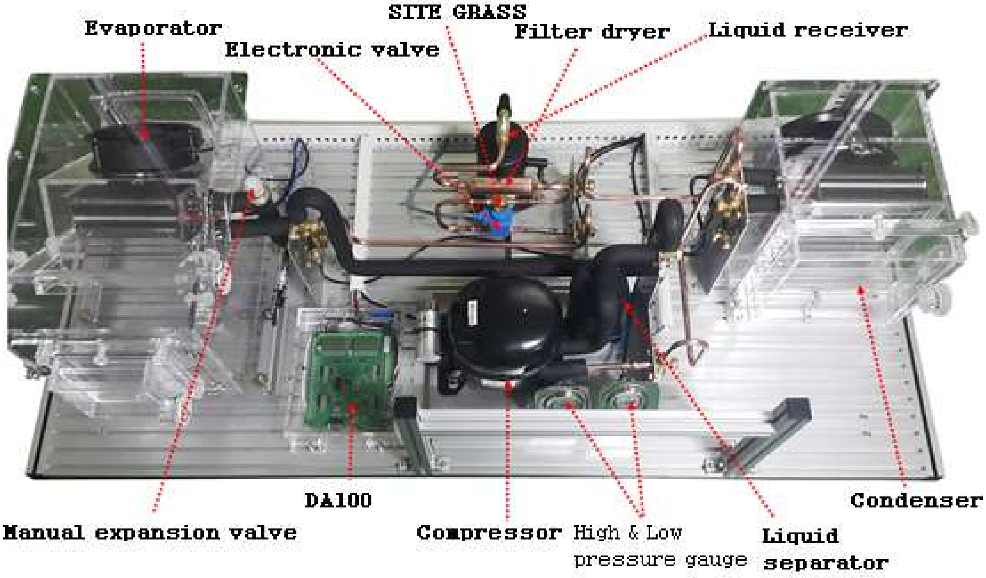
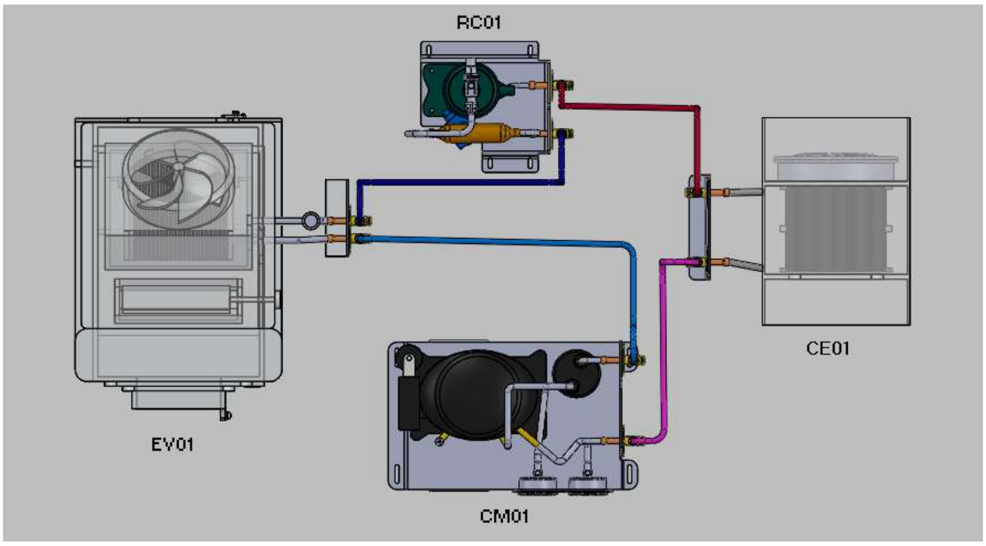
Model : KTE-1000MO

Refrigeration Experiment Apparatus





Korea Technology Institute of Energy Convergence

Korea Technology Engineering Co.,Ltd.

◀ CONTENT ▶

Chapter 1. Description of Refrigeration system

1-1. Description of Refrigeration System 1
1-2. Component of mechanical Refrigeration system 2
1-3. Control panel device component of Refrigeration system 14

Chapter 2. How to way operating equipment and DA100 & Coolpack

2-1. Drawing a P-h diagram using Coolpack 21

Chapter 3. Experiment and Analysis of Refrigeration system

3-1. Basic experiment of Refrigeration system 30
3-2. Measurement of cooling performance according to condensation temperature change 37
3-3. Measurement of cooling performance according to evaporation temperature change .. 41

Chapter 4. Practice of automatic control using sequence and PLC training

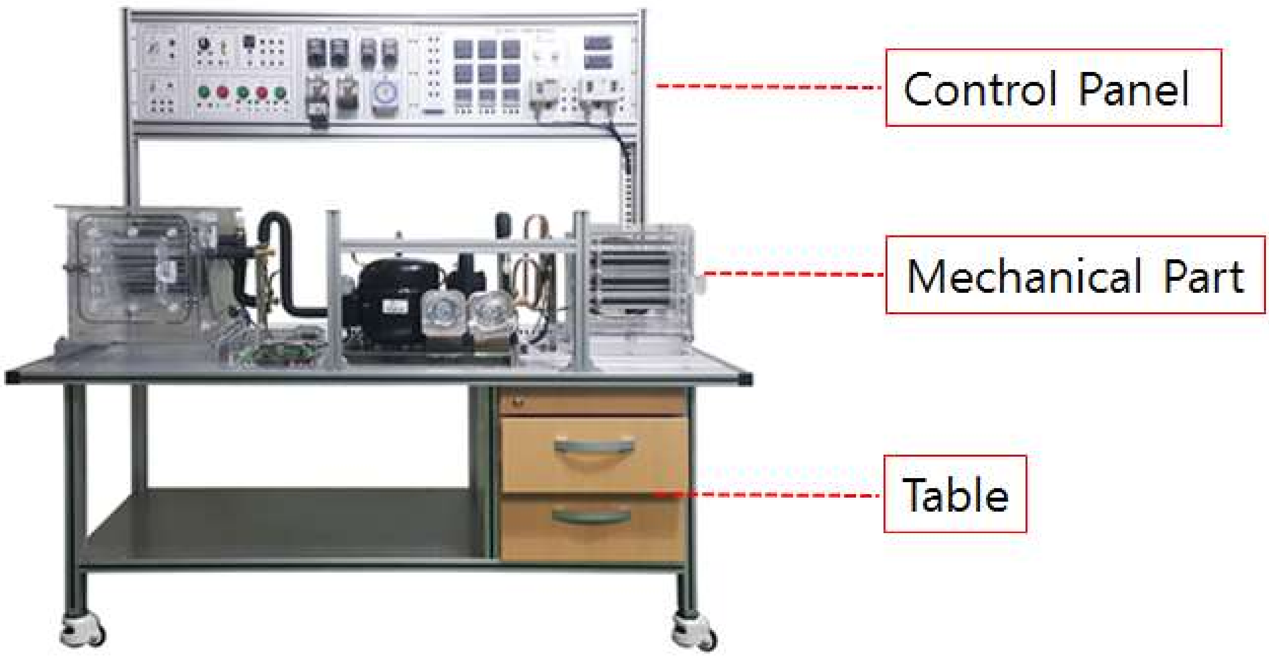
4-1. Practice to configuration self-holding circuit for priority STOP of using sequence control 44
4-2. Practice to configuration of temperature switch using sequence control 46
4-3. Practice to configuration of low pressure switch(LPS) using sequence control 51
4-4. Practice to configuration of high pressure switch using sequence control 58
4-5. Practice to configuration of HPS on pressure switch using sequence control 63
4-6. Practice to configurate direct circuit for low temperature (T_S/W) and low pressure (LPS) control with Refrigeration system 67
4-7. Practice to configuration of pump down control circuit using sequence control 73

Chapter 5. Notice and Guarantee

1. Mechanical trouble and measures 78
2. Caution Notice on operation 78
◎ Warrantee and A/S application sheet 80

Chapter 1. Description of Refrigeration system

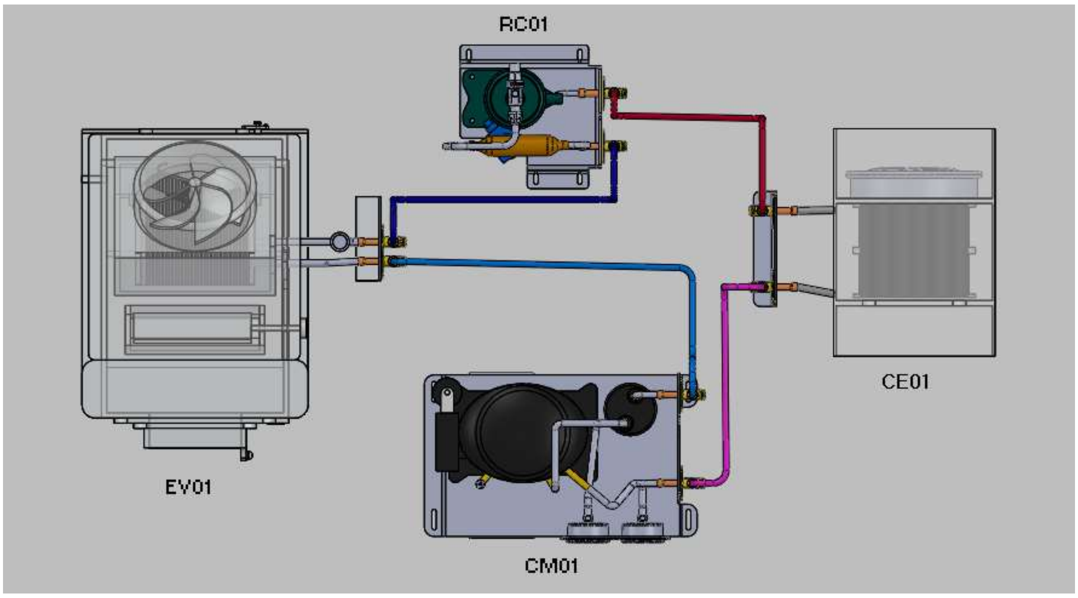
1-1. Description of Refrigeration System



1. CONTROL PANEL : Comosition with N.F.B, Toggle Switch, Am.Vm meter, Buzzer, Lamps(Red, Green, Orange), High.Low Pressure Switch, Magnetic Contactor, Relays, Thermal Switch, Push Buttons, Power Input, these devices make the Refrigeration system run by several electric circuit.

2. MECHANICAL REFRIGERATION : Composition with Compressor, Condenser(with fan motor), Receiver, Filter-dryer, Sight glass, Solenoid Valve, Manual expansion Valve, Evaporator(with fan motor), High.Low pressure gauge, these devices run as set up circuit in Control panel.

1-2. Component of mechanical Refrigeration system



① CM01 : Compressor module

② RC01 : Liquid receiver module

③ EV01 : Evaporator modul

④ CR01 : Condenser module

- Description of Serial and Part number

CM00	Compressor Module	CM01	BA.HD.MO.EV,AHU Applied
		CM02	BR.EP. Applied
CE00	Condenser Module	CE01	BA.HD.MO.EV,AHU Applied
		CE02	BR.EP Applied
RC00	Liquid Receiver Module	RC01	Applied entire equipment
		RC02	BR,EP Applied
EV00	Evaporator Module	EV01	BA.MO.HD.EV.EP Applied
		EV02	AHU Applied
		EV03	BR Applied
		EV04	LT Applied

(1) Compressor Module   Serial No: CM01

Compressor Module

(2) Condenser Module   Serial No : CE01

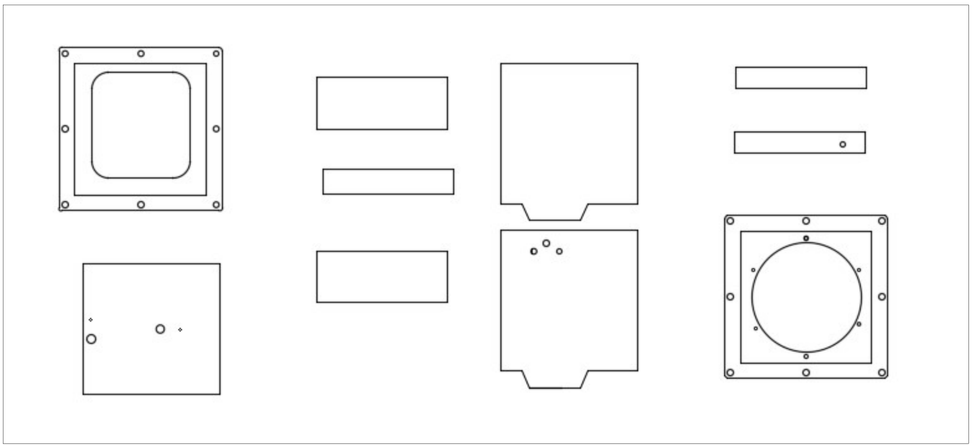
Condenser Module

CE0101: Stainless Steel Bracket
2T SUS consist of three plate W140mm* D35mm* H285m * 1SET
The stainless steel bracket is constructed to fix the acrylic chamber, bottom plate, and service valve and to practice the piping connection with the flare nut.

CE0102: Stainless Steel Bracket fixed bolt
M6*18 * 6EA

CE0103: Acrylic Chamber
Transparent acrylic chamber 8T, 250(W) × 260(D) × 300(H)mm * 1EA
The condenser emits and condenses the refrigerant gas heat at the high temperature and pressure from the compressor to the air at the room temperature. It condenses and liquidizes the heat of gaseous refrigerant through the heat exchange between the gaseous

refrigerant at the high temperature and pressure from the compressor and the surrounding air or cooling water. The condenser emits the hot blow as the external device. The refrigerant gas from the compressor is liquidized to the refrigerant liquid. The condenses the refrigerant gas from the compressor at the high temperature and pressure to the liquid refrigerant at the high temperature and pressure through the heat exchange between the refrigerant gas and water or air at the room temperature. The reason to change the refrigerant gas to the liquid state is to use the latent heat during the change of state. The highest volume of heat can be taken from the evaporator when using the latent heat, that is, when the liquid state is changed to the gaseous state. If the condenser is installed in the place with too higher external temperature or lower ventilation because of foreign substances, the condensing temperature and pressure become increased so that the evaporator will not work properly. Thus, the refrigeration effect can be improved when the condenser is installed near the compressor and on the place that is well ventilated without direct sunlight. The condenser requires the special attention for more effective heat exchange with the external air through the regular fan cleaning. The condenser receives, condenses and liquidizes the refrigerant gas from the compressor. Higher refrigeration effect(that is, if the heat exchange between the coolant and refrigerant gas is well processes) of the condenser reduces the temperature and condensing pressure inside the condenser. The condenser works at the constant condensing temperature as the volume of refrigerant gas from the compressor keeps the balance with the cooling operation of condenser.



View of Chamber

CE0104: Chamber fixed bolt
M6*36 * 4EA

CE0105: Heat Exchanger
Fin-tube air-cooled Type, Surface area 1.5㎡, Fin-Pitch 2.5mm,
Tube 3/8″× 7step × 3row × 165EL * 1EA

CE0106: Fan Motor
220q AC220V 50/60Hz 0.38/0.39A 49/50W * 1EA

CE0107: Fan Motor fixed bolt
M3*70 cross * 4EA

CE0108: Service Valve of Condenser Inlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

CE0109: Service Valve of Condenser Outlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

CE0110: Service Valve fixed bolt
M6*18 * 4EA

CE0111: Pressure Sensor of Condenser Outlet
5V Input to 0.5~4.5V Output, 8~30V Input 4~20mA, to 1~5V Output * 1EA
Range : -1~35kgf/cm2

CE0112: Temperature Sensor of Condenser Inlet
Thermo-Couple K-Type 032q * 1EA

CE0113: Temperature Sensor of Condenser Outlet
Thermo-Couple K-Type 032q * 1EA

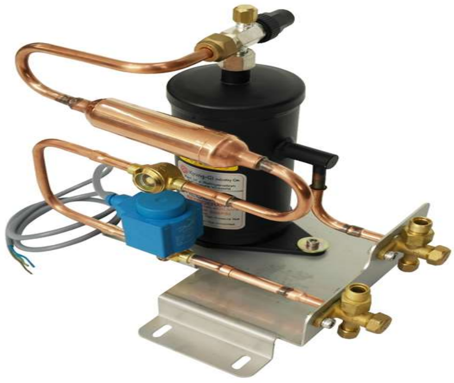
CE0114: Cooper pipe of Condenser Inlet
3/8 inch bending cooper tube * 1EA

CE0115: Cooper pipe of Condenser Outlet
3/8 inch bending cooper tube * 1EA

CE0116: Nipple
3/8 inch Nipple * 2EA
The charging nipple is the requisite to use the manifold gauge for the airtight and vacuum tests and refrigerant filling and transferring of the refrigeration test equipment. It is attached to the low and high pressure ducts on the mechanical compressor output and input sides. Before soldering the charging nipple to the high and low pressure ducts on the compressor output and input sides, the internal rubber(for keeping the airtight state) ring is removed and set again after refrigeration.

(3) Liquid Receiver Module

Serial No : RC01



Liquid Receiver Module

RC0101: Stainless Steel Bracket
2T SUS consist of three plate W140mm* D35mm* H285m * 1SET
The stainless steel bracket is configured to fix the module, bottom plate, and service valve including the liquid receiver, filter dryer, sight glass, and solenoid valve, and to connect the pipe with the flare nut.

RC0102: Stainless steel fixed bolt
M6*18 * 4EA

RC0103: Liquid Receiver
Cylinder Type, Included service valve
capacity : 1/2 Hp, pressure : 22kgf/cm2, Proof test : 33kgf/cm2
Confidential Pressure : 22kgf/cm2G, Available : 75℃, ∅90mm * 1EA
Liquid receiver is a liquid refrigerant reservior before send refrigerant to expansion valve. It play a role to make system stable as send only liquid refrigerant and can pump down to retrieve refrigerant or for repair a equipment.

RC0104: Liquid Receiver fixed bolt
M6*18 * 3EA

RC0105: Service Valve

RC0106: Service Valve Inlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

RC0107: Service Valve Outlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

RC0108: Service Valve fixed bolt
M6*18 * 4EA

RC0109: Filter Drier
⅜"Welding Type * 1EA,
Any moisture or impurities that exist in the refrigerants have a variety of negative impacts on the refrigerators. Then, the filter drier removes moisture or impurities. It is installed between the expansion valve and the receiver.

RC0110: Sight Glass
Welding Type * 1EA
Sight glass is installed between receiver and expansion valve is used to confirm the amount of refrigerant charging. If the amount of charging is good. cannot see any bubbles through the sight glass, only can see the flow of pure liquid.

RC0111: Solenoid Valve
⅜" Welding Type * 1EA
The electronic valve for main duct controls the refrigerant flow as it is opened or closed depending on the power input. It is connected to the temperature switch in eries during the pump-down operation. In this case, the pump-down operation is processed by the opening or closing of the electronic valve for the main duct according to the closing or opening of temperature switch contact.

RC0112: Flare Nut
Size 3/8 inch * 1EA

RC0113: Cooper pipe to liquid receiver and service valve
3/8 inch bending cooper tube * 1EA

RC0114: Cooper pipe to liquid receiver and filter drier
3/8 inch bending cooper tube * 1EA

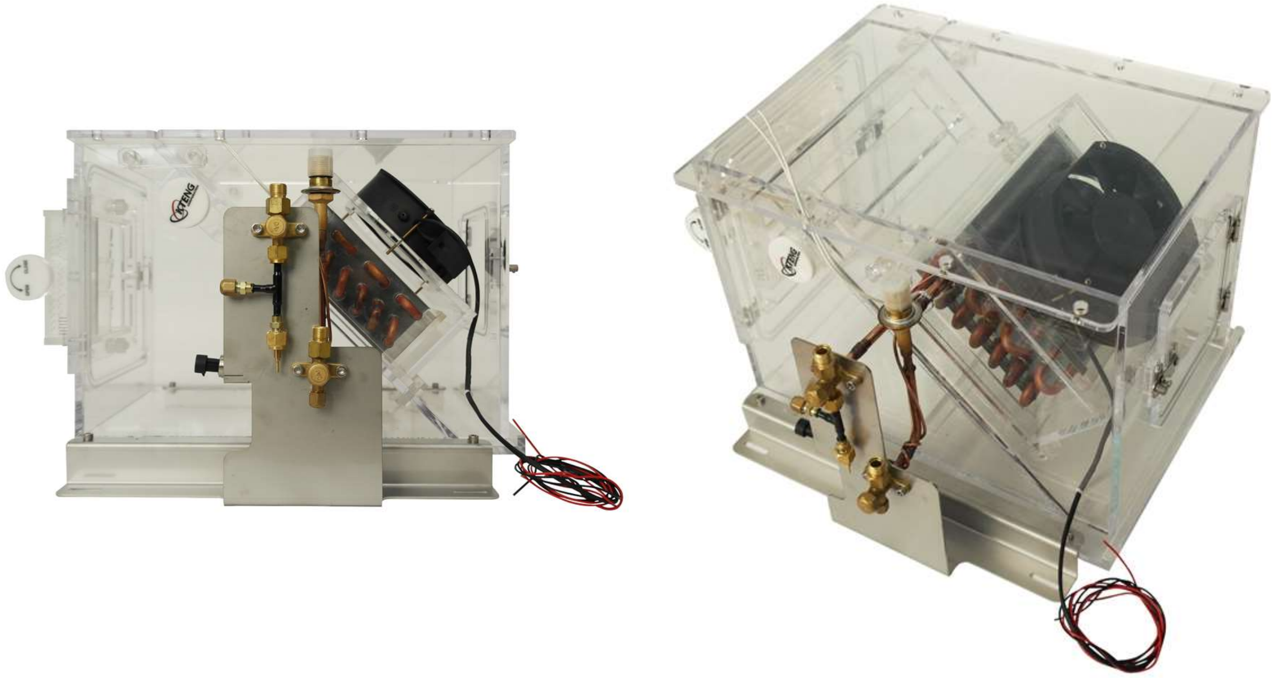
RC0115: Cooper pipe to filter drier and sight glass
3/8 inch bending cooper tube * 1EA

RC0116: Cooper pipe to sight glass and solenoid valve
3/8 inch bending cooper tube * 1EA

RC0117: Cooper pipe to solenoid valve and service valve

3/8 inch bending cooper tube * 1EA

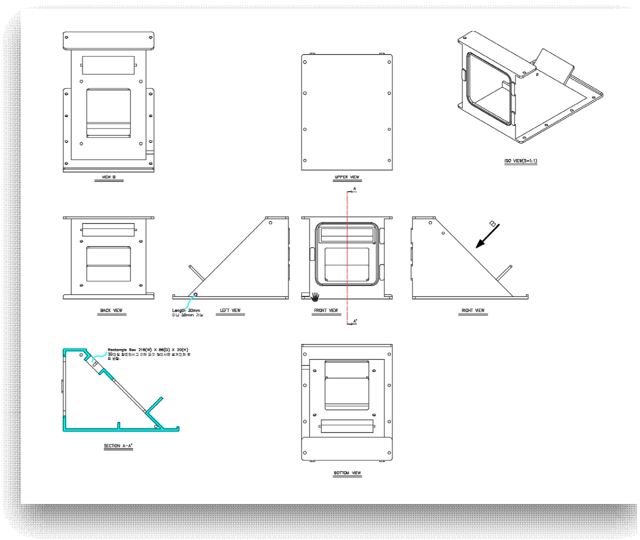
(4) Evaporator Module　　Serial No : EV01



Evaporator Module

EV0101: Stainless Steel Bracket
2T SUS consist of three plate W140mm* D35mm* H285m * 1SET
The stainless steel bracket is designed to fix the bottom plate and the service valve supporting the heat exchanger, fan motor, and acrylic chamber, and to practice the pipe connection with the flare nut.

EV0102: Bottom of Chamber

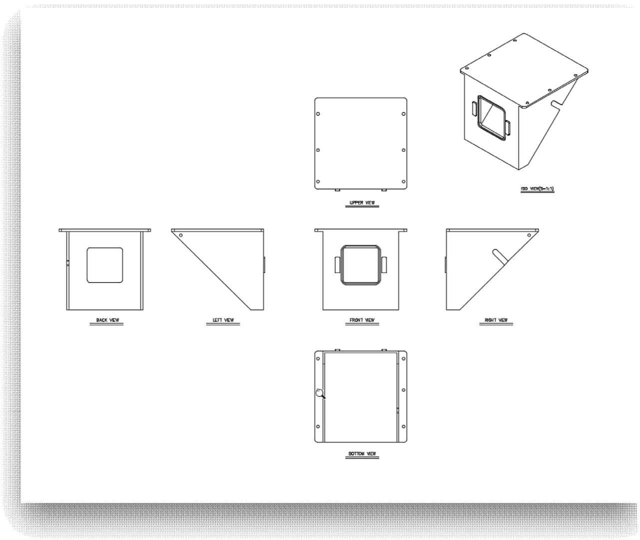


- Configuration
  Bottom plate of Chamber, Heat Exchanger Case, Fan Motor Case, Front Cover, Front damper, Middle of nobe
- Material : Acrylic
- Feature : The bottom and top of the chamber can be seperated and the heat exchanger coil and blower can be replaced the repaired.
- The lower part of the acrylic chamber is the main chamber of the evaporator chamber and is equipped with a heat exchanger and a fan motor for heat exchange experiments.
- The front cover has a damper made of a

Bottom View of the Chamber

rack pinion gear, and the load change experiment is carried out by adjusting the damper opening degree from 0 to 100 %.

EV0103: Top of Chamber



Top View of the Chamber

- Configuration

  It consists of chamber top plate, back door, main chamber and fixed bridge, which are assembled with the bottom of the chamber.
- Material : Acrylic
- Feature : The bottom and top of the chamber can be seperated and the heat exchanger coil and blower can be replaced the repaired.
- The lower part of the acrylic chamber is the main chamber of the evaporator chamber, and was equipped with a heat exchanger and a fan motor to perform heat exchange experiments.
- There is a damper made of a rack pinion gear, and the load change experiment is carried out by adjusting the damper opening degree from 0 to 100 %.

EV0104: Heat Exchanger

Fin-tube air-cooled Type, Surface area 1.5㎡, Fin-Pitch 2.5mm,

Tube 3/8″× 7step × 3row × 165EL * 1EA

EV0105: Heat Exchanger cover

It is made of acrylic material, and fan motor is attached to the cover, and the load change experiment is carried out by controlling the motor speed. * 1EA

EV0106: Chamber connection accessories

It is a part that connects the upper part and the lower part of the acrylic chamber, and is configured to be fixed to both the left and right sides.

Fix with bolts and nuts made of acrylic material, * 2EA

EV0107: Acrylic Bolt

Front cover and main chamber connection * 8EA

Heat exchanger fixed case and main chamber connection * 4EA

Chamber top and bottom connection * 4EA

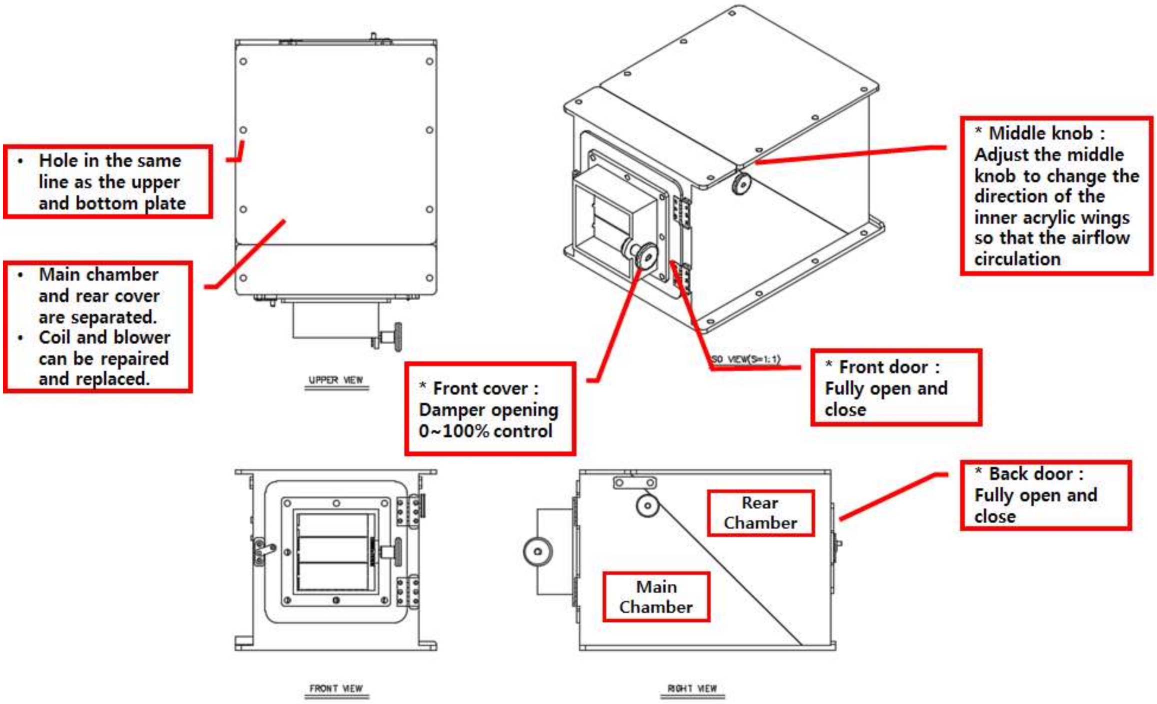
EV0108: Chamber open/close part
Material : Acrylic * 1EA

EV0109: Front door
It is connected to the main chamber and can bel fully opend and closed.
The load can be controlled * 1EA

EV0110: Back door
It is connected to the upper part of the chamber, and it is fully opened and closed, and external air can be introduced into the chamber to perform the load change experiment. * 1EA

EV0111: Front damper
It is connected to the front cover and is made of rack pinion gear type.
Although the front door can bel fully opened or closed, the opening rate can be adjusted for more precise load control. and the experiment can be performed in 6 steps as 0 % (Close), 20 %, 40 %, 60 %, 80 %, 100 % (Open) * 1EA

EV0112: Middle knob
It is role that serves to circulate air between the upper and lower sides of the acrylic chamber. * 1EA



Structure and Features of Acrylic Chamber

EV0113: Hinge

It is the part that connects the front door and back door to the upper and lower sides of the acrylic chamber, and it is necessary when fully opening and closing for the load change experiment. * 4EA

EV0114: Latch

It is used when completely closing the front door and the back door, and is mainly used for the refrigeration experiment.

EV0115: Fan motor

220q AC220V 50/60Hz 0.38/0.39A 49/50W * 1EA

EV0116: Fan Motor fixed bolt

M3*70 cross * 4EA

EV0117: Defrost electrical heater

It is located between the heat exchanger coil and the pin, and when the refrigeration experiment is carried out for a long time, the heat exchanger pins are inserted between the pins. In this case, the heat exchanger does not work smoothly, and it removes it through the thermal defrosting.

Thermal capacity : 500 W, * 1EA

EV0118: Stainless Steel Bracket fixed bolt, M6*18 * 4EA

EV0119: Chamber fixed bolt, M6*18 * 8EA

EV0120: Manual Expansion Valve

Manual Expansion Valve capacity range : 1/2 ~ 1,1/2tons, Temp 0℉(-10℃) * 1EA

The high-temperature, high-pressure liquid refrigerant is adiabatically expanded with a low-temperature, low-pressure liquid refrigerant so as to easily evaporate in the evaporator.

EV0121: Manual expansion valve inlet pipe

3/8 inch bending cooper tube * 1EA

EV0122: Evaporator inlet pipe

3/8 inch bending cooper tube * 1EA

EV0123: Evaporator outlet pipe

3/8 inch bending cooper tune * 1EA

EV0124: Pressure sensor capillary

EV0125: Expansion valve outlet pressure sensor
5V Input to 0.5~4.5V Output, 8~30V Input 4~20mA, to 1~5V Output * 1EA
Range : -1~35kgf/cm2

EV0126: Expansion valve inlet temperature sensor
Thermo-Couple K-Type 032q * 1EA

EV0127: Evaporator inlet temperature sensor
Thermo-Couple K-Type 032q * 1EA

EV0128: Evaporator outlet temperature sensor
Thermo-Couple K-Type 032q * 1EA

EV0129: Service valve inlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

EV0130: Service valve outlet
3/8 inch 3-way valve, Strongly fixed to bracket * 1EA

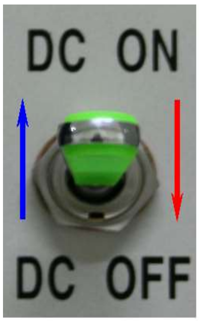
EV0131: Service valve fixed bolt
M6*18 * 4EA

EV0132: Nipple
3/8 inch nipple * 2EA
The charging nipple is the requisite to use the manifold gauge for the airtight and vacuum tests and refrigerant filling and transferring of the refrigeration test equipment. It is attached to the low and high pressure ducts on the mechanical compressor output and input sides. Before soldering the charging nipple to the high and low pressure ducts on the compressor output and input sides, the internal rubber(for keeping the airtight state) ring is removed and set again after refrigeration.

1-3. Control panel device component of Refrigeration system

(1) Main Power (N.F.B)

Main Power



Toggle Switch

The over current breaker(N.F.B) protects the compressor motor, fan motor of condenser or evaporator or wires of the refrigeration training equipment from the over current due to overloads or short circuit. The circuits are automatically cut out so that the equipment stops operation. It is not required to replace like a fuse if any cutout is occurred. The power can be immediately and easily reentered just using a handle.
After connection between equipment and power line, for flowing of current a NFB is used, and then a AC LAMP will be on. And also if a Toggle switch is on, a DATA LOG device is on.

(2) DC Volt, Ampere Meter

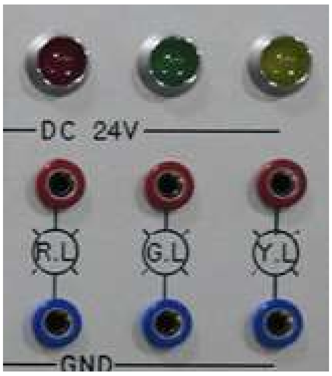
Volt meter (Analog type)

This device installed in equipment measures voltage and current by DC.

(3) Buzzer

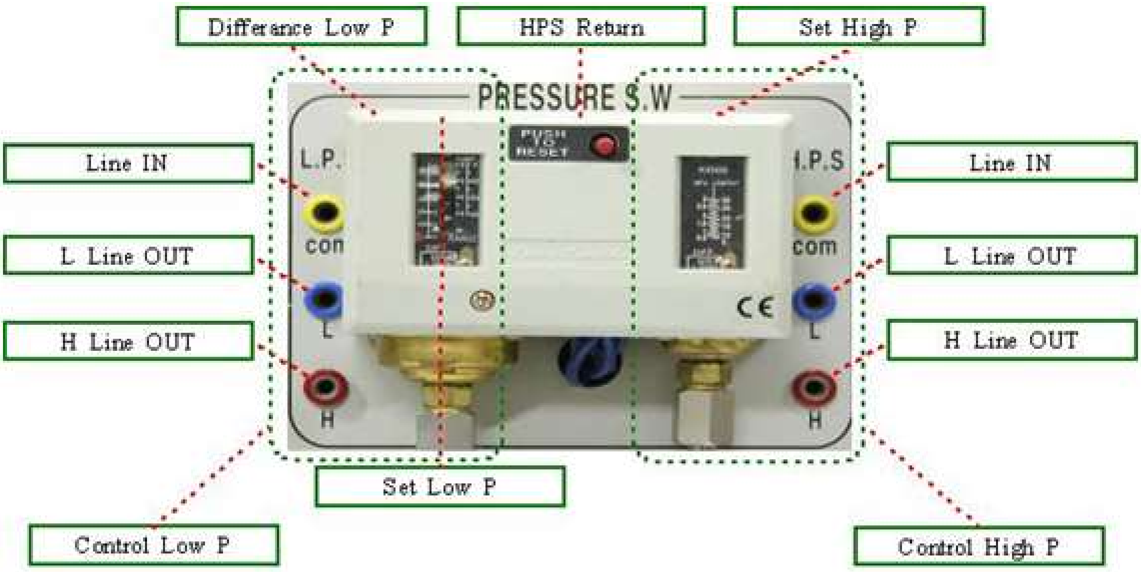
The buzzer and alarm lamp display the abnormal status when a thermal relay and safety devices(H.P.S) are working. That is, the alarm lamp is more effective than the buzzer in the noisy places and the buzzer is more effective than the alarm lamp for the color blind operators in the quiet working places. Using both the buzzer and alarm lamp will be ideal.

(4) Lamp



The power lamp(P.L) is on when the power is connected and the operating lamp (G.L) is on during the operation. the stop lamp(R.L) is on when the operation stops and the emergency lamp or alarm lamp(Y.L) displays the abnormal status during the operation such as operation of thermal relay. The reserve lamp(Y.L) circuit can be configured to be turned on when the automatic control devices such as low temperature switch, temperature control switch and condensation and pressure control switch are operating.

(5) Pressure Switch



The Dual Pressure Switch(DPS) is the set of HPB and LPS. If the high pressure is over a certain level or the low pressure is below a certain level, it stops the motor for compressor. The excessively low differential pressure of LPS induces frequent setout of compressor and this is called Hunting.
On the contrary, the excessively high differential pressure of LPS extends the down time too much. So the temperature in the refrigeration room is increased. This is called Off Set.

A. L.P.S Low pressure control

In Fig. 1-22, the right part of dotted line shows setting value (RANGE) of low pressure, the other part difference (DIFF).

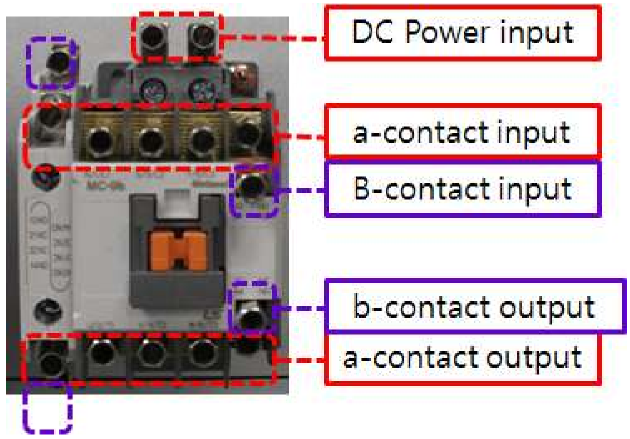
Ⓐ Set your desirable low pressure value by screw pin using screw driver.
Ⓑ Set your desirable difference value by screw pin using screw driver.
Ⓒ Connect between 'H' or 'L' and 'com' as your desirable control.
Ⓓ LPS-L Line OUT
(When the desire value is lower than your setting value, connect 'com' and 'L')
Ⓔ LPS-H Line OUT
(When the desire value is upper than your setting value, connect 'com' and 'H'.)

B. H.P.S High pressure control

Ⓐ Set your desirable high pressure value by screw pin using screw driver.
Ⓑ LPS-L Line OUT
(When the desire value is lower than your setting value, connect 'com' and 'L')
Ⓒ LPS-H Line OUT
(When the desire value is upper than your setting value, connect 'com' and 'H',

RESET : return.)

(6) Magnetic Contactor

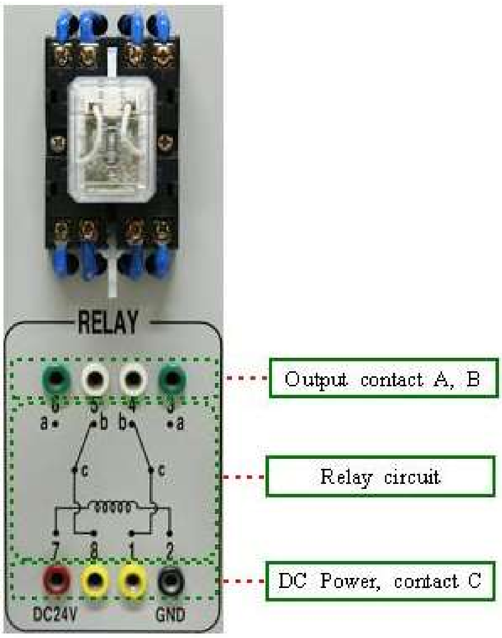


Magnetic contactor (MC) controls compressor motor, condenser motor, solenoid valve and evaporator motor through sequence circuit.

① DC Power red is +, black -.

② When DC power is on, A contact sticks to each other, so current can flow, and B contact separated, so current cut.

(7) Relay

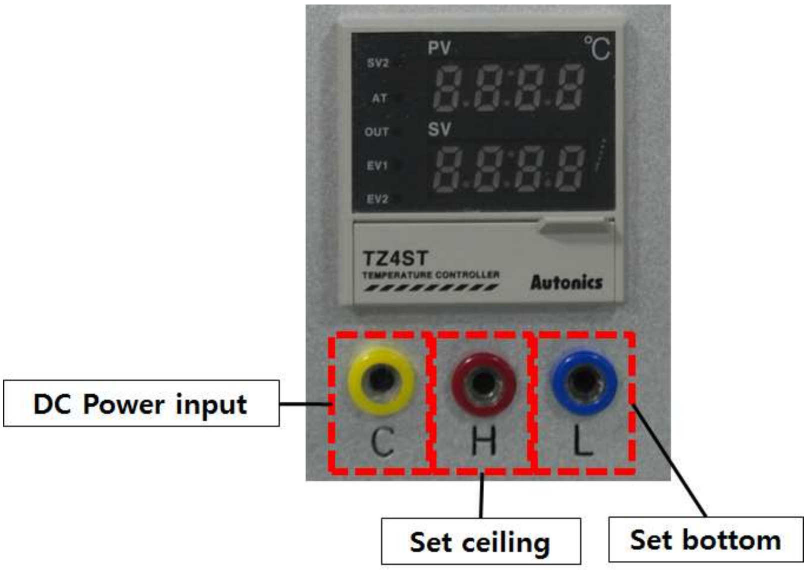


Relay controls compressor motor, condenser motor, solenoid valve and evaporator motor through sequence circuit.

① DC Power red is +, black -.

② When DC power is on, each contactor 1-3, 8-6 are connected each other (Flow current), at same time separated contactor 1-4, 8-5 each other(Close current).

(8) Temperature Switch



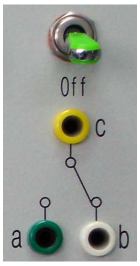
The digital temperature meter(Temp Meter) for measuring temperature measures on a defined areas for the performance test when the refrigeration training equipment is running. Then, it draws the pressure-enthalpy diagram with the measured temperature for the performance test of refrigeration training equipment. At this moment, the digital temperature meter is required to measure the temperature on each area. The performance test of refrigerator will be separately described.

① Setting temperature value by push set button.
② Choose temperature value by push up or down button.
③ Setting deviation value.
④ Connect contactor 'com' and '+ '.
⑤ Connect contactor 'H' or 'L' and '+'.

(9) On/Off Switch

This device is for start, stop, or ON/OFF.
① PB1 is for Running (A contact)
② PB2 is for Stop (B contact)

(10) Toggle Switch



This device is for start, stop, or ON/OFF.
① Connect 'C' and '+' power, operate by selection of 'a' or 'b'

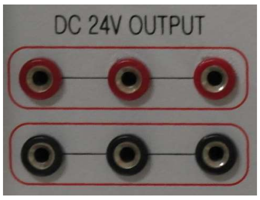
(11) Temperature Display

Comp in : Display temp. at compressor inlet
Comp out : Display temp. at compressor outlet
Exp. v. in : Display temp. at expansion valve inlet
Exp. v. out : Display temp. at expansion valve outlet
Condenser out : Display temp. at condenser outlet
Eva. v. out : Display temp. at evaporator outlet

(12) DC Power input

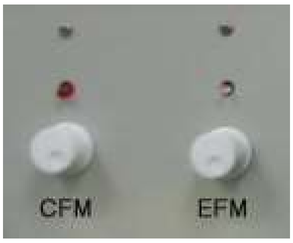
COMP : Compressor Motor
CFM : Condenser Fan Motor
EFM : Evaporator Fan Motor
SV : Solenoid Valve
EXT1,2 : Extra
Plug for electric circuit among each devices
(Red plug +, Black - .)

(13) DC Power Output



Plug for electric circuit among each devices
(Red plug +, Black -)

(14) Condenser, Evaporator Fan Motor Speed Control



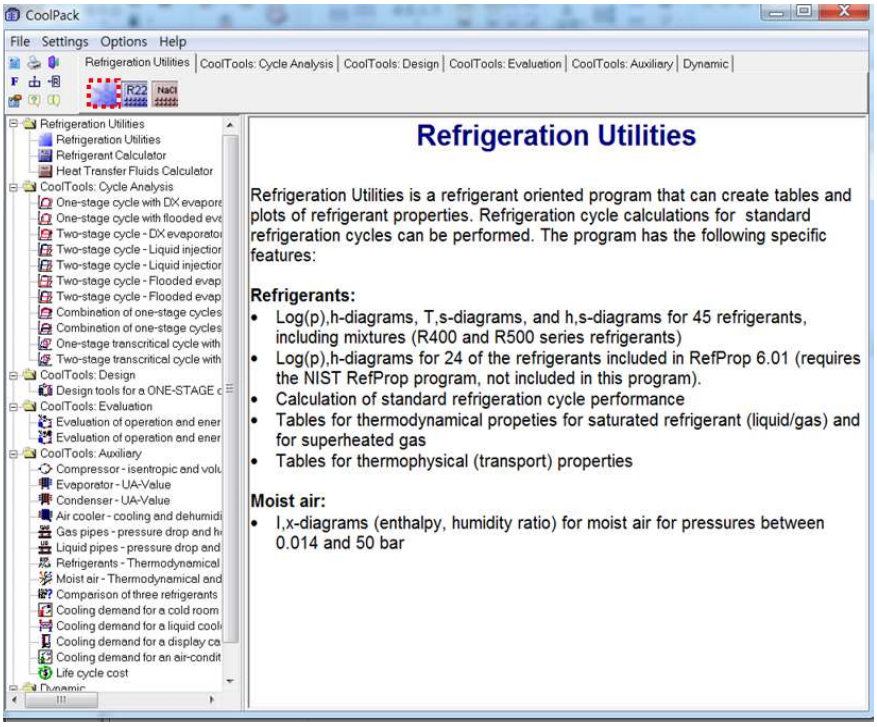
This device controls motor speed of condenser fan motor or evaporator fan motor, right turning speed up, and left turning down. Through motor speed control, efficiency of condensing or evaporating can be controled.

Chapter 2. How to way operating equipment and DA100 & Cautions

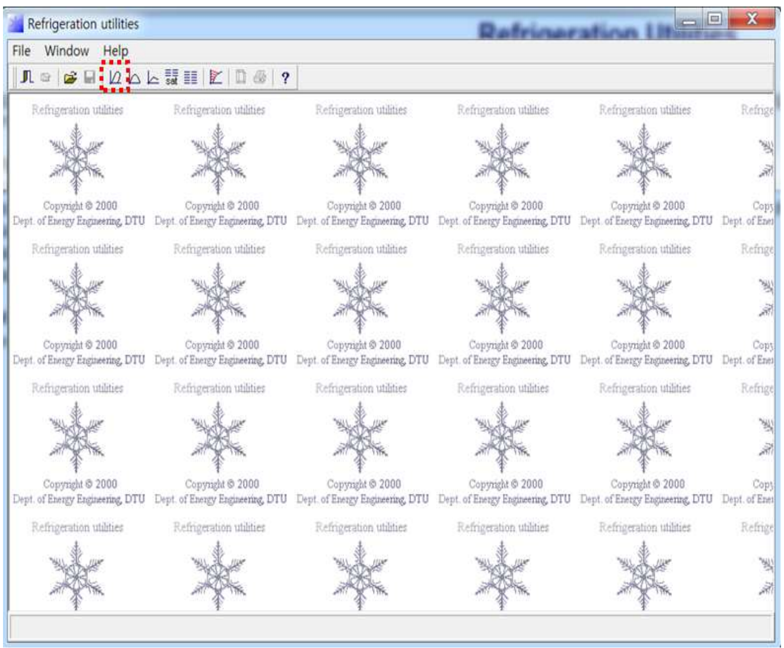
2-1. Drawing a P-h diagram using Coolpack

1. Refrigerant Utilities

① Click “Refrigeration Utilities”

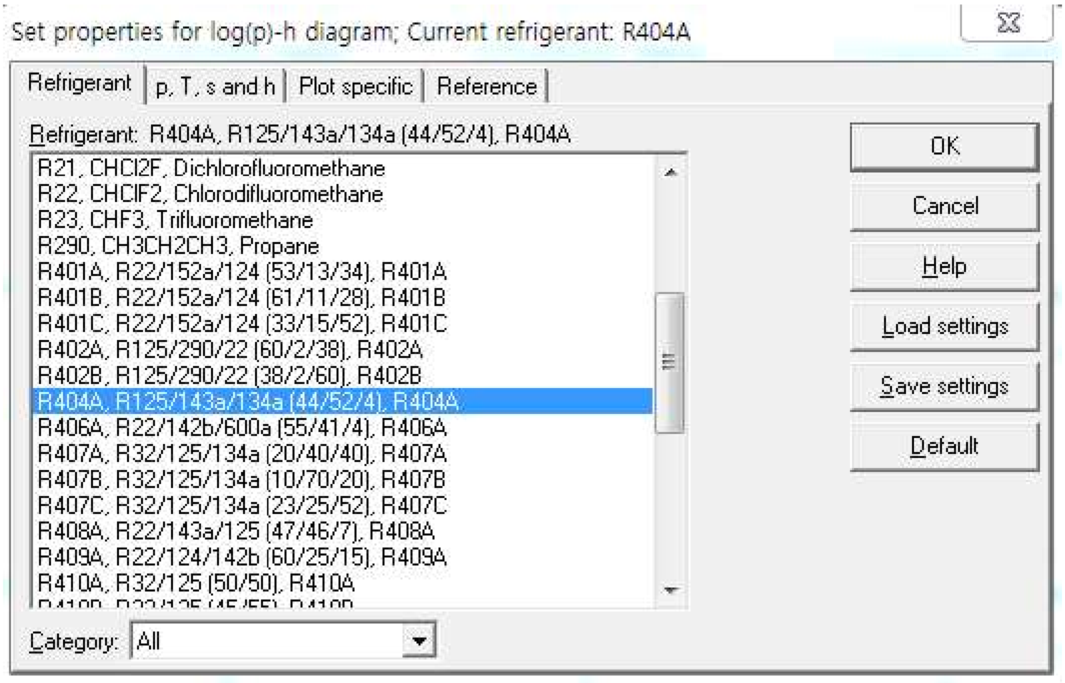


② Click a P-h diagram



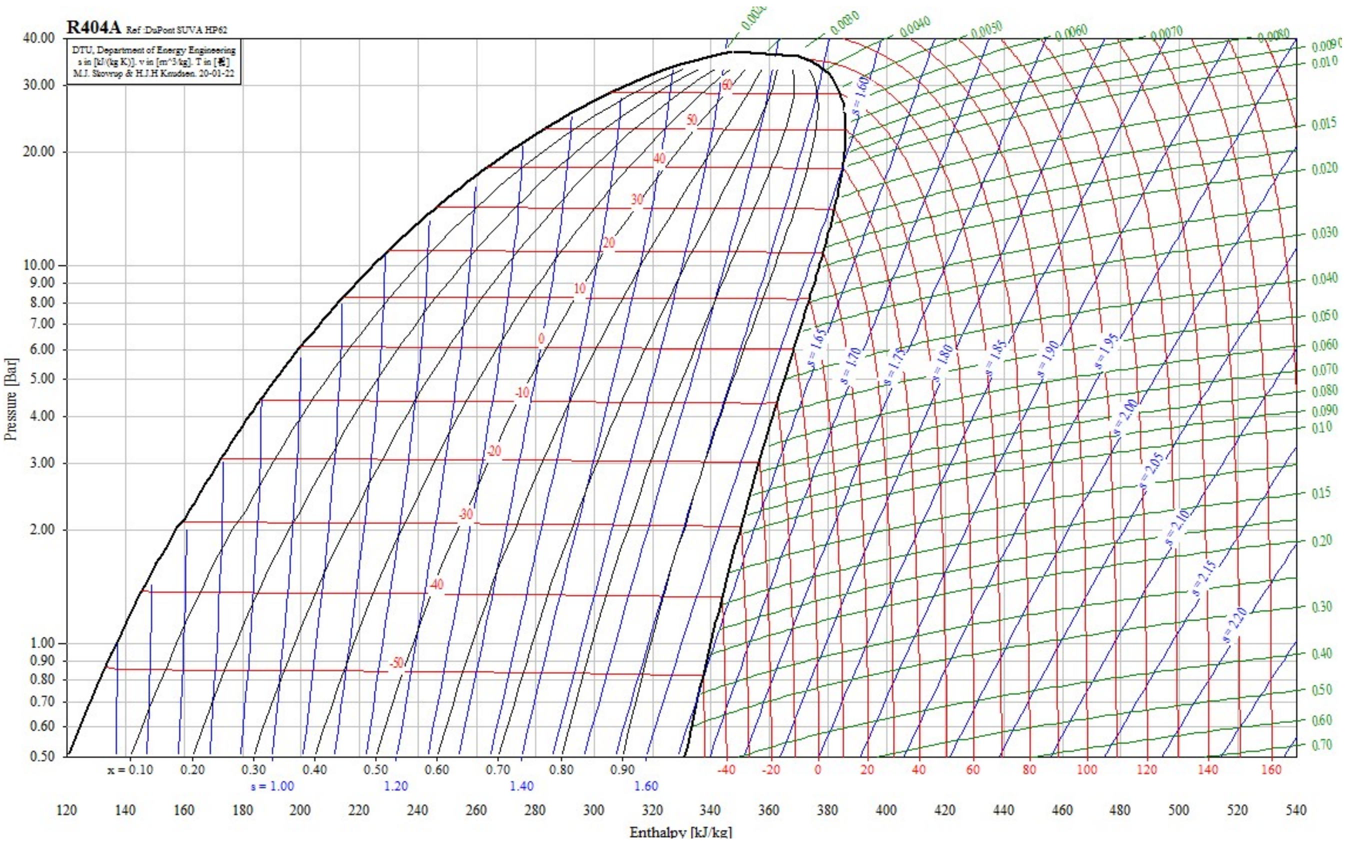
③ Click a Refrigerent (Example_**The refrigerant used varies depending on the equipment**)

- KTE-1000MO : R-404a

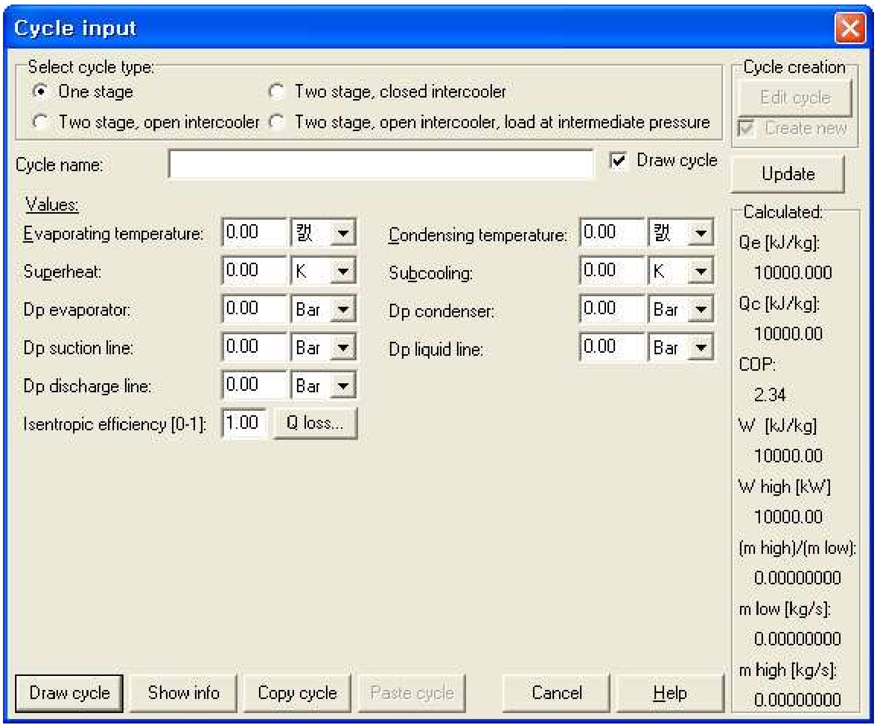


④ Click a “R-404a”

- Click “Cycle”



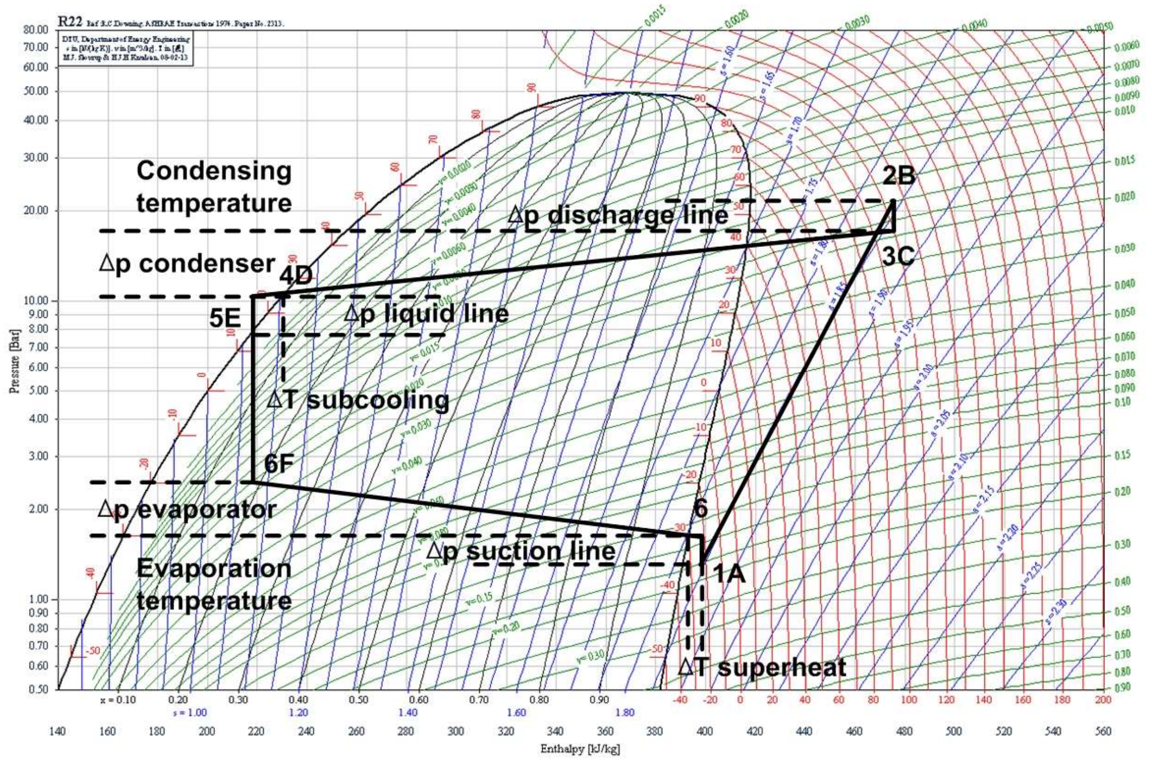
⑤ Cycle input



2. How to applicate the program

(1) Choose your respecting Refrigeration system cycle on 'Select cycle type'
  ① One stage cycle
  ② Two stage cycle
(2) Evaporating Temperature (℃) or evaporating pressure (bar) on running.
(3) Condensing Temperature (℃) or condensing pressure (bar) on running.
(4) Superheat : Superheating temperature (˚K) from outlet of evaporator to inlet of compressor.
(5) Sub Cooling : Sub cooling temperature (˚K) from outlet of condenser (or saturating line on p-h chart) to in front of expansion valve.
(6) DP Evaporator : Temperature (or pressure) Difference between outlet of expansion valve and outlet of evaporator.
(7) DP Condenser : Temperature (or pressure) Difference between inlet of condenser and inlet of expansion valve.
(8) DP Suction line : Temperature (or pressure) Difference between outlet of evaporator and inlet of compressor.
(9) DP Liquid line : Temperature (or pressure) Difference at inlet of expansion valve after isolation expansion process.
(10) DP Discharge line : Temperature (or pressure) Difference between outlet of compressor and inlet of condenser.

(11) P-h Diagram



3. Refrigeration cycle and P-h diagram

(1) Refrigeration cycle

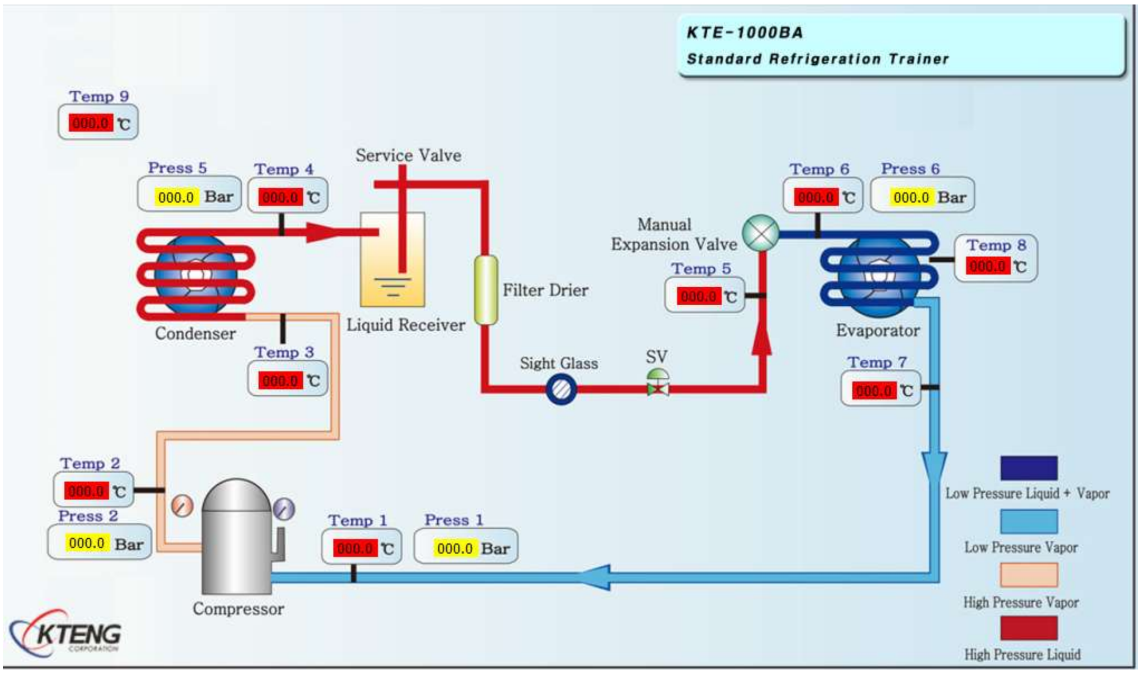


Fig. 4-1. KTE-1000MO Diagram

(2) Analysis Data

1) Data Table

Table 4-1. Data Table

Data point	Table1	Table2	Table3	Table4	Table5	Remark
Evaporation Temperature						
Superheat						
DP Evaporator						
DP Suction line						
DP Discharge						
Condensing Temperature						
Sub Cooling						
DP Condenser						
DP Liquid Line						

2) Calculate heat amount and performance note Table

Table 4-2. Calculating of heat amount and Note Table of performance

Oper Station	Compression Ratio	Refrigerating Effect		condensation Capacity		COP	Work by Compressor
		KJ/kg	Kcal/kg	KJ/kg	Kcal/kg		Kcal/kg
Table1							
Table2							
Table3							
Table4							
Table5							

4. Example drawing a P-h diagram

(1) Data measuring_Variable evaporation Temp

Table 4-3. Data measurement

Data point	Table1	Table2	Table3	Remark
Evaporation Temp	-15℃	-10℃	-5℃	
Condensing Temp	40 ℃	40 ℃	40 ℃	
Isentropic efficiency	1	1	1	
Qe [kJ/kg]	132.157	135.161	138.124	
Qc [kJ/kg]	169.933	168.734	167.675	
COP	3.5	4.03	4.67	
W [kJ/kg]	37.775	33.573	29.551	
Pressure Ratio	6.193	5.063	4.176	

(2) Data measuring_Variable Condensing Temp

Table 4-4. Data measurement

Data point	Table1	Table2	Table3	Remark
Evaporation Temp	-15℃	-15℃	-15℃	
Condensing Temp	40 ℃	30 ℃	20 ℃	
Isentropic efficiency	1	1	1	
Qe [kJ/kg]	132.157	146.855	161.083	
Qc [kJ/kg]	169.933	178.744	186.662	
COP	3.5	4.61	6.30	
W [kJ/kg]	37.775	31.889	25.578	
Pressure Ratio	6.193	4.692	3.483	

(3) Drawing solution P-h diagram

1) Drawing solution about No.1 on Table 4-3.

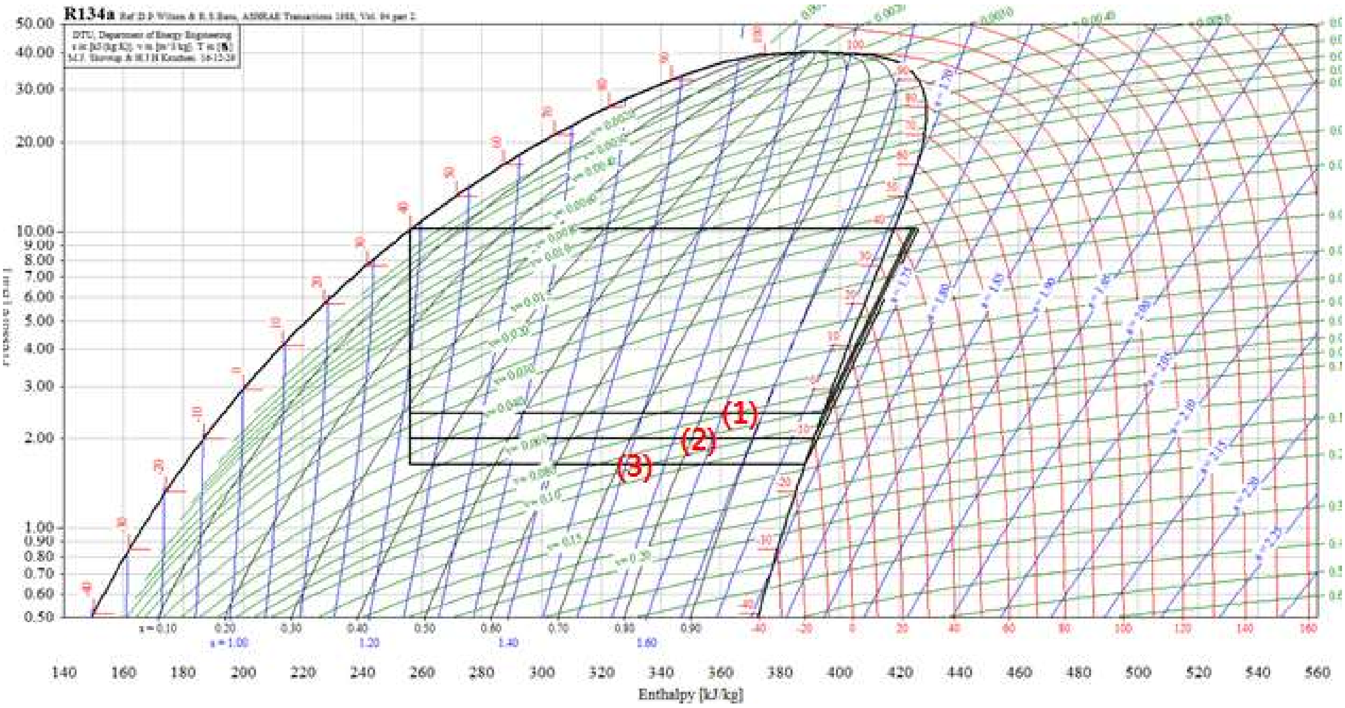


Fig. 4-3. Solution about No.1 on Table 4-3

2) Drawing solution about No.1 on Table 4-4.

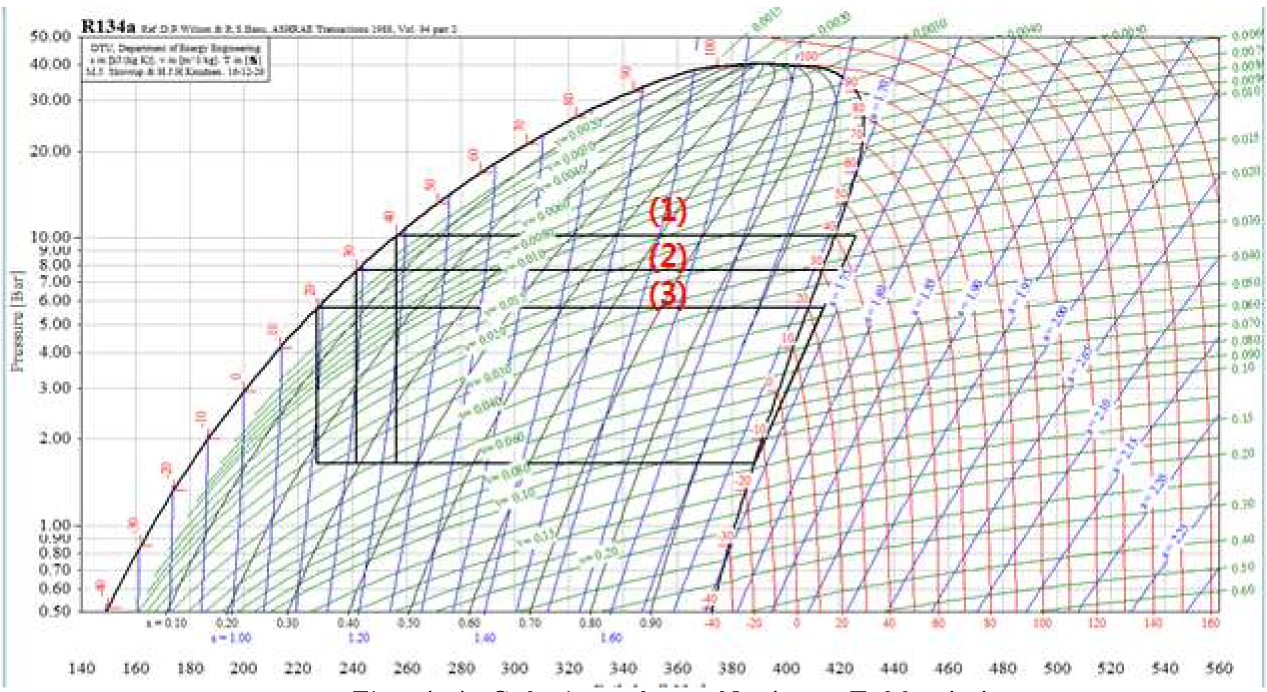


Fig. 4-4. Solution about No.1 on Table 4-4

3) Note a performance test result

Table 4-5. Note a performance test result

Oper Station	Compression Ratio	Refrigerating Effect		condensation Capacity		COP	Work by Compressor
		KJ/kg	Kcal/kg	KJ/kg	Kcal/kg		Kcal/kg
Table1							
Table2							
Table3							
Table4							
Table5							

4) Drawing each P-h diagram as each refrigerant

(1) Condition

1) Evaporating temperature : -15℃
2) Condensing temperature : 30℃
3) Temperature at inlet of compressor: -15℃(Dry gas)
4) Temperature at inlet of expansion valve: -25℃(sub-cooling temp. 5℃)

(2) Formula

1) Refrigeration ability (Qe) = $h_a - h_e$
2) Compressor work (W) = $h_b - h_a$
3) Condensing load (Qc) = $h_b - h_e$ = Qe + W
4) Coefficient of performance (COP) = Qe/W
5) Compression Ratio (Pr) = P_2/P_1

(3) Comparing each Coefficient of performance as each refrigerant

Table 4-6. Comparing each Coefficient of performance as each refrigerant

Refrigerant	Qe	Qc	COP	W	Pr
R-11 (CCI3F, Trichlorofluoromethane)	159.749	190.663	5.17	30.914	6.191
R-113 (CCI2FCCIF2, Trichlorotrifluoroethane)	129.450	154.908	5.08	25.457	8.005
R-114 (CCIF2CCIF2, Dichlorotetrafluoroethane)	103.463	124.941	4.82	21.478	5.372
R-12 (CCI2F2, Dichlorodifluoromethane)	121.284	146.024	4.90	24.740	4.079
R-123 (CHCI2CF3, Dichlorotrifluoroethane)	147.310	176.082	5.12	28.772	6.885
R-1270 (CH3CH=CH2, Propene (propylene))	300.752	363.752	4.77	63.001	3.588
R-134a (CH2FCF3,1,1,1,2-tetrafluoroethane)	154.023	185.913	4.83	31.889	4.692
R-152a (CH3CHF2,1,1-difluoroethane)	254.328	304.795	5.04	50.467	4.530
R-170 (CH3CH3, Ethane)	198.987	258.244	3.36	59.257	2.883
R-21 (CHCI2F, Dichlorofluoromethane)	198.987	258.244	3.36	59.257	2.883
R-22 (CHCIF2, Chlorodifluoromethane)	169.243	204.180	4.84	34.937	4.031
R-290 (CH3CH2CH3, Propane)	293.156	354.359	4.79	61.203	3.717
R-401A, R22/152a/124 (53/13/34), R401A	173.946	209.582	4.88	35.635	4.597
R-401B, R22/152a/124 (61/11/28), R401B	174.475	210.351	4.86	35.876	4.527
R-401C, R22/152a/124 (33/15/52), R401C	167.261	201.184	4.93	33.923	4.742
R-402A, R125/290/22 (60/2/38), R402A	121.226	147.912	4.54	26.686	3.881
R-402B, R125/290/22 (38/2/60), R402B	139.268	169.072	4.67	29.804	3.930
R-404A, R125/143a/134a (44/52/4), R404A	122.321	149.700	4.47	27.379	3.895
R-406A, R22/142b/600a (55/41/4), R406A	197.305	234.413	5.32	37.108	4.632
R-407A, R32/125/134a (20/40/40), R407A	160.990	195.456	4.67	34.466	4.390
R-407B, R-32/125/134a (10/70/20)	126.736	154.856	4.51	28.119	4.198
R-407C, R-32/125/134a (23/25/52)	175.779	212.765	4.75	36.987	4.468
R-408A, R22/143a/125 (47/46/7)	155.205	195.115	3.89	39.909	3.957
R-409A, R22/124/142b (60/25/15)	169.267	210.536	4.10	41.269	4.601
R-410A, R32/125 (50/50)	176.684	214.942	4.62	38.259	3.862
R-410B, R32/125 (45/55)	168.311	204.736	4.62	36.426	3.908
R-500, R12/152a (73.8/26.2)	147.010	177.105	4.88	30.095	4.105
R-502, R-22/115 (48.8/51.2)	110.620	134.616	4.61	23.996	3.784
R-507, R-125/143a (50/50)	125.721	152.951	4.62	27.229	3.852
R-600 (CH3CH2CH2CH3, Butane)	301.166	361.834	4.96	60.667	4.977
R-600a (CH(CH3)3, 2-methyl propane (isobutane))	277.180	333.691	4.90	56.511	4.560
R-717 (NH3, Ammonia)	1127.528	1358.669	4.88	231.141	4.940
R-718 (H20, Water)	2369.155	2959.889	4.01	590.734	25.687
R-744 (C02, Carbon dioxide)	161.693	210.777	3.29	49.084	3.143
RC318 (C4F8, Octafluorocyclobutane)	43.696	60.481	2.60	16.785	5.386

Chapter 3. Experiment and Analysis of Refrigeration System

Experiment Name	3-1. Basic experiment of Refrigeration system	Class time (hr): 24
The object of experiment	(1) Study the basic operating principles of refrigeration system (2) Study and analyze of refrigeration performance using operating the Refrigeration system (3) Using the measured data, draw a P-h diagram with the Coolpack program and analyze the refrigeration performance	

Equipment and Software	Tools	Spec of Toos	Q'nty
. Refrigeration Experiment Equipment (KTE-1000MO)	⸱ Driver	⸱ #2×6×175mm	1
. Coolpack	⸱ Nipper	⸱ 150mm	1
	⸱ Wire Stripper	⸱ 0.5~6㎟	1
	⸱ Hook Meter	⸱ 300A 600V	1/Group

(1) Order of experiment

1) Check the condition

① Temperature of Outdoor Air

② Capacity of compressor

③ Amount of charging refrigerant

④ Check condensation and evaporation temperature, pressure gauge before system operating

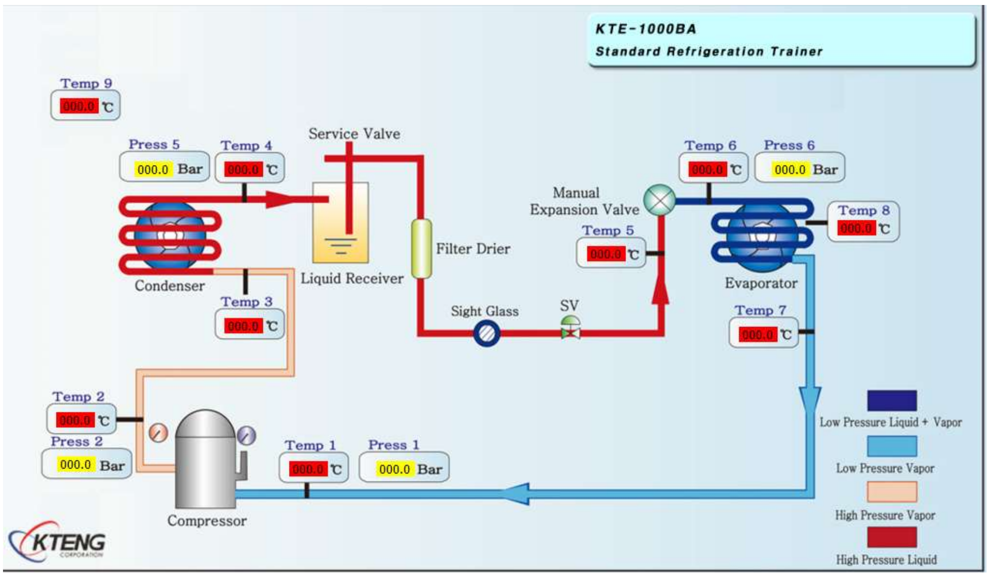


Fig 3-1. Diagram Refrigeration System

(2) Experiment

① Experiment 1, Outdoor air : 23 ℃

Table 3-1. Case 1_Measurement Data Temperature, Pressure, Enthalpy

Operation State 1	Comp In.	Comp Out.	Condenser In	Condenser Out	Exp.V.In	Eva. In	Eva. Out	Chamber
Temp	6.4 ℃	65.4 ℃	58.7 ℃	34.2 ℃	23.8 ℃	-6 ℃	6.4 ℃	3.5 ℃
Press	1.8 bar	8.7 bar	-	8.6 bar	-	1.9 bar	-	-
Enthalpy	407.1 kJ/kg	447.8 kJ/kg	-	233.1 kJ/kg	-	233.1 kJ/kg	-	-

Table 3-2. Calculated Value

Data point	Calculation method	Value
Evaporation Temp	Measurement point at Eva. In	-6 ℃
Condensing Temp	Measurement point at Condenser. Out	34.2 ℃
Qe [kJ/kg]	Refrigeration ability : Qe = $h_a - h_e$	174 kJ/kg
Qc [kJ/kg]	Qc = $h_b - h_e$ = $Q_e + A_W$	214.7 kJ/kg
COP	Coefficient of Performance (COP) = $\frac{Q_e}{A_W}$	4.2781
W [kJ/kg]	Compressor Work (W) = $h_b - h_a$	40.7 kJ/kg
Pressure Ratio	Compression Ratio (Pr) = P2 / P1	4.8

Table 3-3. How to applicate the coolpack program

Data point	Explanation	Value
Evaporating temperature	Temperature at inlet evaporator on running [℃]	- 6 ℃
Condensing temperature	Temperature at outlet condenser on running [℃]	34.2 ℃
Superheat	From outlet of evaporator to inlet of compressor [K] Or Temperature inlet of compressor [℃]	6.4 ℃
Subcooling	Subcooling temperature [K] from outlet of condenser (or saturated line on P-h diagram) to inlet of expansion valve	10.4 K
Dp evaporator	Temperature (or pressure) difference between outlet of expansion valve and outlet of evaporator	0.1 bar
Dp Condenser	Temperature (or pressure) difference between inlet of condenser and inlet of expansion valve	0.1 bar
Dp Suction line	Temperature (or pressure) difference between oulet of evaporator and inlet of compressor	-

(2) Experiment

① Experiment 2, Outdoor air : 23 ℃

Table 3-4. Case2_Measurement Data Temperature, Pressure, Enthalpy

Operation State 1	Comp In.	Comp Out.	Condenser In	Condenser Out	Exp.V.In	Eva. In	Eva. Out	Chamber
Temp	6.4 ℃	66.2 ℃	60 ℃	34.8 ℃	24.8 ℃	-6.5 ℃	6.2 ℃	2.7 ℃
Press	1.8 bar	8.7 bar	-	8.7 bar	-	1.9 bar	-	-
Enthalpy	407.1 kJ/kg	448.9 kJ/kg	-	234.6 kJ/kg	-	234.6 kJ/kg	-	-

Table 3-5. Calculated Value

Data point	Calculation method	Value
Evaporation Temp	Measurement point at Eva. In	-6.5 ℃
Condensing Temp	Measurement point at Condenser. Out	34.8 ℃
Qe [kJ/kg]	Refrigeration ability : Qe = $h_a - h_e$	172.6 kJ/kg
Qc [kJ/kg]	Qc = $h_b - h_e$ = $Q_e + A_W$	214.3 kJ/kg
COP	Coefficient of Performance (COP) = $\frac{Q_e}{A_W}$	4.1364
W [kJ/kg]	Compressor Work (W) = $h_b - h_a$	41.7 kJ/kg
Pressure Ratio	Compression Ratio (Pr) = P2 / P1	4.8

Table 3-6. How to applicate the coolpack program

Data point	Explanation	Value
Evaporating temperature	Temperature at inlet evaporator on running [℃]	- 6.5 ℃
Condensing temperature	Temperature at outlet condenser on running [℃]	34.8 ℃
Superheat	From outlet of evaporator to inlet of compressor [K] Or Temperature inlet of compressor [℃]	6.4 ℃
Subcooling	Subcooling temperature [K] from outlet of condenser (or saturated line on P-h diagram) to inlet of expansion valve	10.0 K
Dp evaporator	Temperature (or pressure) difference between outlet of expansion valve and outlet of evaporator	0.1 bar
Dp Condenser	Temperature (or pressure) difference between inlet of condenser and inlet of expansion valve	0.0 bar
Dp Suction line	Temperature (or pressure) difference between oulet of evaporator and inlet of compressor	-

(2) Experiment

① Experiment 3, Outdoor air : 23.3 ℃

Table 3-7. Case3_Measurement Data Temperature, Pressure, Enthalpy

Operation State 1	Comp In.	Comp Out.	Condenser In	Condenser Out	Exp.V.In	Eva. In	Eva. Out	Chamber
Temp	5.7 ℃	78.4 ℃	71.9 ℃	38.1 ℃	30.4 ℃	-8.5 ℃	2.5 ℃	2 ℃
Press	1.8 bar	9.5 bar	-	9.5 bar	-	1.9 bar	-	-
Enthalpy	406.3 kJ/kg	460.6 kJ/kg	-	243.2 kJ/kg	-	243.2 kJ/kg	-	-

Table 3-8. Calculated Value

Data point	Calculation method	Value
Evaporation Temp	Measurement point at Eva. In	-8.5 ℃
Condensing Temp	Measurement point at Condenser. Out	38.1 ℃
Qe [kJ/kg]	Refrigeration ability : Qe = $h_a - h_e$	163.1 kJ/kg
Qc [kJ/kg]	Qc = $h_b - h_e$ = $Q_e + A_W$	217.5 kJ/kg
COP	Coefficient of Performance (COP) = $\frac{Q_e}{A_W}$	3.0013
W [kJ/kg]	Compressor Work (W) = $h_b - h_a$	54.4 kJ/kg
Pressure Ratio	Compression Ratio (Pr) = P2 / P1	5.3

Table 3-9. How to applicate the coolpack program

Data point	Explanation	Value
Evaporating temperature	Temperature at inlet evaporator on running [℃]	- 8.5 ℃
Condensing temperature	Temperature at outlet condenser on running [℃]	38.1 ℃
Superheat	From outlet of evaporator to inlet of compressor [K] Or Temperature inlet of compressor [℃]	5.7 ℃
Subcooling	Subcooling temperature [K] from outlet of condenser (or saturated line on P-h diagram) to inlet of expansion valve	7.7 K
Dp evaporator	Temperature (or pressure) difference between outlet of expansion valve and outlet of evaporator	0.0 bar
Dp Condenser	Temperature (or pressure) difference between inlet of condenser and inlet of expansion valve	0.0 bar
Dp Suction line	Temperature (or pressure) difference between oulet of evaporator and inlet of compressor	-

(2) Experiment

① Experiment 4, Outdoor air : 23.3 ℃

Table 3-10. Case4_Measurement Data Temperature, Pressure, Enthalpy

Operation State 1	Comp In.	Comp Out.	Condenser In	Condenser Out	Exp.V.In	Eva. In	Eva. Out	Chamber
Temp	5.8 ℃	78.8 ℃	71.9 ℃	37.7 ℃	30.0 ℃	-9.5 ℃	3.4 ℃	2.3 ℃
Press	1.7 bar	9.4 bar	-	9.3 bar	-	1.8 bar	-	-
Enthalpy	406.3 kJ/kg	460.6 kJ/kg	-	241.7 kJ/kg	-	241.7 kJ/kg	-	-

Table 3-11. Calculated Value

Data point	Calculation method	Value
Evaporation Temp	Measurement point at Eva. In	-9.5 ℃
Condensing Temp	Measurement point at Condenser. Out	37.7 ℃
Qe [kJ/kg]	Refrigeration ability : Qe = $h_a - h_e$	164.6 kJ/kg
Qc [kJ/kg]	Qc = $h_b - h_e$ = $Q_e + A_W$	189.1 kJ/kg
COP	Coefficient of Performance (COP) = $\frac{Q_e}{A_W}$	3.028
W [kJ/kg]	Compressor Work (W) = $h_b - h_a$	54.4 kJ/kg
Pressure Ratio	Compression Ratio (Pr) = P2 / P1	5.5

Table 3-12. How to applicate the coolpack program

Data point	Explanation	Value
Evaporating temperature	Temperature at inlet evaporator on running [℃]	- 9.5 ℃
Condensing temperature	Temperature at outlet condenser on running [℃]	37.7 ℃
Superheat	From outlet of evaporator to inlet of compressor [K] Or Temperature inlet of compressor [℃]	5.8 ℃
Subcooling	Subcooling temperature [K] from outlet of condenser (or saturated line on P-h diagram) to inlet of expansion valve	7.7 K
Dp evaporator	Temperature (or pressure) difference between outlet of expansion valve and outlet of evaporator	0.1 bar
Dp Condenser	Temperature (or pressure) difference between inlet of condenser and inlet of expansion valve	0.1 bar
Dp Suction line	Temperature (or pressure) difference between oulet of evaporator and inlet of compressor	-

(3) Data analysis

① Compare with result of experiment

Table 3-13. Compare with data the result of experiment

Experiment	Evaporation Temperature	Condensation Temperature	Superheat	Subcooling	COP
Experiment 1	-6 ℃	34.2 ℃	6.4 ℃	10.4 K	4.2781
Experiment 2	-6.5 ℃	34.8 ℃	6.4 ℃	10.0 K	4.1364
Experiment 3	-8.5 ℃	38.1 ℃	5.7 ℃	7.7 K	3.0013
Experiment 4	-9.5 ℃	37.7 ℃	5.8 ℃	7.7 K	3.028

② Drawing P-h diagram using coolpack : Experiment 4

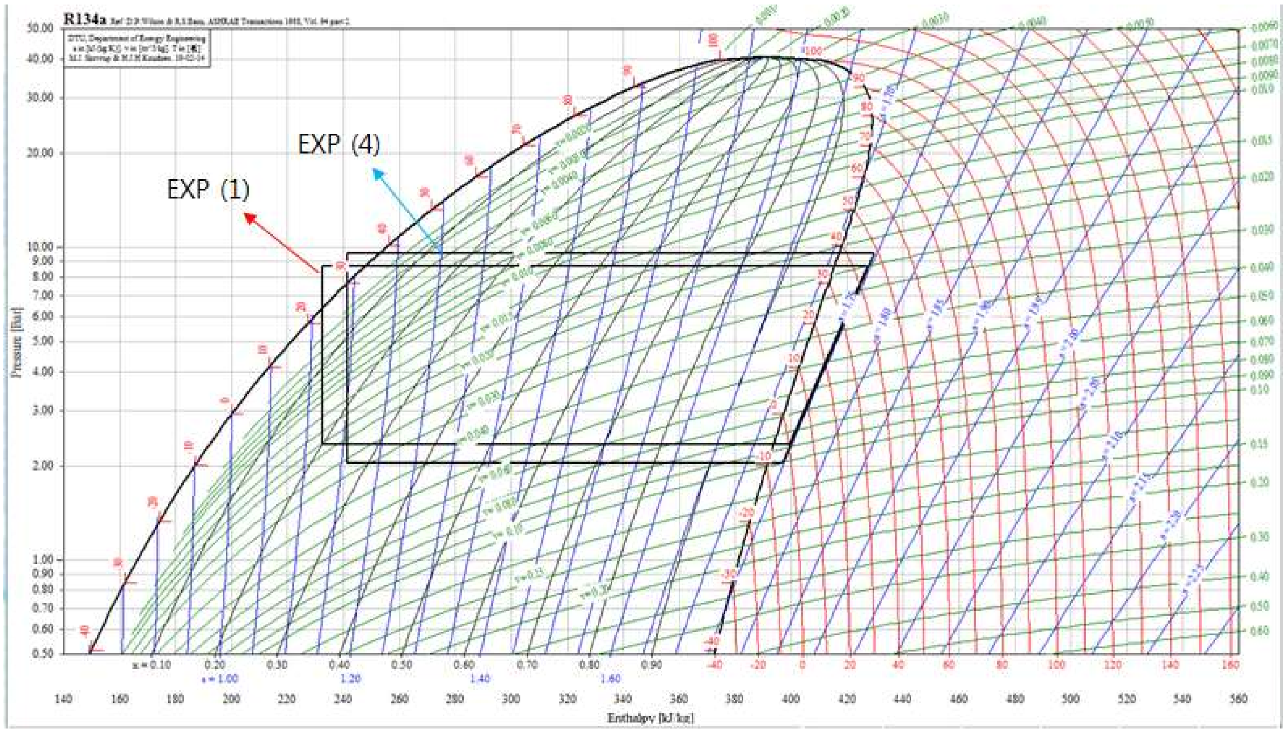


Fig 3-2. P-h Diagram Refrigeration System_Experiment 4

Experiment name	3-1. Basic experiment of Refrigeration system	Class time (hr)
		24

Refrigeration Experiment Equipment
[KTE-1000MO]

、Check Point

1. Practice to basic operation of Refrigeration system
2. Calculated the heat exchange of condensation and evaporation, and COP values.
3. Comparison and analyze the data using save excel file and drawing the P-h diagram.

<table>
<tr><td rowspan="9">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Aliot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70)</td><td>Check ambient temperature and refrigerant charge</td><td>10</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Check expansion valve opening amount</td><td>10</td><td></td></tr>
<tr><td>Evaporator chamber damper operation maintenance</td><td>10</td><td></td></tr>
<tr><td>Organize measurement data and drawing P-h graph</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Drawing of P-h graph according to condensation load</td><td>10</td><td></td></tr>
<tr><td>Review and Result</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Time (Point 20)</td><td colspan="3" rowspan="2">、Demerit mark Point (   ) in every (   ) minute after finish</td><td>Work</td><td>Task</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment Name	3-2. Measurement of cooling performance according to condensation temperature change (high temperature control)	Class time (hr)
		24
The object of experiment	(1) The condenser load control operation circuit can be configured for operation measurement. (2) Condenser ability experimental save the measurement data as an Excel file. (3) Experimental measurement temperature, pressure, enthalpy, heat exchange capacity, and performance data are plotted, analyzed, and presented.	

Equipment and Software	Tools	Spec of Toos	Q'nty
. Refrigeration Experiment Equipment (KTE-1000MO) . Coolpack	ˎ Driver ˎ Nipper ˎ Wire Stripper ˎ Hook Meter	ˎ #2×6×175mm ˎ 150mm ˎ 0.5~6㎟ ˎ 300A 600V	1 1 1 1/Group

(1). Way to operate

1) Variable condition

- Dependent variable : Always open the evaporator damper
- Independent variable : Ambient Temperature
- Manipulation variable : Speed control fan of condenser and evaporator

《Experimental Study on Cooling Load by Controlling Evaporator Damper》

① Cooling

- Open to back door
- Open to front door(Damper)

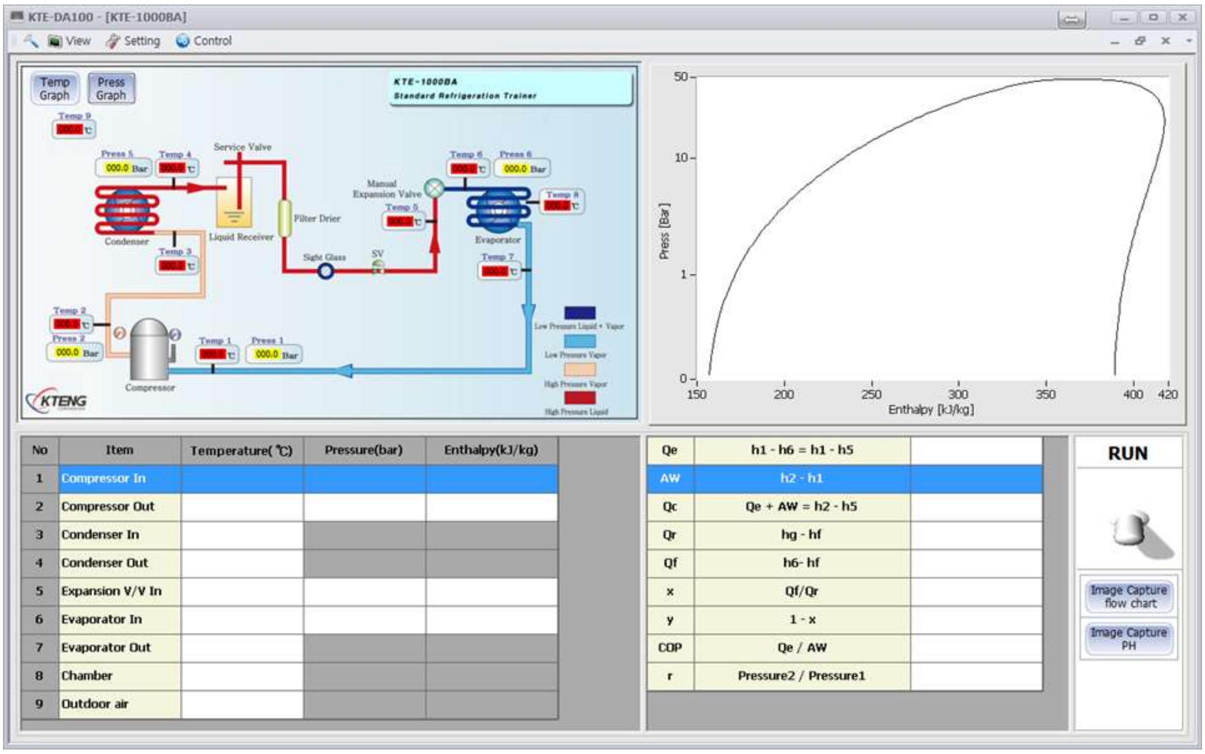
② Refrigeration

- Close to back door
- Open to front door(Damper)

③ Cooling Load Control

- Back door (open or close)
- Front door (0 ~ 100%) adjustable

(2) Diagram (Temp, Press and Heat Exchange amount)



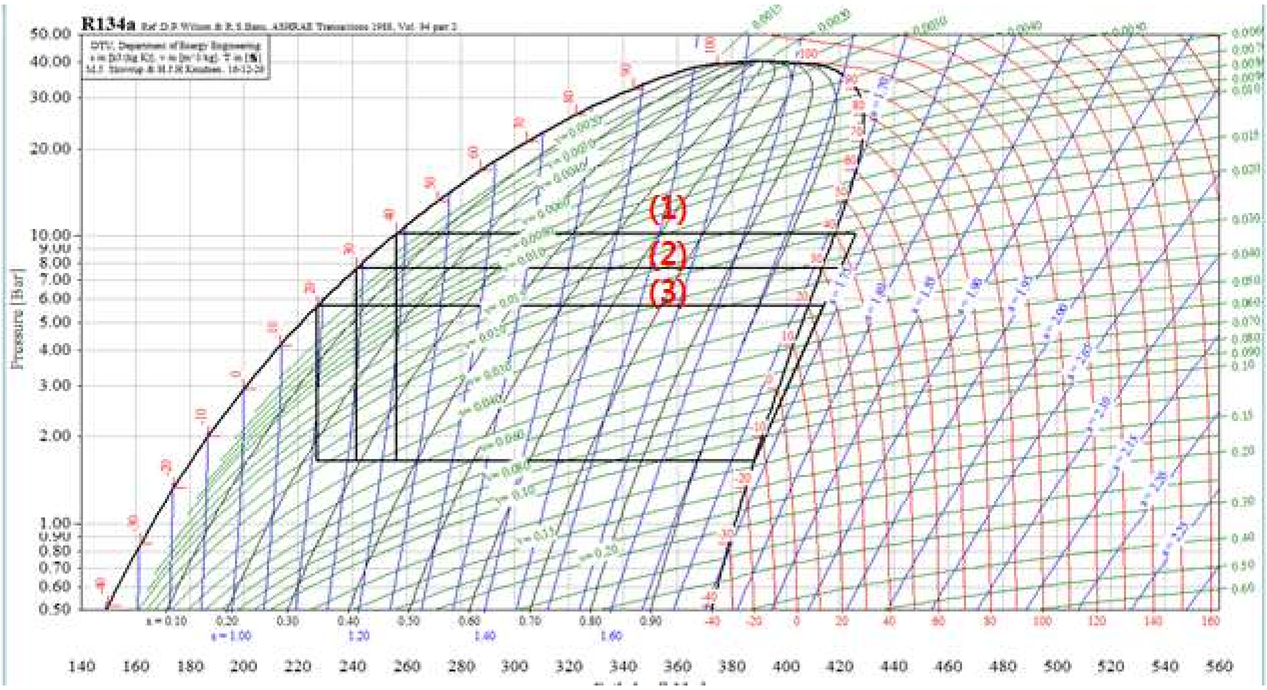
Comp. In : Compressor inlet
Comp. Out : Compressor outlet
Condenser In : Condenser inlet
Condenser Out :Condenser outlet
Expan. V. In : Expansion valve inlet
Expan. V. Out / Evaporator In
: Expansion out(Evaporator in)
: Expansion valve outlet
Evaporator : Evaporator outlet

qe : Refrigeration effect
AW : Compressor work
qc : Condensing heat amount
qr : Evaporating latent heat
qf : Flash gas
x : Dry ratio
y : wet
COP : Coefficient of Performance

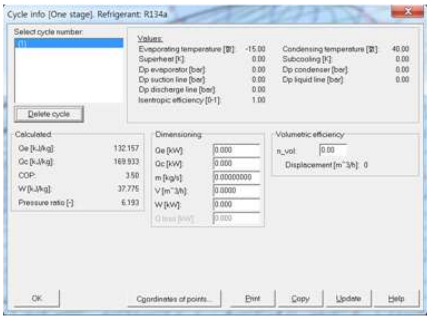
qe : Refrigeration effect
AW : Compressor work
qc : Condensing heat amount
qr : Evaporating latent heat
qf : Flash gas

x : Dry ratio
y : Humidity
COP : Coefficient of Performance
r : Pressure Ratio

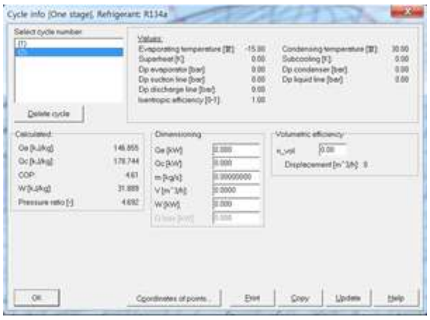
(3) Change in condensation temperature(Pressure)_(High Temperature Control)



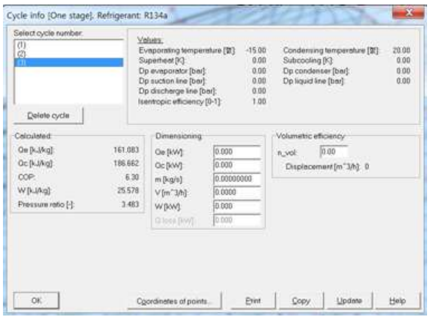
[1] Drawing to P-h graph according to condensation temperature change



[2] Cond Temp : 40 ℃



[3] Cond Temp : 30 ℃



[4] Cond Temp : 20 ℃

state	Eva,temp (℃)	Cond. temp (℃)	Latent heat of evaporation [kJ/kg]	Latent heat of condensation [kJ/kg]	COP	Work [kJ/kg]
(1)	-15	40	132.157	169.933	3.5	37.775
(2)	-15	30	146.855	178.744	4.61	31.889
(3)	-15	20	161.083	186.662	6.3	25.578

The increase of the condensation pressure increases the compression ratio to increase the temperature of the discharge gas, thereby reducing the refrigeration effect and simultaneously increasing the compression days, thereby reducing the coefficient of performance.

Experiment name	3-2. Measurement of cooling performance according to condensation temperature change (high temperature control)	Class time (hr)
		24

､Experimental method

1. Operation circuit as manual operation, cooling and heating automatic temperature control
2. Condensation load : Hyper condensed load, Normal operation, Insufficient condensation load
3. The evaporation load is kept constant.

､Check Point

1. Prepare measurement equipment, tools and materials and check communication and refrigerant charge state.
2. Using the measuring equipment, it meets the given measurement method and conditions and constructs the condenser load control operation.
3. The condensation capacity measurement data according to the load fluctuation of the condenser is stored in an Excel file, and reliable data of a predetermined section is selectively stored.
4. The selected reliability data is further divided into temperature, pressure, enthalpy, heat exchange capacity, and coefficient of performance.
5. Construct a graph using stored temperature, pressure, enthalpy, heat exchange capacity, and coefficient of performance data.
6. Analyze the cause and content of the graph drawn in the Excel file and organize it.
7. The condensation capacity analysis results of condenser load variation are reviewed and the conclusions are summarized.

<table>
<tr><td rowspan="9">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Aliot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70)</td><td>Check ambient temperature and refrigerant charge</td><td>10</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Check expansion valve opening amount</td><td>10</td><td></td></tr>
<tr><td>Evaporator chamber damper operation maintenance</td><td>10</td><td></td></tr>
<tr><td>Organize measurement data and drawing P-h graph</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Drawing of P-h graph according to condensation load</td><td>10</td><td></td></tr>
<tr><td>Review and Result</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Time (Point 20)</td><td colspan="3" rowspan="2">､Demerit mark Point ( ) in every ( ) minute after finish</td><td>Work</td><td>Task</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experimental name	3-3. Measurement of cooling performance according to evaporation temperature change (low temperature control)			Class time (hr) 24
The experiment of object	(1) The evaporator load control operation circuit can be configured for operation measurement. (2) The evaporator performance experiment data is saved as an Excel file. (3) Measurement temperature, pressure, enthalpy, heat exchange rate and performance coefficient data are plotted, analyzed, and released.			
Equipment and Software	Tools	Spec of Tools	Qyn't	
. Refrigeration Experiment Equipment (KTE-1000MO) . Coolpack	· Driver · Nipper · Wire Stripper · Hook Meter	· #2×6×175mm · 150mm · 0.5~6㎟ · 300A 600V	1 1 1 1/Group	

1. Way to operation

1) Variable condition

- Dependent variable : Always open the condenser damper
- Independent variable : Ambient Temperature
- Manipulation variable : Speed control fan of evaporator

《Experimental Study on Cooling Load by Controlling Evaporator Damper》

① Cooling

- Open to back door
- Open to front door(damper)

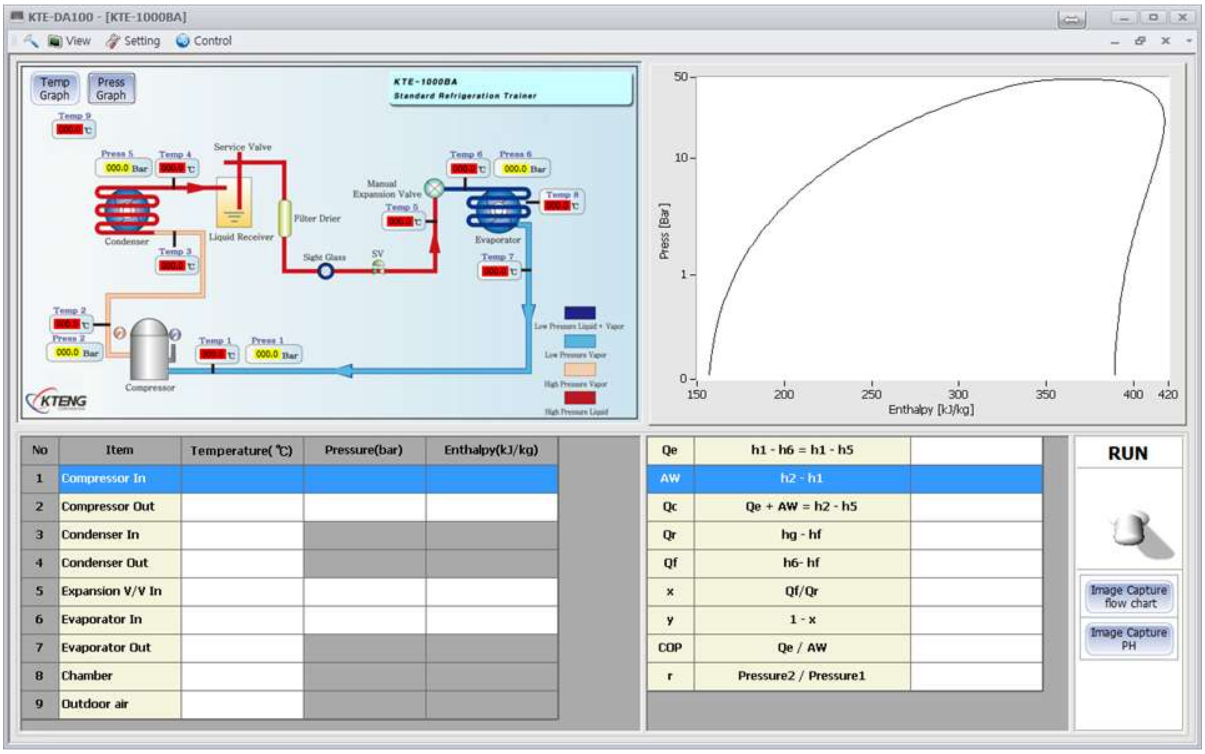
② Refrigeration

- Close to back door
- Open to front door(damper)

③ Cooling load control

- Back door (open or close)
- Front door (0 ~ 100%) adjustable

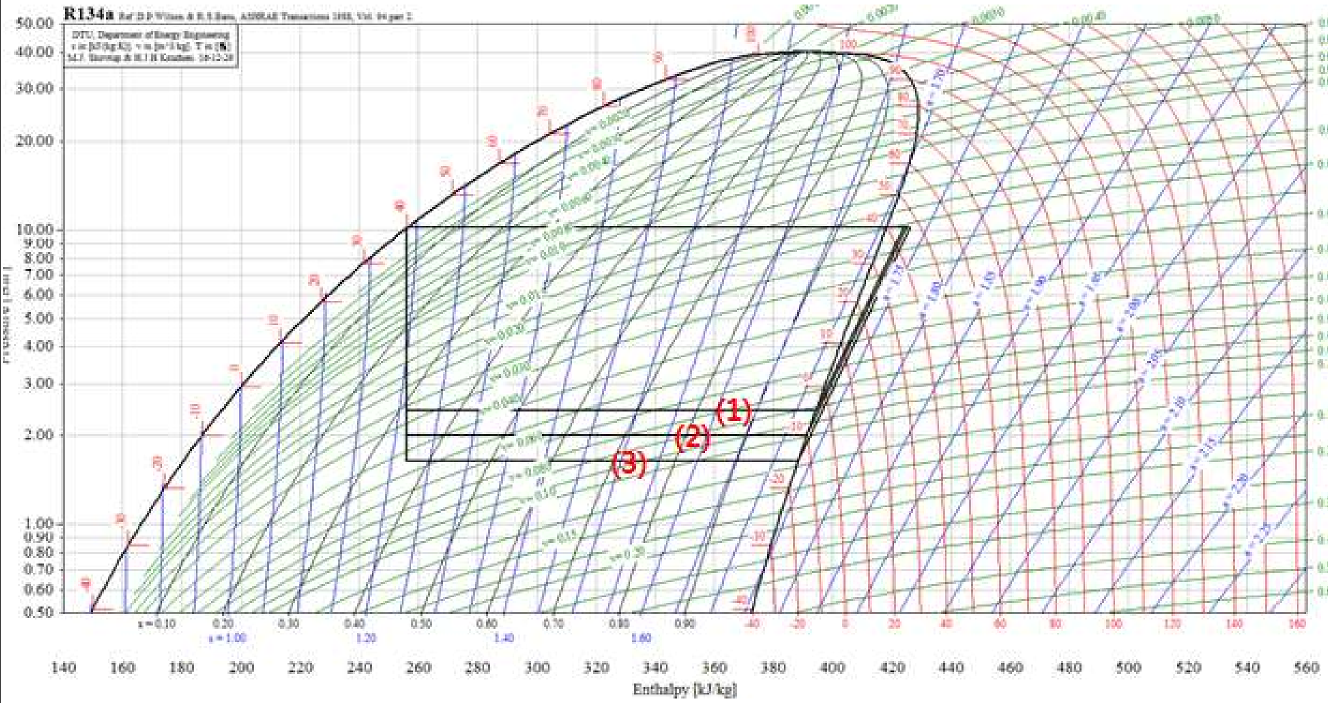
2. Diagram (Measurement temperature and pressure, Heat Exchange rate)



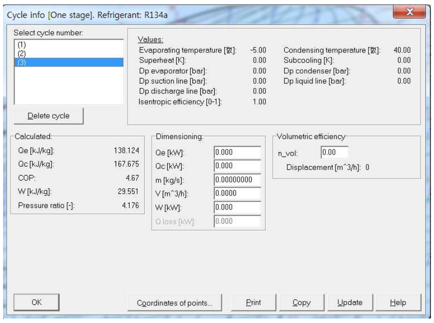
Comp. In : Compressor inlet	qe : Refrigeration effect
Comp. Out : Compressor outlet	AW : Compressor work
Condenser In : Condenser inlet	qc : Condensing heat amount
Condenser Out :Condenser outlet	qr : Evaporating latent heat
Expan. V. In : Expansion valve inlet	qf : Flash gas
Expan. V. Out / Evaporator In	x : Dry ratio
: Expansion out(Evaporator in)	y : wet
: Expansion valve outlet	COP : Coefficient of Performance
Evaporator : Evaporator outlet	

qe : Refrigeration effect	x : Dry ratio
AW : Compressor work	y : Humidity
qc : Condensing heat amount	COP : Coefficient of Performance
qr : Evaporating latent heat	r : Pressure Ratio
qf : Flash gas	

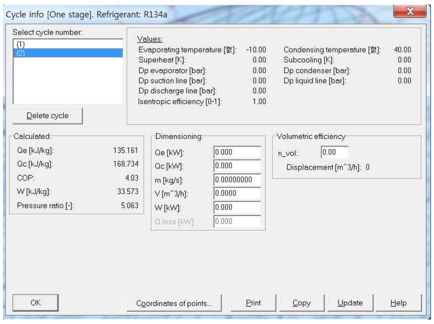
3. Change in evaporator temperature(Pressure)_(Low Temperature Control)



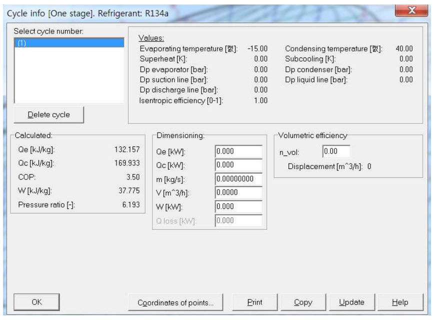
[1] Drawing to P-h graph according to evaporation temperature change



[2] Eva. Temp : -5 ℃



[3] Eva Temp : -10 ℃



[4] Eva Temp : -15 ℃

state	Eva, Temp (℃)	Cond, Temp (℃)	Latent heat of evaporation [kJ/kg]	Latent heat of condensation [kJ/kg]	COP	Work [kJ/kg]
(1)	-5	40	132.157	169.933	3.5	37.775
(2)	-10	40	135.161	168.734	4.03	33.573
(3)	-15	40	138.124	167.675	4.67	29.551

As the evaporation temperature increases, the compression work decrease and COP increases.

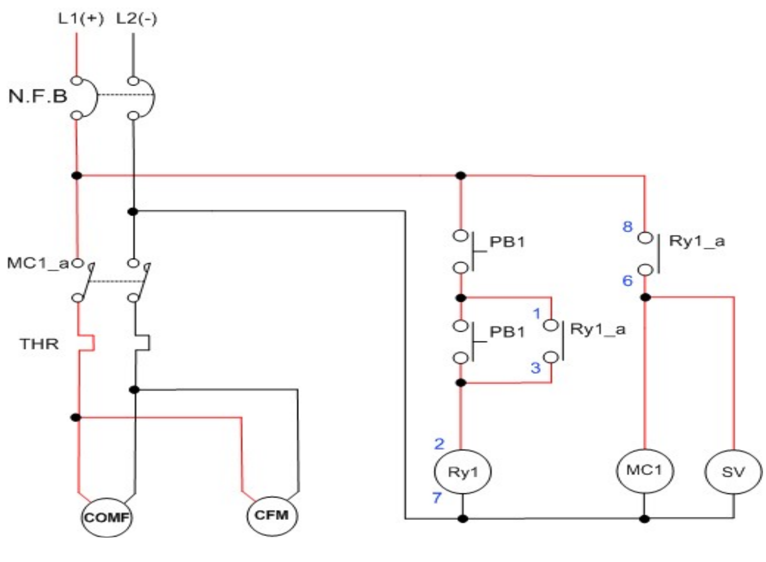
Chapter 4. Practice of automatic control using sequence training

Experiment name	4-1. Practice to configuration self-holding circuit for priority STOP of using sequence control	Class time(hr): 8
The object of experiment	① To understand self-holding circuit for priority STOP, and to operate Refrigeration system as the circuit. ② To describe self-holding circuit configuration for priority STOP of refrigerator.	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration Experiment Equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6× 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

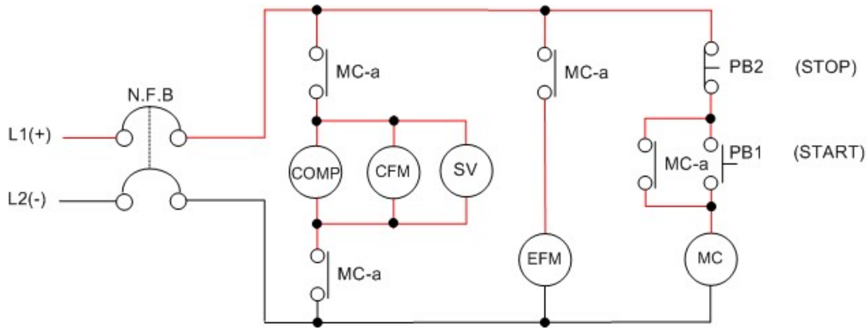
Control Circuit

1. Control circuit



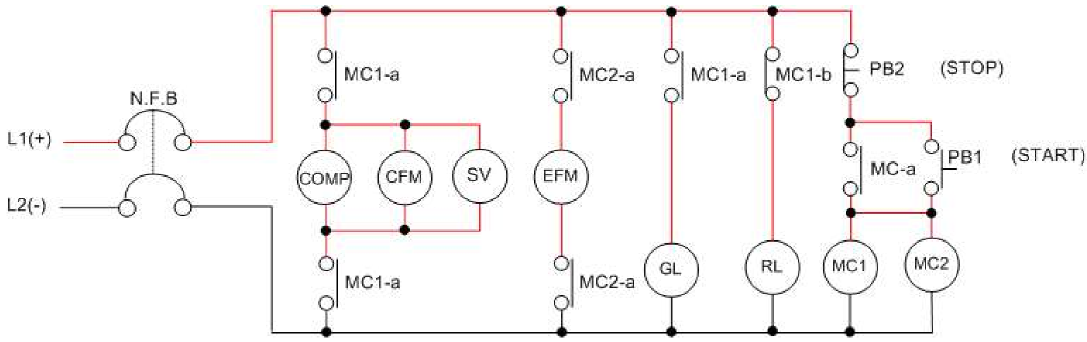
L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
MC : Magnet contactor coil
MC-a : MC "a" contact
CFM : Condenser Fan Motor
SV : Solenoid V/V
PB : Push button
COMP : Compressor motor

2. Manual Operating Circuit(Self-Holding Circuit) Design and Configuration in Refrigerator



The manual operating circuits are configured, tested and experimented using the banana jacks in accordance with the refrigeration cycle drawings and operating circuits. The circuit designs and configuration principles are described below. Turn the Start button on, and the MC coil(MC Electric Coil) is excited. So the relay circuit “a”, the main contact, is closed and the Motor Compressor and Condenser Fan Motor run. Then, the normal operation is started. Press the Stop button to turn the circuit off, and the MC coil(MC Electric Coil) is demagnetized. Then, the main contact is opened and so the Motor Compressor, Condenser Fan Motor and Evaporator Fan stop.

For the manual operation of refrigerator, the self-holding circuit is configured and operated using the relay circuit "a" of the magnetic switch(MC Electric Coil). Press the Start button, and the refrigerator runs. Press the Stop button, and the refrigerator stops. This is the basic application control circuit in the refrigeration devices.



When the N.F.B is opened, the break light(RL) of the relay circuit ‘b' is on as the magnetic switch (MC Electric Coil) is demagnetized. Press the Start button, and the magnetic switch (MC Electric Coil) is excited. Then, the relay contact "a", the main contact, is closed and so the Motor Compressor, Condenser Fan and Evaporator Fan run. Accordingly, the normal operation is started. At this point, the operation light(GL) is on to indicate the refrigerator runs as the relay circuit ‘a' is closed.

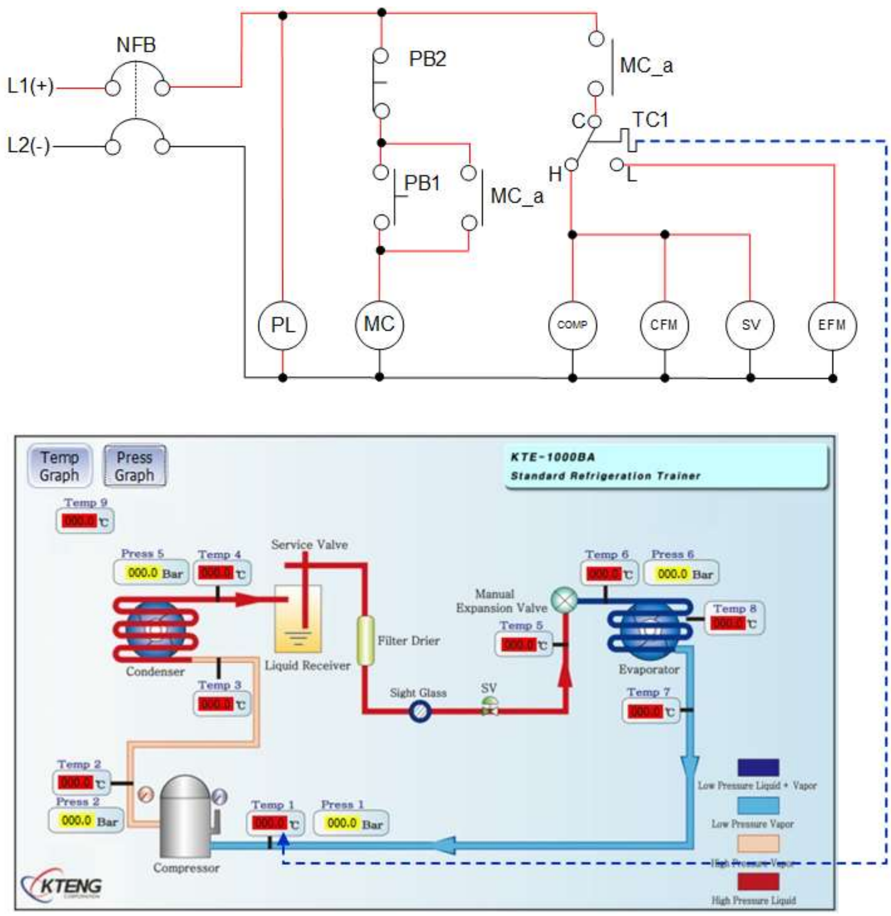
The relay circuit 'b' is opened and so the break light(RL) is off. Press the Stop button, and the magnetic switch(MC Electric Coil) is demagnetized. Then, the main contact is opened and so the Motor Compressor, Condenser Fan Motor and Evaporator Fan stop. Accordingly, the operation light(GL) is off and the relay circuit "b" is closed. Then, the break light(RL) is on to indicate that the operation stops.

As described above, the manual operation to start and stop the refrigerator is carried out by configuring the self-holding circuits using the relay circuit "a" of the magnetic switch (MC Electric Coil). The refrigerators run by pressing the Start button and stop by pressing the Stop button. This method can be applied for the tests, practices and circuit designing in the actual fields.

Experiment name	4-2. Practice to configuration of temperature switch using sequence control			Class time(hr): 8
The object of experiment	① To understand the principal of low temperature control using temperature S/W, and adjust it. ② To configurate and operate circuit for low temperature control . ③ To understand the feature after note and define distribution and variation of low temperature points.			
Experiment equipments		Tool & material	Spec of tools	Q'nty
. refrigeration Experiment Equipment (KTE-1000MO)		. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6× 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

Control Circuit

1. Basic control circuit to temperature switch



L1, L2 : Line voltage
N.F.B : No fuse circuit
COMP1 : compressor 1
MC-a : magnetic contact “a

CFM : Condenser fan motor
SV1 : solenoid valve 1
EFM : Evaporator fan motor
TC1 : Cascade1 output temp switch

No.	Temp	offset	In Temp	Out Temp	real temp	remarks
1	10	6				
2	8	4				
3	5	6				
4	0	4				
5	-2	6				

Temp setting → Cut Out Point reaches → Condensing Unit stop → Temp Cut In Point → Condensig Unit re-operate

On/Off operating in range of set temperature and diff(offset) range.

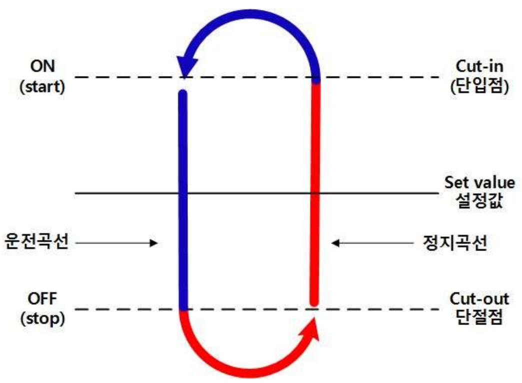
CUT-IN (stop → run) point = temp setting + offset

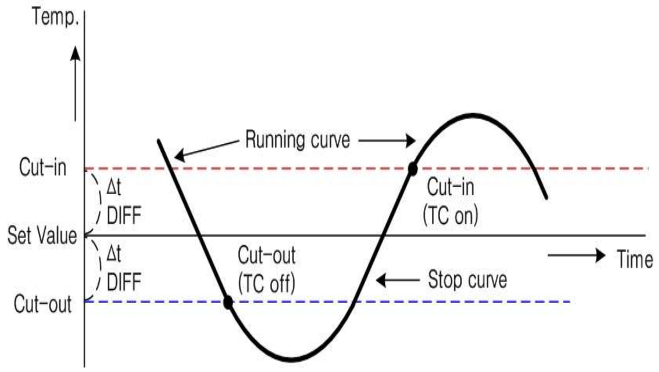
CUT-OUT (stop → run) point = temp setting - offset

ex) Temp set 2℃, offset 3℃,

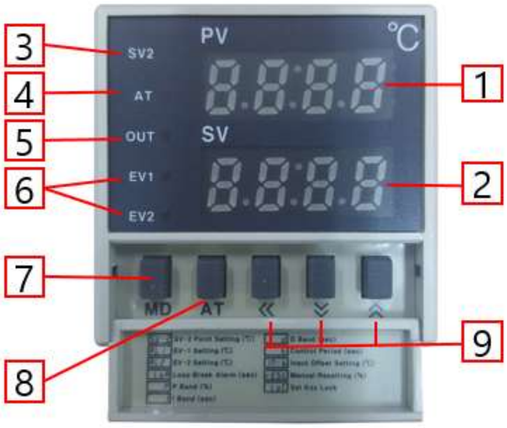
CUT-IN point 2 + 3 = 5[℃] , CUT-OUT point 2 - 3 = -1[℃].

* Temp control run/stop diagram





2. Temperature controller setting



① PV: Measurement display (red)
Displays measured value.
Displays configuration subject in configuration mode.

② SV: Configuration value display (green)
Displays adjusting value.
Displays configuration subject in configuration mode.

③ SV2: SV2 on lamp

④ AT: auto-tuning on lamp

⑤ OUT: output on lamp

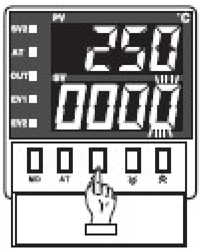
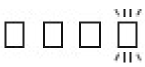
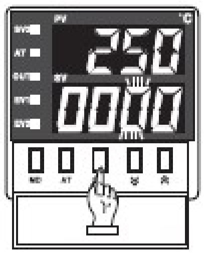
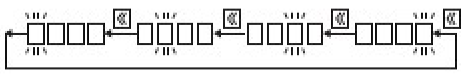
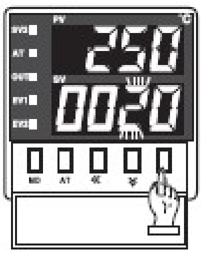
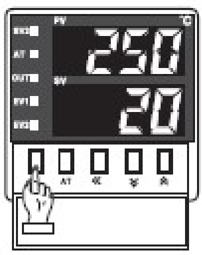
⑥ EV1,2: EVENT output display lamp

⑦ MD key: mode key
Press button for 3sec

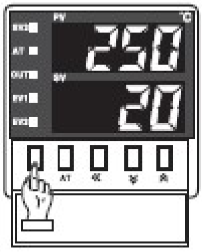
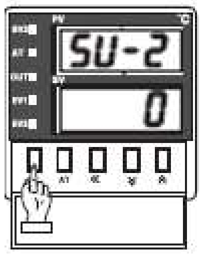
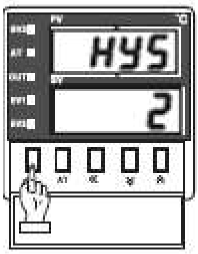
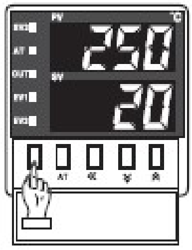
⑧ AT key: Auto-tuning run key

⑨ ∧∨《: adjustment key

* Method

 ① Press 《 key to change value during operation. 	 ② Press 《 key to adjust other numbers. 
 ③ Press ∧∨ key to alter each value.	 ④ Press MD after adjustment.

* Offset

 ① Press MD key for 3 sec during operation.	 ② Check SU-2 on display on PV and press MD 9 times until HYS appears.
 ③ Use ∧∨ key to adjust offset value (basic: 2℃). Can be adjusted between 1~100℃.	 ④ Press MD to return to operation mode.

※ Caution: Offset [Configuration value ± offset/2] can be varied between operation range.

ex) Configuration temp: 10 , Offset: 4 , In case of low temp control:
starting at 10 + 2 = 12 [℃],
stopping at 10 - 2 = 8 [℃]

Experiment name	4-2. Practice to configuration of temperature switch using sequence control	Time
		8

Refrigeration Equipment
(KTE-1000MO)

· **Check Point**

1. Checking tools and materials.
2. Setting the difference as the valves of LPS and explaining the operation principal of it .
3. Configurating circuit of operation with banana jacks using tools and material.
4. Understanding the function of operating circuit.
   ① Explaining the progress when PB1 is pushed.
   ② Explaining the progress that the refrigerator is stoped when pressure at low pressure part goes down on running of compressor motor.
   ③ Explaining the progress that the refrigerator is restarted when pressure at low pressure part goes up on stop of compressor motor
   ④ Explaining the progress that refrigerator starts when PB_2 is pushed.
5. noting and defining distribution and variation of high temperature points
6. Configurating circuit with electric wires and operating using tools and materials.

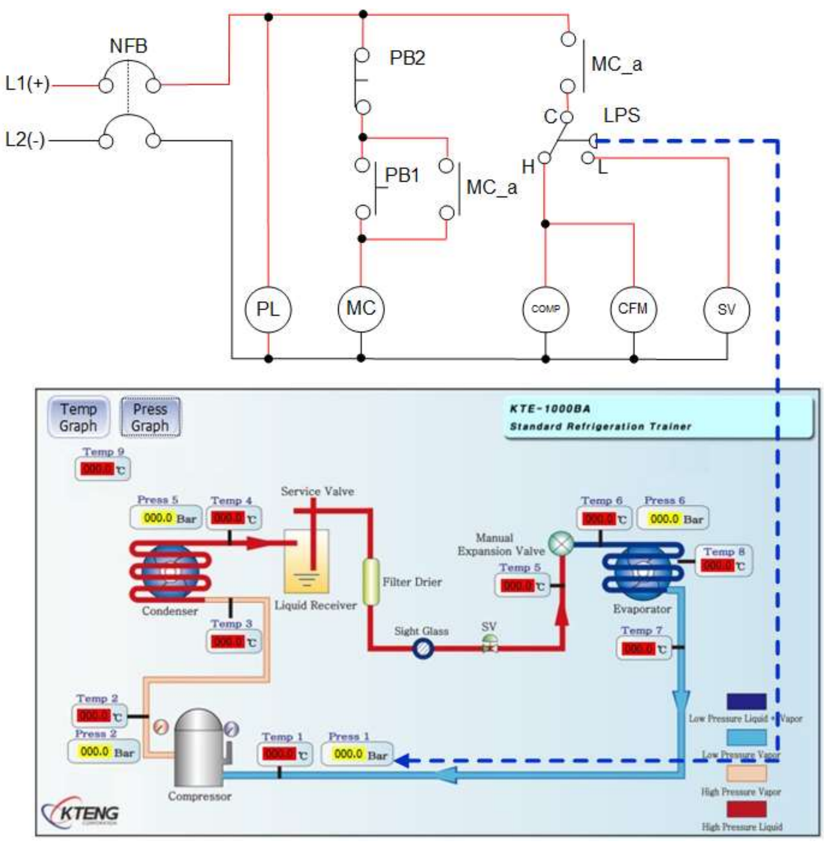
Relationship between technical description rating items and task	Appraisal		Allot	Point	Remark			
	Work (Point 70))	Circuit configuration using banana jack	20					
		Circuit configuration using real wire	20					
		Configuration state	10					
		Understand and description for circuit	20					
	Task (Point 10)	Task attitude and safety	5					
		Application and standstill of tools	5					
	Time (Point 20)	· Demerit mark Point ( ) in every ( ) minute after finish			Work	Task	Time	Total

Experiment name	4-3. Practice to configuration of low pressure switch(LPS) using sequence control	Class time(hr)
		8
The object of experiment	① To understand the principal of low pressure control(LPS), and adjust it. ② To configurate and operate circuit for low pressure control and understand. ③ To understand the feature after note and define distribution and variation of low pressure.	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration experiment equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6 × 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

Control Circuit

1. Basic control circuit



L1, L2 : Line voltage
N.F.B : No-fuse breaker
COMP1 : 1st stage comp
PB : push button
CFM : Condenser fan motor
SV1 : Solenoid valve 1
LPS : Low-pressure switch
MC : Magnetic contact

No.	Cut in P	D.P	Cut out P	Pressure gauge	Remarks
1	3	2	1		
2	3	1	2		
3	4	2	2		

The pressure control Refrigeration system operation through pressure adjustment operation of LPS. Configure the circuit to be turned on/off according to the set pressure value, and operation the Refrigeration system by performing C,H,L contact point control circuit configuration.

Operating refrigeration on/off cycle upon configurations below.

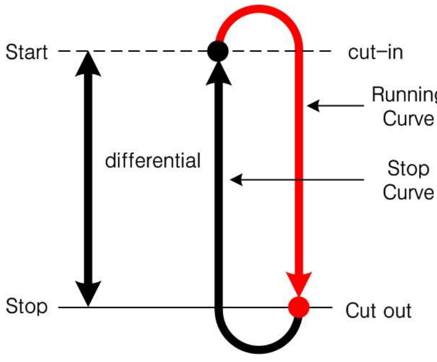
CUT-IN (stop → run) POINT = configuration pressure

CUT-OUT (run → stop) POINT = configuration pressure - offset

ex) configuration pressure 5, offset 3 [bar]

CUT-IN point 5 = 5[bar] , CUT-OUT point 5 - 3 = 2[bar]

* LPS run/stop curve



2. Operate the cooling system through the pressure control circuit diagram

① When the power is connected via NFB, the Power Indicator (PL20) turns on. And PB1 switches or electronic contactor MC switches are all " b " contacts, so the other loads device is not energized.

② Press the PB1 switch, which is an " ON " switch, and the electronic contactor MC coil is created by creating an electric field by closing the MC switch contacts and keeping the MC_contact on the PC1 switch.

③ At the same time, the circuit will close the MC switch contact above the control unit Low Pressure Isolation Switch (LPS). If the LPS switch terminal is live and the pressure on the compressor suction side is lower than the ' cut-in ' pressure on the ' C ' terminal and the pressure on the ' H ' terminal is lower than the ' LPS ' terminal.

④ If the pressure on the low pressure side is higher than the cut-in pressure and electricity flows to the ' H ' terminal, the compressor and condenser compressor's compressor unit are not kept closed and the compressor valve is kept closed.

⑤ If the compressor and the condenser are operated with the electronic valves closed, the refrigerant on the low pressure side continues to flow to the high pressure side, and the pressure on the high pressure side gradually rises, and the pressure on the low pressure side falls.

⑥ If the pressure on the low pressure side falls below the cut-out pressure and the electricity flows to the ' L ' terminal, the compressor and condenser are disconnected from the electrical valve and the electric valve opens.

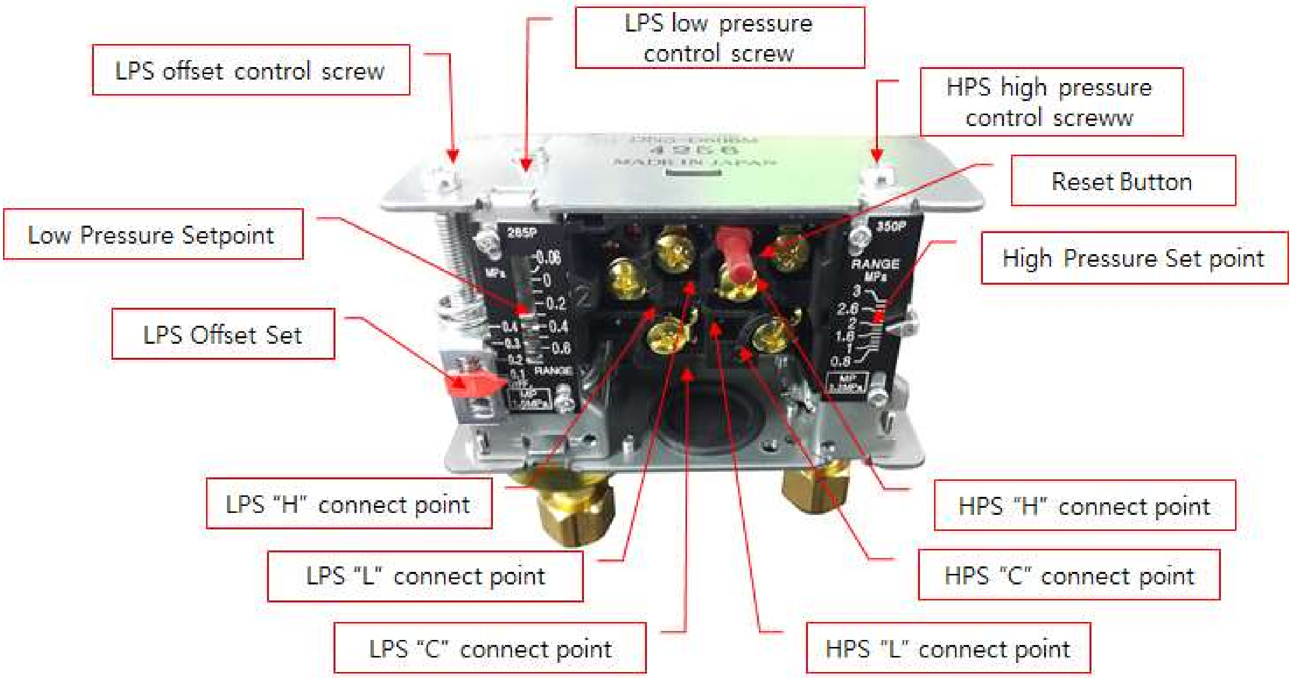
⑦ If the electronic valve opens and the refrigerant flows to the low pressure side, the pressure on the low pressure side rises. When the pressure rises and reaches the single-entry contact, the LPS switch terminal is once again connected to the ' H ' terminal, which closes the electronic valve, stopping refrigerant flow, and operating the compressor. Therefore, the cooling system by this control circuit repeatedly drops the switch on the LPS at the " H " terminal " L " terminal with the same low pressure change at the compressor inlet.

⑧ This control circuit is designed to reduce the periodic time of pressure load fluctuations on the low pressure side of the system, but not used in the case of an actual cooling system.

⑨ If the PB2 switch is pressed, the magnetic flow of the MC coil is cut off, and the electricity supply of the Refrigeration system is stopped.

3. LPS setting

* Dual Pressure Switch (DPS)



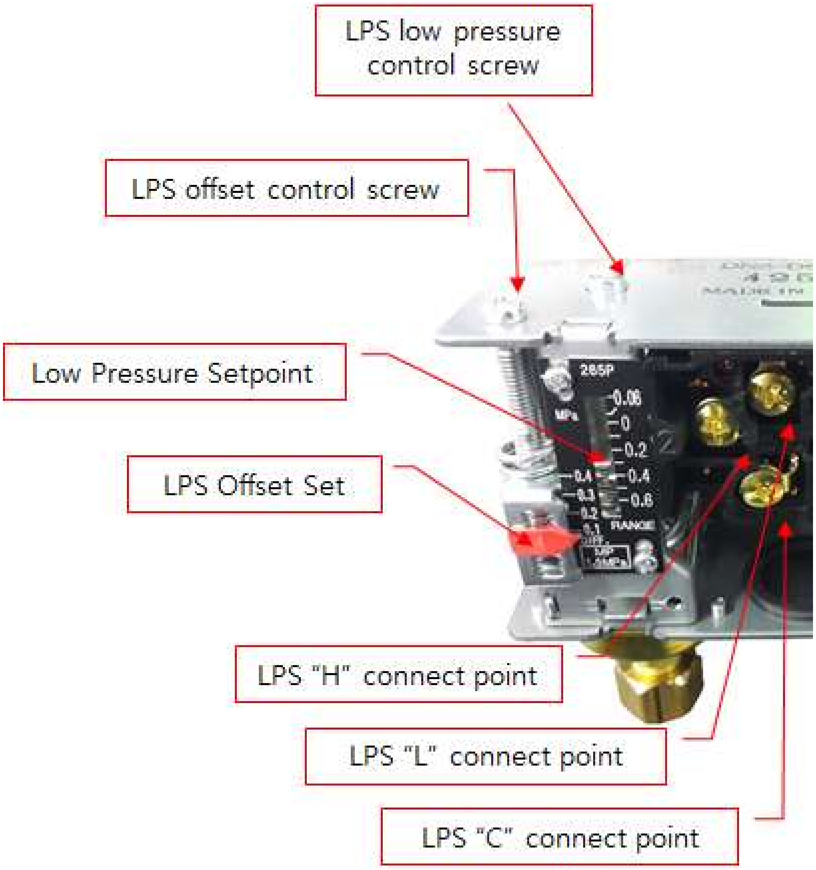
DPS is a multi purpose switch which contains both low-high pressure swtiches. DPS consist of lever, contact adjust screw and run/stop compressor upon refrigerant pressure.

1) Structure

Referring the figure above, LPS is located below cover of DPS and Hand Pressure Switch (HPS) is located next to itself. There are 3 contact each which is 'C' below the LPS, 'A' above, 'H', and 'L'(B contact) on the upper side.
LPS contains pressure up/down adjust screw and HPS has manual return structure which lack of down pressure switch.

High/low pressure switch protects the equipment by opening/closing L,H contact upon high/low pressure configuration during equipment operation.

1) L.P.S. method



Right gradation: Low pressure (RANGE)

Left gradation: offset(DIFF)

① Adjust low pressure by turning the screw clockwise/anti-clockwise with screw driver(+)

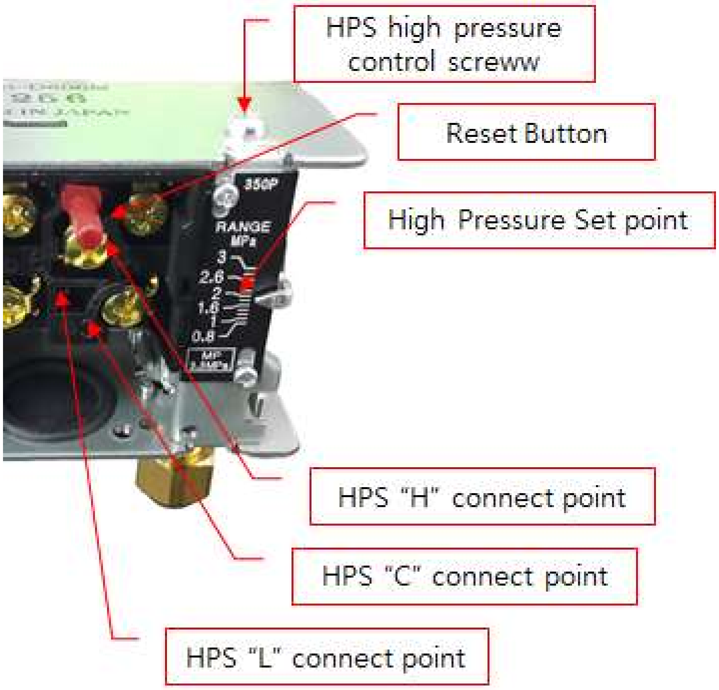
② Also adjust offset by turning the screw clockwise/anti-clockwise with screw driver(+)

③ Apply (+) power on com port and connect to certain port upon configuration (L or H) then connect other side of the cable to Comp (red port) next to DC power input.

④ LPS-L Line OUT (connect to COM -> L line port when pressure drops below configuration pressure)

⑤ LPS-H Line OUT (connect to COM -> H line port when pressure reaches up to configuration pressure)

2) H.P.S. method



① Adjust high pressure by turning the screw clockwise/anti-clockwise with screw driver(+)

② HPS-L Line OUT (connect to COM -> L line port when pressure drops below configuration pressure)

③ HPS-H Line OUT (connect to COM -> H line port when pressure reaches up to configuration pressure, manual return by reset)

Experiment name	4-3. Practice to configuration of low pressure switch(LPS) using sequence control	Time
		8

Refrigeration Experiment Equipment
(KTE-1000MO)

· **Check Point**

1. Checking tools and materials.
2. Setting the difference as the valves of LPS and explaining the operation principal of it .
3. Configurating circuit of operation with banana jacks using tools and material.
4. Understanding the function of operating circuit.
   ① Explaining the progress when PB1 is pushed.
   ② Explaining the progress that the refrigerator is stoped when pressure at low pressure part goes down on running of compressor motor.
   ③ Explaining the progress that the refrigerator is restarted when pressure at low pressure part goes up on stop of compressor motor
   ④ Explaining the progress that refrigerator starts when PB_2 is pushed.
5. noting and defining distribution and variation of high temperature points
6. Configurating circuit with electric wires and operating using tools and materials.

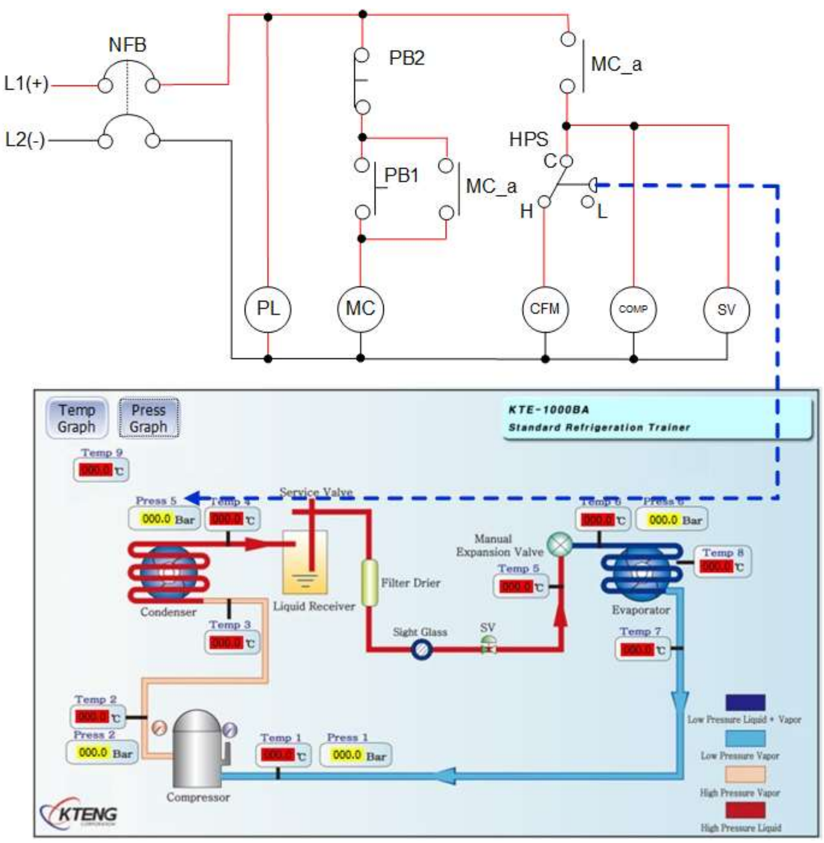
<table>
<tr><td rowspan="9">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Allot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70))</td><td>Circuit configuration using banana jack</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Circuit configuration using real wire</td><td>20</td><td></td></tr>
<tr><td>Configuration state</td><td>10</td><td></td></tr>
<tr><td>Understand and description for circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Task attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Application and standstill of tools</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Time (Point 20)</td><td colspan="3" rowspan="2">· Demerit mark Point (   )
in every (   ) minute after finish</td><td>Work</td><td>Task</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	4-4. Practice to configuration of high pressure switch using sequence control	Class time(hr) 8
The object of experiment	① To understand the principal of high pressure control (HPS), and adjust it. ② To configurate and operate circuit for high pressure control and understand. ③ To understand the feature after note and define distribution and variation of high pressure to control the outlet of condenser.	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration experiment equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6 × 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

Control Circuit

1. Basic control circuit



L1, L2 : Line voltage
N.F.B : No-fuse breaker
COMP1 : 1st stage comp
PB : push button

CFM : Condenser fan motor
SV1 : Solenoid valve 1
LPS : Low-pressure switch
MC : Magnetic contact

No.	Cut in P	D.P	Cut out P	Pressure gauge	Remarks
1	12	3	9		
2	12	2	10		
3	11	2	9		

The pressure control Refrigeration system operation through pressure adjustment operation of HPS. Configure the circuit to be turned on/off according to the set pressure value, and operation the Refrigeration system by performing C,H,L contact point control circuit configuration.

According to operate refrigeration on/off cycle upon configurations below

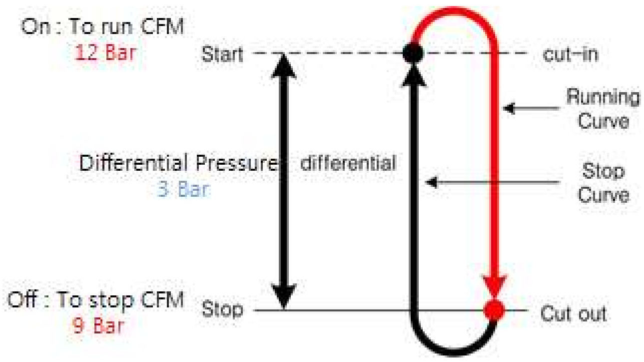
CUT-IN (stop → run) POINT = configuration pressure

CUT-OUT (run → stop) POINT = configuration pressure - offset

ex) configuration pressure 12, offset 3 [bar]

CUT-IN point 12 = 12[bar] , CUT-OUT point 12 - 3 = 9[bar]

* HPS run/stop curve



2. Operate the cooling system through the high pressure control circuit diagram

① When the power is connected via NFB, the Power Indicator (PL20) turns on. And PB1 switches or electronic contactor MC switches are all " b " contacts, so the other loads device is not energized.

② Press the PB1 switch, which is an " ON " switch, and the electronic contactor MC coil is created by creating an electric field by closing the MC switch contacts and keeping the MC_contact on the PC1 switch.

③ At the same time, the circuit will close the MC switch contact above the control unit High Pressure Isolation Switch (HPS). The compressor and the SV connected to the MA-a contact output terminal are activated and the electricity flows to the hogh-pressore diferential pressure switch terminal. If the pressure on the outlet side of the condenser is higher than the pressure set by the differential pressure switch, electricity flows from the ‘c’ terminal to the ‘H’ terminal. If the pressure is lower than the LPS pressure, It flows toward the ‘L’ terminal.

④ If the pressure on the high pressure side is higher than the cut-in pressure and electricity flows to the ' H ' terminal, Condenser fan is supplied to the motor to operate the condenser and start the Refrigeration system operating.
(Present, run as compressor, solenoid valve, condenser fan motor)

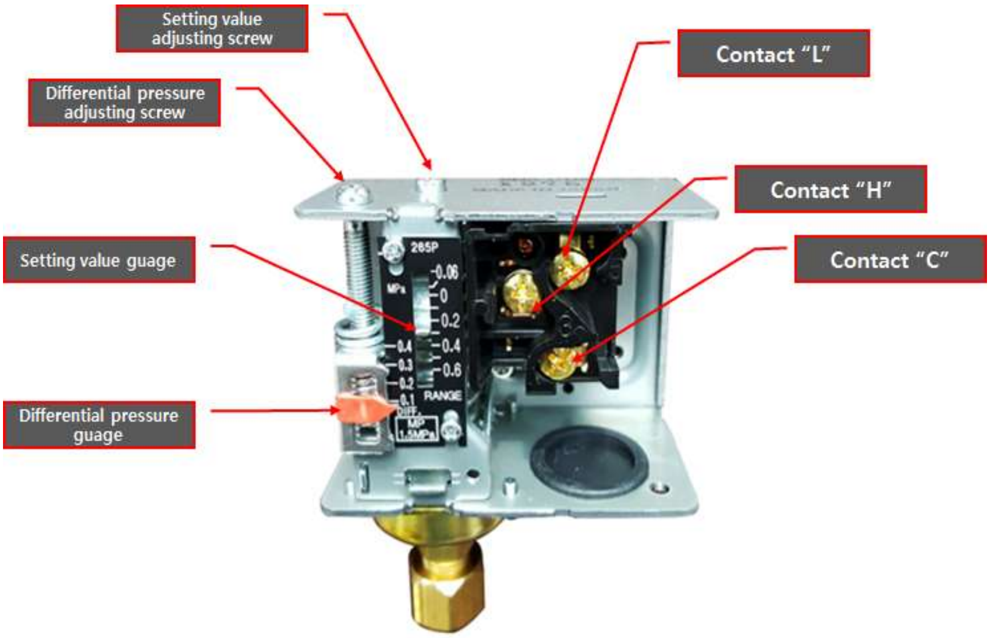
⑤ During the operation of condenser, the refrigerant passes through the condenser inner coil and exchanges the heat with the wind supplied from the fan. Therefore, the refrigerant pressure in the high-pressure side is gradually lowered.

⑥ When the pressure on the high pressure side becomes lower than the cut-out pressure and the electricity is changed from the ‘c’ terminal of the differential pressure switch to the ‘L’ terminal, the power supply to the condenser fan motor is cut off and the condenser is stopped.

⑦ The refrigerant circulates in the condenser without heat exchange, and the high pressure side pressure rises. When the pressure reaches the cut-in point, the differential pressure switch terminal is connected again to the ‘H’ terminal. Therefore, the condenser is restarted and the high-pressure side pressure is lowered. According to the high pressure change of the condenser outlet, it is a system in which the terminal of the differential pressure switch is repeatedly operated.

⑧ If PB2 is pressed, the flow of electricity to the MC coil is cut off, self-holding circuit is cut off, and the Refrigeration system is stopped.

3. How to way the high pressure switch



The high-pressure switch consists of a section for setting the set value at which the condenser starts to operate and a deviation according to the operating range.

The connecting hose connects with the high pressure part of the system (Outlet of condenser).

① Adjust high pressure setting value by turning the screw clockwise/anti-clockwise with screw driver(+).

② Adjust offset setting value by turning the screw clockwise/anti-clockwise with screw driver(+).

③ HPS-L Line OUT (connect to COM -> L line port when pressure drops below configuration pressure).

④ HPS-H Line OUT (connect to COM -> H line port when pressure reaches up to configuration pressure, manual return by reset).

Experiment name	4-4. Practice to configuration of high pressure switch using sequence control	Time
		8

Refrigeration Experiment Equipment
(KTE-1000MO)

· **Check Point**

1. Checking tools and materials.
2. Setting the difference as the valves of HPS and explaining the operation principal of it .
3. Configurating circuit of operation with banana jacks using tools and material.
4. Understanding the function of operating circuit.
   ① Explaining the progress when PB1 is pushed.
   ② Explaining the progress that the refrigerator is stoped when pressure at high pressure part goes down on running of compressor motor.
   ③ Explaining the progress that the refrigerator is restarted when pressure at high pressure part goes up on stop of compressor motor
   ④ Explaining the progress that refrigerator starts when PB_2 is pushed.
5. noting and defining distribution and variation of high temperature points
6. Configurating circuit with electric wires and operating using tools and materials.

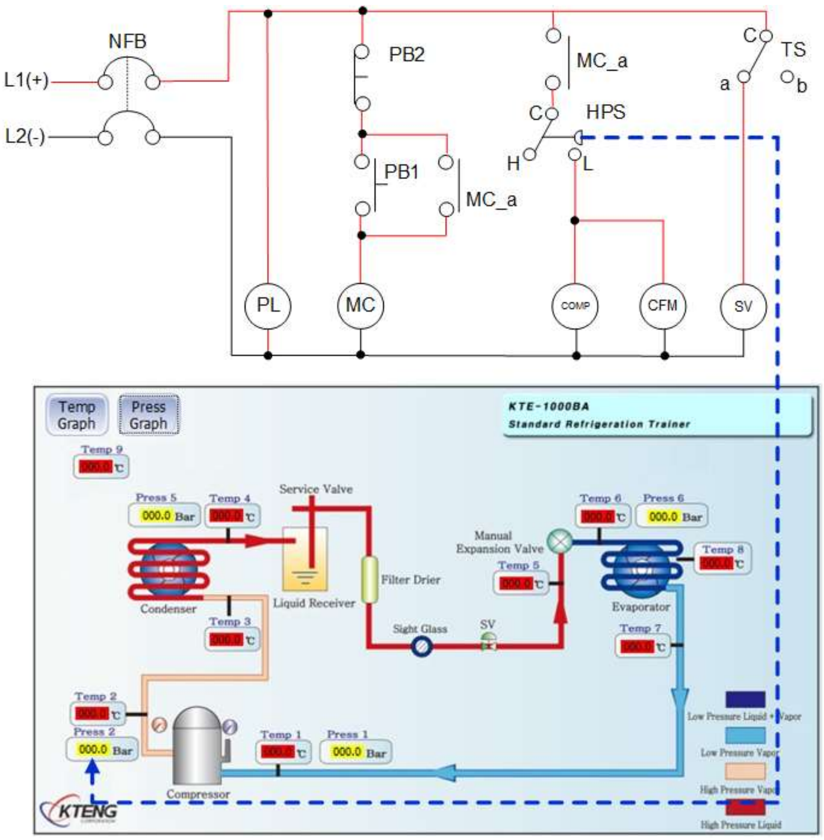
Relationship between technical description rating items and task	Appraisal		Allot	Point	Remark			
	Work (Point 70))	Circuit configuration using banana jack	20					
		Circuit configuration using real wire	20					
		Configuration state	10					
		Understand and description for circuit	20					
	Task (Point 10)	Task attitude and safety	5					
		Application and standstill of tools	5					
	Time (Point 20)	· Demerit mark Point ( ) in every ( ) minute after finish			Work	Task	Time	Total

Experiment name	4-5. Practice to configuration of HPS on pressure switch using sequence control	Class time(hr) 8
The object of experiment	① To understand the principal of high pressure control (HPS), and adjust it. ② To configurate and operate circuit for high pressure control and understand. ③ To learn how to take when abnormal pressure occurs during operation by controlling the high-pressure side (outlet of the compressor) of the refrigerator	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration experiment equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6 × 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

Control Circuit

1. Basic control circuit



L1, L2 : Line voltage
N.F.B : No-fuse breaker
COMP : Compressor
TS : Togle switch

CFM : Condenser fan motor
SV1 : Solenoid valve 1
LPS : Low-pressure switch
MC : Magnetic contact

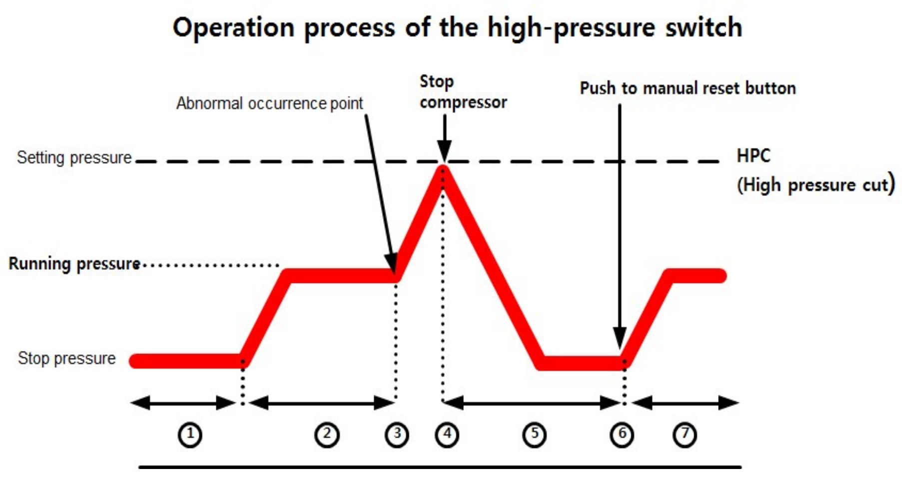
No.	Cut in P	D.P	Cut out P	Pressure gauge	Remarks
1	6				
2	10				
3	14				

The HPS pressure adjustment operation can be used to forcibly stop the Refrigeration system in case of abnormally high pressure.

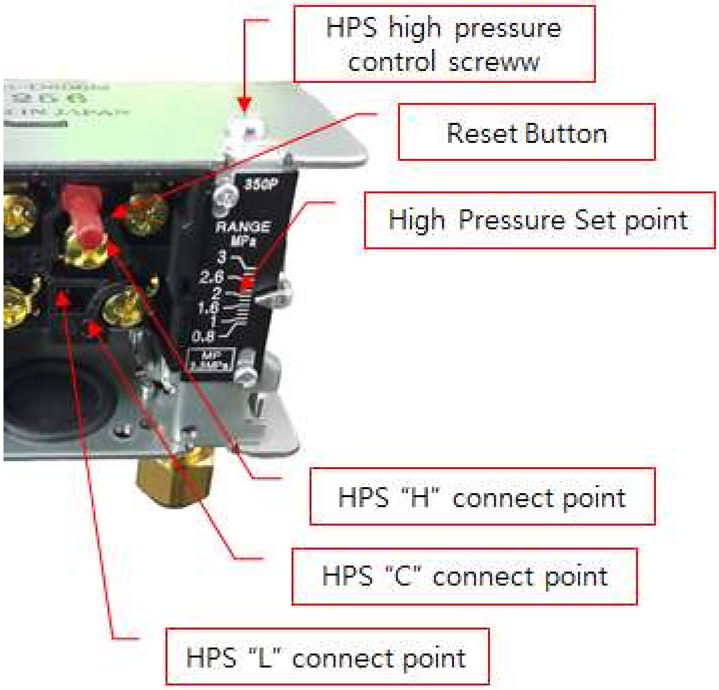
After the equipment is configurated the wire according to the control circuit to start normal operation when the toggle switch is turned to contact ‘b’, the solenoid valve is closed and the high pressure is forcibly raised to enable the operation of the HPS

※ Caution : Set the high pressure high and ensure that the low pressure drip to 0 bar during the experiment does not last long. (Open the SV within a reasonable time. Within 10 seconds)

1. Operation process of the high-pressure switch



2. How to set the HPS



① Adjust high pressure by turning the screw clockwise/anti-clockwise with screw driver(+).

② HPS-L Line OUT (connect to COM -> L line port when pressure drops below configuration pressure)

③ HPS-H Line OUT (connect to COM -> H line port when pressure reaches up to configuration pressure, manual return by reset)

<table>
<tr><td rowspan="2">Experiment name</td><td rowspan="2">4-5. Practice to configuration of HPS on pressure switch using sequence control</td><td>Time</td></tr>
<tr><td>8</td></tr>
</table>

Refrigeration Experiment Equipment
(KTE-1000MO)

· **Check Point**

1. Checking tools and materials.
2. Setting the difference as the valves of HPS and explaining the operation principal of it .
3. Configurating circuit of operation with banana jacks using tools and material.
4. Understanding the function of operating circuit.
   ① Explaining the progress when PB1 is pushed.
   ② Explaining the progress that the refrigerator is stoped when pressure at high pressure part goes down on running of compressor motor.
   ③ Explaining the progress that the refrigerator is restarted when pressure at high pressure part goes up on stop of compressor motor
   ④ Explaining the progress that refrigerator starts when PB_2 is pushed.
5. noting and defining distribution and variation of high temperature points
6. Configurating circuit with electric wires and operating using tools and materials.

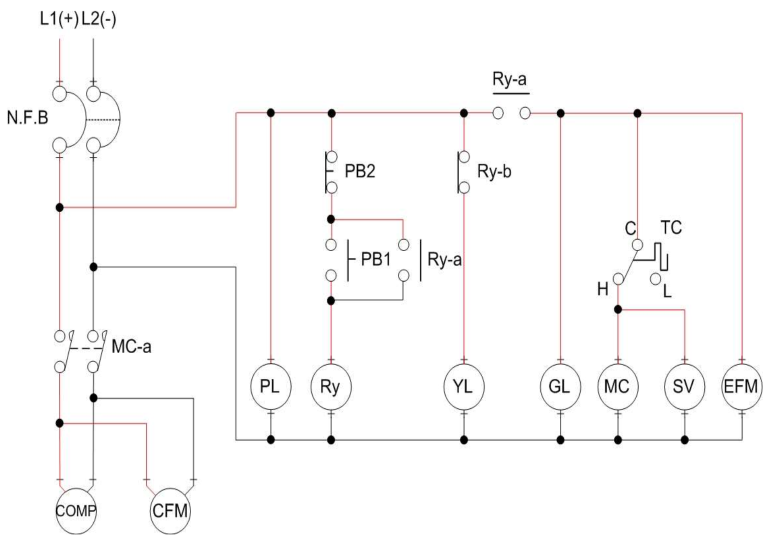
<table>
<tr><td rowspan="9">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Allot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70))</td><td>Circuit configuration using banana jack</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Circuit configuration using real wire</td><td>20</td><td></td></tr>
<tr><td>Configuration state</td><td>10</td><td></td></tr>
<tr><td>Understand and description for circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Task attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Application and standstill of tools</td><td>5</td><td></td></tr>
<tr><td rowspan="2">Time (Point 20)</td><td colspan="3" rowspan="2">· Demerit mark Point (   )
in every (   ) minute after finish</td><td>Work</td><td>Task</td><td>Time</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Experiment name	4-6. Practice to configurate direct circuit for low temperature (Temperature S/W) and low pressure (LPS) control with Refrigeration system	Class time(hr)
		8
The object of experiment	① To configurate direct circuit at low pressure part using temperature S/W and Pressure S/W. ② To make wiring as the circuit ③ To note and understand variation of temperature and pressure when system is controlled by low pressure and low temperature	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration experiment equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6 × 175mm . 150mm . 0.5~6mm^2 . 300A 600V	1 1 1 1/Group

Control Circuit

1. Advanced control circuit to temperature switch



L1, L2 : Line Voltage

N.F.B : No fuse circuit breaker

PB : Push button

CFM : Condenser Fan Motor

SV : Solenoid V/V

COMP : Compressor motor

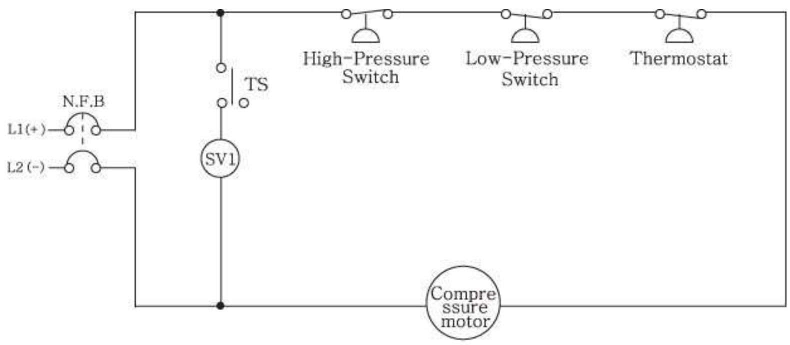
MC : Magnet contactor coil

MC-a : MC "a" contact

PL : Power Lamp

Test Steps	Evaporation Temperature Setting(℃)	Deviation	Evaporation Pressure Control (in P)	D.P	Operating(in), Stop(out) T.P	
					Temperature (Temp)	Pressure(P)
1	0	3				
2	−1	3				
3	−2	3				
4	−3	2				
5	−4	2				
6	−5	2				

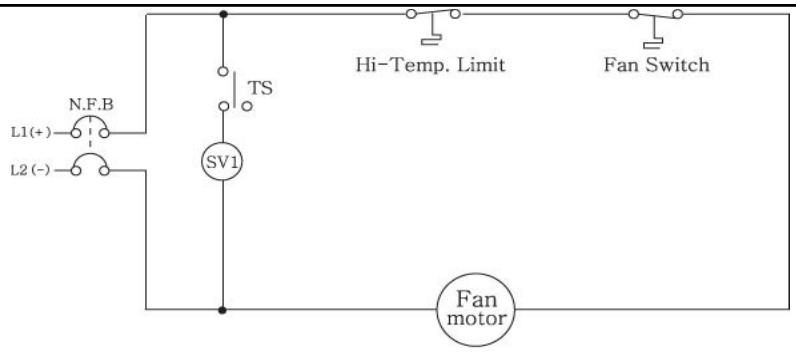
1. 1. Serial and Parallel Circuit Configuration



EXE NO . 2

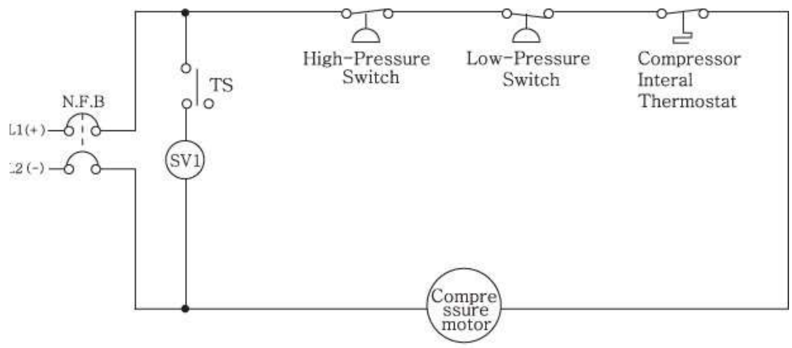
The switches and controllers are generally connected in series. They control and manage more than one loads each. The electric circuit that we can understand the most easily and simply is the serial circuit. In the serial circuit, the current shall pass through one circuit. The serial circuit is connected to most control circuits in the heating and air conditioning and refrigeration devices.

The control circuit means the electric circuit controlling several important loads in the device. If all control components are connected on the circuit in series, opening the components or switches make the circuit open and loads intercepted as shown in EXE No. 2.



EXE NO . 3

The serial circuit is used as the electric circuit in the heating, air conditioning and refrigeration devices for controlling the temperature and devices. EXE NO, 3 shows the circuit on the controller. The controller is connected to the devices that are controlled by the electric motor in series. The serial circuit includes the safety devices required to keep the safe operation of devices. EXE NO, 4 shows how the safety devices are connected to the serial circuit in order to stop the compressor if any unstable operations are occurred. In this case, if the safety device is opened, the relevant circuit is also opened and so the compressor stops working.



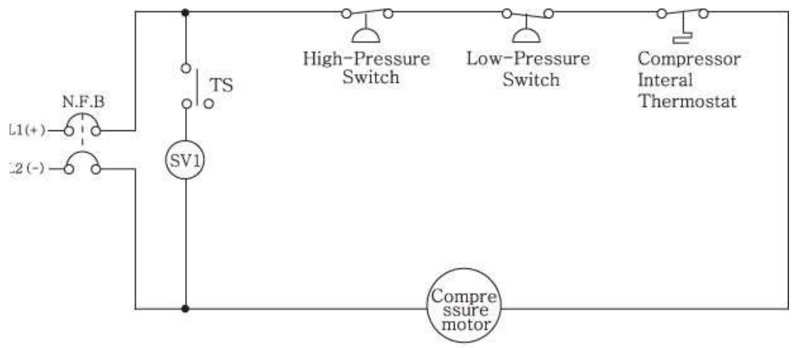
EXE NO . 4

The currents in the serial circuit flow in the same way on the entire circuit because there is only one channel that the currents can follow.

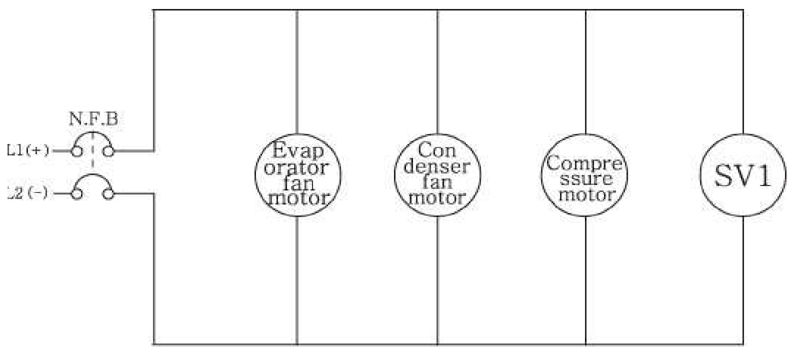
$I = I_1 = I_2 = I_3 = I_4$ ....

The parallel circuit has more than one channels for the currents in the heating and cooling system. The currents in the parallel circuit can flow along more than two channels at the same time. The parallel circuit is used in the heating and cooling system control industry because most loads work with each line voltage. The line voltage is supplied from the main power unit to a specific unit, which is generally 100V or 220V. The parallel circuit is aligned to enable the line voltage to reach to all loads connected in parallel as shown in EXE NO, 5. Each load in the circuit is supplied with the line voltage of 220V.

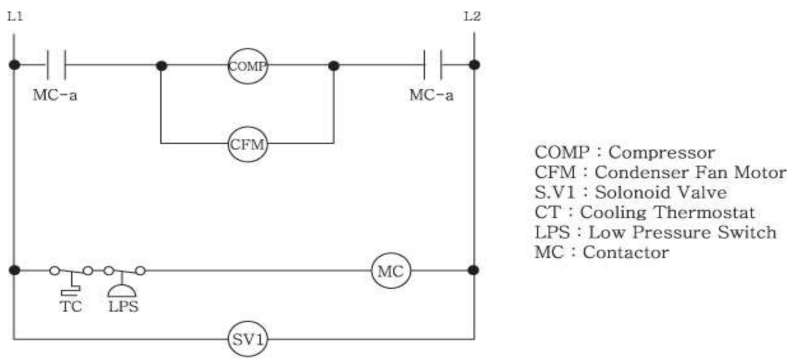
The parallel circuit is used to supply the accurate line voltage to each circuit in the controller, which is called "Power Circuit". EXE NO, 6 presents the controller with several circuits in the parallel circuit with the line voltage. Many other circuits with the currents are configured in the parallel structure as shown in the figure. Each circuit connected from the line 1 to the line 2 are connected to other circuits in parallel and receives the voltage. The parallel circuits are used in all power circuits supplying the loads of air conditioning and refrigeration devices. The loads in a device need to be connected to the power supply unit in the separate types or in parallel to supply the sufficient line voltage to loads. It is very rare that the field engineers calculate the currents or voltages in the parallel circuits, but the designers decide them in most cases. However, the field engineers are very familiar with the principles or concepts of basic parallel circuits. The currents in the parallel circuits have the fixed values for each circuit sector and some variables are generated depending on the resistance in each sector in the circuit.



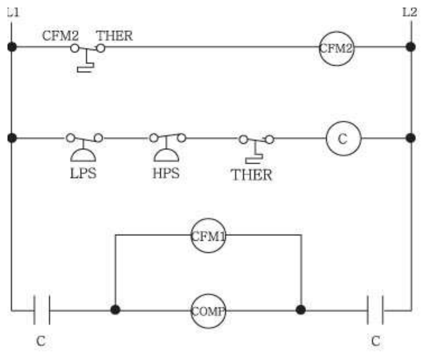
EXE NO . 4



EXE NO . 5



EXE NO . 6



Legend
LPS : Low-Pressure Switch
HPS : High-Pressure
THER : Htermostat
COMP : Compressor
C : Contactor
CFM1 : Condenser Fan Motor1
CFM2 : Condenser Fan Motor2

EXE NO . 7

All currents in the parallel circuit match up to the total currents on each sector. The currents on each sector in the circuit are calculated when the resistance and voltage are given. The equation for all currents in the parallel circuit is:

$$I = I_1 + I_2 + I_3 + \ldots$$

For the parallel circuit, the more the resistance is applied to the circuit, the smaller the entire resistance becomes. All resistances in the parallel circuit can't be calculated by adding all resistances. The total resistance can be obtained according to the formula below.

The reciprocal proportion of total resistance matches up to the value adding the reciprocal proportion of each resistance. The formula belows describes it.

The split voltage in the parallel circuit is the line voltage on the loads. Each load in the parallel circuit is the entire voltage on the loads. For example, if 220 V is applied to one load, it means that the load has the entire voltage 200V.

$$V = V_1 = V_2 = V_3 = V_4 = \ldots$$

The serial−parallel circuit combines the serial and parallel circuits. It is found in the entire wiring design for the air conditioning and refrigeration devices. This type of electric circuit mixes the serial and parallel circuit as shown in EXE NO. 7. The serial−parallel circuit can be more easily understood when it has several components. If not, it is very difficult to understand it. The serial−parallel circuit is used to connect the circuit supplying the power to loads to the control circuit. Most serial−parallel circuit applications aim to supply the accurate voltage to the contact lines with the switches to enable all loads to control the devices in series. Each electricity in the serial−parallel circuit shall be carefully measured because each proportion of circuit can be explicitly defined as serial or parallel circuit. Once the circuit line is defined, the electricity shall be calculated later.

Experiment name	4-6. Practice to configurate direct circuit for low temperature (Temperature S/W) and low pressure (LPS) control with a Refrigeration system	Time
		8

Refrigeration Experiment Equipment
(KTE-1000MO)

・Check Point

1. Checking tools and materials.
2. Configurating circuit of operation with banana jacks using tools and material.
3. Understanding the feature of direct circuit using automatic control switch(temperature, pressure) and explaining it.
4. Understanding the function of operating circuit.
   ① Explaining the progress when PB1 is pushed.
   ② Explaining the progress that the refrigerator is stopped when the temperature switch or pressure switch is opened on running.
   ③ Explaining the progress that the refrigerator is restarted when the temperature switch or pressure switch is closed on no running.
   ④ Explain the progress that refrigerator is operated when PB_2 is pushed.
5. Noting and defining distribution and variation of pressure points
6. Configurating circuit with electric wires and operating using tools and materials.

<table>
<tr><td rowspan="8">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Allot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70))</td><td>Circuit configuration using banana jack</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Circuit configuration using real wire</td><td>20</td><td></td></tr>
<tr><td>Configuration state</td><td>10</td><td></td></tr>
<tr><td>Understand and description for circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Task attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Application and standstill of tools</td><td>5</td><td></td></tr>
<tr><td>Time (Point 20)</td><td colspan="3">· Demerit mark Point ( )
in every ( ) minute after finish</td><td>Work

</td><td>Task

</td><td>Time

</td><td>Total

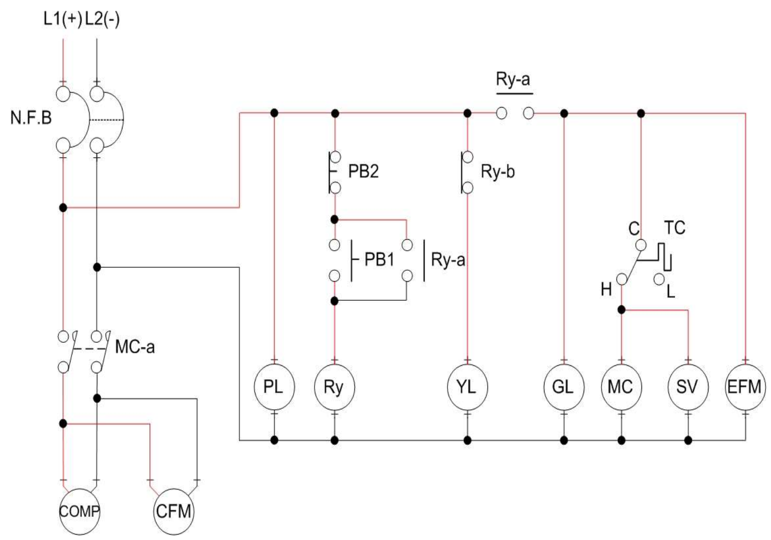
</td></tr>
</table>

Experiment name	4-7. Practice to configuration of pump down control circuit using sequence control	Class time(hr)
		8
The object of experiment	① To understand and applicate the principal of pump down operation in Refrigeration system. ② To configurate pump down circuit. ③ To wire pump down circuit. ④ To set the value of temperature S/W and pressure S/W for pump down operation. ⑤ To note and understand variation of temperature and pressure when system is operated as pump down circuit.	

Experiment equipments	Tool & material	Spec of tools	Q'nty
. refrigeration experiment equipment (KTE-1000MO)	. Driver . Nipper . Wire Stripper . Hook meter	. #2× 6 × 175mm . 150mm . 0.5~6mm² . 300A 600V	1 1 1 1/Group

Control Circuit

1. Advanced control circuit to temperature switch



L1, L2 : Line Voltage

N.F.B : No fuse circuit breaker

PB : Push button

CFM : Condenser Fan Motor

SV : Solenoid V/V

COMP : Compressor motor

MC : Magnet contactor coil

MC-a : MC "a" contact

PL : Power Lamp

2. Operating cooling system through temperature control circuit diagram

① Check if the power lamp turns on when N.F.B power is applied. Press PB1 to confirm that the MC is powered.

② Press PB1 to explain the operation process. Mc-a is actuated, and the TC (Thermo-stat) is powered and Comp, CFM, SV (Open) and EFM are operational according to the set temperature values.

③ If PB1 is pressed, L contacts are operated in the TC (Temperature Controler), and EFM is operated.

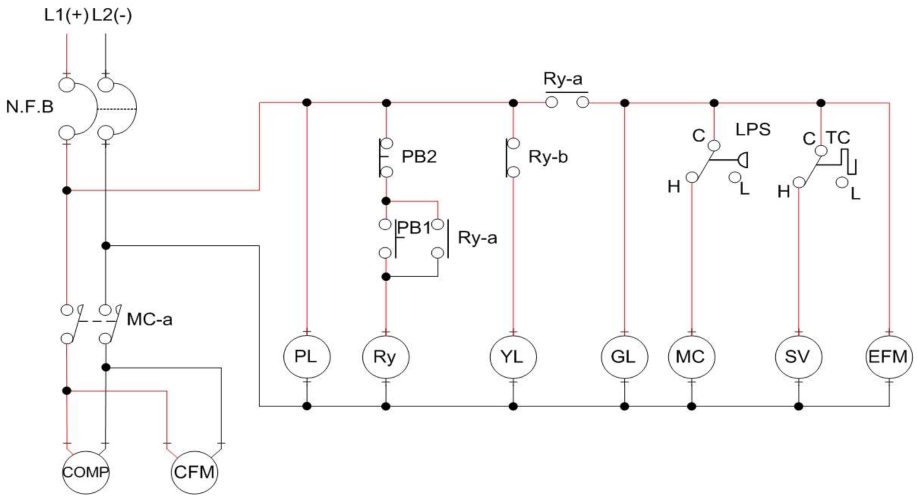
④ If PB1 is detached, the H contact of the TC is powered.
Therefore, Comp, CFM connected to H contact is operational and SV opens.

⑤ TC (thermostat) refers to the control of evaporation temperature. The temperature setting value is set to the ambient air temperature (ambient air temperature or exit) or below. Construct a circuit to enable the H contact to operate, since the current evaporation temperature is higher than the established evaporation temperature.
When the H contact is active, the connected Comp and CFM are operated and the SV (Solenoid Valve) open to reduce the evaporation temperature. When the evaporation temprature value is lower than the TC set value through H contactor control, the L contacts energised.

⑥ When power is applied to the L contact, Comp and CFM connected to the H contact are turned off, while the SV closes, and EFM operates to give evaporation load.

⑦ Connect the circuit as shown in the control diagram, and check if the above operating cycle operates repeatedly.

3. Control circuit for pump down a Refrigeration system



L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
PB : Push button
MC-a : MC "a" contact
RY : Relay coil
Ry_a : Relay"a"contact
Ry_b : Relay "b"contact
YL : Yellow Lamp

COMP : Compressor motor
CFM : Condenser Fan Motor
SV : Solenoid V/V
MC : Magnet contactor coil
LPS : Low Pressure S/W
TC : Temperature control S/W
PL : Power Lamp
GL : Green Lamp

Test Steps	Evaporation Temperature Setting(℃)	Deviation	Evaporation Pressure Control(in P)	D.P	Remarks
1	0℃	2 or 1			
2	-1℃	2 or 1			
3	-2℃	2 or 1			
4	-3℃	2 or 1			
5	-4℃	2 or 1			
6	-5℃	2 or 1			
7	-6℃	2 or 1			

4. Practice of operating the pump down control circuit with contact control (C, H, L)

① When the power is turned on the breaker N.F.B, the power indicator(PL) is turned on.
The 'a'contact of the PB1 switch or the Magnetic Contactor, Ry, MC switch does not supply electricity to the other load device because only the YL connected to the Ry switch 'b' contact is turned on.

② When the ‘ON’ switch PB1 is pressed, a magnetic field is formed through the relay roil. The Ry switch contact. Ry_a contact, is then closed and the PB1 switch is turned off conversely. Ry_b contact is opened and YL is turned off.

③ At the same time, electricity is supplied to the low-pressure switch and the temperature switch terminal, which are control devices, in the circuit diagram. In the case, if the low-pressure line pressure on the suction side of the compressor is higher than the pressure set in LPS, electricity flows from the ‘c’ terminal to the ‘H’terminal. On the other hand, if less than the LPS set pressure, electricity flows from the ‘c’ terminal to the ‘L’terminal. In the case of the temperature switch, electricity flows from the ‘c’terminal to the ‘H’terminal of the ‘L’terminal according to the set temperature of the evaporator outlet.

④ When the evaporator outlet temperature is higher than the set temperature and the electricity flows to the ‘H’terminal, the solenoid valve is opened and at the same time the low pressure side is higher than the set pressure. Electricity is supplied and Refrigeration system operation is activated.

⑤ When the evaporator outlet temperature drops below the se temperature due to sufficient Refrigeration system operation, the contact of the temperature switch is connected from the ‘c’terminal to the ‘L’terminal, and the solenoid valve is closed. When the compressor and the condenser operate with the solenoid valve closed, the refrigeration on the low pressure side flows continuously to the high pressure side, so that the pressure on the high pressure side gradually rises and the pressure on the low pressure side drops.

⑥ When the pressure on the low pressure side becomes lower than the set pressure and electricity flows to the ‘L’terminal, the electricity supply to the compressor and the condenser is cut off and the operation is stopped. When the solenoid valve is closed, the compressed refrigerant is collected in the liquid receiver. (Pump down)

⑦ When the evaporator outlet temperature rises and the solenoid valve is opened again and the refrigerant filled in the receiver flows to the low pressure side, the pressure on the low pressure side rises. When the pressure rises to reach the set value, the LPS switch terminal is connected again to the ‘H’terminal to start the compressor and the condenser start the Refrigeration system operation. Therefore, this control circuit uses a temperature switch and a pressure switch to automatically shut down the equipment when the evaporator temperature reaches a certain temperature and to pump down the circuit.

⑧ When you press the switch ‘PB2’ which is ‘off’ switch, the flow of electricity to the Ry coil is cut off, self-holding is cut off and the Refrigeration system is stopped because the electricity supply to the Refrigeration system is cut off.

Experiment name	4-7. Practice to configuration of pump down control circuit using sequence control	Time
		8

Refrigeration Equipment
(KTE-1000MO)

、Check Point

1. Checking tools and materials.
2. Configurating circuit of operation with banana jacks using tools and material.
3. Understanding the feature of parallel circuit using automatic control switch(temperature, pressure) and explaining it.
4. Understanding the function of operating circuit.
   ① Explaining the process when PB1 is pushed.
   ② Explain the process that temperature S/W is opened on running
   ③ Explain the condition for Pressure S/W is opened on running.
   ④ Explain the process that refrigerator stops when pressure S/W is opened
   ⑤ Explain the process that refrigerator starts when PB_2 is pushed.
5. Noting and defining distribution and variation of pressure points
6. Configurating circuit with electric wires and operating using tools and materials.

<table>
<tr><td rowspan="8">Relationship between technical description rating items and task</td><td colspan="2">Appraisal</td><td>Allot</td><td>Point</td><td colspan="4">Remark</td></tr>
<tr><td rowspan="4">Work (Point 70))</td><td>Circuit configuration using banana jack</td><td>20</td><td></td><td colspan="4" rowspan="6"></td></tr>
<tr><td>Circuit configuration using real wire</td><td>20</td><td></td></tr>
<tr><td>Configuration state</td><td>10</td><td></td></tr>
<tr><td>Understand and description for circuit</td><td>20</td><td></td></tr>
<tr><td rowspan="2">Task (Point 10)</td><td>Task attitude and safety</td><td>5</td><td></td></tr>
<tr><td>Application and standstill of tools</td><td>5</td><td></td></tr>
<tr><td>Time (Point 20)</td><td colspan="3">、Demerit mark Point (   )
in every (   ) minute after finish</td><td>Work

</td><td>Task

</td><td>Time

</td><td>Total

</td></tr>
</table>

Chapter 5. Notice and Guarantee

1. Mechanical trouble and measures

1-1. When the Power lamp does not connect

(1) If the power lamp do not work when the N.F.B turn on. Please check inserts a power cord in the reverse side of N.F.B or installation in power input.

1-2. When trouble of the other parts

(1) Contact us when Operation of other parts is strange or out of work. Then we will handle rapidly.

2. Caution Notice on operation

2-1. Power Supply

(1) Main power of this equipment is use a single phase AC 220V.

(2) After equipment action order turns on N.F.B and watches circuit diagram and finishes wiring by RCA cable in proposition that power cord was counted, DC toggle switch does on.

(3) Use RCA cable and power supply at equipment operate secures because use DC 24V, but should observe to +, - mixing use of monad as operating power is DC.

(4) Also, base and control panel of equipment is all aluminum quality of the material when interlink red + terminal, should take care not to reach in aluminum base.

2-2. Machine Equipment

(1) When using a charging nipple installed at low pressure and high pressure side of, notice refrigerant not to leak.

(2) Use after making sure how to use well exactly operating a manual expansion valve .

(3) When going out of factory, super heating and sub cooling are set up 5±2℃, but as your continue using the setting value will be changed.

(4) Notice fragile arcrylic duct of evaporator for visual inside. Be careful not to break it.

(5) If you separate any component of product by yourself, the system gets damage and you never get A/S from us.

2-3. Data Acquisition device and Software

(1) After set up circuit of electric panel on the main equipment, connect Data Acquisition device and computer. Check if the cable is connected correct, turn on the switch on panel.(* Please follow step by step as manual book.)

2-4. Else

(1) After reading the manual book, operate the system.

(2) If you have any question, call us.

◎ Warrantee and A/S application sheet

Product Warrantee Certification

Fill out this sheet, and send by Fax or E-mail..

MODEL		
WARRENTEE TERM	1 YEAR	
PURCHASING DATE	(M/D/Y)	
ORGANIZATION	**SCHOOL**	
	DEPARTMENT	

Headquarters :679-7 2Fl Sinhyun-Li, Opo-Eup, Gwangju-City, Gyonggi-Do, KOREA (zip : 464-895)
Head Office : #133-1 Sinhyun-li, Opo-eup, Gwangju-City, Gyeonggi-Do KOREA (zip : 464-895)
TEL : +81-31-749-5373 | FAX : +81-31-749-5376 | kteng@kteng.com | www.kteng.com

Educational lab equipment training programs

KTE-101 : Refrigeration System Experiment Practical Course
KTE-102 : Refrigerant Parallel Valve Automatic Control Experiment Practical Course
KTE-103 : E.P.R(Evaporation Pressure Parallel Control) Refrigeration Experiment Practical Course
KTE-104 : Heat Pump System Performance Experiment Practical Course
KTE-105 : Cryogenic Cold & Heat(Dual Refrigeration) System Performance Experiment Practical Course
KTE-106 : Brine Refrigeration(Ice-storage Refrigeration) System Performance Experiment Practical Course
KTE-107 : Vehicular Heating and Cooling Performance Experiment Practical Course
KTE-108 : Air-conditioning System Performance Experiment Practical Course
KTE-109 : Chiller Method Air-conditioning System Performance Experiment Practical Course
KTE-201 : Solar • Wind Power Control Basic Circuit Configuration Practice
KTE-202 : Solar Generation Test Practice
KTE-203 : Solar System Equipment Configuration Practice
KTE-204 : Wind Power Generation Test Practice
KTE-205 : Solar • Wind Power Hybrid Generation Practice
KTE-206 : Hydrogen Fuel Cell Generation Practice
KTE-301 : Solar Radiant Energy Measurement Practical Experiment
KTE-302 : Solar Hot water boiler Performance Practical Experiment
KTE-303 : Geothermal Heat Pump Cooling & Heating Practical Experiment
KTE-304 : Solar-Thermal Combined Geothermal System Practical Experiment
KTE-401 : LED Basic Theory & Performance Assessment Practice
KTE-402 : LED Application System Configuration Practice
KTE-403 : LED Lighting Equipment Practice
KTE-404 : LED Media Facade Lighting Practice
KTE-405 : LED Luminescent property analysis Experiment
KTE-406 : OLED Unit Element Characteristic Evaluation Experiment
KTE-501 : PLC Automation Control Practice Basic
KTE-502 : PLC Automation Control Practice Intermediate
KTE-503 : PLC Automation Control Basic Advanced
KTE-601 : Sequence Control Practical Basic Course
KTE-602 : Sequence Control Practical Intermediate Course
KTE-603 : Sequence Control Practical Advanced Course
KTE-701 : Power Equipment Basic Course
KTE-702 : Power Equipment Intensive Course
KTE-901 : Water-based Fire Extinguishing Equipment
KTE-902 : Gas Fire Extinguishing Equipment
KTE-903 : Alarm Equipment
KTE-904 : Fire Extinguisher
KTE-905 : Evacuation Equipment
KTE-1101 : Robot Control Practical Basic Course
KTE-1102 : Robot Control Practical Intermediate Course
KTE-1103 : Robot Control Practical Advanced Course
KTE-1201 : Welding Machine Practical Basic Course
KTE-1202 : Welding Machine Practical Intermediate Course
KTE-1203 : Welding Machine Practical Advanced Course
KTE-1301 : Basic Pneumatic Practice
KTE-1302 : Electro-pneumatic Basic Practice
KTE-1303 : Electro-pneumatic Intermediate Practice
KTE-1401 : Automatic Control Mechatronics Basic Practice
KTE-1402 : Automatic Control Mechatronics Intermediate Practice
KTE-1403 : Automatic Control Mechatronics Advanced Practice

Renewable Energy / Refrigeration & Air-conditioning & Welding
Automation controls(PLC) / Robot controls / Electric & Electronics(LED lighting)
Firefighting & safety / Big data & ICT / Automobile & ship / Nano chemical

3E EDUCATION ENGINEERING ENVIRONMENT

KTENG CORPORATION

KTENG Co., Ltd.
TEL: 82-31-749-5373 | FAX: 82-31-749-5376
overseas@kteng.com | http://www.kteng.com
11, Meorusut-gil, Opo-eup, Gwangju-si,
Gyeonggi-do, 12771, South Korea