °C) or 15 (for °F) and press ENTER

This will operate the thermal load.

Step 42: Change ST back to 20 (if you are in °C) or 68 (if you are in °F).

Step 43: Repeat steps 15-40 and measure the compressor on time, off time, temperatures and pressures for two fan speed and with and without thermal load.

Step 44: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it.

All the devices should shut OFF.

Step 45: Wait 5 minutes.

Low pressure pressurestat control:

At states 21-26 the control is done according to LP (Low pressure) value.

Step 46: Change the STATE no. to 21 (for °C) or 22 (for °F) and press ENTER.

Step 47: Lower the PROGRAM switch and raise it.

Step 48: 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

S1	D1	S2	D2	SP	PD	E1	L1	E2	RT
				33	17	LO			

LP	HP	T1	T2	T3	T4	T5	T6	T7	T8

Step 49: Observe the temperature and pressure values and wait for the system to stabilize.

Step 50: When LP is at a stable point, record the temperature and pressure values at the stabilization point.

The cooling chamber temperature should continue to go down.

Step 51: Wait until the compressor stops working.

Step 52: Record the pressures and temperatures and measure the time.

Step 53: Wait until the compressor turns ON.

Step 54: Record the pressures and temperatures and the compressor OFF time.

Step 55: Wait until the compressor turns OFF

Step 56: Record the pressures and temperatures and the compressor ON time.

Step 57: Press the '*' key and check that the evaporator fan (E1) changes to HI.

Step 58: Wait until the compressor turns OFF.

Step 59: Record the pressures and temperatures and the compressor ON time.

Step 60: Wait until the compressor turns ON.

Step 61: Record the pressures and temperatures and the compressor OFF time.

Step 62: Press the '*' key again and check that E1 is changed into 'LO'.

Step 63: Fill in the following table with the stabilization point's values of the two setup points:

No.	Comp.	E1	Time	S1	D1	LP	HP	T1	T2	T3	T4	T5	T6
1.	ON	LO											
2.	OFF	LO											
3.	ON	HI											
4.	OFF	HI											

Step 64: The system at 21-26 states allows you to change the SLP value in a certain range.

Key in the number 20 and key '#'.

Step 65: Change the STATE no. to 21 or 22.

Step 66: Wait until the compressor stops working.

Step 67: Record the pressures and temperatures and the compressor OFF time.

Step 68: Wait until the compressor turns ON.

Step 69: Record the pressures and temperatures and the compressor ON time.

Step 70: Change the fan speed to High.

Step 71: Wait until the compressor turns OFF.

Step 72: Record the pressures and temperatures and the compressor OFF time.

Step 73: Wait until the compressor turns ON.

Step 74: Record the pressures and temperatures and the compressor ON time.

Step 75: Fill in the following table with the stabilization point's values of the two setup points.

No.	Comp.	E1	Time	S1	D1	LP	HP	T1	T2	T3	T4	T5	T6
1.	ON	LO											
2.	OFF	LO											
3.	ON	HI											
4.	OFF	HI											

Step 76: Change the STATE number to 24 (for °C) or 25 (for °F) and press ENTER

This will operate the thermal load.

Step 77: Change SP back to 33.

Step 78: Repeat steps 55-77 and measure the compressor on time, off time, temperatures and pressures for two fan speed and with and without thermal load.

Step 79: Change the STATE no. to 00 and press ENTER.

Lower the PROGRAM switch and raise it.

All the devices should shut OFF.