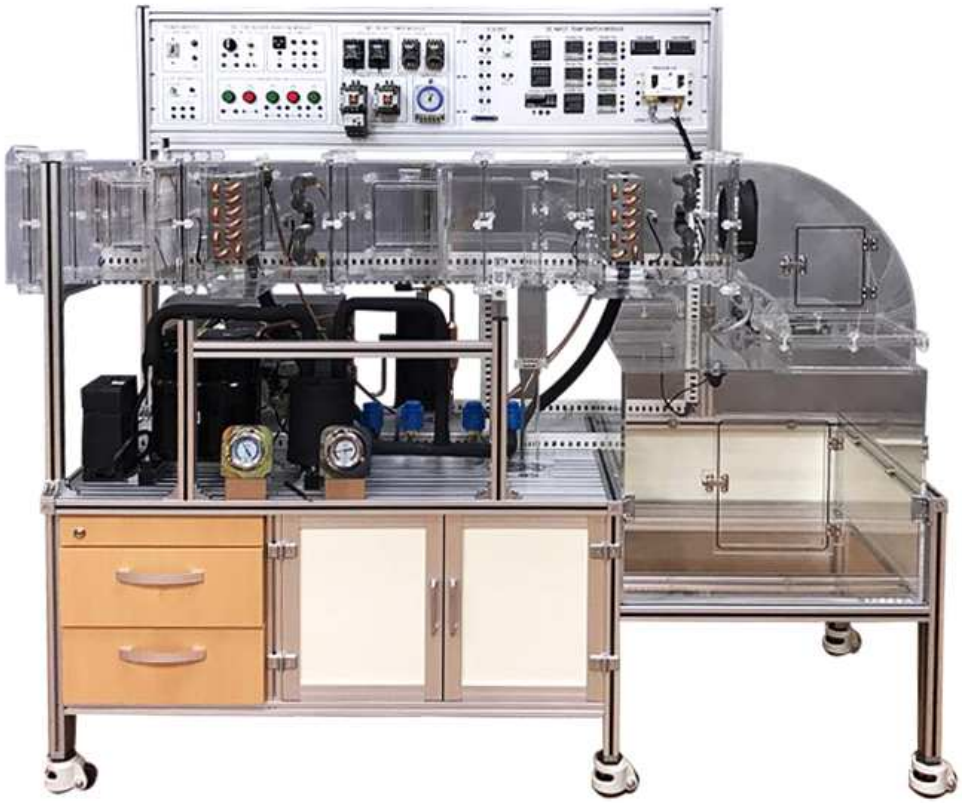
Model : KTE-1000AHU
AIR HANDLING UNIT
USAGE MANUAL



Korea Technology Institute of Energy Convergence
Korea Technology Engineering Co.,Ltd.

※Please read the user manual before the operating.

When setting the humidity in the indicator, 40% or more and 75% or less is recommended.

Do not disassemble or repair it as it is dangerous.

This product operates at 220 V and should be careful when used.

Never insert your hand in the fan that is operating

CONTENT

Chapter 1. Description of an Air Handling Unit

Chapter 2. Component of an Air Handling Unit

Chapter 3. Construction and Operation as circuit

Chapter 4. Air Handling Unit Construction Initial Setting

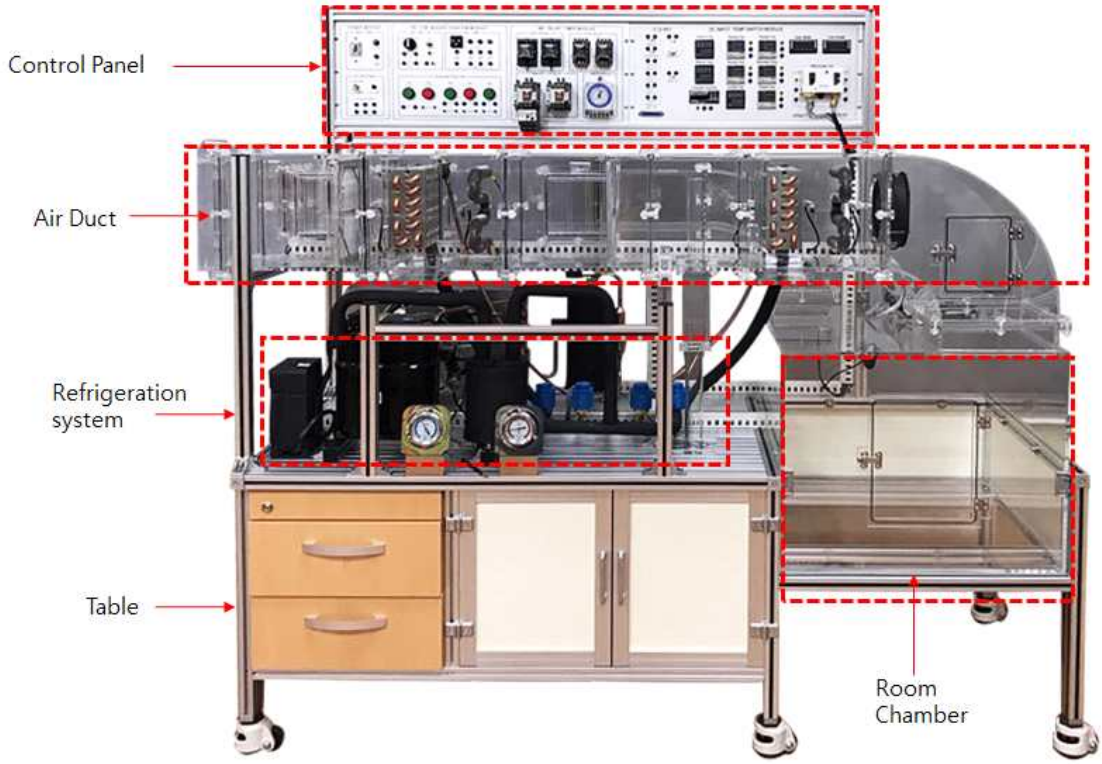
Chapter 5. Air Handling Unit Construction and Operation as circuit

Chapter 4. Notice and Guarantee

Chapter 1. Description of an Air Handling Unit

1. Air Handling Unit Experiment Equipment

1-1. System Description of Air Handling Unit Experiment Equipment



(1) CONTROL PANEL : Comosition with Select Switch, N.F.B, T.H.R, Toggle Switch, Am · Vm meter, Buzzer, Lamps(Red, Green, Orange), Differential Pressure Switch, Magnetic Contactor, Relays, Temperature controler, Temperature display device, Thermal Switch, Push Buttons, Power Input, these devices make the refrigeration system run by several electric circuit.

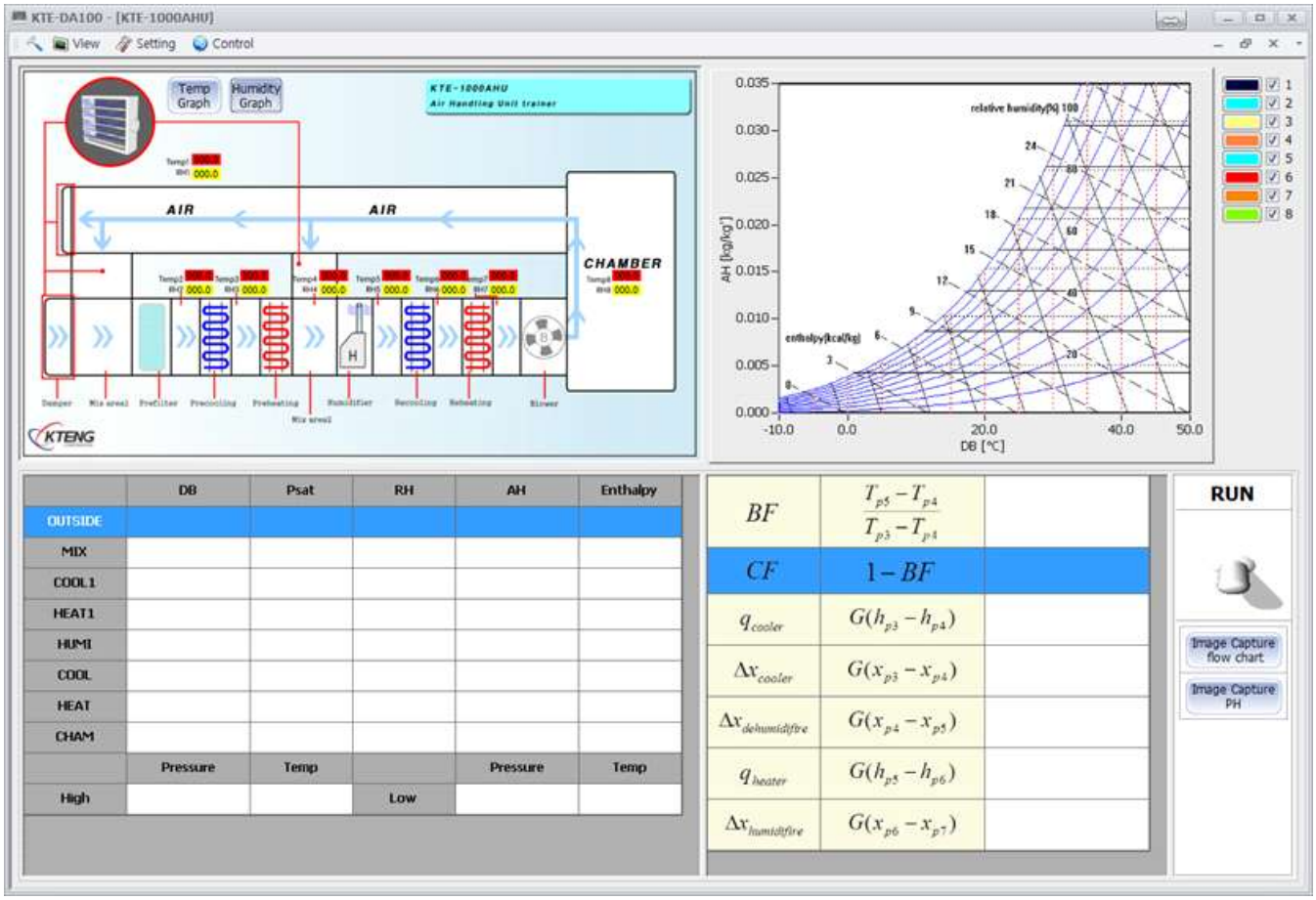
(2) MECHANICAL REFRIGERATION : Composition with ⓐ Mechanical refrigeration part of Compressor, Condenser(with fan motor), Receiver, Filter-dryer, Sight glass, Solenoid Valve, Manual expansion Valve, Evaporator(with fan motor), Heat exchanger, Accumulator, High · Low pressure gauge, and ⓑ Heating part of preheater and reheater, ⓒ Humidifying part of water shower, water tank, and water heater, and ventilation ducts these devices run as set up circuit in Control panel.

(3) SOFTWARE P/G : KTE-DA100(Software) supply tools with that temperature, pressure, enthalpy, amount of the exchanged heat in each position can be measured in real time, and then saved by Microsoft excel, so that the saved data can be show and analysis by graph.

(4) DAQ module : Composition with Sensors, Transducers: Thermocouples, Humidifier, and DAQ hardware.

1-2. System cycle and Measuring device for Air Handling System

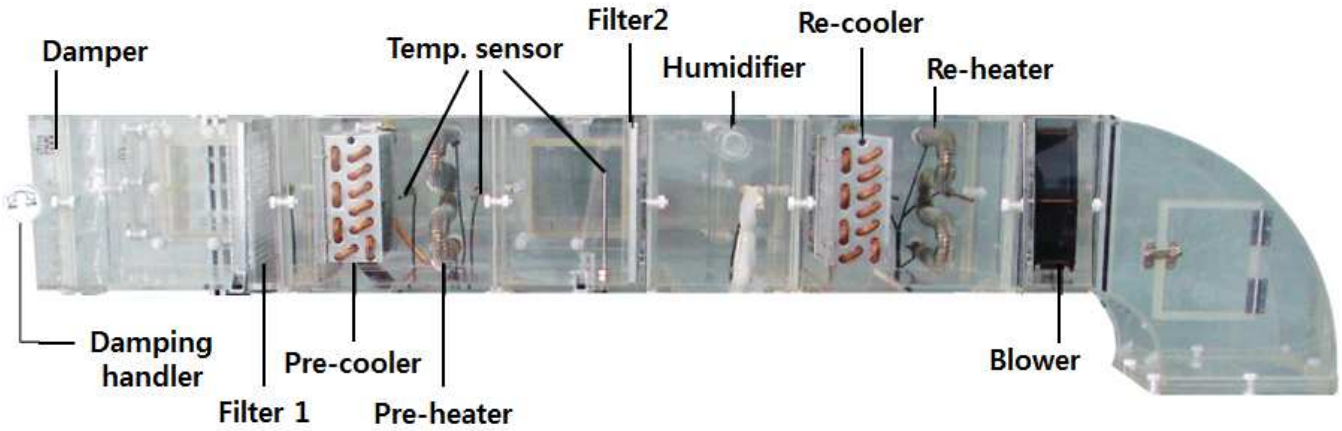
(1) Psychrometric chart monitoring program of Air Handling Unit system



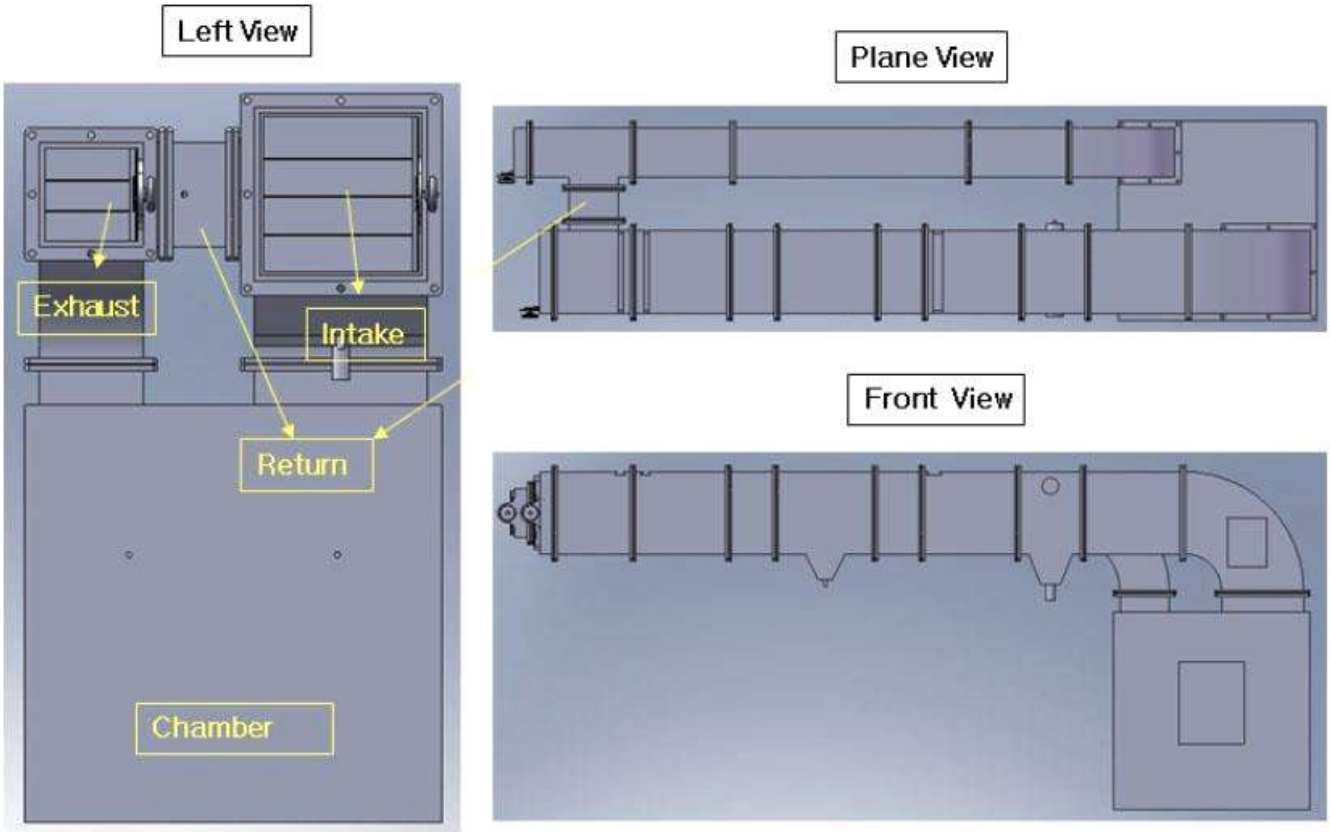
(2) Temperature, Pressure position for measurement in Air handling unit system

Measuring point	Remark
Outside	
Mixture position	
Pre-Cooling	
Pre-Heating	
Humidifying	
Re-Cooling	
Re-Heating	
Inside Chamber	

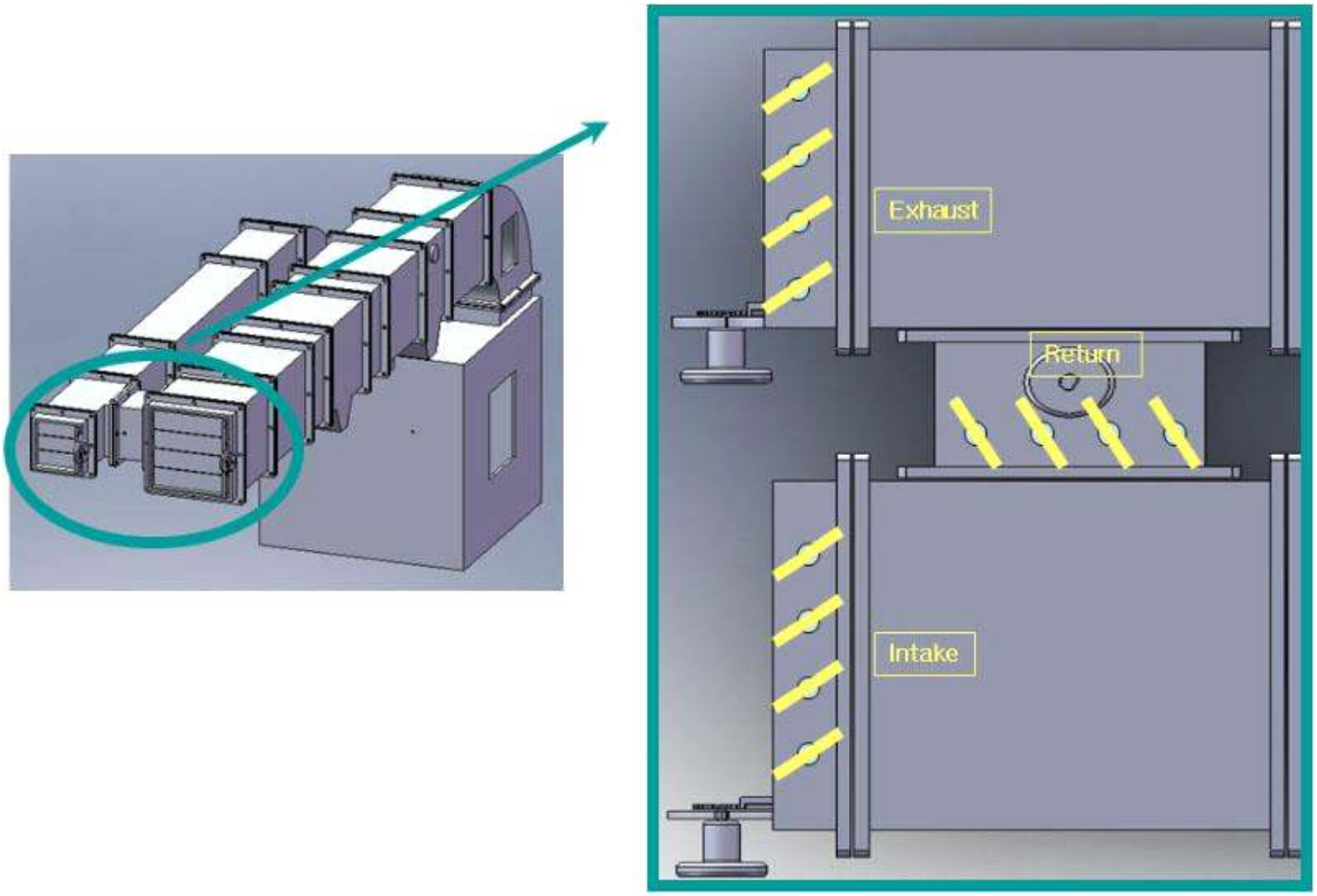
1-3. Air duct component



Air Handling duct device

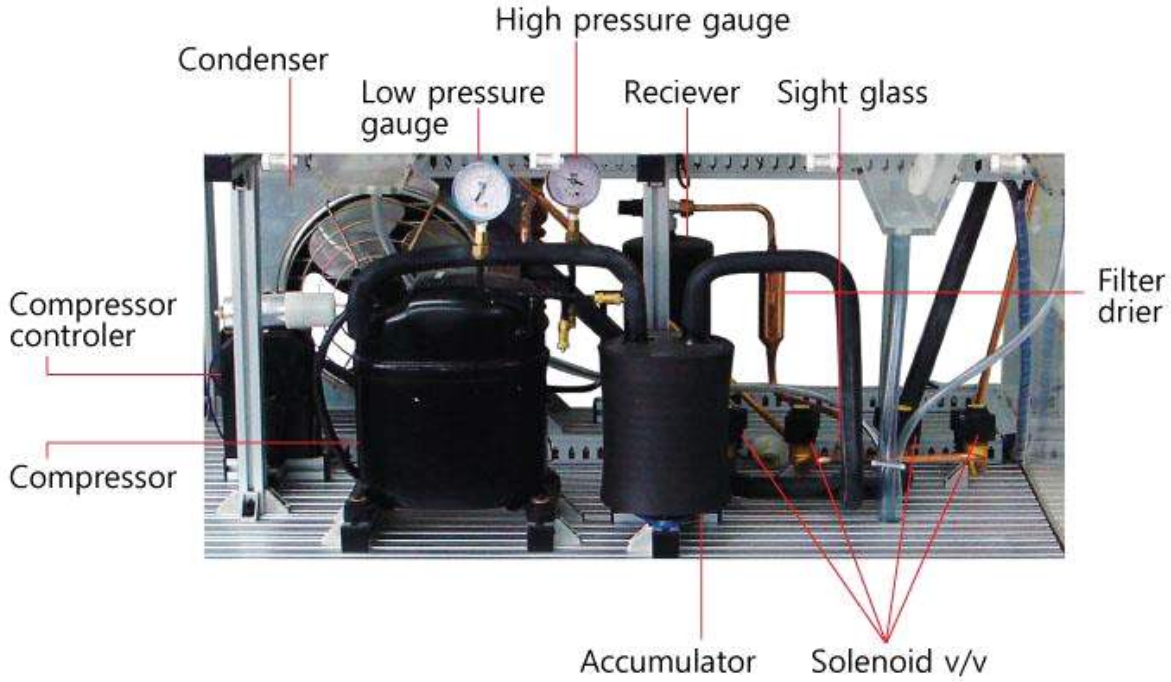


Ait duct figure



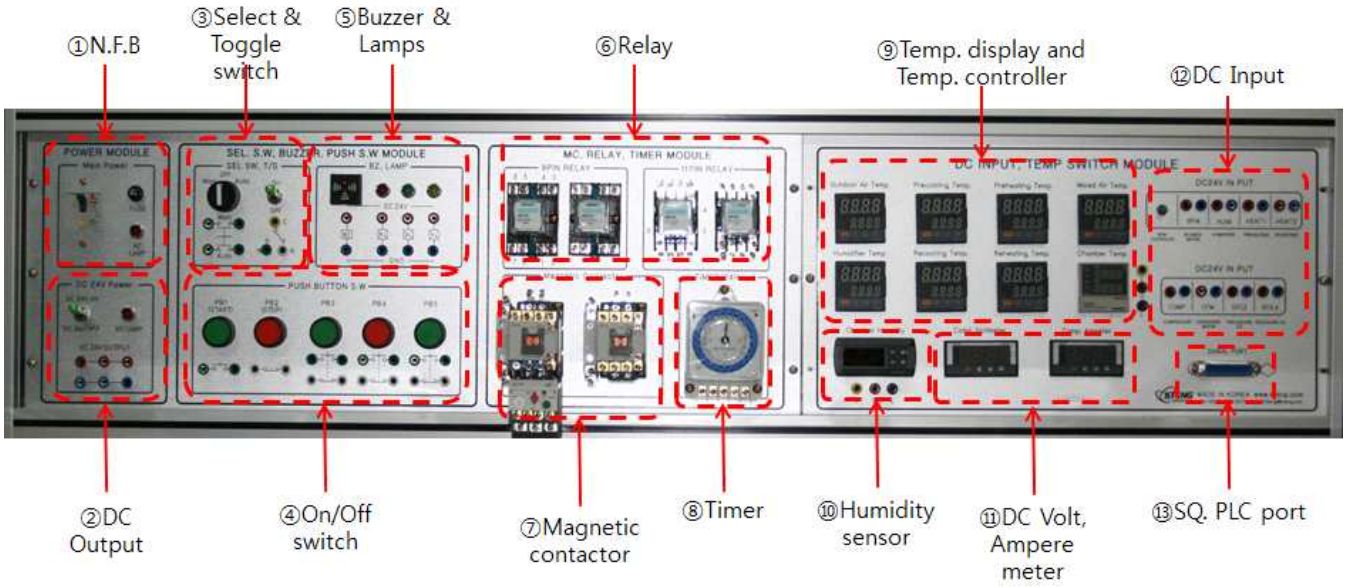
Intake and exhaust air

1-4. Mechanical refrigeration device component



① Condenser
② Low Pressure Gauge
③ High Pressure Gauge
④ Receiver
⑤ Sight Glass
⑥ Filter Drier
⑦ Solenoid Valve
⑧ Accumulator
⑨ Compressor
⑩ Compressor Controller

1-5. Control panel device component for Air Handling Unit System



① N.F.B
② DC Output
③ Select & Toggle switch
④ On/Off switch
⑤ Buzzer & Lamps
⑥ Relay
⑦ Magnetic contactor
⑧ Timer
⑨ Temp. display and Temp. controller
⑩ Humidity sensor
⑪ DC Volt, Ampere meter
⑫ DC Input
⑬ SQ, PLC port

Chapter 2. Component of an Air Handling Unit

1. Mechanical device component

(1) Compressor

※ Specification
- Model : P-18TN(ACC)
- 3/4HP
- Range : Medium, High temperature
- Eva Temp. : -25℃~10℃
- Motor Type : CSR
- Refrigerant : R-134a
- Single phase 220V, 50/60 Hz
- Controller

The motor compressor absorbs heat from an object in the evaporator of the standard refrigeration test equipment, increases the pressure by compressing the vaporized gas refrigerant at low-temperature and low-pressure and reduces the distance between molecules. Then, it increases the temperature and thus makes the gas easily in the condenser at the room temperature. That is, it sends the heat from the evaporation of refrigerant at the low heat source(evaporator) to the superheat source(condenser) at the high temperature and pressure.

(2) Condenser

※ Specification
Size : 400(W) × 280(H) × 210(D)mm
Motor : AC220V 5-60Hz 4P 16W
Capacity : 1 HP

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.

(3) High Pressure Gauge

This device is for measurement of refrigerant pressure behind of compressor, liquid type high pressure gauge. Range is -1 ~ 35kgf/cm2.

(4) Low Pressure Gauge

This device is for measurement of refrigerant pressure front of compressor, liquid type low pressure gauge. Range is -1 ~ 20kgf/cm2.

(5) Nipple

The charging nipple is the requisite to use the manifold gauge for the airtight and vacuum tests and refrigerant filling and transferring of the standard 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.

(6) Sight Glass

A sight grass that is for indication of refrigerant charging level and status with direct and simple way is available to HFC, HCFC, CFC family with no matter within －50℃ ~＋80℃.
Overcharging of refrigerant makes lubricating oil happening bubble, compression liquid, so that it makes an accident sometimes. For protecting this, through an installed sight grass refrigerant should be charged suitable.

(7) Liquid Receiver

Refrigerant that flows from condenser stays at a receiver before it goes expansion valve. The amount of staying refrigerant at a receiver must be constant for control refrigerant amount emitting into an evaporator. And also it need for recharging (pump down operation) when its repair.

① The general size of liquid receiver is proper to retrieve 50% of filled refrigerant in NH3 refrigerator and to receive 100% of filled refrigerant for freon refrigerator.
② The liquid receiver shall not be fully filled. The proper amount of filling is about 3/4(75%) of the diameter.
③ It is installed at the bottom of condenser. The regular pressure tube with the proper thickness is installed at the top of receiver and condenser.

④ If two receivers with the different diameters are installed in parallel, the top of receivers is aligned.

⑤ The liquid level meter is covered with the metal cover to prevent the damages. The manual and automatic valve(ball valve) are mounted for preventing the leakage of refrigerant if any damages are occurred.

⑥ The safety valve is mounted on the top of receiver to prevent any risks if any unprecedented accidents are occurred.

(8) Filter Drier

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.

(9) Solenoid Valve

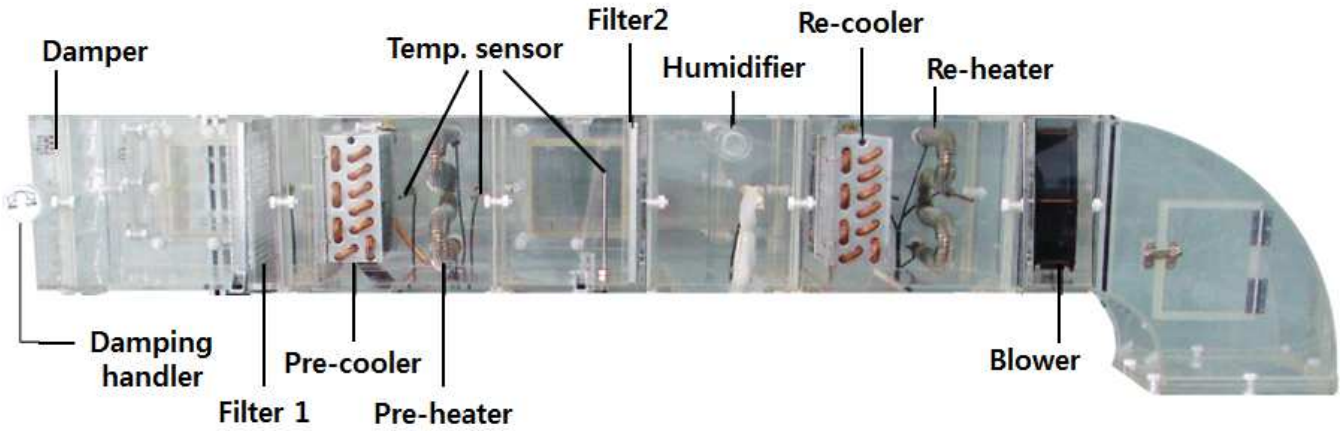
The electronic valve for main duct controls the refrigerant flow as it is opened or closed depending on the power input. It is connected to the temperature switch in series during the pump-down operation. In this case, the pump-down operation is processed by the opening or closing of the electronic valve for the main duct according to the closing or opening of temperature switch contact.

(10) Expansion Valve

Manual Expansion Valve

The manual expansion valve insulates and expands the high temperature and pressure liquid refrigerant to the low temperature and pressure liquid refrigerant for easy expansion in the expander. The condensed and liquidized refrigerant is rapidly discharged from the narrow side to the wide side(crossing action) and starts the evaporation because the pressure is removed. Moreover, the volume of refrigerant is properly adjusted for the absorption of sufficient heat in the evaporator.

(11) Preheater



It heats the external air for the preliminary heating.

(12) Precooler

It cools the external air for the preliminary cooling.

(13) Ventilator

It intakes the air into a room. The amount of ventilation can be adjusted.

(14) Humidifier

It adjusts the humidity of air into a room.

(15) Reheater

It reheats the air that is preliminarily heated and humidified.

(16) Recooler

It cools and dehumidifies the indoor air after the precooled air passes through the humidifier.

(17) Humidifying Water Heater

It adjusts water for humidifying as users want.

2. Automatic control device component

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

Main Power N.F.B

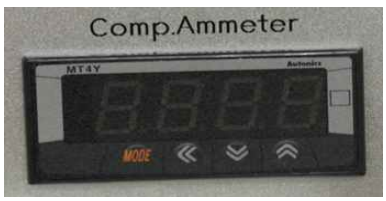
The over current breaker(N.F.B) protects the compressor motor, fan motor of condenser or evaporator or wires of the refrigeration training equipment from the over current due to overloads or short circuit. The circuits are automatically cut out so that the equipment stops operation. It is not required 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 Power Output

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

(3) DC Volt Meter

Volt meter (Digital type)



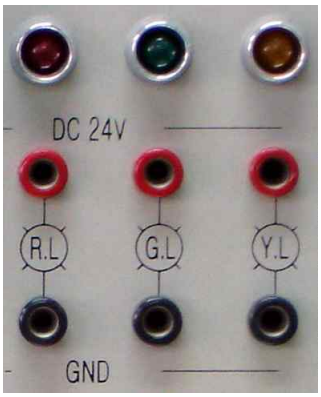
Ampere meter (Digital type)

This Compressor installed in equipment measures Voltage and Ampere by AC.

(4) 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.

(5) Lamp



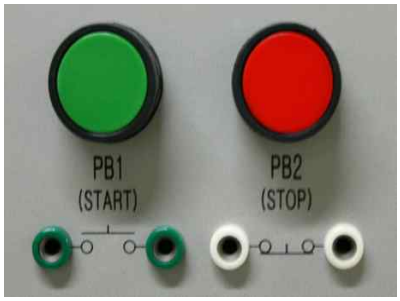
The power lamp(P.L) is on when the power is connected and the operating lamp (G.L) is on during the operation. the stop lamp(R.L) is on when the operation stops and the emergency lamp or alarm lamp(Y.L) displays the abnormal status during the operation such as operation of thermal relay. The reserve 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.

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).

(7) On/Off Switch

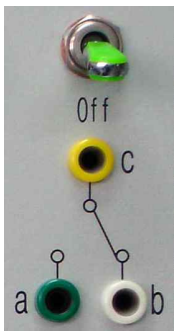


This device is for start, stop, or ON/OFF.

① PB1 is for Running (A contact)

② PB2 is for Stop (B contact)

(8) Toggle Switch



This device is for start, stop, or ON/OFF.

① Connect 'C' and '+' power, operate by selection of 'a' or 'b'

(9) 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.

(10) Relay

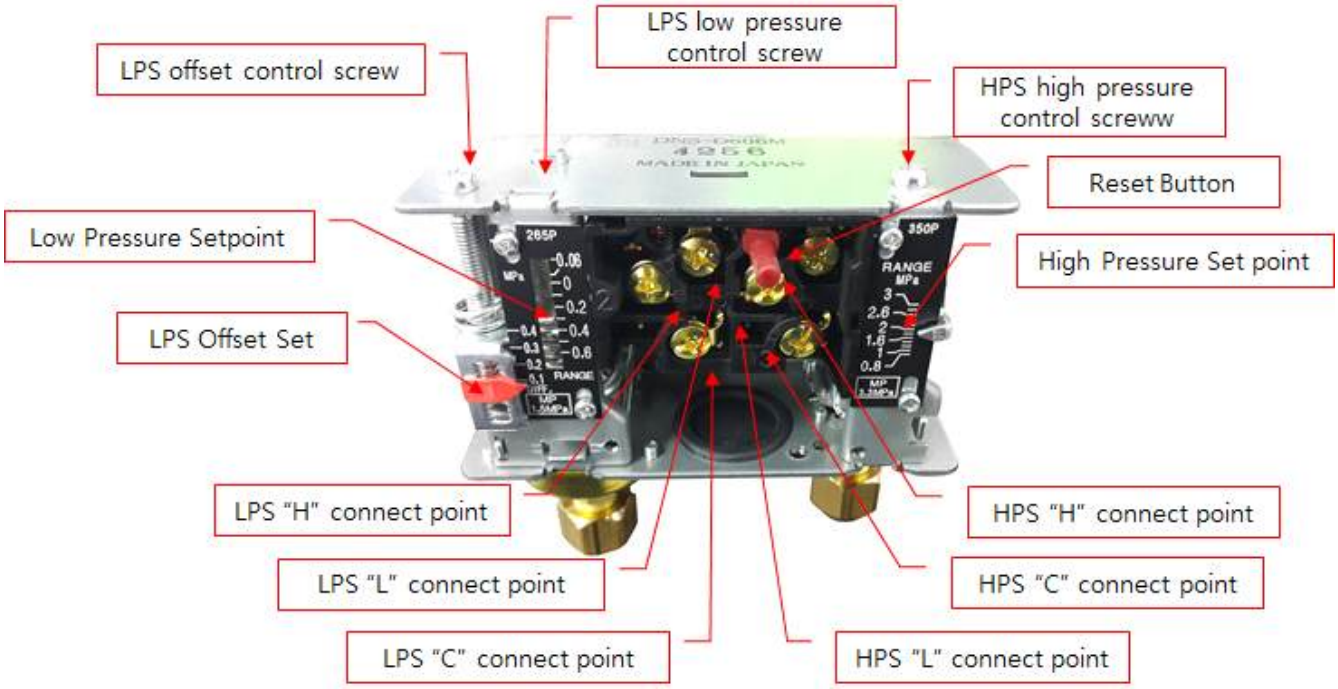
Relay controls compressor motor, condenser motor, solenoid valve and evaporator motor through sequence circuit.

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).

(11) 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'.)

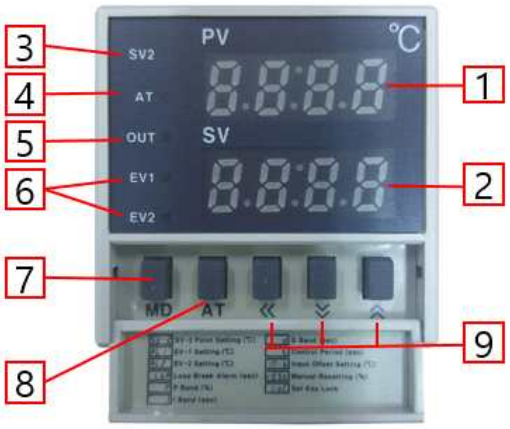
B. H.P.S High pressure control

Ⓐ 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')

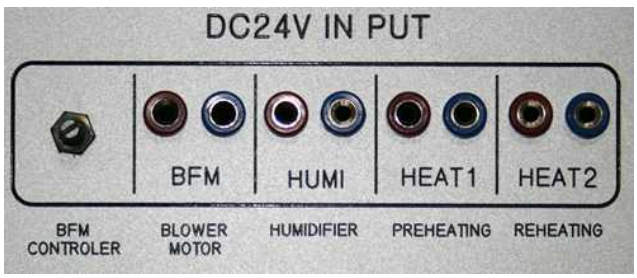
Ⓒ LPS-H Line OUT(When the desire value is upper than your setting value, connect 'com' and 'H', RESET : return.)

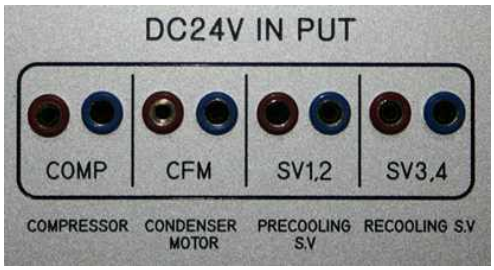
(12) Temperature Controller



① PV : Measurement display (Red)
Displays measured value,
Displays configuration subject in configuration mode.
② SV : Configuration value displays (Green)
Displays adjusting value.
Displays configuration subject in configuration mode.
③ SV 2 : SV2 on lamp
④ AT : Auto-Turning on lamp
⑤ OUT : Output on lamp
⑥ EV 1,2 : EVENT output display lamp
⑦ MD key : Mode Key Press button for 3 sec.
⑧ AT key : Auto-tuning run key
⑨ ∧ ∨ 《 : Adjustment key

(13) DC Power input





BFM : Blower Fan Motor
HUMI: Humidifier
HEAT1: Pre-heater
HEAT2: Re-heater
COMP : Compressor Motor
CFM : Condenser Fan Motor
SV1 : Solenoid Valve 1
SV2 : Solenoid Valve 2
SV3 : Solenoid Valve 3
SV4 : Solenoid Valve 4
Plug for electric circuit among each devices(Red plug +, Black - .)

Chapter 3. Construction and Operation as circuit

1. How to make electric circuit

1-1. Step operation

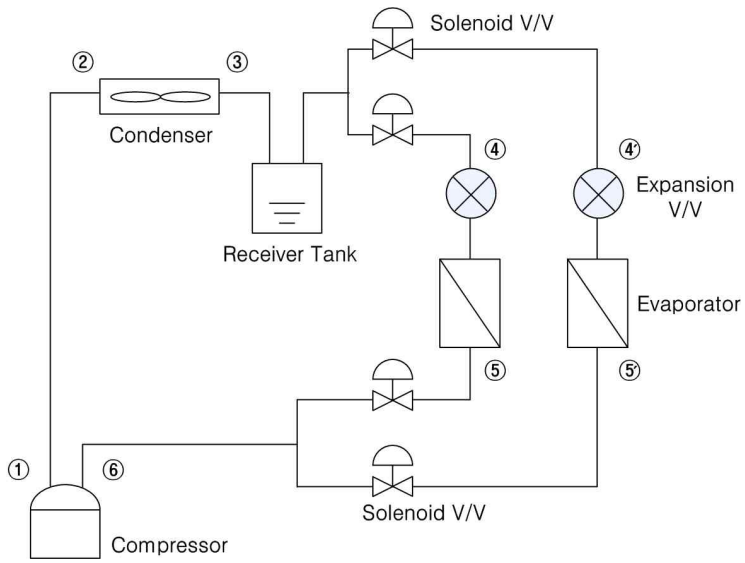
① Make set up circuit for opration.
② Set temperature of Dry bulb temp. controller as 15℃.
③ Check water tank of humidifier, if no water, full in water it.
④ Blower has to be run, when electric heater or cooling device is on.
⑤ N.F.B is on.
⑥ T/S.W is made on, so that Dx-coil and Air handling unit is run
⑦ Measure each specific state.

1-2. Operation condition

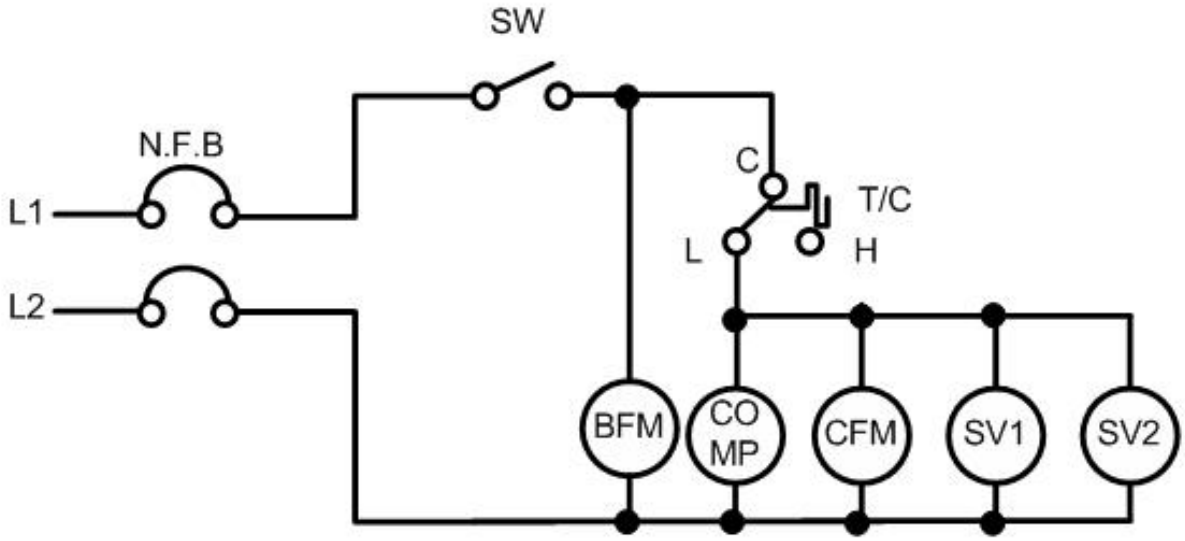
① Refrigerant evaporating pressure : 1.9kg/cm^{2}G (Te : -15℃)
② Refrigerant condensing pressure ; 11kg/cm^{2}G (Tc : 30℃)
③ Temperature compressor inlet (△T) ; 5℃
④ Temperature of refrigerant at expansion V/V inlet : 25℃
⑤ Room Chamber Temp. : Setting as 15℃ diff as 2℃
⑥ Exhaust air temp. : Setting as 10℃ (Compressor stop)

1-3. Refrigerant Flow diagram

① System flow



② Electric circuit



Chapter 4. Air Handling Unit Construction Initial Setting

1. How to make electric circuit

1-1. Step operation

① Make set up circuit for opration.
② Set temperature of Dry bulb temp. controller as 15℃.
③ Check water tank of humidifier, if no water, full in water it.
④ Blower has to be run, when electric heater or cooling device is on.
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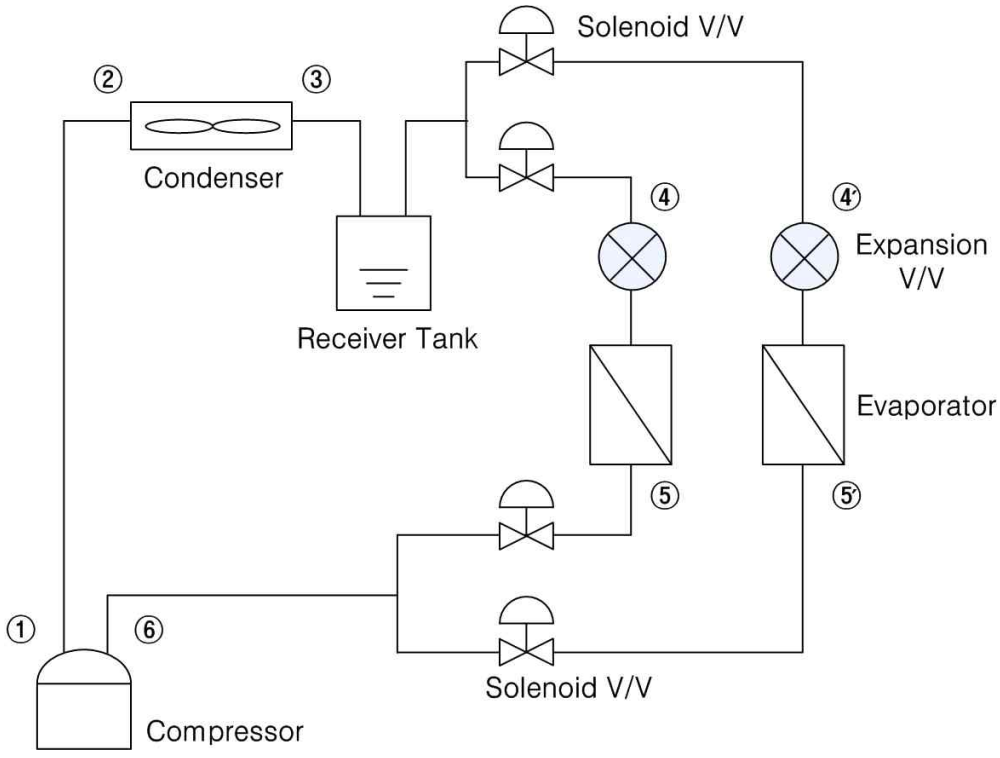
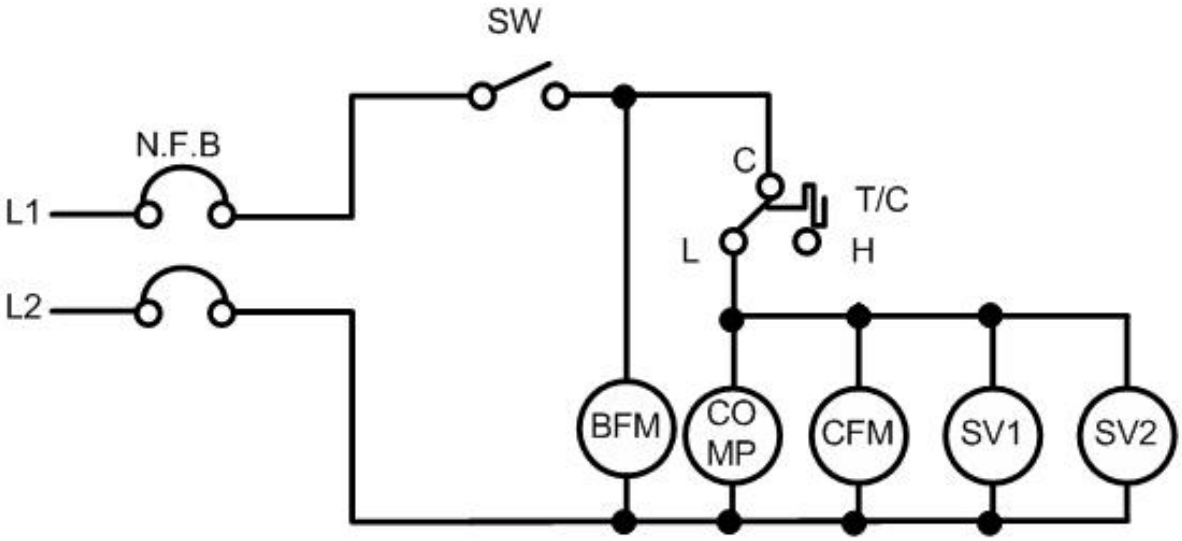
1-3. Refrigerant Flow diagram

① System flow



② Electric circuit



Chapter 2. Standard Refrigeration Performance Analysis Using DA100 Software

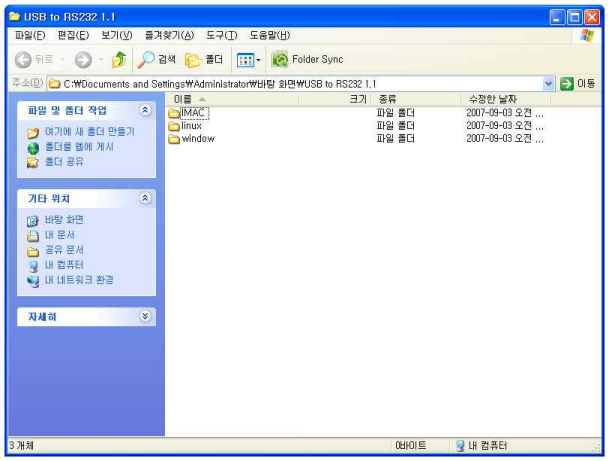
2-1. INSTALL USB TO SERIAL

- Communication method is using computer and RS232 protocol for communication.
- If you got a desktop which is connected with Serial Port back. you don't have to install USB To Serial.
- If you got a desktop which doesn't have note book or Serial Port, you need to install progress for collecting data using USB Port.

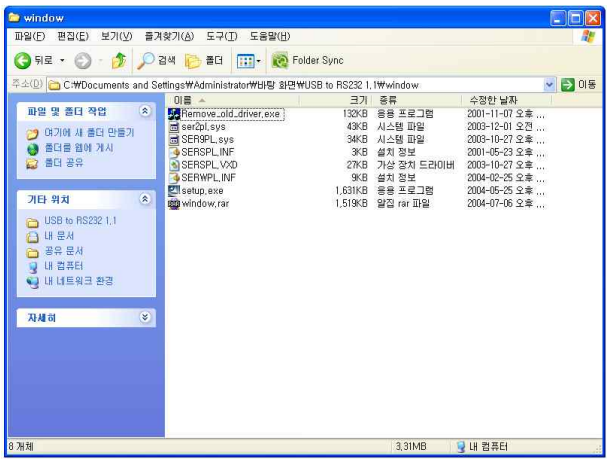
① Put install CD into CD-ROM.

② After reading "CD-ROM DIRECTORY", Following screen is indicated.

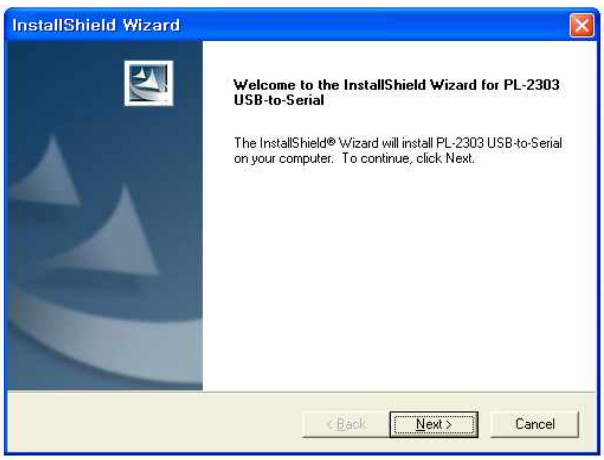
③ Double click window folder in this screen.



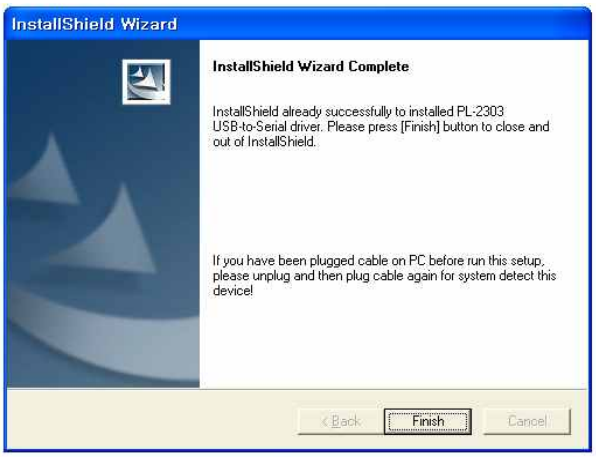
④ Go into window folder following file is indicated. In here, operate 'Setup.exe' which is installation file.



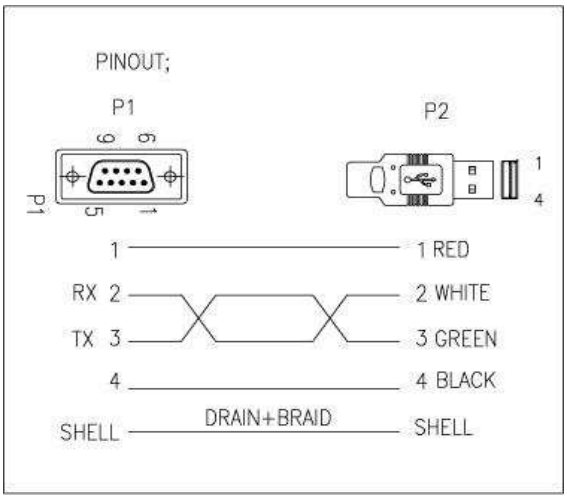
⑤ Click "Next" then it goes to install.



⑥ After installing, next screen is indicated.

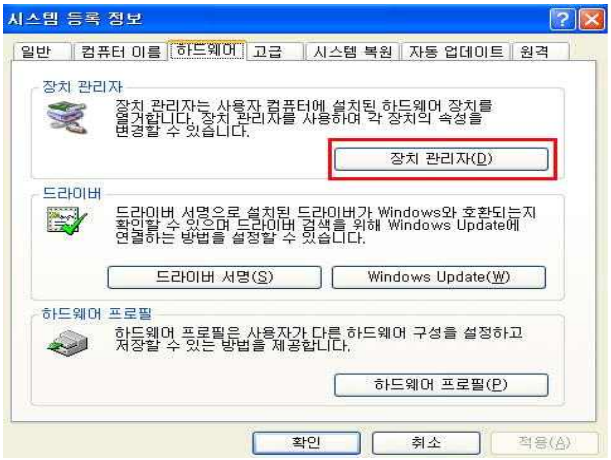


⑦ USB TO SERIAL PORT wiring diagram.

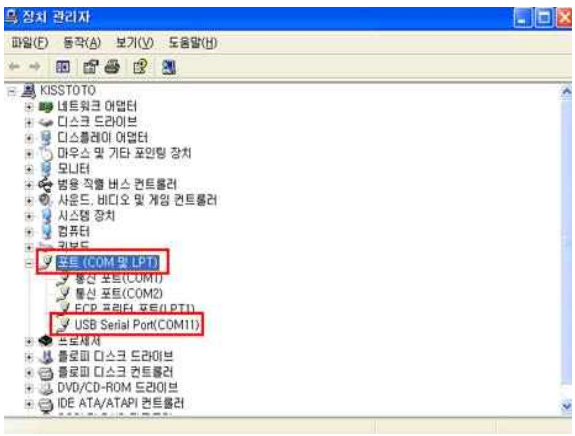


⑧ Method to set Communication Port Click “Start”//Option//into Control Panel. Double click “System” in Control Panel.

⑨ Click “Hardware tap”.

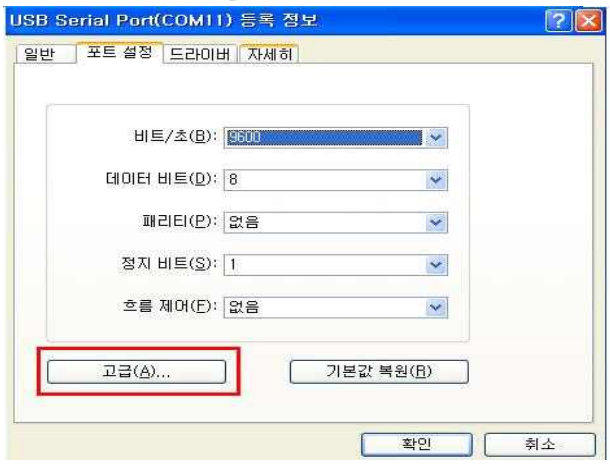


⑩ Click “Device Administrator.



⑪ When you click like picture, emerge USB SERIAL PORT. After mouse right click “USB SERIAL PORT” and click “Attribute.”

⑫ Click “Port option”

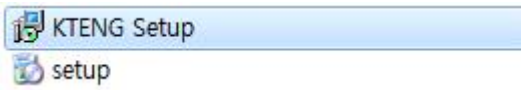


⑬ Click “High rank”

⑭ After setting appropriately to port for user equipment. Click OK.

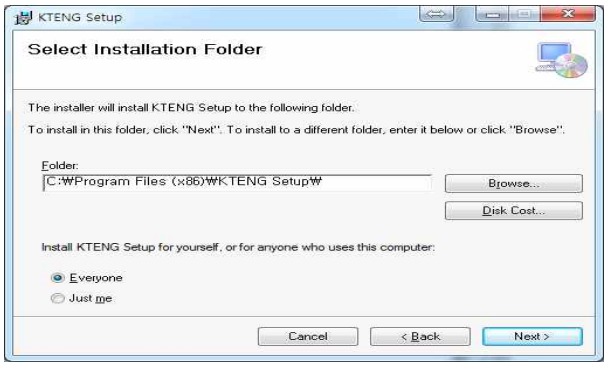
KTE-DA100 Installation and Operating

1) KTE-1000AHU Installation

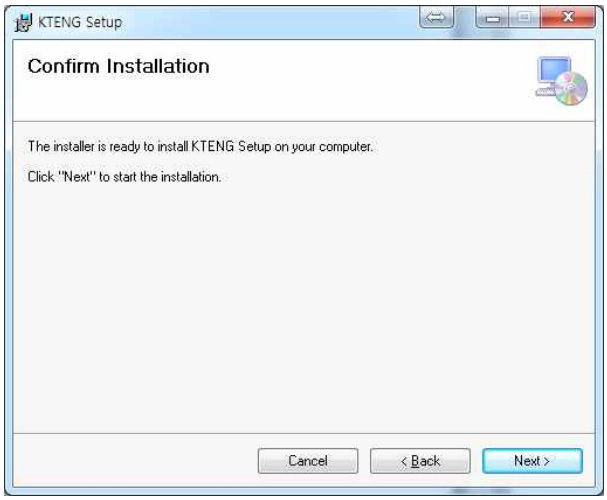


① You can see a installation files that in CD or USB for installation then double click ‘KTENG Setup’ file to start installation. If the progrma cannot be installed using ‘KTENG Setup’, try to ‘setup file.

② If you can see a ‘Setup Wizard’ screen, click the ‘Next>’.

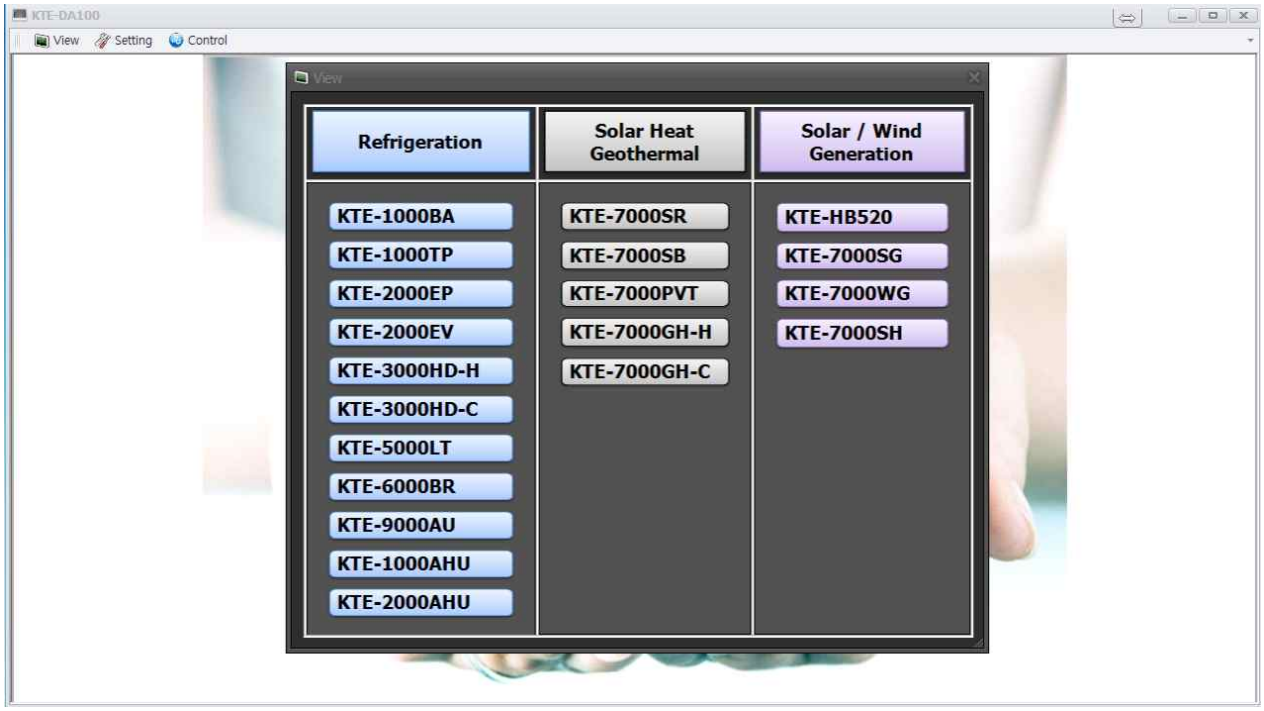


③ You can change a installation route. If you want to change a installation route. click the ‘Browse..’ and find a new route then click the ‘Next>’



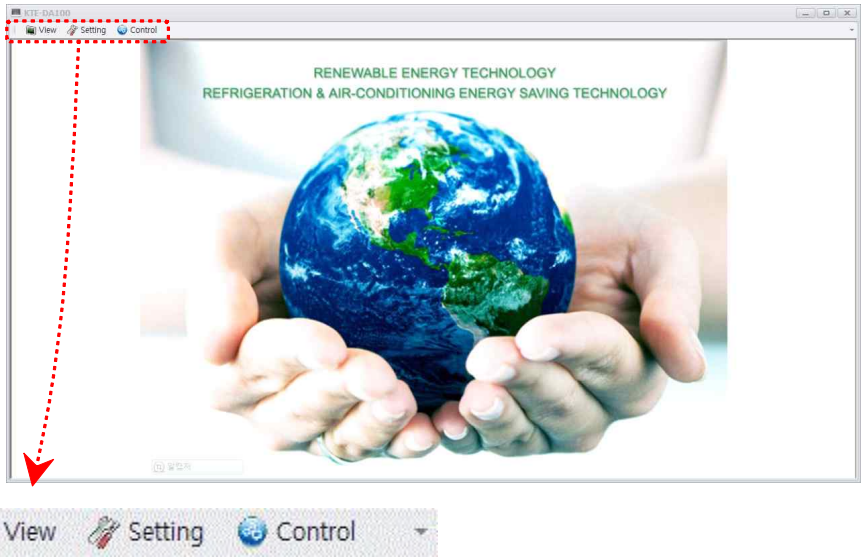
④ If require to confirm installation intention. Please click the ‘Next>’

⑤ Start program by using icon in wallpaper or routing folder then the main page of program come up.

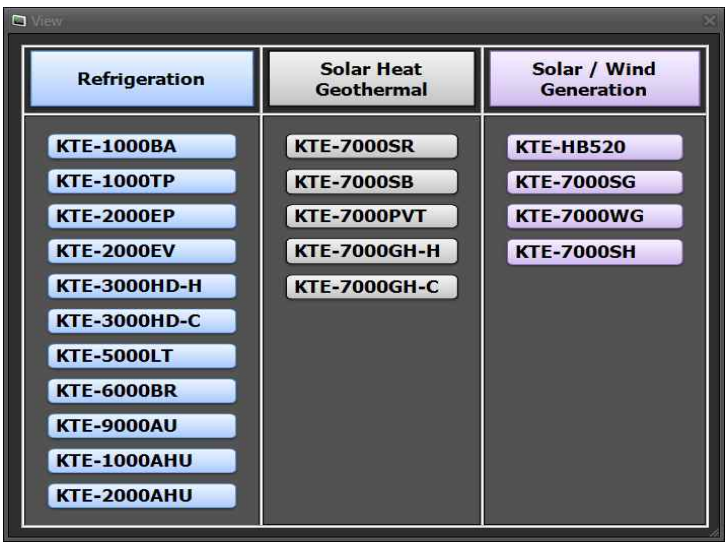


Model.	Equipment	Model.	Equipment
KTE-1000BA	Standard Refrigeration Eqxperiment Equipment	KTE-7000SR	Solar Radiation Energy Experimental Equipment
KTE-1000TP	Temperature, Pressure & Defrost Control Refrigeration Equipment	KTE-7000SB	Solar Heating Hot Water Boiler Experimental Equipment
KTE-2000EP	Evaporation Pressure Parallel Control Experimental Equipment	KTE-7000PVT	PVT Performance Measuring Equipment
KTE-2000EV	Refrigerant Parallel Expansion Valve Experimental Equipment	KTE-7000GH-H	Geothermal Heat Pump Experimental Equipment
KTE-3000HD-H	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Heating Mode)	KTE-7000GH-C	Geothermal Heat Pump Experimental
KTE-3000HD-C	4-Way Reverse Valve Control Heat Pump Experimental Equipment (Cooling Mode)	KTE-HB520	Hybrid Power Conversion Experimental Equipment
KTE-5000LT	Binary Refrigeration Experimental Equipment	KTE-7000SG	Solar Power Conversion Experimental Equipment
KTE-6000BR	Brine Refrigeration Experimental Equipment	KTE-7000WG	Wind Power Conversion Experimental Equipment
KTE-9000AU	Car Air-Conditioner Experimental Equipment	KTE-7000SH	Solar-Hydrogen Fuel Cell Experimental Equipment
KTE-1000AHU	Air-Conditioning Unit Automatic Control Equipment		
KTE-2000AHU	Air Handling Unit Lab-View Programming Equipment		

2) Main Menu Composition

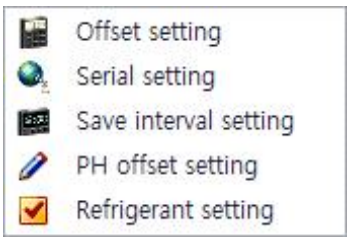


① View

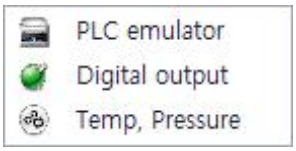


(Refrigeration 11, Solar Heat/Geothermal 5, Solar/Wind Generation 4)

② Setting



③ Control



[1] Setting

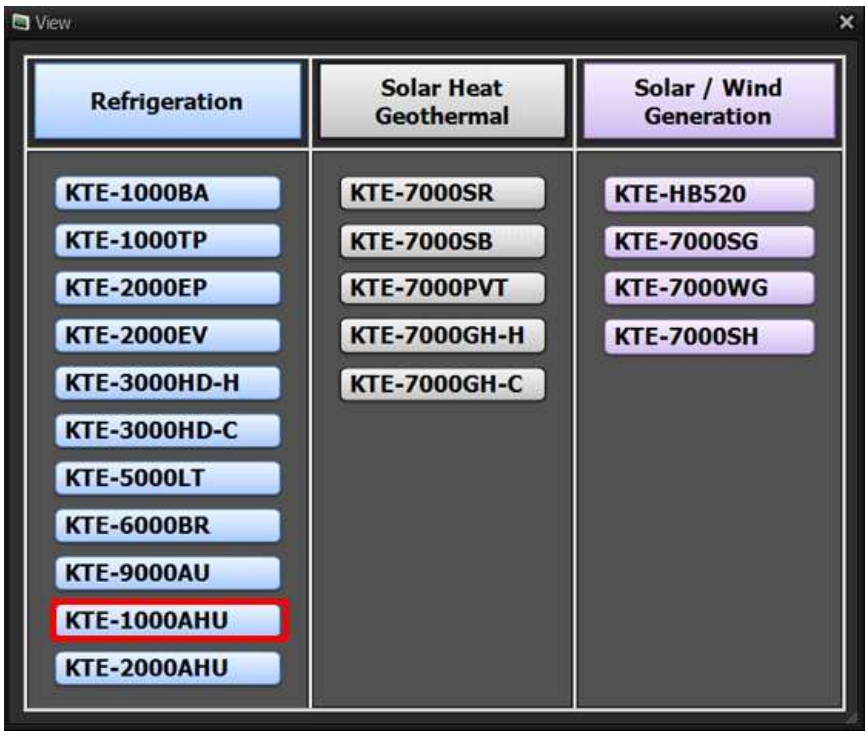
Menu	Explain
Offset Setting	Setting initial pressure, temperature
Serial Setting	Communicating port setting
Save Interval Setting	Setting data acquisition time interval
PH Offset Setting	Setting range of axis at p-h chart
Refrigerant Setting	Select refrigerants

[2] Control

Menu	Explain
PLC emulator	Using PLC control
Digital output	Control a Hardware
Temp, pressure	Control a temperature, pressure

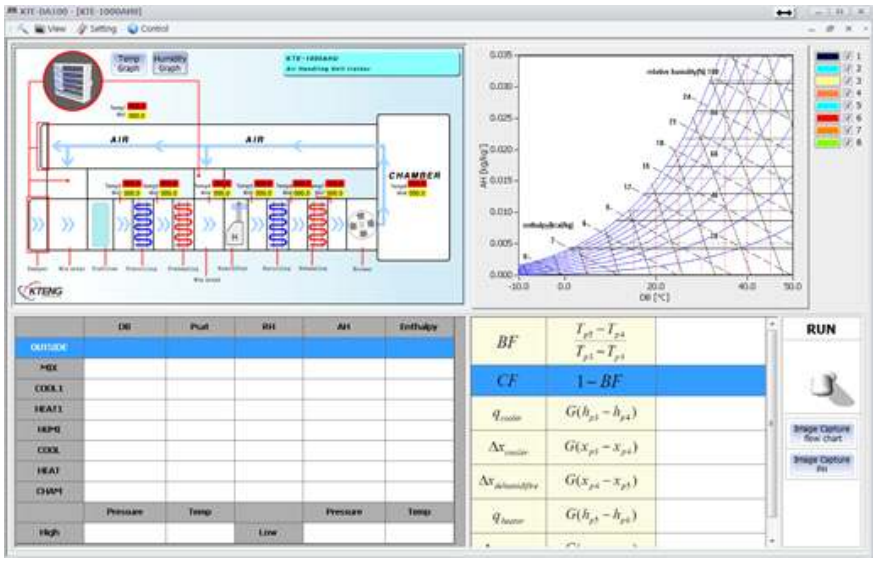
2-2. Application of data acquisition equipment (KTE-1000AHU)

1) Selection of Model



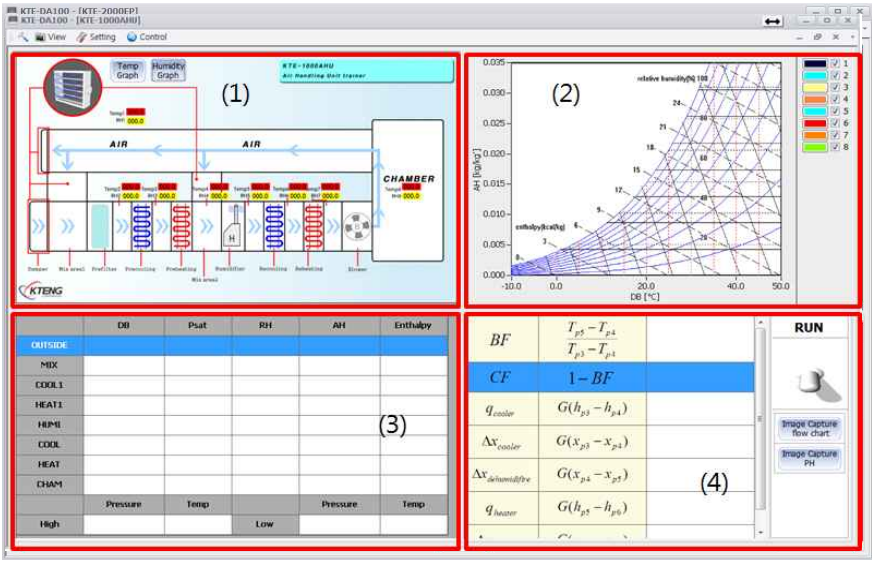
① When program started. 'View' screen is activated.

② Select a model what you want.
(Click the KTE-1000AHU)



③ Main user interface of KTE-1000AHU is activated.

2) Composition of main user interface



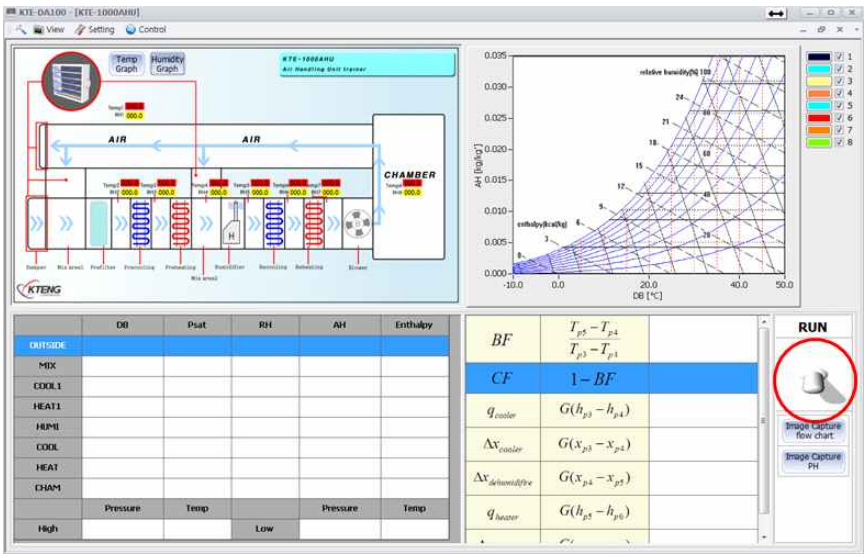
① Schematic diagram of system show temp, press, in realtime.

② Psychometric chart

③ Data table of temp, humidity, and enthalpy.

④ Calculation value of performance(BF,CF,q,x)in HX.

3) Operating and Saving data

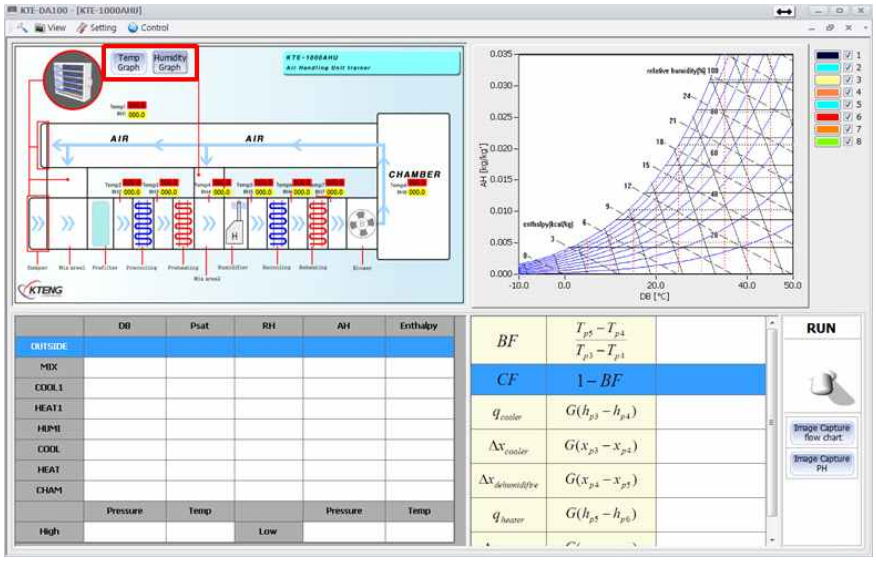


① Click a toggle switch to run program to save data.

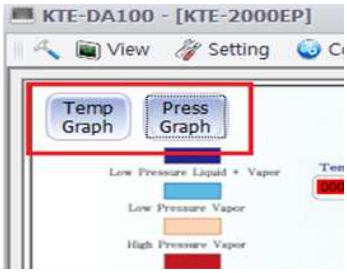
② Write a title and save a file by excel.

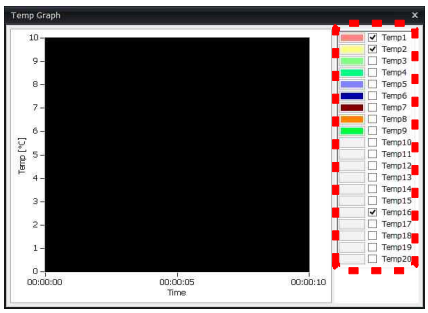
※ The reason of writing title first is that can save data even though unavoidable situation happened.

4) Find a graph

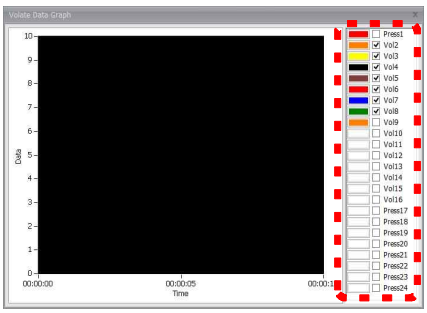


① If you want to see a temp, and humidity, graphically, please click a icon in red box below.



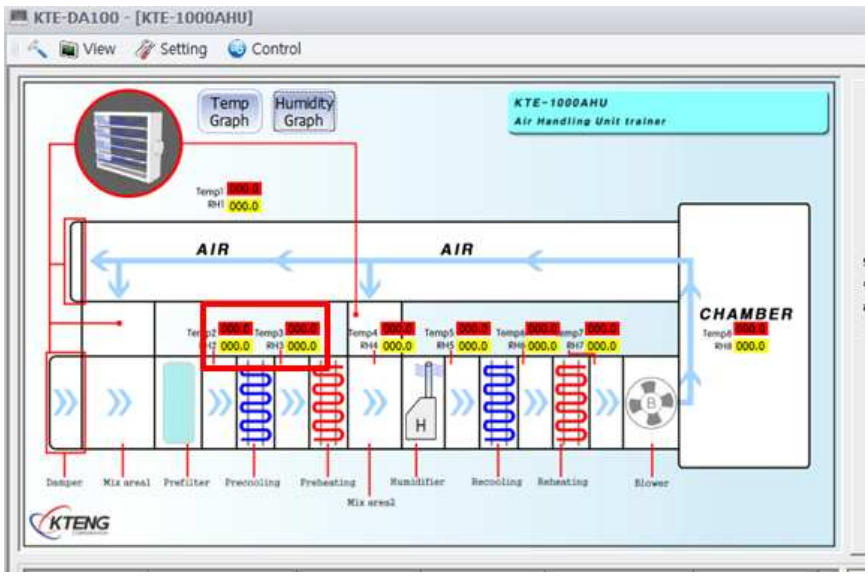


Temperature Realtime Graph

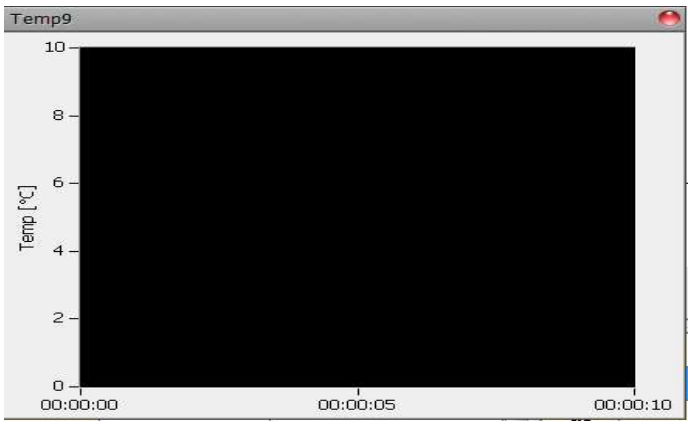


Humidity Realtime Graph

② You can always see the graph for location and figure through checking temperature, humidity

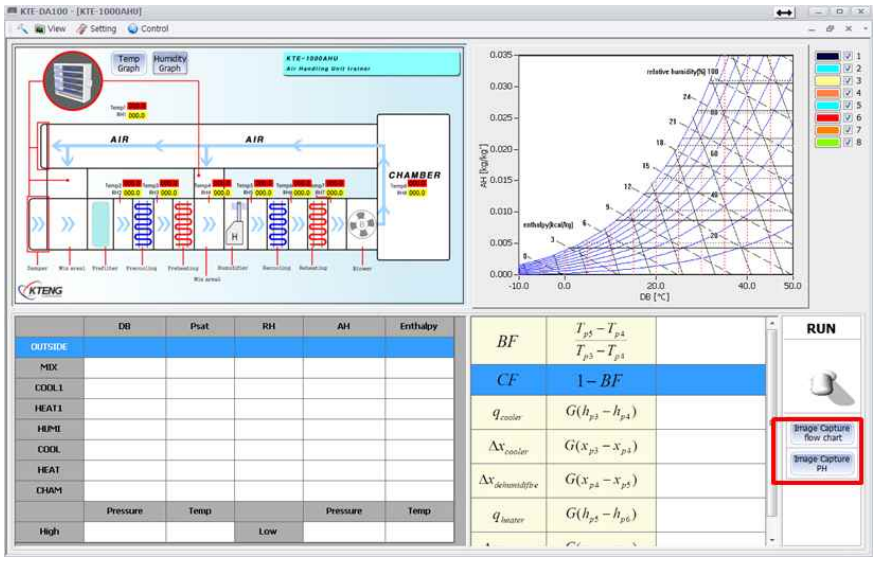


③ Seeing the graph for individual temperature and pressure is that double click display of monitor then indicate the graph window as below.



④ You can always check the temperature.

5) Function for capture



① The bottom of the right side, click image cpature flow chart and image capture PH then it is saved to JPG files.

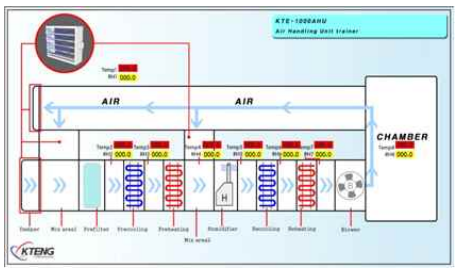
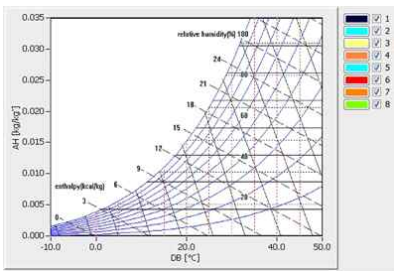


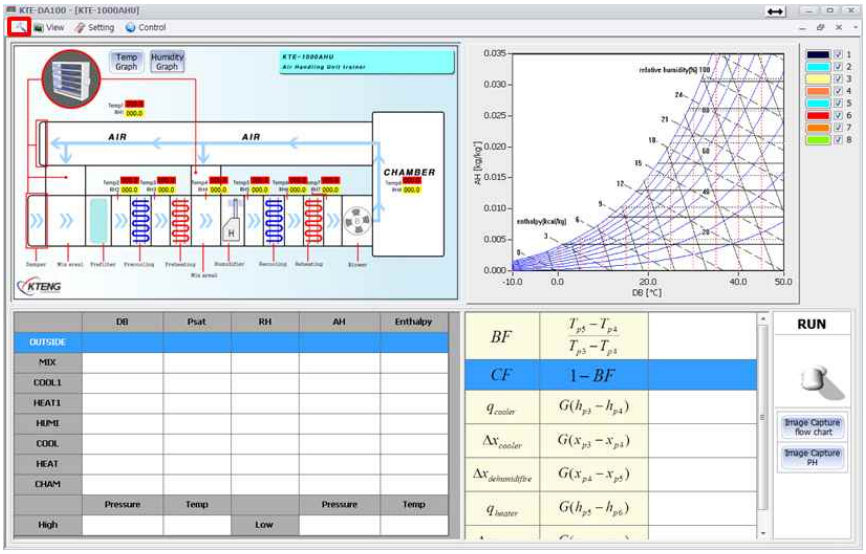
Diagram capture (Flow Chart)



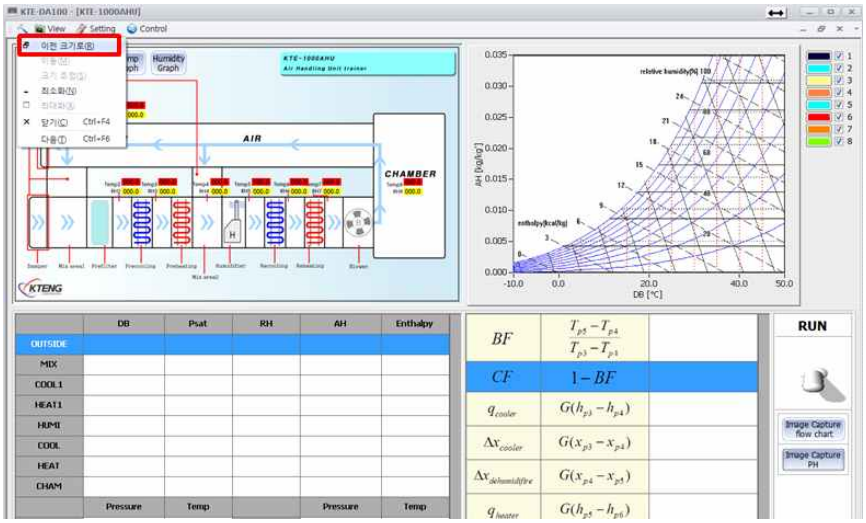
PH diagram capture

② Monitor when choosing
-Diagram(FlowChart) capture
-Psychometric chart capture

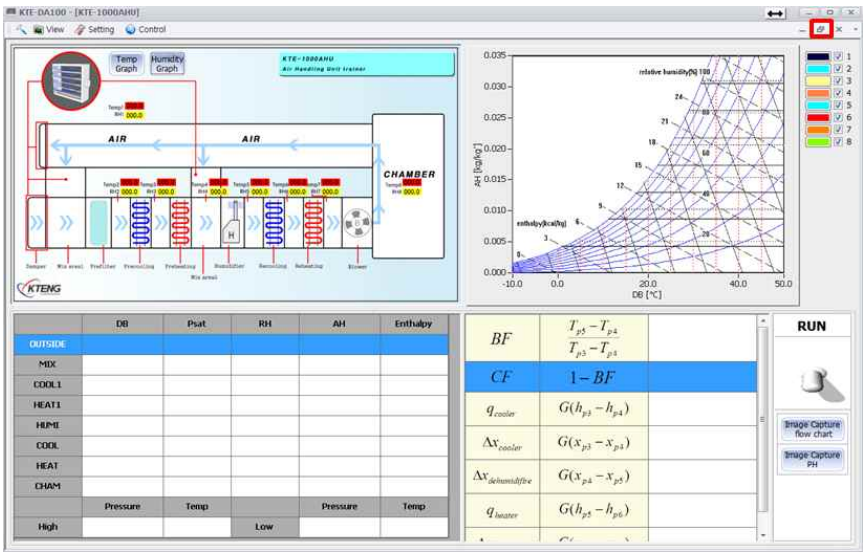
6) Tools



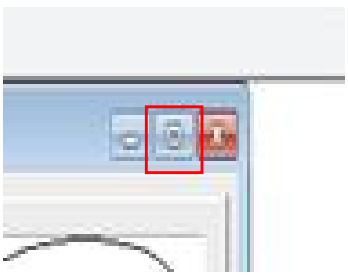
① Click  in Tools

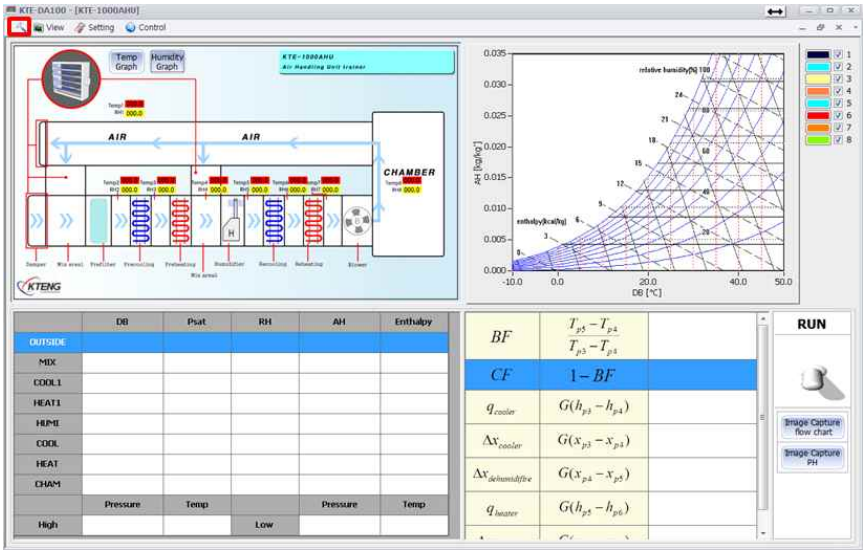


② When you click (R) for before size, the window is activated for moving

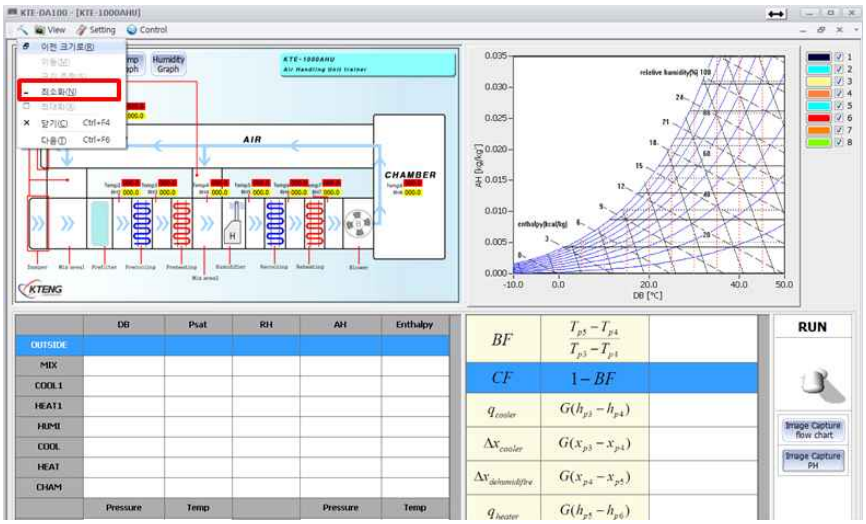


③ Click that button, the window is bigger.





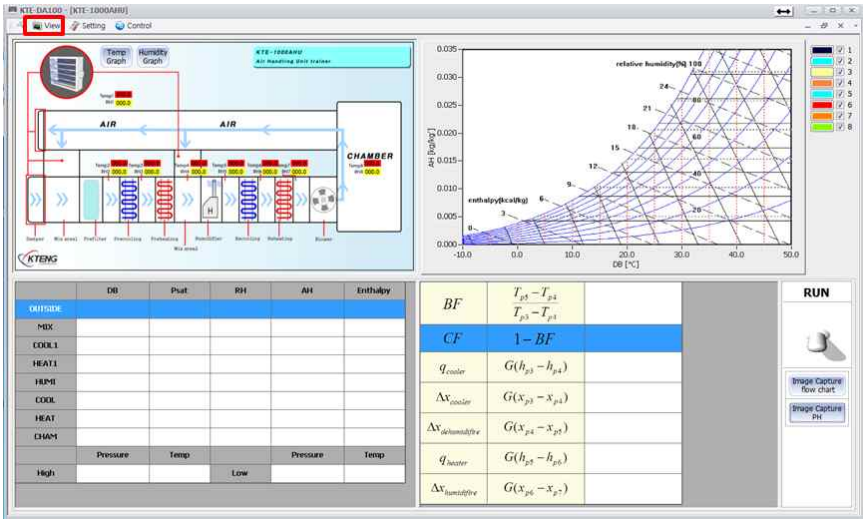
④ Click 



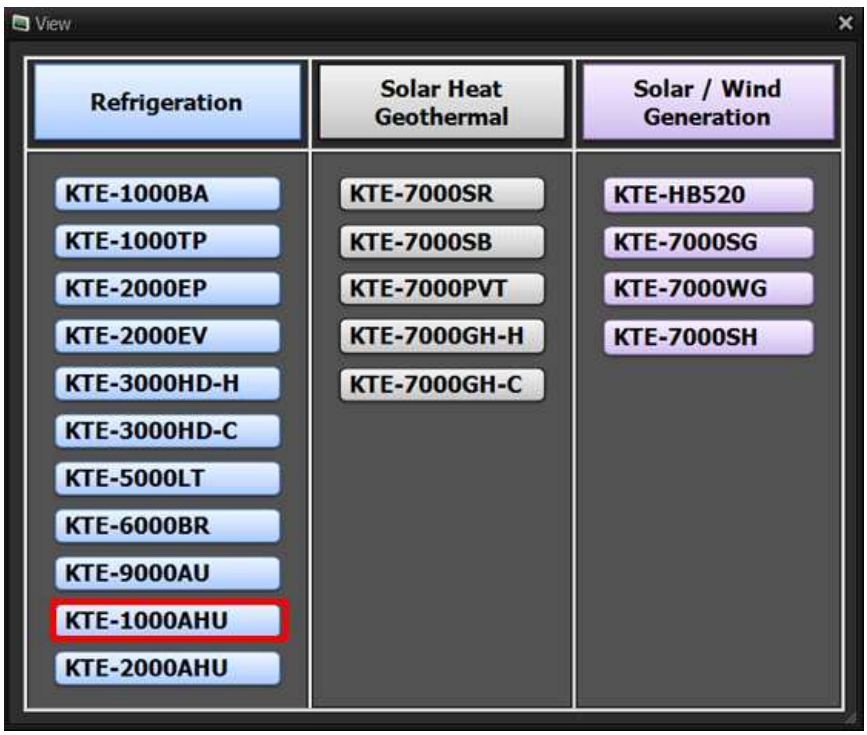
⑤ When click the minimum(N), indicate bottom of the left side.

⑥ When click whole monitor, it is returned.

7) View



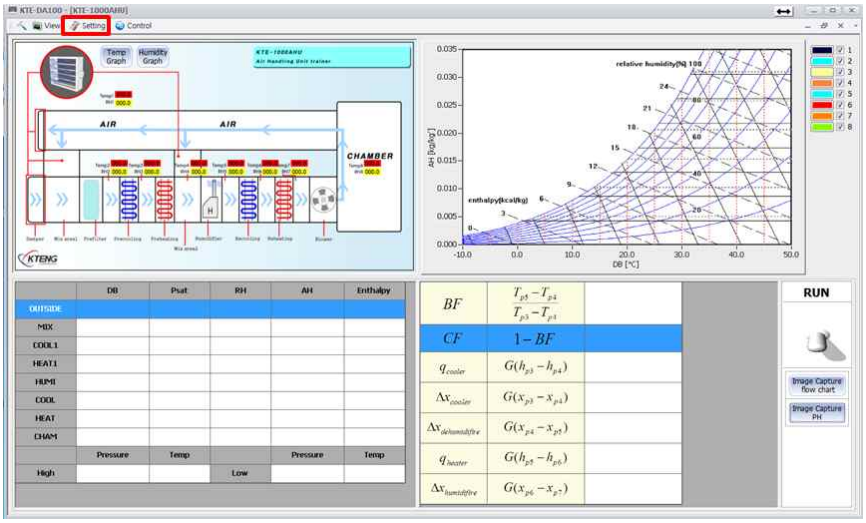
① Click the view in tools.



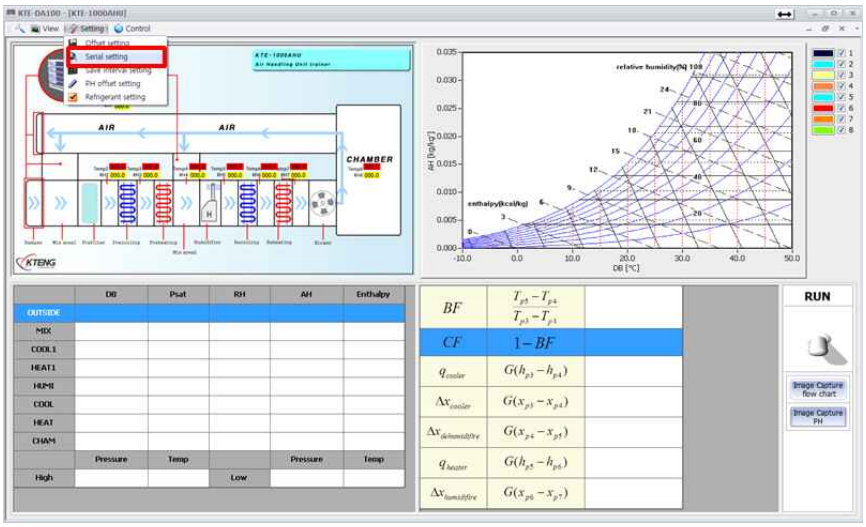
② When you click the view and click Model name then it goes to main screen and it indicates program screen which is connected with real equipments.

8) Setting

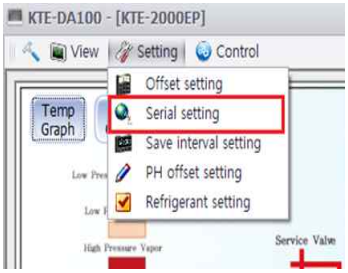
(a) Serial setting



① Click Setting



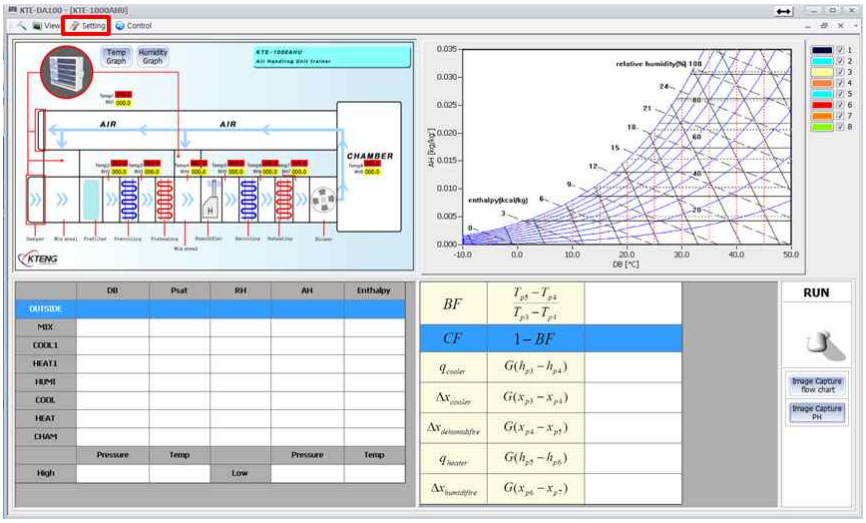
② Click Serial setting



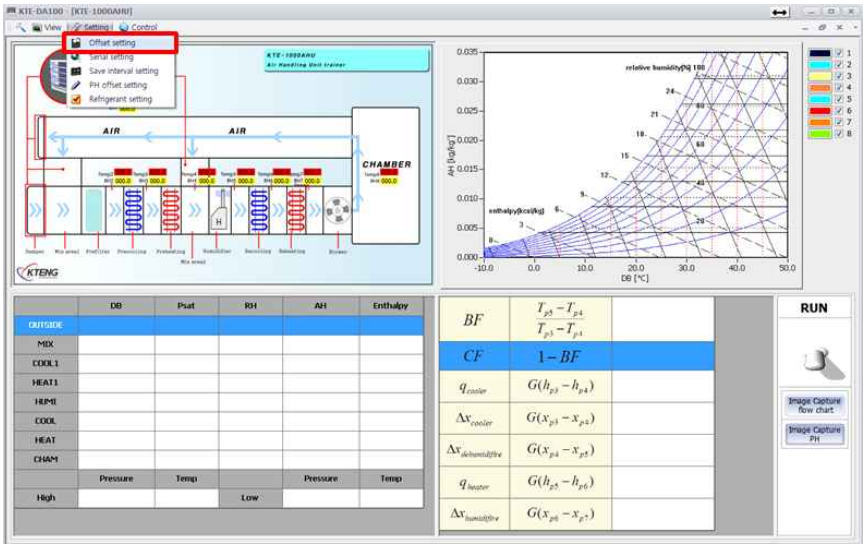
③ COM No is changed depend on port location. choose COM NO and Click OK.

※ Checking port No is on Page use to serial installation

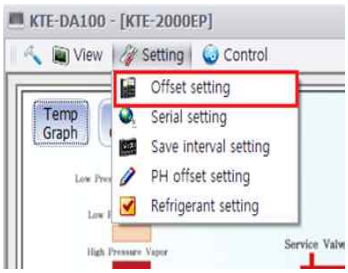
(b) Offset setting

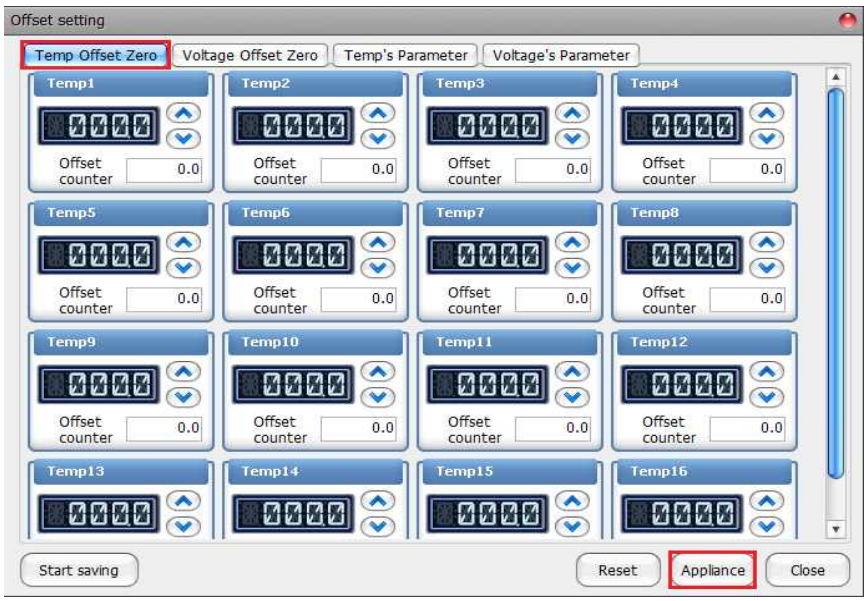


① Click Setting in Tools



② When you click Offset setting, below screen is indicated.

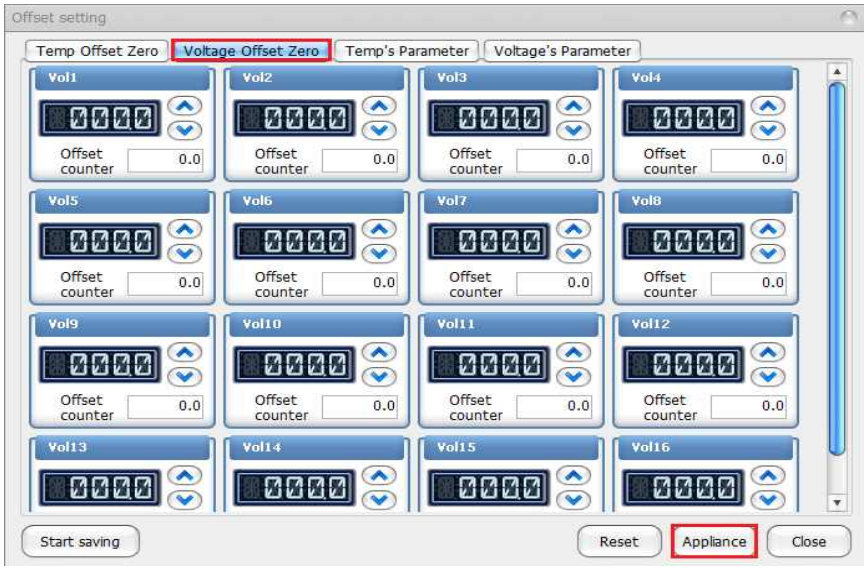




③ Temp Offset Zero is that can control temperature

: You can control using direction key

: It is indication for temperature figure. Click the application then click the Close for applying the figure.

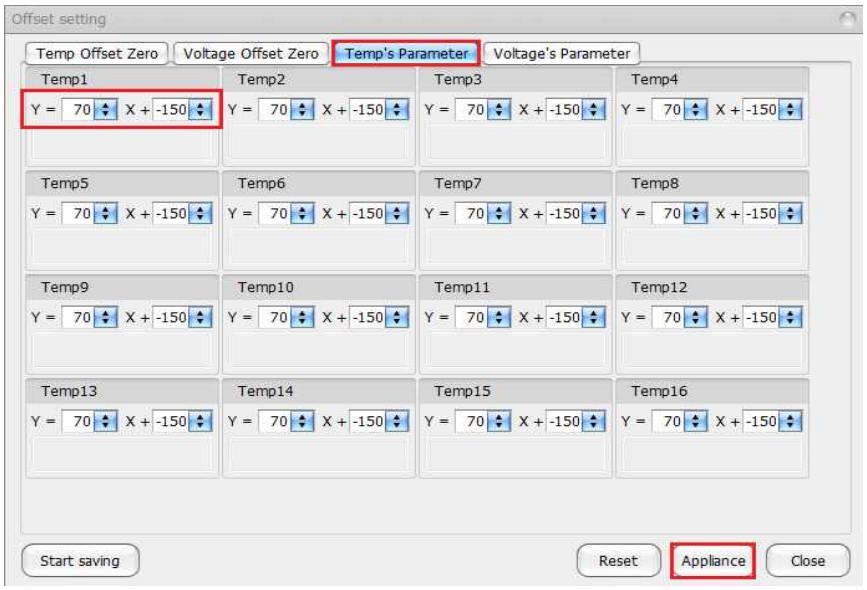


④ Voltage Offset Zero is a part of can control voltage.

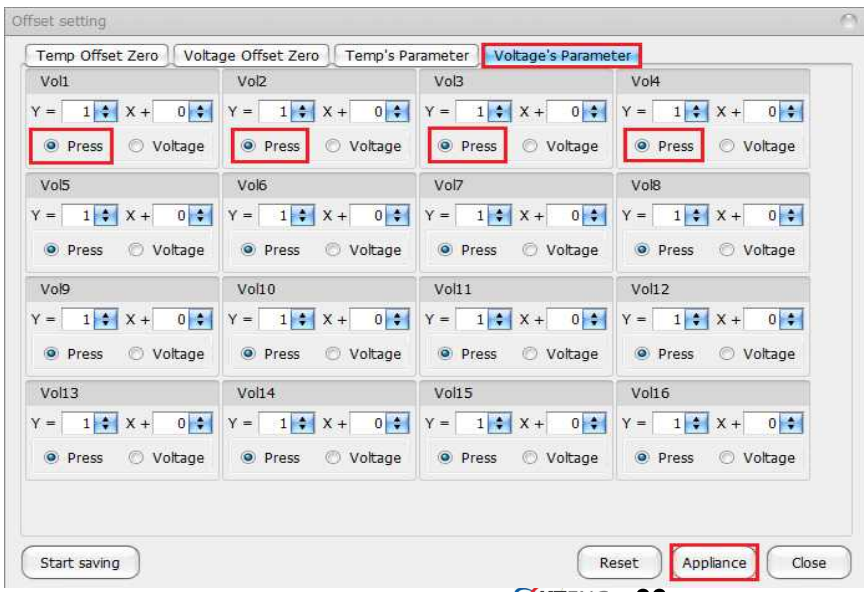
: You can control using direction key.

: It is indication for voltage figure

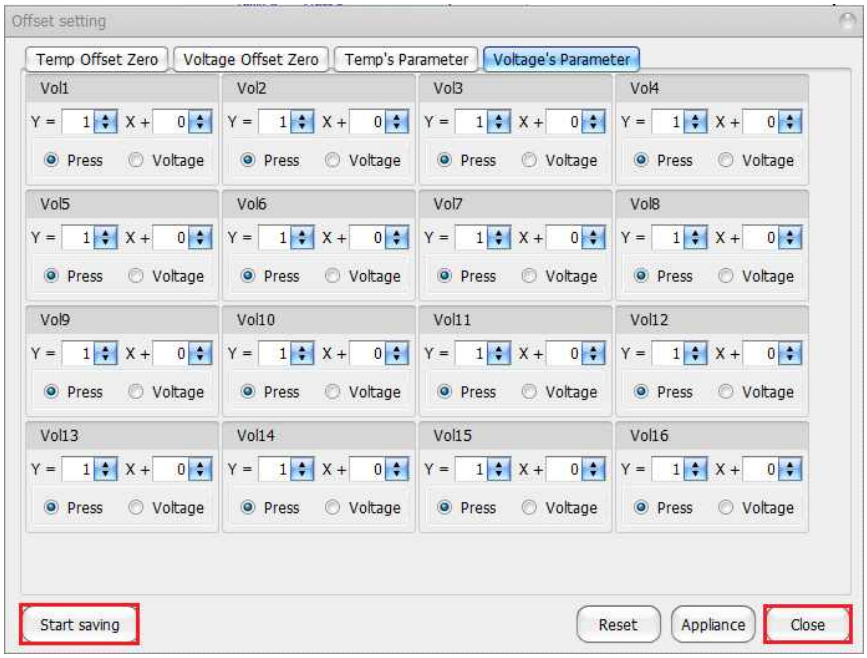
Click the application then click the Close for applying the figure.



⑤ Temp's Parameter must enter a value of Y=70X-150 on all of the items is a place to enter a formula that converts the output signal of the thermometer with temperature. click the "Application" and click "Close" for Application.

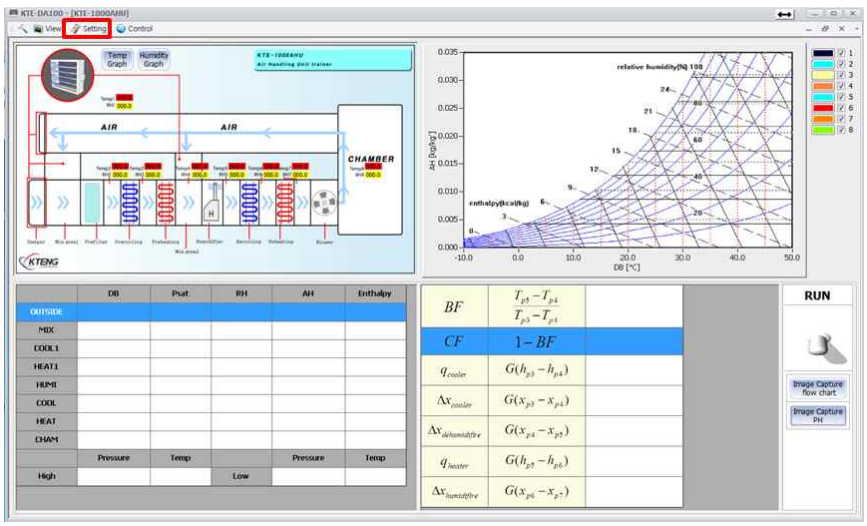


⑥ Voltage`s Parameter has a function which can input the figure for changing input figure, You can set as choosing Pressure, Voltage. Click "Application" and click "Close" for Application.

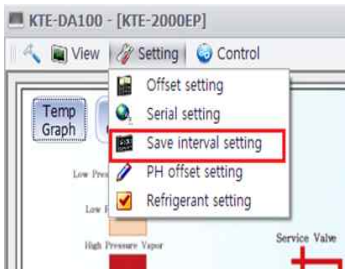


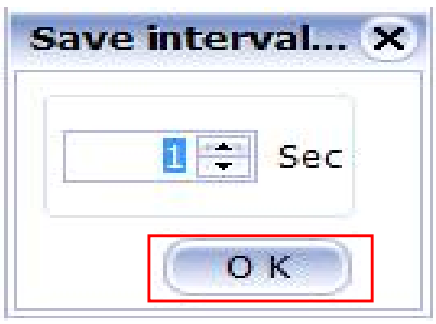
⑦ Start saving set figure and Click “Close” on the left screen.

(c) Save interval setting



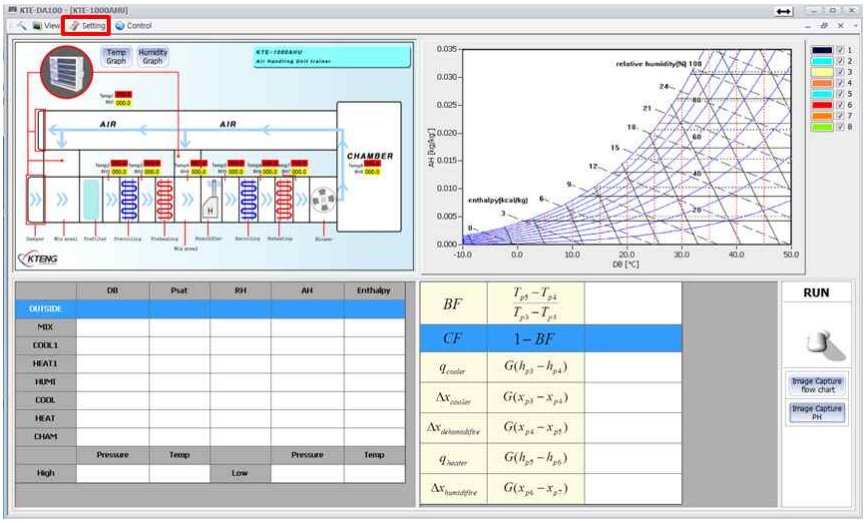
① Click Save interval setting



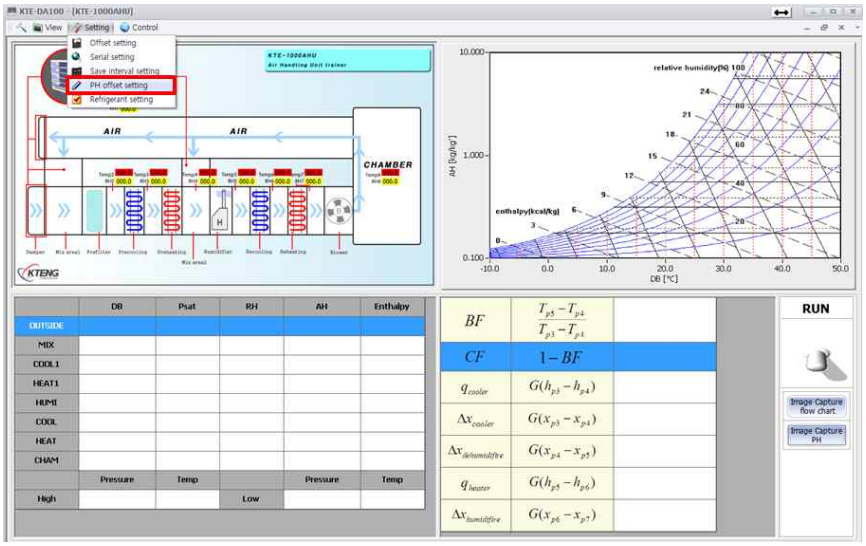


② Save interval setting is a function for setting a data storage time interval. The time interval as an Excel file can be stored in line. (However, the number of seconds Sec) because when set to one minute is ste to 60 sec.

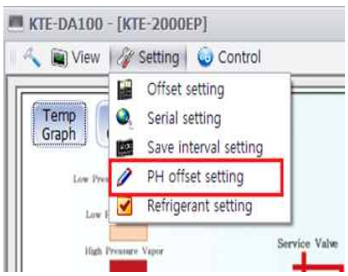
(d) PH offset setting

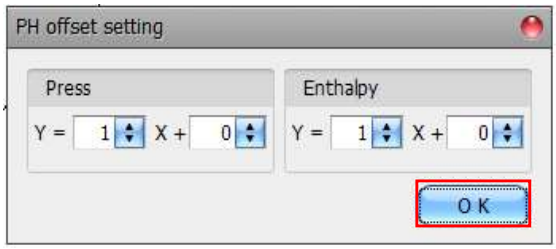


① Click Setting



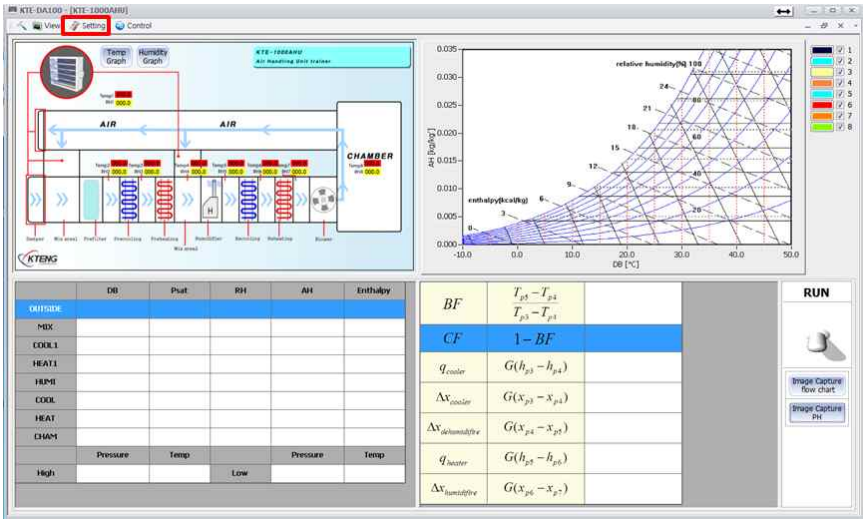
② Click PH offset setting



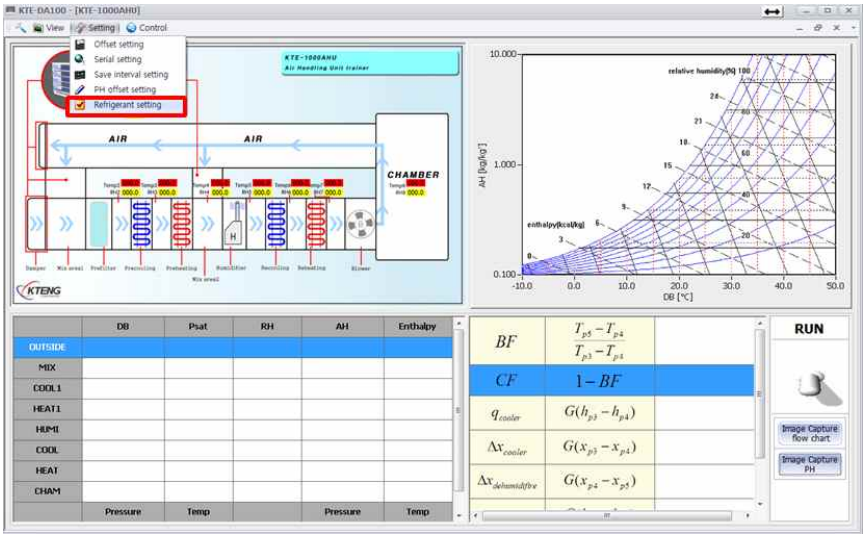


③ On the main screen the PH offset setting.
The axis values of the Enthalpy adjustment function.

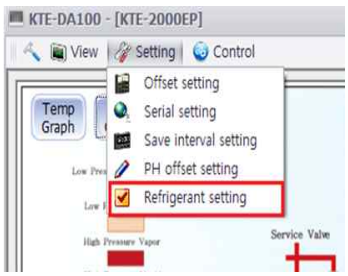
(e) Refrigerant setting

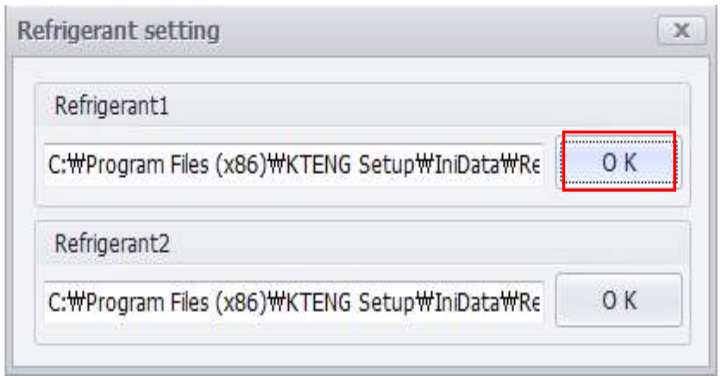


① Click Setting

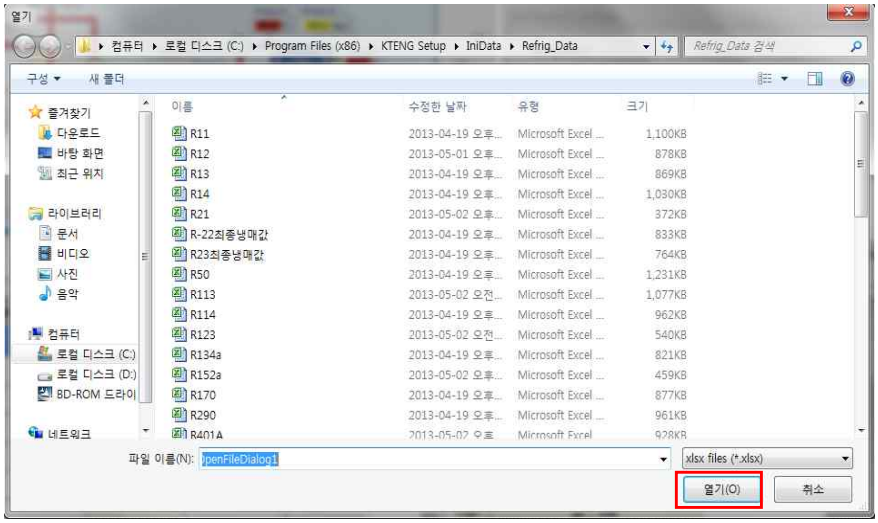


② Click Refrigerant setting





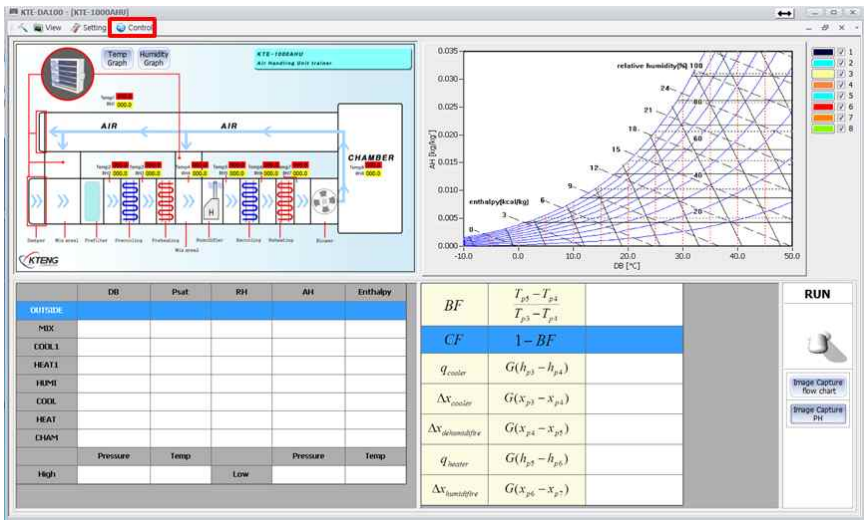
③ Refrigerant setting is a function for selecting the refrigerant-1 stage refrigeration cycle. Refrigeration thounsand 2-stage refrigeration cycle is selected for the selection of the Refrigerant 2 Refrigerant and can be applied to the program.
Click "OK"



④ Select the type of refrigerant and click “Open” to apply to the program.

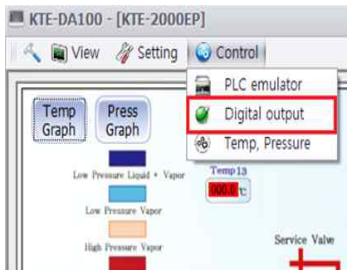
9) Control

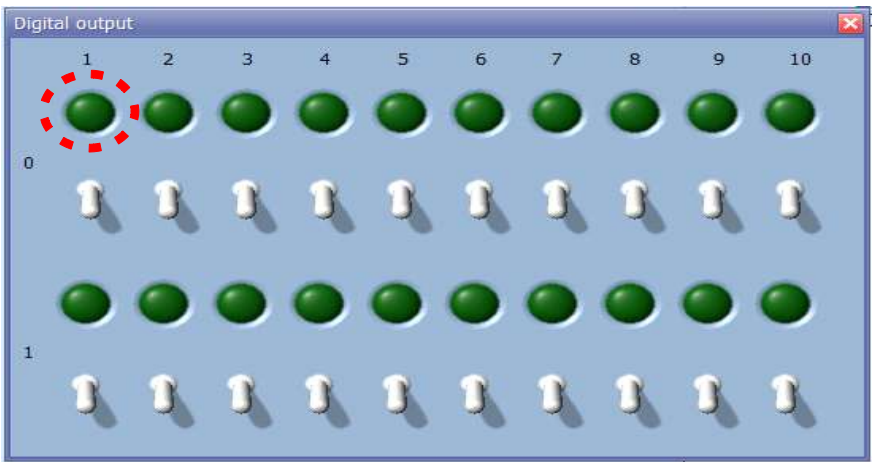
(a) Digital output



① Click Control in Tools.

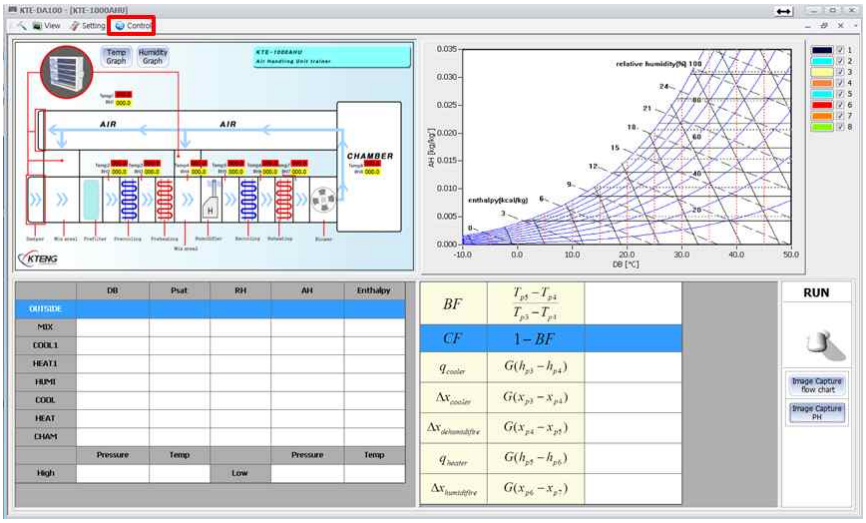
② Click Digital output





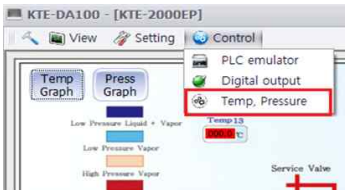
③ Digital output is the second comp by number and to the switch ON/OFF when you work with equipment to operating the stand relay and the operation or without through the lamp Function to determine.

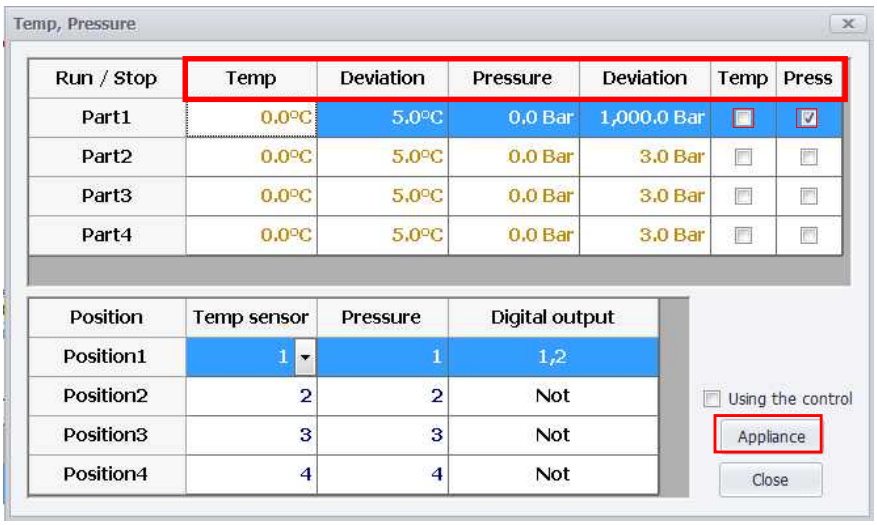
(b) Temp, Pressure



① Click Control

② Temp, Pressure has a function which is interlocked with temperatuere and pressure. When click “Temp, Pressure”, indicate the window as below





③ Temp(set temperature) deviation, Pressure(set pressure) deviation is indicated deviation and it can be saving the figure you want and it can choose both Temp and Pressure.
Temp sensor : Selection for pressure sensor location
Digital output : Selection output port what you want to control After setting, Click “Appliance” and “Close”.

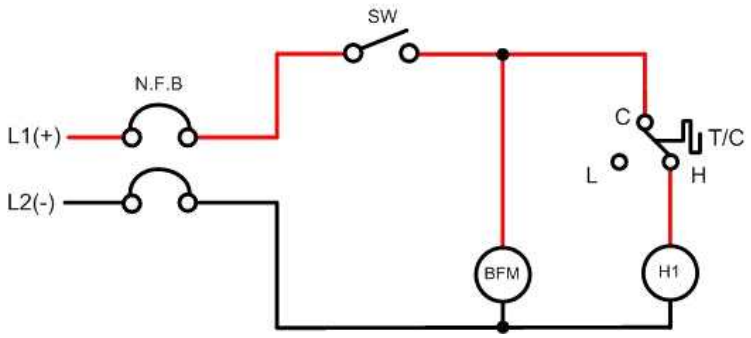
- Temp sensor : Choose location of temperature sensor.
- Pressure : Choose location of Pressure sensor.
- Digital output : Choose location of output.

Chapter 5. Air Handling Unit Construction and Operation as circuit

Experiment name	5-1. Configuration circuit for mixture and heating between returned air(RA) and outside air(OA) of air-conditioning system and operation	Class time(hr)
		8
The object of experiment	① To make the air that is flown from outside and the one that is inside mix and be wormer, at last make to needed air for temperature. ② To related circuit as ① and operate.	

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

Control Circuit



[Related Theory]

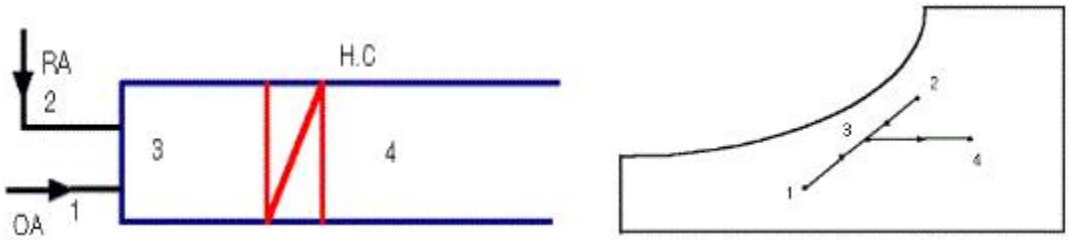
1. Changes in Actual Devices

A. Mixed Heating

OA : External Air
RA : Indoor Return Air
HC : Heating Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.
-For the process 3 → 4, the mixed air passes through the heating coil and receives the energy(heat). Then, the relative humidity drops and the Dry Bulb Temperature and Enthalpy go up. The Specific Humidity is not changed.

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Changed	Up	Up
2 → 3	Down	Changed	Down	Down
3 → 4	Up	Down	No change	Up



Mixed Heating

2. Configuration of circuit

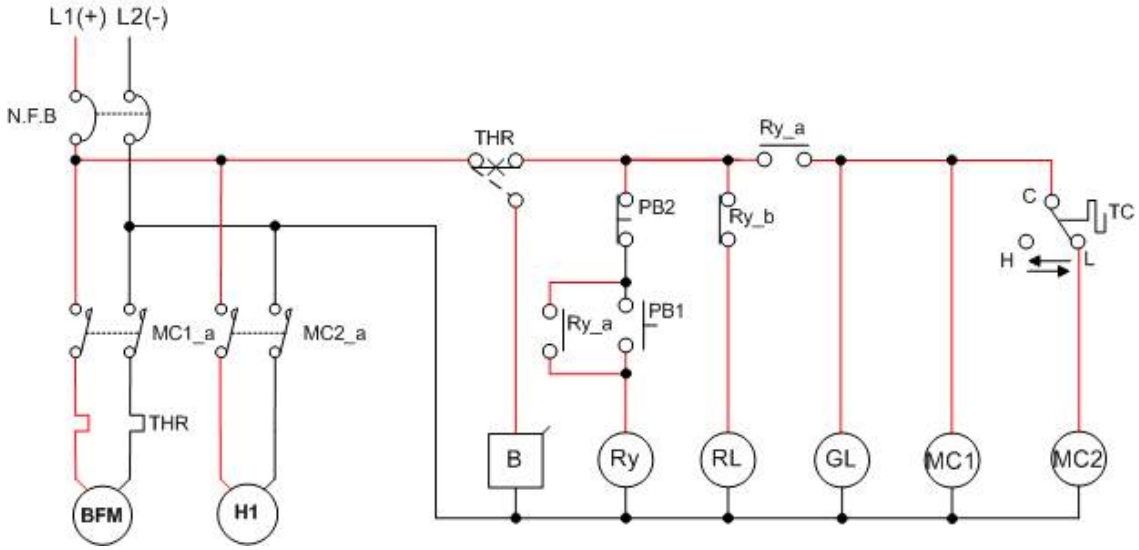
A. Connect with GND Output on Power Module and on Terminal Base Module terminal "-" of "BFM".

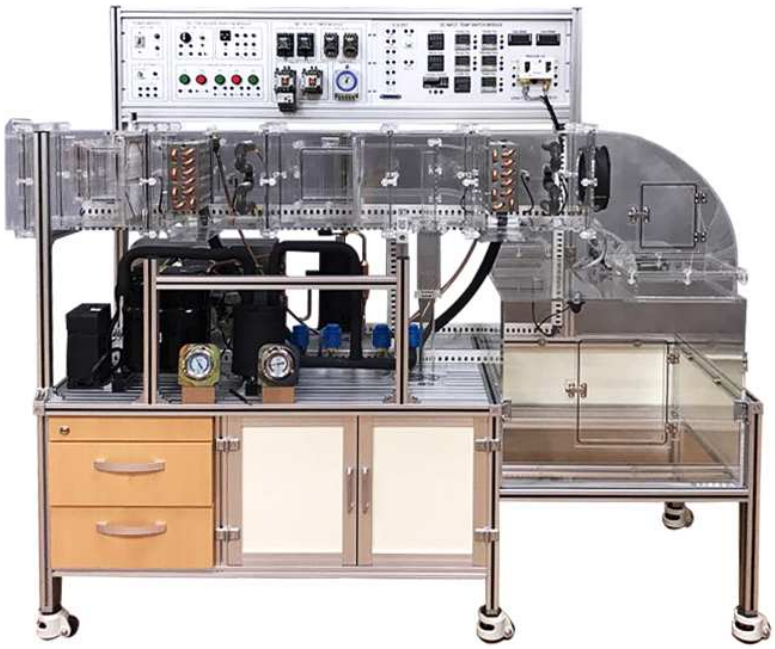
B. Connect with terminal "-" of "BFM" and terminal "-" of "HEATER1".

C. Connect with DC24V Output on Power Module and "C" contact(Output) of "TOGGLE S.W" on S.W Module, and connect with "a" and "+" of "BFM".

D. Connect with "+" of "BFM" and "COM"(output)of "Preheating" on THERMO METER MODULE, and connect with "H" and "+" of "HEATER1".

E. After setting temperature S/W of preheating, operate air mixture operation as toggle S/W is ON("a"contact).





Air Handling Unit (KTE-1000AHU)

· Check Point

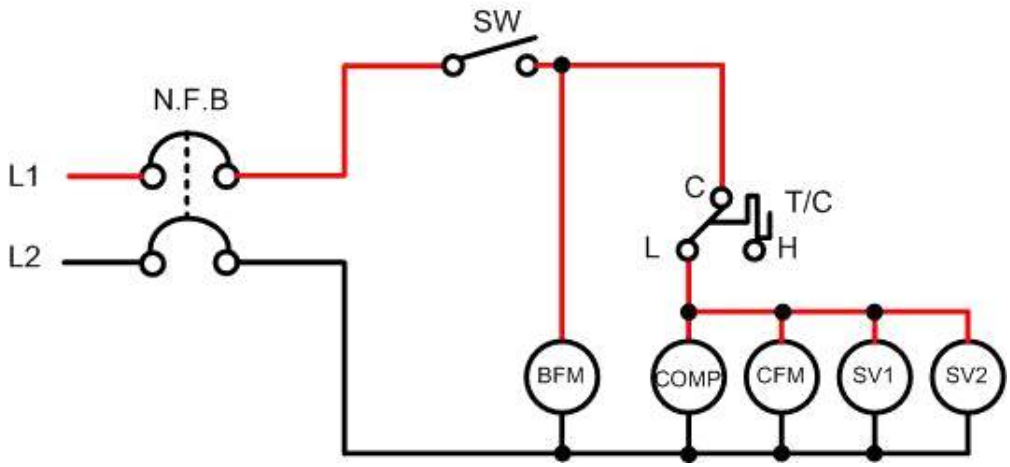
1. Set an air-conditioning trainer and a real wiring experiment kit, and then check them.
2. Understand the function of operating circuit.
   ① Explain the progress when S/W (PB, TS)is on or off .
   ② Ajust dampers of OA and RA for making mixture air.
   ③ Measure airflow of RA and OA.
   ④ Set temperature S/W heat control type.
3. Check the electric devices and analysis the temperature distribution and variation during the system running.
4. Configurate circuit using banana jacks and operate using banana jacks with experiment equipments, tools and materials.
5. Configurate circuit using real wires(KTE-4000SQ) and operate using banana jacks with experiment equipments, 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	5-2. Configuration circuit for mixture and cooling between returned air(RA) and outside air(OA) of air-conditioning system and operation	Class time(hr)
		8
The object of experiment	① To make the air that is flown from outside and the one that is inside mix and be cooler, at last make to needed air for temperature. ② To related circuit as ① and operate.	

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

Control Circuit



L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
COMP : Compressor Motor
SV : Solenoid V/V
SW : Switch
CFM : Condenser Fan Motor
TC : Temperature control S/W

[Related Theory]

1. Mixed Cooling

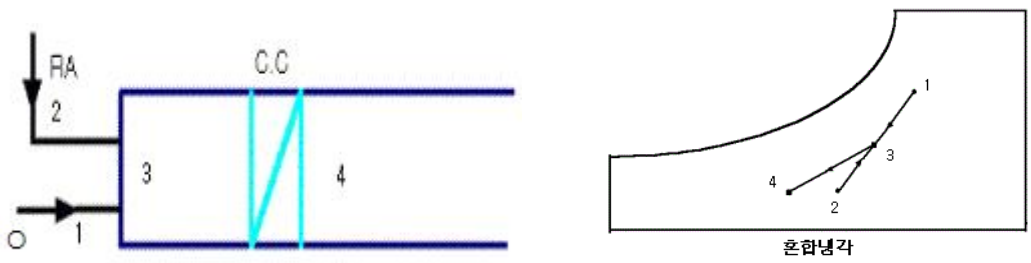
OA : External Air
RA : Indoor Return Air
CC : Cooling Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.

-For the process 3 → 4, the mixed air passes through the cooling coil and receives the energy(heat). Then, the relative humidity goes up and the Dry Bulb Temperature and Enthalpy drop. At this point, the dew point temperature and then the specific humidity drop as passing through the cooling coil.

{Dew Point Temperature is achieved at about 90% to 95% of Relative Humidity}

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Down	Changed	Down	Down
2 → 3	Up	Changed	Up	Up
3 → 4	Down	Up	Down	Down



Mixed Cooling

2. Configuration of circuit

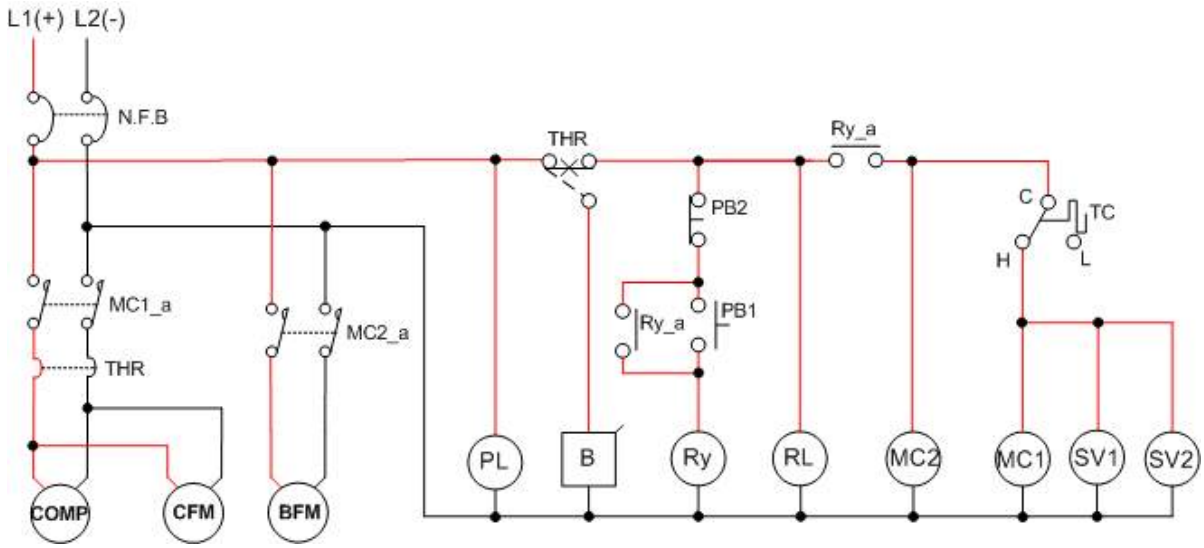
A. Connect with GND Output on Power Module and on Terminal Base Module terminal "-" of "BFM".

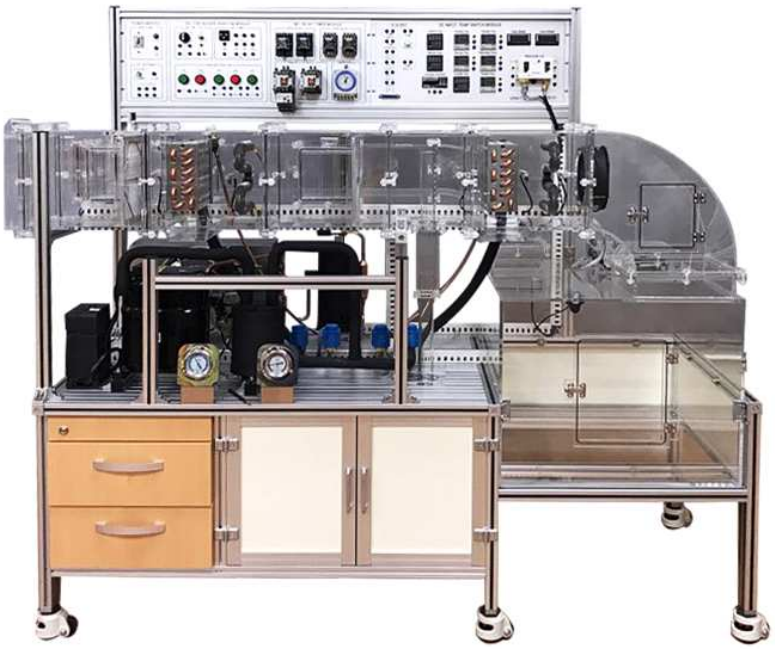
B. Connect continually with "-" of "BFM", "-" of "COMP", "-" of "CFM", "-" of "SV1", "-" of "SV2".

C. Connect with "POWER M" of DC 24V OUTPUT and connect with "C" contact of "TOGGLE S.W" continually connect with "a" and "-" of BFM on S.W MODULE.

D. Connect with "+" of "BFM" and "Preheating" "COM" of "THERMO METER M", and connect with "L" and "COMP" "+", "CFM" "+" and "SV1" "+" 단자, "SV2" "+".

E. After setting temperature S/W of precooling, operate air mixture operation as reversing toggle S/W .





Air Handling Unit (KTE-1000AHU)

· Check Point

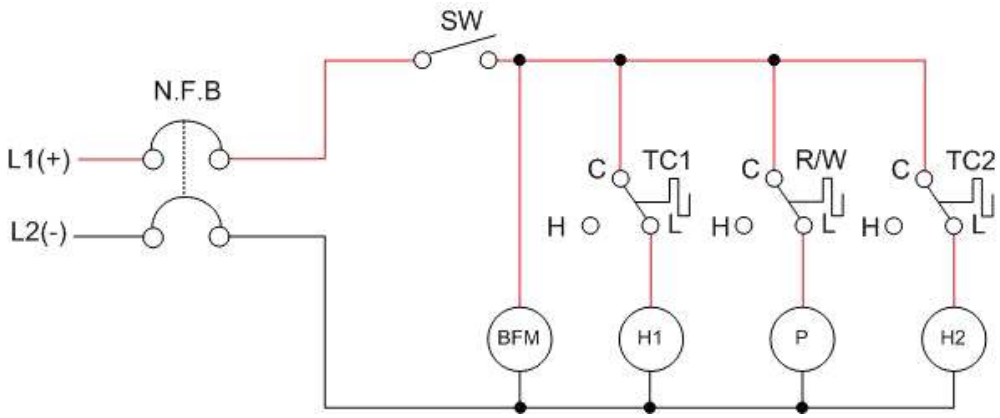
1. Set an air-conditioning trainer and a real wiring experiment kit, and then check them.
2. Understand the function of operating circuit.
   ① Explain the progress when S/W (PB, TS)is on or off .
   ② Adjust dampers of OA and RA for making mixture air.
   ③ Measure airflow of RA and OA.
   ④ Set temperature S/W cool control type.
3. Check the electric devices and analysis the temperature distribution and variation during the system running.
4. Configurate circuit using banana jacks and operate using banana jacks with experiment equipments, tools and materials.
5. Configurate circuit using real wires(KTE-4000SQ) and operate using banana jacks with experiment equipments, 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	5-3. Configuration circuit for mixture and preheating, cleaning and reheating between RA and OA of the air-conditioning system and operation	Class time(hr)
		8
The object of experiment	① To make the air that is flown from outside and the one that is inside mix and be wormer, at last make to needed air for temperature. ② To related circuit as ① and operate.	

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

Control Circuit



L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
SW : Switch
TC : Temperature control S/W

[Related Theory]

1. Mixing → Preheating → Cleaning(Cyclic Water Spray) → Heating

OA : External Air　　RA : Indoor Return Air　PHC : Preheating Coil

AW : Air Washer　　HC : Heating Coil

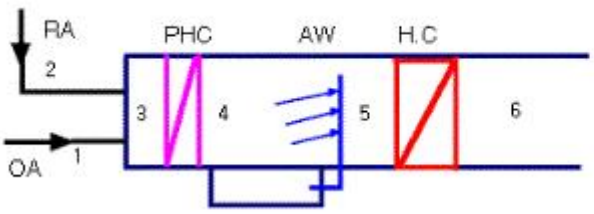
-For the process 1 → 3 ← 2, return air in a room and external air are mixed.

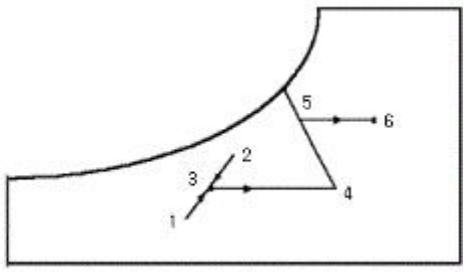
-For the process 3 → 4, the air goes to the preheating coil.

-For the process 4 → 5, the air passes through the cleaning step and the humidity goes up.

-For the process 5 → 6, the air is heated by the heating coil

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Changed	Up	Up
2 → 3	Down	Changed	Down	Down
3 → 4	Up	Down	No changes	Up
4 → 5	Down	Up	Up	No changes
5 → 6	Up	Down	No changes	Up





Mixing-> Preheating -> Cleaning(Cyclic Water Spray)-> Heating

2. Configuration of circuit

A. Connect with GND Output on Power Module and on Terminal Base Module terminal "-" of "BFM".

B. Connect with terminal "-" of "BFM" and "-" of "HEATER 1" and terminal "-" of "PUMP", "-" of "HEATER2".

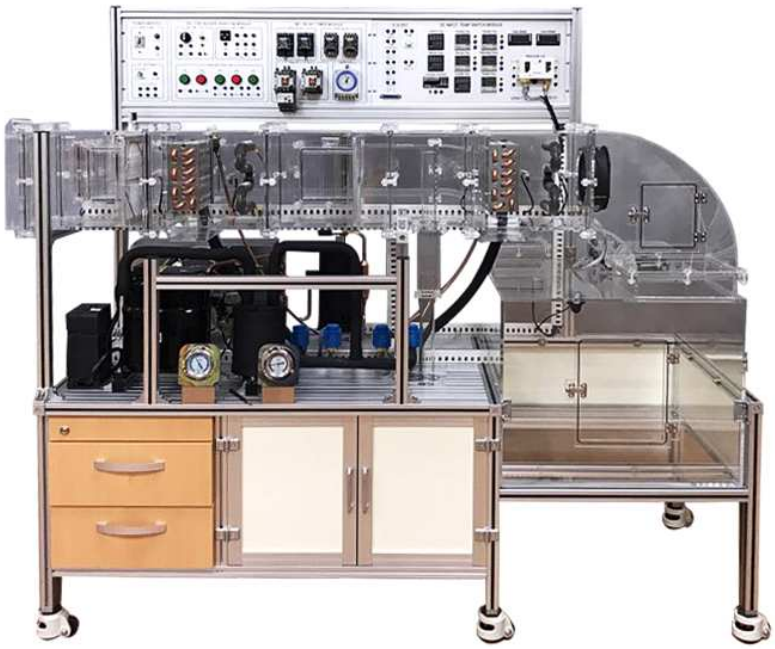
C. Connect with DC24V Output on Power Module and "C" of "TOGGLE S.W" on S.W Module, and connect with "a" and "+" of "BFM".

D. Connect with "+" of "BFM" and "COM" of "Preheating" on THERMO METER MODULE, and connect with "H" and "+" of "HEATER 1".

E. Connect with "COM" of "Preheating" and "COM" of "Reheating" on THERMO METER MODULE, and connect with "H" and "+" of "PUMP".

F. Connect with "COM" of "Relative Humidify" and "COM" of "Reheating" on THERMO METER MODULE, and connect with "H" and "+" of "HEATER2".

G. After setting temperature and humidity S/W , operate air mixture and preheating , spray water and heating operation as adjusting toggle S/W



Air Handling Unit (KTE-1000AHU)

· Check Point

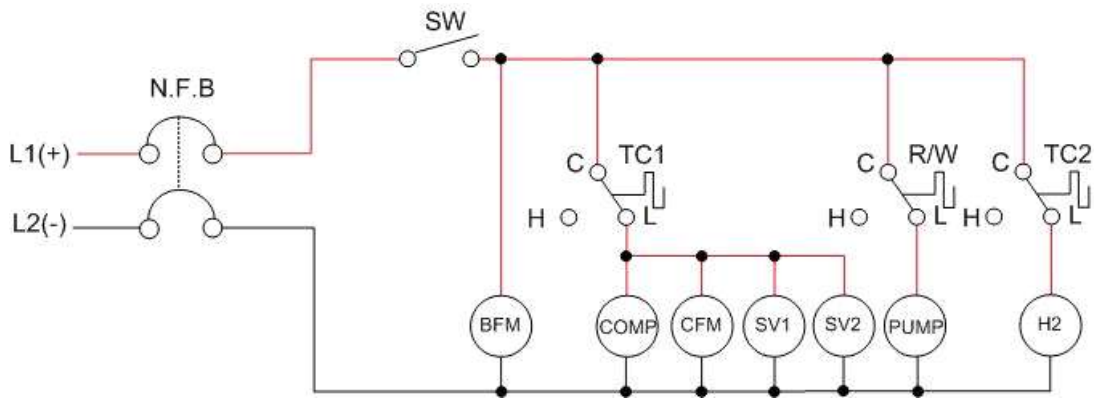
1. Set an air-conditioning trainer and a real wiring experiment kit, and then check them.
2. Understand the function of operating circuit.
   ① Explain the progress when S/W (PB, TS)is on or off .
   ② Adjust dampers of OA and RA for making mixture air.
   ③ Measure airflow of RA and OA.
   ④ Set temperature S/W heating control type.
3. Check the electric devices and analysis the temperature distribution and variation during the system running.
4. Configurate circuit using banana jacks and operate using banana jacks with experiment equipments, tools and materials.
5. Configurate circuit using real wires(KTE-4000SQ) and operate using banana jacks with experiment equipments, 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	5-4. Configuration circuit for precooling of OA, and mixture of the OA and RA, and then cleaning and reheating operation	Class time(hr)
		8
The object of experiment	① To make the air that is flown from outside and the one that is inside mix and be wormer, at last make to needed air for temperature. ② To related circuit as ① and operate.	

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

Control Circuit



L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
COMP : Compressor Motor
TC : Temperature control S/W
SV : Solenoid V/V
SW : Switch
CFM : Condenser Fan Motor

[Related Theory]

1.External Precooling → Mixing →Cleaning → Reheating

OA : External Air　　RA : Indoor Return Air　　PHC : Preheating Coil

AW : Air Washer　　RHC : Reheating Coil

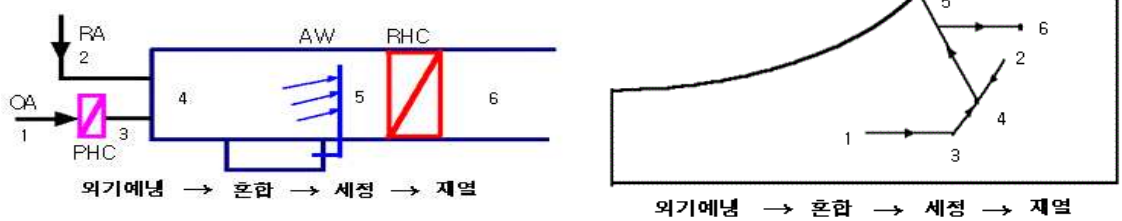
-For the process 1 → 3, the external air is heated by the preheating coil.

-For the process 3 → 4 ← 2, the external air heated is mixed with the indoor return air.

-For the process 4 → 5, the mixed air passes through the cyclic water spray and the humidity goes up.

-For the process 5 → 6, the air passes through the reheating coil

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Down	No changes	Up
2 → 4	Down	Changed	Down	Down
3 → 4	Up	Changed	Up	Up
4 → 5	Down	Up	Up	No changes
5 → 6	Up	Down	No changes	Up



External Air Precooling -> Mixing -> Cleaning -> Reheating

2. Configuration of circuit

A. Connect with GND Output on Power Module and on Terminal Base Module terminal "-" of "BFM".

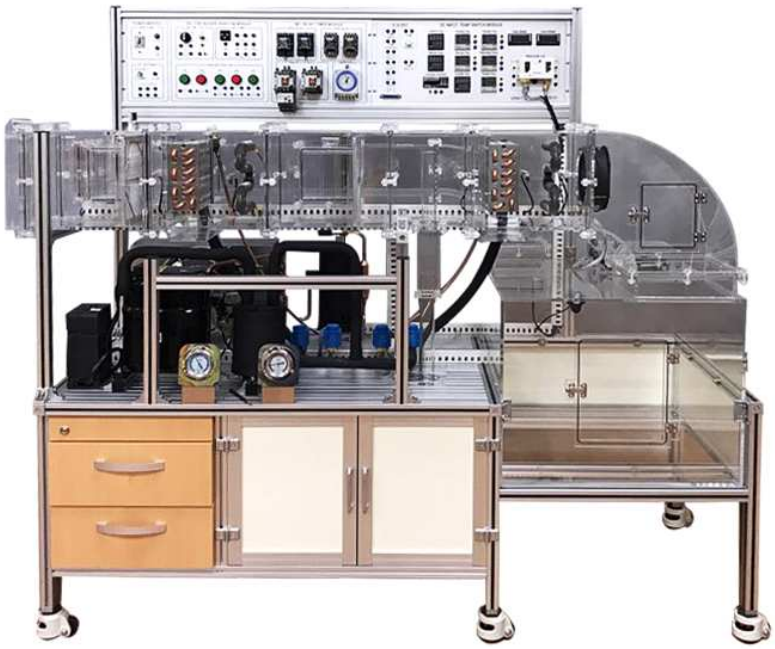
B. Connect with terminal "-" of "BFM" and "-" of "COMP" and terminal "-" of "CFM", "-" of "SV1", "-" of "SV2", "-" of "PUMP", "-" of "HEATER 2".

C. Connect with "+" of "BFM" and "COM" of "Precooling" on THERMO METER MODULE, and connect with "H" and "+" of "COMP", "+" of "CFM", "+" of "SV1", and "+" of "SV2".

D. Connect with "COM" of "Precooling" and "COM" of "Relative Humidify" on THERMO METER MODULE, and connect with "L" and "+" of "PUMP".

E. Connect with "COM" of "Relative Humidify" and "COM" of "Reheating" on THERMO METER MODULE, and connect with "H" and "+" of "HEATER2".

F. After setting temperature and humidity S/W , operate air mixture and precooling , cleaning and reheating operation as adjusting toggle S/W



Air Handling Unit (KTE-1000AHU)

· Check Point

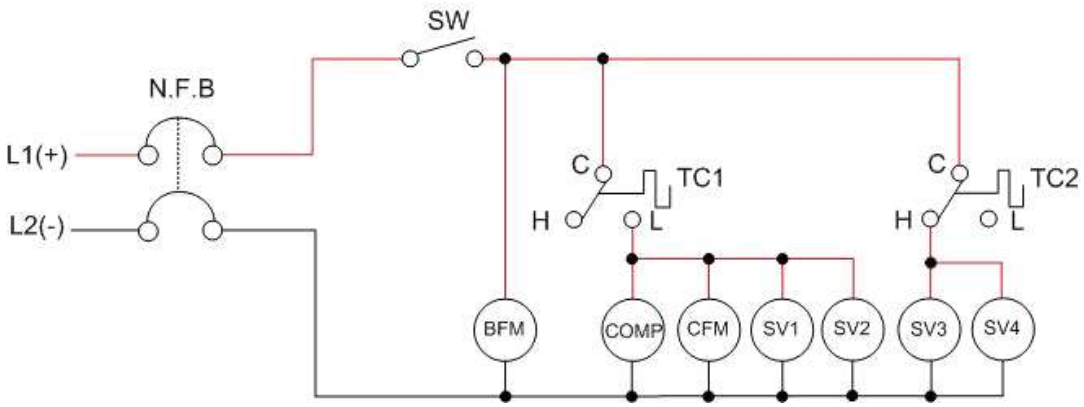
1. Set an air-conditioning trainer and a real wiring experiment kit, and then check them.
2. Understand the function of operating circuit.
   ① Explain the progress when S/W (PB, TS)is on or off .
   ② Adjust dampers of OA and RA for making mixture air.
   ③ Measure airflow of RA and OA.
   ④ Set temperature S/W cooling, heating and humidity control type.
3. Check the electric devices and analysis the temperature distribution and variation during the system running.
4. Configurate circuit using banana jacks and operate using banana jacks with experiment equipments, tools and materials.
5. Configurate circuit using real wires(KTE-4000SQ) and operate using banana jacks with experiment equipments, 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	5-5. Configuration circuit for precooling of OA, and mixture of the OA and RA, and then cleaning and recooling operation	Class time(hr)
		8
The object of experiment	① To make the air that is flown from outside and the one that is inside mix and be wormer, at last make to needed air for temperature. ② To related circuit as ① and operate.	

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

Control Circuit



L1, L2 : Line Voltage
N.F.B : No fuse circuit breaker
COMP : Compressor Motor
TC : Temperature control S/W
SV : Solenoid V/V
SW : Switch
CFM : Condenser Fan Motor

[Related Theory]

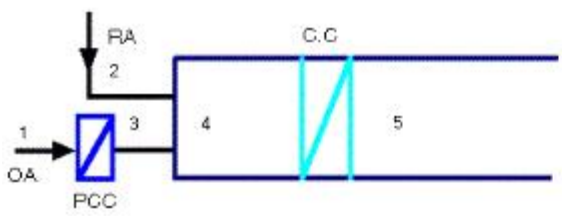
1. External Air Precooling → Mixing → Cooling

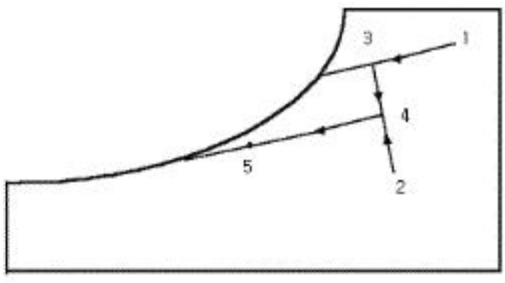
OA : External Air　　RA : Indoor Return Air

CC : Cooling Coil　　PCC : Precooling Coil

-For the process 1 → 3, the external air is cooled in the precooling coil.
-For the process 3 → 4 ← 2, the external air cooled is mixed with the indoor return air.
-For the process 4 → 5, the air passes through the cooling coil.

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Down	Up	Down	Down
2 → 4	Up	Up	Up	Up
3 → 4	Down	Down	Down	Down
4 → 5	Down	Up	Down	Down





External Air Precooling -> Mixing -> Cooling

2. Configuration of circuit

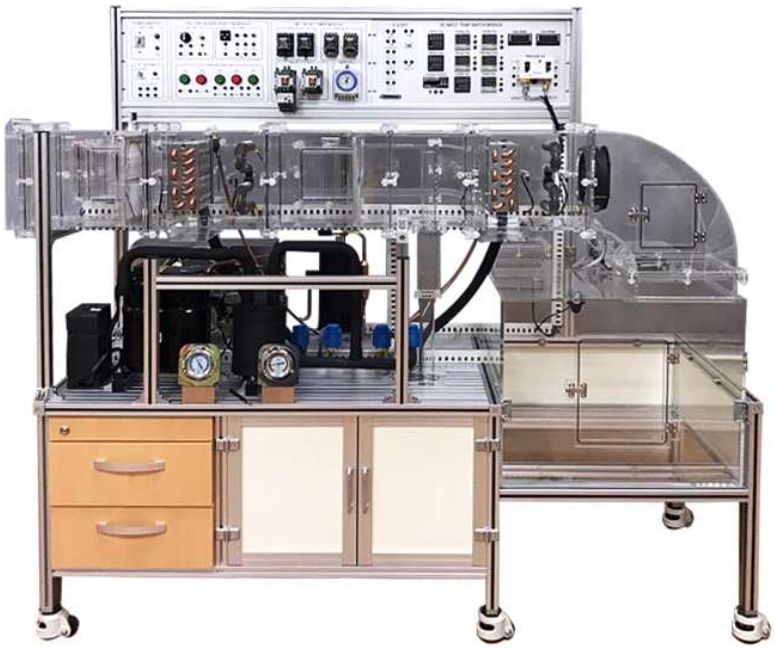
A. Connect with GND Output on Power Module and on Terminal Base Module terminal "-" of "BFM".

B. Connect with terminal "-" of "BFM" and "-" of "COMP" and terminal "-" of "CFM", "-" of "SV1", "-" of "SV2", "-" of "SV3", "-" of "SV4".

C. Connect with "+" of "BFM" and "COM" of "Precooling" on THERMO METER MODULE, and connect with "L" and "+" of "COMP", "+" of "CFM", "+" of "SV1", and "+" of "SV2".

D. Connect with "COM" of "Precooling" and "COM" of "Recooling" on THERMO METER MODULE, and connect with "L" and "+" of "SV3", "+" of "SV4".

E. After setting temperature, and operate as adjusting toggle S/W



Air Handling Unit (KTE-1000AHU)

· Check Point

1. Set an air-conditioning trainer and a real wiring experiment kit, and then check them.
2. Understand the function of operating circuit.
   ① Explain the progress when S/W (PB, TS)is on or off .
   ② Adjust dampers of OA and RA for making mixture air.
   ③ Measure airflow of RA and OA.
   ④ Set temperature S/W precooling and preheating control type.
3. Check the electric devices and analysis the temperature distribution and variation during the system running.
4. Configurate circuit using banana jacks and operate using banana jacks with experiment equipments, tools and materials.
5. Configurate circuit using real wires(KTE-4000SQ) and operate using banana jacks with experiment equipments, 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

※ Appendix : General description of Air Conditioning Theory and experiment

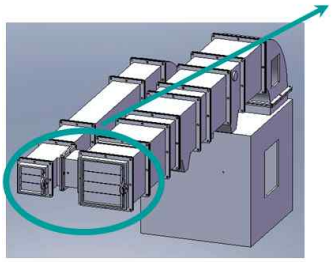
1. General Description
   0. The air flow: external air-mixed air- pre-heater - precooler - ventilator - humidifier- reheater- re-cooler - indoor - ventilation. (Ventilation is performed only by a ventilator. The air vent is built. Pressure proportioner type 2 ventilation method is applied.)
   0. The precooler and re-cooler are the refrigerator using R-22.
   0. The pre-heated and reheater are the electric reheater using 220V.
   0. The equipment is compatible with the sequence control test equipment. The preheating, precooling, reheating, re-cooling and humidifying are automatically controlled according to the indoor loads and setting values.
   0. The temperature on each state point is measured and recorded in the digital values during the operation of equipment and the wet air chart can be drawn.

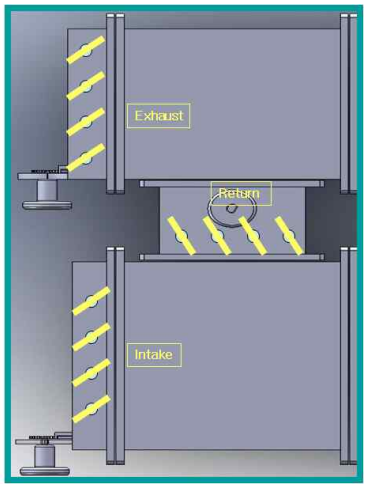
2. Air system
   - Ambient Condition
     · Dry Temp. : 20℃ · Wet bulb Temp. : 11.7℃
     · Relative Humidity : 34%
   - Air Conditioning Room
     · Dry Temp. : 15℃ · Relative Humidity : 30%
   - Exhaust air temp. 10℃
   - Return Air Temp : 15℃
   - Evaporating Temp. : -15℃
   - Reheating Coil Capacity : 1kw
   - Normal air density : 1.2kg/m^3

3. Operation condition: Up to Experiment No. 6.(Configuration circuit for mixture and cooling between returned air(RA) and outside air(OA) of air-conditioning system and operation)
   - Intake air volume : 25% of the blower volume
   - Ventilation volume and exhaust volume: Damper need to control for that ventilation Volume is 75% of the blower volume.
   - Sensible Heat Factor (SHF) : 0.85

4. Duct Specification

- Volume (CMM)





Outdoor Air		Exhaust Air		Return Air		Intake Air	
Open rate (%)	Air Vol. (CMM)	Open rate (%)	Air Vol. (CMM)	Open rate (%)	Air Vol. (CMM)	Open rate (%)	Air Vol. (CMM)
Close	0	Close	0	Open	xx	·	3.5
25% Open	0.7	25% Open	0.5	75%	xx	·	4
50% Open	1.9	50% Open	2.0	50	xx	·	4.2
75% Open	3.1	75% Open	3.1	25	xx	·	4.4
100% Open	4.5	100% Open	4.6	0	xx	·	4

Each date is gotten from 9 point by an airflow meter, it is average value. The difference range of outdoor air and exhaust can be controled by adjusting return damper.

- Free Area (m^2)

Open rate	Outdoor/Intake Air Duct	Return/Exhaust Air Duct
Close	0	0
25% Open	0.014	0.005
50% Open	0.028	0.009
75% Open	0.041	0.014
100% Open	0.055	0.018

· Outdoor/Intake Air Duct Size : 234mm× 234mm

· Return/Exhaust Air Duct Size : 134mm× 134mm

5. Quantity of Total Heat

Quantity of Total Heat Qt, Sensible Heat Factor q_s ,Quantity of Latent heat q_L

$Qt = q_s + q_L$

As the condition, Outdoor air volume 25%, Return and Exhaust air volume 75%, SHF is 0.85.

- Mix point statue

$$t_3 = \frac{t_1 \times Q_1 + t_2 \times Q_2}{Q_1 + Q_2} = \frac{20 \times 0.25 + 15 \times 0.75}{0.25 + 0.75} = 16.25℃$$

$$x_3 = \frac{x_1 \times Q_1 + x_2 \times Q_2}{Q_1 + Q_2} = \frac{0.005 \times 0.25 + 0.0032 \times 0.75}{0.25 + 0.75} = 0.00365 kg/kg'$$

$$i_3 = \frac{i_1 \times Q_1 + i_2 \times Q_2}{Q_1 + Q_2} = \frac{7.7 \times 0.25 + 5.5 \times 0.75}{0.25 + 0.75} = 6.05 kcal/kg$$

- At Mix point 3point, SHF is parallel, and exhaust temp. (10℃), cross point h4 is 4.3kcal/kg.

⇒ Qt = G× (h3-h4)
= 1.2(kg/m^3)× Q(m^3/h)× (h3-h4)(kcal/kg)
= 1.2(kg/m^3)× (4× 60)(m^3/h)× (6.05-4.3)(kcal/kg‘)
= 504kcal/h

i) q_s = G× (h3 - h4) = G× 0.24× (t3-t4) = 1.2× 0.24× Q× (t3-t4)
= 1.2(kg/m^3) × 0.24(kcal/kg·℃) × Q(m^3/h) × (t3-t4) ℃
= 0.29 (kcal/m^3·℃) × Q(m^3/h) × (t3-t4) ℃
∴ q_s = 0.29(kcal/m^3·℃) × 240(m^3/h) × 6.25(℃)
= 435kcal/h

ii) q_L = G× (h3 - h4) = G(kg/h) × 597.5(kcal/kg') × (x3-x4)(kg/kg')
= 1.2(kg/m^3) × Q(m^3/h) × 597.5(kcal/kg') × (x3-x4)(kg/kg')
= 717(kcal/m^3) × Q(m^3/h) × (x3-x4)(kg/kg')
∴ q_L = 717(kcal/m^3) × 240(m^3/h) × (0.00365-0.0033)(kg/kg')
= 60.3kcal/h

iii) L = G× (x3 - x4)
= 1.2(kg'/m^3) × Q(m^3/h) × (x3 - x4)(kg/kg')
= 1.2(kg'/m^3) × 240(m^3/h) × (0.00365-0.0033)(kg/kg')

= 0.0576kg/h

v) $Qt = q_s + q_L$

= 435 +60.3 = 495.3 kcal/h ≒ 504kcal/h

6. Related theory of Psychrometric chart drawing

6-1 Air Conditioning Test Equipment Overview

A. Definition on Air Conditioning

-. The air conditioning means to keep the most optimum conditions such as temperature, humidity, air current and toxic gases for people or objects inside a room,

-. The comport air conditioning or general air conditioning aims the comfort, hygiene and health for the people inside a room(houses, offices, department stores, hospitals, hotels, theaters, etc.)

-. The industrial air conditioning aims to keep the most appropriate indoor conditions for the equipment in a room or objects manufactured or assembled in a room and additionally keep the comfort and clean environment for the people in a room.

B. Four Factors for Air Conditioning

-. Temperature, humidity, cleanness, distribution

※ Five factors are also considered including the "Radiative Effect on Walls".

C. Indoor Environment of General Air Conditioning

-. Thermo-balance of Human Body

People intake food every day and change food to energy by burning oxygen through the respiratory function. With this energy, people keep their lives and continue the activities such as labor or exercises. Some of this energy is used for works and the others are released out of our bodies as the thermal energy. People are warm-blooded animal that shall always keep the body temperature at about 36℃~37℃. If the thermal production and discharge in a body are not balanced, the body temperature is increased or dropped. Then, people feel uncomfortable or are suffered from diseases. The change of energy going in and out of human body is called "energy metabolism". The least amount of energy necessary to maintain the vital involuntary activities is called "basal metabolism" and the metabolic rate when people don't make any activities is called "resting metabolism". The metabolic rate is proportionate to the body surface area and the resting metabolism is 20% higher than the basal metabolism in average. The basal metabolic rate is about 35 $kcal/hm^3$ for the male adult. The unit for the metabolic rate is

generally met. 1 met is 50 $kcal/m^2h$ on the basis of the metabolic rate during the thermal stability meaning the comfort state. 20%~25% , 40%~50% and 20%~30% of 50 $kcal/m^2h$ are discharged out of the body through evaporation, radiation or convection current, respectively.

The thermo-balance of human body who carries out the normal activities can be described in the formula below.

$$M = E \pm r \pm C \pm S$$

M : Metabolic Rate(kcal/h·person)
E : Thermal exchange between the human body and the surroundings through evaporation (kcal/h·person)
r : Thermal exchange between the human body and the surroundings through radiation (kcal/h·person)
C : Thermal exchange between the human body and the surroundings through convection current(kcal/h·person)
S : Calorie accumulated in the human body (kcal/h·person)

+, the right side of the formula above, is the radiation of heat to the surroundings and - means the heat going into the human body.

When S = 0, the body temperature is constant.

When S 〉 0, the body temperature goes up(people feel hot)

When S 〈0, the body temperature drops(people feel cold).

The calorie from the metabolism depending on the activities is described in the table below.

Degree	Activity	Metabolic Rate (kcal/h)
Very Light	Sleeping sitting, office works typing	6.25 100 113~138
Light	Sitting, arm and leg movement at the medium level, standing simple works on the working table sitting and severe arm and leg movement	138 ~ 163 138 ~ 163 163 ~ 200
Medium	Works on the working table, walking broun pushing or pulling activities at the medium level	188 ~ 250 250 ~ 350
Heavy	Intermittent intermediate works, pushing or stretching works (digging and shoveling) continuous severe works	375 ~ 500 500 ~ 600

(Note) when the person who weighs 70kg continuously works without taking a rest.

Work Category	Metabolic Rate (met)	Work Category	Metabolic Rate (met)
Resting		Office works	1.2 ~ 1.4
Sleeping	0.7	typing	
Simple Standing	1.0	general office works, drawing	1.1 ~ 1.3
Gradually Standing Up	1.2		
Walking at		Teachers	1.6
0.89 m/s	2.0	Shop Workers	2.0
1.34 m/s	2.6	Dances	2.4 ~ 4.4
1.79 m/s	3.8	Tennis	3.6 ~ 4.6
		Basketball	5.0 ~ 7.6
		Research works	1.4 ~ 1.8
		Plants	
		Simple works(electric engineering works)	2.0 ~ 2.4
House working		Heavy works(steel industry)	3.5 ~ 4.5
Cleaning	2.0 ~ 3.4	Carpenter's works	
Cooking	1.6 ~ 2.0	Mechanic Saw	1.8 ~ 2.2
Manual Washing	2.0 ~ 3.6	Hand Saw	4.0 ~ 4.8
Marketing	1.4 ~ 1.8	Forging Plant	
		Air Hammer	3.0 ~ 3.4
		Dewing	5.0 ~ 7.0

Metabolic Rate by Work(met)

0. Heat generated in the human body(qm)

qm = qr + qE + qS

qr : Radiation heat, qE : Evaporation heat, qS : Accumulated heat in a body

0. Comfort condition in a human body

The most comfort state for people is when the heat produced in a body and the heat discharged out of a body are on balance. Then, the comfort varies depending on the characteristics such as wearing clothes or not and mental status of people. The comfort indexes include the uncomfort index, effective temperature, adjusted temperature and new effective temperature.

The general room conditions in the air conditioning are 26℃DH and 50%rH in summer and 20℃DH and 50%rH in winter.

-. UI(uncomfort index)

The uncomfort index considers only the influence by heat environment. It is calculated with the dry-bulb and wet-bulb temperature.

UI = 0.72 (Db + Wb) + 40.6

Db : Wet-bulb temperature(℃) Wb: Dry-bulb temperature(℃)

Uncomfort Index(UI)	Comfort
86 or over	Hot weather that is difficult to endure
80 or over	Most people feel uncomfortable
75 or over	Over 50% feel uncomfortable
70 or over	Some feel uncomfortable (people start feeling uncomfortable)
70 or below	People feel comfort

Comfort by Uncomfort Index

0. ET(effective temperature- sensible temperature, virtual temperature)

The conditions deciding the room temperature that is saturated(relative humidity:100%) without wind making people feel the same comfort as that in a room under a certain temperature and humidity are dry-bulb and wet-bulb temperature(humidity) and air current.

※ Static Air: Air at 0.08 ~ 0.13 m/s

The effective temperature 20℃ is the sensible temperature that people feel at 20℃ under the static air with 100% of relative humidity.

0. Adjusted Effective Temperature

The adjusted effective temperature is measured using the globe thermometer with the thermometer in a center of sphere instead of dry-bulb temperature. It is used when the radiative effect exists with the operative temperature(OT).

$$\text{Eq ,T} = 9.56 + 0.6t_w - (23.9 - t) \times (0.4 + 0.127\, v^{0.5})$$

Eq ,T : Average Radiation Temperature (℃)
t_w : Equivalent Temperature
v : Speed of Wind (m/min)

0. Operative Temperature(OT)

OT is the general temperature for the heat and cold in a room. It is indicated by the average between the radiation temperature on the indoor wall(including ceiling and floor) and the room temperature. It is equivalent to the globe temperature with the gentle wind(0.18m/s) that people can't feel.

$$OT = (\text{Average Radiation Temperature} + \text{Room Temperature}) / 2$$

D. Air Conditioning Facility Configuration

The indoor air shall keep temperature and cleanness in a certain range for making people live and work under the comfort environment such as offices in buildings or living rooms in houses. However, the external conditions around the rooms are always changed. Since the heat going in and out of rooms through the external walls or windows always causes the indoor temperature and humidity to be changed, the room temperature and humidity shall be kept by adjusting the heat exchange between the outdoor and indoor. The respiration or smoking of people and operation of a variety of devices in a room generate carbon dioxide, dusts, carbon monoxide, ammonia and sulfurous acid gas that are toxic to human bodies. The higher density of those toxic gases make other people uncomfortable. For reducing the density of impurities that shall not be included in indoor air or are harmful to people, those impurities shall be removed or even though they are included in a room, the indoor air shall be kept clean by the intake of external air with the very low density of impurities. this activity is called ventilation. Since the external air introduced for ventilation has different temperature and humidity from the indoor air, even the indoor air shall be cooled and dehumidified or heated and humidified. The heat going in and out of the space for the air conditioning is called "indoor heat load' and the amount of heat required for cooling or heating the external air for ventilation to the indoor conditions is called "external flow load". This heat load is called heating load when the heating is required and cooling load when the cooling is required.

0. Heating Source or Cooling Source

Heating air requires the boiler providing the vapor or warm water supplying the heating source and cooling air requires the refrigerator providing the cooling source.

0. Air Handing Unit(AHU)

Firstly, the dust and impurities shall be removed from air. And the temperature and humidity of air shall be adjusted using the heating or cooling sources.

0. Air Distributor

It is the device to appropriately distribute air to the required areas. It includes the vents and ducts.

0. Automatic Controller

The automatic controllers automatically control a variety of factors for more effective operation in heating and cooling and keeping the room temperature and humidity to a certain level.

6-2. Air Properties

The air on the earth consists of main elements such as nitrogen and oxygen and other small amounts of gases such as argon carbon dioxide and neon including vapor. The air also contains dusts, gases or vapors generated by people or nature. However, the air is the mixture of dry air and vapor in the theoretic calculation of air conditioning.

The air that doesn't include vapor is dry air and that including vapor is moist air.

A. Air Types

0. Dry air : without any vapor.

-. Composition(Vol%) N2 : 78% O2 : 20.93% Ar : 0.933% CO2 : 0.03% Ne : 1.8 x 10-3% He : 5.2 x 10-4 %

-. Average Molecular Weight(ma) = 28.964 kg·m / kg·oK

-. Gas Constant(Ra)=29.27 kg·m / kg·oK

-. Specific Weight(γa)=1.293 kg/N㎥ (For 20℃, 1.2 kg/㎥)

-. Specific Volume (Va)=0.7733 N㎥/kg(For 20℃, 0.83 ㎥/kg)

0. Moist air : The moisture is mechanically mixed in air with the moisture.

Category	Description
State	Dry Air + Vapor = Moist Air
Weight	1kg + χkg = (1+χ)kg
Partial Pressure	Pa(Partial Pressure of Dry Air) + Pw(Partial Pressure of Vapor) = P(Voltage of Moist Air)
Volume	Va + Vw = V

0. Saturated air

The amount of vapor included in air is limited by the air temperature(varies on temperature and pressure). The air including the maximum vapor is called "saturated air". When the air temperature goes up, the saturation pressure is also increased. So air can contain more vapor. When the air temperature drops, the vapor limit in air is also decreased. Then, the saturation pressure is also dropped.

0. Mist Air

When the saturated air temperature gradually drops from t℃ to t`℃, the vapor is condensed as much as χ-χ`. Then, the vapor floats in the air in a state of minute water drop or mist. This kind of air is called "mist air".

0. Unsaturated air

It is the moist air that doesn't reach to the saturation point. The indoor air is mostly unsaturated air. (Note) The saturated air becomes the unsaturated air with heating and

the supersaturated air with cooling.

B. Relative State of Air

0. Dry bulb temperature(DB, t,℃)

Temperature indicated by the general thermostat

0. Wet bulb temperature(WB, t`,℃)

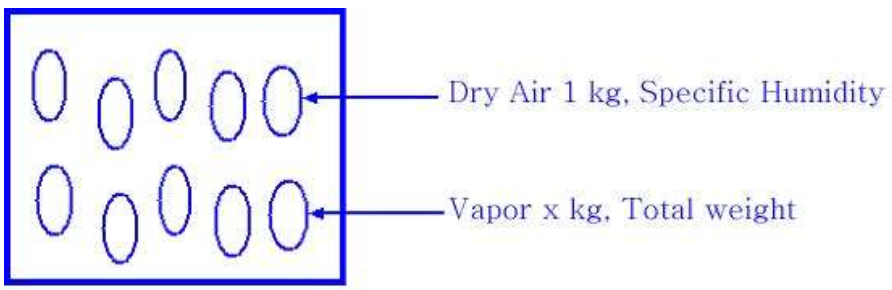
It is measured by the wet bulb thermostat. In the web bulb thermostat, water is vaporized from the water curtain and takes heat. Then, the water curtain temperature drops and becomes lower than the dry bulb temperature of air. At this moment, the heat is moved from air to the water curtain due to the temperature gap between the dry bulb temperature and water curtain temperature to increase the water curtain temperature. The water curtain temperature becomes constant at the point where the heat loss by evaporation is equivalent to the acquired heat from the electric heat. The temperate at this point is called "web bulb temperature".

0. Dew point temperature (DP, t",℃)

It means the temperature when the vapor in moist air is separated from air and starts to be condensed, that is, the temperature of saturated moist air with the same partial pressure as the vapor partial pressure of moist air.

0. Specific humidity(SH, χ, kg/kgDA)

It is the value dividing the vapor weight included in moist air by the dry air weight, that is, vapor weight per 1 kg of dry air.



(Note) With only cooling or heating without dehumidifying or humidifying, the specific humidity is not changed.

$$x = \frac{r_w}{r_w} = \frac{\frac{P_w}{R_w \cdot T_4}}{\frac{p_w}{R_w \cdot T_4}} = \frac{\frac{p_w}{47.06}}{\frac{P - P_w}{29.27}}$$

Pw : Partial Pressure of Vapor (kg/㎥)　　Rw : Gas constant of vapor(47.06 kg·m / kg·oK)

Pa : Partial Pressure of Dry Air(kg/㎥)　　Ra : Gas constant of dry air(29.27 kg·m / kg·oK)

P : Atmospheric Pressure(Pw + Pa)　　T : Specific humidity of moist air(oK)

0. Relative humidity(RH, Φ,%) :

The ratio of the partial pressure of vapor to that of saturated air at the same temperature. It is the ratio of moist weight included in the moist air of 1㎥ and moist weight included in the saturated moist air of 1㎥ at the same temperature.

$$\Phi = \frac{\gamma_w}{\gamma_s} x100$$

$$\Phi = \frac{P_w}{P_s} x100$$

r_w : Moist weight included in 1m3 of moist air　　p_w : Partial pressure of vapor of moist air

r_s : Moist weight included in 1m3 of saturated air　　p_s : Partial pressure of vapor in the saturated moist air at the same temperature

(Note) Heating air causes the relative humidity to be dropped and cooling air makes it be increased.

Φ = 0% ------- Dry air

Φ = 100% ----- Saturated air

$$\Phi = \frac{P_w}{P_s} \quad \text{에서} \quad P_w = \Phi P_s$$

$$\chi = 0.622 \frac{\Phi P_s}{P - \Phi P_s}$$

$$\therefore \Phi = \frac{\chi P}{(0.622 + \chi) P_s}$$

0. Saturation degree(SD ,Ψ, %), relative humidity:

Ratio of specific humidity of moist air to the specific humidity of saturated moist air at the same temperature.

$$\Psi = \frac{\chi}{\chi_s} \times 100$$

x : Specific humidity of moist air　　x_s : specific humidity of saturated moist air at the same temperature

$$\Psi = \frac{\chi}{\chi_s} \times 100$$

$$\Psi = \frac{0.622\Phi\frac{P_s}{P} - \Phi P_s}{0.622\Phi\frac{P_s}{P} - P_s} \left(\because \chi_s\text{일 때 } \Phi = 1\text{이므로}\right)$$

$$\Psi = \Phi\frac{P - P_s}{P - \Phi P_s}$$

0. Specific volume(SV, υ, m3/kg')

Volume of the moist air containing 1kg of dry air.

◉ When the vapor amount in 1kg of dry air is χkg,

-. State formula of 1kg of dry air

Pa V = R T

-. State formula of 1kg of vapor

Pm V = x Pw T

-.

$P = P_a + P_w$ 에서

$V(P_a + P_w) = V \cdot P = T \cdot (P_a + \chi P_w)$

$$\therefore V = \frac{T \cdot (P_a + \chi P_w)}{P}$$

$$V = (29.27 + 47.06\chi)\frac{T}{P} = (0.622 + \chi)47.06 \cdot \frac{T}{P}$$

T : 절대온도 (°K) P : 압력 (kg/cm²)

T : Absolute Temperature, P : Pressure

0. Enthalpy of Moist Air(TH, I, kcal/kg') :

The enthalpy of moist air is the value adding the heat amount(sensible heat) that the dry air contains and heat amount(latent heat+sensible heat) that the vapor has at the same temperature. That is, it is combination of sensible heat and latent heat of moist air of the unit weight.

◉ When the vapor amount included in 1kg of dry air is χkg

-. Sensible heat of dry air(ia) : The dry air at 0℃ is 0.

ia = Cp t = 0.24(kcal/kg)

Cp : Constant pressure specific heat of air (0.24kcal/h/kg)

-. Vapor Enthalpy (iw) : The dry air at 0℃ is 0.

iw= gamma +Cpw t=597.3+0.441t(kcal/kg')

γ : Latent heat of evaporation when vapor is at 0℃(579.3kcal/kg')

Cpw : Constant pressure specific heat of vapor(0.441kcal/kg')

-. Enthalpy of moist air(i)

i=ia + iw

0. Sensible heat factor(SHF):

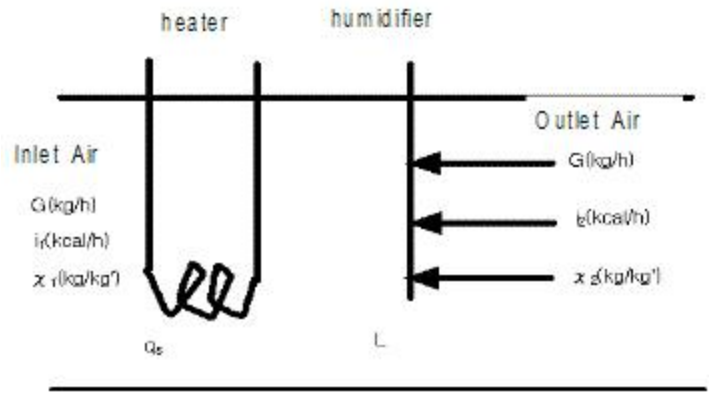
Ratio of sensible heat factor to total heat. It is the state change of air going in a room.

$$SHF = \frac{q_s}{q_s + q_L} = \frac{q_s}{q_T}$$

0. Moisture ratio(U) : Change of total heat according to the change of moist(specific humidity)

-. Energy balance and mass balance

Flow air inside the insulated duct and apply the heat amount qs((kcal/h) and moist L(kg/h).



A. Energy balance

Heat into Device= Gi1+qs+Li2

Heat from Device = Gi2

∴ Energy Balance Formula = Gi1+qs+LiL = Gi2

B. Mass balance on moist

Moist into Device= Gχ1+L

Moist from Device= Gχ₂

∴ Mass balance formula=G(χ2-χ1)=L

-. Heat and Moist Ratio

$$U=\frac{di}{d\chi}$$

$$U=\frac{i_2-i_1}{\chi_2-\chi_1}=\frac{q_s+L\,i_L}{L}=\frac{q_s}{L}+iL$$

Divide the energy balance formula by mass balance formula,

i1 : Moist air enthalpy before change(kcal/kg)
i2 : Moist air enthalpy after change(kcal/kg)
iL : Moist enthalpy(kcal/kg')
χ1 : Specific humidity of moist air before change(kgl/kg')
χ2 : Specific humidity of moist air after change(kgl/kg')
L : Total moist increased or decreased (kg/kg')
qs : Total heat increased or decreased(kcal/h)

(Note) when the moist is not changed,

$$U=\frac{di}{d\chi}=\frac{di}{0}=\infty$$

when there is not enthalpy change,

$$U=\frac{di}{d\chi}=\frac{0}{d\chi}=0$$

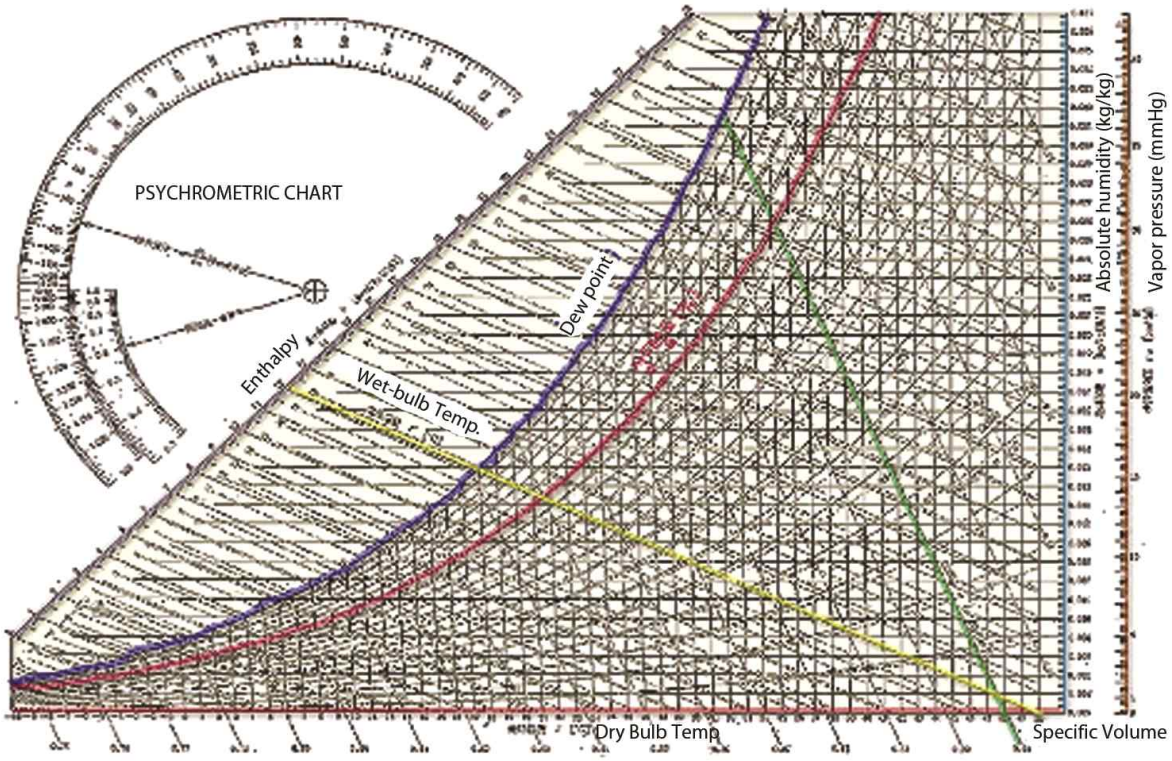
0. Adiabatic saturation temperature of moist air(t" , ℃)

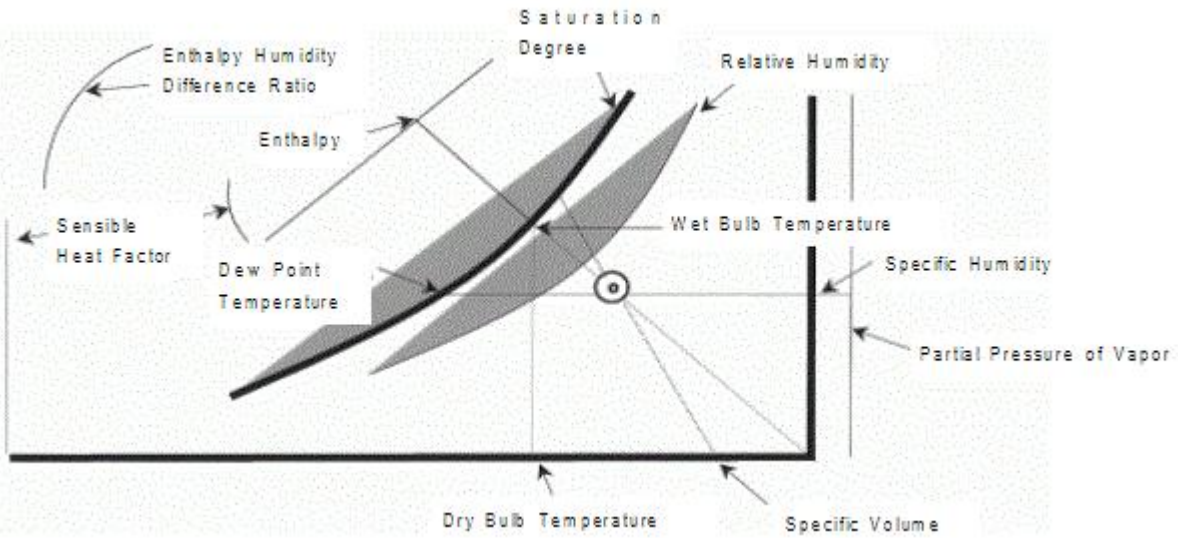
$$t'=\frac{i_s-i}{\chi_s-\chi}\quad (\text{단, } t' \geq 0℃)$$

The temperature when water coexists at the same temperature as the saturated moist air in a container insulated from the outside, that is, the temperature at the outlet air when same water is circulated and sprayed using the "Air Washer" that is completely insulated and air becomes saturated, the temperature is called "adiabatic saturation temperature". The adiabatic saturation temperature is equivalent to the scale on the wet bulb thermostat on the air current that the wind speed is over 5m/s.

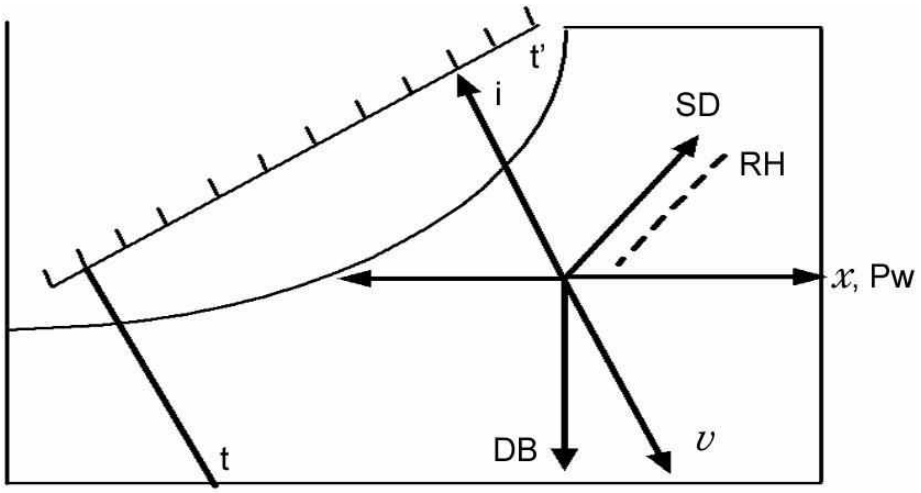
is : Saturated air enthalpy at the temperature t'
χs : Specific humidity of saturated air at the temperature t'
i : Wet air enthalpy at the temperature t' χ : Specific humidity of wet air at the temperature t'

6-3. Basic Moist Air Chart





1) Air Chart Configuration

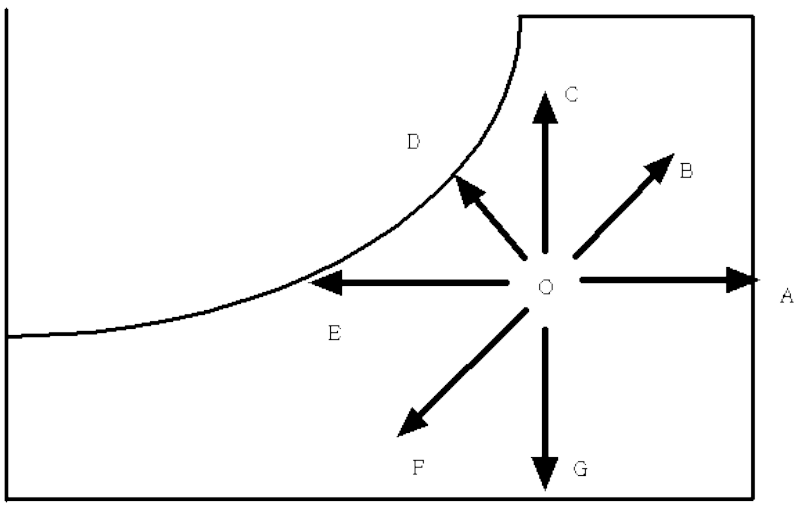


SHF : Sensible Heat Factor　U : Enthalpy Humidity Difference Ratio　RH : Relative Humidity(%)
SD : Saturation Degree(%)　t` : Wet Bulb Temperature(℃)　ν : Specific Volume (㎥/kg`)
I : Enthalpy (㎉/kg`)　DP : Dew Point Temperature(℃)　DB : Dry Bulb Temperature(℃)
χ : Specific Humidity(kg/kg`)　Pw : Partial Pressure of Vapor

$$Enthalpy\ Humidity\ Difference\ Ratio(u) = \frac{Change\ of\ Enthalpy}{Change\ of\ Absolute\ Humidity} = \frac{\Delta h}{\Delta x}$$

$$Sensible\ Heat\ Factor(SHF) = \frac{Change\ of\ Total\ Heat}{Change\ of\ Enthalpy} \fallingdotseq 1\frac{597.5}{\mu}$$

2) Air Chart Reading

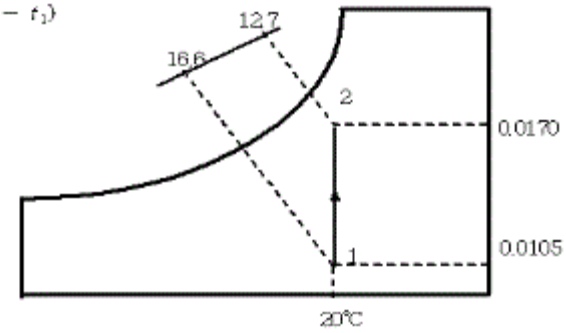


OA : Heating　OB : Heating and Humidifying　OC : Constant Temperature Humidifying
OD : Evaporating and Cooling(Insulating and Humidifying)　OE : Cooling
OF : Cooling and Dehumidifying　OG : Dehumidifying

3) Basic Changes and Calculation of Air Chart

A. Heating and Cooling

$$q = G \cdot (i_2 - i_1) = G \cdot C_p \cdot (t_2 - t_1)$$
$$= \frac{Q}{V} \cdot C_p \cdot (t_2 - t_1)$$
$$= Q \cdot \gamma \cdot C_p \cdot (t_2 - t_1)$$
$$\therefore q_s = 0.28Q(t_2 - t_1)$$



qs : Deheating Amount (kcal/h)　　G : Air Amount (kg/h)　　Q : Air Volume(m3/h)

ro : Latent Heat (kcal/h)　　Cp : Constant Pressure Specific Heat of Air (0.24 kcah/kg℃)

υ Specific Volume (m3)　　t : Dry Bulb Temperature (℃)

(Note) When the surface temperature of cooling coil during cooling is over the dew point temperature of passing air, the cooling is processed with the constant specific humidity. When the surface temperature of cooling coil is below the dew point temperature, cooling and dehumidifying are concurrently processed.

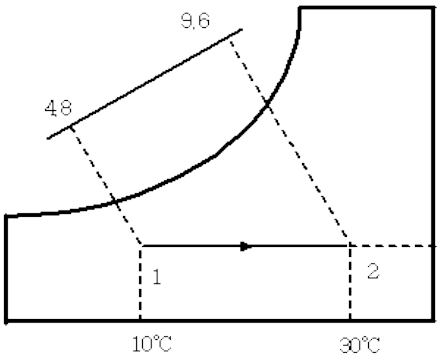
☞ Example

Required energy when heating 1000kg/h of air at 10℃ of Dry Bulb Temperature and 0.0038kg/kg of Specific Humidity to 30℃ of Dry Bulb Temperature

풀이) $q = G \cdot (i_2 - i_1) = G \cdot C_p \cdot (t_2 - t_1)$

1) $q = 1000 \times (9.6 - 4.8)$
$= 4800(kcal/h)$

2) $q = 1000 \times 0.24 \times (30 - 10)$
$= 4800(kcal/h)$

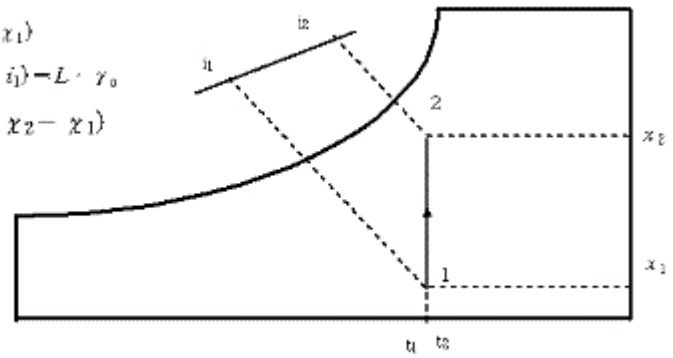


B. Humidifying and Dehumidifying

$L = G \cdot (x_2 - x_1)$

$q_L = G(i_2 - i_1) = L \cdot \gamma_0$

$\therefore q_L = 715Q(x_2 - x_1)$



Humidifying and Dehumidifying

L : Amount of Humidifying (kg/h) G : Air Amount (kg/h),

x : Absolute humidity (kg/kg') r_o : Latent Heat (kcal/h)

☞ Example

-Condition : Dry Bulb Temperature 26℃

-Air Amount: 1000kg/h

-Energy and humidifying water amount required for humidifying from 0.0105 kg/kg of Specific Humidity to 0.017 kg/kg.

Solution

1) *Moist Amount* $L = G \cdot (x_2 - x_1)$

$= 1000x(0.0170 - 0.$

$= 6.5\ (kg/h)$

2) *Energy* $qL = G(i_2 - i_1)$

$= 1000x(16.6 - 12.7)$

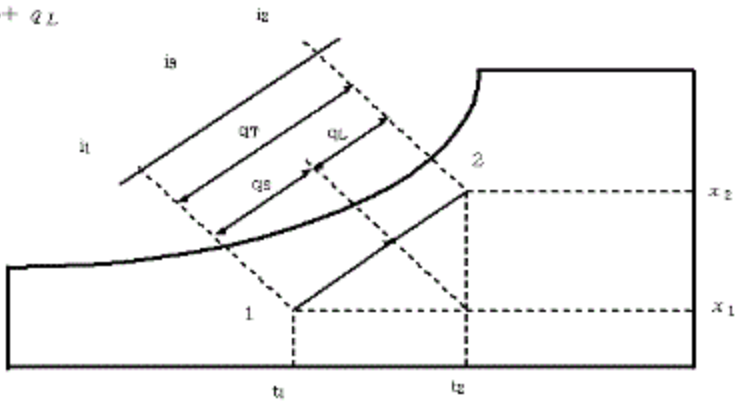
$= 3900\ (kg/h)$

C. Heating and Humidifying

$$q_T = G(i_2 - i_1) = q_S + q_L$$

$$L = G \cdot (x_2 - x_1)$$

$$SHF = \frac{q_S}{q_S + q_L}$$



q_r : Total Heat G : Air Amount q_S : Deheating Amount q_L Latent Heat

x : Absolute Humidity SHF : Sensible Heat Factor L : Humidifying Amount

☞ Example

-Condition : Dry Bulb Temperature -10C, Absolute Humidity,

-Air Amount Energy, humidifying amount and SHF required to heat and humidify to 26℃ of Dry Bulb Temperature and 0.017 of Absolute Humidity.

Solution

1) *Energy*

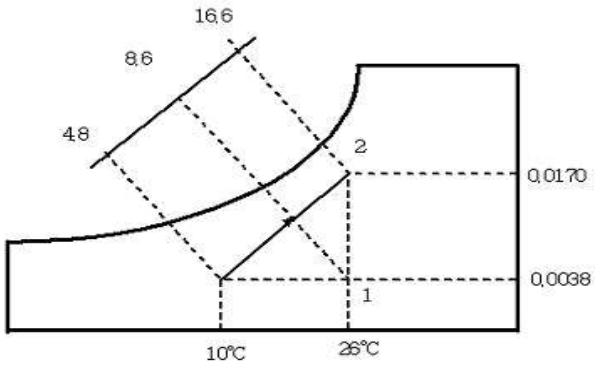
$$q_T = G(i_2 - i_1)$$
$$= 1000x(16.6 - 4.8)$$
$$= 11800\ (kcal/h)$$

2) *Water Amount*

$$L = G \cdot (x_2 - x_1)$$
$$= 1000x(0.017 - 0.0038)$$
$$= 13.2\ (kg/h)$$

3) *Sensible Heat Factor*

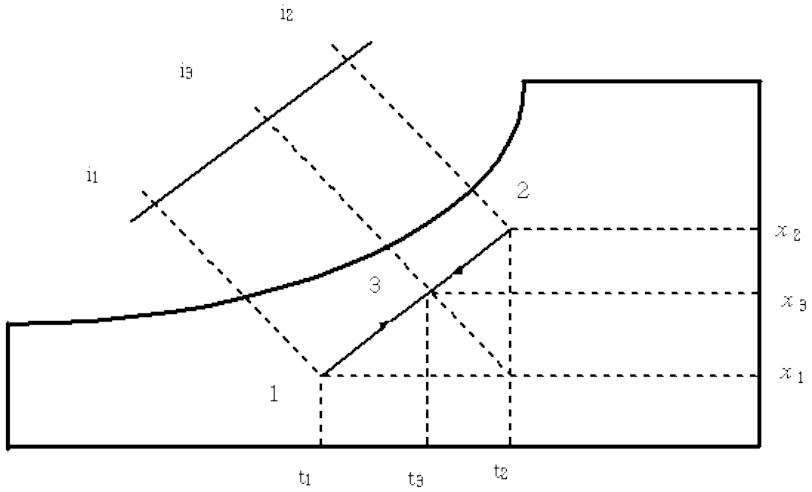
$$SHF = \frac{q_S}{q_S + q_L} = \frac{8.6 - 4.8}{16.6 - 4.8} = 0.332$$



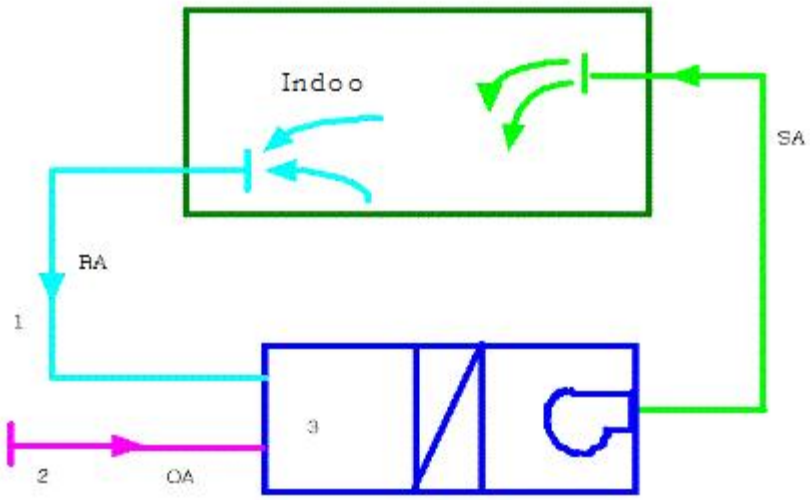
D. Insulating and Mixing

The external air is 2, the external air amount is Q2, the indoor ventilation is 1 and indoor ventilation speed is Q1. The temperature, humidity and enthalpy of mixed air 3 are described below.

$$t_3 = \frac{t_1 \cdot Q_1 + t_2 \cdot Q_2}{Q_1 + Q_2} \qquad x_3 = \frac{x_1 \cdot Q_1 + x_2 \cdot Q_2}{Q_1 + Q_2} \qquad i_3 = \frac{i_1 \cdot Q_1 + i_2 \cdot Q_2}{Q_1 + Q_2}$$



Insulating and Mixing



Insulating and Mixing

☞ Example

Conditions

A- Dry Bulb Temperature: 27℃ , Specific Humidity: 0.011(kg/kg), Air Amount: 700kg/h

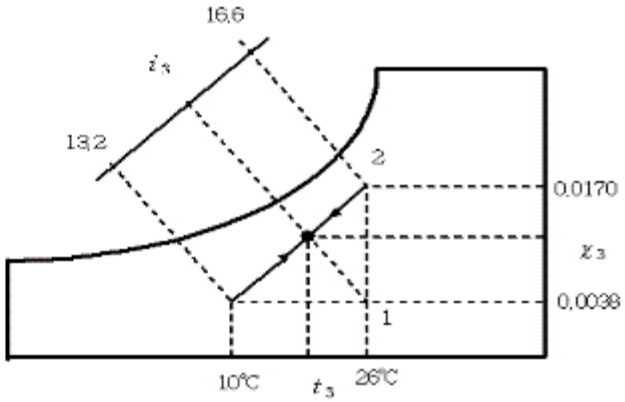
B- Dry Bulb Temperature: 35℃ , Specific Humidity: 0.024(kg/kg`), Air Amount: 300kg/h, when mixing A and B, Find t3, i3 and X3.

Solution

$$t_3 = \frac{t_1 \cdot Q_1 + t_2 \cdot Q_2}{Q_1 + Q_2} = \frac{27 \times 7 + 35 \times 3}{10} = 29.4℃$$

$$x_3 = \frac{x_1 \cdot Q_1 + x_2 \cdot Q_2}{Q_1 + Q_2} = \frac{0.011 \times 7 + 0.024 \times 3}{10} = 0.0149\ kg/kg'$$

$$i_3 = \frac{i_1 \cdot Q_1 + i_2 \cdot Q_2}{Q_1 + Q_2} = \frac{23.2 \times 7 + 13.2 \times 3}{10} = 16.2\ kcal/kg'$$

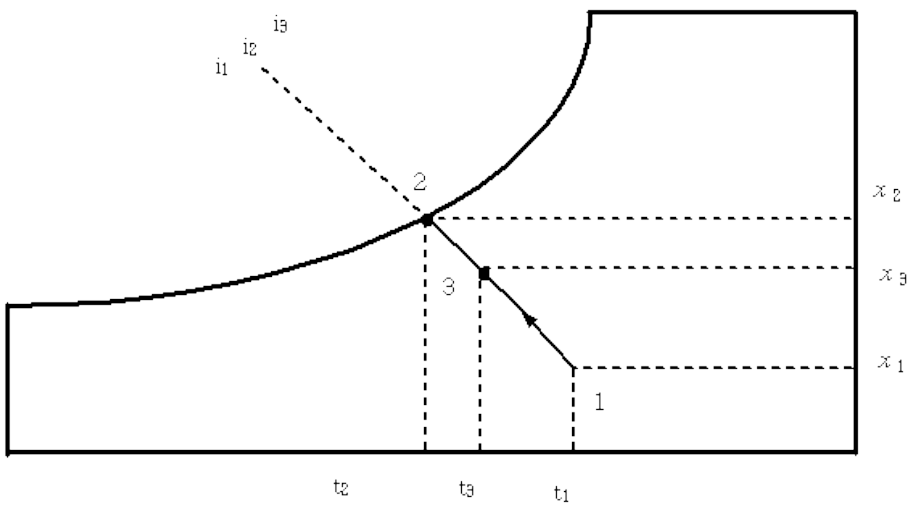


E. Humidifying

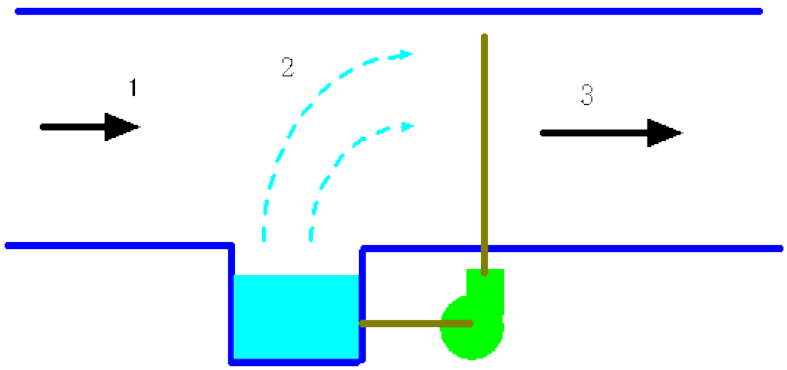
-. Cyclic Water Spray Humidifying(Insulating, Humidifying and Cleaning)

When the cyclic water is insulated and sprayed in the air washer, the input air '1' moves toward the saturation curve on the wet bulb temperature line passing through the point '1' on the chart. At this moment, the enthalpy is constant(i1 = i2). This is called "insulating change(insulating and humidifying)". The efficiency of air clearing is 100%. The passing air finally becomes the saturated air on the point '2'. However, since the efficiency is actually below 100%, the passing air stops on the point '3' on the chart.

Efficiency of AW= $\frac{1-3}{1-2} \times 100$



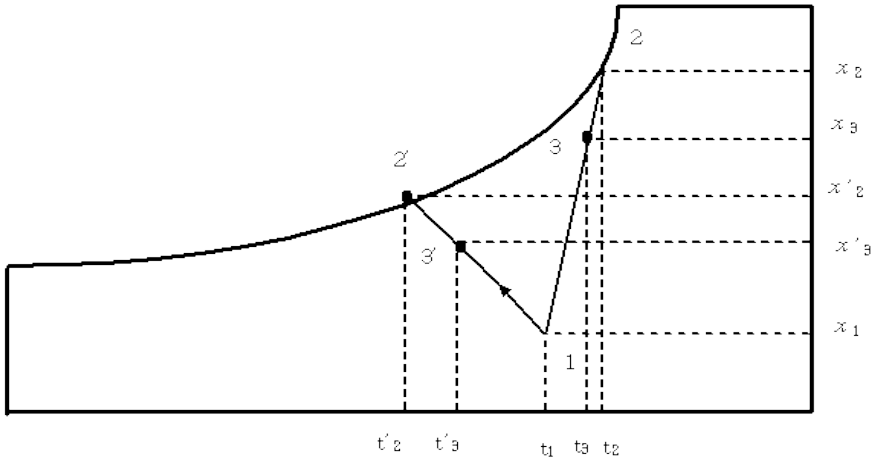
Cyclic Water Spray Humidifying(Insulating, Humidifying and Cleaning)



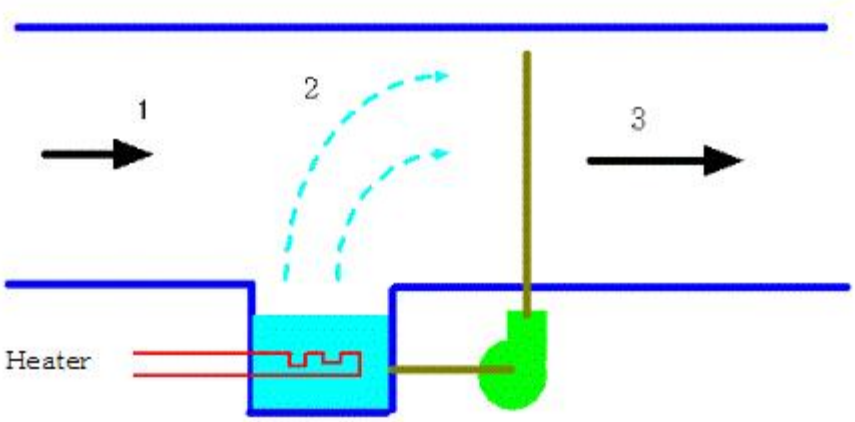
Cyclic Water Spray Humidifying(Insulating, Humidifying and Cleaning)

-. Warm Water Spray Humidifying

When the cyclic water is heated and sprayed in air, the passing air is humidified and the dry bulb temperature is changed depending on the temperature and amount of water at the same time. The inlet air point '1' and warm water temperature point '2' on the saturation curve are taken on the chart. The outlet state is the efficiency point of AW '3' that connects the points 1 and 2.



Warm Water Spray Humidifying



Warm Water Spray Humidifying

☞ 1000m3/min of air at DB 20%℃ and WB 10℃ passes through cyclic water spray process of AW with the efficiency of 80%, identify the outlet air state and humidifying water amount.

Solution)

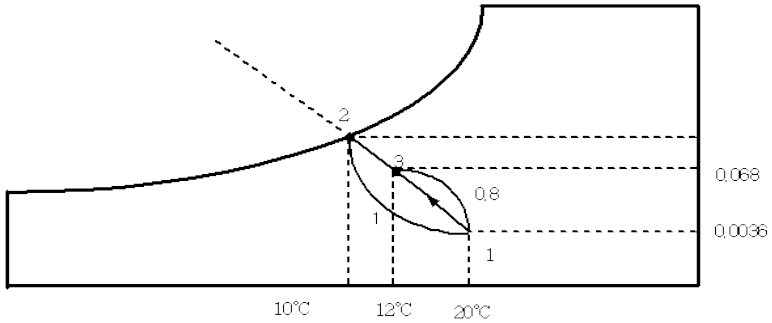
1) Outlet Air State

DB 20℃, SH 0.0068 kg/kg' WB 10℃, RH 80% SV 0.835 m3/kg

2) Humidifying Water Amount (L : kg/h)

$$= \frac{1000}{0.835} \times 60 \times (0.0068 - 0.0036) \fallingdotseq 230 kg/h$$

$= \frac{1000}{0.835} \times 60 \times (0.0068 - 0.0036) \fallingdotseq 230 kg/h$



순환수분무가습(단열가습.세정)

Cyclic Water Spray Humidifying(Insulating, Humidifying and Cleaning)

☞ 1000CMM of air at DB 20℃ and WB 10℃ passes through AW spraying water, identify the outlet air state and moist amount on AW. (However, AW efficiency is 90% and the temperature of sprayed water is constant)

Solution)

$1)\, Outlet\ Air\ Temperature\,(t_3) = \frac{t_1 \times 10 + t_2 \times 90}{100} = 24.5$

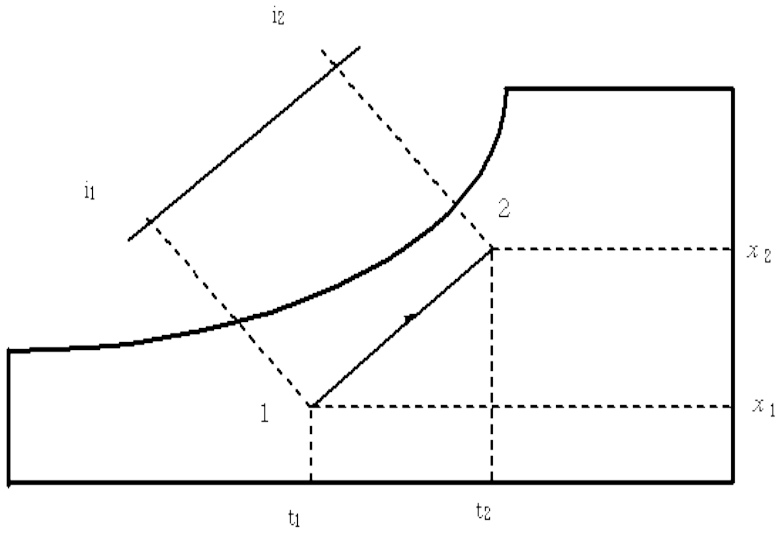
$2)\, AW\ Passing\ Air\ Amount\,(G) = \frac{1000}{0.835} \fallingdotseq 1200 kg/min$

$3)\, Outlet\ Air\ State : t_3 = 24.5℃\ \ WB = 23.9℃\ RH = 95\%\, x = 0.0186 kg/kg'$

$4)\, Humidifying\ Amount\,(L) : 1200 \times 60 \times (0.0186 - 0.0036) = 1123.2 kg/h$

-. Vapor Humidifying

It is the most frequently used method in AW. The saturated vapor is directly sprayed in air. The dry bulb temperature and humidity are increased and become the heating and humidifying state.



Vapor Humidifying

F. Sensible Heat Factor (SHF)

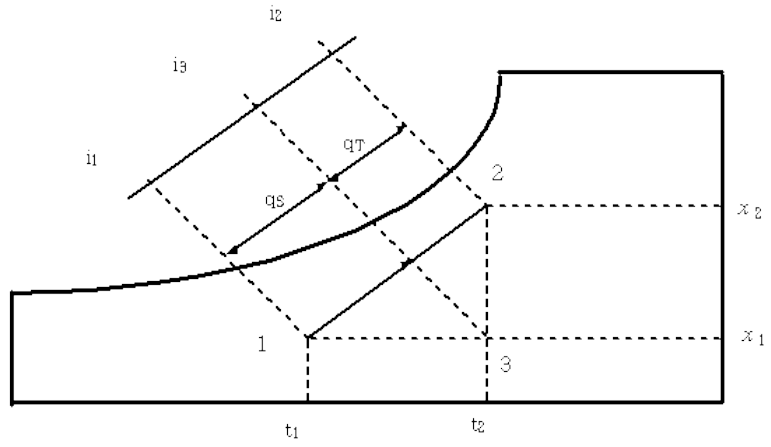
When a room is cooled to DB t2℃ and X2(kg/kg), the ventilator temperature needs to be DB t1℃ X1(kg/kg), lower than room temperature.

$$q_s = G \cdot C_p \cdot (t_2 - t_1) = 0.28Q(t_2 - t_1)$$

$$q_L = \gamma_o \cdot G \cdot (\chi_2 - \chi_1) = 715Q(\chi_2 - \chi_1)$$

$$SHF = \frac{q_s}{q_s + q_L} = \frac{G \cdot C_p \cdot (t_2 - t_1)}{G \cdot C_p \cdot (t_2 - t_1) + \gamma_o \cdot G \cdot (\chi_2 - \chi_1)}$$

$$= \frac{C_p \cdot (t_2 - t_1)}{C_p \cdot (t_2 - t_1) + \gamma_o \cdot (\chi_2 - \chi_1)}$$



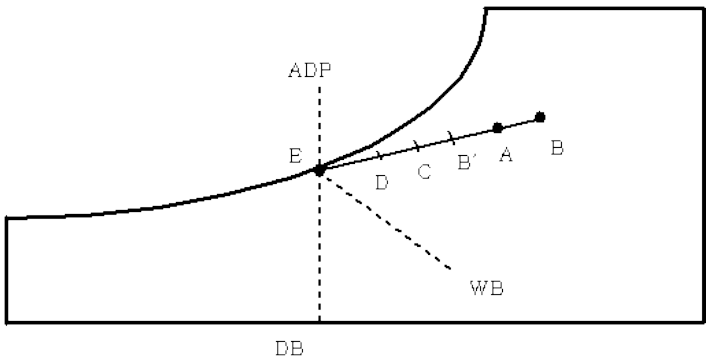
SHF

As explained above, SFH is not related to the ventilation amount(G). Cp DOT ro is a constant. When SHF is invariable, (X2-X1) is proportionate to (t2-t1). Then, when SHF is invariable, the minimum state '1' and the final state '2' are on the same straight line on the chart.

(Note) Sensible Heat Factor line starts from the outlet air and ends to the indoor air.

G. Apparatus Dew Point (ADP)

With constant SHF, when the indoor air at the state B is cooled to the state A, the air is ventilated to the point B, B-A=A-B which is extended from B-A. (If the ventilation is out of SHF line, it becomes the state 'F'). In this case, the ventilation of air C requires less air amount than air B and the ventilation of air D requires less air amount than air C. Moreover, the maximum point is E. This point is called "Apparatus Dew Point" and DB,WB and DP are on the same point.



장치노점온도

Apparatus Dew Point (ADP)

H. By-pass Factor (BF)

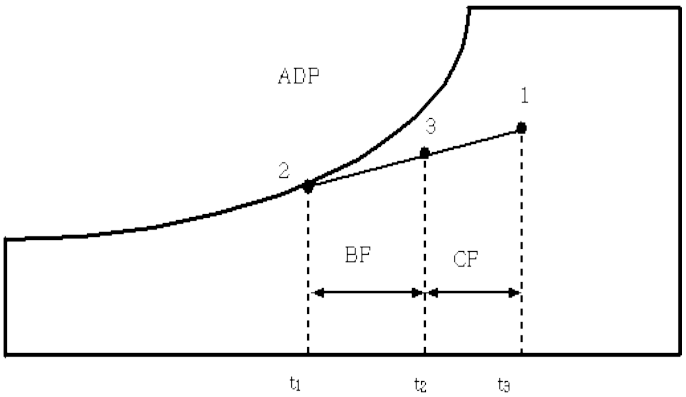
BF means the air ratio passing through the ventilator without contact with cooling or heating air. The air ratio that completely contacts is called "Contact factor".

BF=1-CF

The air passing through cooling or heating coil is not saturated. The ideal saturation is achieved at the state '2', but the state '3' in reality.

$$Bf = \frac{3-2}{1-2} \qquad Cf = \frac{1-3}{1-2}$$

$$\therefore\ t_3 = t_1 \times Bf + t_2 \times (1-Bf)$$



By pass Factor

(Note) Increasing number of coil columns mean reducing Bf.

2 Columns-------- $(Bf)2$

4 Columns-------- $(Bf)4$

6 Columns-------- $(Bf)6$

4) Changes in Actual Devices

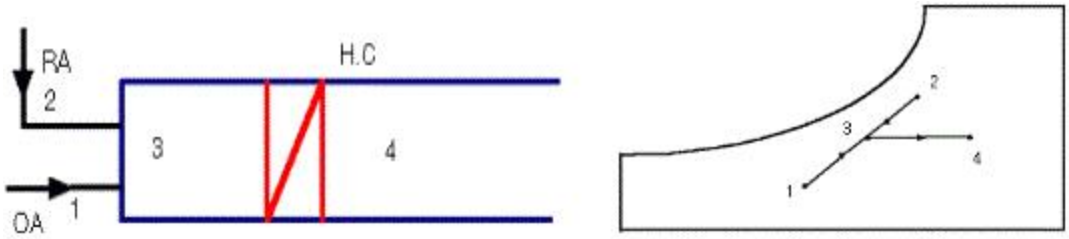
A. Mixed Heating

OA : External Air RA : Indoor Return Air HC : Heating Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.

-For the process 3 → 4, the mixed air passes through the heating coil and receives the energy(heat). Then, the relative humidity drops and the Dry Bulb Temperature and Enthalpy go up. The Specific Humidity is not changed.

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Changed	Up	Up
2 → 3	Down	Changed	Down	Down
3 → 4	Up	Down	No change	Up



Mixed Heating

B. Mixed Cooling

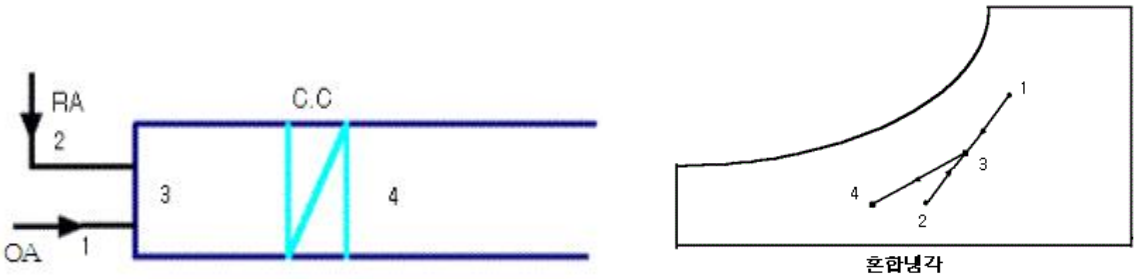
OA : External Air RA : Indoor Return Air CC : Cooling Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.

-For the process 3 → 4, the mixed air passes through the cooling coil and receives the energy(heat). Then, the relative humidity goes up and the Dry Bulb Temperature and Enthalpy drop. At this point, the dew point temperature and then the specific humidity drop as passing through the cooling coil.

{Dew Point Temperature is achieved at about 90% to 95% of Relative Humidity}

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Down	Changed	Down	Down
2 → 3	Up	Changed	Up	Up
3 → 4	Down	Up	Down	Down



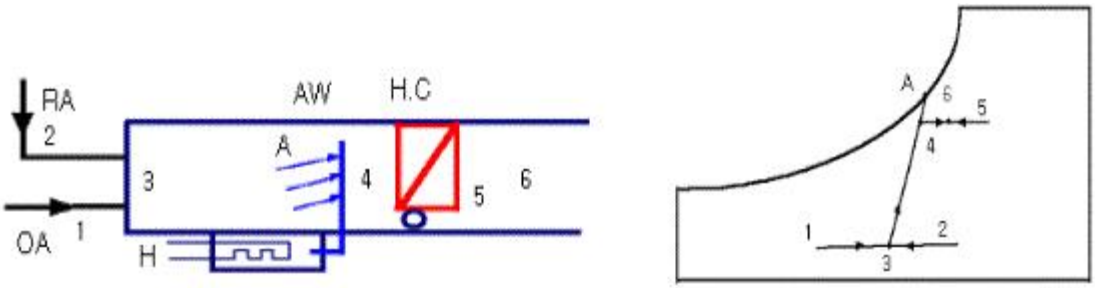
Mixed Cooling

C. Mixing → Humidifying(Warm Water Spray) → Heating(Partial By-pass)

OA : External Air　　RA : Indoor Return Air　　H : Heater
AW : Air Washer　　HC : Heating Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.
-For the process 3 → 4, the mixed air passes through the warm water spray heated in a heater and the humidity goes up.
-For the process 4 → 6 ← 5, the air passed through the heating coil meets the air after partial by-pass.

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Changed	Up	Up
2 → 3	Down	Changed	Down	Down
3 → 4	Up	Up	Up	Up
4 → 6	Up	Down	No changes	Up
5 → 6	Down	Up	No changes	Down



Mixing → Humidifying(Warm Water Spray) → Heating(Partial By-pass)

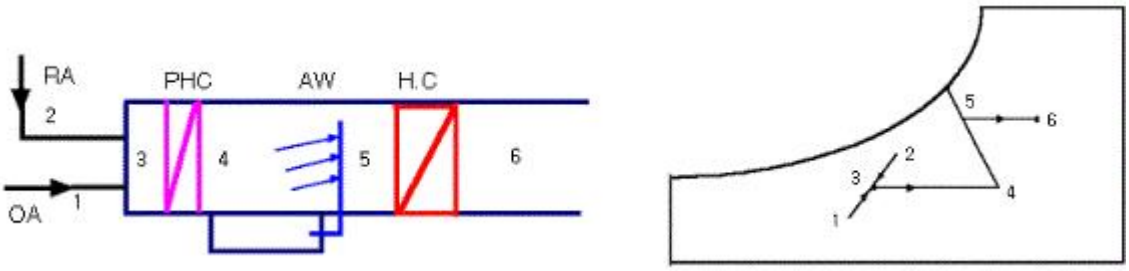
D. Mixing → Preheating → Cleaning(Cyclic Water Spray) → Heating

OA : External Air　　RA : Indoor Return Air　　PHC : Preheating Coil

AW : Air Washer　　HC : Heating Coil

-For the process 1 → 3 ← 2, return air in a room and external air are mixed.
-For the process 3 → 4, the air goes to the preheating coil.
-For the process 4 → 5, the air passes through the cleaning step and the humidity goes up.
-For the process 5 → 6, the air is heated by the heating coil

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Changed	Up	Up
2 → 3	Down	Changed	Down	Down
3 → 4	Up	Down	No changes	Up
4 → 5	Down	Up	Up	No changes
5 → 6	Up	Down	No changes	Up



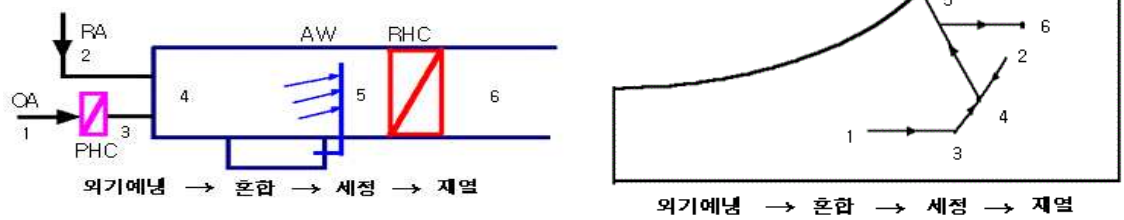
Mixing-> Preheating -> Cleaning(Cyclic Water Spray)-> Heating

E. External Precooling → Mixing →Cleaning → Reheating

OA : External Air RA : Indoor Return Air PHC : Preheating Coil
AW : Air Washer RHC : Reheating Coil

-For the process 1 → 3, the external air is heated by the preheating coil.
-For the process 3 → 4 ← 2, the external air heated is mixed with the indoor return air.
-For the process 4 → 5, the mixed air passes through the cyclic water spray and the humidity goes up.
-For the process 5 → 6, the air passes through the reheating coil

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Up	Down	No changes	Up
2 → 4	Down	Changed	Down	Down
3 → 4	Up	Changed	Up	Up
4 → 5	Down	Up	Up	No changes
5 → 6	Up	Down	No changes	Up



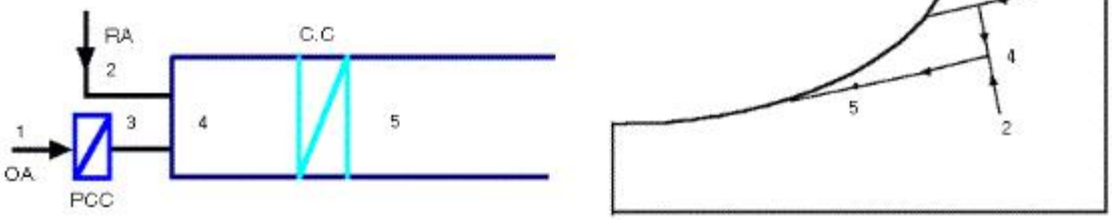
External Air Precooling -> Mixing -> Cleaning -> Reheating

F. External Air Precooling → Mixing → Cooling

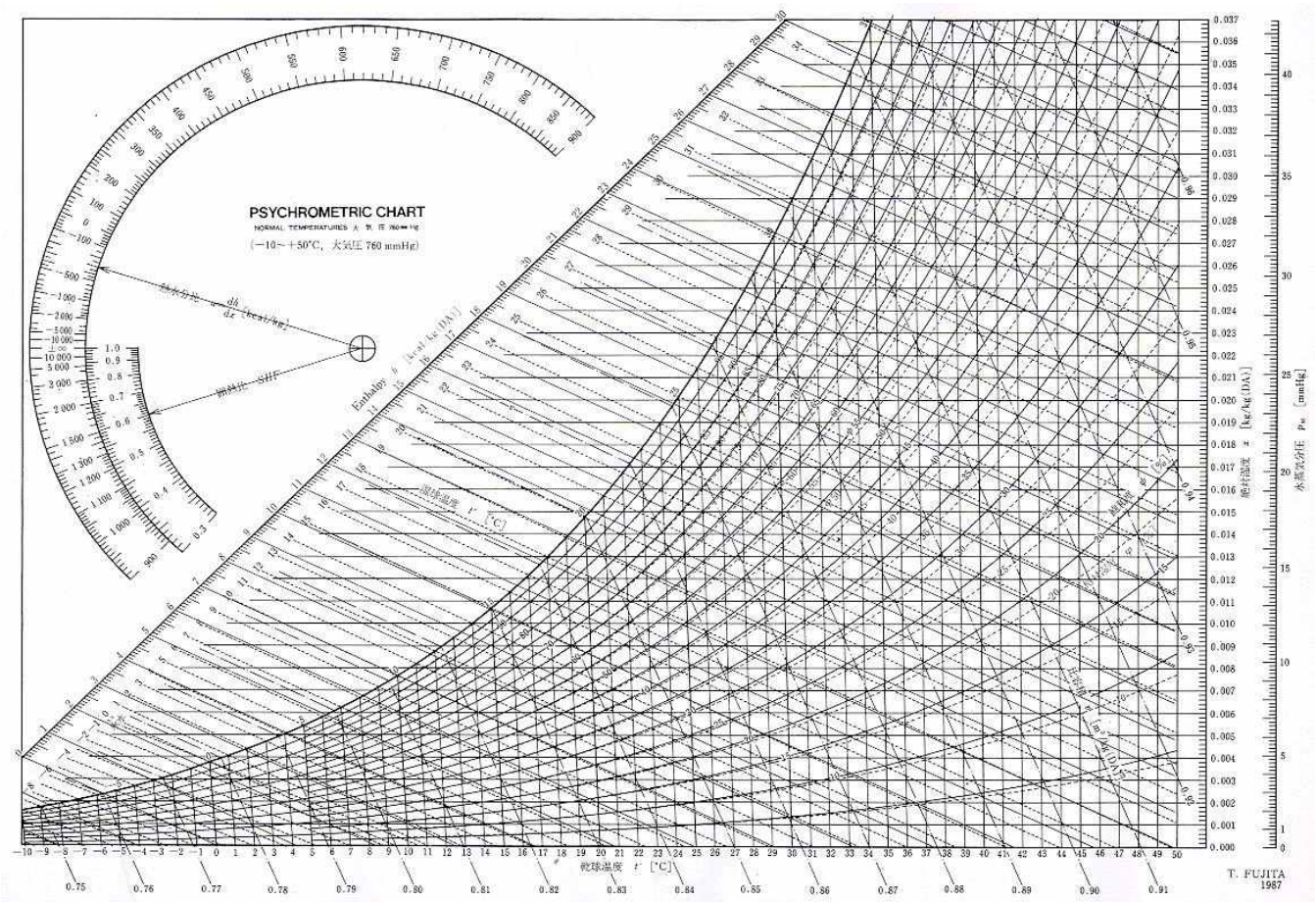
OA : External Air RA : Indoor Return Air
CC : Cooling Coil PCC : Precooling Coil

-For the process 1 → 3, the external air is cooled in the precooling coil.
-For the process 3 → 4 ← 2, the external air cooled is mixed with the indoor return air.
-For the process 4 → 5, the air passes through the cooling coil.

State	Dry Bulb Temperature	Relative Humidity	Specific Humidity	Enthalpy
1 → 3	Down	Up	Down	Down
2 → 4	Up	Up	Up	Up
3 → 4	Down	Down	Down	Down
4 → 5	Down	Up	Down	Down



External Air Precooling -> Mixing -> Cooling



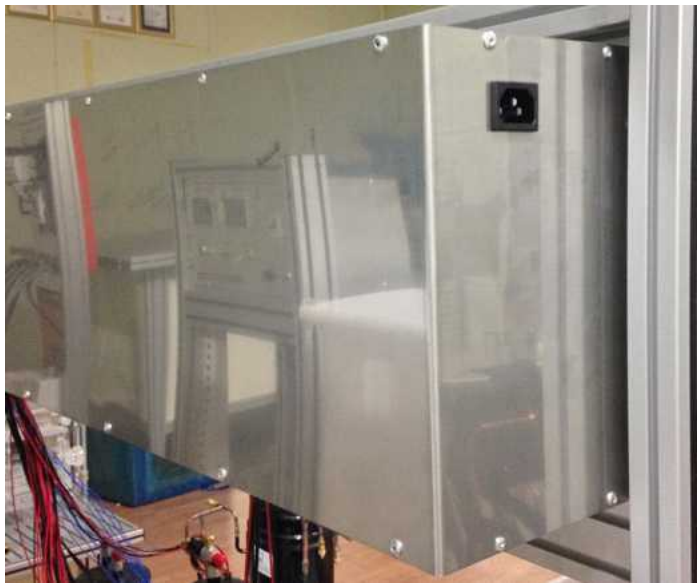
Chapter 6. Notice and Guarantee

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.

Check the AC LAMP is turn on



Installed the N.F.B on reverse side of control panel

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	

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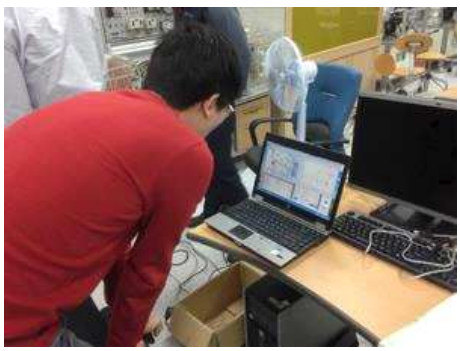
Factory : 133-1 Shinhyen-ri opo-eup, gwangju-si, geonggi-do, KOREA 464-895

Educational lab equipment training programs

KTE-101 : Standard 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



※ Please contact us for educational training program registration

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

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