Haier

SYJS-002

Commercial Air Conditioner

Haier and Higher

Selected Design and Installation for Haier Commercial Air Conditioners

Haier Group
2001

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Section one   Basic features of humid air

Any air that contains vapor is called humid air. Vapor always exists in the air, so there is no absolutely dry air in nature. Therefore:

Humid air = dry air + vapor

Dry air is considered as ideal gas in the engineering thermodynamics. The vapor in humid air has low partial pressure (generally within several tens of millimeters of mercury) but has large specific volume, which can be treated as ideal air in engineering calculation. Humid air can be taken as an example of mixed gases and it is in conformity with the ideal gas law. The relations between the various state parameters can be described by an ideal gas state equation, i.e.:

$$Pv=RT \text{ or } PV=mRT$$

of which: P pressure of the gas (Pa)

v specific volume of the gas (m^3/kg)

T thermodynamic temperature of the gas (K)

G gross mass of the gas (kg)

V volume of the gas (m^3)

R constant of the gas, depending upon the nature of the gas (J/kg.K)

Dry air: Ra=287 J/kg.K

Vapor: Ra=461 J/kg.K

1-1   Basic features of humid air

Humid air is the object of air conditioning. First of all, let us study the basic features. i.e. the physical parameters, such as pressure, temperature, humidity and enthalpy.

Pressure

Because humid air is composed of dry air and vapor, so, according to Dalton's law, the total pressure is the sum of the partial pressure of the dry air (Pa) and the partial pressure of the vapor (Pw):

$$P=Pa+Pw$$

Because air is to be processed into humid air in the air conditioning engineering, so the pressure of the humid air P is the local atmospheric pressure.

Atmospheric pressure varies with the altitudes and geographic latitudes and with the changes of seasons and weather. The standard atmospheric pressure or physical atmospheric pressure refers to the perennial average atmospheric pressure on the sea level at latitude 45° (mmHg). One standard atmospheric pressure equals 760mmHg. The altitude, which affects the atmospheric pressure significantly, can be obtained from local meteorological departments.

Saturated air and unsaturated air

Under specific temperature conditions, the more of vapor molecules in the air, the larger the partial pressure of the vapor.If the vapor content in the air exceeds a specific value, moisture will emanate from the air. This shows that under specific temperature conditions, there is a maximum limit of vapor content in the humid air, i.e. there is a maximum value of partial pressure of the vapor in the humid air. The maximum value is the saturated vapor partial pressure under such temperature Pw. If the quantity of water evaporated into vapor is equal to that of vapor condensed into water, it shows that the vapor in the air reaches the maximum value, i.e. reaches saturation. This is the above-mentioned air and vapor mixture - saturated humid air or saturated air. If the partial pressure of the vapor is lower than the saturated partial pressure under a specific temperature, the vapor will be in an overheat state. This humid air, a mixture of dry air and overheat vapor, is called unsaturated air. From the above we can see that under specific temperature conditions, the partial pressure of the vapor is a basic factor in the judgment of vapor content, i.e. whether the air is dry or humid. The higher the temperature, the larger the partial pressure of the vapor.

1-2 Temperature

Since humid air is the mixture of dry air and vapor, the temperature of the humid air will be the temperature of the dry air, i.e. the temperature of the vapor, because the two are in evenly mixed state due to the thermal motion of molecules. It is also called "dry- bulb temperature t".

$T=Ta=Tw \quad t=ta=tw$

Temperature is usually indicated by t or T. t stands for centigrade temperature ℃ , T stands for absolute temperature K.

$T=t+273K$

The dew point temperature is indicated by t″ .

When the temperature drops to t″ under specific (t) and pressure (p), the vapor in the air will be condensed into water drops (dew), i.e. reach the saturated state in the humid air. Now it is called dew point temperature.

"Dew" is a common phenomenon. In the morning during summer, slabs and grass in the open are usually covered by tiny water drops, as if it rained during the night. Where do these tiny water drops come from? They are formed by the vapor in the humid air. Suppose the max temperature during the daytime in summer is 36℃ , due to evaporation of underground moistures, the partial pressure of vapor in the air is 35.67mmHg and the saturated partial pressure of vapor at 36℃ is 44.57mmHg. According to Table 1-1.1, it is not in the saturated state. During the night, the temperature drops to 36℃ and the corresponding saturated partial pressure of the vapor is 17.53mmHg. The 35.67mmHg partial pressure of vapor in the air goes far beyond the partial pressure of vapor at 20℃ ,so the vapor will be condensed into water because the air can not contain that much vapor, until the saturated partial pressure of the vapor in the air is dropped to 17.53mmHg. Therefore, dew is resulted from the change of partial pressure of the vapor in the air caused by the temperature drop, because the extra moistures will be emanated in the saturated state.From the above example we can see that the partial pressure of the vapor in the air at 36℃ is 35.67mmHg, it is still in a unsaturated state. According to Table 1-1.1, we know that the saturated partial pressure of the vapor in the air is 35.67mmHg at 32℃ . That is to say that the air is in a saturated state when the temperature drops to 32℃ . If the temperature continues to drop, the vapor in the humid air will condense. We call this temperature "dew point temperature".

Wet-bulb temperature t′

Water or ice will absorb heat in the air and cause the temperature to drop. The temperature obtained at the sensing bulb is a saturated temperature value when water and ice are under adiabatic conditions, i.e. continuous evaporation of water at the sensing bulb causes the temperature to drop until saturation is reached. The temperature is the ambient temperature under such a condition (atmospheric pressure [P] and the state at that time), i.e. the wet bulb temperature at the dry bulb temperature [t] time. The wet bulb temperature of the wet bulb temperature thermometer is the reading of humid air between the dry bulb temperature t and dew point temperature t″. For example, the dry bulb temperature t is 24℃, the wet bulb temperature t′ is 20℃ (relative humidity is [ϕ] = 69.6%, the dew point temperature t″ =18.1℃). The airflow speed and radiant heat are 10~17% higher on the wet bulb temperature thermometer. The larger the air speed, the smaller the reading. Air speeds higher than 5m/sec are taken as the adiabatic saturated temperature value.

1-3 Humidity

Humidity shows the vapor content in the air. It has the following ways of indication:

Absolute humidity x

The vapor mass in 1 cubic meter of humid air is called absolute humidity, which can be expressed by kg/m^3. For example, if the absolute humidity of humid air at 20℃ is 0.015 kg/m^3, it shows that the vapor mass in 1 cubic meter of such humid air is 0.015kg. Because the volume of humid air changes with the changes of temperature, which causes corresponding changes of unit volume vapor. This will cause trouble to calculation. Therefore, absolute humidity is not used in application.

Humidity content d is the vapor mass mixed with 1 kg of dry air.

Suppose there are Ga (kg) dry air and Gw (kg) vapor in the humid air, then

$$\text{Humidity content (d)} = \frac{Gw}{Ga} \ (\text{g/kg}' \text{ dry air})$$

Relative humidity ϕ is the ratio of the absolute humidity x of humid air and the absolute humidity xb of saturated air under the same temperature.

$$\phi = \frac{x}{x_b} \times 100\%$$

For example, if the saturated humidity content of air at 22℃ is 16.66g/kg dry air, the relative humidity ϕ=100%. If the vapor content in each kilogram of humid air under such temperatureis 8.33g, the relative humidity ϕ=50%. Therefore, relative humidity is a major parameter in design and application, which is usually obtained through the readings of dry bulb temperature and wet bulb temperature, or obtained by consulting Table 1-1.2.

* kg′ stands for kilogram dry air.

Table 1-1.1 Air table (Atmospheric pressure=760mmHg, air below 0℃ ice contact)

t ( )	p_s kg/cm²	h_s mmHg	$d_s(x_s)$ kg/kg (dry air)	i_s kJ/kg' (dry air)	v_s m³/kg' (dry air)	v_a m³/kg
-20.0	$1.052x10^{-3}$	0.7739	$0.6340x10^{-3}$	-18.593	0.7179	0.7172
-18.0	$1.273x10^{-3}$	0.9362	$0.7671x10^{-3}$	-14.961	0.7237	0.7228
-16.0	$1.535x10^{-3}$	1.129	$0.9255x10^{-3}$	-10.850	0.7296	0.7285
-14.0	$1.846x10^{-3}$	1.358	$1.113x10^{-3}$	-8.900	0.7355	0.7342
-12.0	$2.214x10^{-3}$	1.629	$1.336x10^{-3}$	-6.881	0.7414	0.7398
-10.0	$2.648x10^{-3}$	1.948	$1.598x10^{-3}$	-4.7828	0.7474	0.7455
-8.0	$3.159x10^{-3}$	2.323	$1.907x10^{-3}$	-2.5940	0.7535	0.7512
-6.0	$3.757x10^{-3}$	2.764	$2.270x10^{-3}$	-0.2970	0.7596	0.7568
-4.0	$4.458x10^{-3}$	3.279	$2.695x10^{-3}$	2.1246	0.7658	0.7625
-2.0	$5.275x10^{-3}$	3.880	$3.192x10^{-3}$	4.6907	0.7721	0.7682
0.0	$6.228x10^{-3}$	4.581	$3.772x10^{-3}$	7.4214	0.7785	0.7738
2.0	$7.194x10^{-3}$	5.292	$4.361x10^{-3}$	10.1751	0.7850	0.7795
4.0	$8.290x10^{-3}$	6.098	$5.031x10^{-3}$	13.0904	0.7915	0.7852
6.0	$9.531x10^{-3}$	7.010	$5.791x10^{-3}$	16.1867	0.7982	0.7908
8.0	$1.0933x10^{-2}$	8.042	$6.652x10^{-3}$	19.4906	0.8050	0.7965
10.0	$1.2504x10^{-2}$	9.205	$7.625x10^{-3}$	23.018	0.8120	0.8021
12.0	$1.4294x10^{-2}$	10.514	$8.725x10^{-3}$	26.807	0.8192	0.8078
14.0	$1.6292x10^{-2}$	11.98	$9.964x10^{-3}$	30.875	0.8265	0.8135
16.0	$1.8531x10^{-2}$	13.61	0.01136	35.246	0.8341	0.8191
18.0	$2.104x10^{-2}$	15.47	0.01293	39.989	0.8420	0.8248
20.0	$2.383x10^{-2}$	17.53	0.01469	45.13	0.8501	0.8305
22.0	$2.695x10^{-2}$	19.82	0.01666	50.69	0.8585	0.8361
24.0	$3.042x10^{-2}$	22.38	0.01887	56.76	0.8673	0.8418
26.0	$3.427x10^{-2}$	25.21	0.02134	63.34	0.8766	0.8475
28.0	$3.854x10^{-2}$	28.35	0.02410	70.52	0.8862	0.8531
30.0	$4.327x10^{-2}$	31.83	0.02718	78.40	0.8963	0.8588
32.0	$4.849x10^{-2}$	35.67	0.03063	86.99	0.9070	0.8645
34.0	$5.427x10^{-2}$	39.90	0.03447	96.38	0.9183	0.8701
36.0	$6.055x10^{-2}$	44.57	0.03875	106.73	0.9304	0.8758
38.0	$6.759x10^{-2}$	49.70	0.0435	118.06	0.9431	0.8815
40.0	$7.523x10^{-2}$	55.34	0.04884	130.57	0.9568	0.8871
42.0	$8.363x10^{-2}$	61.52	0.05478	144.31	0.9714	0.8928
44.0	$9.284x10^{-2}$	68.29	0.06140	159.83	0.9872	0.8985
46.0	0.10288	75.68	0.06878	176.29	1.004	0.9041
48.0	0.11386	83.75	0.07703	194.87	1.022	0.9089
50.0	0.12583	92.6	0.08625	215.49	1.042	0.9155
52.0	0.13886	102.4	0.09657	238.39	1.064	0.9211
54.0	0.15303	112.6	0.1081	263.92	1.088	0.9268
56.0	0.16842	123.9	0.1211	292.44	1.114	0.9325
58.0	0.18511	133.2	0.1358	324.39	1.143	0.9381
60.0	0.2032	149.5	0.1523	360.26	1.175	0.9438
62.0	0.2228	163.8	0.1709	400.88	1.210	0.9495
64.0	0.2439	179.5	0.1922	446.67	1.250	0.9551
66.0	0.2667	196.2	0.2164	498.71	1.295	0.9608
68.0	0.2913	214.3	0.2442	558.33	1.346	0.9665
70.0	0.3178	233.8	0.2763	627.18	1.404	0.9721
72.0	0.3464	254.8	0.3136	706.89	1.471	0.9778
74.0	0.3770	277.3	0.3573	799.78	1.548	0.9835
76.0	0.4099	301.5	0.4090	910.13	1.640	0.9891
78.0	0.4452	327.5	0.4709	1041.56	1.748	0.9948

Table 1-1.1 Air table (Atmospheric pressure=760mmHg, air below 0℃ ice contact)

t ( )	p_s kg/cm^2	h_s mmHg	$d_s(x_s)$ kg/kg (dry air)	i_s kJ/kg' (dry air)	v_s m^3/kg' (dry air)	v_a m^3/kg
80.0	0.4830	355.3	0.5460	1201.0	1.879	1.0004
82.0	0.5235	385.1	0.6387	1397.6	2.040	1.0061
84.0	0.5668	416.9	0.7557	1645.4	2.241	1.0112
86.0	0.6130	450.9	0.9072	1966.5	2.502	1.0174
88.0	0.6623	487.2	1.111	2397.0	2.850	1.0231
90.0	0.7150	525.9	1.3970	3002.8	3.340	1.0288
92.0	0.7710	567.1	1.8290	3916.6	4.076	1.0344
94.0	0.8307	611.0	2.551	5441.7	5.306	1.0401
96.0	0.8942	657.7	3.999	8501.8	7.770	1.0458
98.0	0.9616	707.3	8.352	17698.6	15.17	1.0514
100.0	1.03323	760.0	----	----	----	1.0571

t = temperature, p_s, h_s = saturated vapor pressure, x_s = absolute humidity of saturated air, i_s = enthalpy value in saturated air V_s= saturated air specific volume V_a = dry air specific volume

Table 1-1.2 Corresponding ϕ values of different air temperatures and dew point temperatures

Air tempe-rature (℃)	Relative humidity of humid air ϕ (%)									
	60	65	70	75	80	85	90	95	100	
+30	+20.9	+22.3	+23.6	+24.8	+25.9	+27.0	+28.1	+29.1	+30.0	
28	19.0	20.4	21.7	22.9	24.0	25.1	26.1	27.1	28.0	
26	17.2	18.5	19.8	21.0	22.1	23.1	24.1	25.1	26.0	
24	15.3	16.6	17.8	19.0	20.1	21.1	22.1	23.1	24.0	
22	13.4	14.7	15.9	17.0	18.1	19.1	20.2	21.1	22.0	
+20	11.5	12.8	14.0	15.1	16.2	17.2	18.2	19.1	20.0	
18	9.9	10.9	12.1	13.2	14.2	15.2	16.2	17.1	18.0	
16	7.7	9.0	10.2	11.3	12.3	13.3	14.3	15.2	16.0	
14	5.8	7.0	8.2	9.3	10.3	11.3	12.3	13.2	14.0	
12	3.9	5.1	6.3	7.4	8.4	9.4	10.3	11.2	12.0	
+10	2.1	3.3	4.4	5.4	6.4	7.4	8.3	9.2	10.0	
8	+0.3	+1.4	2.5	3.5	4.5	5.4	6.3	7.2	8.0	
6	-1.5	-0.4	+0.7	+1.7	2.7	3.6	4.4	5.2	6.0	
4	3.2	2.1	-1.1	-0.2	+0.7	+1.6	2.5	3.3	4.0	
2	4.9	3.9	3.0	2.1	-1.2	-0.3	+0.5	+1.3	2.0	
+0	6.5	5.5	4.6	3.7	2.9	2.1	-1.3	-0.6	0.0	
2	8.4	7.4	6.4	5.6	4.8	4.0	3.3	2.6	-2.0	
4	10.3	9.3	8.3	7.5	6.7	6.0	5.3	4.6	4.0	
6	12.1	11.2	10.3	9.5	8.7	8.0	7.3	6.6	6.0	
8	13.9	13.9	12.2	11.4	10.7	10.0	9.3	8.6	8.0	
-10	15.4	14.8	14.1	13.3	12.6	11.9	11.2	10.6	10.0	
12	17.7	16.7	15.9	15.1	14.4	13.8	13.2	12.6	12.0	
14	19.8	18.8	17.9	17.1	16.4	1.8	15.2	14.6	14.0	
16	11.9	20.9	20.0	19.2	18.5	17.8	17.8	16.5	16.0	
18	24.1	23.0	22.2	21.4	20.9	19.8	19.8	18.5	18.0	
-20	-26.2	-25.2	-24.2	-23.4	-22.8	21.8	-21.8	-20.5	-20.0	

1-4 Enthalpy

In air conditioning engineering, the cooling or heating is done under constant pressure, during which the heat exchange is usually calculated by the enthalpy potentials before and after the process. The enthalpy potential is:

i_2-i_1=Cp (t_2-t_1)(kJ/kg)

of which:

i_2 enthalpy content in the air after heating or cooling, kJ/kg;

i_1 enthalpy content in the air before heating or cooling, kJ/kg;

C_p specific heat at constant pressure of humid air, kJ/kg・℃;

t_2 air temperature after heating or cooling, ℃;

t_1 air temperature before heating or cooling, ℃.

Therefore, enthalpy potential can reflect the heat variation in the air. If the enthalpy potential is positive, it means the air absorbs heat, and vice versa, but the absolute value of enthalpy is meaningless. The enthalpy content in (1+0.001d) kg humid air is the sum of enthalpy content in 1kg dry air and enthalpy content in dg (g) vapor.

Enthalpy in humid air is indicated by I, so

I=ia + 0.001Iw (kJ/kg)

Of which

ia = enthalpy content in 1kg dry air, kJ/kg;

iw = enthalpy content in 1kg vapor, kJ/kg.

Neither the enthalpy content in dry air nor enthalpy content in vapor is absolute value, but is a relative value. If the enthalpy content in dry air at 0℃ is 0 and the specific heat at constant pressure of dry air and overheat vapor within the air conditioning engineering sphere is constant, then:

i_a = Cp・t = 1.01(t-0)=1.01t;

i_w = 2500+1.84t.

The enthalpy in humid air I is:

I = 1.01t + 0.001d (2500+1.84t)(kJ/kg)

Of which 1.01 -- specific heat at constant pressure of dry air, kJ/kg・℃;

1.84 -- specific heat at constant pressure of vapor, kJ/kg・℃;

2500 heat of water vaporization at 0℃, kJ/kg.

From the above formula we can see that the enthalpy in humid air is composed by two parts: 1.01t+0.001d × 1.84t is air temperature related sensible heat, 0.001d × 2500 is the absorbed heat of vaporization, called latent heat.

Section two Humid air I-d diagram (enthalpy humidity diagram)

2-1Humid air I-d diagram

Humid air I-d diagrams under different atmospheric pressures are made to facilitate use in engineering. The diagram contains various values of enthalpy content, humidity, specific volume and vapor partial pressure of humid air under specific atmospheric pressures H(mmHg), which has direct impact on the normal operation of air conditioners. Therefore, humid air enthalpy humidity diagrams are proposed to express the above parameters. Humid air enthalpy-humidity diagram is also called Mollier diagram, which was first proposed by a German scientist named Mollier in 1923. Though amended several times, the basic contents are similar. Now there are no uniform standards in China, so the listed enthalpy - humidity diagram is often used (see the attached diagram).

What is an i-d diagram used for then? An i-d diagram shows various parameters of the mixture of dry air and vapor under specific pressure H. (When an i-d diagram is made, some specific values below 760mmHg are considered. But the most often used is the 760mmHg pressure.) the following parameters will be shown in the diagram:

Enthalpy i (kJ/kg);

Humidity content d (g/kg);

Temperature t (℃);

Relative humidity Φ(%);

Vapor partial pressure Pw (mmHg); and some relevant diagrams.

Two heat systems are available in the diagram: metrical (kcal/kg) and SI (kJ/kg).

Fig. 1-1 is a sketch map of an i-d diagram. Now let us study the positions and uses of various lines of the map:

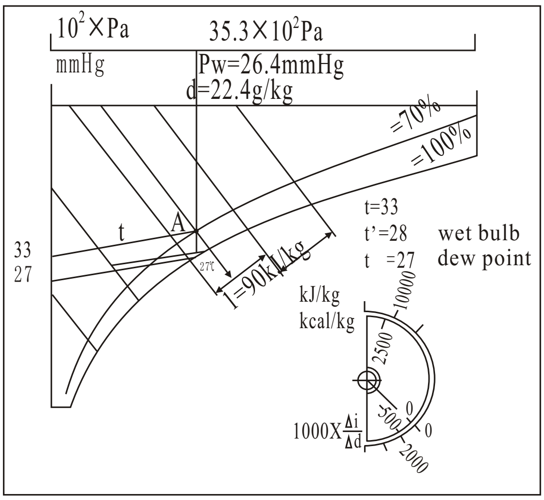


Fig. 1-1Humid air enthalpy humidity diagram sketch map

In the figure:

1. Isenthalpy (i)

Isenthalpy is a group of parallel straight lines, with an angle of approximately 45° with the horizontal line. The i value at the point of A in the map is 90kJ/kg.

2. Equi-humidity content line (d)

A group of vertical lines in the i-d diagram. The d value above the point of A in the map is 22.4g/kg.

3. Isotherm (t)

A group of upward slanting straight lines in the i-d diagram. The point of A in the map is on the 33℃ isotherm (From the isotherm and the relative humidity line and the isenthalp, the wet bulb temperature t′ and dew point temperature t″ can be determined. See paragraphs below).

4. Equi-relative humidity line (Φ)

The relative humidity line of the saturated humid air with relative humidity Φ=100% is an upward extending parabola. Other Φ lines have the similar shape and arranged in an ascending way. But they seem more similar as they are closer to the lower temperature zones. The point of A in the map is on the 70% equi-relative humidity line.

5. Relation curve between the **vapor partial pressure hs** and humidity content in the i-d diagram.

The upper horizontal coordinate is d and the upper one is Pw. So the Pw value can be easily obtained according to the line relation. The humidity content at A in the map is d=22.4g/kg' and so the Pw value can be obtained by drawing a vertical line Pw=26.4mmHg (35.3×10^2Pa).

6. Heat-humidity ratio line (ε)

Various heat-humidity ratios (ε) are available at the lower right corner of the i-d diagram. The ratio shows the relations between the heat and humidity change from one condition point to another.

$$\varepsilon = \frac{i_2 - i_1}{0.001(d_2 - d_1)} = \frac{\Delta i}{0.001\Delta d} = \frac{Q}{S} \cdots\cdots\cdots \quad (1 \bullet 5)$$

of which: i_1, d_1 enthalpy and humidity content in the air at the initial condition point;

i_2, d_2 enthalpy and humidity content in the air at the finish condition point;

Q gross heat, (kJ/kg);

S humidity content, (kg/kg').

Connect condition point 1 and condition point 2 in the map and translate the line to the central point of the heat and humidity ratio semi-circle, the intersecting point of the line with the semi-circle is the heat humidity ratio (two unit systems are available in the map).

Fig 1-2 is an air conditioner operational sketch map during room temperature drop. The change of the i value and the d value of the air can be explained through Fig. 1-3. Point 1 is the initial point (the initial temperature t_1=33℃ and the isotherm and the equi-relative humidity line with Φ=70% meet at point "1"). Other parameters at point 1: i_1=90.8kJ/kg, d_1=22.4g/kg'. After the indoor air is cooled and dehumidified by the windows-type air conditioner, the indoor air reaches the parameters at the finish point (i.e. room temperature t_2= 26℃ , relative humidity Φ=55%). Other parameters can be obtained from the intersectional point of the 26℃ isotherm and the 55% relative humidity line, i.e. Point 2. Therefore, changes has taken place mainly in the enthalpy content and humidity content of the indoor air from the initial point "1" to the finish point "2". (enthalpy content i = i_1-i_2, humidity content d = d_1-d_2), i.e.

$$\varepsilon = \frac{90.8-58.3}{0.001\times(22.4-11)} = \frac{32.5}{0.0114} = 2850kJ/kg$$

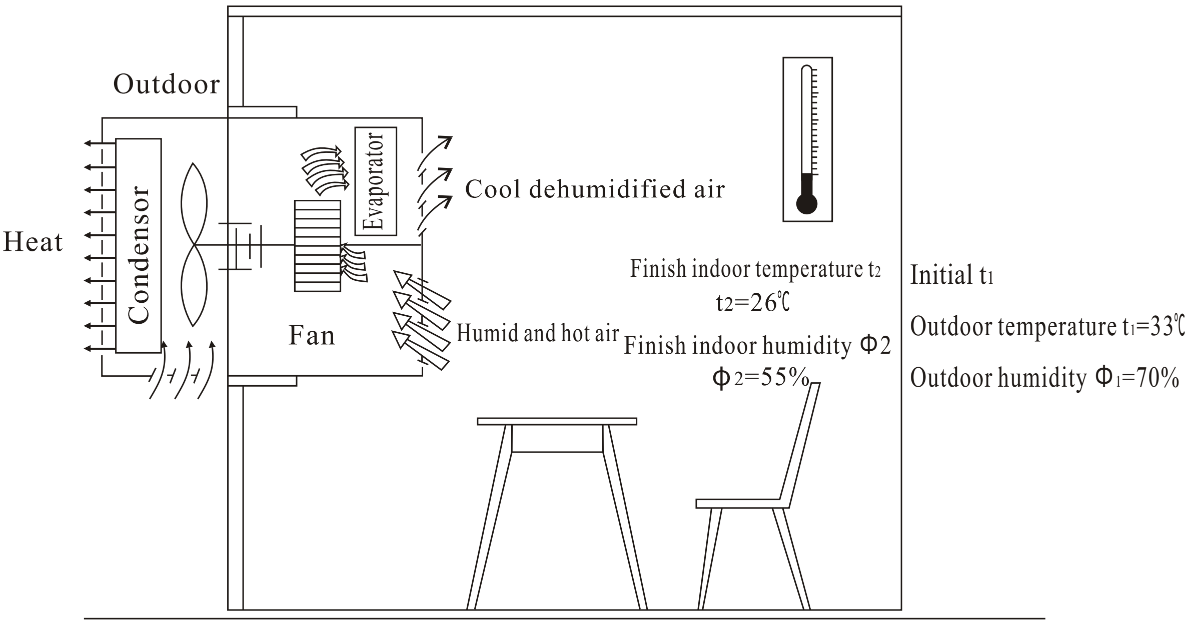


Fig 1-2Air conditioner cooling operational factors

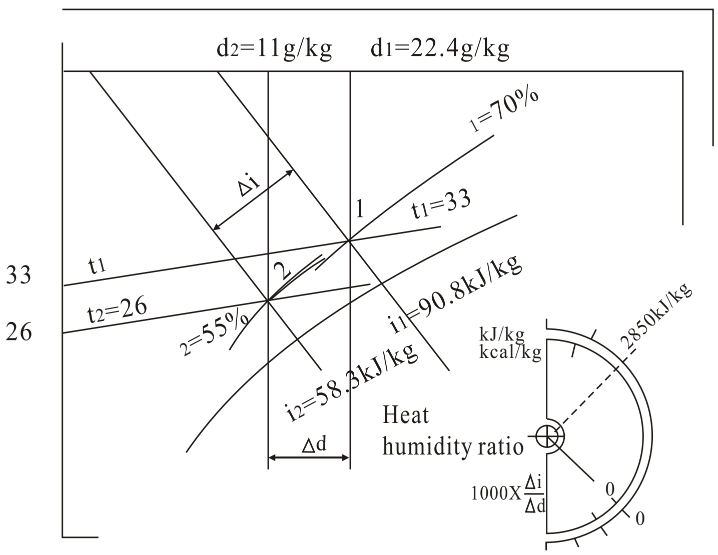


Fig. 1-3Conditional relations in the i-d diagram during cooling operation of air conditioner

According to the ε definition, the greater the heat humidity ratio, the faster the enthalpy content of the humid air grows than that of the humidity does. Limit conditions are: when the i value is positive, d=0 and heat humidity ratio $\varepsilon=\infty$ during equi-humidity heating run; when the i = 0, d is positive and heat humidity ratio $\varepsilon=0$ during equi-enthalpy humidifying run. So the cycle from $\varepsilon=0$ to $\varepsilon=\infty$ is heat humidifying process.

2-2 Application of the i-d diagram

There are many different cycles under various conditions of humid air. The following are some conditions during air conditioning run:

1、Mixture of humid air under two different conditions

An air conditioner does not run simply for cooling (heating) and dehumidifying (humidifying). It usually supplies some fresh air (new air) to the room. So the processed air in the room is a mixed air. The parameters of the mixed air are determined according to the mass of the air G_1 and G_2 kg/h, enthalpy content in the air i_2 and i1 and humidity content d_2 and d_1.

Fig. 1—4 is an i-d diagram of humid air under various conditions. Parameters include: t_1=20℃ , i_1= 46.2kJ/kg', Φ_1=69.4%, d_1=10.3g/kg (if G_1=3kg), $G_1(i+d_1)$kg, mixed new air $G_2(i+d_1)$kg (if G_2=2kg), the conditions are t_2=30℃ , i_2=64.9kJ/kg.

Formula under G_3 condition of the adiabatic mixed air:

$$\left.\begin{array}{l} G_3=G_1+G_2(G_3=5kg) \\ G_3(1+d_3)=G_1(1+d_1)+G_2(1+d_2) \\ G_3i_3=G_1i_1+G_2i_2 \end{array}\right\} \cdots\cdots\cdots \quad (1\cdot 6)$$

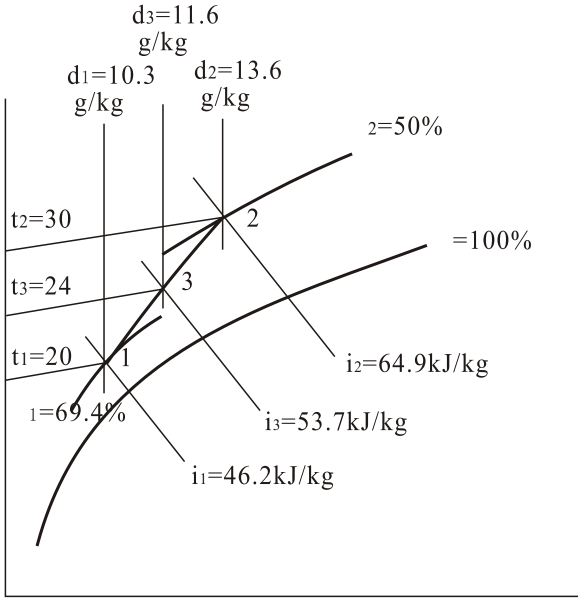


Fig.1-4 Conditions in the i-d diagram of humid air under two different conditions

$$d_3=\frac{d_1G_1+d_2G_2}{G_3} =0.01082\text{g/kg} \quad \text{Supposed calculation} \qquad (a)$$

$$i_3=\frac{i_1G_1+i_2G_2}{G_3} =53.68\text{kJ/kg} \quad \text{Supposed calculation} \qquad (b)$$

$$\therefore \quad \frac{i_2 \quad i_3}{d_2 \quad d_3} = \frac{i_3 \quad i_1}{d_3 \quad d_1} \qquad (1\cdot 7)$$

From the above formulae, we can prove that point 3 is on the 1-2 line segment of the i-d diagram, i.e.

$$\overline{23} : \overline{13} = G_1 : G_2$$

The position of point 3 is dependent on the ratio of back air volume G_2 and new air volume G_1:

$$\frac{G_2}{G_1} = \frac{d_3-d_1}{d_2-d_3} = \frac{\text{1-3 line length}}{\text{2-3 line length}}$$

When the back air volume G_2 is equal to the new air volume G_1, i.e. $G_2/G_1=1$, point 3 is at the middle point of line segment 1-2; when the back air volume is greater than the new air volume, i.e. $G_2>G_1$, point 3 is close to the back air point 2; when the air is all new air, i.e. $G_2<G_1$, point 3 is close to the new air point 1.

So, the mixed parameters of the humid air can be obtained from the ratio of the back air volume G2 and the new air volume G1 after connecting the line between the two condition points.

Example: The ratio of the back air volume and the new air volume of a certain air conditioning room $G_2/G_1=5$ (Max allowance), the winter new air $t_1=-15℃$, $Φ_1=70\%$, indoor back air condition $t_2= 20℃$, $Φ_2=50\%$, try to get the mixed conditional parameters of the humid air.

Solution: Find out point 1 and point 2 in the i-d diagram, connect point 1 and point 2 into a straight line, according to

$$\frac{G_2}{G_1} = \frac{\text{line length 1-3}}{\text{line length 2-3}} = 5$$

The parameters of the mixed humid air in Fig. 1-5 are obtained by point 3:

$t_3=14.5℃$

$Φ_3=62\%$

$d_3=6.5g/kg$

$i_3 = 31kJ/kg$

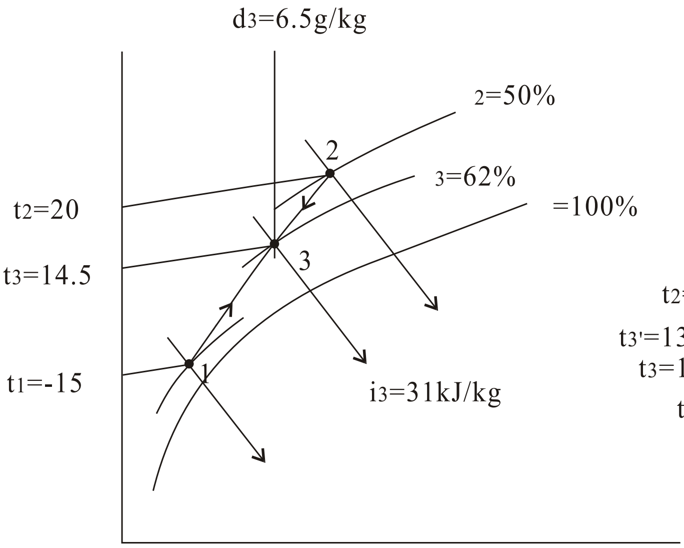


Fig. 1-5 Parameters of mixed air at confirmation point 3

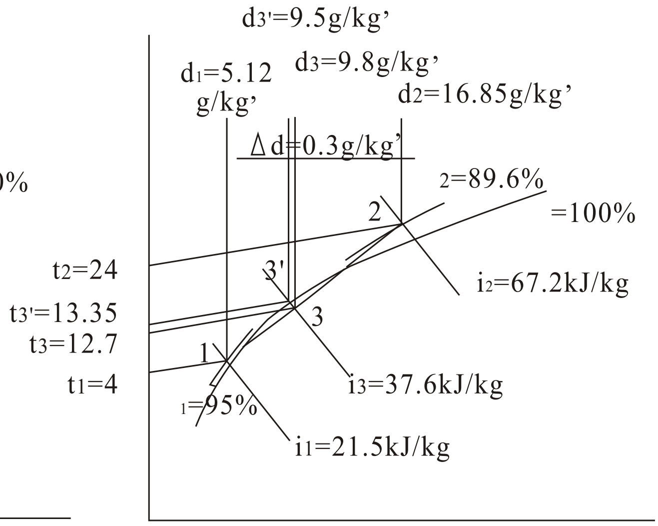


Fig. 1-6 Saturated fog air resulted by mixed air

2 Supersaturated fog mixed air that may be produced by mixture of air of two different states

State parameters as shown in Fig. 1-6: When new humid air G_1 of t_1= 4℃ and Φ_1=95% mixes with back air G_2 of t_2=24℃ and Φ_2=89.6%, G_3 of point 3 on connection line of point 1-2 is outside of the supersaturated air area, (Φ_3 > 100%, in fog state) t_3=12.7℃ . Point 3' acquired by displacing point 3 along constant enthalpy line is of stable state. At this point, for 1 kg dry air,the mixed air should condensate water (fog) of d = d_3 - $d_{3'}$ g/kg' provided Δ d = 0.3g/kg.

3、Heating or cooling for humid air under special conditions

I、Heating for humid air under constant humidity

This procedure is also called "enthalpy increasing under constant humidity". As shown in Fig.1-7, humid air at point 1, t_1 = 19℃ , i_1 = 47.2 kJ/kg', d_1 = 11g/kg', Φ_1 = 80% (constant), is heated to t_2 = 27℃ . Displacing point 1 along constant humidity line (d_1 = 11 g/kg) upward until reaching constant temperature line (27℃) to get point 2, i_2 = 55.4kJ/kg', Φ_2= 49.3%. Increased heat volume to heating 1 kg humid air is Δ i = i_2 i_1 (Δ i = 8.2kJ/kg' in the example).

II、Cooling for humid air under constant humidity

If humid air of point 1 state is cooled by the heat exchanger (without dehumidifying), it will turn along constant humidity line downward to point 1" on saturation curve Φ=100%, and t_1" = 15.2℃ is dew point and Δi is the reduced heat volume. This procedure is inverse to the aforesaid "enthalpy increasing", thus it is called "enthalpy reducing under constant humidity".

III、Dehumidified cooling for humid air under dew point in the heat exchanger

This procedure is called "enthalpy reducing while dehumidifying". Changes in i d chart can be seen from Fig. 1-8.

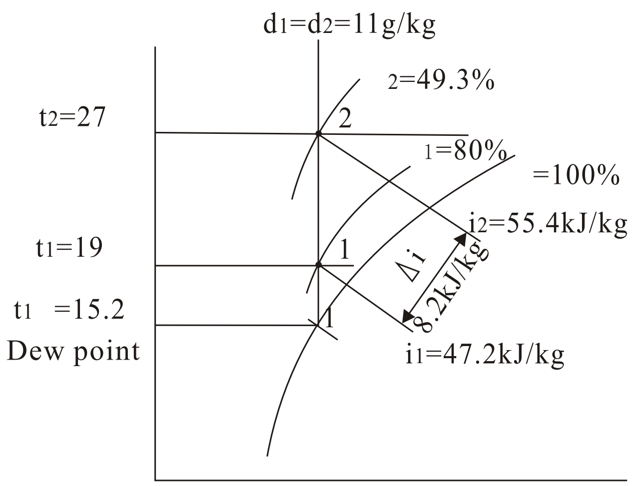


Fig. 1-7 Example for procedure of "enthalpy increasing (reducing) under constant humidity"

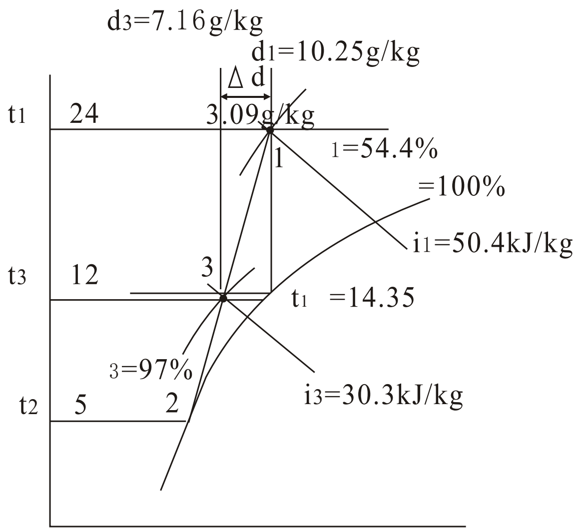


Fig. 1-8 Example for procedure of "enthalpy increasing while dehumidifying"

Humid air at point 1: t1 = 24℃ , Φ1 = 54.4%, d1 = 10.25g/kg' reaches dew point on the surface of heat exchanger, that is, the cross point with saturation curve Φ = 100% when displacing point 1 vertically downward is t_1" = 14.35℃ . Humid air of point 1 state is congealed on surface of the heat exchanger whose temperature is 5℃ by condensed water film. t2 = 5℃ is selected during design and standard working state of evaporating temperature on exchanger surface is also +5℃ . Thus why point 3 state of humid air processed by heat exchanger is always between 1-2 portion. (actual temperature at wind outlet t_3 = 12℃), point 3 is just where 1-2 portion crosses with 12℃ constant temperature line, its parameters checked from i-d chart is: t_3 = 12℃ , i_3 =30.3 kJ/kg', $Φ_3$ = 97%, d_3 = 7.16g/kg'. Reduced heat volume during this "enthalpy reducing while dehumidifying" procedure is Δi = 20.1kJ/kg, humidity reduction volume Δd = 3.09g/kg'.

IV、 When humid air contacts with large amount of hotter water

This case is called "enthalpy, humidity & temperature increasing" procedure as shown in Fig.1-9.Humid air of point 1 state: t1 = 10℃ , d1 = 5.3g/kg',Φ1 = 70% and i_1 = 23.5kJ/kg' contacts hotter water: t_2 =16℃ . Since hotter water is at constant temperature and saturated, firstly plot point 1 in the i-d chart. Point 2 is plotted where 16℃ constant temperature line crosses saturation curve Φ = 100%. Point 3 should be on connection line between 1-2. The temperature of processed humid air is t_3 = 14℃ , so the cross point of 14℃ temperature line and 1-2 line is just point 3, whose parameters are: $Φ_3$ = 93%, d_3 = 9.25g/kg', i_3 = 37.6kJ/kg.

In the above example, Δi = 14.1kJ/kg', increased humidity volume Δd = 3.95g/kg, and increased temperature Δt = t_3 t_1 = 4℃ .

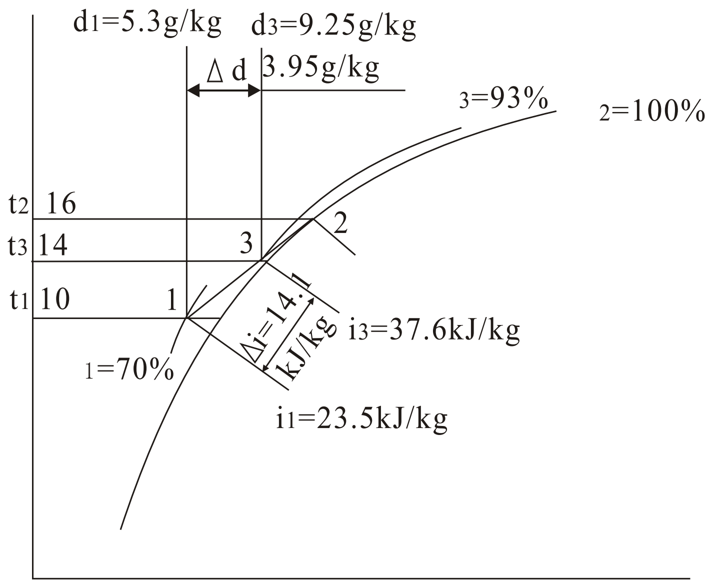


Fig. 1-9 Example for "enthalpy, humidity & temperature increasing" procedure

In the above we have introduced some practical examples for i-d Chart of humid air. In fact,there are many processing method for humid air during air conditioning procedure, as summarized in the following table 1 and Fig. 1-10.

In air conditioning, equipment/facility/machine dew point is often used to show temperature ofnearly saturated state (normally between Φ = 90~95%) after the air being processed by surface cooler. During practical use, DON'T confuse it with physical conception of dew point.

Table 1

Procedure line	Air processing procedure	Processing method
A--1	Enthalpy reducing while dehumidifying	Spray with water below temperature below t" Let water below temperature t" passing surface cooler of water type Cool with surface cooler of linear evaporating type with evaporating temperature of refrigerant below t"
A--2	Enthalpy reducing under constant humidity	Spray with water of average temperature slightly below t" Cool with surface cooler with water of average temperature below t"
A--3	Enthalpy reducing while humidity increasing	Spray with water, or cool with surface cooler with temperature of water or evaporating refrigerant lower, than t ' higher than or equal to t".
A--4	Humidity increasing with constant enthalpy	Spray circularly with water.
A--5	Enthalpy & humidity increasing while temperature reducing	Spray with water of temperature higher than t' but lower than air.
A--6	Enthalpy & humidity increasing under constant temperature	Spray with water of air temperature and spray saturated steam
A--7	Enthalpy, humidity & temperature increasing	Spray with water higher than air temperature and spray super hot steam
A--8	Enthalpy increasing under constant humidity	Heating with heater of heat source (media) type.
A--9	Enthalpy increasing while humidity reducing	Dehumidifying with mechanical and solid dehumidizer.
A--10	Humidity reducing under constant enthalpy	Dehumidifying with solid dehumidizer.
A--11	Enthalpy & humidity reducing while temperature increasing	Spray with liquid dehumidizer higher than air temperature
A--12	Enthalpy & humidity reducing under constant temperature	Spray with liquid dehumidizer of air temperature

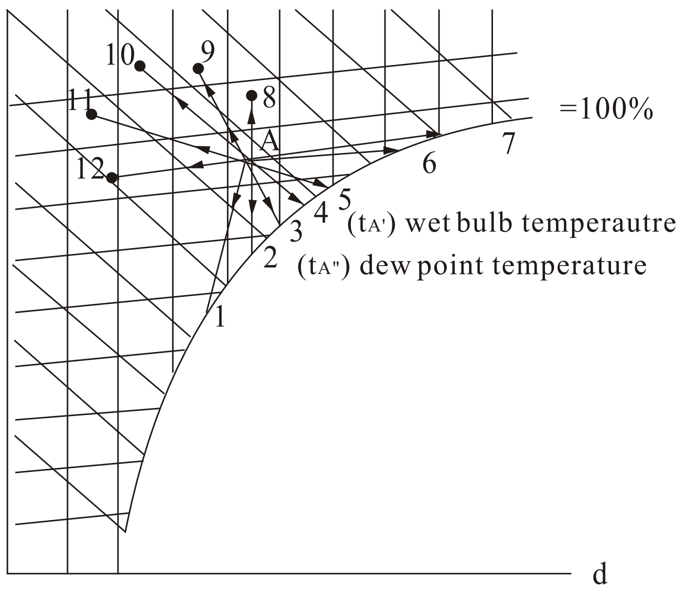


Fig. 1-10 Procedures on I-d chart for processing of humid air

Section Three Environmental conditions

The main purpose of air conditioning is to create a natural environment suitable for people's living, industrial production and science research, therefore environmental parameters all of great importance for such solutions. As science and technology is advancing, it is more and more important to control air pollutions, which has been required in many respects. Thus why environment protection is one of the most important duties.

3-1 Weather information of main cities

This section gathers weather information including annual average, maximum, and minimum air temperature, humidity and wind speed, as main references of outdoor air conditions for air conditioning design (see attached tables).

3-2 Necessary air quality and quantity for human needs

Natural air composes of nitrogen, oxygen, carbon dioxide and other rare gases (with proportions as shown in table 1-3).Composition rates in the table are at 0 sea level height. In plateau section, oxygen content of the air is much less as seal level height rises. Increased in dustrial pollution as a result of expansion of industrial cities causes more poisonous gas content in the atmosphere and takes great harms to the human being and natural world. The table hereunder is the list of necessary air quantity & quality for normal human needs.

Table 1-3 Main composition of human exhalant air

composition	Volume proportion(%)	Volume proportions under standard atmospheric pressure(%)
Nitrogen	79.2	78.03
Oxygen	15.4	20.99
Carbon dioxide	4.4	0.033
Water vapor	Saturated vapor quantity under normal temperature	Moisture content under temperature of the very time

Due to human physiological activities, oxygen of inspired air is exchanged in human blood andcarbon dioxide is breathed out, thus why oxygen content in the exhalant air reduces while carbon dioxide increases.

Human respiration varies with different ages and genders,as shown in the following table.

Table 1-4 Human respiration values

Age	CO_2%		O_2%	Exhalant volume ml/time	Respiration frequency times/min	Respiration volume ml/time	O_2 exhaustion ml/time	CO_2 producing volume ml/min
15~20	Male	3.3	16.5	270	21.3	5.660	252	185
	Female	3.3	16.2	204	20.4	4.146	194	138
21~25	Male	3.8	15.8	273	22.0	6.011	307	225
	Female	3.3	16.3	213	22.0	4.375	201	142
26~30	Male	3.9	15.7	307	19.0	5.833	309	228
	Female	3.2	16.3	229	19.7	4.518	207	142

Age	CO_2%	O_2%	Exhalent volume ml/time	Respiration frequency times/min	Respiration volume ml/time	O_2 exhaustion ml/time	CO_2 producing volume ml/min
31~40	Male 3.8	15.9	285	20.6	5.978	297	218
	Female 3.2	16.3	185	22.1	4.042	185	132
41~50	Male 3.1	16.6	274	21.9	5.992	254	183
	Female 2.9	16.8	198	20.5	4.072	163	116
Average	Male 3.55	16.1	282	20.9	5.893	283.9	207.9
	Female 3.34	16.4	206	20.5	4.230	189.8	134.1
Ratio of Male to Female	1.06	0.98	1.37	1.02	1.39	1.49	1.55

Air exchange volume in normal living environment (including where smoking exists) is as shown in the following table 1-5.

Table 1-5 Air exchanging volume in different environment with smoking Cubic meter/hour · square meter ($m^3/h \bullet m^2$)

Building	type	Smoking degree	Air exchange volume ($m^3/h \bullet m^2$)		Minimum air exchange volume on base of floor area($m^3/h \bullet m^2$)
			Recommended	minimum	
apartment	common	common	34	17	—
	high	common	51	42	6
hotel	single room	much	51	42	6
dining room	buffet	much more	20	17	—
	room	much more	25	20	—
kitchen	mess hall	—	—	—	73
	dining room	—	—	—	37
government office	for residing	none	13	8.5	0.9
	—	none	13	8.5	—
canteen	—	none	13	8.5	—
	—	common	25	17	—
theater		none	—	—	36
hospital	operation room	none	51	42	6
	single room	none	34	17	—
	intensive ward	a little	25	17	—
	common	a little	42	25	4.5
office	individual	none	51	42	4.5
meeting room	—	very much	85	51	22.5

It also can be calculated with typical method according to floor area as the following:
In rooms where there are many people, air exchange volume per square meter is $75m^3/h$.
Normally, air exchange volume per square meter is $30m^3/h$.

3-3 Maximum allowance and exchange volume of poisonous gas, substance, and odour

As a result of industrial development, various kinds of poisonous gas and substances are discharge and mostly scattered in the air. Especially, increasing cars releases more carbon monoxide gas content, which seriously causes air pollution and should be effectively controlled.

In respect of present regulations for mechanical air exchange, the introduced air should meet the following standards:

1. Dust quantity < 0.15 mg/m³.
2. Carbon monoxide < 10PPm (10 millionths)
3. Carbon dioxide < 1000PPm (1000 millionths)
4. Temperature within 17 ~28 .
5. Relative humidity 40-70%.
6. Air flow less than 0.5m/s.

Since human body continuously releases bad odour, it is necessary to continuously introduce fresh air and discharge odour out of room as shown in Fig. 1-11.

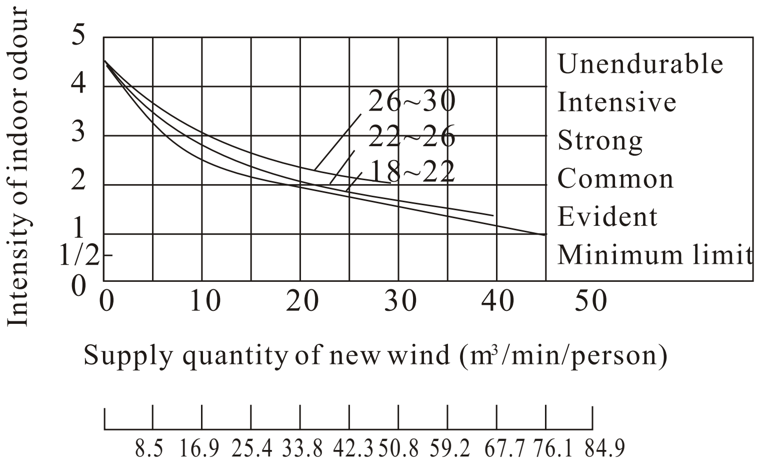


Fig.1-11 (m³/min/person)

The following table 1-6 lists harmful degree to human bodies caused by poisonous gases and substances such as carbon monoxide, sulfur dioxide (mainly produced burnt heavy oil and coal smokes), and photochemical oxides (mainly including nitrogen dioxide and nitrogen mon-oxide released by hi-temperature combustions, and poisonous secondary product produced by hydrocarbons in discharged gas under ultraviolet radiation of the sunlight), while table 1-7 lists maximum allowable intensities of some substances.

Table 1-6

Intensity %	Contact time and symptoms	Intensity %	Contact time and symptoms
0.02	Within 2-3 hours: Forehead aches	0.32	In 5-10 minutes: headache, vertigo In 30 minutes: dying or dead
0.04	Within 1-2 hours: forehead aches, feeling sick Within 2.5-3.5 hours: Rear head aches	0.64	In 1-2 minutes: headache, vertigo In 10-15 minutes: dying or dead
0.08	In 45 minutes: vertigo, convulsion, disgorge In 2 hours: absentia	1.28	In 1-3 minutes: dying or dead
0.16	In 20 minutes: headache, vertigo, disgorge In 2 hours: dying or dead		

Table 1-7 Maximum allowable intensity of some poisonous substances

Substance name	Chemical formula	Allowable intensity	Substance name	Chemical formula	Allowable intensity
Aniline	$C_6H_9NH_2$	5ppm	Sulfur dioxide (sulfurous acid gas)	SO_2	5ppm
Ammonia	NH_3	100ppm			
Carbon monoxide	CO	100ppm	Nitrogen dioxide	NO_3	5ppm
Chloride	Cl_2	1ppm	Nitrobenzene	$C_6H_2NO_2$	1ppm
Chromic oxide	CrO_3	0.1ppm	Carbon bisulfide	CS_2	20ppm
Hydrocyanic acid	HCN	10ppm		OC_2H_3	
Mercury	Hg	0.1mg/m^3		SPO  NO_3	0.1mg/m^3
				OC_2H_3	
Toluene	$C_6H_3CH_3$	200ppm	Benzene	C_6H_6	25ppm
Plumbum	Pb	0.15mg/m^3	Formaldehyde	HCHO	5ppm

3-4 Air humidity and temperature ranges suitable for human bodies

In common living,optimal temperature range for humans:21.7℃（normally within18.9~23.9℃) in summer and 18.9℃ (normally within 17.2~21.7℃) in winter. In very hot weather, suitable temperature rang for human bodies of quiet state is 23.3~28.9℃ .

Comfortable air conditioning in civil and public buildings:

Indoor air temperature:26~28℃ in summer and 18~22℃ in winter. Temperature difference between indoors and outdoors should not exceed 7℃ to avoid heat impact (hot rheum).

Indoor air relative humidity: 40~60% in summer while none specified in winter, yet it is recommended $\Phi \geq 35\%$ in high class buildings.

Average air flow speed: 0.2~0.5m/s in summer and 0.15~0.3 m/s in winter.

Indoor air parameters for air conditioning in public buildings are listed in table 1-8.

Parameters for indoor air conditioning in buildings of different requirements can be referred to examples in "design manual of air conditioning".

Table 1-8

Season	Parameter	Public building		
		General standard	Recommended in China mainland	Recommended in Hong Kong & Maca
Summer	t(℃)	25~27	27~28	27~28
	Φ(%)	40~70	40~60	50
	V(m/s)	0.5 below		0.12
Winter	t(℃)		18~20	20~22
	Φ(%)		40~60	50
	V(m/s)			0.12

Chapter 2 The calculation method of the design and air conditioning

This chapter will introduce several methods of the design and calculation of air conditioning.

Part 1 The accidence method and requirement of the design and calculation

Before bringing forward the air conditioning design task, one must study and understand the requirement of the air conditioning area (indoor conditions), and on the basis of both indoor and outdoor conditions, raise the methods that will be adopted for the cooling down or warming up and other methods of humidification, dehumidification and dusting off etc.

Fig. 2-1 is a typical sketch map for air conditioning equipments

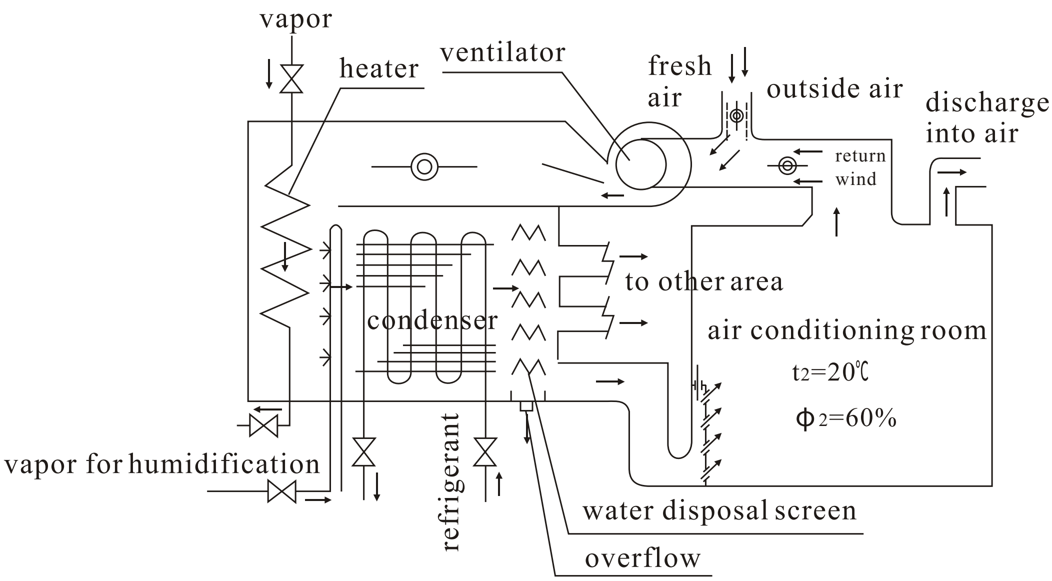
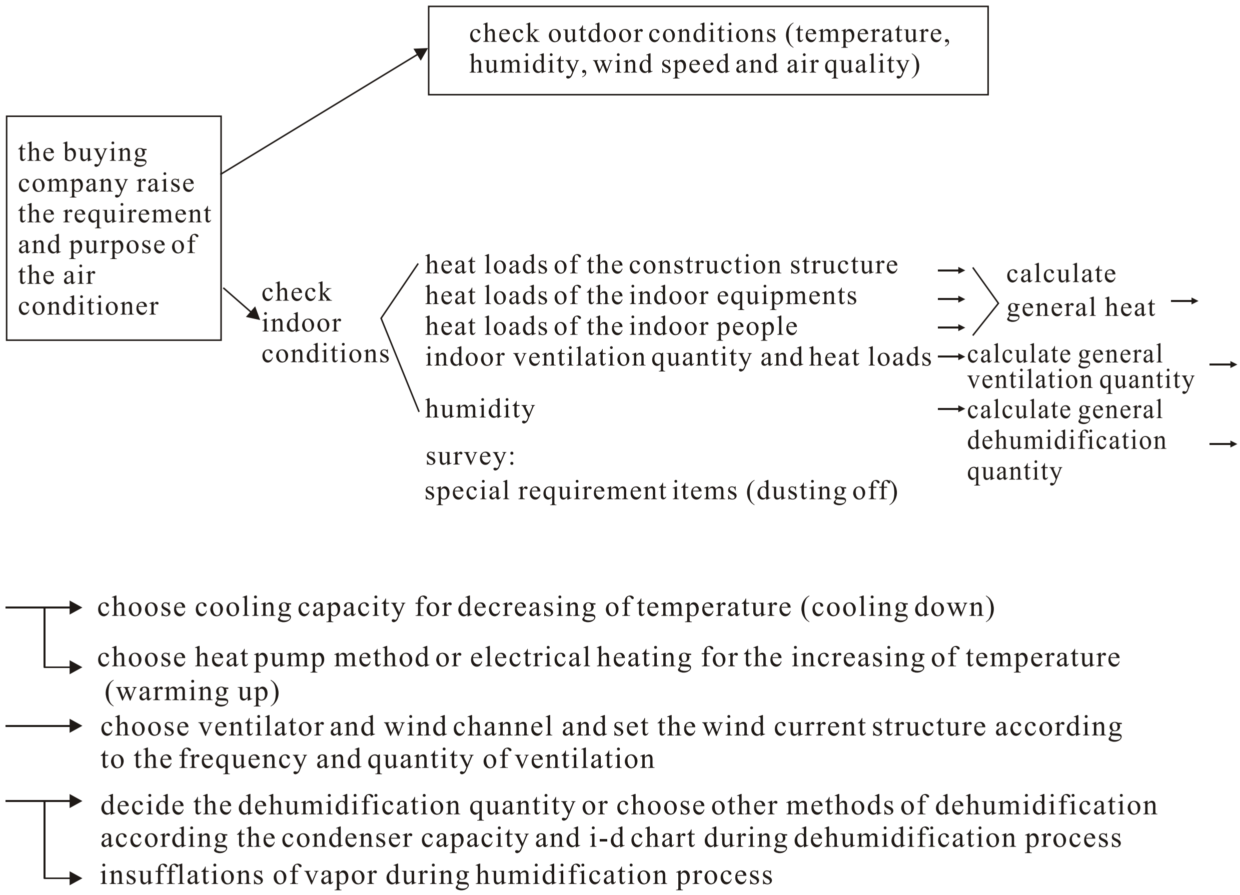


Fig. 2-1

There are various types of air conditioning equipments. Small ones are for the resolution of the temperature, humidity and ventilation control within one room, while large ones integral air conditioning, and the control of the temperature, humidity and ventilation, etc. in different rooms or public areas is done in the central control room. Small air conditioning equipments mainly belongs to the combined integral type, and it has window type, cabinet type, and split type, MRV type, etc. Integral air conditioner has large capacity condenser and vapor boiler, which can send, processed air to every room through air processing cabinet(coil pipe set).

The calculation is mainly carried out according to the following procedures:



1-1 Indoor and outdoor conditions

1 Indoor conditions

The indoor conditions are based on the most suitable conditions in summer or winter. Situations such as season, working condition, quantity of people, the heat generating and air discharge of the mechanical equipments, etc. should be observed to make decision for the indoor conditions. The temperature and humidity have influence on people, and also have large influence on the usage and storage of various fine machines and apparatus. The indoor appropriate temperature and humidity should be decided according to the need. Table 2-1 lists the indoor conditions for various industries of the air conditioner.

Table 2-1 The indoor conditions of air conditioning for industries

Industry	temperature (℃)	humidity (%)	Industry	temperature (℃)	humidity (%)
Optic machine, optic glass fusion	24	45	painting air drier	24 21 31	60
optic glass rubbing	27	80	chemical industry	20 24	45 60
metering room	20	40 60	medical trochepressing	24 27	40
electronical apparatus			sugar-coat processing	27	35
transformer manufacturing	22	15	biology preparation	22 27	10 40
electronical pipe assemble	20	40	textile industry	27 29	60 80
computer	22	40	syndicated fiber industry	27	60
condenser manufacturing and assemble	24	40	printing industry	24 27	45 60
foundry	15 02		cigarette industry	24 25	65 75

Table 2-2 lists the normal living indoor conditions, and table 1-8 also has the reference.

Table 2-2 Normal living indoor conditions

outside condition		Indoor	
		normal	special
summer	32℃ ~33℃ wet bulb temp 27℃	27℃ , humidity 50%	27℃ , humidity 50%
winter	-2~+3℃	20℃ , humidity 50%	21℃ , humidity 50%

time		A.M. 8:00	9:00	10:00	11:00	noon	P.M. 1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00
correction value	dry bulb (℃)	-3.4	-1.9	-0.9	-0.6	-0.3	-0.1	0	0	-0.5	-1.7	-3.0	-4.1	-4.7
	wet bulb (℃)	-0.9	-0.5	-0.3	-0.2	-0.1	0	0	0	-0.2	-0.5	-0.8	-1.1	-1.2

Table 2-3 lists the indoor conditions of the living area for the air conditioning

Table 2-3 Indoor conditions in the living area

	summer		winter	
	temperature (℃)	humidity Φ(%)	temperature (℃)	humidity Φ(%)
hotel, bedroom, kitchen, meeting room	24-26	50-65	20-25	40-55
hospital, sickroom, diagnosing room, surgery room	26 27	50-60 50-60	22-23 21-22	40-60 40-60
office, meeting room, theater	26-27	50-65	20-22	40-65
shops, museum, exhibition room	25	70	20-22	40-50

2、 Outside air conditions (outdoor conditions)

Owing to the difference of the geographical positions, the meteorological conditions are also different, so the following parameters must be followed to make the calculation. The parameters of the temperature, humidity and wind speed are listed the attached tables for various places. If the design calculation doesn't has strict requirements, then carry out the calculation on the basis of temperature at 33℃ and comparative humidity at 70%.

The working environmental temperature is set in accordance with the international standard ISO5151:1994, as listed in table 2-4.

Table 2-4 The outside working temperature for air conditioners

type of air conditioner	weather type		
	T1	T2	T3
Cool wind type	18 ~43	10 ~35	21 ~52
heat pump type	-7 ~43	-7 ~35	-7 ~52
electrical heating type	~43	~35	~52

note: The lowest working temperature for heat pump type air conditioner without defrosting set can be 5℃ .

Table 2-5

working condition			indoor condition (℃)		outdoor condition (℃)	
			dry bulb temp	wet bulb temp	dry bulb temp	wet bulb temp
cooling running	Rated cooling	T1 T2 T3	27 21 29	19 15 19	35 27 46	24 19 24
	maximum running	T1 T2 T3	32 27 32	23 19 23	43 35 52	26 24 31
	froze	T1 T2 T3	21	15	21 10 21	— — —
	minimum running		21 2)	15	recommended minimum temperature 3)	
	dew discharge of condensed water		27	24	27	24
heating running	heat pump rated heating	high temp low temp super low temp	20	15 (maximum)	7 2 7	6 1 8
	maximum running		27	—	24	18
	minimum running 4)		20	—	5	6
	automatic defrost		20	12	2	1
	rated electrical heating		20	—	—	—

note:

1)During the cooling test of the air conditioner, if there is no condensed water evaporating, the wet bulb temperature requirement can be neglected.

2)The controller should guarantee the running the machine when it is 21℃ or above.

3)Those machines that stipulated by the manufacturing factory to be suitable to work under low temperature or super low temperature environments should be tested under low temperature and super low temperature; If there defrost occurs during the heating capacity - test (high temperature, low temperature or super low temperature), air enthalpy value (see standard attachment **A2**) should be adopted to conduct the heating capacity test.

4)If the air conditioner can run under the super low temperature condition, its minimum test should be conducted at dry bulb -7℃ and wet bulb -8℃ .

To air conditioners, there are different conditions: the working conditions at the warming and cooling. See table 2-5 .The JIS standard set the outside dry bulb temperature 35±0.5℃ , wet bulb temperature at 24±0.5℃ ; the indoor dry bulb temperature 27±1℃ , wet bulb temperature at 19.0±1℃ ; for warming, the indoor dry bulb temperature 20±1℃ , outside dry bulb temperature at 7±1℃ , and wet bulb temperature at 6±0.5℃ . We can see from the national standard in table 2-4 that the weather is classified into three categories which caused the outdoor difference, and this should be observed during the design calculation. The indoor choices are subject to the outside air temperature. Table 2-6 lists the corresponding optimum temperatureconditions based on the outside temperature. The difference of the indoor and outdoor temperature should be too large. If the indoor temperature is too low, when people go outdoors, they will get hit by the hot and may cause sickness. The values in the table are only for reference as there are many differences among people for the ages, dressing state, work type, indoor time and personal constitution, etc.

Table 2-6 Outdoors temperature and corresponding indoor optimum temperature

outside temp (℃)	36	34	32	30	28	26	24	20	15	10	0
indoor optimum temp (℃)	29	28	27	25	24	23	22	19	19	18	18
indoor optimum humidity (℃)	55	55	60	60	60	65	65	65	65	70	70

Part 2 Temperature decreasing (cooling) loads calculation

There are temperature decreasing (cooling) loads (the enthalpy and humidity decreasing process for wet bulb air) calculation and temperature raising loads(the enthalpy increasing and humidity decreasing process for wet ball air) calculation for the design calcuation of the air conditioning. It can be conducted separately.

Temperature decreasing loads mainly include the following:

- indoor loads
  - sun radiation heat – – – – through the window glasses, walls and roofs – – – – – – – – – – sensible heat
  - conductive heat caused by temperature difference – – – through the window glasses, walls and roofs, partition walls, floor and ceiling – – – – – – – – – – sensible heat
  - heat generated indoors – – lights (sensible heat) and human body heating – – – – – – – – – – – – sensible heat, latent heat
  - hot air coming from outdoors – – air come from outdoor from the gap of the window and door, and opening and closing of the window and door (the air come from the condenser) – – – – – – – – – – – sensible heat, latent heat

outdoor air (ventilation) loads – – the indoor air come from outdoors – – the difference of the temperature and humidity between indoor and outdoor formed enthalpy decreasing and humidity decreasing heat

– – sensible heat, latent heat

other heat loads – – loss in wind channel, air blower power heat – – sensible heat, latent heat

2-1 heat loads of glass window

Among the heat loads generated by the room construction, glass window is a main item: the radiation heat of the sunlight to glass window

$$Qg=F\cdot Ig\cdot q_1 \qquad (2\cdot 1)$$

in the formula: Qg- the area of the glass window at all directions (m^2)

Ig- the radiation heat by the sun (W/m^2)

q_1- shading modulus

Table 2-7 the radiation heat Ig value of the sun to glass window at 35 degree north latitude in the end of July

(W/m^2 window frame area)

time / direction	A.M. 6	7	8	9	10	11	noon 12	P.M. 1	2	3	4	5	6
N	79	58	44	44	49	49	49	49	49	44	44	58	79
NE	342	445	392	267	124	51	49	49	49	44	42	33	15
E	374	542	564	497	340	150	49	49	49	44	42	33	15
SE	165	307	398	386	331	233	110	50	49	44	42	33	15
S	15	33	43	69	110	155	171	155	110	69	43	33	15
SW	15	33	42	44	49	50	110	233	331	392	377	307	165
W	15	33	42	44	49	49	49	150	340	497	564	542	374
NW	15	33	42	44	49	49	49	51	124	267	392	445	342
FLAT	67	240	428	597	716	792	822	792	716	597	428	240	67

Table 2-8 heat reserving modulus within 24 hours (with curtain and constant temperature)

direction	weight (kg/m^2 ground area)	A.M. 6	8	10	12	P.M. 2	4	6	8	10	12
NE	Above 730	0.47	0.54	0.27	0.20	0.18	0.16	0.12	0.08	0.06	0.05
	Above 150	0.55	0.73	0.36	0.19	0.15	0.12	0.07	0.02	0.01	0.00
E	Above 730	0.39	0.62	0.49	0.23	0.20	0.17	0.12	0.09	0.08	0.06
	Above 150	0.46	0.80	0.64	0.25	0.16	0.11	0.07	0.02	0.01	0.00
SE	Above 730	0.04	0.47	0.64	0.53	0.27	0.21	0.16	0.12	0.10	0.08
	Above 150	0.00	0.57	0.84	0.69	0.30	0.17	0.09	0.04	0.02	0.00
S	Above 730	0.06	0.23	0.51	0.66	0.64	0.42	0.22	0.17	0.13	0.11
	Above 150	0.10	0.43	0.77	0.88	0.56	0.24	0.11	0.05	0.02	0.01
SW	Above 730	0.08	0.09	0.11	0.39	0.68	0.61	0.23	0.18	0.14	0.11
	Above 150	0.03	0.06	0.07	0.47	0.81	0.79	0.26	0.12	0.05	0.03
W	Above 730	0.08	0.09	0.10	0.10	0.36	0.63	0.55	0.19	0.15	0.12
	Above 150	0.03	0.06	0.08	0.08	0.42	0.81	0.74	0.19	0.09	0.05
NW	Above 730	0.08	0.10	0.10	0.10	0.16	0.49	0.60	0.17	0.13	0.10
	Above 150	0.03	0.07	0.09	0.10	0.17	0.63	0.79	0.18	0.09	0.04
N (sunless)	Above 730	0.08	0.67	0.74	0.79	0.83	0.86	0.88	0.26	0.20	0.17
	Above 150	0.00	0.74	0.88	0.94	0.93	0.98	0.99	0.17	0.08	0.04

Table 2-9 heat reserving modulus within 12 hours (with curtain and constant temperature)

direction	weight (kg/m^2 ground area)	A.M.			P.M.		
		6	8	10	12	2	4
NE	730	0.59	0.62	0.33	0.25	0.22	0.20
	490	0.59	0.64	0.35	0.24	0.20	0.17
	150	0.62	0.75	0.37	0.16	0.15	0.12
E	730	0.51	0.71	0.57	0.29	0.25	0.21
	490	0.52	0.73	0.58	0.29	0.24	0.19
	150	0.53	0.82	0.65	0.25	0.16	0.11
SE	730	0.20	0.59	0.74	0.61	0.33	0.26
	490	0.18	0.57	0.75	0.63	0.34	0.20
	150	0.09	0.61	0.86	0.69	0.30	0.17
S	730	0.28	0.40	0.64	0.77	0.73	0.49
	490	0.26	0.38	0.64	0.79	0.77	0.51
	150	0.21	0.48	0.79	0.89	0.56	0.24
SW	730	0.31	0.27	0.25	0.50	0.72	0.69
	490	0.33	0.25	0.24	0.50	0.74	0.70
	150	0.29	0.18	0.14	0.50	0.82	0.79
W	730	0.63	0.28	0.25	0.22	0.46	0.71
	490	0.63	0.28	0.24	0.20	0.44	0.72
	150	0.77	0.25	0.17	0.13	0.44	0.82
NW	730	0.68	0.27	0.23	0.20	0.24	0.56
	490	0.71	0.27	0.22	0.19	0.23	0.58
	150	0.82	0.25	0.18	0.14	0.19	0.64
N (sunless)	730	0.96	0.96	0.96	0.96	0.96	0.96
	490	0.98	0.98	0.98	0.98	0.96	0.96
	150	1.00	1.00	1.00	1.00	1.00	1.00

The heat to the window by the sun radiation has heat reserving effect for indoor material and can be reckoned in the strict calculation of the temperature decreasing loads. It can be calculated in the following formula:

$$Qg=F \cdot Igmax/q_1 \cdot q_2 \qquad (2 \cdot 2)$$

In the formula: Igmas= the highest value the sunlight radiation within one day on this direction (w/m^2)

q_2= the heat reserving modulus (see table 2-8, 2-9)

2-2 wall and roof radiation and heat conducting capacity

The radiation and heat conducting of the wall and roof of the construction structure are taken simultaneously. So in the calculation, it is the summation of the radiation heat and conductive heat.

In the heat reserving modulus, the formula for calculation of the construction ground weight (kg/m²) is as follows:
with wall:

$$\frac{\text{(wall weight)} + 1/2\ \text{(partition wall, ceiling, ground weight)}}{\text{(the room ground area)}}$$

without walls:

$$\frac{\text{(1/2 (partition wall, ceiling, ground weight)}}{\text{(the room ground area)}}$$

the bottom floor:

$$\frac{\text{(wall weight)} + \text{ground weight} + 1/2\ \text{(partition wall, ceiling)}}{\text{(the room ground area)}}$$

all construction area:

$$\frac{\text{(wall, partition wall, ground, ceiling and the structure body weight)}}{\text{(the room ground area to part of)}}$$

If there is insulation on the floor, since it helps to reserve the temperature, add the ground area weight by 1/2.

1、 The calculation formula

Normally, the structure of the walls and roofs is formed by several parallel walls as shown in Fig.2-2. The heat was transmitted to indoors through several walls. The temperature difference between the indoor and outdoors is mainly caused by the conductive heat from the sunlight and the sun radiation heat. The calculation of the radiation heat and the conductive heat can be taken in the following formula:

$Q=kF\Delta te$ ……………………………………………………………………(2 3)

In the formula: Q- the heat caused by the radiation and the conductive heat (W)
F- the area of the wall and roof (m²)
Δ te- relative outside temperature difference(℃)
k- heat conduction modulus (W/m²)

The relative outside temperature difference Δ te is related to the sun irradiation temperature, wall attenuation modulus, outside temperature and indoor temperature, and it also has relation with the structure of the wall and roof.

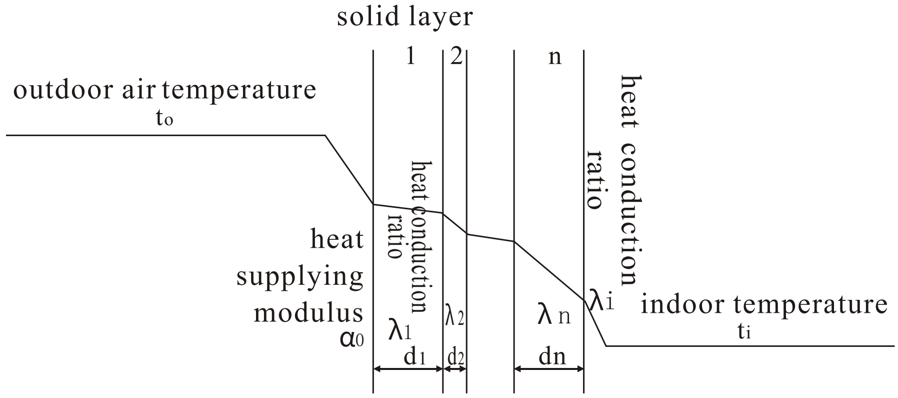


Fig.2-2

Table 2-10 Glass synthesis shield modulus

glass category	glass modulus (no shield)	inner side (sheet shutter)			inner side (rotiform shutter)			out side (sheet shutter)		inner side (sheet shutter)	
		bright color	demitint	dark	bright color	demitint	dark	bright	out side bright inner side bright	bright	demitint dark
normal glass	1.00	0.56	0.65	0.75	0.41	0.62	0.81	0.15	0.13	0.20	0.25
thick glass (6mm)	0.94	0.56	0.65	0.74	0.41	0.62	0.80	0.14	0.12	0.19	0.24
endothermic glass 40-80%	0.80	0.56	0.62	0.72	0.41	0.59	0.78	0.16	0.11	0.16	0.20
endothermic ratio (48-56%)	0.73	0.53	0.59	0.63	0.39	0.56	0.68	0.11	0.10	0.15	0.18
endothermic ratio (56-70%)	0.62	0.51	0.54	0.56	0.37	0.51	0.61	0.10	0.10	0.12	0.16
double layer glass	0.90	0.51	0.62	0.67	0.37	0.58	0.73	0.14	0.12	0.18	0.22
normal glass thick glass	0.80	0.53	0.59	0.65	0.39	0.56	0.70	0.12	0.11	0.16	0.20
[out side endothermic (45-56%)]	0.52	0.36	0.39	0.43	0.26	0.37	0.47	0.10	0.10	0.10	0.13
[inner side normal glass (48-56%)] inner side thick glass	0.50	0.36	0.39	0.43	0.26	0.37	0.47	0.10	0.10	0.10	0.12
glass with paint											
bright color	0.28										
demitint	0.39										
dark color	0.50										
colorful glassdarkcolor	0.56										
transparent green	0.46										

Note: 1) wind speed 2.2m/sec, sunlight degree at 30°
2) when shedding from the light, the top of the two sides should have ventilation, and when shedding the outside of the window by canvas, the value is 1.4 times.

The conductive heat value can calculated by the following formula:

$$k = \frac{1}{\frac{1}{a_i} + \frac{d_1}{\lambda_1} + \frac{d_2}{\lambda_2} + \cdots\cdots\cdots\cdots + \frac{d_n}{\lambda_n} + \frac{1}{a_o} + \frac{1}{a_a}} \cdots\cdots (2.4)$$

In the formula:

a_i= the heat exchange modulus of the indoor surface (W/m^2•℃)

λ = the heat conduction ratio of different construction material (W/m•℃)

d= the thickness of different material(m)

a_o= the heat exchange modulus of the outdoor surface (W/m^2•℃)

a_a= the heat exchange modulus of the air (W/m^2•℃)

a_i, a_o and a_a as shown in table 2-11. The heat conduction ratio λ of different construction material is listed in relative tables in this chapter. The heat conduction ratio of glass can be seen in table 2-12.

Table 2-11 the heat exchange modulus of the indoor surface (W/m^2 ℃)

surface position	thermal current direction	α_i (stillness air)		α_o		aero sphere α_a
		normal material (e=0.9)	aluminum foil (B=0.05)	wind speed (6.7m/s)	wind speed (3.3m/s)	thickness mm 20 38 100
horizontal	upward	9.26	4.31	34.0	22.7	winter··········· 6.69 summer··········· 7.27
vertical	flat	8.29	3.35			winter ··········· 5.85 summer ··········· 6.58
horizontal	downward	6.13	1.24			winter5.56 4.94 4.59 summer 6.69 6.07 5.73

(the e value in the table is the surface radiation ratio)

Table 2-12 Glass window heat conduction modulus kg value (W/m^2 ℃)

glass type	vertical	horizontal
1 layer glass	6.42	summer······ 4.88 winter······ 7.95
2 layer glass air layer 20mm~100mm	3.00	—
air layer 13mm	3.12	—
air layer 6mm		summer······ 2.84 winter······ 3.97
3 layer glass air layer 20mm~100mm	1.93	
air layer 13mm	2.04	
air layer 6mm	2.33	
glass piece 150×150×100	3.40	
200×200×100	3.16	
300×300×100	2.95	

2 The heat conduction modulus of several representative walls

Table 2-13 The heat conduction modulus of several representative walls (W/m² •)

wall structure		unit area weight (kg/m²)	summer	winter
structure	concrete layer (mm)			
outside surface with tile outside surface with sand mortar concrete (main structure) inner side sand mortar lime decoration	120 150 200 250	335 400 510 620	4.00 3.73 3.34 3.04	4.24 3.94 3.51 3.17

3 The heat conduction modulus of several representative roofs

Table 2-14 The heat conduction modulus of several representative roofs (W/m² •)

roof structure			unit area equivalent weight (kg/ m²)	summer	winter
wood, side roof, 12mm high pressure ceiling			40	1.91	2.20
concrete (main structure water proof sand mortar)	concrete thickness 100mm	with ceiling	275	1.90	2.19
		without ceiling	305	3.37	4.41
	concrete thickness 150mm	with ceiling	385	1.79	2.05
		without ceiling	415	3.06	3.88
out side water proof sand mottar 20mm cinder condrete 60 mm pitch 10mmm concrete (main structure)	concrete thickness 120mm	with ceiling	490	1.65	1.81
		without ceiling	520	2.65	3.11
	concrete thickness 150mm	with ceiling	555	1.62	1.76
		without ceiling	590	2.54	2.93

"with ceiling " condition: there is air below the concrete, ceiling uses 12mm high pressure paper board

"without ceiling" condition: below concrete is 15mm sand mortar and 3mm lime decoration.

4、 the corresponding outside temperature difference △ te value (table 2-15)

Table 2-15 the corresponding outside temperature difference △ te value (℃)

structure		direction	A.M. 8		10		noon		P.M. 2		4		6		8	
unit area weight	structure sample		D	L	D	L	D	L	D	L	D	L	D	L	D	
100kg/m²	wood structure	NE	10.9	4.2	12.0	5.4	6.5	4.2	5.4	4.2	6.5	6.5	6.5	6.5	4.2	4.2
		E	15.3	6.5	18.7	8.7	16.4	7.6	5.4	5.4	6.5	6.5	6.5	6.5	4.2	4.2
		SE	6.0	2.0	13.1	7.6	14.2	8.7	12.0	7.6	7.6	6.5	6.5	6.5	4.2	4.2
		S	-3.5	-3.5	0.7	-1.3	10.9	5.4	15.3	9.8	13.1	9.8	7.6	6.5	4.2	4.2
		SW	-3.5	-3.5	-1.3	-2.4	2.0	0.9	13.1	10.9	20.9	14.2	22.0	14.2	12.0	9.5
		W	-3.5	-3.5	-1.3	-1.3	2.0	2.0	9.8	5.4	20.9	14.2	25.4	17.6	10.9	10.9
		NW	-3.5	-3.5	-1.3	-2.4	3.0	0.9	5.4	4.2	12.0	9.8	20.9	13.1	17.6	12.0
		N	-3.5	-3.5	-2.4	-2.4	0.9	0.9	4.2	4.2	6.5	5.5	5.4	5.4	3.1	3.1
300kg/m²	wood structure	NE	-2.4	-3.5	12.0	5.4	9.7	4.3	4.3	2.0	5.4	4.3	6.5	6.5	5.4	5.4
		E	-0.2	-1.3	15.4	6.5	15.9	8.1	6.5	6.5	5.4	5.4	6.5	6.5	5.4	5.4
		SE	-0.2	-2.4	9.8	4.3	14.3	7.6	13.1	7.6	8.7	6.5	6.5	6.5	5.4	5.4
		S	-3.5	-3.5	-2.4	-2.4	5.4	2.0	12.0	7.6	13.1	8.7	9.8	7.6	5.4	5.4
	10cm stone wall	SW	-1.3	-2.4	-1.3	-2.4	-0.2	-0.2	5.4	3.1	16.5	10.9	18.7	13.1	17.6	12.0
		W	-1.3	-2.4	-1.3	-1.4	0.9	-0.2	4.3	3.1	13.1	8.7	20.9	14.3	22.0	14.3
		NW	-3.5	-3.5	-2.4	-2.3	-0.2	-0.2	3.1	2.0	5.4	5.4	15.4	10.3	17.6	12.0
		N	-3.5	-3.5	-2.4	-2.4	-1.3	-1.3	2.0	2.0	4.3	4.3	5.4	5.4	5.6	5.6
500kg/m²	20cm concrete and stone wall	NE	0.9	-0.2	0.9	-1.3	7.6	3.1	6.5	3.1	4.2	2.0	5.4	3.1	5.4	4.2
		E	2.0	0.9	6.5	3.1	12.0	5.4	12.0	5.4	8.7	4.2	6.5	4.2	6.5	4.2
		SE	2.0	-0.2	2.0	0.9	7.6	4.2	8.7	5.4	8.7	5.4	6.5	5.4	5.4	4.2
		S	-0.2	-0.8	-0.2	-0.8	0.9	-0.8	5.4	2.0	7.6	5.4	8.7	5.4	6.5	5.4
	15-20cm concrete laying	SW	2.0	-0.2	0.9	-0.2	2.0	-0.2	3.1	0.9	6.5	4.2	10.9	7.6	12.0	7.6
		W	2.0	0.9	2.0	0.9	2.0	0.9	3.1	2.0	5.4	3.1	9.8	6.5	14.2	8.7
		NW	0.9	-0.2	0.9	-1.3	0.9	-0.2	0.9	0.9	2.0	2.0	5.4	4.2	9.8	6.5
		N	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-0.2	-0.2	0.9	0.9	2.0	2.0	3.1	3.1
		NE	2.0	0.9	2.0	-0.2	2.0	-0.2	6.5	3.1	6.5	3.1	4.2	3.1	4.2	3.1
750kg/m²	30cm concrete and stone wall	E	4.2	2.0	3.1	2.0	4.2	2.0	8.7	4.2	8.7	5.4	7.6	4.2	5.4	4.2
		SE	3.1	0.9	3.1	0.9	2.0	0.9	6.5	3.1	7.6	4.2	7.6	4.2	6.5	4.2
		S	2.0	0.9	0.9	-0.2	0.9	-0.2	0.9	-0.2	4.2	2.0	6.5	4.2	7.6	5.4
		SW	3.1	0.9	3.1	0.9	2.0	0.9	2.0	0.9	3.1	2.0	4.2	3.1	8.7	6.5
		W	4.2	2.0	3.1	2.0	3.1	2.0	4.2	1.0	4.2	1.0	5.4	3.1	7.6	4.2
		NW	2.0	0.9	2.0	-0.2	2.0	-0.2	2.0	0.9	2.0	0.9	3.1	2.0	4.2	3.1
		N	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-1.3	-2.0	-2.0	0.9	0.9	2.0	2.0

note: (1)The above table is the combination of the USA warming and cooling air condition engineer guide book in 1963 and the Modern Air Conditioning by Carrier. Its condition is north altitude 37° , July, the highest temperature difference between indoors and outdoors is 7℃ (highest outdoor temperature 33℃ , indoor temperature 26℃)

(2)If the highest temperature difference is not 7℃ , make increase or decrease accordingly on the basis of the above ratio.

(3)In the table, "D" means the out side wall is in dark, the 90% of sun radiation is absorbed, and 10% is reflected."L" is bright color, when it is a stable color, 50% is absorbed, 50% reflected. demitint is the value between the above two.

5、 The outside temperature difference of the roof

Table 2-16 The corresponding outside temperature difference of the roof △ te (℃)

state	structure: unit area weight	structure: structure sample	A.M. 8	10	noon 12	P.M. 2	4	6	8	10
roof with direct sunlight	50kg/	wood board 25cm + insulation 0-5cm	5.4	19.5	28.7	33.1	26.4	13.2	4.2	0.9
	80kg/	concrete 5cm + + insulation 0-5cm	2.0	15.3	25.3	30.9	26.4	16.4	6.5	2.0
	100kg/	wood board 2.5-5cm concrete 5cm + insulation 10cm	-1.3	9.8	20.9	27.7	28.7	22.0	9.8	4.2
	200kg/	concrete 10cm + insulation 0-5cm	-1.3	9.8	19.8	26.4	27.7	0.91	0.9	5.4
	300kg/	concrete 15 cm	0.9	2.0	12.0	19.8	24.2	23.2	16.4	8.7
	400kg/	concrete 15cm + insulation 5 cm	2.0	2.0	9.8	17.5	22.0	23.2	17.5	9.8
roof with sunlight shadow	100kg/	light structure	-3.5	-1.3	2.0	5.4	6.5	5.4	3.1	-0.2
	200kg/	medium structure	-3.5	-2.4	-0.2	3.1	5.4	5.4	4.2	2.0
	300kg/	heavy structure	-2.4	-2.4	-1.3	0.9	3.1	4.1	4.2	3.1

(1) the highest temperature difference between indoors and outdoors in the table is 7℃ , if the difference is not the same, the figures in the table should be increased or decreased accordingly.

(2)If the roof color is dark, use the figure in the table. If it is bright color, use the minimum value.

(3)The heat of the roof with slope is mainly from radiation, and the roof area should be calculated as horizontal cast area.

(4)If there is insulation for the ceiling or there is blower for ventilation, the temperature difference of the area with direct sunlight can be decreased by 25%.

6、 heat exchange modulus of the standard surface

Table 2-17 heat exchange modulus of the standard surface a (W/m² ℃)

surface	category	winter	summer	
dark roof	inner side	9.3	6.2	average wind speed (1)3.5 m/sec (2)7 m/sec
roof	outside	33.5 (2)	22.7 (1)	
wall	inner side	8.4	8.4	
wall	outside	33.5	22.7 (1)	

7、 heat exchange modulus and thermal resistance of the stillness air (air conditioner)

Table 2-18 heat exchange modulus (W/m² ℃) and thermal resistance (m²℃ /W)of the stillness air (air conditioner)

surface 45° slope position	heat current direction	radiation ratio					
		0.90		0.20		0.05	
		a	1/2	*a*	1/2	*a*	1/2
horizontal	upward	9.26	0.145	5.29	0.256	4.31	0.314
45° slope	upward	9.08	0.148	5.00	0.271	4.14	0.327
vertical	flat	8.29	0.162	4.21	0.321	3.35	0.405
	downward	7.50	0.181	3.41	0.401	2.56	0.529
horizontal	downward	6.13	0.219	2.11	0.642	1.24	1.084

8 Heat conduction ratio of various material

The following table shows heat conduction ratio the material in common use in construction

Table 2-19 Heat conduction ratio of various material λ (W/m •℃)

material	λ (W/m℃)		(kg/m³)	reference
	λi (1)	λo (2)	density	
Copper plate Zinc-plated iron plate Aluminum plate	372 44 204	372 44 204	8300 7860 2700	
Granite Marble Limestone Valley rock Sandstone Lava Lava	3.0 2.8 2.1 1.3 1.6~2.1 0.30 0.14	3.0 2.8 2.1 1.4 1.6~2.1	2600~2900 2500~2700 2170 1400~1900 2150~2300 900~950 600~680	
Soil Sand Sand scree Sand + sand scree Concrete Concrete have been shaken and strengthened 〃 〃 〃 Epispastic concrete Cement mortar 〃 sawdust mortar 〃 〃 pearlite mortar 〃 vermiculite mortar 〃 〃	0.37 0.52 0.60 0.47 0.79 1.73 1.5 2.2 0.27 0.47 0.67 0.8 0.23~0.35 1.4 0.72 0.20 0.23 0.21 0.30 0.101 0 0.84 0.074	– – 0.65 0.53 0.91 – 1.6 2.3 – 0.48 0.69 0.84 – 1.5 – – – – – – – – –	1600 1300~1900 1890 1700 1850 2244 2200 2400 800 1350 1720 1780~1980 500~800 2110 1860 730 810 918 1142 1234 1024 901	Cement concrete use Lava sand scree surface, normal sand Lava sand scree, normal sand Cinder, brick, sand scree, normal sand Composition: Cement:1 lime sawdust 5 Cement:1 lime 1 sawdust 4 Cement:1 pearlite 3 Cement:1 pearlite 2 Cement:1 lime vermiculite 2 Cement:1 lime vermiculite 3 Cement:1 lime vermiculite 4
Cement mortar Gesso mortar (light frame material) 〃 vermiculite mortar zeolite mortar lime piece (wood) + mortar mortar + lime piece (wood)	0.72 0.21 0.58 0.12 0.035 0.314 0.267	– – 0.60 – 1.63 0.34 –	1959 721 1940 950 – – –	Mortar 1, vermiculite 1 or asbestos lime piece 1cm, mortar 1.5cm~1.9cm
Brick wall 〃 Brick	0.60 0.72 0.72	0.64 0.78 –	1660 1800~1900 1924	
Hard wood Soft wood Pine Fir veneer	0.16 0.12 0.16 0.128 0.14	– – 0.17 0.14 0.14	721 513 430~480 330~360 545~560	
Brick, tile Tile for floor Terrazzo Mix mucus brick	1.28 1.80 1.80 0.39	1.28 1.80 1.80 –	2400 – – 1780	0.6~1.0cm 1.5~2.0cm 2.5cm 2.5cm

Table 2-19 Heat conduction ratio of various material λ (W/m·℃)

material	λ (W/m℃)		(kg/m³)	reference
	λi (1)	λo (2)	density	
Pitch brick (for floor)	0.44	—	1924	
Base brick	0.32	—	1830	
Soft wood board	0.038	—	104～128	
〃	0.044～0.051	—	160～240	
Soft wood board for floor	0.065	—	401	
Carbonized soft wood plate	0.058	—	250	
〃	0.046～0.052	—	100～160	
Carbonized soft wood plate	0.10	0.13	230	4.8×5.3×6.0
Gesso plate	0.20	0.22	860	
〃	0.015～0.017	—	820	0.9～1.2
Asbestos plate	0.26	—	1150	
Asbestos and cement plate	1.40	1.5	2240	Dement 68:32
Thick paper	0.21		700	
	0.041～0.038	—		
Nitryl fiber Bakelite plate (electrical wood plate)	2.15 0.039	—	1400	Lamination plate (stuffed with cloth and paper)
	0.29～0.36 0.047	—	1300～1350	
methacrylic acid ester (organic glass)	0.16～0.26 0.035	—	1180～1190	
Polystyrene plate (epispastic)		—	20~30	
Polystyrene tube (epispastic)	0.73～0.76	—	25~35	30±5℃
Bakelite resin plate (epispastic)	0.044 0.060	—	60	
Aldehyde epispastic plate	0.049	—	19	
Pitch	0.062 0.116	0.73～0.76	2120～2230	
Asbestos	0.042	0.044	100～200	
Asbestos like cotton	0.036	0.060	300	
Plate asbestos		0.049	257	
〃		0.062	330	
〃		0.116	720	
Glass cotton		0.042	200	
Glass cotton plate		0.036	152	
Glass cotton plate	0.041	0.042	300	
Scoria cotton	0.046	0.046	300	
Window glass	0.79	0.79	2540	
Epispastic glass structure	0.073～0.076	—	195～220	
Light silicon dioxide	0.065	0.065	350	
Vermiculite	0.14	—	330	
〃	0.036	—	180～220	20℃
〃	0.07	—	112	
Pearlite (for rendering)	0.22	—	720	
〃	0.08	—	300	Average 0.29
Cinder (coal)	0.23	0.26	500	
〃	0.41	0.44	1000	

Note: (1)inner side use (air conditioning humidity 60-70%)

(2)Out side use (air conditioning humidity 80-90%)

9 The heat conduction modulus of several insulation material W/m℃
Table 2-20

material	Quality & shape	proportion (g/ 3)	Safety temperature ℃	heat conduction modulus λ_t (t··· Average temperature℃)	λ_{10}
ox hair, wool	(ox hair 50, other hair 30, plant fiber 20)	0.135 0.135	100 100	0.0337+0.000133 t 0.0335+0.000130 t	0.0407 0.0405
Hemp	jute processed by combing machine, add agglutinant to adhere the curl	0.169 0.160 0.160	100 70 70	0.0369+0.000137 t 0.0355+0.000130 t 0.034+0.0012 t	0.0444 0.0405 0.0409
Carbonized soft wood plate	granule granule one side carbonized overheat, vapor carbonized	0.159 0.186 0.160 0.118	130 130 130 130	0.0368+0.000079 t 0.0381+0.000079 t 0.0340+0.00009 t 0.0355+0.00010 t	0.0437 0.0452 0.0406 0.0424
molding polystyrene	air in the foam, EGK black non continuous foam air in the foam, red continuous foam	0.184 0.170	450 450	0.0408+0.000180 t 0.0408+0.000138 t	0.0494 0.0491
polyurethane (soft)	tap open, continuous foam	0.080 0.060 0.033	200 200 200	0.0325+0.000136 t 0.0273+0.000114 t 0.0290+0.000150 t	0.0397 0.0330 0.0355
polyurethane (hard)	tap close, R-11 foaming water foaming R-11 foaming water foaming	0.027 0.080 0.030 0.036	200 200 200 100	0.0180+0.000123t 0.0325+0.000136 t 0.016+0.00013 t 0.025+0.00013 t	0.0223 0.0394 0.0201 0.0306
asbestos insulation plate	normal insulation plate	0.268 0.275	400 400	0.037+0.00012 t 0.037+0.00012 t	0.0444 0.0444

10 the heat resistance of the cement concrete with empty hole d/ (·℃ /W)
Table 2-21

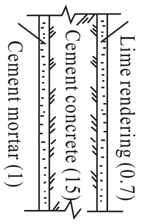
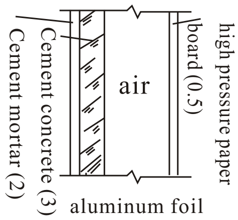
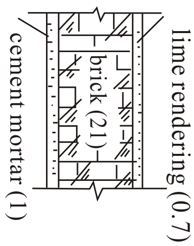
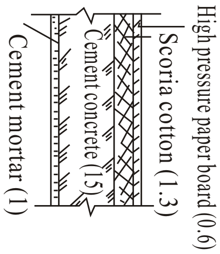
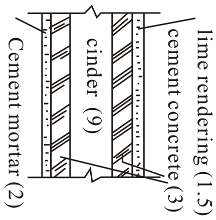
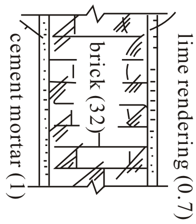
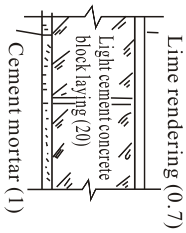
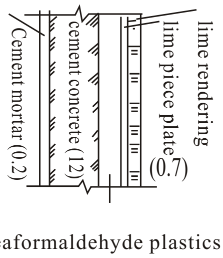
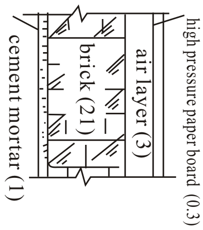
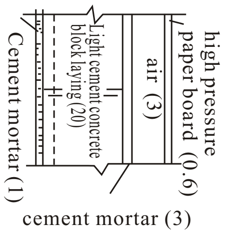
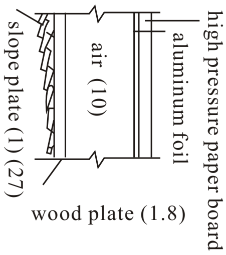
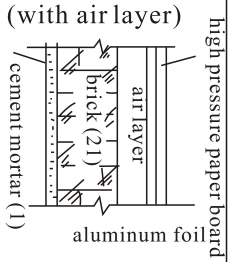
category	Thickness (cm)	3 oval empty holes		Filling the hole as doing with the left		3 oval BI empty holes concrete (cm)
		Inner side	Out side	Inner side	Out side	
Heavy concrete block (dry air ball proportion 2.3)	10 15 20	0.17 0.19 0.21	0.14 0.15 0.17	0.08 0.12 0.15	0.07 0.11 0.147	0.169 (10) 0.264 (20)
Light concrete block with empty hole (dry air ball proportion 1.8)	10 15 20	0.23 0.28 0.32	0.19 0.22 0.26	0.14 0.20 0.27	0.11 0.19 0.18	Cinder as main material 0.264 (10) 0.409 (20)
Light concrete block with empty hole (air dry ball proportion 1.5)	10 15 20	0.28 0.35 0.41	0.22 0.27 0.32	0.18 0.27 0.35	0.14 0.21 0.28	Light material 0.357 (10)
Light concrete block with empty hole (air dry ball proportion 1.2)	10 15 20	0.28 0.36 0.42	0.22 0.27 0.32	0.19 0.27 0.35	0.15 0.22 0.28	0.477 (20)

11 The heat conduction modulus of the roof
Table 2-22

category	λ (W/m℃)	Thickness (cm)	Reference
Zinc-plated plate	0.07~0.09	1.1~1.8	Pine halftone plate (1cm) + pitch water proof paper (1mm)+ laying material
Coppered plate	0.09~0.10	1.2~1.3	
Natural stone plate	0.14~0.17	1.8~2.9	
Asbestos plate	0.16~0.17	2.3~2.8	
Weave shape plate	0.05	3.4	
tile	0.29~0.36	7.4~7.6	Wood halftone + pitch water proof paper + tile

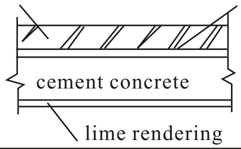
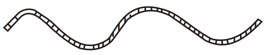
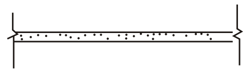
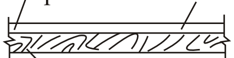
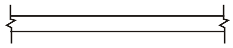
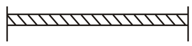
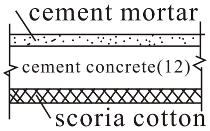
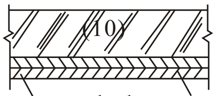
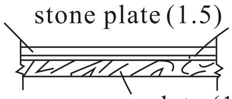
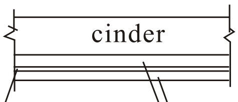
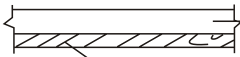
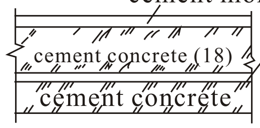
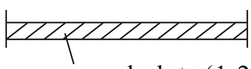
12 The heat conduction modulus of various type of walls

The following drawing 2-3 lists the heat conduction modulus (k value) of various type of walls (W/m²℃)

structure	Thick (cm)	*k*	structure	Thick (cm)	*k*	structure	Thick (cm)	*k*
Cement concrete wall 	17	4.1	assembled Cement concrete wall 	18	2.0	brick wall 	23	1.7
Cement concrete wall 	18	1.9	assembled Cement concrete wall 	19	1.7	brick wall 	34	1.1
Light cement concrete block laying wall 	18	1.9	assembled Cement concrete wall 	17.4	0.99	brick wall (with air layer) 	25	1.3
Light cement concrete block laying wall 	25	1.1	assembled Cement concrete wall 	13	1.5	brick wall (with air layer) 	26	1.0

13 The heat conduction modulus of various roofs and ceilings

Drawing 2-4 The heat conduction modulus(k value) of various ck value roofs and ceilings(W/m^2)

structure	Thick (cm)	*k*	structure	Thick (cm)	*k*
wave shaped zinc-plated steel plate roof 		12		19	3.3
wave shape tile roof 	0.6	11	paint ceiling 	2.4	3.1
zinc-plated steel plate roof 	1.5	5.0	sugar cane pressed plate ceiling 	1.3	2.8
veneer ceiling 	0.3	4.9	cement concrete ceiling 	15	2.4
plate ceiling 	0.7	4.3	plate ceiling 	13	2.0
stone plate roof 	2.7	4.8	plate ceiling 	8	1.9
soil tile roof 	3.2	4.0	cement concrete ceiling 	32	1.9
nailed ceiling 	1.2	4.0			

2-3 heat conduction from other parts

There are also partition walls and floor ceiling in the surrounding construction structure:

1 Glass window

Table 2-23-1 The heat conduction modulus (k) of several representative glass windows (W/m^2)

category	heat conduction modulus k	category	heat conduction modulus k
one layer glass (winter)	6.42	three layer glass (air layer thickness 13mm)	3.12
(summer)	5.91	(air layer thickness 20mm)	3.01
two layer glass (air layer thickness 6mm)	3.49	glass block (average)	3.17

In the table, the modulus is under the condition of the temperature difference between indoors and outdoors without the radiation, it is calculated on the basis of the outdoor dry bulb temperature.

2 Partition wall

Table 2-23-2 The heat conduction modulus of representative partition walls (W/m^2)

partition wall structure			unit area weight	*k*
main structure cement concrete or	cement concrete	100mm	$290kg/m^2$	3.31
cement concrete laying block		120mm	$335kg/m^2$	3.19
two sides cement mortar 15mm	cement concrete laying block	100mm	$210kg/m^2$	2.28
lime rendering mm		150mm	$240kg/m^2$	2.09
wood one layer wall two sides lime piece with lime rendering			$20kg/m^2$	2.90
wood two layer wall (empty in center) two sides lime piece with lime rendering			$40kg/m^2$	1.59

Relations with neighbors:

If neighbor has temperature decreasing (cooling) equipments, partition can be excluded from the calculation.

No temperature decreasing (cooling) equipments in neighbor:

With the info of neighbor room temperature: temperature difference = neighbor temperature indoor temperature

Without the info neighbor room temperature: temperature difference = outside air temperature (2~3℃) - indoor temperature

Neighbor room is kitchen or vapor boiler room: temperature difference = (35~40℃) - indoor temperature

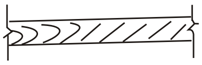
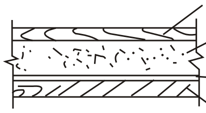
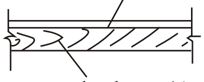
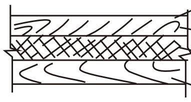
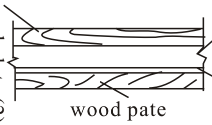
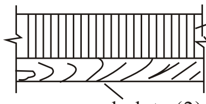
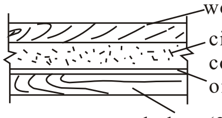
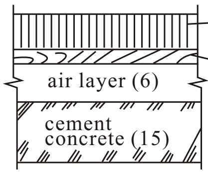
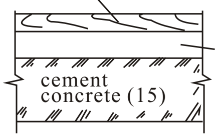
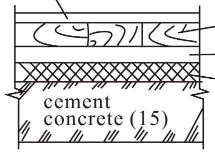
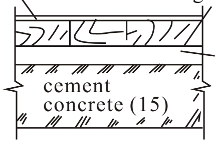
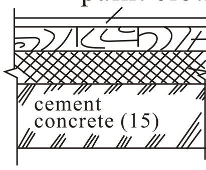
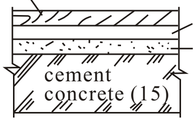
3 Heat conduction modulus of roof and ceiling

Table 2-24 The heat conduction modulus of roof and ceiling

ceiling, floor				unit area weight (kg/m^2)	upward warm current	downward warm current
(wood plate)	edge plate (10mm) floor plate (18mm) air layer ceiling plate (floor is high pressure paper board 12mm)			110	1.58	1.35
pitch plate (tile) 5mm mortar 15mm cement concrete (main structure) with ceiling air layer, high pressure paper board 12mm no ceiling mortar 15mm with 3mm mortar on it		cement concrete 100mm	with roof	270	1.83	1.52
			without roof	300	2.15	2.34
		cement concrete 150mm	with roof	380	1.72	1.45
			without roof	410	2.90	2.19

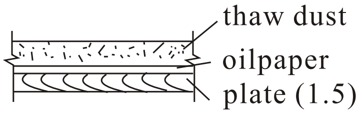
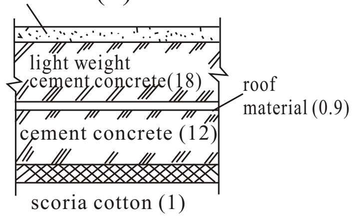
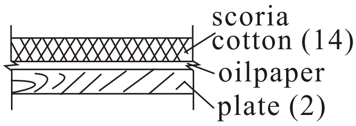
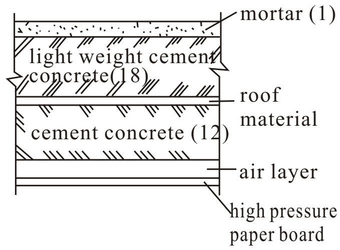
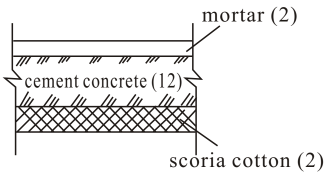
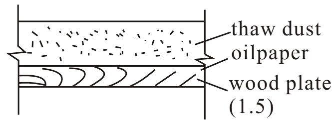
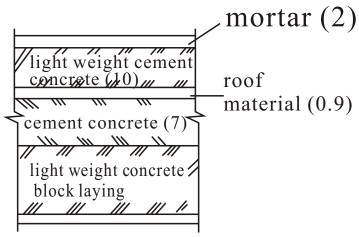
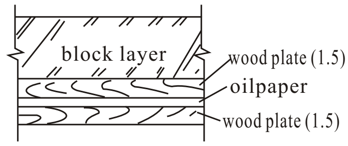
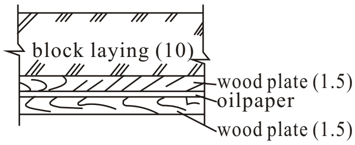
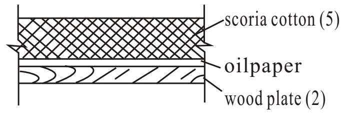
floor

Fig. 2-5 heat conduction modulus of various floors

structure	Thick (cm)	*k*	structure	Thick (cm)	*k*
wood floor 	1.4	3.8	wood floor 	13	1.4
paved wood floor 	1.7	3.4	wood floor 	6.5	1.3
double plate floor 	9.2	1.9	straw mattress floor 	7.2	1.0
plate floor 	8.0	1.7	cement concrete floor 	28	0.77
cement concrete floor 	23	1.7	cement concrete floor 	23	0.9
cement concrete floor 	23	1.7	cement concrete floor 	23	0.77
cement concrete floor 	23	1.5			

ceiling

Drawing 2-6 Heat conduct modulus of various ceiling (W/m²℃)

structure	Thick (cm)	*k*	structure	Thick (cm)	*k*
plate ceiling 	4.5	1.7	cement concrete ceiling 	33	1.4
plate ceiling 	3.5	1.7		36	1.4
cement concrete ceiling 	16	1.7	wood plate ceiling 	7.5	1.15
light weight block laying ceiling 	30	1.5	wood plate ceiling 	18	1.14
plate extension ceiling 	13	1.4		7	0.84

temperature condition of upper and lower floor:

both upper and lower floor has temperature decreasing (cooling) and temperature increasing (warming) equipments, ceiling can be excluded in the calculation

only lower floor has temperature decreasing (cooling) and temperature increasing (warming) equipments, floor can be excluded in the calculation

neither upper nor lower floor has temperature decreasing (cooling) and temperature increasing (warming) equipments, the calculation can be made according to the temperature difference calculation method of partition wall

2-4 ventilation and leak of wind

It is indispensably that the air conditioning area must have the supply of a certain quantity of fresh air (fresh wind), and we call it "ventilation". If there is not enough ventilation, the people in the room will feel headache and giddy, etc. People who stay in the area with shortage of ventilation for a long time are easy to get sick. From the point of the construction, the air conditioning room has a high requirement of the airtight, and the fresh air is not easy to come in, so ventilation is very important. Actually, fresh air continuously leaks from the gap of the windows and doors, and in normal calculation, the air leakage quantity is larger than ventilation quantity. (some special rooms such as surgery room, high precision, and no dust constant temperature room, etc. only use processed fresh air.)

There are two kinds of ventilation procedures: the return system uses the current indoor air circulation to decrease temperature (or increase temperature), with addition of some fresh air. This is energy saving for the running of the air conditioning equipment. If it can reach the sanitary requirement, the return wind system should be the first choice. The other kind is called direct current system. All the air send to the room in this system is processed and it doesn't use return wind. It can only be adopted when there is large quantity of poisonous or flammable gas generating in the room.

There are two ways to realize ventilation: natural ventilation or forced ventilation.

1 Natural ventilation:

The temperature difference between indoor and outdoor forms the pressure difference of the air current, and the air can naturally flow and substitute. The flow is through the passes of the construction, window, door or special ventilation pipe.

The flow of the natural ventilation can be calculated as follows:

In the formula:

$=4.03h (m/s)$ (2 • 5)

$V=C.A.\quad 3600 (m^3/h)$ (2 • 6)

h= pressure difference between indoor and outdoor millimeter water pole height (mmH_2O)

u= air flow speed (m/s)

A= The peristome effective area of the air flow (m^2)

C= flow quantity modulus

When the air flow speed at the peristome is at right angle, the flow quantity modulus C is:

window C=0.6~0.7

gap C= 0.3~0.4

V=air flow quantity cube meter / hour (m^3/h)

When natural ventilation tube (straight tube) is adopted, the pressure difference comes from the air density difference between the inside and outside which is mainly due to the height of the tube. The air in the tube then flows. The air flow speed u caused by the density difference is:

$$\mu = 3.13\sqrt{\frac{H(t_1-t_2)}{273+\frac{t_1-t_2}{2}}}$$

$$= 0.185H(t_1-t_2) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2.7)$$

In the formula:

H- air pole vertical height (m) the vertical distance between the inlet and outlet of the air

t_1- the average temperature at the inside of the tube ℃

t_2- the average temperature at the outside of the tube ℃

This condition can maintain the positive pressure of the indoor air quantity.

During the process of the natural ventilation, the unit for the air pressure difference between indoor and outdoor is millimeter water pole height (mmH_2O). Table 2-25 lists the ventilation frequency of the natural ventilation. The ventilation quantity at the construction surrounding structure gap is neglected.

Table 2-25 Natural ventilation frequency in various rooms
(ventilation quantity per hour = n×indoor cubage)

indoor type	ventilation times n
room with window open to the air	0.5~0.75
meeting room, canteen	1~2
dormitory	0.5
aisle	1
classroom	0.5~3
common workshop	0.5~3
office	0.5~1

2 Forced ventilation:

Every air conditioner is installed with a ventilator, and the air is blown into indoor by the force of the ventilator whether it uses the fresh air or return air. Since the natural ventilation can't process the air (such as the temperature, humidity, cleanliness) , and can't meet the requirement of the air conditioner, forced ventilation can speed up the reaching of the expected requirements. The ventilator should be chosen according to the ventilation conditions, and include the ventilated air in the heat loads calculation. Following is the list of the leakage air quantity from gap and the required fresh new air quantity required by the ventilation.

1 leakage wind from the opening and closing of the door

2-26 The leakage wind quantity required by every one indoors (m^3/h)

room category	type of door	
	revolving door (wide 1.8m)	simple leaf type (0.9m)
office (personal)	—	4.2
office (public)	—	6.0
small shop	11.0	13.5
bank	11.0	13.5
sickroom	—	6.0
drugstore	9.5	12.0
restaurant (open in night)	7.0	8.5
restaurant (canteen)	3.4	4.2
shoe store	4.6	6.0
clothing store	3.4	4.2
barber's	6.8	8.5
smoking room	34.0	50.0

(1)The above figure is on the basis of average frequency of door open and close, and the people number only includes those always in office

(2)the leakage wind quantity is relative to the in and out of people

1 people pass per hour

revolving door …… 2.2 m^3/h

simple leaf door …… 3.4 m^3/h

(3)When the outdoor wind speed reaches 7.5m/s, the door was blown open, and the figure increased by 0.6 times.

2 The standard air quantity (fresh air) required by human body

The fresh air needed by human body is also the fresh new air quantity. The following table lists the figures under different situations:

Table 2-27

places	smoking condition	fresh air quantity needed per person (m^3/h)	
		optimum quantity	minimum quantity
department store	forbidden	13.0	5.5
hospital (surgery room)	forbidden		32
hospital (sickroom)	forbidden	34	calculated per square meter of the room floor
theatre	forbidden	13.0	8.5
office (personal)	forbidden	42.5	25.5
office (personal)	small quantity	51.0	42.5
office (common)	small quantity	25.5	17.0
canteen	small quantity	25.5	20.5
barber's	small quantity	25.5	17.5
bank	small quantity	17.0	13.0
public flat	small quantity	34.0	25.5
hotel	large quantity	51.0	42.5
meeting room	very large quantity	85.0	51.0

(1)As the surgery room uses anesthetic, to prevent explosion, all the wind should be fresh wind from outside

(2)The outside air quantity of the meeting room can be amended as follows:

…… 7.5 (m^3/h) per indoor square meter, underground construction

…… 30 (m^3/h) per indoor square meter

If there is temperature and humidity conditioning, above figures are above 30%.

3 cooling loads

The leakage air and the ventilated fresh air are the cooling loads of the outside air; This loads is sensible heat loads, and can be calculated like following.

Fresh air quantity (including leakage air and ventilated air) cubic meter/hour (m^3/h) ×temperature difference ℃ × 1.214 kilojoule /m^3℃ (kJ/ m^3℃) = cooling loads watt (W)

In the formula: 1.214 is get from the following the formula:

$$\frac{\text{specific heat of the air 1.01 kilojoule /kilogram ℃ (kJ/ kg℃)}}{\text{standard air specific votume 0.83 } m^3 \text{ /kilogram } (m^3/kg)} = 1.214 \text{ kilojoule /}m^3\text{℃ (kJ/ } m^3\text{℃)}$$

The temperature difference refers to the difference between indoor and outdoor

2-5 The indoor heat (sensible heat latent heat)

The heat generated in indoors is mainly two parts: sensible heat and latent heat. The indoor heat is generated from human body, machine, lights and utensils. The following two parts will explain this.

sensible heat:

1、 sensible heat generated by human body

Table 2-28 (W)

action	place room temperature ℃	sensible heat				
		28	27	25.5	24	21
sit quietly	theater	51	57	62	67	76
seated working (light work)	school	52	57	63	70	80
office working walk slowly	office shop	52	58	63	71	83
sit or stand	bank	52	58	64	74	84
sit (dining)	west restaurant	56	64	70	81	93
seated working	factory	56	64	71	86	106
common dance	dance hall	64	71	80	94	116
walk working	factory	78	87	95	110	134
heavy work	factory (heavy work)	131	136	142	154	178

Note: (1) The table is published on ASHRAE guidebook, figure for Asian people should be 80% of the figure.

(2) The heat generated in the west restaurant includes the heat generated by utensils

2、 Sensible heat generated by machinery and equipments

The heat generated by motor driven machines can be calculated as follows:

P: the rated output of motor (kW) 1 kilowatts (kW)

ηm: efficiency of the motor 2~5 kilowatts (kW) ηm at 0.81

7.5~15 kilowatts (kW) ηm at 0.85

15 kilowatts (kW) ηm at 0.88

(1)When the motor and the machine are installed indoors

cooling loads = $P \times \frac{1}{\eta m}$ = input efficiency of the motor kilowatts (kW)

(2)When motor installed outside, machine installed indoors

cooling loads = P = machine shaft horsepower kilowatts (kW)

(3)When motor installed indoors, machine installed outside:

cooling loads = $P \times \frac{1- \ m}{\eta m}$ = input efficiency (kW) × (1- ηm)

3、Sensible heat generated by lights

The heat quantity generated by lights is on the basis of the watts (W) of the lights.

normal incandescent lamp watts (W)

fluorescent lamp 1.25×watts (W)

When using heat discharging lights, only a part of the heat will come indoors. For normally installed lights, if there is heat discharging(to outdoors) condition, for those with cover, the efficiency is 80%, and without cover, the efficiency is 60%.

Table 2-29 lists the figure of the lights per person

4、 The heat generated by indoor utensils

The utensils, various lab apparatus and heating utensils will generate a large quantity of heat in the air conditioning room. This should also be included in the calculation. The following table 2-30 lists the heat quantity generated by the utensils, and table 2-31 lists the heat generating quantity of several flammable gases.

If there is a vapor pipe leading into the air conditioning room, the heat generated by the pipe must be included.

The heat generated can be calculated as follows:

Q=3.14×D×L×k×(tm-tn) watt …………………… (2.8)

In the formula:

D The diameter of the pipe including insulation meter (m)

L length of the insulated the pipe meter (m)

k the heat conduction modulus of the insulated pipe watt / square meter • (W/m^2)

t_m- the temperature of the hot vapor inside the pipe

t_n the air temperature of indoor

Table 2-29 The about value of people and lighting

place	people (m^2/person)	lighting (W/ m^2)
hotel (office)	6.6	10
hotel (personal room)	1.8	10
bank	5.0	20
institution office (underground)	2.3	20
institution office (ground floor)	1.8	30
institution office (top floor)	3.3	20
stock exchange hall	5.0	20
office (personal)	4.1	20
restaurant	1.7	20
store	3.3	20
barber's	3.3	50
theater	0.8	

Note: The lighting is according to the standard of fluorescent lamp, and in comparatively dark public office, increase the lighting to 30~40 (W/ m^2)

Table 2-30 Heat generating quantity of several utensils

name of utensils	sensible heat W
electrical disinfector (15×20×43cm)	790
electrical disinfector (23×25×50cm)	1512
Bunsen burner (city gas , 7/17 inch)	279
bread oven (electrical heat 15×28× height 23cm)	709
gas warming oven for house use	2093
hatch gas oven for house use	2326

Note: If there are forced air discharging on the utensil, the figure in the calculation is 1 2 of the above.

Table 2-31 The heat generating quantity of several flammable gas

name of gas	sensible heat kJ
acetylene	57960
H_2	12818
water gas	10080~10500
carbonized gas	16800~23100
coal oil for lamp	35532
liquefied petroleum gas	41580

Indoor latent heat part

5、 Outdoor air leak into the air conditioning room through the gap of the door and window, and those come into the room during indoor ventilation

Table 2-32 lists the leakage heat quantity of the vapor or warm water pipe

Table 2-32 The leakage heat quantity of the vapor or warm water pipe

watts / ℃ (W / ℃) at 1 meter (m) long pipe

(the insulation is the 85% magnesia for the substitution of asbestos)

pipe inner diameter inch in	insulation thickness (mm)		
	25	38	50
1/2	0.28	0.24	0.21
3/4	0.31	0.26	0.22
1	0.35	0.29	0.26
1 1/4	0.42	0.35	0.29
1 1/2	0.45	0.36	0.31
2	0.52	0.42	0.36
2 1/2	0.60	0.47	0.42
3	0.70	0.56	0.47
3 1/2	0.78	0.60	0.52
4	0.85	0.66	0.57
5	0.97	0.78	0.66
6	1.17	0.91	0.74
8	1.48	1.13	0.92
10	1.80	1.35	1.12

When cooling, the absolute humidity of fresh air in the air conditioning room is usually higher than the air indoors, so the difference of the humidity is expressed by the latent heat loads as follows:

wind quantity m^3/hour (m^3/h) ×absolute humidity difference kilogram dry bulb air (kg/kg') ×3020=latent heat loads watts (W) ······················ (2.9)

In the formula: the conversion coefficient 3020 kJ/ m^3 is calculated by the following:

$$\frac{\text{Water evaporating latent heat } 2507\ (kJ/kg)}{\text{Standard air specific votume } 0.83\ (m^3/kg)} = 3020 \text{ kilojoule/}m^3\ (kJ/m^3) \quad \cdots\cdots (3.10)$$

6 The latent heat generated by human body

Table 2-33 lists the latent heat generated by human body

Table 2-33 the latent heat generated by human body

action	Room temperature (℃) Places	Latent heat				
		28	27	25.5	24	21
sit quietly	theater	51	45	41	35	28
seated working (light work)	school	64	59	53	47	36
office working	office	78	72	67	59	48
walk slowly	shop					
sit or stand	bank	93	87	81	71	62
sit (dining)	west restaurant	105	97	91	79	67
seated working	factory	163	155	148	133	113
common dance	dance hall	184	177	167	154	131
walk working	factory	214	204	195	180	157
heavy work	factory (heavy work)	293	288	284	272	248

Note: (1) The table is published on ASHRAE guidebook, figure for Asian people should be 80% of the figure.
(2) The heat generated in the west restaurant includes the heat generated by foodstuffs and utensils.

Table 2-34 The heat and humidity discharged by human body

	action	Typical sample	Basic data (mature man)		design value		Sensible heat (kJ/h), upline Humidity discharged (g/h), downline					Collection
			Average metabolizing rate (m^3 h)	Breathing out quantity (m^3h)	Co: discharge quantity (m^3h)	Heat discharged (kJ/h)	Room temperature (℃) 20	22	25	26	27	
1	sit quietly	listeners in theater	0.28	17	15	365	256 30	235 38	202 46	189 57	172 63	0.897
1	sit quietly	reading	(0.20)	(16)	(13)	344						
2	seated working (light work)	office, university	0.51	20	18	420	269 44	248 52	210 68	193 75	176 81	0.888
2	working (light work)	office	(0.40)	(19)	(17)	395						
3	office working	office, hotel	0.60	21	20	445	277 60	256 69	210 86	193 92	181 99	0.947
4	walk slowly	department store, shop	0.89	25	23	517	277 60	256 69	210 86	193 92	181 99	0.818
5	sit or stand	bank, drugstore	0.89	25	23	517	281 77	265 85	227 102	210 109	189 117	0.909
6	seated working (light)	factory	1.8	35	33	748	365 137	319 157	248 189	223 198	197 208	0.938
7	medium intension dance	dance hall	2.2	40	38	844	399 163	353 183	269 214	248 227	353 235	0.944
8	walk 4.8km/h	factory	2.6	45	42	937	458 194	403 218	323 253	298 264	353 275	1.00
9	heavy work	factory, ball match	4.5	67	64	1407	596 313	542 336	466 367	445 375	433 382	0.967

Note:
(1)The human body surface area of the European & American and Asian standard mature man is respectively at 1.81 and 1.60 square meters. According to this ratio, the figure for Asians should be 0.884 times of that of the American design figure.
(2)Collection modulus is the comprehensive modulus including all mature man, mature woman and children according to the common proportion. According the standard of the heat discharged by mature man, for mature woman, it is 0.82 times, and for children, it is 0.75 times. The designed value in the table is calculated by the multiplication of the heat discharged in the basic data.

Table 2-35 vapor quantity generated by burning

Category	vapor quantity generated	vapor quantity generated
City gas	450～620g/m³	0.047g/kJ
Liquefied petroleum gas	3100g/kg	0.075 g/kJ
Coal oil for lamp	1130g/l	0.032 g/kJ
Acetylene	700g/ m³	0.012g/kJ
H_2	3052g/m³	0.055g/kJ

7、 The heat generating quantity of various utensils latent heat

Table 2-36 Latent heat of various utensils

Utensil name	Latent heat (W)
electrical disinfector (15×20×43cm)	698
electrical disinfector (23×25×50cm)	1163
Bunsen burner (city gas 7/16 inch)	70
bread oven (electrical heat 15×20×height 23cm)	128
gas warming oven for house use	233
hatch gas oven for house use	1163

2-6 Loss in wind channel, ventilator, safety ratio, bypass modulus, latent heat ratio

Choose dew point temperature, humidity decreasing quantity, and ventilation quantity for the set of the dew point temperature.

1、 Loss in wind pipe

The temperature of wind pipe outside of the cooling is higher than the cooling, and there are temperature difference between the inside and outside of the pipe. The wind pipe is long and the surface heat will come into the pipe. Under strict calculation, it is calculated by the following:

Incoming heat $Q=G \cdot Cp(Ta-T_1)[1-\exp(-\frac{kSL}{G \cdot Cp})]$ …… (2.11)

Increasing temperature $\Delta T = (Ta-T_1)[1-\exp(-\frac{kSL}{G \cdot Cp})]$ …… (2.12)

In the formula:

G the wind quantity in the wind pipe kilogram/hour (kg/h)

cp specific heat of the air current in the wind pipe kilojoule / kilogram (kJ/kg)

Ta temperature of the outside air (℃)

T_1 the temperature at the inlet of the wind pipe (℃)

e 2.72

S perimeter of the wind pipe (m)

L total length of the wind pipe (m)

k heat conducting modulus (W/m²℃)

b insulation material meter (m)

a_o the heat exchange modulus at the outside of the wind pipe (W/m²℃)

Limpid air is air with 10,2 m/s, when touching constructions, it is 30.

a_1- the heat exchange modulus at the inside of the wind pipe (W/m²℃)

V- the speed of the wind current inside the wind pipe m/s

2、 Power of the ventilator

The energy of the ventilating is finally displayed as heat, the indoor sensible heat loads (the ventilator referenced here is those installed behind the condenser).

The indoor sensible heat loads ratio of the ventilator power %

$$= 0.81 \frac{\Delta P}{\Delta T \cdot \eta} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2.13)$$

In the formula:

ΔP = ventilator static pressure or total pressure millimeter mercury (mmHg)

η = ventilator efficiency

ΔP ventilator at 0.45~0.55 for static pressure

ΔP ventilator at 0.6~0.7 for total pressure

ΔT = temperature difference between indoor and ventilated air (℃). Normally, the low speed air pipe is 12~14(℃), and the high speed air pipe is 14~16 (℃).

3 Safety ratio

Since we can not take everything into consideration of the calculation of the loads, we usually have allowance for the general loads. The allowance uses the increase of proper value and is a very important item in the calculation. It is usually called safety ratio. The correct calculation includes: (loss in wind pipe) + (ventilator power) + (safety ratio) to increase the general sensible heat ratio. Under some conditions, including (loss in wind pipe) + (safety ratio) is enough. The safety ratio will increase the general sensible heat differently according to following situations:

Normal condition 10%

High speed wind pipe and high static pressure ventilator 15%

High precision temperature control, under the condition that the set has enough allowance 20%

4 Bypass modulus - B•F

The outside air goes through ventilator and gets cooled by condenser coil pipe (the evaporator on the cooling system), then is sent directly to indoors. Part of the heat of the outside air loses (sensible heat and latent heat). The air is then cleaned by air cleaner and it is humidity decreased air at the outlet of the wind. The temperature of cooling system was set at dew point (see the first part of this chapter heat exchanger at below dew point, humid air was cooled and humidity decreased and the process shown in table 1-9). If the temperature of the condenser is high, use B •F to show.

B•F = when the air and the set is not fully bypassed

1 - B•F = air and set fully bypassed, satisfy the dew point condition of the set

$$B \cdot F = \frac{3 - 2}{1 - 2}$$ (as shown in table 1-8)

5、 sensible heat ratio S•H•F

(1)The rate of total heat generated indoors and the total indoor sensible heat can use S•H•F to show:

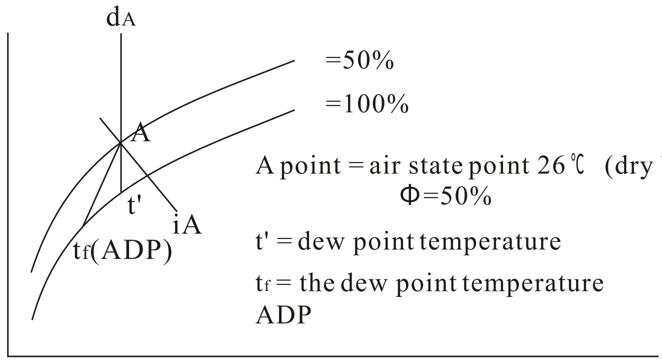
$$S \cdot H \cdot F = \frac{\text{total indoor sensible heat}}{\text{total heat generated indoors}} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2.14)$$

(2) Dew point temperature

Under a certain of air conditions, use sensible heat ratio to calculate the set dew point temperature. The sensible heat ratio goes through the original point, and we get a beeline. Then draw a vertical line from the indoor state point with the equi-relative humidity line. The temperature at the cross point on the saturation line is the dew point temperature of the system. (drawing 2-7)

(3)set dew point temperature A•D •P

It is for cooling air conditioner for multi rooms. If the indoor temperature is lower than the dew point temperature of the system, we can use A•D •P to show it in calculation and it called the set dew point temperature.



Drawing 2-7

6、 humidity decreased air quantity

Decide the humidity decreasing air quantity to set the dew point temperature and calculate the temperature difference.

temperature difference = (1 - B• F) (room temperature - A•D •P) ···········(2.15)

The temperature difference is the dry bulb temperature difference between the inlet and outlet of the condenser. The room temperature is the ventilation air temperature plus the temperature difference.

The required quantity of the humidity decreased air can be calculated as follows:

$$\text{quantity of humidity decreased air} = \frac{\text{total indoor sensible heat}}{(\text{temperature difference}) \times 1.214\text{kJ/m}^3℃} \cdots\cdots (2.16)$$

7 ventilation air quantity

In the calculation of the humidity decreased air quantity, if the difference between the room temperature and ventilation air temperature is too large, it will form uneven layer of air current indoors. Especially in the stable temperature and stable humidity systems, it requires small temperature difference and even distribution of the indoor humidity. The following formula can give the result of the ventilation temperature and ventilation air quantity.

$$\text{ventilation air quantity} = \frac{\text{total indoor sensible heat}}{(\text{indoor ventilation air temperature}) \times 1.214\text{kJ/m}^3℃}$$

$$\text{or} = \frac{\text{humidity decreased air quantity} \times (\text{temperature difference})}{(\text{room temperature} \quad \text{ventilation air temperature})} \cdots\cdots\cdots (2.17)$$

The difference between the ventilation air quantity and humidity decreased air quantity is the bypass air of the cooling system, and it must be used repeatedly.

by pass of cooling system = ventilation air quantity - humidity decreased air quantity

To design and choose the ventilator and the wind pipe capacity, the basic standard should be ventilation air quantity.

2-7 humidity discharged quantity

In the air conditioned room, owing the need of the people and work, various quantity of vapor will be generated, and plus the vapor in the leakage air and ventilation air from the gap of doors and windows, the humidity required by the indoor design is increased. So if the design and calculation have strict requirement, the humidity discharged should be included. Humidity decreasing measures should be taken to maintain the required relative humidity. In calculation, the following figures and values can be chosen to use:

The dehumidity quantity of the fresh air quantity entered indoors (leakage air quantity + ventilated air quantity):

fresh air quantity (leakage air quantity + ventilated air quantity) (m^3/h) ÷ fresh air temperature and humidity specific voltume v (m^3/kg) ×(the absolute humidity air quantity in outdoor fresh air temperature - the absolute humidity air quantity in outdoor fresh air temperature) (kg/kg') = fresh air dehumidity quantity.
(kg/h) ……………………………………………………………(2.18)

The calculation of the prevention from dew in inside construction surface can use the following formula:

$$\theta i = ti - \frac{Ri}{R}(ti - to) \quad \cdots\cdots (2.19)$$

$$\theta x = to + \frac{Rx}{R}(ti - to) \quad \cdots\cdots (2.20)$$

$$\theta o = to + \frac{Ro}{R}(ti - to) \quad \cdots\cdots (2.21)$$

The modulus of the prevention from dew in inside construction surface K

$$K < ai\frac{ti - td}{ti - to} \quad \cdots\cdots (2.22)$$

In the formula:

θ i-high temperature- side surface temperature (℃)
θ x-the central part temperature of various walls (℃)
θ o-low temperature - side surface temperature (℃)
ti-high temperature - side (indoor) air temperature (℃)
to-low temperature - side (indoor) air temperature (℃)
Ri-heat resistance of the surface of walls indoors (m^2℃ /kJ)
Ro-heat resistance of the surface of walls outdoors (m^2℃ /kJ)
R-the total heat resistance of the wall (m^2℃ /kJ)
k-the heat conduction modulus of the walls (kJ/ m^2℃)
ai-the heat exchange modulus of the wall surface indoors (kJ/ m^2℃)
td-the dew point temperature of the indoor air

Example of the temperature decreasing loads:

This part will introduce an example of the temperature decreasing loads in a room. The calculation is based on the before mentioned methods.

For example: to get the result the cooling loads and air blowing quantity
Place: the top floor of an office building in Shanghai
Indoor condition: 26 ℃ , ϕ50%
Indoors loads: 30 people, fluorescent light 3.2 kW
Circumstance state: direction: south, have sunlight shining, neighbor room cooling and warming, downstairs warming.
Construction structure:
roof: water proof mortar 20mm, cement concrete 150 mm
high pressure paper board 12mmm ceiling
wall: outside bright color tile wall, mortar 15 mm

Cement concrete is 150mm thick with mortar and varnishing on the internal side.

Floor: Asphalt, mortar thickness 15mm, cement concrete thickness 150mm

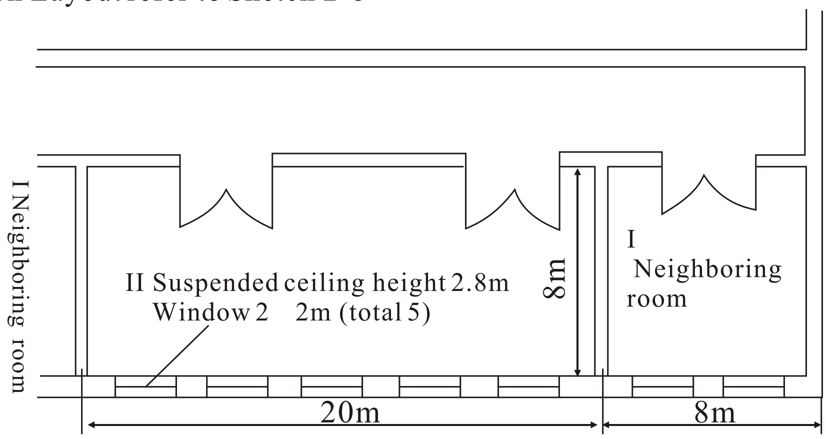
Suspended ceiling with 12mm high-pressure paper board

Partition: Cement concrete 100mm thick, with varnishing on both sides

Window: With one layer of glass and with light-colour louvers inside

Cooler:

Construction Layout refer to Sketch 2-8



Drawing 2-8 Office Construction Layout

E.g. Calculation

Data referring to tables are also illustrated in the example

(1)Radiant heat on window from the sun:

Substitution of (2.1) $Qg=F \cdot Ig \cdot q_1$, which rendering into:

20m² (F) 43 (Ig) 0.56 (q_1) =482W

→ value of 2pm refer to table 2-10

→ value of 4pm for the room to the south (design requirement) refer to table 2-7

(2)Radiant heat and transfer heat on walls and roof:

Substitution of (2-3):

Walls: Q=kF te, rendering into:

36m² (F) 5.4 (te) 3.73 (k) =725W

→ Table 2-15 → Table 2-13

Roof:

160m² (F) 24.2 (te) 1.79 (k) =6930W

→ Table2-16 → Table 2-14

(3)Transfer heat on those except walls and roof

Glass windows:

20m² (F) 5.5 (te) 5.91 (k) =650W

→ Table 2-23-1

Partition Wall:

56m² (F) 3.5 (te) 3.31 (k) =649W

→ Table 2-23-2

→ (unknown neighboring room =outdoor temp.-(2-3)-room temp)

Floor:

→ Table 2-24

160m² (F) 3.5 (te) 1.72 (k) =963W

(4)Air Leaking Volume and Air Change Volume

Air change 765m^2/h 5.5 (te) 0.2BF 1.214 =243W

↳ Air change rate (by-pass ratio)

(5)Inside generated heat

People:

30 persons 63 0.8 = 1512W

↳ Body service of Asian people is 0.8 times that of Europeans

↳ Table 2-28 (light operation while sitting at 25.5)

Lighting:

3200W 1.25 =4000W

↳ fluorescent light is 1.25 times that for incandescent lamp

(6)Inside sensible heat

Air change: 76m^3/h 0.0099kg/kg' 0.2BF 3020 =4574kJ/h =1088W

↳ Formula (2.10)

↳ Humidity difference

People: 30 persons 67 0.8=1608W

↳ Body service of Asian people is 0.8 times that of Europeans

↳ Table 2-33 (office operation at 25.5)

Refer to P71 table for Solution and Calculation

2-8 Some quick calculations of cooling for Air Conditioner

This section introduces some quick calculations of using air conditioner as

1、Proposal A

Relatively precise calculations:

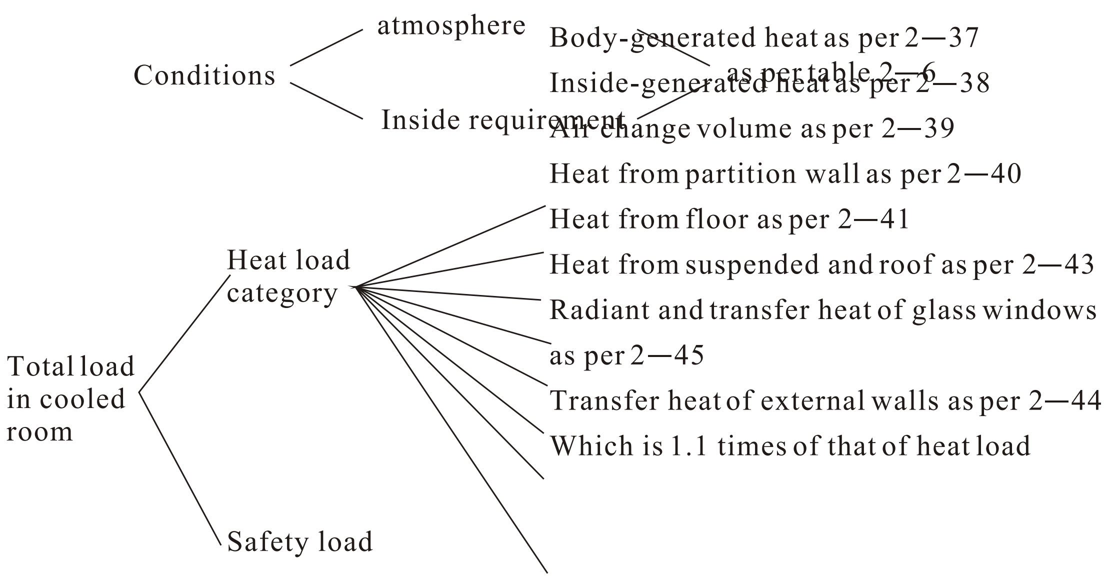


Table 2—37 A Body-generated Heat

Status	Example	Generated Heat (W)
Sitting quiet	Theatre	105
Office activity in sitting status	Office/apartment	105
Walking slowly	Organs/department/shops	140
Activity in sitting status	Dining-room	140
Sitting with light labor	Working site	163
Normal dance	Dance hall	233
Walking	——	256
Normal heavy labor	Working site	291
Heavy labor	Working site	430

Table 2—38 B Heat from inside electrical appliances

Category	Calculation	Heat (W)	
Lamp or fluorescent light	kW×1.25=		Note: (1)The gas heat value is dependant on the local actual value (2)If there is extraction units fitted with the gas appliances, the generated heat is to be times 1/2.
Gas appliances	m^3/h×4100= m^3/h×5800=		
1/8～1/2HP 1/2～3 HP 3～20 HP	HP×1200= HP×1070= HP×860=		
Other electrical appliances like hair-dressing appliances	kW		

Table 2—39 Air Change Volume

C Required fresh air				
Smoke	Example	No. of people	m^3/h (per person)	m^3/h
No smoking	Hospital /theatre		×20=	
Light smoking	Office/house /canteen		×25=	
Relative heavy smoking	Dance hall		×40=	
Heavy smoking	Conference room		×50=	
Natural air change volume				
H= height (m), L= length (m), W= width (m), S=(ratio) European structure S=1.7, Japanese structure S=2.4 H L W S=m^3/h				

D Heat value of the outside air (kJ/m^3)						
Humidity of outside air		60%	65%	70%	75%	80%
Outside temperature	32	172	239	281	328	370
	33	235	286	328	378	424
	34	281	332	328	428	483

Note:
(1)When the required air and auto ventilation volume is large, refer to the data in the table.
(2)In the given outdoor temperature and humidity, heat refer to 2—39 D.

Table 2—40 E Heat from partition walls (W)

Structure		Temperature difference between inside and outside (℃)		
		5	6	7
Inside wall	One-story structure	16.3	19.8	23.3
	Two-story structure	10.5	12.8	15.1
Partition	(wood or bone paper or cloth)	12.8	15.1	17.5
Barrier wall	(one layer)	25.6	31.4	36.0
Glass	(one layer)	32.6	38.4	45.1
Wood	Thickness 2.5cm	19.8	23.3	26.7
	Thickness 4.0cm	15.1	17.5	20.9
Steel plate		29.1	34.9	40.7

Note:
(1)If there are windows in partition, window area should be reduced.
(2)If the roof glass receives the heat directly from the sun, it should be regarded as the direct light from the sun.

Table 2—41 F Transfer heat of the floor (W)

Structure		Temperature difference between inside and outside (℃) 5	6	7
Construction floor		2.3	3.5	4.7
Earth floor		9.3	11.6	1.2
Wooden floor	1-layer board	11.6	14.0	18.6
	2-layer board	5.8	7.0	9.3
	sawdust between 2 boards	4.7	5.8	7.0
Rice-straw mattress		3.5	4.7	5.8
Cement floor	Normal structure	5.8	7.0	9.3
	Insulated	2.3	3.5	7.0

Note:
(1)For the structure that the first story is earth floor or a multi-story building, calculation should be based on Table 2—41F or 2—42G separately.

Table 2—42 G Transfer heat of the intermediate floors (W)

Structure		Temperature difference between inside and outside 5	6	7
Wooden structure	Wooden suspended ceiling	9.3	11.6	12.8
	Straw-mat suspended ceiling	4.7	5.8	7.0
Cement ceiling (floor)	Normal structure	16.3	19.8	23.3
	Insulated structure	9.3	10.5	12.8
	Heavy structure	7.0	8.1	9.2

Table 2—43 J Transfer heat of the roof exposed to the sun

Structure		Outdoor dry-bulb temperature 32	33	34
Flat roof	5cm thick cement concrete, water-proof with mortar	172	177	181
	10cm thick cement concrete, water-proof with mortar	109	117	122
	15cm thick cement concrete, water-proof with mortar	59	63	67
	10cm thick cement concrete, water-proof with asphalt	63	66	70
	15cm thick cement concrete, water-proof with asphalt	44	48	51
	5-15cm thick cement concrete, water-proof with mortar metal strip and suspended gunite ceiling	64	66	69
Ridged roof	Galvanized-steel roof (steel roofing material, iron plate)	113	115	117
	Tiled roof (steel plate, tiles)	101	104	106
	Asbestos roof (steel plates, roofing material, asbestos)	108	111	113

Note:
(1)For suspended ceiling and roof, calculations can be based on Table 2—42G and 2—43J.
(2)When the temperature difference between inside and outside is confirmed, the calculation for suspended ceiling is to refer to table 2—42G.
(3)When the temperature difference between inside and outside is confirmed, the calculation for roof is to refer to table 2—43J.
(4)When roof is two-side type with suspended ceiling inside, the data applied is 40% of the figures shown in the tables. I.e. 60% is for the ventilation between roof and suspended ceiling.

Table 2—44 M Transfer heat of glass (W)

Type of obstruction of sun shine			Orientation								
			H	N	NE	E	ES	S	SW	W	WN
Direct sun shine without obstruction			940	108	108	108	108	191	471	477	288
Obstruction with canvas			310	60	60	60	60	86	170	176	115
Outside louvers			400	69	69	69	69	101	213	157	144
Inside	Louvers	Outer side white	626	85	85	85	85	138	320	324	209
		Outer side intermediate color	715	92	92	92	92	154	364	368	235
		Outer side dark color (dark red/dark blue)	805	99	99	99	99	167	406	412	262

Note:

(1)H is vertical shining, N is north, E is east, S is south and W is west.

Table 2-45 N Transfer heat of external wall (W/m^2)

Structure		Outside temperature( )	Orientation							
			N	NE	E	ES	S	SW	W	WN
Wooden structure	Internally painted wall External waterproof with mortar (European style double-layer wall)	32	15	17	15	27	30	41	28	24
		33	17	20	17	28	33	43	30	27
		34	20	22	20	30	34	44	33	29
	Internally earth wall External with board underneath (True wall)	32	21	24	22	36	42	56	40	34
		33	24	27	24	40	44	59	43	37
		34	27	30	28	42	48	62	45	40
Cement concrete wall or cement wall	Internally plastering Externally tiling Cement concrete 10cm thick	32	23	38	40	60	52	52	24	24
		33	28	42	43	64	57	56	27	31
		34	31	47	48	69	60	59	36	36
	As above Cement concrete 15cm thick	32	15	37	44	45	30	24	22	23
		33	19	40	48	49	34	28	24	27
		34	22	43	51	52	37	31	28	30
	As above Cement concrete 20cm thick	32	12	35	42	41	17	23	20	21
		33	14	38	45	44	21	26	22	24
		34	17	41	49	48	23	29	26	27
	Internally plastering Externally mortaring Cement concrete 10cm thick	32	27	42	44	67	59	58	31	31
		33	31	48	49	72	63	63	36	42
		34	35	51	53	76	67	66	41	40
	As above Cement concrete 15cm thick	32	19	47	55	57	37	31	27	30
		33	23	50	59	62	42	35	31	34
		34	27	55	63	65	45	40	35	47
	As above Cement concrete 20cm thick	32	13	40	47	47	20	26	22	34
		33	16	43	50	49	22	29	24	27
		34	20	45	53	52	27	33	28	30
Light cement or brick wall	Internally plastering Externally rendering Light cement 20cm thick	32	10	37	28	27	9	21	12	14
		33	12	40	30	28	10	23	14	15
		34	14	41	31	30	13	24	15	17
	As above Packed with coal slag	32	7	27	20	19	6	15	8	9
		33	8	28	21	20	8	16	9	10
		34	9	29	23	21	9	17	10	13
Sintered brick wall	Internally plastering Externally mortaring Brick 21cm thick	32	7	23	27	24	8	13	10	13
		33	9	26	29	27	10	15	12	14
		34	10	27	30	28	12	16	14	16
	As above Brick 32cm thick	32	3	8	9	8	3	8	7	7
		33	5	9	10	9	5	9	8	8
		34	6	10	12	10	6	10	9	9

The sum of A, B, C, D, E, F, G, J, M, N value shown in tables from 2-37 to 45 is the full cooling load.

Cooling Load Work Sheet (Proposal A)

Address:

Floor　　　　　　　　　　　　Room Number

Room area　　m^2　　　　Room capacity (width)　(length)　(height) = m^3

Outside designed condition: dry-bulb temperature　　　Relative humidity　　%

Inside designed condition: dry-bulb temperature　27　Relative humidity　60%

Date:　Y　M　D　　　　　　　　Responsible person:

ITEM				Formula	Heat W
1	Human body			(No. of people) A=	
				(No. of people) A=	
2	Room heat resource			B=	
3	Air change			C(m^3/h) D=	
4	Partition wall			(m^2) E=	
				(m^2) E=	
				(m^2) E=	
				(m^2) E=	
5	Floor	Ground floor		(m^2) =F	
		Intermediate floors		(m^2) G=	
6	Ceiling and roof	Ceiling for intermediate floor		(m^2) G=	
		Ceiling with direct sun shine		(m^2) =J	
7	Glass window			(m^2) M=	
				(m^2) M=	
				(m^2) M=	
8	External wall			(m^2) N=	
				(m^2) N=	
				(m^2) N=	
				(m^2) N=	
				(m^2) N=	
9	Full cooling load	Sum of all items		(1)+(2)+(3)+　(8)=	
10	Safety load			(9)　1.1	

Construction Layout (with orientation marked)

2　Quick calculation of cooling for air conditioner

This method is a quick way of calculation to select an air conditioner as a cooling unit. To fill in the following table 2-46, and to work out the total heat volume.

Table 2-46 Quick calculation of cooling for air conditioner (Proposal B)

	Factor multiplier = Heat volume W					
(1) external wall	Cement concrete / stone (European-style)		Wooden/brick		Area (H W)	
	With sunshine	Without sunshine	With sunshine	Without sunshine		
E	28		17		m^2	
SE	30		23		m^2	
S	19		21		m^2	
SW	16		33		m^2	
W	16	10	29	7	m^2	
NW	16		24		m^2	
N	12		12		m^2	
NW	23		16		m^2	
(2) partition paint (internal wall)	8				m^2	
paper	10				m^2	
cloth partition barrier wall	23				m^2	
glass	23				m^2	
(3) ceilings and roofs	Intermediate floor or ceiling without direct sunshine		Ceiling with direct sunshine		Ceiling (roof) area: internal L W	
			European style	Japanese style		
	12		47	64	m^2	
(4) floors	Intermediate floor 12		Ground floor 9		Floor area(L W) m^2	
(5) glass windows	Without sunshine		With sunshine		Window area (L W)	
			No obstruction	m^2		
E, SE, N, NE	29		93	70	m^2	
W, SW	29		465	291	m^2	
S	29		180	122	m^2	
NW	29		279	180	m^2	
(6) human body	116				number of people	
(7) Air change	European style construction 12		Japanese style construction 12		Total internal capacity L W H m^3	
(8) heat source electrical appliances	1047				kW/h	
gas others	4187	5234		5815	m^3/h	
(9) total heat volume	(1)+(2)+(3)+(4)+(5)+(6)+(7)+(8)=				W	
(10) safety load heat volume	(9) 1.1		=		W	
			TOTAL		W	

Designed condition:

Outside temperature/humidity 33 /RH70%

Inside temperature/humidity 27 /RH60%

3 Calculation of cooling load based on floor area

The following table 2-47 is JIS standard, which was compiled by Japanese air conditioning industrial committee and is a quick way of calculating the cooling load according to room area while it bears a relatively large error.

Table 2-47 JIS standard

Type of the room				Cooling load per unit area (W/m^2)	Times of air change (n/h)	Window are/floor area (%)	Person per $10m^2$	Lighting Fluorescent (W/m^2)	Remarks
Offices	No window		Top	145	1	0	2	20	
			Middle	105					
	North		Top	163	1	20	2	20	
			Middle	116					
	West		Top	233	1	20	2	20	
			Middle	169					
Shops	Frequent passing			180	2	40	3	40	
	Infrequent passing			157	1				
Hotel /hospital room	South			116	1	20	1	20	
	West			169					
Coffee bar	Without fan			116	1	10	6	10	With electric heather
	With fan			302	4				
Cafeteria	Narrow window	No fan	South	192	1	10	6	20	Include heat from kitchen
			West	221					
		With fan	South	262	4				
			West	290					
	Wide window	No fan	South	221	1	10	6	20	
			West	302					
		With fan	South	290	4				
			West	372					
Drinking bar	Without fan			192	1	10	6	10	At night
	With fan			256	4				
Beauty saloon				290	1	20	2	20	Include heat from appliances
Barbershop				233	1	20	2	20	
Residence Wooden 1-story house	Japanese style		South	221	1.5	40	3	0	
			North	163	1.5	20	3	10	
	European style		South	192	1	30	3	0	
			West	233					
Organs	European style(south)		Top	186	1	30	3	10	
			Middle	145					

South means that the room is connected with exterior through the south wall also include windows, the same for west and north.

The conditions applying table 2-47 are:

(1)The highest outdoor temperature is 37 , and indoor temperature is about 27 .

(2)The houses are in normal structure, ceilings are relatively high above the ground.

(3)Doors and windows are open when there are people passing, otherwise they are in close state.

(4)No other large heat generators except those illustrated in the table.

(5)The floors are all intermediate floors except those indicated in the table.

(6)Windows are all exposed to the sunshine and with louvers inside or outside except those indicated in the table.

(7)Air exchanger gate is in close state.

Time of air change means the air change volume and air leaking volume, others mean air change in air exchanger.

Time of heat exchange means the ratio of the air coming inside per hour and the room capacity.

(8)Air-cooling condenser is located outdoor is to provide obstruction of the sunshine and the ventilation as well.

To apply this quick calculation illustrated in table 2-47 to the example in (I), we can get the approximate result.

Example in (一): the floor area is 160m^2, and it is classified into the item of "organs, European style (south)" and "top" which is 186W/m^2, so:

The cooling load =160m^2×186W/m^2=29760W

The standard load =27256W

Error is 2514W

The approximation can be tested by table 2-48 as well.

Table 2-48 Test Data for Cooling Load

	Obvious heat ratio			Indoor obvious heat load (W/m^2)			Cooling load (W/m^2)			Air vent ($m^3/h/m^2$)		
	low	Average	high	low	average	high	low	average	High	low	average	high
Apartments Hotel rooms for individuals	0.80	0.84	0.94	28	38	53	41	63	94	9.2	13	17
Libraries	0.80	0.83	0.90	63	110	142	94	162	236	17	29	39
Banks	0.75	0.83	0.88	66	120	151	110	170	236	26	37	46
Department store (underground)	0.65	0.73	0.85	50	66	83	76	107	123	14	18	22
Department store (first floor)	0.72	0.80	0.88	57	94	136	83	127	190	16	26	37
Department store (2nd floor)	0.74	0.82	0.94	50	66	83	76	98	127	14	18	22
Department store (above second floor)	0.74	0.82	0.89	63	114	145	101	167	234	17	31	39
Hotel rooms for groups of people	0.84	0.91	0.93	60	83	116	72	114	164	18	24	35
Office buildings	0.82	0.89	0.93	76	104	136	104	142	201	22	31	40
Offices for individuals	0.65	0.72	0.80	1026	164	252	284	372	488	32	44	49
Cafeteria, beauty saloon	0.69	0.80	0.91	104	177	284	157	240	369	28	48	77
Barbershops, theatres	0.65	0.70	0.72	*95	*107	*129	*186	*195	*207	*26	*34	*15

Note: (1) Data in this table is converted from the data recorded in Modern Air Conditioning.
(2) * is for each person.

Calculations:

Construction: office building

Address: Shanghai
Room: office at the top floor
Area: 20m×8m=160m^2
Volume:160m^2×2.8m=450m^3

Designed condition
Highest outdoor condition:
DB32 , WB27 , RH68%

Indoor condition:
DB26 , WB-, RH50%

Time: 4pm, which is the time of highest load

condition	DB℃	WB℃	RH%	/kg'
Outdoor	31.5	26.8		0.0204
Indoor	26		50	0.0105
Difference	5.5			0.0099

Obvious heat ratio dew point

$$\frac{17.769\text{ (indoor obvious heat)}}{20.629\text{ (indoor full heat volume)}}=0.86\text{(SHF)}$$

dew temperature=13.5℃, protocol dew temperature(ADP)=13.5℃

Dehumidifying air volume
(1-0.2BF) ×(26℃ ambient-13.5℃ ADP)=10℃

$$\frac{17.769\text{(indoor obvious heat)}}{10℃\times 0.34}=5.226\text{ m}^3\text{/h}$$

Air blowing:

$$\frac{\text{M}^2\text{/h dehumidifying air} \times ℃}{℃\text{ ambient- } ℃\text{ air blowing}} = \text{ m}^3\text{/h}$$

Air change
30 persons 25.5 m^3/h=765
m^2 m^3/h m^2=
air change =765m^3/h

Note: difference between the highest outdoor temperature (32) and indoor temperature (26) is 6 , usually the radiant transfer heat temperature is (-1)

Air change time=5226m^3/h/450m^3=11.6 times/h

Obvious heat load/floor area
=1769/160 m^2=111W/m^2

People=5.3 m^2/person

Lighting=20W/m^2

Item	Area², volume	Radiant heat×Δte	ratio	W

Radiant heat to windows from the sun
2.2m×20m^2(total 5)×43×0.56=482
m^2× × =
m^2× × =
m^2× × =

Radiant heat and transfer heat of walls and roofs
36m^2×5.4×3.73=752
m^2× × =
m^2× × =
m^2× × =

Transfer heat of others except walls and roofs:
for the roof receiving the sunshine:
160m^2×24.2×1.79=6930
for the roof not receiving the sunshine.
Glass window 20m^2×5.5×5.91=650
Partition wall 56m^2×3.5×3.31=649
Ceiling m^2× × =
Floor 160m^2×3.5×1.72=963

Air leaking and air change volume
Air leaking: m^3× ×1.214 =
Air change: 765m^3×5.5×0.2BF×1.214 =243

Heat generated internally
Human bodies: 30 persons×63×0.8=1512
Machines: kW× =
Lighting: 3200W×1.25× =4000
Others: × × =
× × =
subtotal of indoor obvious heat 16,154
loss in duct % + power of air blower + safety ratio 10% =1615
Indoor obvious heat total 17769W

Indoor latent heat
Leaking are: m^3/h kg/kg' 3020=
Air change:
765m^3/h 0.0099kg/kg 0.2BF 3020=4575=1088W
Human bodies: 30 persons 63 0.8=1512
Equipment and others: 2600
Loss in duct %+ safety ratio 10%=260
Total indoor latent heat=2860W

Outdoor load
Obvious heat:
765m^3/h 5.5 (1-0.2BF) 1.214/4.2=973W
Latent heat: 765m^3/h 0.0099kg/kg' (1-0.2BF) 3020/4.2=4575=4356W
Subtotal of cooling load 25958W
Loss in return duct %+pump power %+loss in auxiliary duct 5% 1298W

Cooling Load Total	27,256W

SECTION III CALCULATION FOR HEATING LOAD

Heating load is to heat a room to and maintain a specified temperature and humidity. The calculation of this s to be based on the data in specific conditions.

1 Categories of heating load

- (1) Indoor load
  - Transfer heat caused by temperature difference
    - Heat through windows (obvious heat)
    - Heat through external walls and roof (obvious heat)
    - Heat through partition, floor, ceiling (obvious heat)
  - Air leaking—through seam of windows/doors (obvious/latent heat)
  - Humidifying—water evaporation from sprayer and evaporator (latent heat)

(2) Outdoor air load—indoor air requirement—heat for the air coming inward and reaching the indoor temperature (obvious heat)

(3) Others—other loss of heat—loss in ducts (obvious heat)

2 Estimate of the indoor heat loss

Table 2-49

Structure	Heat loss (W/m^2)
Cement concrete (rooms at the top floor)	128～209
Cement concrete (rooms on intermediate floors and ground floor)	81～128
Cement concrete (with floor area above 1500 m^2)	81～105
European-style wooden structure (applicable for all rooms)	128～174
European-style wooden structure (with floor area under 1500m^2)	105～128

3　Indoor temperature and changes

Table 2—50

Ceiling height (m)	Room temperature (℃) (1.5m level above ground)					
	t=16	18	20	21	22	23
3.0	17.4	19.6	21.8	22.8	23.8	24.8
3.2	17.6	19.8	22.0	23.0	24.0	25.0
3.4	17.8	20.1	22.3	23.3	24.3	25.3
3.6	18.0	20.3	22.5	23.5	24.5	25.5
3.8	18.2	20.5	22.8	23.8	24.8	25.8
4.0	18.4	20.7	23.0	24.0	25.0	26.0
5.0	19.0	21.3	23.9	24.9	26.1	27.2
6.0	19.2	21.5	23.9	25.0	26.2	27.4

4、 Heat transfer—roof, walls, glass windows, ceilings, partitions, floors.

The calculation of the heat loss through the multi-layer walls (both internally and externally) during heat transfer as illustrated in Sketch 2—2 is mainly based on temperature difference. While calculating for heating, the radiant heat from the sun and relative outdoor temperature difference are not taken into consideration, as they are for cooling calculation.The following formula can apply for the heating calculation for roof, walls, glass windows, ceilings, partition walls and floors:

$Q=kF(t_i-t_o)$……………………………(2.23)

Among this: Q—transfer or leaking heat (W)

F—area of wall, roof, glass window (m^2)

t_i—designed indoor temperature (℃)

t_o—given outdoor temperature (℃)

k—transfer coefficient of thermal media toward wall

$W/m^2 \cdot ℃$ (as for the calculation for cooling)

In calculating the leaking heat from partition walls, ceilings and floors, F indicates the same figure shown in the above formula, t_o is the dry-bulb temperature in the neigh boring site. If the neighboring room is also equipped with heating facilities, the above formula can be applied. If the temperature of the neighboring site is by no means known, i.e. the temperature difference is unknown, the following formula is applicable ”

Δt (temperature difference ℃) =[(designed indoor temperature) - (given outdoor temperature)] × 0.5 ………………………………………………………………(2.24)

5、Heat transfer and leaking through underground walls & ground

Based on underground temperature difference:

Leaking heat = transfer ratio × contacting area between wall and ground × (indoor temperature ground temperature) (W)

The transfer coefficients are:

for inner wall surface a_i=9.3W/m²℃

for outer wall surface a_o=0

for soil 1.28~2.3W/m²℃

6、 Air leaking and air changing

(1)Seam method

Table 2—51 illustrates the leaking air volume through the seams in different types of windows/doors in different wind speed. Length of the seams should be measured individually. When there are above 3 external walls in a room, only 2 of them toward the wind will be taken into consideration. Seam length should be no less than half of the total seam length of all the doors and windows in the room.

Table 2—51 leaking air through doors/windows---seam method

Type of door /window	Leaking air through each meter of seam (m³/h)					
	Wind speed (m/s)					
	2.0	4.5	7.0	9.0	11.0	13.5
Wooden window which can be opened both up and down	0.7	2.8	3.6	5.5	7.4	9.7
As above, cannot be closed	2.5	6.4	10.3	14.5	18.7	23.4
Steel window which can be opened both up and down	1.8	4.2	6.9	9.6	12.8	15.6
Steel rotary window (for factories)	4.9	10.0	16.2	22.8	28.4	34.5
Glass door (seam 3mm wide)	26.7	83.5	78.0	11.1	13.4	162
Wooden/steel external door (seam 3mm wide)	5.0	12.8	20.6	29.0	36.8	46.8
External door for factories (seam 3mm wide)	17.8	35.7	53.5	72.4	89.1	106

(2)Area method

This method is easier than seam method, which will apply the following formula:

Heat loss (W)=(indoor temperature-outdoor temperature)℃× (leaking air) (m³/h) × 1.214kJ/ m³℃

The data illustrated in table 2—52 and 2—53 are only for the occasion that the door/window is right towards the wind. When the door/window is not right towards the wind, only the door/window area that ARE right toward the wind will be taken into consideration, and the ratio should be 0.6 times of that illustrated in the tables. When the two opposite doors are open simultaneously, the area should be the sum of both doors, and data in the tables should be increased by 25%. When two doors in a right angle position are open simultaneously, there is no need in increase the data in the tables. For an external door without storm porch, when it is not frequently open, the ratio should be 0.7 times of that illustrated in the tables.

Table 2—52 Area method—air leaking through window (in winter) (wind speed 7m/s)

Types of windows	Air leaking through window ($m^3/h/m^2$)	
	Small-size window 760 1800(mm)^2	Large-size window 1400 2400(mm)^2
Wooden window which can be opened both up and down	16	9.7
As above, cannot be closed	44	28
Steel window which can be opened both up and down	29	18
Steel rotary window (for factories)	40	36
Ratio between rotary part area and the window area	60	53

Table 2—53 Area method—air leaking through door (in winter) (wind speed 7m/s)

Types of doors	Only through seam ($m^3/h/m^2$)	Through seam and door during open-close ($m^3/h/m^2$)
Glass door with seam 1.5mm wide	167	370
Wooden door 900 2.140	37	240
Small-size factory gate	28	56
Garage gate	74	167
Auto garage gate	74	250

7、Humidifying

Due to that the outdoor air is relatively dry in winter, the air coming inward will reduce the humidity of the indoor air. To maintain a specified indoor humidity, it is necessary to spray some steam into the air or to evaporate the water from the evaporator. Humidifying should be based on the following formula:

Humidifying volume (water kg/h) = (indoor absolute humidity outdoor absolute humidity) (kg/kg') × (air leaking volume + incoming air volume) (m^3/h) × 1.2 ……(2.25)

8、Outdoor air load

(1)When outdoor air comes inside, it is heated by the indoor temperature, which causes indoor heat loss and should be regarded as external air load during calculation.

Outdoor air load (W) = temperature difference between outside and inside (℃) × air incoming volume (m^3/h) × 0.34 ……… (2.26)

Calculation of air incoming volume can refer to table 2—25, the calculation for cooling.

(2)Effective temperature difference

During heating, the blowing air temperature should be higher than indoor temperature so as to avoid indoor heat loss, the difference between blowing air temperature and indoor temperature is called effective temperature difference.

9、Example of heating load calculation

Conditions can be referred to example shown in Chapter II (see sketch 2—8)

Inside condition: 20℃ , Φ40%, see table 2—54

Table 2—54 Calculation of Heating Load

Structure name: office building				Address:Shanghai CityDate:					
Designed condition	Indoor	outdoor	difference	Room name					
				Top floor					
Dry bulb	20	-1	21	Indoor dimension					
Wet bulb			-	$20m\times8m=160m^2$		m× m= m²		m× m= m²	
Relative humidity %	40	50	-	$160m^2\times2.8m=450m^3$		m²× m= m³		m²× m= m³	
Absolute humidity kg/kg'	0.0058	0.0018	0.004						
Part of transfer	coefficient	t	W/m²	m²	W				
Glass window	6.42	21	134.82	20	2.696				
External wall	3.94	21	82.74	36	2,978				
Roof	2.05	21	43	160	6,888				
Partition	3.31	10	33	56	1,854				
Floor	1.45	0	-						
Total Loss of Transfer Heat				14,416					
Leaking air t 21 0.34				m³/h 345	W 2,463	m³/h	W	m³/h	W
Subtotal of indoor heat loss				16,879					
Safety ratio 10%				1,688					
Total of indoor heat loss				18,567					
Outdoor air t 21 0.34				m³/h 765	W 5,462	m³/h	W	m³/h	W
Total of heating load				24,030					
Humidifying Difference of absolute humidity 0.004kg/kg 1.2				Leaking air + outdoor air m³/h 1110	/h 4.44	Leaking air + outdoor air m³/h	/h	Leaking air + outdoor air m³/h	/h
Effective t (air blow temp.- room temp)	(1/0.34) (indoor heat loss/air blow)			$\frac{18,567W}{5,180m^3h\times0.34}=10.5℃$		$\frac{W}{m^3/h\times0.34}=℃$		$\frac{W}{m^3/h\times0.34}=℃$	
Calculation of leaking air									
Seam method/area method					m³/h				
Window 6.9m³/h*m(seam) m³/h • m²				10×5	345				
Skylight m³/h*m(seam) m³/h • m²									
Door m³/h*m(seam) m³/h• m²									
Door (close) m³/h • m²									
Times of air change				Room capacity	m³/h	Room capacity	m³/h	Room capacity	m³/h
Times of air change Max times/hr Min times/hr				m³		m³		m³	
Remarks:				Air blow temperature =20 +10.5=30.5 Indoor heat loss =116W/m²					

Example to explain the heating load calculation illustrated in table 2—54.

Designed condition: absolute humidity: 0.0058-0.0018=0.0040kg/kg'

0.0058 and 0.0018 can be obtained from sketch i-d.

(1)Heat transfer

Glass window:

20 (m^2) × 6.42 × 21 = 2696W

(Δt ℃)

table 3—23—1 (winter)

External wall: 36(m2)×3.94×21=2978W

table 3-13(winter)

Roof:

160 (m^2) × 2.05 × 21 = 6888W

table 3—14 (winter)

Partition wall:

56 (m^2) ×3.31 ×10 = 1854W

(Δt ℃)

table 3—23—2

(2)Leaking air

21(Δt ℃) × 0.34 × 345 (m^3/h) = 2463W

obtained from the following calculation (6)

(3)Outdoor air load

21(Δt ℃) × 0.34 ×765 (m^3/h) = 5462W

table 3—27 (30 persons×25.5 m^3/h)

(4)Humidifying volume

Absolute humidity difference 0.004kg/kg'×1110 (m^3/h)=4.44kg/h

(765 m^3/h+345 m^3/h)

(5)Effective temperature difference

$$\text{Effective temperature difference (℃)} = \frac{\text{indoor heat loss (kJ/h)}}{\text{Air blow (m}^3\text{/h)} \times 0.34} \cdots\cdots\cdots\cdots (2.27)$$

When there are several temperature requirements in a room and only one Air Conditioner is equipped, the air blow is to be calculated based on the highest temperature required.

(6)Seam air

Seam method

Window 6.9m^3/h*m (seam) × (10×5m) m^2=345m^3/hr

(each seam length 8m+25% total 5)

[table 2—49: wind speed is 7m/s (for steel window with opening both up &down)]

(7)Air blow temperature

20+10.5℃ (effective temperature difference) =30.5℃

(8)Indoor heat loss

Total indoor heat loss is:

18567W/160m^2 (room internal area)=116W/m^2

Section IV Quick Calculations for Heat Pump Load (Heating & Cooling)

The quick calculation introduced in this section is based on the B, E coefficients illustrated in the following tables. <B—coefficient for cooling and E—coefficient for heating.>

1、In the given condition, to obtain the B, E coefficients from the following 10 tables.

Table 2—55 Heat load coefficient for external walls

Types of walls	Coefficient B (W/m^2)								Coefficient E (W/m^2)
	N	E	S	W	N	E	S	W	
Light structure (wooden)	20	43	34	59	33	40	50	49	2.9
Medium structure (concrete block)	17	47	40	65	37	44	56	52	3.5
Heavy structure (20mm concrete)	19	40	36	43	34	40	47	30	

Note: normally the brick wall can be considered as "Medium structure", and the coefficients should be 1/3 larger. (Figures in the tables are only applicable for 25cm thick brick & mortaring wall. If the thickness is 40cm, the wall can be regarded as "Heavy Structure".)

Table 2—56 Heat load coefficient for roof

Types of roofs		Coefficient B (W/m^2)	Coefficient E (W/m^2℃)
Light structure (roofing is tiling, stone plating, galvanized sheeting)	No suspended ceiling	191	3.5
	With suspended ceiling	70	1.7
Medium structure (normal thickness of concrete with insulation)	No suspended ceiling	107	2.3
	With suspended ceiling	44	1.7
Heavy structure (thick concrete with insulation)	No suspended ceiling	50	1.2
	With suspended ceiling	27	1.2

Table 2—57 Influence coefficient F for glass windows with obstruction of sunshine

Type of obstruction	Coefficient F
With internal curtain for Venetian arch window	0.7
With internal curtain	0.8～0.9

Table 2—58 Heat load coefficient for glass windows

Types of windows	Coefficient B (W/m^2)									Coefficient E (W/m^2℃)
	Visors	Windows exposed to sunshine								
		N	E	S	W	NE	SE	SW	NW	
Normal glass window (one layer 3mm)	70	174	686	361	826	512	500	616	628	6.4
Normal glass window (one layer 6mm)	64	163	628	337	756	465	454	558	570	6.4
Heat-absorption glass window(one layer 3mm)	41	105	430	256	512	314	314	385	395	6.4
Double layer glass window (outer heat-absorption glass, inner normal glass)	35	81	337	198	395	250	244	302	302	2.6
Glass block	29	47	384	151	419	233	221	267	279	2.9

Note: if the windows are in two orientations, the larger figure should be considered during the calculation, others should be regarded as shady windows.

Table 2—59 Heat load coefficient for partition walls

Types of partition	Coefficient B (W/m^2)	Coefficient E (W/m^2)
Barrier, glass	15	5.2
others	9	3.1

Table 2—60 Heat load coefficient for ceilings and floors

Types of ceilings and floors	Coefficient B (W/m²)	Coefficient E (W/m²)
Cement concrete	12	3.5
Floor covered with paint cloth	8	2.3
Wooden floor	5	1.2
Ground floor	0	1.2

Table 2—61 heat load coefficient of outdoor air

Applications	Coefficient B (W/people)	Coefficient E (W/people)
Light smoking areas like banks, shops, theatres	158	3.5
Offices, conference rooms, hotels, cafeteria, patient rooms	240	8.7
Heavy smoking areas	465	17

Table 2—62 Heat load coefficient of leaking air

	Coefficient B (W/m²)	Coefficient E (W/m²)
Standard	9	0.35
High frequency of passing, external walls have large area contacting with outside	9×(1.7～2.3)	0.35(1.7～2.3)

Table 2—63 Correction coefficient F for the outdoor air in different regions

Region	F	Region	F
Northeast/Inner Mongolia	0.8	Yangtse river area	1.0
South/north of Yellow river	0.9	China south region	1.1

Table 2—64 Heat generated by human bodies

Status	Application	W/person
Sitting	Theatre	116
Office activity and walking/sitting intermittently	Office, hotel, cafeteria, department store	140
Laboring	Factory, workshop	233

Note: Of the number of people is unknown, the following parameters can be applicable:

1 people/10m²: for hotels, guest rooms, individual patient rooms

2 people/m²: for offices, barbershops, photo-shooting rooms

3 people/m²: for conference rooms, residence houses

5 people/10m²: for conference rooms, coffee bars, cafeterias

2 Conditions for quick calculation of heating/cooling load

(1)Cooling load

When the air conditioned is a combined type of re-heat and by-pass, or the outdoor air is cooled before it comes inside, the humidity adjustment will be ignored.

The max load should be dependent upon the following conditions:

Outdoor: dry-bulb temperature 33 , wet-bulb temperature 27 , relative humidity 62%;

Indoor: dry-bulb temperature 26 , wet-bulb temperature 19.5 , relative humidity 55%.

Coefficient B in the tables is dependent upon the condition that the temperature difference between outdoor and indoor is 7 , and the sunshine load is included.

Outdoor air load means the outdoor air is 33.6kJ per cubic meter.

The coefficient B for urban gas are 16800-23100kJ/m^3, 10080-10500kJ/m^3, that for liquid gas is 41580kJ/m^3.

(2)Heating load

Heat volume of the construction, including the pre-heat.

For humidifying, the heat volume should be included in the load.

T is the temperature difference between outside and inside.

When the room is connecting with the outside, T=(indoor temperature-outdoor temperature)

When there is partition wall, ceiling, floor connecting the neighboring room equipped with heating system, T=(indoor temperature-outdoor temperature)/2

When the floor is ground floor, T=(indoor temperature-outdoor temperature)/2

3 Examples on calculations of heating and cooling

The calculations of heating and cooling can apply the methods illustrated previously, the following two examples are applying the Coefficients B, E introduced in this section.

(1)Heating/cooling conditioning for a radiographic machine in a hospital

Given conditions:

Address: Beijing

Rooms: Radiographic Rooms

Rooms area: Room No. 1: 15m 4m=60m^2

Room No. 2: 15m 4m=60m^2

Control room: 7.5m 4m=30m^2

Room volume: height 3.2m

Room No. 1: 192m^3

Room No. 2: 192m^3

Control room: 96m^3

Construction: External wall: 25cm brick wall, outside mortaring and inside plastering

Ceiling: cement concrete slab (there is heating system in the upper room on the second floor with the room temperature at 18)

Glass window: double-layer 3mm glass, with curtains or sun shading board inside.

Partition: 25cm brick wall with mortaring (there is heating system in neighboring room with temperature at 18).

Floor: Cement concrete ground covered with wooden boards.

Cooling in summer:

Indoor dry-bulb temperature t=25 , relative humidity 55%

Outdoor dry-bulb temperature 35 , relative humidity 60%

Heating in winter:

Indoor dry-bulb temperature t=22 , relative humidity 50%

Outdoor dry-bulb temperature -12 , relative humidity 49%

Number of people in rooms:

Room No. 1: 10 max; room No. 2: 3 max; control room: 2 max

Lighting:

Room No. 1: 0.2kW

Room No. 2: 0.2kW

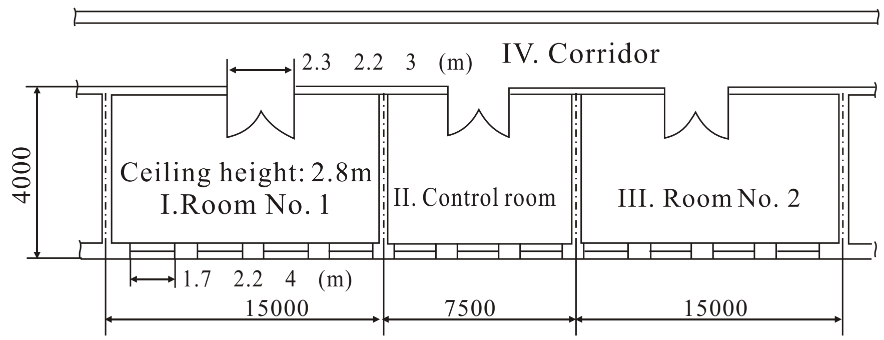
Control room: 0.1kW

Electrical appliances:

Room No. 1: 1kW

Room No. 2: 10kW

Control room: 1kW



Sketch 2—9 Layout of the Radiographic Rooms in a Hospital

We can conclude from the above calculations that: in summer, the rooms should be equipped with the conditioner which have above 19,669W cooling capacity; and in winter, a heating system which can provide 29,924W heat is necessary.

(2)To obtain parameters from Graph i-d.

Cooling in summer:

Designed outdoor temperature: 35℃ (t_A)

Designed outdoor relative humidity 60%

Designed room temperature 25℃ (t_B)

Designed room relative humidity 55%

Table 2—65

Name of construction: __________ Y_M_D Responsible person: __________

Address: __________________ Room area=(L)_____ ×(W)___ = ___m²

Name of room: ________ Floor: ___ Room volume-(Area)___×(H)____ = ___m³

Items			A		Cooling					Heating		
					Coef. B	C= A B	Coef. F		Load Q=f c	Coef. E	t (inside/ outside)	Load H=A E T
External wall			Area m²				1					
External wall			Area m²				1					
External wall			Area m²				1					
External wall			Area m²				1					
			Area m²				1					
Glass window			Area m²				Ratio of sun-shine					
Glass window			Area m²				Ratio of sun-shine					
Partition, ceiling, floor			Area m²				Ratio of sun-shine					
Partition, ceiling, floor			Area m²				1					
Partition, ceiling, floor			Area m²				1					
Partition, ceiling, floor			Area m²				1					
New air	Outdoor air required by people		No. of people				Coef. of region		Max.			Max.
New air	Outdoor air leaking inside		Room volume	m²			Coef. of region		Max.			Max.
	Body generated heat		No. of people				1					
Room generated heat	Lighting	Fluores-cent		kW	1250		Rate of utilization					
Room generated heat	Lighting	incan-descent		kW			Rate of utilization					
Room generated heat	Electric appliances			kW			Rate of utilization					
Room generated heat	Gas	Urban gas		m³/h			Rate of utilization					
Room generated heat	Gas	Liquid gas		m³/h			Rate of utilization					
Total Load					Total Q				W	Total H		W

Sketch of Construction Layout:

Table 2—65

Name of construction: Hospital 98Y×M×D Responsible person: XXX

Address: Beijing City Room area=(L) 37.5m ×(W) 4m =150m²

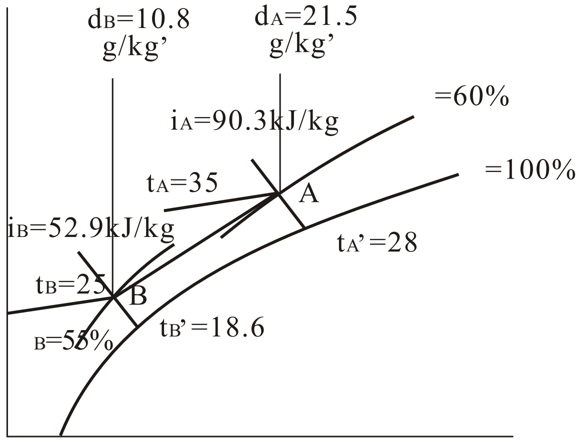
Name of room: Radiographic Floor: 1 Room volume-(Area)150m²×(H)3.2m=480m³

Items		A		Cooling					Heating		
				Coef. B	C= A B	Coef. F		Load Q=f c	Coef. E	t (inside/ outside)	Load H=A E T
External wall	S:37.5×3.2-41.1	Area m²	78.9	40	3,156	1		3,156	2.9	34	7,780
External wall											
External wall											
External wall											
roof	37.5×4		150	12	1800	1		1,800	3.5	4	2,100
Glass window	S: 11 1.7 22 double layer glass		41.1	198	8,378	Ratio of sun-shine	0.7	5,865	2.6	34	3,633
Glass window	Normal 3mm glass										
Partition, ceiling, floor	E: 4 3.2 W: 4 3.2		25.6	9	230	1		230	3.1	4	317
Partition, ceiling, floor			104.8	9	943			943	3.1	4	1,300
Partition, ceiling, floor			15.2	15	228			228	3.1	4	188
Partition, ceiling, floor			150	0	0			0	1.2	34	6,120
New air	Outdoor air required by people	No. of people	15	240	3,600	Coef. of region	0.9	5184	8.5	4	8486
New air	Outdoor air leaking inside	Room volume	480m²	12	5,790				0.52		
	Body generated heat	No. of people	15	116	1,740	0.5		750			
Room generated heat	Lighting: fluore-scent	0.5kW		1250	625	Rate of utilization	0.5	313			
Room generated heat	Lighting: incand-escent	kW									
Room generated heat	Electric appliances	12kW			12000		0.1	1,200			
Room generated heat	Gas: Urban gas										
Room generated heat	Gas: Liquid gas										
	Total Load			Total Q		19,669W			Total H		29,924W

Sketch of Construction Layout:

To refer Graph i d for the process of A B (see graph 2—10), which includes the processes of "de-enthalpy, dehumidifying and cooling". Parameters for A and B are as following:

	Temperature (℃)	Humidity (Φ)	Dew temperature (℃)	Enthalpy kJ/kg	Absolute humidity kg/kg'
Outdoor (A)	t_A=35℃	60%	t'_A=28℃	i_A=90.3	d_A=0.0215
Indoor (B)	t_B=25℃	55%	t'_B=18.6℃	i_B=52.9	d_B=0.0108
Difference	Δt =10℃	5%		37.4 kJ/	Δd=0.0107



Graph 2—10 Parameters in Graph i d from t_A=35℃ , Φ=60% to t_A=25℃ , Φ=55%

In graph i—d, when t_A=35℃ and Φ=60%, the specific volume of wet air is 0.93m^3/kg. If the leaking air is 480m^3/h, and t_B is at dew point, the specific volume of the saturated wet air is 0.84m^3/kg. The weight of the saturated wet air is:

480m^3/h ÷ 0.9393m^3/kg = 516kg/h

① De-enthalpy

Air penetrating the room is 480m^3/h, which is 516kg/h, the total volume of de-enthalpy is:

37.4kJ/kg×516kg/h=19298.4kJ/h=5361W,

While using the quick calculation "Leaking Air" introduced previously:

480m^3×coefficient 12×regional coefficient 0.9=19298kJ/h, 19298 ÷ 3.6 = 5361W

These two results are the same.

Dehumidifying

Leaking air dehumidifying:

Say the air is 516kg/h and difference of absolute humidity is 0.0107kg/kg', thus we can conclude the dehumidifying as:

516kg/h 0.0107kg/kg'=5.52kg/h

Changing air dehumidifying:

Say air requirement for each person is $34m^3/h$ (table 2—27), total 15 people in the room, coefficient is 0.5 (because not all the 15 people are in the room at the sametime). Therefore,

Air changing = $34m^3/h \times 15 \times 0.5 = 255m^3/h$

When t_A=35℃ , the air mass will be $255m^3/h \div 0.93m^3/h$ = 237kg/h

Dehumidifying = 237kg/h ×0.0107kg/kg' = 2.54kg/h

Volatile from human bodies:

Say there are 15 people, coefficient is 0.5, the applicable parameter in table 2—35 for light activity at 25℃ is 189g/h=1.13kg/h

15×0.5×189g/h×0.8 (1 in the table indicates the body surface of the European people) = 1130g/h =1.13kg/h

Total volatile is:

Leaking air dehumidifying + changing air dehumidifying + volatile from human bodies + volatile from appliances + other volatile

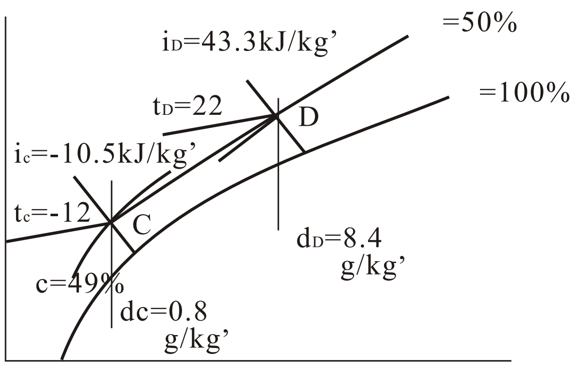
So the total volatile is 5.52+2.54+1.13=9.19kg/h

The formula for humidifying can go to No. 7 in this section, quick calculation is:

Humidity exchange (g/h) = (indoor absolute humidity-outdoor absolute humidity) (g/kg') × (leaking air + changing air) (m^3/h) × 1.2

The leaking air can be obtained through Area Method in table 2—53:

Window area1.7×2.2(m^2)×11 (number of windows)×9.7 (leaking air m^3/h)×1.2 =$488m^3/h$



Drawing 2—11 Parameters in graph i--d during Heating in winter

Parameters in graph i--d for heating in winter

	Temperature (℃)	Humidity (Φ)	Dew temperature (t')	Enthalpy kJ/kg	Absolute humidity kg/kg'
Outdoor (C)	−12℃	49%		i_C=-10.5	d_C=0.0008
Indoor (D)	22℃	50%		i_D=43.3	d_D=0.0084
Difference	Δt=4℃			Δi=53.8	Δd=0.0076

Humidity exchange =(0.0084kg/kg'-0.0008kg/kg')×(488+255)×1.2=6.78kg/h

Humidity increase =indoor heat exchange volatile from human body

=6.78kg/h 1.13kg/h =5.65kg/h

(2)Conditioning of the operation room in a hospital

① Conditions:

Given conditions:

Address:

Chengdu City

Outdoor: (see table 2—66)

In summer:

Highest temperature is 33℃ , highest wet-bulb temperature 27.2℃ , relative humidity Φ 65% ,temperature for external structure during calculation is 30℃

In winter:

Lowest temperature -1℃ , relative humidity 82%

Indoor: (designed condition)

Summer: 27℃ , relative humidity 60%

Winter: 27℃ , relative humidity 70%

Construction:

2nd floor (total 4 floors), layout (see sketch 2—15)

External wall: concrete with internally plastering & externally cement mortaring.

Glass window: one layer with normal glass, 3mm thick

Partition: plastered single-brick wall

Floor: concrete terrazzo

Ceiling: (floor of the 3rd floor)

Number of people: 10

Lighting: 20W/m², total 1000W

Electrical appliances: 5kW including all operation instruments

② Calculations (see table 2—62)

Result of the quick calculation

Table 2—66

Name of construction: Patient's Building

Address: Chengdu City

Room name: operation room

Floor: northeast 2nd floor (total 4 floors)

Area: L (10m)×W (5m)=50m²

Y M D Responsible person:

Outdoor: summer 33 , 65%, wet-bulb 28.4

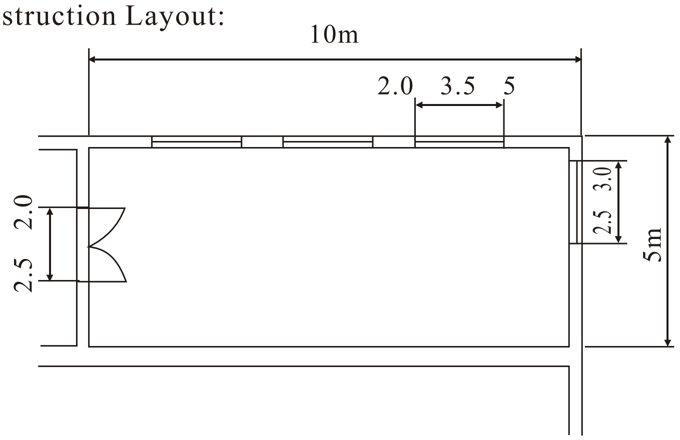
Winter -1 , 82%

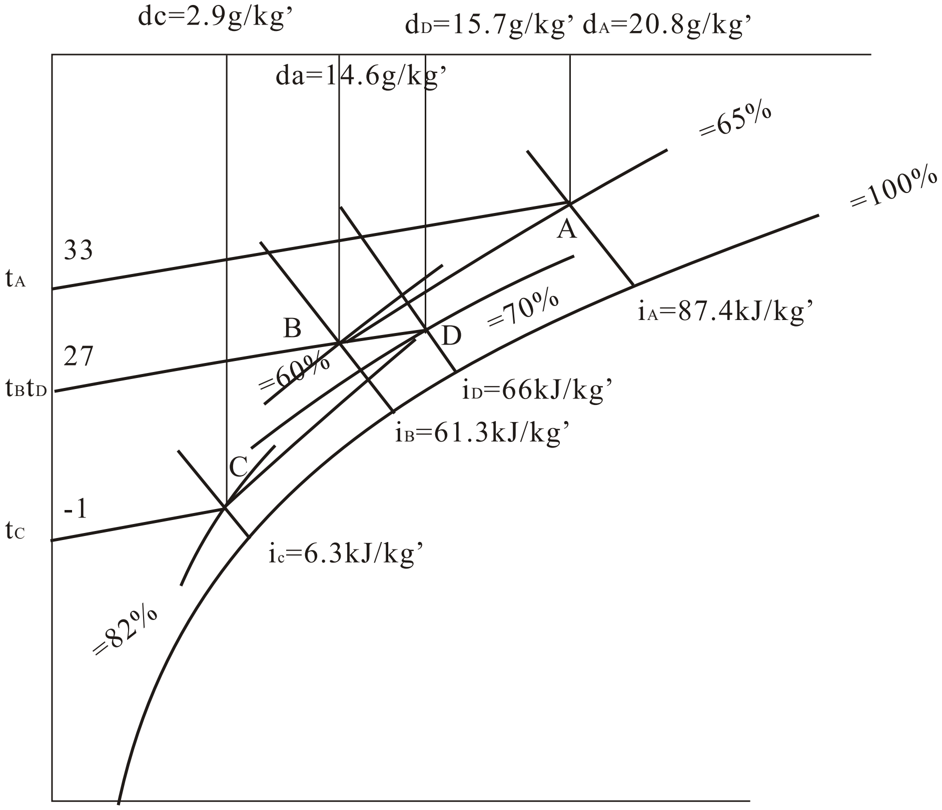
Indoor: 27 , 80%,

winter 27 , 70%

Items		A		Cooling: Coef. B	Cooling: C=A×B	Cooling: Coef. F		Cooling: Load Q=f c	Heating: Coef. E	Heating: t (inside/outside)	Heating: Load H=A E T
External wall	E:5.0×3.5−15	Area m²	2.5	47	118	1		118	2.9	28	203
	N:10×3.5−22.5		12.5	17	213			213	2.9		1015
roof											
Glass window	E:2.5×30×2		15	686	10290	With curtain	0.7	7203	6.4	28	2688
	N:2.5×30×3		22.5	174	3915		0.7	2740	6.4		4032
Partition, ceiling, floor	S:10×3.5		35	9	315			315	3.1	18+9	1953
	W:glass door2.5×3		5	15	75			75	5.2		468
	W:5.0×3.5-5		12.5	9	113			113	3.1		698
	Floors:2×10×5		100	12	1200			1200	3.5		6300
New air	Outdoor air required by people	No. of people	10	240	2400	Coef. of regi-on	1.1	2640	8.7	28	2436
	Outdoor air leaking inside	Room volume	175m²	9	1575				0.35		
Room generated heat	Body generated heat	No. of people	10	140	1400	0.6		840			
	Lighting: fluore-scent	1kW		1.25	1250	Rate of utilization	0.5	625			
	Lighting: incand-escent										
	Electric appliances	5kW			5000		0.1	500			
	Gas: Urban gas										
	Gas: Liquid gas										
Total Load				Total Q 16582W					Total H 19793W		

Sketch of Construction Layout:





Total cooling load is 16582W

Drawing 2-12

Total heating load 19793W

(c)Parameters in i-d are shown in Drawing 2—12

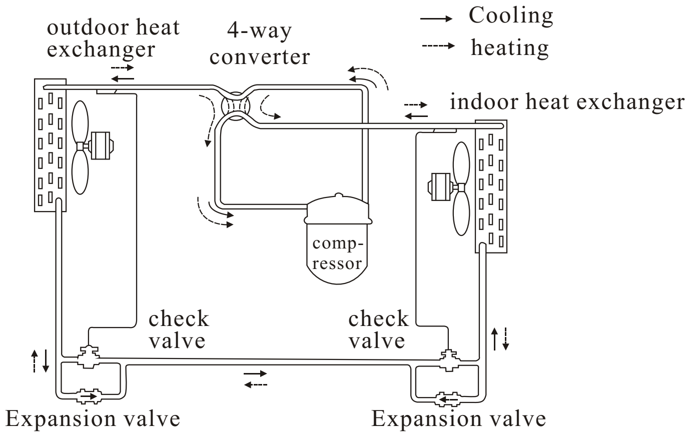
Summer: cooling conditions indicated in i-d.

	Temperature ( )	Humidity ( )	Dew temperature ( )	Enthalpy(kJ/kg)	Absolute humidity (kg/kg')
Outdoor (A)	33℃	65%	27℃	86.5	0.0208
Indoor (B)	27℃	60%	21.2℃	61.3	0.0146
Difference( )	6	5%		25.2	0.0062

Winter: heating conditions indicated in i-d.

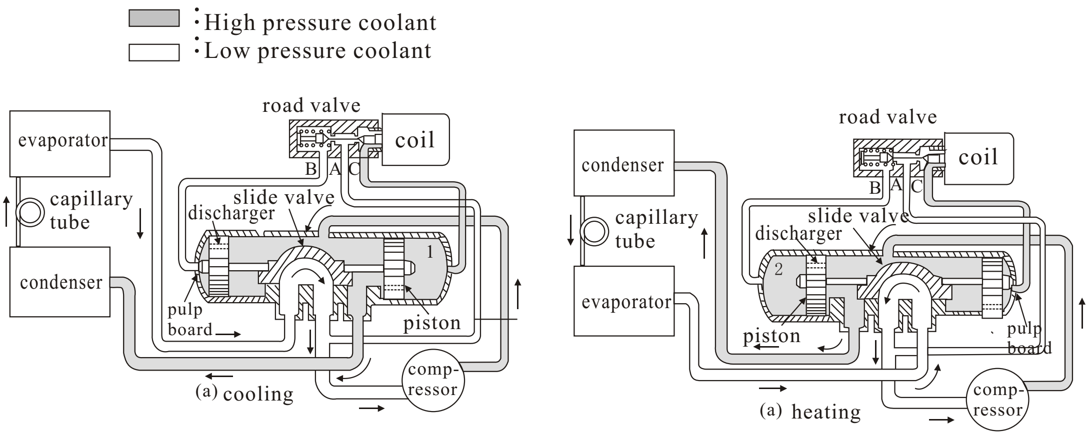
	Temperature ( )	Humidity ( )	Dew temperature ( )	Enthalpy kJ/kg	Absolute humidity kg/kg'
Outdoor (A)	-1℃	82%		6.3	0.0029
Indoor (B)	27℃	70%		66.0	0.0157
Difference( )	28	12%		-59.7	-0.0128

MRV is also called intelligent multi-system heat-pump air conditioner.Simply speaking, it is a single-stage steam-compressed cooling & cycling system. In the working cooler in summer, the coolant is transferred to evaporator, where it is evaporated and absorb the heat so as to cool the room down (Cooling). Moisture in the air is partly taken away during the process (Dehumidifying). In winter, the four-way converter is converted, the gaseous coolant in the compressor coming from indoor evaporator is liquefied after heat radiation to the room, then the liquefied coolant is evaporated in the outdoor condenser, obtaining heat from the atmosphere (evaporation), thus the room is heated (heating). This kind of working system is called "heat pump" system. Sketch 3—1 shows the compressor heat pump system.



Sketch 3—1 Heat Pump Cycling System

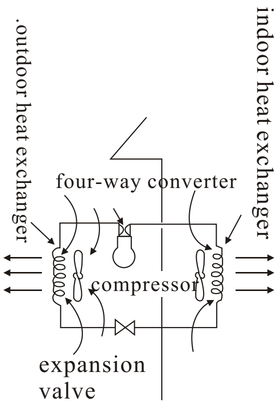
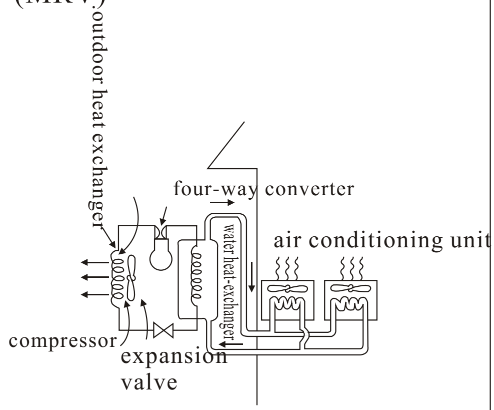
The main part in the single-stage compressed cooling and cycling system is "fourway converter" (or 4-way valve). The valve is in two different orientation, by moving the internal piston, it can function as "heating"and "cooling". Therefore, the indoor evaporator and outdoor condenser are also called Indoor Heat Exchanger and Outdoor Heat Exchanger. This is the working process of the heat-pump air conditioner as shown in Sketch 3—2.



Sketch 3—2 Working Principle of four-way Valve

This section is mainly to discuss the single-stage steam-compressed heat-pump system. Based on heat source, heat pump is classified into air heat pump and water heat pump. Air heat pump can be sub-classified into air vs air and air vs water, as shown in table 3—1.

Table 3—1 Air heat pump

Description	Air vs air	Air vs water
Heat source	Air (outdoor air/air discharge)	Air (outdoor air/air discharge)
Dissipation	Air	Water
Characteristics	To obtain the heat from outside and to discharge heat directly to the room (heating). On the contrary, to absorb the heat from the room and discharge to outside (cooling). This type is mainly applicable for residence and rooms with small area. The decrease of the outdoor temperature will result in the low efficiency of heat pump, so the addition of auxiliary heater is necessary.	To generate the heat obtained from outside into warm water, then tramsfer to the room (heating). On the contrary, the cool water transferred into room is heated (cooling), then the generated heat is discharged to outside through heat exchanger.
Sketches	Window type, split type, multi-system (MRV) 	Small-size air-cooled water system (MRV) 

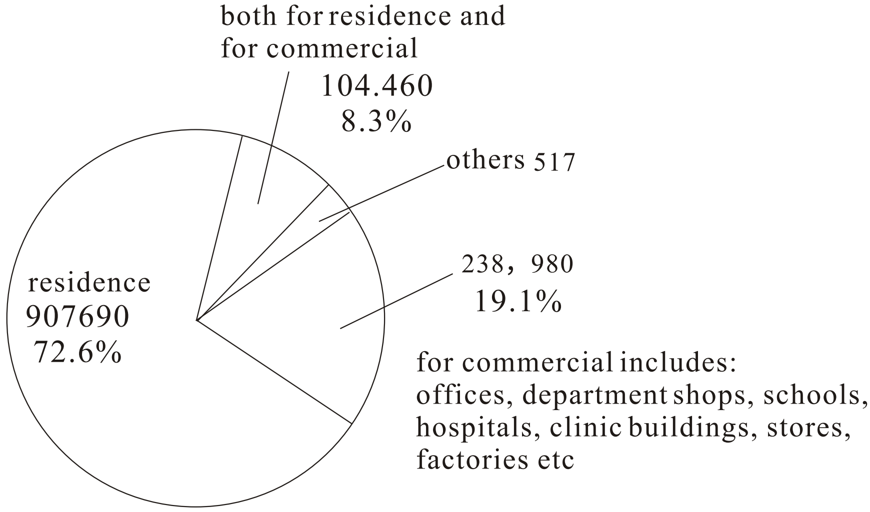
Besides that, water heat pump, which mainly utilizes the underground water or recycled water and is applicable for large-scale central air conditioning system, here will not be discussed in detail.

Section I Selection of MRV Air Conditioner

1-1 Objects and characteristics of marketing

Objects

As shown in Sketch 3—3, the total pieces of construction with the construction area below 2000m^2 is 1,251,058, which is above 90% of the whole construction. While it only takes 50% of the land area. Even so, these constructions are mainly for shops and offices, which is the most potential market for MRV.



Sketch 3—3 Marketing Objects of MRV Air Conditioner

Characteristics:

The following characteristics make the market potential for MRV:

1.It is applicable for the places with many offices or shops, the temperature and running time can be controlled for individual office or shop.

2.Running and maintenance cost can be calculated and controlled individually.

3.No need for control room. It is economic, power saving and comfortable.

Section II Air-cooled Heat Pump (MRV) Air Conditioner

This type takes air as the media. Room air is transferred through the fan to the heat exchanger, where it is heated or cooled and distributed to the room. The heat absorbed by the coolant in the indoor heat exchanger is transferred to outdoor heat exchanger by tubes and then discharged to atmosphere. This is the process of heat exchanging.

2-1 Advantages

1、No need for chilled water or water system. It is water-saving, especially applicable for the areas lacking water.

2、Simple assembly and installation. The only work is to assemble indoor and outdoor units and to connect them with tubes.

3、Low occupancy of area. Unlike water-cooled type which needs cooling tower, pumps etc.

4、Environmental protection. It is a fully electrical appliance which has no contamination to atmosphere. Piping diagram see Sketch 3—7.

5 Easy maintenance and repair, low cost.

During selection of the air-cooled type air conditioner:

1 Decrease of outdoor temperature will result in the decrease of heating capacity, so the selection of heating capacity should be dependant upon climate condition as well.

2 The installation of tubes may be limited by length and height difference, so the selection of location should take the tube length and height difference into consideration.

3 The media is air, so good ventilation needs considering during installation and air flow will not be affected by walls, ceilings or floors.

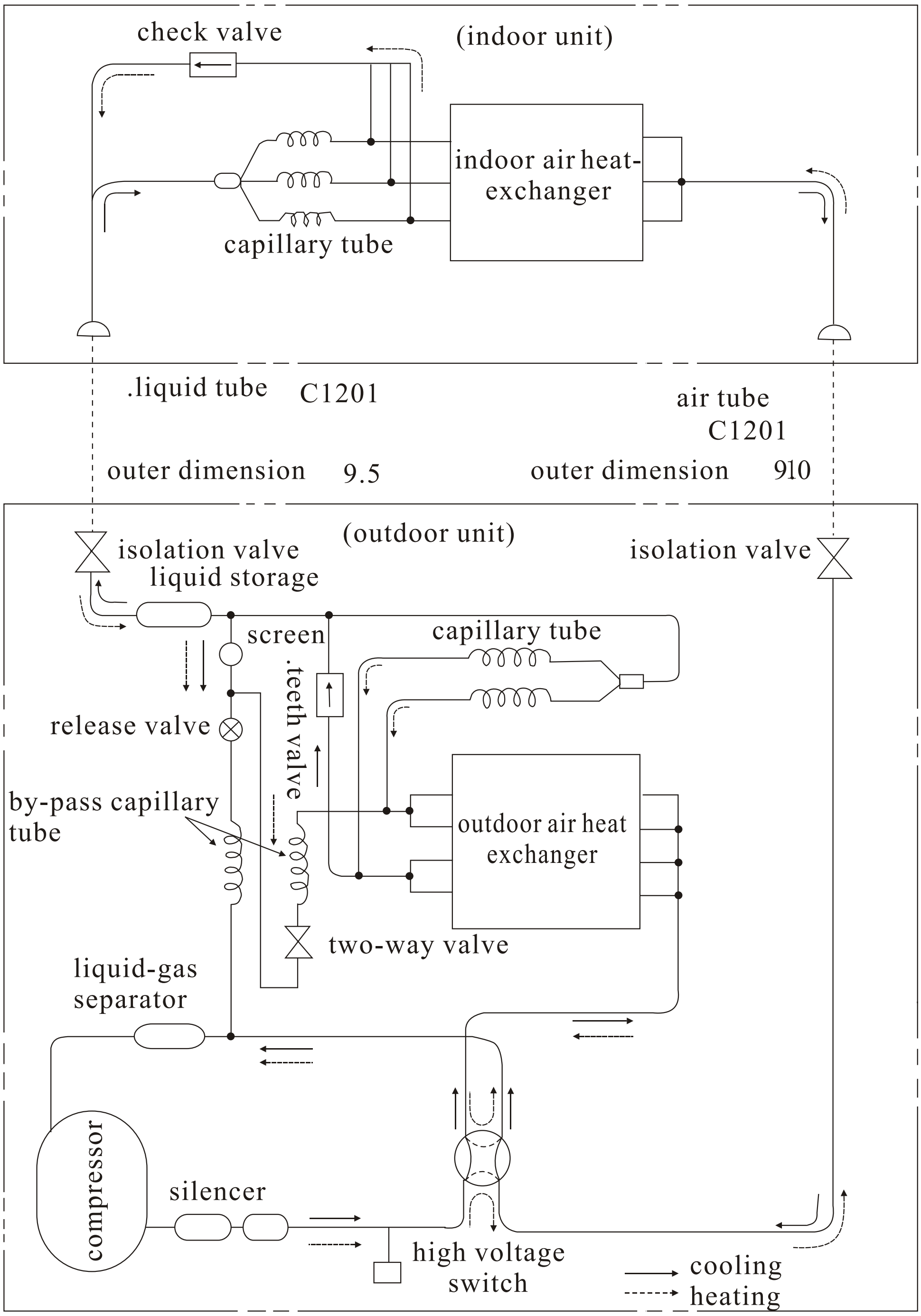
Heat pump air conditioners can be classified into integral type and split type. Among split-type air conditioners, indoor units are diversified, as ceiling type, wall-type, grounded type and multi-split type

During selection of air conditioners:

1、To calculate the heating/cooling load of the room (see Chapter II) and analyze their relations carefully.

2、To select the type according to table 3—8. Better to install several small-size air conditioner for the large room or multi-rooms.

3、The selection should be dependant upon climate, room condition and product performances. Normally, the performance indicators given in the brochure are complying with GB/T7725-1966. Table 2—4 and 2—5 illustrate the conditions of indoor and outdoor temperatures; and table 3—2 illustrates the JIS standard.



Sketch 3—7 Air-cooled Heat Pump Piping System

Table 3—2—1 JIS Temperature Condition (Integral unit) (unit: ℃)

Conditions			Indoor inlet air condition		Outdoor Condition					
					Cool-air type outdoor AC		Water-cooled cool-air AC		Water-cooled heat-pump outdoor AC	
			Dry-bulb	Wet-bulb	Dry-bulb	Wet-bulb	water inlet	water outlet	water inlet	water outlet
Cool air test		Cool air	27±1	19.5±0.5	35±1	24±0.5(3)	30±0.5	35±0.5	18±0.5	29±0.5
Cool air test		Over load	32±1	22.5±0.5	43±1	25.5±0.5(3)	32±0.5	-(4)	24±0.5	-(4)
Cool air test		Condensation	27±1	24±0.5	27±1	24±0.5(3)	—	27±0.5	—	27±0.5
Cool air test		Low temperature	21±1	15.5±0.5	21±1	15.5±0.5(3)	—	21±0.5	—	21±0.5
Warm air test	Heat pump	Warm air	21±1	—	7±1	6±0.5	—	—	15.5±0.5	-(4)
Warm air test	Heat pump	Over load	24±1	—	21±1	15.5±0.5	—	—	21±0.5	-(4)
Warm air test	Heat pump	Defrost	21±1	—	15±1	0.5±0.5	—	—	—	—
Electrical heater			21(2)	—	—	—	—	—	—	—

Note:

(1)During defrosting, no matter how it regulates in table 3—2—1, it complies with table 3—2—2.

21±3

(2)Indicating the datum temperature in surrounding areas.

1.5±6

(3)Being applicable for those whose web-bulb temperature can influence outdoor heat exchanger (functions as the heat source for outdoor heat exchanger and utilizes the potential heat of water.)

(4)Being applicable for cool air condition

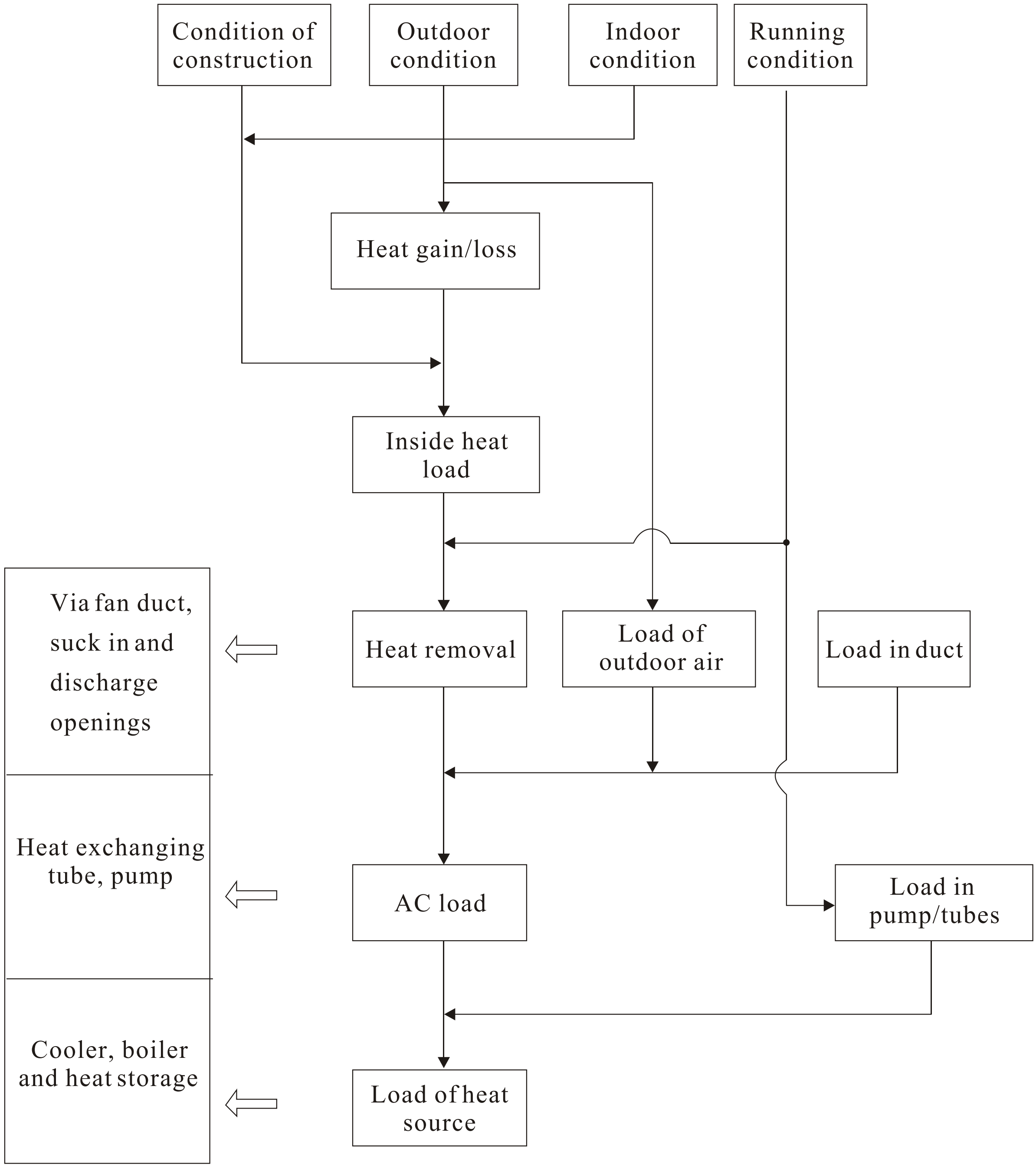
Table 3—2—2 JIS Defrosting Condition (Integral unit) (unit: ℃)

		Warm air (defrosting)
Indoor	Dry-bulb temperature Wet-bulb temperature	
Outdoor	Dry-bulb temperature Wet-bulb temperature	

• Cooling capacity

Air conditioning capacity is dependant upon indoor wet-bulb temperature and outdoor dry-bulb temperature, so the calculated cooling capacity based on designed conditions is only for reference.

Relations of the AC Loads



The following are the required indoor and outdoor conditions for heating and cooling:

Cooling Capacity:

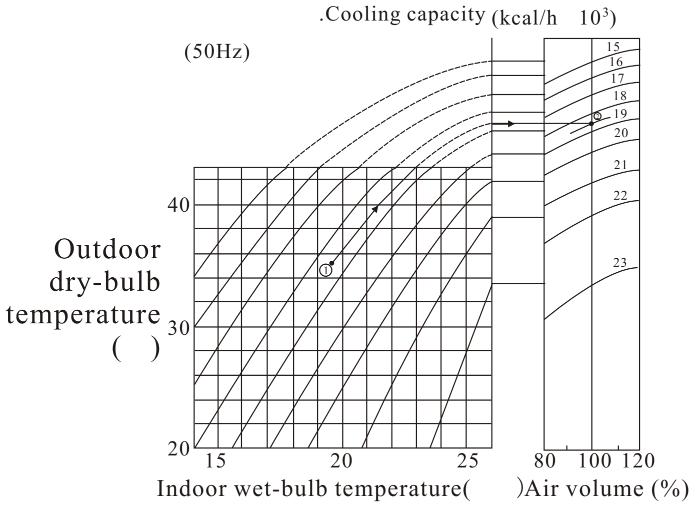
As the cooling capacity is dependant upon the indoor wet-bulb temperature and outdoor dry-bulb temperature, the data obtained from the calculation which is based on designed conditions are subject to correction.

E.g. Indoor wet-bulb temperature: 19.5℃

Outdoor dry-bulb temperature: 35℃

Frequency: 50Hz

Therefore, we can read out the cooling capacity for RPA-88H (7.5P) is 18500kcal/h (21516W) from Sketch 3—8.



Sketch 3—8 Cooling Curve for RPA-88H Air Conditioner

Heating Capacity:

As the heating capacity is dependant upon the indoor dry-bulb temperature and outdoor wet-bulb temperature, the data obtained from the calculation which is based on the designed conditions are subject to correction.

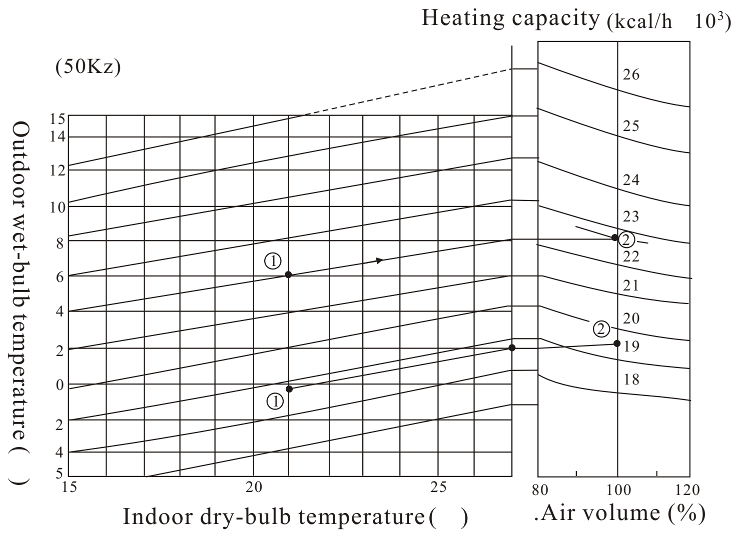
E.g. Indoor dry-bulb temperature: 21℃

Outdoor dry-bulb temperature: 0℃

Frequency: 50Hz

Therefore, we can read out the heating capacity for RPA-88H (7.5P) is 18400kcal/h (22562W) from Sketch 3—9.

Normally, the designed conditions for cooling can be equal or below the performance testing conditions stated in GB/T7725-1996. The cooling capacity may also refer to the indicators stated in the brochure. However, for heating, the outdoor temperature may be usually below the conditions stated in the standard, thus the heating capacity will be decreased. Therefore, the capacity can only be obtained and corrected according to the Heating Performance Curve. Say the heating capacity is at 100% under the standard conditions, when the outdoor temperature descends to 0 , the estimated capacity would become 85%; and when the temperature is -5 , capacity would change to 75%.



Sketch 3—9 Heating Curve for RPA-88H Air Conditioner

Table 3—3 provides the performance indicators

Table 3—3 (kcal/h*1.163=w)

[capacity: (kcal/h)] [50/60Hz]

	Cooling capacity (kcal/h)	Heating capacity (kcal/h)		
	Outdoor DB 35 Indoor WB19.5	Outdoor WB 7 Indoor DB 21	Outdoor WB 0 Indoor DB 21	Outdoor WB 5 Indoor DB 21
RPA-38H (3 HP)	7 100/7 700	9 300/9 900	8 000/8 500	7 000/7 500
RPA-58H (5 HP)	11 500/12 500	16 000/17 000	13 800/14 500	12 200/12 600
RPA-88H (7.5 HP)	18 500/20 000	22 800/24 000	19 400/20 400	17 000/17 800
RPA-108H (10 HP)	22 000/24 000	29 000/32 000	25 800/28 500	22 800/25 800
RDA-152H (15 HP)	35 000/40 000	36 000/41 000	31 000/35 800	26 500/29 800
RDA-202H (20 HP)	46 000/50 000	50 000/55 000	42 000/47 500	36 000/41 500
RDA-252H (25 HP)	56 000/63 000	60 000/68 000	50 100/55 900	43 300/46 900
RDA-302H (30 HP)	67 000/75 000	75 000/80 000	61 900/65 700	53 000/55 200

The indoor or outdoor dry-bulb or wet-bulb temperature will affect the performance of heat-pump air conditioner during heating or cooling. Table 3—4 illustrates their relationship.

Table 3—4 Environment dry-bulb/wet bulb temperature influence on heat-pump AC performance

	Indoor temperature				Outdoor temperature			
	Dry bulb (DB)		Wet bulb (WB)		Dry bulb (DB)		Wet bulb (WB)	
	up	down	up	down	up	down	up	down
Cooling capacity (Q_C)			up	down	down	up		
Heating capacity (Q_H)	up	down					up	down

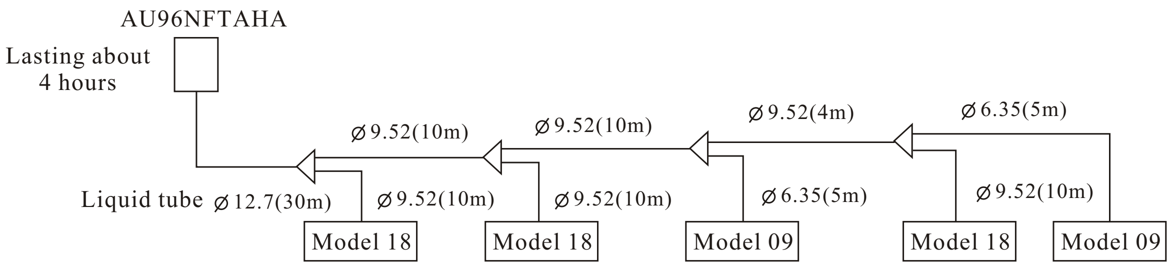
Air flow is below 100%, if the variation is over 20%, the AC performance will be affected.

So enough attention should be paid to the heating capacity while selecting the air conditioner. Due to the fact that the capacity would be reduced with the descending of the outdoor temperature, it is necessary to add an electric heater or to select a large-size air conditioner while it is costly. During heating, the defrosting is functioning and cold air will come out. When the defrosting is working, the inside fan should be stopped.

4 Relations between tube length and heating/cooling capacity

The tubes connecting the indoor unit and outdoor unit of a split-type air conditioner are specified in length and height difference, which are dependant upon suppliers and equipment models. Normally, the length is 25-50m, and the height difference is diversified. When the heat exchanger is above the compressor, the tube should be within 30m and when the heat exchanger is below the compressor, the tube should be no more than 20m. Due to the fact that the height difference has great influence on performance, the relative specifications must be followed strictly, otherwise, it will cause problems to units. (Requirements for installation refer to Chapter IV)

Under the circumstances that one outdoor unit is combined with one or more indoor units, the tubes will be different in length. Normally, the tube is 5m long for one outdoor unit with one indoor unit. If the tube needs extension, the coolant should be added.



Liquid tube Ø 6.35=5+5=10m

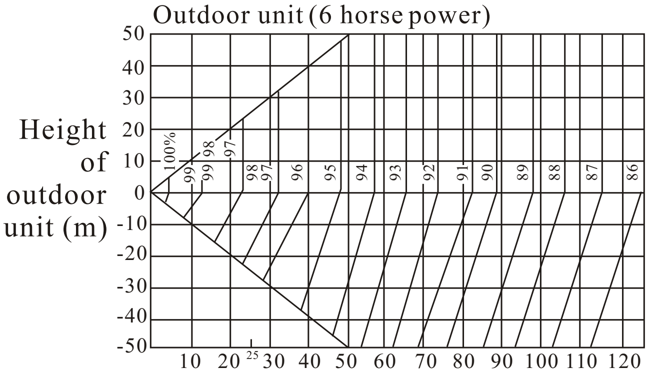
Ø 9.52=10+10+10+10+4+10=54m

Ø 12.7=30m

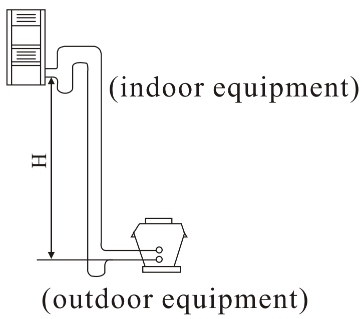
R=(10m 0.03kg/m)+(54m 0.065kg/m)+(30m 0.115kg/m)=7.26kg

Normally, the extension of tubes and addition of coolant within specifications have little effect on cooling capacity as they do on heating capacity, shown in Sketch 3—11. Therefore, the tubes should be insulated to avoid heat loss.

100% indicates the capacity calculated upon performance



Sketch 3—11 Relation between tubes and installation height for 6HP units



(note) cooling capacity no change because of enclosed coolant addition

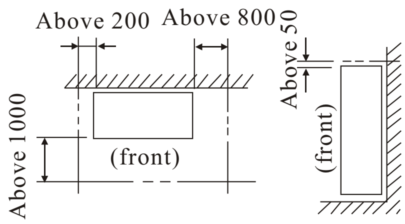
2-2 Notes before AC application:

Attention need to be paid to the following points during design, installation and application, so as to make the air conditioner run soundly.

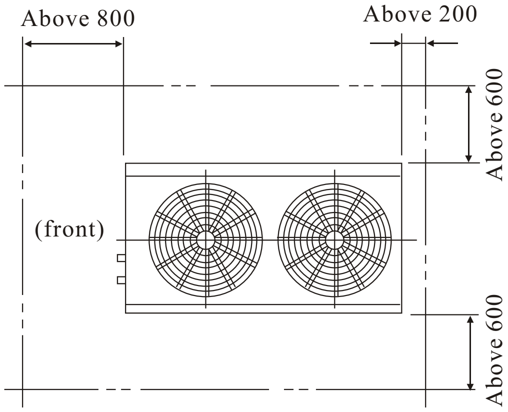
1、The room to be fitted with air conditioner should have enough space for air sucking and maintenance.

2、The enough maintenance space and good ventilation are required for the outdoor unit. Discharge from the outlet should not be blocked or opposite to others, as shown in sketch 3—13.

3、Outdoor heat exchanger should be cleaned regularly to avoid dust blocking air flow.



Sketch 3—12 Space for indoor unit



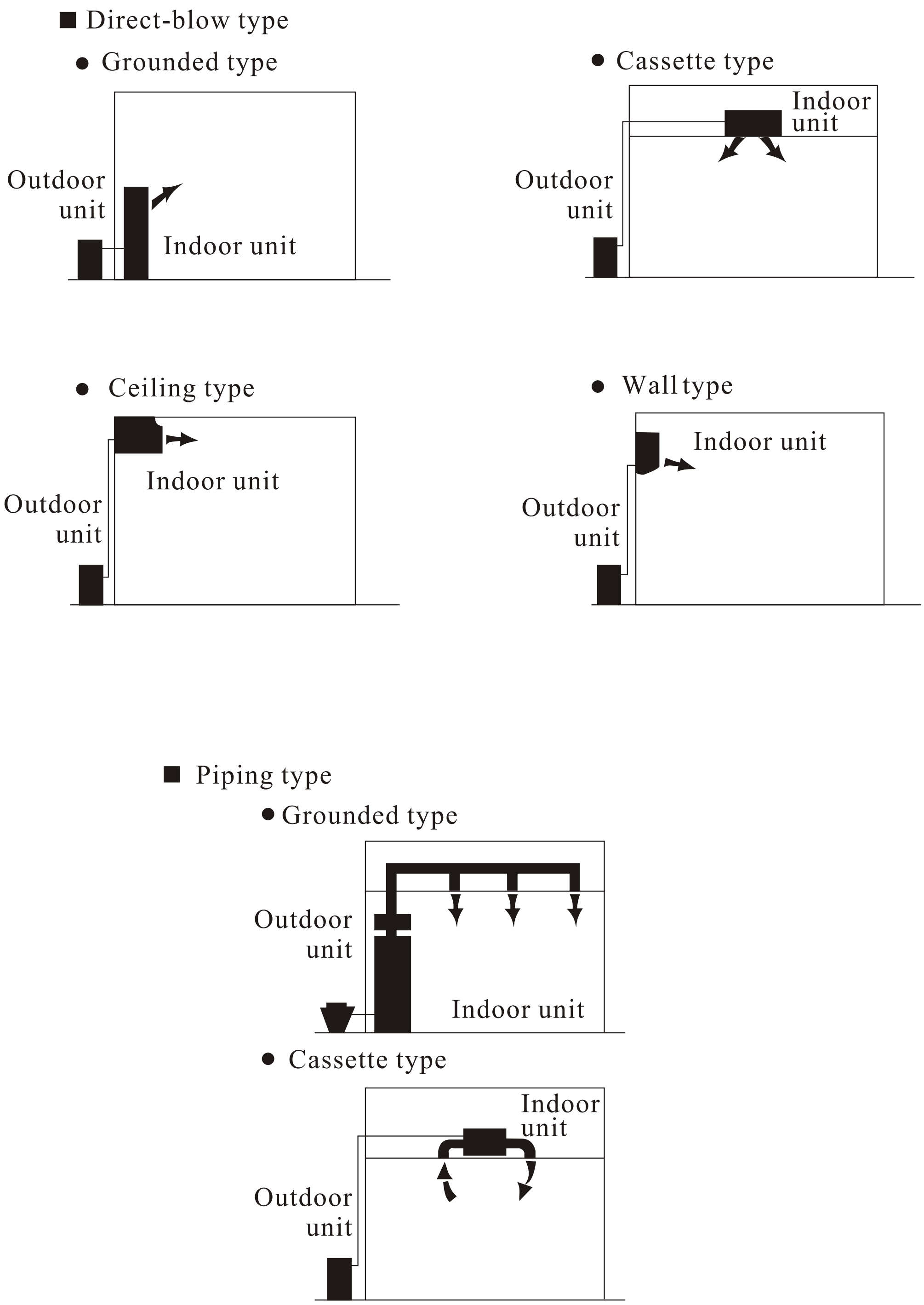
Sketch 3—13 Space for outdoor unit

4、Equipment should be free from chloride and other corrosive gas.

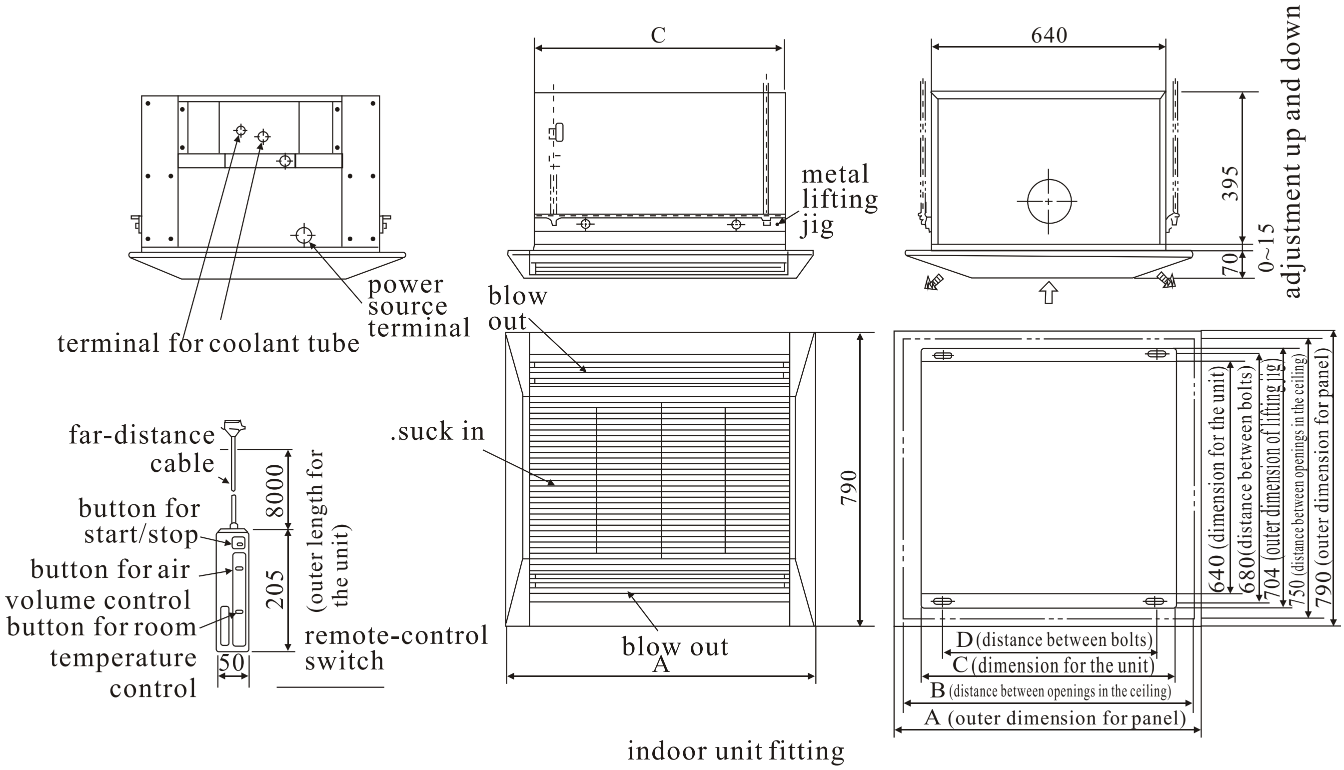
5、Trench and piping are required for the defrosting water being discharged soundly.

6、Units should be free from dust collection. Actions need to be taken to remove snow (to be discussed in detail in Chapter IV). Dimensions and installation of Haier MRV refer to Appendix.

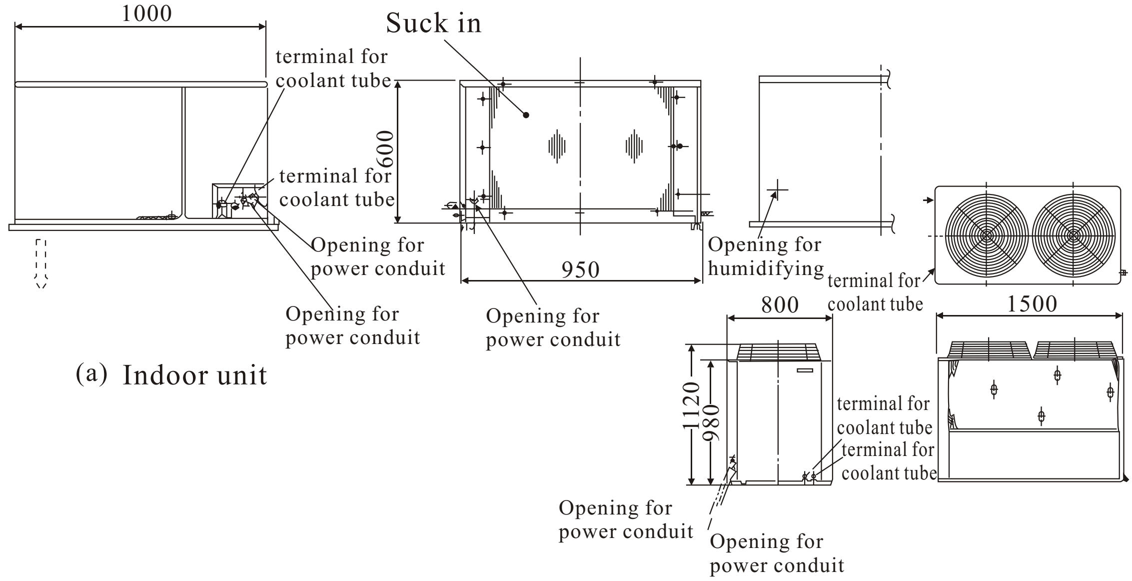
Sketch 3—14 illustrated types of air-cooled heat-pump air conditioner and the Appendix provides the technical data of MRV.



Sketch 3—14 (A) Categories of air-cooled heat-pump AC



Sketch 3—14 (C) Cassette type heat-pump AC

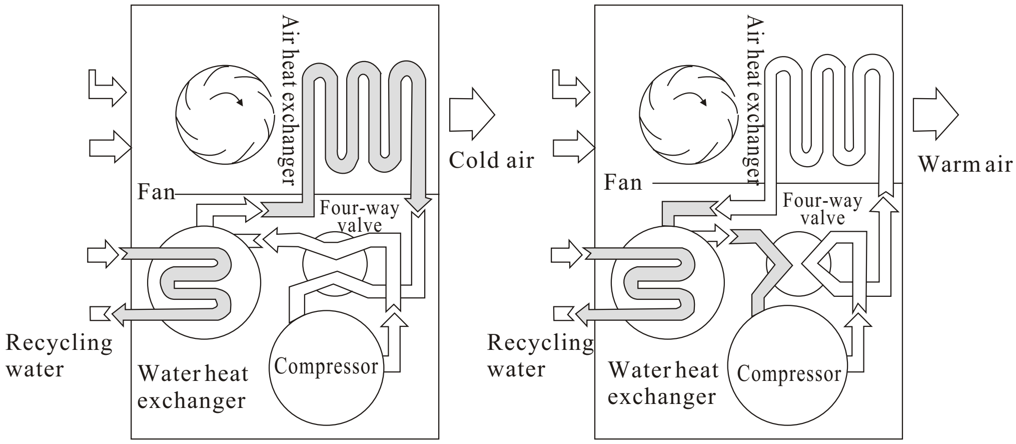


Sketch 3—14 (B) Air-tube Air-cooled Heat-pump AC

Section III Water-cooled Heat-pump (MRV) Air Conditioner

Here we only discuss the heat-pump system with outdoor air cooling and indoor water cooling.

This system is primarily equivalent to the cooling system introduced previously except that there is an additional "Coolant-Water Heat Exchanger" in the outdoor unit. In summer, the cooling system cools the heat exchanger down and generates cold water which is then pumped to indoor unit (Cooling). In winter, cooling system is converted to heat pump and heat the exchanger to generate hot water which is pumped to indoor unit (Heating), as shown in Sketch 3—15. In extremely cold winter, the efficiency of heat generation decreases, the water can be heated by electricity to provide heat. Solar energy can also be used to increase efficiency.



(a) Heating Recycling (b) Cooling Recycling

Sketch 3—15

Advantages:

1.No need for boiler. Heat-pump system can generate both cold and hot water.

2.One or more air-cooled heat pumps can be fitted outside, no need for boiler, water tower or control room.

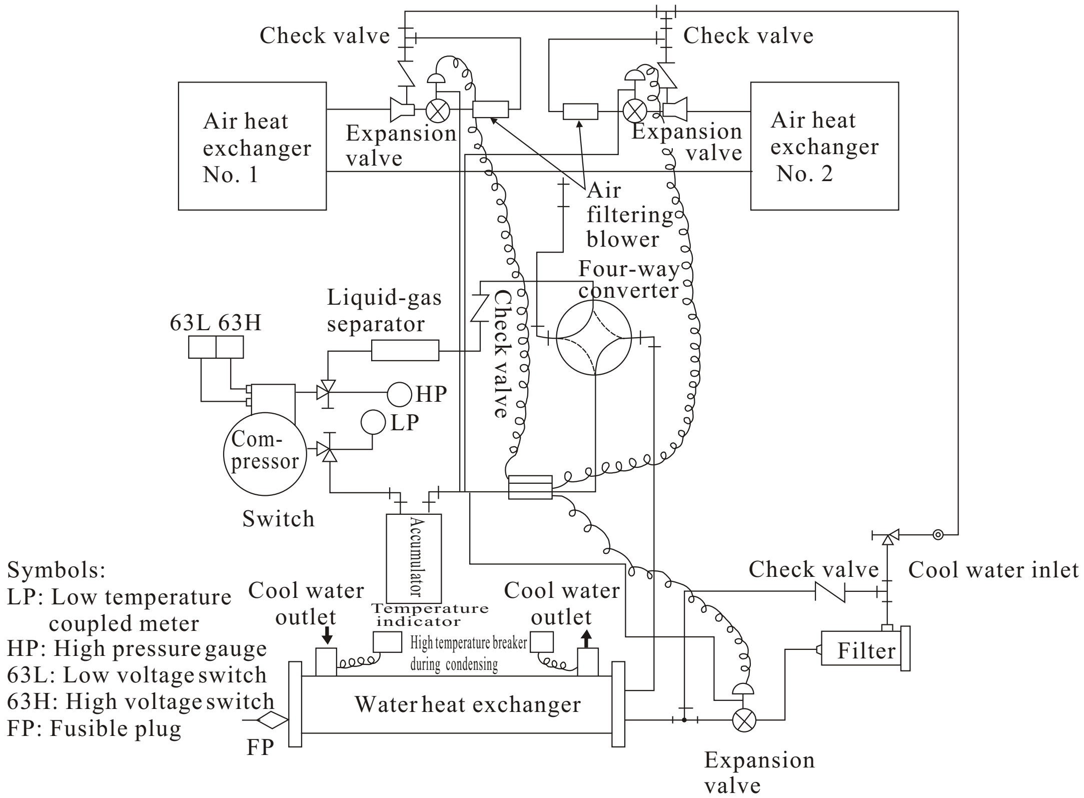
3.Fully electrical, no contamination to environment.

Note: Hot water temperature is usually below boiler water (standard is 45℃), so the calculation of blade area for exchanger need to be corrected considering capacity decrease.

3-1 Notes for model selection

1、To calculate cooling and heating load carefully.

2、The heating and cooling capacities based on the designed outdoor temperature need correction. Normally, we need refer to the technical data in product brochure, sometimes can also refer to JIS standard. Table 3—5 is the introduction for outdoor air cooling and indoor water cooling units. There is no standard to be referred for this type in China yet.



Sketch 3—16 Water-cooled Heat-pump Piping Diagram

Table 3—15 JIS standard for Temperature℃

Conditions		Application Side		Heat source side			
		Cool water		Water-cooled		Air-cooled	
		Inlet temp	Outlet temp	Inlet temp	Outlet temp	Dry-bulb temp	Wet-bulb temp
Cooling test	Cooling	12±0.5	7±0.5	30±0.5	35±0.5	35±1	21±0.5(4)
Cooling test	Overload	-(2)	15±0.5	32±0.5	- (3)	43±1	25.5±0.5(4)
Cooling test	Low temp	-(2)	5±0.5	- (3)	21±0.5	21±1	15.5±0.5(4)
Heat pump test	Heating	40±0.5	45±0.5	15.5±0.5	7±0.5	7±1	6±0.5
Heat pump test	Overload	-(3)	50±0.5	21±0.5	-(6)	21±1	15.5±0.5
Heat pump test	Defrosting (I)	40±0.5	-(6)	-	-	1.5±1	0.5±0.5

Note:

(1)Defrosting conditions mean the conditions set before the actual defrosting. When defrosting starts, conditions stated in table 3—6 should be maintained regardless of table 3—5.

(2)Applicable for cooling condition, determining water volume of application side.

(3)Applicable for cooling condition, determining water volume of heat source side.

(4)Applicable for wet-bulb temperature and can affect the heat exchanger on heat source side (as heat source, it can utilize the potential heat from water).

(5)Applicable for heat pump condition, determining water volume of application side.

(6)Applicable for heat pump condition, determining water volume of heat source side.

Remarks: The tolerances indicated in the table are the allowed temperature variation during the test.

Table 3—6 Defrosting Condition in JIS Standard (for cooler)℃

		Heating (defrosting)
Application side	Water inlet temperature Water outlet temperature	40±3 —
Heat source side	Dry-bulb temperature Wet-bulb temperature	1.5±6 —

In reality, we usually make some corrections according to the technical chart and actual requirements. E.g.

Cooling:

Given the conditions of outdoor dry-bulb temperature 35℃ , cool water outlet 7℃ and frequency 50Hz, we can read out from table 3—7 that the cooling capacity for RVA-404 (40HP) is 90000kcal/h (104670W).

Heating:

Influenced by the water outlet temperature and outdoor wet-bulb temperature, the capacity based on designed conditions need to be corrected. Given the conditions of outdoor wet-bulb temperature 0℃ , water outlet 45℃ and frequency 50Hz, we can read out from the table 3—7 that the heating capacity is 86500kcal/h (100600W). When the wet-bulb temperature is 7℃ , the heating capacity will rise to 100000kcal/h (116300W).

Under the normal summer conditions, the capacity will meet the requirements. While in winter, outdoor temperature is usually below the designed condition, so correction must be made according to the technical data for outdoor unit.

3-2 Selection of Unit Model

Attention must be paid to the heating capacity during model selection, as discussed in the previous section. Electrical heating should be added if necessary.

Table 3—7 Performance indicators for Air-cooled Cool-water Heat-pump outdoor unit RVA-404H (40HP)

(Cooling)

Frequency (Hz)	Outdoor temp (℃)	Cold water outlet temperature ( )									
		5		7		9		12		15	
		Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)
50	25	96.0	32.1	102.5	33.6	108.5	35.4	118.0	38.3	126.5	41.5
	30	90.0	34.3	96.0	35.8	101.5	37.8	110.5	40.8	119.0	44.2
	35	84.5	36.3	90.0	38.1	95.5	40.1	103.5	43.4	111.0	46.9
	40	78.5	38.4	84.0	40.3	88.5	42.5	96.5	45.9	103.0	49.7
	45	73.0	40.4	77.5	42.5	82.0	44.8	89.0	48.4	95.5	52.5
60	25	113.0	38.7	120.0	40.1	128.0	41.6	138.5	44.4	149.0	47.5
	30	106.0	40.9	112.5	42.5	119.0	44.3	129.5	47.1	139.5	50.5
	35	98.5	43.1	105.0	44.8	111.5	46.6	120.5	49.9	130.5	53.0
	40	91.5	45.5	97.5	47.2	103.0	49.2	112.0	52.5	120.5	56.0
	45	84.0	47.7	89.0	49.8	94.5	52.0	103.0	55.0	110.5	59.0

(Heating)

Frequency (Hz)	Outdoor temp ℃	Accumulated heating capacity rate	Warm water outlet temperature ( )									
			35		40		45		50		55	
			Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)	Capacity 10^3 (kcal/h)	Power (kW)
50	15	1.00	121.0	32.7	120.0	35.2	119.0	37.9	117.5	40.8	116.5	43.9
	7	0.97	102.5	30.4	101.5	32.4	100.0	34.4	98.5	36.6	97.5	39.0
	4	0.93	96.0	29.7	94.5	31.4	93.5	33.3	92.0	35.1	90.5	37.4
	0	0.94	88.0	29.1	86.5	30.4	85.0	31.8	83.5	33.5	82.0	35.2
	-5	0.96	79.0	28.7	77.0	29.4	75.5	30.4	74.0	31.5	72.0	32.7
	-10	0.97	71.0	28.5	69.0	28.8	68.0	29.3	65.0	29.9	63.0	30.5
	-15	0.97	64.0	28.8	61.5	28.6	59.5	28.5	57.0	28.6	55.0	28.7
60	15	1.00	140.0	38.2	138.0	40.8	135.5	43.6	133.5	46.6	131.0	49.8
	7	0.97	119.0	36.1	117.0	38.2	115.0	40.6	113.0	43.0	111.0	45.5
	4	0.93	111.5	35.5	109.5	37.4	108.0	39.6	106.0	41.8	104.0	44.2
	0	0.94	102.0	34.8	100.5	36.7	99.0	38.6	97.0	40.6	95.5	42.5
	-5	0.96	91.0	34.4	89.5	35.9	88.5	37.6	87.0	39.2	85.0	41.1
	-10	0.97	81.0	34.2	80.0	35.5	79.0	36.8	78.0	38.3	76.5	39.8
	-15	0.97	72.5	34.4	71.5	35.5	71.0	36.7	70.0	37.8	69.0	39.0

Notes:

(1)The performance indicators are only applicable for the standard water volume. If the water volume is changed, there will be a variation in capacity: at min flow, the variation is about +3% and at max flow, the variation would be about 1%.

(2)When the water temperature and outdoor temperature is between the figures shown in the tables, it could be calculated by proportion, but can not exceed the range specified in (1).

3-3 Selection of indoor units

Cold water (warm water) system, also called "fan coil set", is applied in indoor unit, and its capacity is determined by the followings:

1、Cooling Capacity

1.Cold water inlet temperature　2.Cold water flow

3.Return air wet-bulb temperature　4.Air flow

2、Heating Capacity

1.Warm water inlet temperature　2.Warm water flow

3.Return air dry-bulb temperature　4.Air flow

Table 3—8 illustrates the types of fan coil sets and table 3—9 and 3—10 provide their technical data for heating and cooling capacities.

Since the temperature of the warm water supplied by heat pump is lower than that from the boiler and the temperature will decrease at the inlet of coil set, in order to ensure the heating capacity, a larger unit than that indicated in the tables is proposed.

2 Cautions during installation

1.A large space is required for outdoor unit to avoid the short circuit caused by suck-in air and blow-out air. Space above the unit should be at least 1.8m.

2.Heat exchanging tubes cannot be blocked by dust or leaves to avoid the influence on air flow.

3.The position should be free from chloride and contamination.

4.Condense water generated from defrosting can be discharged through the trench smoothly.

5.When the water maintained in the piping system decreases, there should not be frequent start and stop. There should be an expansion water storage keeping the highest level. Or a time-lapse relay need to be added in the circuit, specifying that the unit can be shut down at least 5 minutes after the start up. The following table provides the minimum water maintained in the system for your reference, while in actual performance, the water volume is also to include water in the indoor fan coils and tubes.

6.The piping system might be frozen, in this case, anti-frozen liquid should be applied, which can also be applied to outdoor unit heat exchanger.

Minimum water volume in the system	
Capacity of units	Minimum water volume (L)
3HP	56
5HP	115
7.5HP	160
10HP	210
15HP	350
20HP	450
30HP	500

Table 3—8 Types of water-cooled indoor units (fan coil sets)

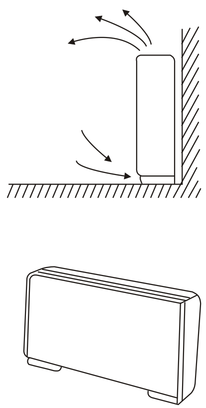
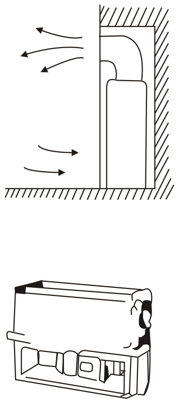
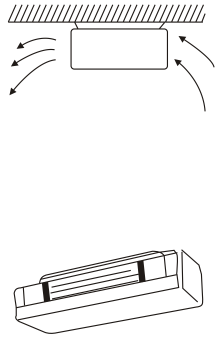
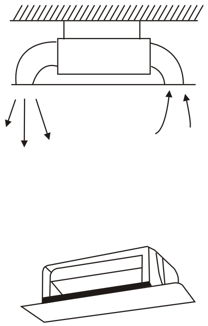
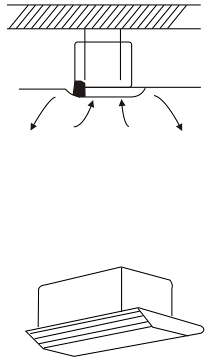
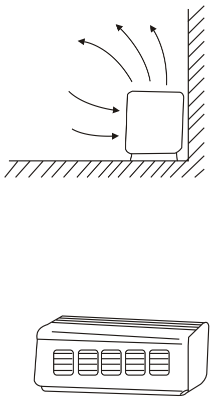
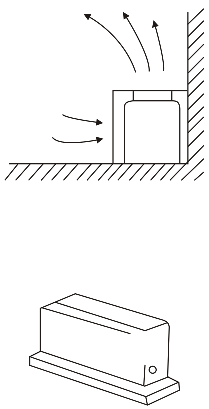
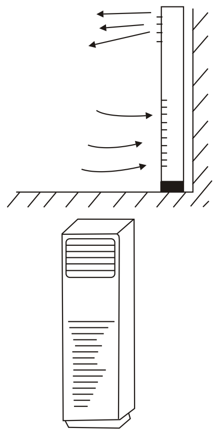
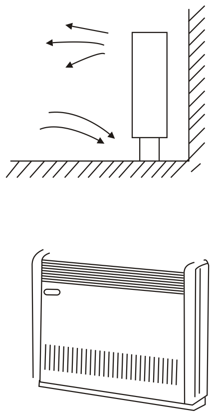
Type	Grounded type	Grounded and covered type	Ceiling type	Cassette and hidden type	Cassette type
Sample					
Type	Lower-grounded type	Lower-grounded and covered type	Cabinet type	Common fan coils	
Sample					

Table 3—9 Cooling capacity for fan coil sets (for grounded/grounded and covered/ceiling/cassette and hidden/cassette/ lower grounded types)

(unit: kcal/h)

Categories	Cold water e/min	Water resistance mAq	Indoor 26℃ DB/19℃ WB						Indoor 27℃ DB/19.5℃ WB					
			Water inlet 5℃		Water inlet 7℃		Water inlet 9℃		Water inlet 5℃		Water inlet 7℃		Water inlet 9℃	
			Full heat	Obvious heat	Full heat	Obvious heat	Full heat	Obvious heat	Full heat	Obvious heat	Full heat	Obvious heat	Full heat	Obvious heat
2	5	0.18(0.33)	1,600	1,170	1,390	1,080	1,180	1,000	1,610	1,220	1,500	1,090	1,270	960
	8	0.40(0.70)	1,890	1,280	1,650	1,190	1,400	1,090	1,890	1,350	1,700	1,200	1,490	1,060
	10	0.60(1.00)	2,000	1,330	1,760	1,230	1,490	1,130	1,990	1,400	1,790	1,250	1,570	1,100
	15	1.16(1.95)	2,140	1,410	1,910	1,290	1,630	1,180	2,130	1,490	1,920	1,330	1,680	1,170
3	6	0.35(0.52)	2,350	1,720	1,980	1,500	1,590	1,370	2,370	1,740	2,140	1,550	1,870	1,370
	10	0.88(1.20)	2,720	1,800	2,320	1,640	1,880	1,470	2,780	1,910	2,510	1,710	2,190	1,510
	12	1.20(1.60)	2,830	1,860	2,430	1,680	1,970	1,510	2,890	1,920	2,600	1,760	2,280	1,520
	18	2.38(3.05)	3,020	1,950	2,610	1,760	2,150	1,570	3,100	2,040	2,790	1,820	2,440	1,610
4	10	0.66	3,350	2,240	2,900	2,100	2,450	2,000	3,340	2,370	3,000	2,120	2,640	1,870
	16	1.50	3,800	2,350	3,350	2,210	2,840	2,100	3,790	2,480	3,420	2,220	2,990	1,960
	20	2.14	3,980	2,410	3,500	2,270	2,970	2,130	3,950	2,560	3,560	2,290	3,120	2,020
	25	3.10	4,110	2,460	3,630	2,300	3,100	2,150	4,080	2,600	3,680	2,330	3,220	2,050
6	10	0.78	4,200	3,150	3,600	2,950	2,950	2,750	4,630	3,290	4,170	2,940	3,650	2,600
	15	1.58	4,750	3,400	4,100	3,150	3,400	2,900	5,230	3,570	4,500	3,190	4,130	2,820
	20	2.60	5,050	3,550	4,400	3,250	3,700	3,000	5,600	3,710	5,040	3,310	4,420	2,930
	30	5.32	5,400	3,700	4,750	3,400	4,000	3,100	5,960	3,890	5,370	3,480	4,700	3,070
8	12	0.77	5,200	4,000	4,530	4,800	3,780	3,550	5,510	4,210	4,960	3,760	4,350	3,330
	18	1.70	6,250	4,450	5,550	4,130	4,650	3,820	6,630	4,680	5,980	4,180	5,240	3,690
	24	2.80	6,850	4,750	6,150	4,400	5,250	4,000	7,400	4,980	6,670	4,450	5,840	3,930
	35	5.25	7,500	5,120	6,800	6,700	5,900	4,300	8,080	5,410	7,280	4,840	6,380	4,270
12	20	1.55	8,620	6,350	7,500	6,000	6,250	5,600	9,340	6,680	8,420	5,970	7,370	5,280
	25	2.22	9,300	6,600	8,150	6,200	6,850	5,850	10,150	6,960	9,150	6,220	8,010	5,500
	32	3.40	9,900	6,900	8,800	6,450	7,520	6,000	10,830	7,230	9,600	6,460	8,550	5,710
	40	5.75	10,300	7,100	9,300	6,600	8,020	6,150	11,280	7,510	10,170	6,710	8,910	5,930

Table 3—10 Heating capacity for fan coil sets (for grounded/grounded and covered/ceiling/cassette and hidden/cassette/ lower grounded types)

(unit: kcal/h)

Categories		Warm water e/min	Water resistance mAq	Indoor 18℃ DB						Indoor 21℃ DB					
				Water inlet 40℃	Water inlet 45℃	Water inlet 50℃	Water inlet 60℃	Water inlet 70℃	Water inlet 80℃	Water inlet 40℃	Water inlet 45℃	Water inlet 50℃	Water inlet 60℃	Water inlet 70℃	Water inlet 80℃
				Full Heat						Full Heat					
Grounded/grounded& covered/ cassette/and hidden	2	5	0.18	1,410	1,730	2,050	2,690	3,330	3,970	1,220	1,540	1,860	2,500	3,140	3,780
		10	0.60	1,560	1,920	2,270	2,980	3,690	4,400	1,350	1,710	2,060	2,770	3,480	4,190
		15	1.16	1,610	1,970	2,340	3,070	3,800	4,530	1,390	1,750	2,120	2,850	3,580	4,310
	3	6	0.35	2,050	2,510	2,980	3,910	4,840	5,770	1,770	2,230	2,700	3,630	4,560	5,410
		12	1.20	2,270	2,780	3,300	4,340	5,370	6,400	1,960	2,480	3,000	4,030	5,060	6,090
		18	2.38	2,420	2,970	3,520	4,620	5,720	6,820	2,090	2,640	3,190	4,290	5,390	6,490
	4	10	0.66	2,780	3,410	4,050	5,310	6,580	7,840	2,400	3,030	3,670	4,930	6,200	7,460
		16	1.50	2,980	3,660	4,340	5,690	7,040	8,400	2,570	3,250	3,930	5,280	6,640	8,000
		25	3.10	3,080	3,780	4,480	5,880	7,280	8,680	2,660	3,360	4,060	5,460	6,860	8,260
	6	10	0.78	3,970	4,870	5,780	7,580	9,380	11,190	3,430	4,330	5,230	7,040	8,840	10,650
		20	2.60	4,400	5,400	6,400	8,400	10,400	12,400	3,800	4,800	5,800	7,800	9,800	11,800
		30	5.32	4,510	5,540	6,560	8,610	10,660	12,710	3,900	4,920	5,950	8,000	10,050	12,100
	8	12	0.77	4,950	6,080	7,200	9,450	11,700	13,950	4,280	5,400	6,530	8,780	11,030	13,280
		24	2.80	5,820	7,140	8,460	11,110	13,760	16,400	5,030	6,350	7,670	10,320	12,960	15,610
		35	5.25	6,150	7,550	8,940	11,740	14,540	17,330	5,310	6,710	8,110	10,900	13,700	16,490
	12	20	1.55	7,130	8,750	10,370	13,610	16,850	20,000	6,160	7,780	9,400	12,640	15,880	19,120
		32	3.40	8,050	9,890	11,720	15,380	19,040	22,700	6,960	8,790	10,620	14,280	17,940	21,600
		40	5.75	8,300	10,280	12,190	16,000	19,810	23,620	7,340	9,140	11,050	14,860	18,670	22,480
Ceiling type	2	5	0.33	1,280	1,570	1,860	2,440	3,020	3,600	1,100	1,390	1,680	2,260	2,850	3,430
		10	1.00	1,420	1,740	2,060	2,710	3,350	4,000	1,230	1,550	1,870	2,520	3,160	3,810
		15	1.95	1,460	1,790	2,130	2,790	3,460	4,120	1,260	1,590	1,930	2,590	3,260	3,920
	3	6	0.46	1,930	2,360	2,800	3,680	4,550	5,430	1,660	2,100	2,540	3,420	4,290	5,170
		12	1.60	2,130	2,610	3,100	4,060	5,030	6,000	1,840	2,320	2,810	3,770	4,740	5,710
		18	3.05	2,270	2,780	3,300	4,330	5,360	6,390	1,960	2,470	2,990	4,020	5,050	6,080
	4	10	0.66	2,550	3,130	3,710	4,870	6,030	7,190	2,200	2,780	3,360	4,520	5,680	6,840
		16	1.50	2,730	3,350	3,970	5,220	6,460	7,700	2,360	2,980	3,600	4,840	6,090	7,330
		25	3.10	2,820	3,460	4,100	5,380	6,660	7,940	2,430	3,070	3,710	4,990	6,290	7,560
	6	10	0.78	3,500	4,290	5,090	6,680	8,270	9,860	3,020	3,820	4,610	6,200	7,710	9,380
		20	2.60	3,900	4,790	5,680	7,450	9,230	11,000	3,370	4,260	5,150	6,920	8,650	10,470
		30	5.32	4,000	4,910	5,820	7,640	9,460	11,280	3,460	4,370	5,280	7,100	8,950	10,730
	8	12	0.77	4,510	5,540	6,560	8,610	10,660	12,710	3,900	4,920	7,950	8,000	10,050	12,100
		24	2.80	5,320	6,530	7,740	10,160	12,580	15,000	4,600	5,810	7,020	9,430	11,850	14,270
		35	5.55	5,630	6,910	8,190	10,750	13,300	15,870	4,860	6,140	7,420	9,980	12,540	15,100

Section 4 Air purification

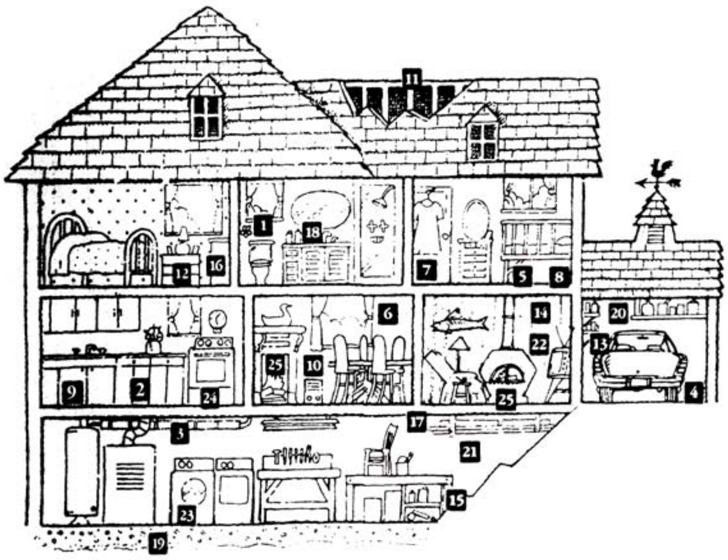
With rapid development of industry and destroying of natural environment, there are serious industrial pollution in atmosphere caused by substance such as carbon dioxide, sulfur dioxide, ammonia, and poisonous gases given off by automobiles such as nitrogen oxide, and foe like micronic dust. Besides poisonous gases and micronic dust and germs brought in form outdoor space, there are still a lot existing polluted particles, dirt, fiber, parasite (acarid) in a tight indoor space. According to reports, about more than 2000 kinds of substance shall pollute interior air and affect its quality. An investigation form environment protection department shows that copy machine, draught machine, indoor decorating, painting, carpet shall give off volatile organic compound like formaldehyde, dimethylbenzene etc. In addition, air conditioner without good maintenance and repairing shall even strengthen indoor air pollution. Bad indoor air quality shall have serious effect on human health and may cause problems like anaphylaxis, headache, gastric disorder, sickness and discomfort feeling or stimulation in nose, lung or throat. It may even cause infection of flu.

In the following drawing 3-17, common indoor pollution sources are listed.

For homey-typed air conditioner, it mainly concentrates on indoor temperature and humidity without strict stipulation on air purification.

Common indoor pollution source

1.Outdoor air
2.Combination of asbestos board cabinet
3.Heat-insulation material for asbestos pipeline
4.Waste gases given off by automobiles
5.Carpet
6.Curtain
7.Dry clothes
8.Acarid
9.Kitchen detergent
10.Air conditioner
11.Moisture
12.Camphor ball
13.Painting, volatile organic solvent
14.Closet
15.Insecticide
16.Wooden furniture, wardrobe
17.Wooden clapboard
18.Poisonous gases given off by indoor furnishings
19.Oxygen
20.Organic gas fuel
21.Adornment
22.Smoke of cigarette
23.Waste heat given off by dryer
24.Waste gases given off by mashgas stove
25.Andiron



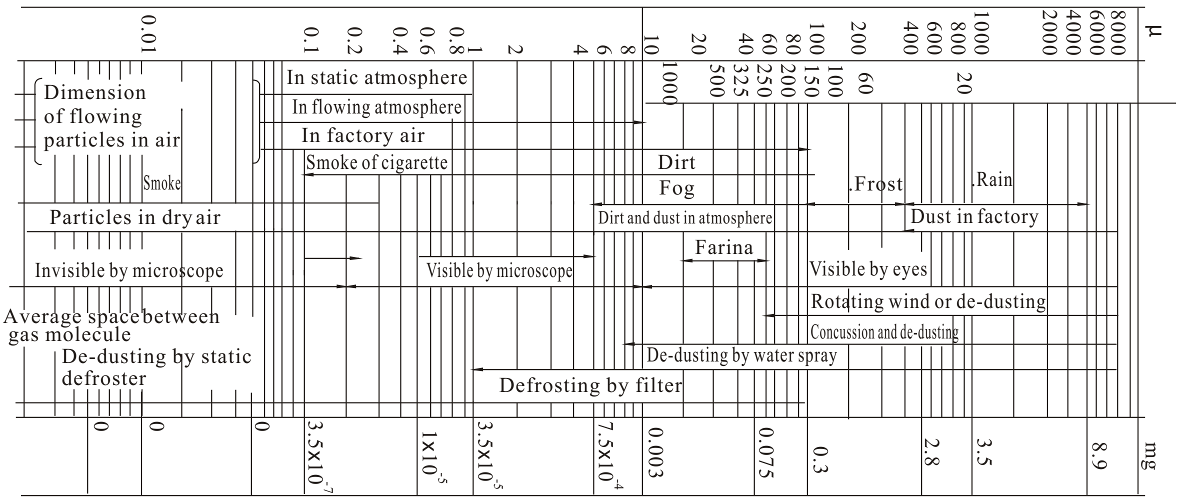
Drawing 3-17 Distribution of common indoor pollution source

4-1 Status of present air quality

Presently there are lot kinds of particles in atmosphere. Natural human body shall filtrate inbreathed air by its nasal cavity hair before inbreathing air through respiratory organ into lung. Particles with a diameter over 6 um shall be blocked and dust with diameter of 1 um shall enter lung and attach on bronchus wall, be discharged with phlegm. Seston with diameter below 1 um shall enter alveolus pulmonis and be discharged during expiration. Only small amount of it shall adhere on alveolus pulmonis.

Flowing particles with a diameter over 76 um in air are called grit. Flowing particles with a diameter over 1 um and below 76 um in air are called dust. And particles with a diameter between 0.1 um and 1 um are called fume. Distribution of flowing particles in air shall be referred to as the following drawing 3-18, which shows disposal of flowing particles is a complicated process.

Air purification is complicated and shall be particularly dealt with.



Drawing 3-18 Distribution of flowing particles in air

4-2 Physical concept in air purification process

1 Dust concentration in air

Dust quantity in unit volume air is called dust concentration. It has three scalar quantity units:

1 Mass concentration

Dust quality in unit volume air is called mass concentration. (mg/cubic meter, mg/m^3)

2 Particle concentration

Total granule amount of different kinds of particles in unit volume air is called particle concentration. (granule/cubic meter, granule/liter)

3 Particle diameter granule concentration

Granule amount of a certain particle diameter in unit volume air is called particle concentration of particles within a certain particle diameter scope.

2 Dust concentration of outdoor air

As outdoor dust concentration varies a lot according to different geographic location and season, it is recommended to survey outdoor air dust concentration at site where air conditioner is installed for reference of air purification measures (it is recommended to choose the worst location). Generally, outdoor air quality concentration in suburb with landscape, greening, paving is between 0.2 and 0.5 mg/ m^3. Outdoor air quality concentration is between 1 and 5 mg/ m^3 in city areas. In industrial zones, outdoor air quality concentration shall vary according to manufacturing station. It shall vary a lot when a lot dust was given off.

3 Indoor dust concentration required

There are some certain requirements for air conditioner on air cleanness. Indoor air dust concentration shall be divided as the following listed according to different technical requirements:

1 General cleanness

Under general cleanness, there are no specific air dust concentration requirements. It is required that air be with simple disposal and kept clean. For example, air conditioner filter net commonly used in families.

2 Purification

Under purification, there are certain requirements on indoor air dust concentration. Usually there are requirements on quality concentration.

3 Super-purification

Under super-purification, there are strict requirements on indoor air dust concentration. Usually there are requirements to particle concentration, even to particle diameter granule concentration.

In the following chart 3-11, it is classified to show the cleanness degree.

Degree	Dust			Animalcule			
	Particle diameter um	Concentration		Plank tonic bacteria		Dropping bacteria	
		Granule/ft^3	Granule/l	Entries/ft^3	Entries/m^3	Entries/m^2 circumference	Entries/h. 900mm circumference
100	Above0.5	≯100	≯3.5	0.1	3.5	12,960	0.49
10000	Above0.5 Above5.0	≯10000 ≯65	≯350 ≯2.5	0.5	17.6	64,800	2.45
10万	Above0.5 Above0.5	≯10万 ≯700	≯3500 ≯25	2.5	88.4	324,000	12.2

P.S ft refers to feet

4 Factors affecting indoor air dust concentration and relative control measures

1Dust brought in by air inlet system

If part of outdoor fresh air is adopted without disposal when taking in, dust shall be brought in. Proper air filter shall be adopted to organize air-flowing type, which meets purification requirements.

2Effect by surrounding circumstance

Sites needs purifying shall be laid in areas with clean surrounding air and be far away from traffic roads. Positive pressure shall be maintained in purifying area in case dust enters indoor space from aperture.

3 Dust caused by peeling off, destroying of building enclosure.

Floor surface, wall and top surface shall be with materials of hard quality, smooth surface and easy cleaning. Plastic-group painting shall be adopted for decorating when necessary.

4 Dust caused by technical operation itself and equipment, material, personnel entering the purification area.

Techniques shall be improved and all equipment, materials, personnel entering the purification area shall be de-dusted by air spraying before entering.

The following chart 3-12 lists calculated dust distribution and it is divided by quantity concentration with dust and quality concentration with dust.

Location	Quantity concentration with dust ≥0.5um (Entries/l)	Location	Quality concentration withdust (mg/m³)
Countryside	$0.3\sim1.0\times10^5$	Countryside or suburb	0.2～0.8
Districts in big cities	$1.2\sim2.0\times10^5$	City central area	0.8～1.5
Industrial central zone	$2.5\sim3.0\times10^5$	Light industry factory area Heavy industry factory area	1.0～1.8 1.5～3.0

4-3 Measurement of dust concentration

1 Measurement of quality concentration

1 Weight method with high efficiency filter paper (direct method)

quality concentration $g=\frac{\Delta G}{Lt}=\frac{(G_2-G_1)\times1000}{Lt}(mg/m^3)$

ΔG----added weight of high efficiency filter paper after sampling(mg)

G_1-------quality of high efficiency filter paper before sampling(mg)

G_2------- quality of high efficiency filter paper after sampling(mg)

L -------Air sampling flux through high efficiency paper (L/min)

t ----------Sampling time (min)

(2) Measuring dust optical density by densimeter method (indirect method)

Optical density added ΔOD on high efficiency filter paper before and after sampling shall be measured by dust optical density measuring densimeter. And meanwhile measuring air-sampling flux (l/min) through high efficiency filter paper.

Then, on the basis of relation curve between dust optical density ΔOD and dust accumulated quantity ΔG measured in advance, check the corresponding ΔG value according to ΔOD value measured, and calculate quality concentration according to formula in direct method.

This method is only suitable for sites where dust source is fixed or without large change.

3 Measurement of particle concentration

First use dust sampling apparatus such as concussion sampler, millipore filter to accumulate dust in air and then observe under high degree microscope, and calculate total dust particle quantity of different particle diameter, then use air sampling flux and sampling time to do the following calculation:

Particle concentration $n=\frac{\Sigma N}{Lt}$ (granule/L)...(4.2)

Particle diameter particle concentration $n1=\frac{N1}{Lt}$ (granule/L)............................(4.3)

ΣN----total particle amount of particles with different diameter (granule)

N1------total particle amount of particles with diameter within a certain scope (granule)

4-4 Disposal method of air purification

In daily life, our aim in air purification is to eliminate particles, which are most harmful and easy for human body to absorb and cause serious burden to immunity system. We called this kind of particle Roaming Suspended Particles (hereinafter referred to as R.S.F). It includes fragments, leaf mold, germs, acarid, pollen, cigarette smoke, fur and hair of pets and so on.

Basic methods of improving air quality are as the following listed:

1 Control of pollution source

It is recommended that you shall be cautious in using insecticide, paintings and different cleansers to prevent pollution source entering air and reduce effect of too much dust in atmosphere to indoor air. And meanwhile you shall often clean and maintain air conditioner to prevent dust accumulation on surface of filter net and heat exchanger, and germ subsistence. Family pets shall be insulated to reduce animal infectious disease.

2 Improvement of ventilation condition

It is recommended that you shall enhance fresh air circulation to dilute or clean indoor air pollution. Fresh air volume needed by each people is listed in chart 2-27. Wherever there is other equipment such as copy machine, or wherever oily smoke is given off, air exchange quantum shall be increased.

3 Air purification

Air pollution source shall be removed or control increasing of pollution concentration by taking the following measures:

4-5 Air purification type

There are two main air purification types: mechanical filter cartridge type dust collecting and electrostatic dust collecting.

1、Main performance index

(1) Filtration efficiency

Under rated wind capacity, ration of air dust concentration difference between area behind the filter and in front of the filter to air dust concentration in front of filter is called filtration efficiency η (%)

$$\eta=\frac{G_1-G_2}{G_1}\times 100\%\cdots\cdots\ (4.4)$$

G_1, G_2---represents air dust concentration in front of and behind filter. (%)
Filtration efficiency is divided into weight efficiency, quantity efficiency and particle diameter quantity efficiency.

1.Weight efficiency

$$\eta g=\left(1-\frac{g_2}{g_1}\right)\times 100\%\cdots\cdots\ (4.5)$$

g_1,g_2 represents air quality concentration in front of and behind filter. (mg/m^3)

2.Quantity efficiency η n

$$\eta n=\left(1-\frac{n_2}{n_1}\right)\times 100\%\cdots\cdots\ (4.6)$$

$$3\eta\ nl\ \eta\ n1=\left(1-\frac{n_2 1}{n_1 1}\right)\times 100\%\cdots\cdots\ (4.6)$$

There are a lot of methods to measure filtration efficiency. Measuring result would differ a lot using one same filter with different methods as their reflected physical characters differ a lot. Therefore it is recommended that you shall not only compare the value of filtration efficiency but also pay attention to its measuring method when judging filtration efficiency of a filter. Otherwise it is subject to make big mistake.

2 Penetration rate

Penetration rate is the ratio of air dust concentration behind filter to that in front of filter.

$$\text{Penetration rate } K=\frac{G_2}{G_1}\times 100\%=(1-\eta)\times 100\%\cdots\cdots\ (4.8)$$

Penetration rate reflects left dust quantity after air passes through filter. Filtration reflects dust quantity being filtrated when air passes through filter.

For instance, there are two filters with high filtration efficiency, their filtration efficiency is separately 99.98% and 99.99%. It seems these two filters are of similar performance form filtration efficiency. Actually penetration rate of the former is 0.02% and that of the later is 0.01%. Their penetration performance differs for nearly one time. Therefore it is more accurate to use penetration rate for control of air dust concentration behind high filtration efficiency.

3 Air resistance-----resistance under rated filter wind capacity (mm. H_2O)

1.Initial resistance: It refers to resistance under rated wind capacity when it is put into use without dust accumulation.

2. Final resistance: It refers to specific resistance value stipulated when demarcating filter allowable dust gravity (g) or resistance value when user demolishes or changes filter.

(4 Allowable dust capacity----It refers to allowable dust capacity (g) when air resistance in filter reaches final resistance value.

2 Domestic filter divisions

Low efficiency filter----its weight efficiency (atmosphere dust) is lower than 60%, it includes foamed plastic filter, metal grid oil-soaked filter, self-oil cleaning filter.

Medium efficiency filter-----its weight efficency (atmosphere dust) is in between 60%and 90%. It includes foamed plastic filter, glass fiber filter.

High efficiency filter----its weight efficiency is higher than 90%. It includes high efficiency filter, fine efficiency and electrostatic air filter. Combination of high efficiency filter paper and static de-dusting is used for high efficiency filtration. In addition, water spray air decontamination or chloridize lithium solution spray decontamination shall be adopted for killing microbe. And poisonous gases shall be disposed by chemical solution.

Choice of air filter shall be with a throughout consideration of indoor purification requirements, system resistance, outdoor air dust quantity, management and maintenance, price and costs.

To indoor space with common cleanness requirements, grade one low efficiency filter shall be adopted.

To indoor space with certain cleanness requirements, both grade of low efficiency and medium efficiency filter can be used. When outdoor air dust content is very low and system pressure is with remains, grade one medium filter with low resistance and high dust absorbing capacity could be used.

To indoor space with super cleanness requirements, low efficiency and medium efficiency shall be adopted for front filter and high efficiency filter be installed as nearer to the wind duct as possible for preventing pollution along pipe line. It could also avoid effects to proper use of filter paper by high relative humidity behind air disposal equipment. Meanwhile, it is beneficial to system resistance balance.

In order to reach proper effect of filter, special attention shall be paid to installation tight besides correct calculation and proper layout. Especially, it has to be tight with the frame when installing high efficiency filter to prevent wind leakage.

Resistance loss shall be measured regularly during use no matter what kind of filter you use. Filter shall be cleaned when wind force weakens to ensure filtration performance.

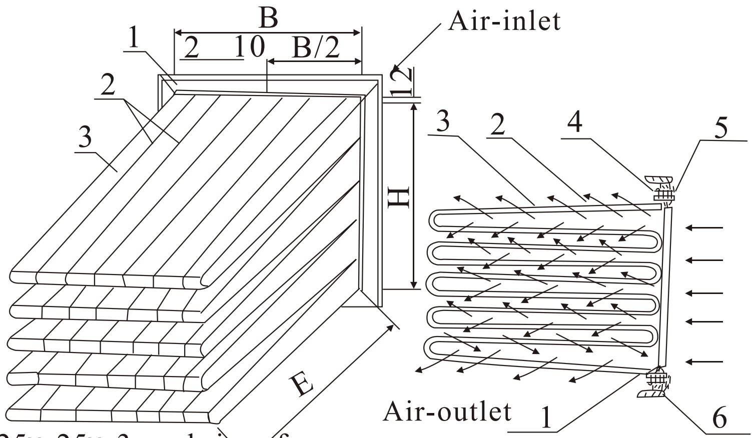
3 Mechanical filter cartridge type dust collecting

Fiber or foam shall be used as filtration material. Details shall be referred to the following listed:

11 M-typed foam filter

M-typed foam filter uses hatched polyurethane foam as filter bed. When filtrated dust accumulation reaches certain amount, and final resistance reaches preset value, you shall take filter off and rinses it. Filter could be circular use after airing. The structure shall be referred to the following chart 3-19:

M-typed foam filter is with low initial resistance, high dust capacity, high filtration efficiency and easy to cleanout. It is suitable for popular use in future. Its defect is foam quality is not stable and is easy to be destroyed when contacting with organic solvent.

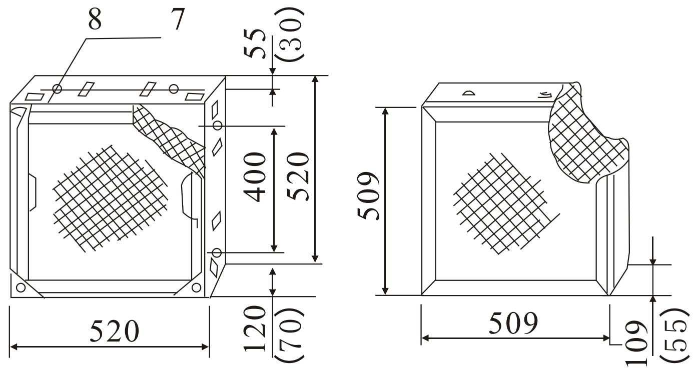


1.25x 25x 3 angle iron frame
2.Φ3 mm steel wire support
3.Foam filter bed
4.Φ8 mm fixing bolt
5.Screw cap
6.Site installed frame (40x 40x 4 steel iron)

Drawing 3-19 M-typed foam filter

2 Metal grid oil-soaked filter

Metal grid oil-soaked filter is expanded metal soaked with No 10 to No 30 machine oil on surface in the frame. Dusts of disposed air shall adhere to filter net when passing through it. Machine oil shall be used for cleaning when dust accumulation has reached its capacity. Filer shall be circular used after cleaning, insolation and re-soaked with machine oil. It is convenient for manufacture and repeat use. Filtrated wind capacity is higher than that of similar products for same air-in area. Its defect is filtration efficiency is low and maintenance is complicate. The structure shall be referred to following drawing 3-20.



Drawing 3-20 Metal grid oil-soaked filter

3 Self-oil clean filter

Self oil-clean filter make use of electromotor and gear change mechanism to drive used filter net to turn regularly and to be soaked with machine oil automatically.

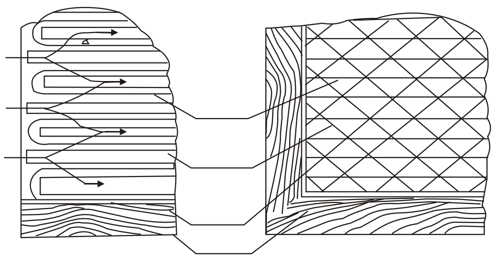
Therefore its cleaning and oil change is centralized and convenient. Its defect is air may be with oil smog when section wind speed is over 8 meters/ second.

4 Glass fiber filter

It is divided into two types---D type and X type. Glass fiber is used as filtration material and it shall not decay even after it is damp. Its wind resistance is higher than similar product and dust capacity is relatively low.

5 GB type and GS type high efficiency air filter

Asbestos paper is used as filter bed in this kind of filter. Its structure shall be referred to the following drawing 3-21.



Drawing 3-21 GB type and GS type high efficiency air filter

GB type and GS type high efficiency air filter has a quantity efficiency of 99.9% to particles with a diameter between 0.3 and 0.6 um. Its defect is filter paper could not resist high humidity (above 80%) and high temperature.

Filter net in home air conditioner is an elementary filter net with very low efficiency (2%) and it is only capable of reducing time of indoor heat exchanger blocked by dusts.

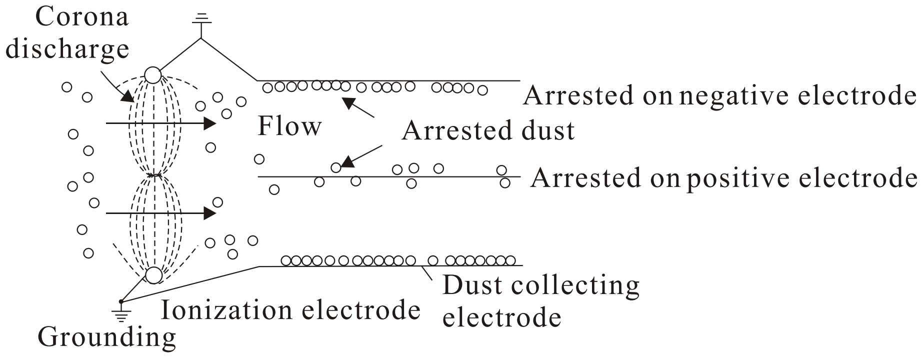
4 Electrostatic strainer mesh dust collecting

Electrostatic filter make use of high voltage electrode to cause air ionization and dust electrification. Thus cause directional movements under electric field to achieve air filtration.

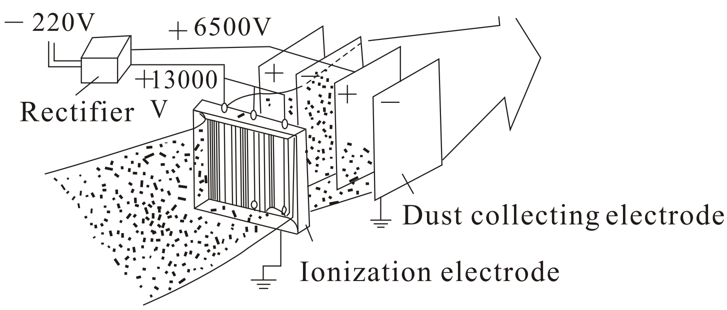
Electrostatic filter commonly used in air conditioner and ventilation engineering is two-period form. One period is ionization and the outer is dust collecting. The principle shall be referred to the following drawing 3-22.

Ionization period is with parallel streamline tubular column type (plate type) grounding electrode of equal space. Discharge lead is laid between tubular electrodes (0.2mm tungsten filament, another name corona electrode). When direct voltage of 10 to 12 kv was applied to discharge lead, light discharge shall occur and air passing through this area shall carry out ionization. Positive ion and negative ion shall surround discharge lead and electron shall move towards discharge wire (positive voltage is applied on discharge wire) and then be neutralized. Positive ion shall attach on surface of neutral dust when encountering it. And then dust with positive charge shall enter dust- collecting period with Flow. There are high voltage electrode plate and grounding electrode plate paralleling to Flow. Uniform electric field shall be formed between electrodes under 5kv direct current. When particles with positive charge enter electric field, it shall move at the direction vertical to Flow movement direction and attach on grounding electrode plate under action of Coulomb force.

Electrode filter is generally applied to ventilation engineering and carry out air purification. Its filtration efficiency has connections with electric-field strength, diameter dimension, flow speed and time particles stayed in dust collecting period.



a.



b.

Drawing 3-22 The principle of dust collecting

Counting efficiency to different particle diameters are as the following listed:

Over 5u,	100%
Between 2 and 5 u	>90%
Below 2u	85-90%

4-6 Special air purification

1 Active carbon deodorization filter

Specific active carbon adsorption apparatus is installed on air-duct in some special air conditioners to eliminate poisonous gases, gases with odor through adsorption function of active carbon. There are a lot of tiny holes inside active carbon. For instance, active carbon with1g quality is with about 2 cubic cm holes. Effective interface area of active carbon is about 1000 square meters. Therefore tiny holes greatly enlarged interface are a of active carbon with air and could absorb more peculiar smell. Under normal conditions active carbon shall absorb dusts with a quality of 20 to 30% of its own quality. The following chart listed adsorption capacity of active carbon to different poisonous gases.

Chart 3-13

Name of substance	Adsorption and holding capacity	Name of substance	Adsorption and holding capacity
Ammonia NH_3	Little amount	Carbon monoxide CO	Little amount
Sulfur dioxide SO_2	10	Benzene C_6H_6	24
Chlorine CL_2	15	C_5H_5N	25 (given offby burning of tobacco)
Carbon dioxide CO_2	Little amount	Butyric acid $C_5H_{10}O_2$	35 (sweat, body smell)
Carbon bisulfide CS_2	15	Odor of cook	About 30
Ozone O_3	Could be deoxidized to O_2	Odor of bathroom and washroom	About 30

Filter paper for air purification and adsorption is generally installed on home air conditioner, which is combination of active carbon and paper fiber. Therefore such filter paper shall be changed after a period of use.

2 Molecular sieve adsorption and deodorization

Molecular sieve is a kind of man-made aphrizite, which owns even smaller holes in unit of angstrom than active carbon. (A) is used to denote its hole diameter. For instance, molecular sieve marked with 4A, 5A,and 12X. As diameter of its holes is even smaller than that of active carbon, it could adsorb poisonous gases with smaller molecule diameter such as ozone, nitrogen oxide. And molecular sieve could be circular use through heating to eliminate all adsorbed dusts.

3 Light catalyst sorbent deodorization

Light catalyst sorbent prevailing used in Japan could adsorb poisonous gases or harmful gases such as sulfured hydrogen, ammonia, aminomethane (fish odor), and formaldehyde. Its adsorption capacity shall be strengthened after solarization. At present it is installed in many family air conditioners to keep indoor air in home with air conditioners clean and comfortable.

4 Air ionization

Ion in atmosphere could be divided into three kinds as the following listed:

1 light ion: it consists of one electric charge and a lot of neutral gas molecules. Usually light ion with negative electric charge is called negative ion. Light ion with positive electric charge is called positive ion.

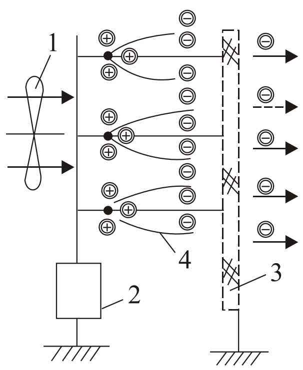
2 Medium ion: it is a tiny electric particle with about 1000 gas molecules.

3 Heavy ion: it is particle with electric charge which is about 1000 times lighter than light ion.

Usually it is easy to collect and eliminate electriferous particles of negative ions. There are small amount of medium ions in outdoor air. In polluted air, usually proportion of medium ions shall increase due to decreasing of light ions. Air conditioner needs some light ions in indoor air, especially negative ions, which have very good physical action on human body, such as bringing blood pressure down, restraining asthma etc. therefore, negative ion generator is often adopted for supply certain amount of negative ion to room with air conditioner for improving sanitary conditions.

Negative ion generator usually makes use of corona discharge to carry out air ionization. Its work principle is as drawing 3-23 shows. It uses uneven electric field caused by high voltage action between needle-like electrode and metal net electrode to get air ionization. When negative high voltage pulse is applied on the needle-like electrode, air near needle-like electrode shall be with ionization. Positive ions generated shall be adsorbed on positive electrode, and negative ions shall move towards metal net electrode, pass through metal net and be combined into air-in current under wind force.

Usually negative ion generator is with a voltage of 50KV, pulse frequency of 50 Hz and wind speed within 10m/s.



Drawing 3-23 Air ionization principle drawing

1.Fan 2.Pulse generator 3.Metal net grounding electrode
4.Needle-like plate electrode

5 Ozone

Ozone is a kind of normally existing gas in atmosphere, which is naturally generated from action of high strength ultraviolet rays on oxygen (O_2). Ozone is good in nature. Small amount of ozone is beneficial to human health but excessive ozone is harmful to human health and with odor. Therefore ozone amount shall be under control. Usually it is about 0.003 PPm (its concentration in every million unit air volume). Some air conditioners are equipped with ozone generator, whose discharge and accumulating amount could be controlled.

Section 5 Ventilation

Besides cold producing (for temperature down) and heat producing (for temperature up) in air-conditioner system, disposed air and fresh wind supply to each spot (site) shall be considered in large air-conditioner system including commercial system. Therefore ventilation is divided into two parts, air-in duct and fan. As fan has been well equipped in commercial system, we only need a general understanding of relative duct technology and carry out simple calculation and choice.

5-1 Choice of duct dimension

1 Equivalent diameter of round and rectangular pipeline

Designer could choose round or rectangular section for air distribution system. Our aim in choice is to find the best relationship among each factor: it includes making economic use of building space, economic investment expenditure, rigi dity and strength of pipe form. Rectangular pipe shall usually save building space. For a period of time manufacturing of round pipe is very expensive but now corkscrew saddle joint prefabricated type pipe is cheaper than rectangular pipe. Though round pipe is more expensive, corkscrew pipe could be used on oval-shaped section. Rectangular pipes are commonly used in low speed system and round pipes are commonly used in high-speed system. You need to have comprehensive consideration when making the choice. Round pipe has a larger rigidity than rectangular pipe, which shall make it possible to adopt lighter specification in an existing system. In addition, rigidity strengthening shall reduce possible vibration noise of pipe walls.

Choice of pipe dimension shall be first under the supposition that it is round section pipe. According to the following listed two different suppositions, change diameter into equivalent rectangular dimension.

1 Flux and pressure drop keeps the same, but velocity of flow differs

2 Velocity of Flow and pressure drop keeps the same, but flux varies.

You could choose round pipe diameter through drawing 3-24 and rectangular pipe diameter through drawing 3-25.Pressure loss caused by friction in plastic pipes is about 70% of that of galvanized pipeline. Therefore we could use flow characteristic of smooth pipes in calculation and time a coefficient to pressure under same conditions in galvanized pipeline.

Dimension choice chart is usually provided in product contents to corkscrew pipe of different shape.

There are three basic methods, and changeable factor in chart (chart 3-24 and chart 3-25) is often useful for choosing dimensions, they are:

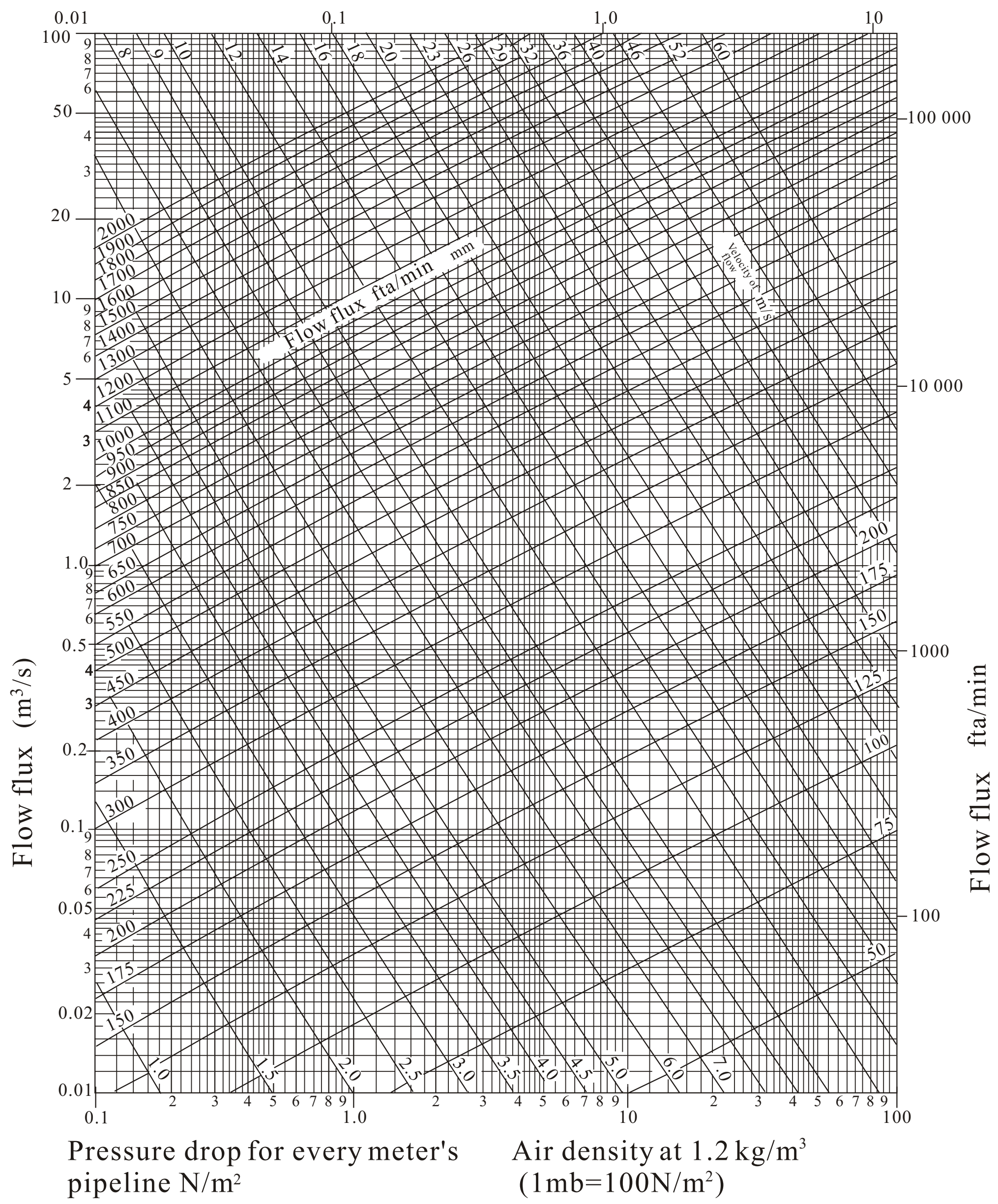
1Chosen speed

2Equal pressure drop

3Static pressure callback

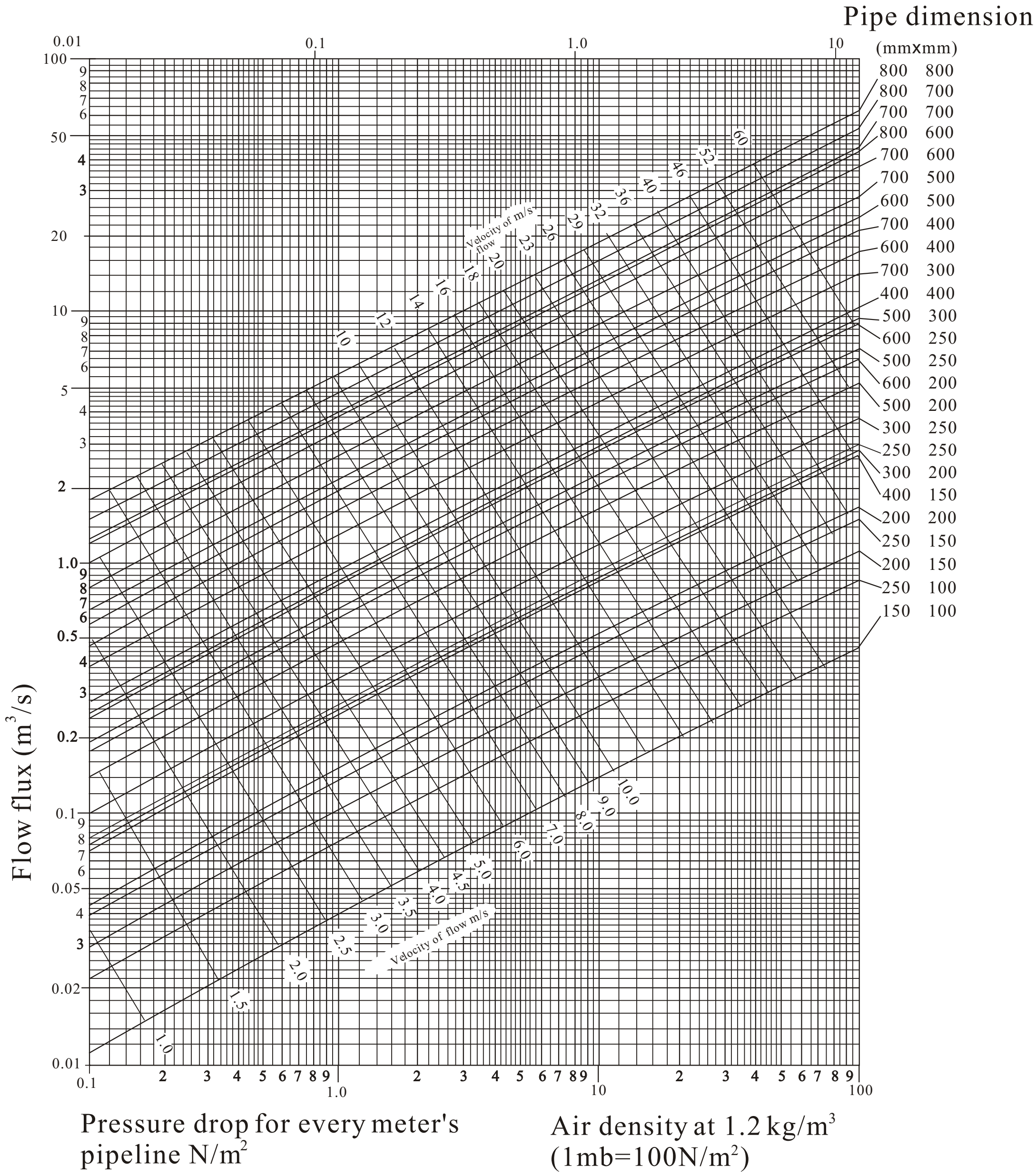
These methods are not complicated. Choice on speed and pressure drop is on the basis of experience. Higher value corresponds to lower pipe diameter and therefore save space and cost. Lower value corresponds to better noise and vibration control effect, save fan pressure. You could do the comparison and coordination at random. If proper measures are taken to control noise and vibration, the recommended valuemay be conservative. The above view is the same with wind pipeline design. On the contrary, static pressure recovery method works with changing energy into useful forms in system. And it also takes heat supply and loss form surrounding air of pipes into consideration. If ratio of pipe length and width is very large, heat exchange shall be strengthened. Heat exchange shall also be strengthened when Flow transports in lowflow speed.

Under temperature of 62 F, pressure drop for every 100 feet long pipeline



Drawing 3-24 choice chart of round pipe diameter

Under temperature of 62 F, pressure drop for every 100 feet long pipeline



Drawing 3-25 choice chart of rectangular pipe dimension

(1)Choice flow velocity

We suppose that we could make any stipulation on flow velocity. Actually it needs rich experience to make stipulation on flow velocity and anyway, we do not recommend this method except for simple system layout. Louver air valve is needed to balance air quantum among each branch pipes. Choice of flow velocity at air-outlet of fan shall not exceed values listed in chart 3-14. System using values in this chart is usually called low speed system.

(2) Equal pressure drop

To equal pressure drop system, pressure drop value is a constant value. It is easier to reach circuit balance for symmetrical layout than restricted flow velocity method. If each branch pipe is of different length, different pressure drop shall be needed (if branch pipe is very short and with high pressure-drop, large damp shall be needed. On the contrary, if branch pipe is very long and joint may be lack of needed staticpressure, only very small damp is allowed).

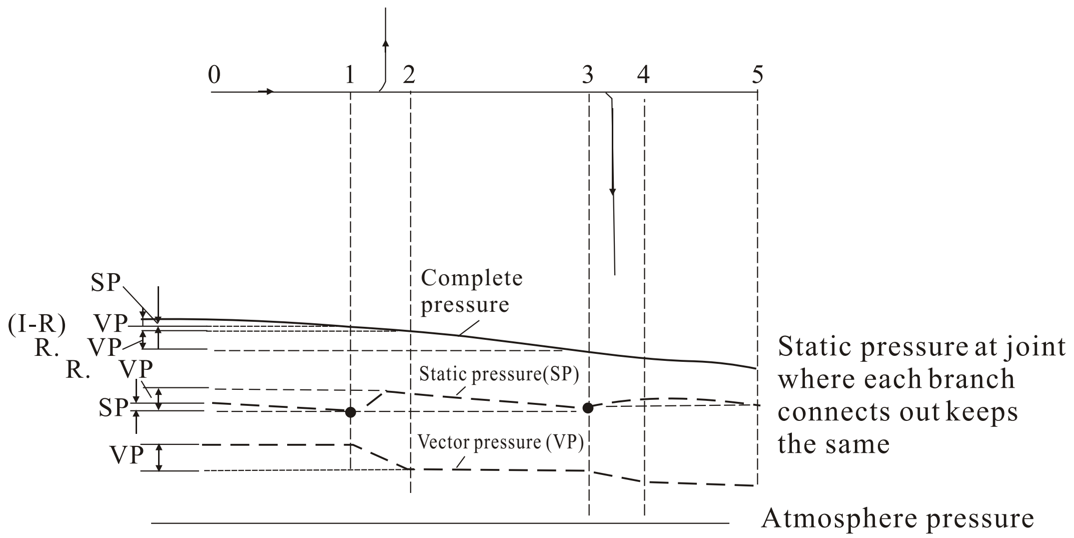
It is advisable to choose flow velocity according to noise at air-outlet of fan and estimate on the basis of pressure drop. It is still necessary to balance flux in branch pipes by louver air valve and end terminus control apparatus.

Table 3-14

Application buildings	Flow velocity (m/s)				
	Main			Branch	
	Air-in		Air feedback	Air-in	Air feedback
	Noise	Friction			
Dwelling houses	3	5	4	3	3
Hotel bedroom	5	7	7	6	5
Private office, library	6	10	7	8	6
Theatre, odeum	4	7	6	5	4
Public offices, restaurants, department store, banks	7	10	7	4	3

(3)Static pressure recovery

Principle of static pressure recovery is to make use of static pressure gained at joints by reducing vector pressure to compensate pressure lost caused by friction in latter pipes. Drawing 3-26 shows a very simple example. Pipe diameter of pipe section 0-1was chosen using one of above list methods. Its static pressure recovery coefficient is R and useable static pressure gained at joint 1-2 is R*VP: this static pressure shall be for compensation of friction loss in pipe section 2-3. Same process shall be taken at joints 3-4 on main. The advantage of this method is static pressure where each branch is jointed keeps the same; therefore it is propitious to keep balance.



Drawing 3-26 choice of pipe diameter using static pressure recovery method

Simple calculation of air duct shall be carried out following the listed formula

(1) Round pipe

Wind flux

$$L = 3600 \bullet \frac{\pi}{4} d^2 v \, m^3/h$$

d—— inner diameter of pipe (m)

v—— wind velocity (m/s)

Unit frictional resistance: $R_\circ = \frac{\lambda}{d} \bullet \frac{v^2 \gamma}{2g}$ mm water column/meter

λ—— frictional resistance coefficient

γ—— air volume weight

g —— acceleration of gravity

$\frac{v^2 \gamma}{2g}$ ——vector pressure

Renault value

$$Re = \frac{vd}{v}$$

v —— movement coefficient of viscosity (m^2/s)

Frictional resistance coefficient

$$\frac{1}{\sqrt{\lambda}} = 2\log\left(\frac{K}{3.71d} + \frac{2.51}{Re\sqrt{\lambda}}\right)$$

K---equivalent absolute harshness of inner surface of wind pipe

(2) **Rectangular air duct**

Wind flux $L=3600abv\,m^3/h$

a —— inner side dimension of long side of rectangular air duct (meter)

b —— inner side dimension of short side of rectangular air duct (meter)

Unit frictional resistance

$$Re=\frac{\lambda}{\frac{2ab}{a+b}}\cdot\frac{v^2\gamma}{2g}\text{ mm water column/meter}$$

Renault value

$$Re=\frac{v\cdot\frac{2ab}{a+b}}{v}$$

Frictional resistance coefficient

$$\frac{1}{\sqrt{\lambda}} = 2\log\left(\frac{K}{3.71\frac{2ab}{a+b}} + \frac{2.51}{Re\sqrt{\lambda}}\right)$$

2. Use of data

(1) Inner diameter of air duct or side length of air duct shall be following outer diameter or outer side length listed in chart 3-15 or 3-16. Wall thickness and allowable difference shall be calculated.

(2)Air with an atmosphere pressure of 760mm mercury and temperature of 20℃ is standard status. r value is $1.2kg/m^3$, $v=15.06\times10^{-5}m^2/s$.

(3) Standard acceleration of gravity $g=9.80665\ m/s^2$

(4) Equivalent absolute harshness---- To air duct made of steel plate, K equals 0.15mm.To air duct made of plastic plate, K equals 0.01mm.

3. Amendments of harshness

When inner surface harshness value K of actually adopted pipe differs a lot with value in chart, checked R value form the chart shall be timed by harshness amending coefficient ε_o, whose value shall be referred to the following table 3-17:

Universal specification of air duct

Table 3-15 Specification of round air duct

Outer diameter D (mm)	Air duct made of steel plate		Air duct made of plastic material		Outer diameter D (mm)	De-dusting air duct		Air tight duct	
	Allowable offset of outer diameter (mm)	Wall thickness (mm)	Allowable offset of outer diameter (mm)	Wall thickness (mm)		Allowable offset of outer diameter (mm)	Wall thickness (mm)	Allowable offset of outer diameter (mm)	Wall thickness (mm)
100					80 90 100				
120					110 120				
140		0.5			130 140				
160					150 160				
180				3.0	170 180				
200					190 200				
220			1		210 220		1.5		2.0
250					240 250				
280					260 280				
320	1	0.75			300 320				
360					340 360				
400					380 400				
450				4.0	420 450	1		1	
500					480 500				
560					530 560				
630					600 630				
700					670 700				
800		1.0			750 800				
900				5.0	850 900		2.0		3.0 ~ 4.0
1000					950 1000				
1120			1.5		1060 1120				
1250					1180 1250				
1400					1320 1400				
1600		1.2 ~ 1.5		6.0	1500 1600				
1800					1700 1800		3.0		4.0 ~ 6.0
2000					1900 2000				

Universal specification of air duct

Table 3-16 Specification of rectangular air duct

<table>
<tr><th rowspan="2">Outer diameter A B (mm)</th><th colspan="2">Air duct made of steel plate</th><th colspan="2">Air duct made of plastic material</th><th rowspan="2">Outer diameter D (mm)</th><th colspan="2">De-dusting air duct</th><th colspan="2">Air tight duct</th></tr>
<tr><th>Allowable offset of outer sides (mm)</th><th>Wall thickness (mm)</th><th>Allowable offset of outer sides (mm)</th><th>Wall thickness (mm)</th><th>Allowable offset of outer sides (mm)</th><th>Wall thickness (mm)</th><th>Allowable offset of outer sides (mm)</th><th>Wall thickness (mm)</th></tr>
<tr><td>120 120</td><td rowspan="26">-2</td><td rowspan="6">0.5</td><td rowspan="23">-2</td><td rowspan="14">3.0</td><td>630 500</td><td rowspan="26">-2</td><td rowspan="13">1.0</td><td rowspan="26">-3</td><td rowspan="7">5.0</td></tr>
<tr><td>160 120</td><td>630 630</td></tr>
<tr><td>160 160</td><td>800 320</td></tr>
<tr><td>200 120</td><td>800 400</td></tr>
<tr><td>200 160</td><td>800 500</td></tr>
<tr><td>200 200</td><td>800 630</td></tr>
<tr><td>250 120</td><td rowspan="17">0.75</td><td>800 800</td></tr>
<tr><td>250 160</td><td>1000 320</td><td rowspan="11">6.0</td></tr>
<tr><td>250 200</td><td>1000 400</td></tr>
<tr><td>250 250</td><td>1000 500</td></tr>
<tr><td>320 160</td><td>1000 630</td></tr>
<tr><td>320 200</td><td>1000 800</td></tr>
<tr><td>320 250</td><td>1000 1000</td></tr>
<tr><td>320 320</td><td>1250 400</td><td rowspan="13">1.2</td></tr>
<tr><td>400 200</td><td rowspan="9">4.0</td><td>1250 500</td></tr>
<tr><td>400 250</td><td>1250 630</td></tr>
<tr><td>400 320</td><td>1250 800</td></tr>
<tr><td>400 400</td><td>1250 1000</td></tr>
<tr><td>500 200</td><td>1600 500</td><td rowspan="8">8.0</td></tr>
<tr><td>500 250</td><td>1600 630</td></tr>
<tr><td>500 320</td><td>1600 800</td></tr>
<tr><td>500 400</td><td>1600 1000</td></tr>
<tr><td>500 500</td><td>1600 1250</td></tr>
<tr><td>630 250</td><td rowspan="3">1.0</td><td rowspan="3">-3</td><td rowspan="3">5.0</td><td>2000 800</td></tr>
<tr><td>630 320</td><td>2000 1000</td></tr>
<tr><td>630 400</td><td>2000 1250</td></tr>
</table>

P.S This universal specification of ventilation duct is with ratification and checks of "ventilation duct design finalization" checkup meeting and is used as universal specification.

Table 3-17

K \ v	2	4~6	8~12	14~22	24~30
0~0.01	0.95	0.90	0.85	0.80	0.75
0.10	1.00	0.95	0.95	0.95	0.95
0.20	1.00	1.05	1.05	1.05	1.05

When air duct made of plastic plate, corresponding value of ε shall be referred to table 3-19.

Table 3-18

K \ v	2	4~8	10~12	14~22	24~30
0	1.00	1.00	1.00	0.95	0.95
0.10	1.05	1.10	1.15	1.20	1.25

Chapter 4 Installation and Construction

Installation engineering of commercial and family air conditioners is the key point to ensure proper use and product quality. To good quality products, without proper installation, it shall not operate well and thus manufacturer's fame may be ruined.

Installation sequence of air conditioner is as following listed:

	Name of engineering	Key points
Prior to construction	Project assignment	Assign person to set switch
	Completion of construction drawing	Separately finish control layout system drawing, cold intermedium tubing system drawing, and Power supply wiring system drawing.
During construction	Sleeve inserting engineering	Take slope of water drainage pipes into consideration
	Installation of indoor unit	Confirm type of unit in case confusion occurs
	Cold intermedium tubing engineering	Be cautious to keep dry, clean and tight
	Water drainage engineering	Slope down
	Air duct engineering	Ensure adequate wind quantum
	Heat insulation engineering	No interspace at joints of heat insulation material
	Electric engineering (Control wire, Power supply wire)	Multi-core wires are forbidden to use Control wire shall be two-core shielded wire.
	Set each enactment switch	Following control layout system drawing and avoid mistaken enactment
	Outdoor unit base engineering	Keep foundation at level
	Installation of outdoor unit	Prevent ventilation short circuit and ensure maintenance space, system be marked separately
	Air tight test	Finally confirm if air pressure keeps 28.0 kg/cm3 within 24 hours
	Vacuum dry	Use vacuum pump which could reach a vacuum degree of 775 mm Hg
	Superaddition and filling of cold intermedium	Record superadded quantity of cold intermedium on outdoor unit or notebook
	Installation of decorating boards	
	Trail run and adjust ment	Trail run each indoor unit and make sure there is no wrong tubing and wiring
	Deliver instruction manual	Instruct and meanwhile deliver materials to user

P.S Above listed are common construction sequences and may differ at site.

Section 1 Installation Design and Construction of Outdoor Unit

1-1 Layout of machines and installation design

Unit layout and installation plan shall be following design of indoor air conditioner. Therefore erectors shall communicate with personnel of construction engineering and equipment engineering. The following listed factors shall be taken into consideration under the precondition that performance of air conditioner shall not be weakened.It includes factors relating building itself and air-conditioner engineering such as maintenance of equipment, equipment vibration, precautions of noise and vibration proof of structure. Laws and regulations relating environmental protection, safety shall also be considered.

1 Cautions against building structure

1 Complete unit layout drawing (indoor unit and outdoor unit) and quality table to confirm structure strength at installation site (loading).

2 When heavy units are installed, you shall consider placing units on roof beam or add reinforced concrete beam on reinforced concrete column to support units in advance.

3 Check delivery route for unit transportation on architectural engineering drawing before delivering units. Openings shall be set when necessary and with consent of construction department. Openings shall be clearly marked on drawing without pretermission.

4 To heavy units, vibration proof bearing capacity shall be taken into consideration. Whether it shall be part of the building structure or part structure shall be strengthened shall be with discussion and ratification of designer of the building.

2 Relationship with existing projects

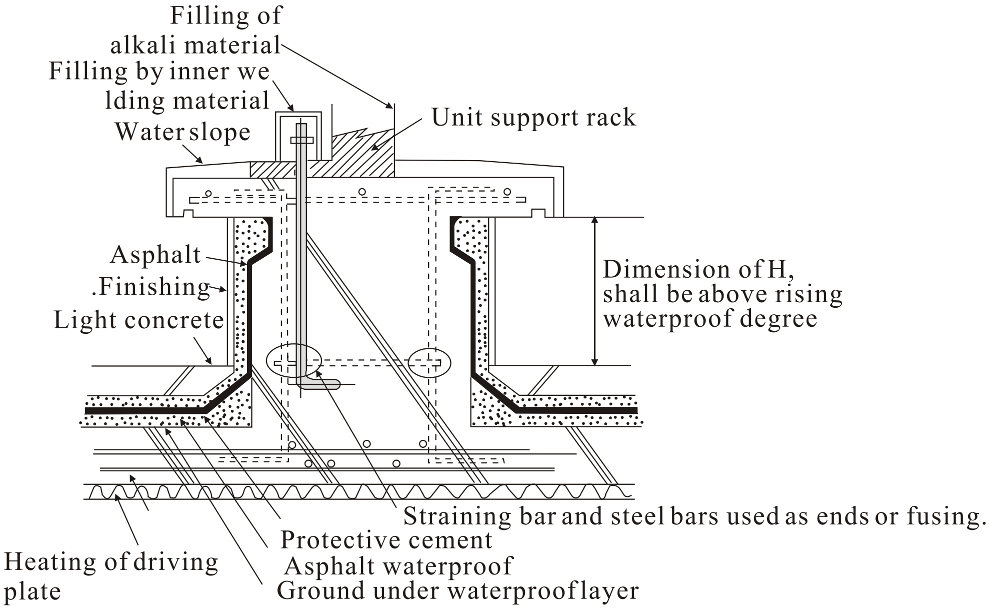
To projects whose construction is complete, you shall carefully confirm and well plan installation procedure with considerations of factors such as type of building, use of rooms, difference of units in ceiling, walls, floor and etc.

Outdoor construction

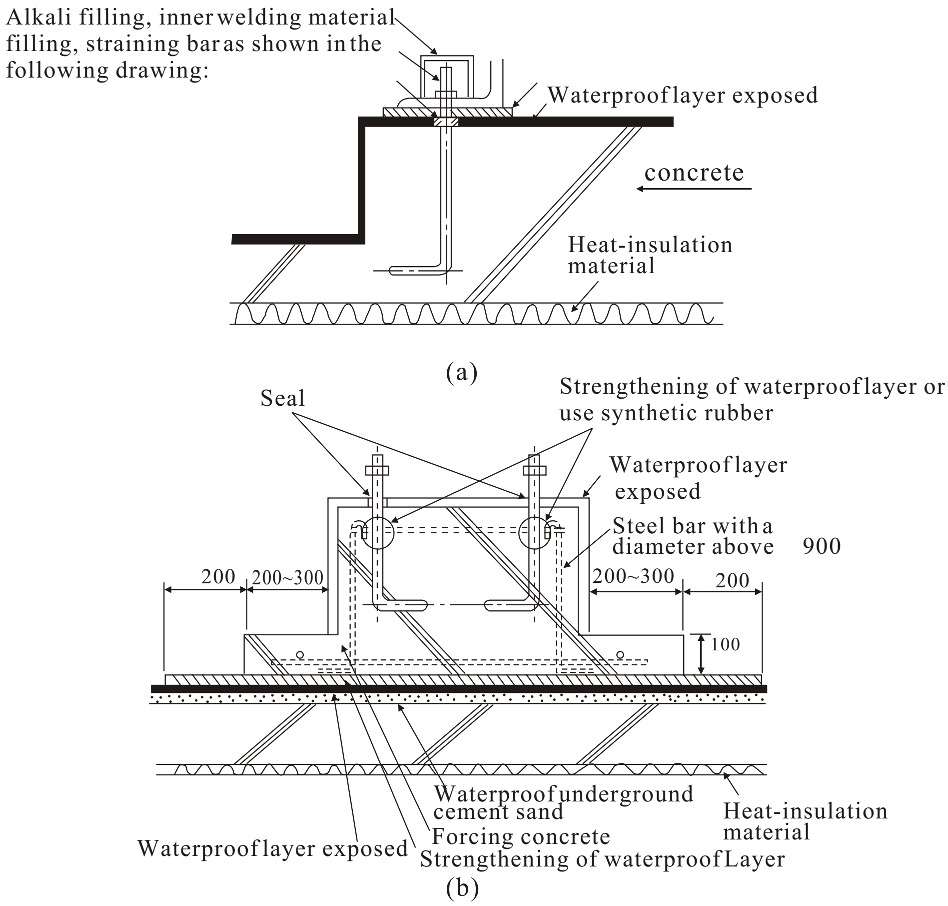
1 When outdoor unit is installed on roof, it is very important to cooperate roof waterproof engineering with outdoor unit foundation engineering. There are different waterproofing methods for roof and it shall be with discussion with construction engineers. Foundation shall be well designed and construction.

1.It is very easy to destroy waterproof layer when installing outdoor unit on asphalt waterproof roof. You shall first carry out construction on foundation base of machine room and then install units. Refer to drawing 4-1.

2.Waterproof materials shall be set on top surface of foundation base of outdoor -unit as drawing 4-2 (b) shows. If you adopt the above method, Footing bolts shall penetrate waterproof layer. Therefore it shall be completely concealed after fixing and installation of bolts completed. To the latter method, space left around foundation base shall be tightly filled and curing is very important. No tiny cracks are allowed to occur.



Drawing 4-1. Relationship between asphalt waterproof layer and foundation



Drawing 4-2 Construction of exposed waterproof layer and outdoor unit foundation

P.S. 1.Straining bolts shall be electroplate by fused zinc or stainless steel

2.Sraining bolts (exposed part shall be with rust-preventing disposal) shall not be put into concrete until units are installed.

3. Transverse movements caused by earthquake shall be taken into consideration

(2 When units are placed on ground floor or floor surface, you shall confirm if there are pipes of power supply, telecommunication, cable, water supply and drainage, and facilities like coal gas pipes. Construction shall not be carried out until consultation with structural engineers and check with engineering drawings.

3 Layout of outdoor unit

1.Layout requirements

Noise of outdoor unit shall be taken into consideration when planning layout of outdoor unit. Outdoor units shall be installed where noise has little effect to adjacent buildings.

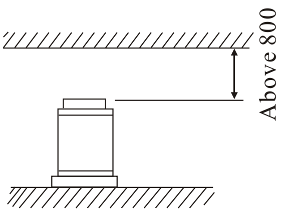
Outdoor units shall be installed where maintenance and monitoring is convenient

Outdoor units shall be installed where air circulates well and without strong wind blowing off.

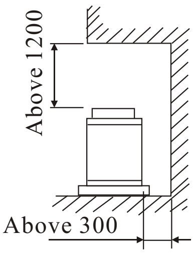
Outdoor units shall be far away form heat source and to ensure blowing off air shall not be blocked.

2.Set space

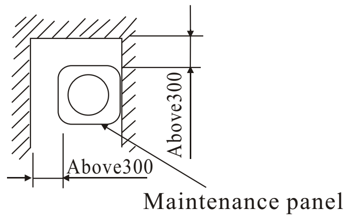
Maintenance space shall be left for outdoor unit in the layout as drawing 4-3 shows:



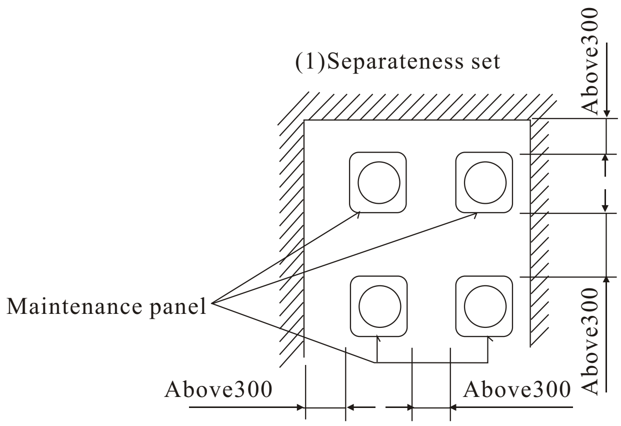
a.When there is only obstacle on top of outdoor unit (blowing off side), both left and right side of the unit, in front of it and behind it shall be at open station.

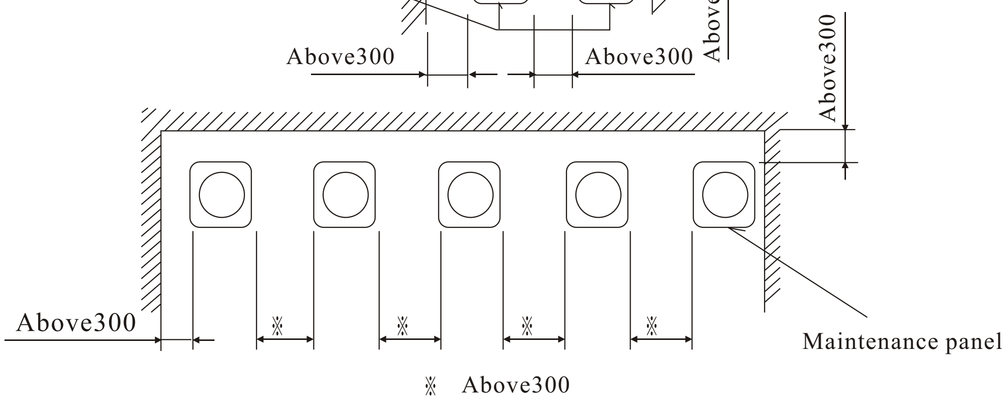


b.When there is obstacle on top of the unit(blow off side) and at side (air-in side), if obstacle is only at air-in side and as shown on the drawing, the top obstacle shall not affect proper operation of the unit.



c.When the top is open station (blow off side) and there is space as shown in the drawing, obstacles in the direction 2 shall not affect its proper operation (top is open space).





(2) Relationship among each unit when there are multi units.

Drawing 4-3 Set space

1-2Installation of Haier Commercial MRV Outdoor Unit

(1) Installation location

⚠ Cautions

Please avoid installing outdoor unit in following places:

- Place where flammable gases are easy to leak (Failure may occur if air conditioner is installed in such special sites. Special maintenance shall be needed if units are installed in such places).
- Sites with high oil content (including machine oil). (Special maintenance shall be needed if units are installed in such places).
- Sites with high salt content (near seashore) or high-sulfurated material (hot well area).
- Places where wind blew off form outdoor unit faces adjacent window.
- Places where operation noise of outdoor unit is easy to spread.
- Places without sufficient bearing capacity.
- Places not level.
- Places without proper ventilation.
- Places near equipments with electromagnetic waves or high frequency.

(2) Transportation

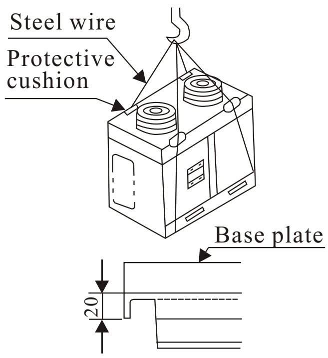
1 Tightly tie outdoor unit by 4 steel cables with a diameter of 6mm.

2 Use cushion at interface between steel cable and unit in case outer shape destroyed or distorted

3 Load stepping plates shall be adopted when lifting

(3) Installation

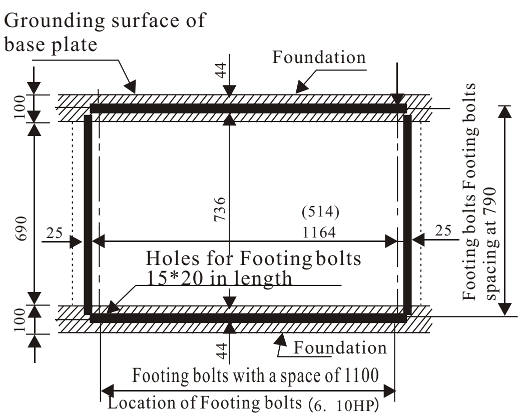
1 Outdoor unit shall be laid and connected with a space above 20mm as showing in the right drawing.

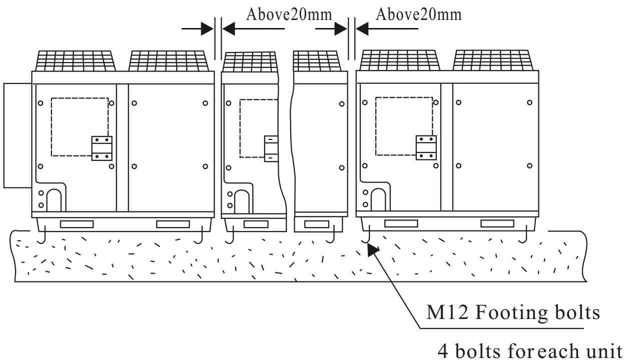


Outdoor unit	Quality (kg)
6Hp	173
10Hp	304

2Outdoor unit shall be fixed by Footing bolts as shown in the right drawing.

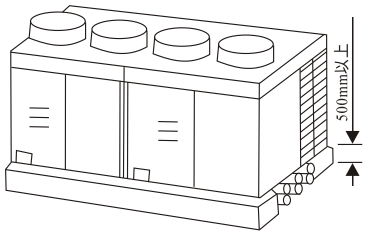
- Space between Footing bolts and grounding surface of foundation shall refer to the left drawing.

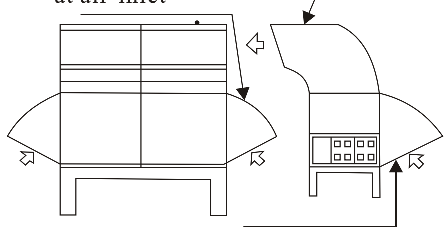




3Two-span foundation shall be used for cold intermedium tubing when pipes educed from the bottom. Height of foundation shall be above 500mm as shown in the following drawing.

4Snow proof measures shall be taken in area with snowfall as shown in the right drawing. (Failures may occur without proper snow proof measures). Please build rack higher and install snow proof cover at air-outlet.





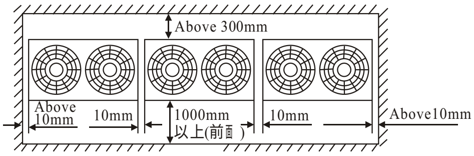
(4) Installation space

1 Installation shall be as what shown in the left drawing. Repairing surface shall be order and outdoor unit be installed side by side. Power supply box shall be on side surface of outdoor unit.

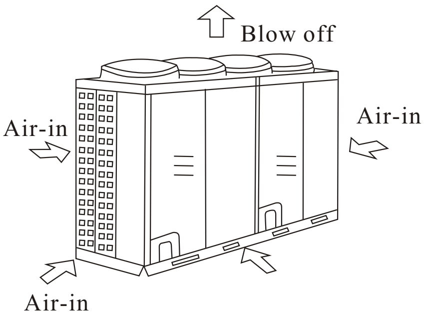
2 Sufficient space shall be left for operation and maintenance.

P.S Where there is obstacle on top of unit, please keep it above 2000mm from outdoor unit.

Height of obstacles surrounding outdoor units shall be kept under 400mm and above duct of heat discharge.



Top view of outdoor unit

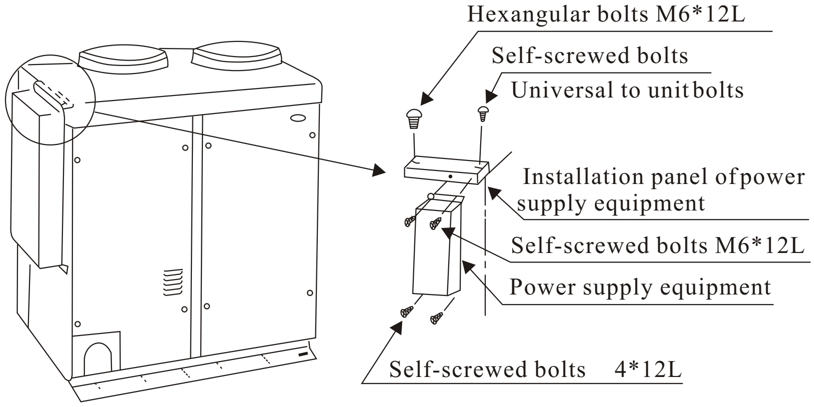


Installation and Service side

(5) Installation of Power supply equipment

1. Installation

Installation shall be carried out on the left or right side of outdoor unit. Power supply equipment shall be installed after installation panel of power supply equipment was installed to outdoor unit panel.

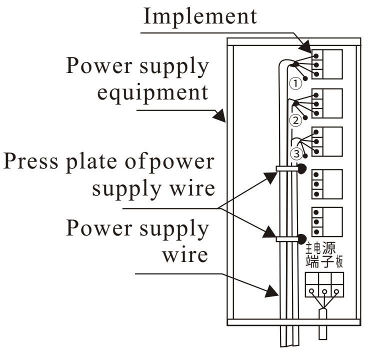


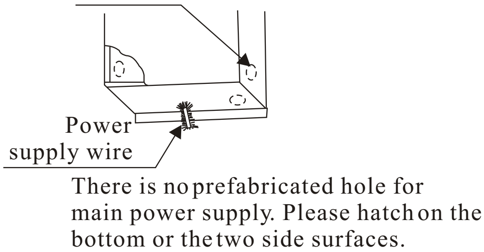
2. Electric wiring

(1) Connect power supply wire to power switch as the following drawing:

- Power supply wires were marked with codes.
- Please check with power supply switch code in the following drawing for use.

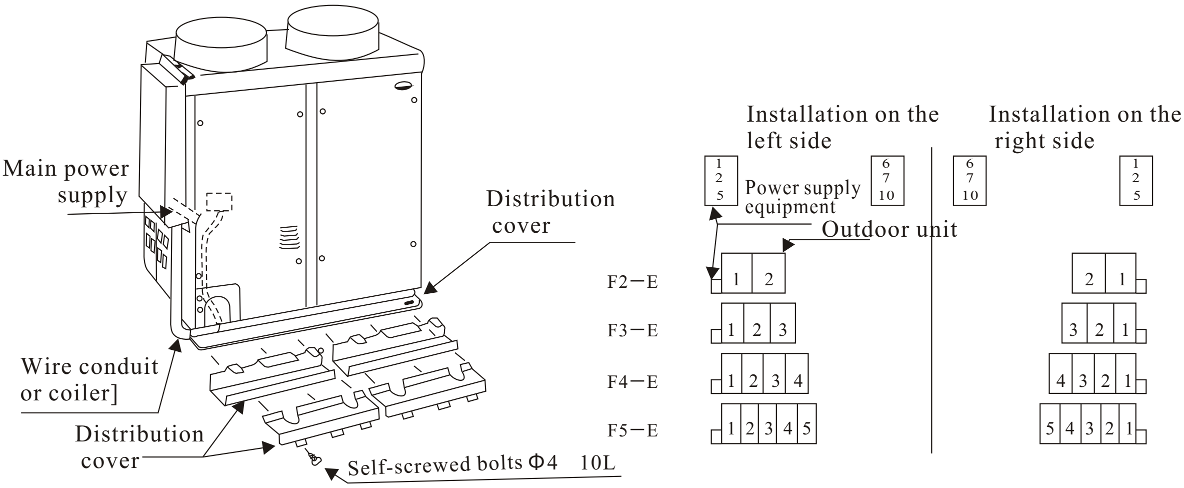
(2) Please connect main power supply to power supply post row.

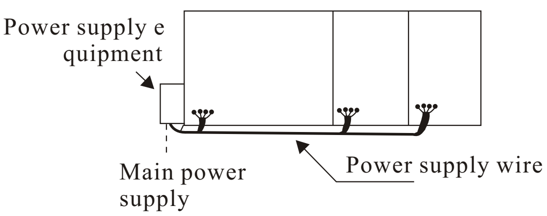




(3) Please following the drawing to carry out power supply distribution

- All power supply wire passing through the baseboard shall with standard names. Take off distribution cover.
- Power wire between power supply equipment and distribution conduit shall pass through coiler or wire conduit. (Prepared at site)
- Power supply wire of outdoor unit is brought in through perforation at base plate.
- According to different equipment types of power supply equipments; you shall refer to sequence of the following drawing for correspondence to power supply equipment number.



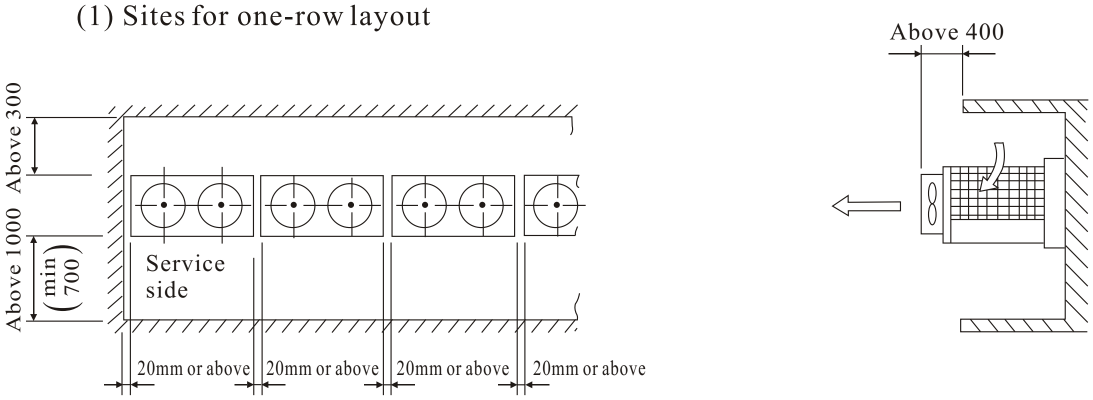


(4) Please connect power supply wire to power supply post row (L1, L2, L3, N) in electrical box.

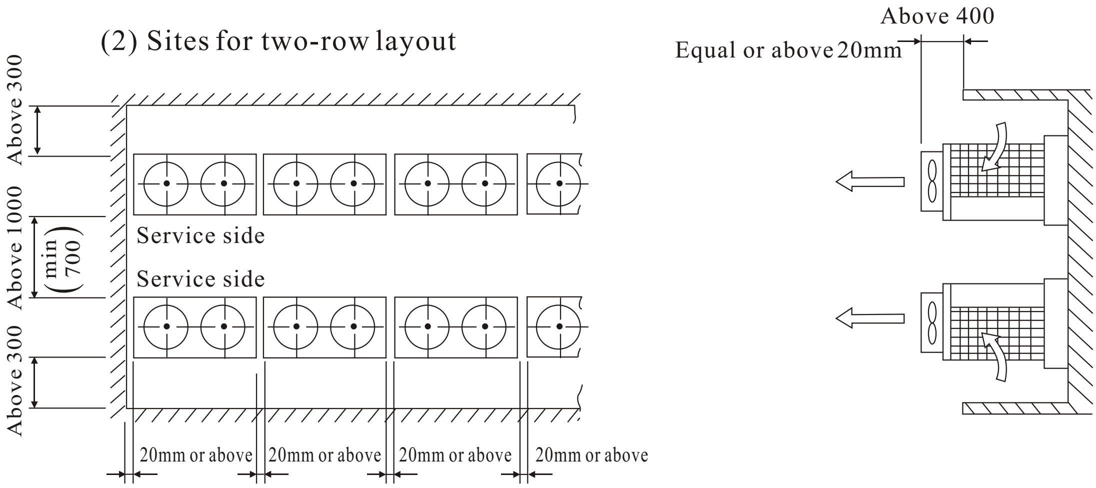
(6) Centralized layout

I When outer wall is lower than outdoor unit

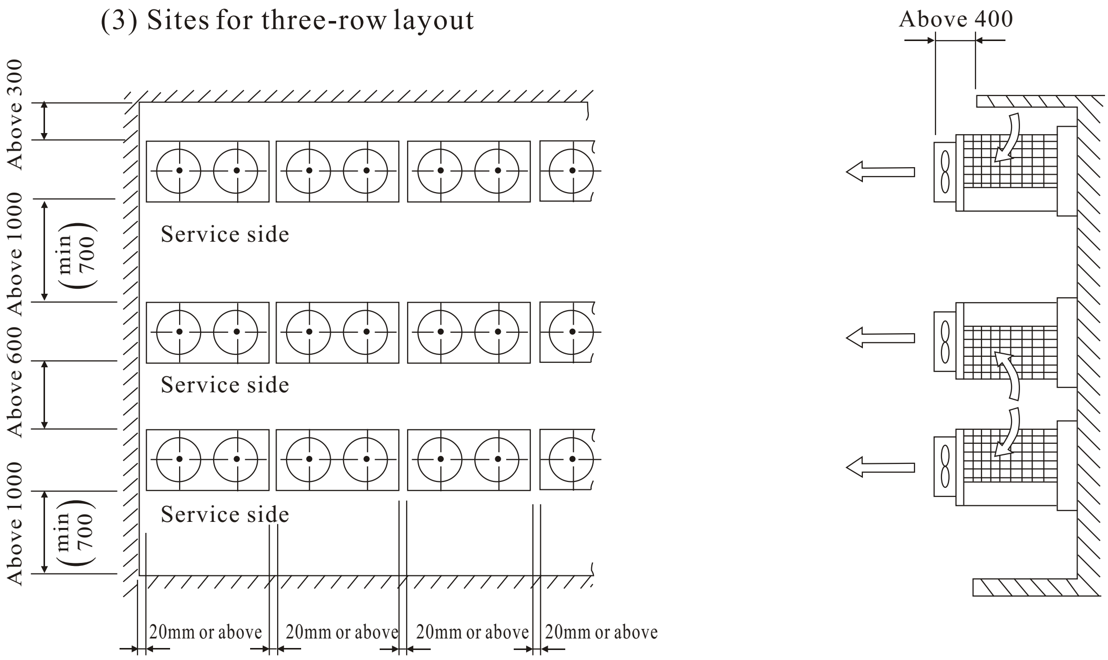
(1) Sites for one-row layout



(2) Sites for two-row layout

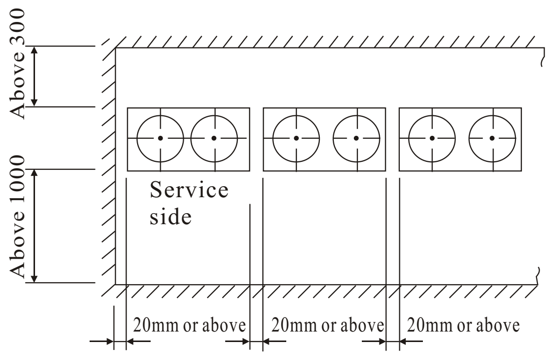


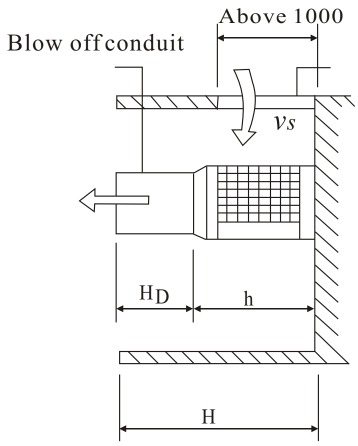
(3) Sites for three-row layout



II When outer wall is higher than outdoor unit

(1) When it is possible for set opening



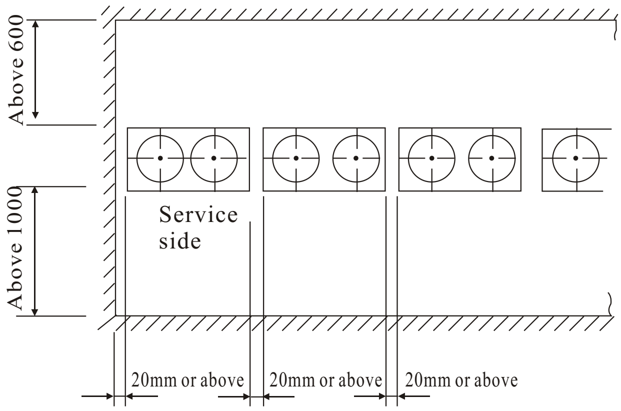


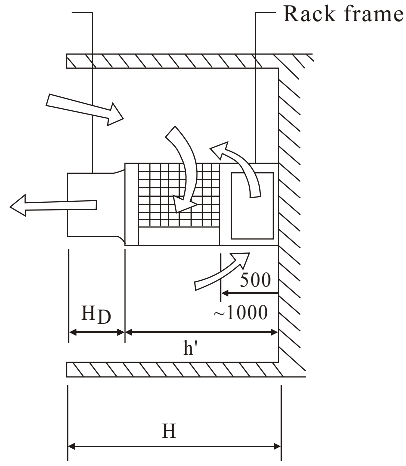
Opening rate when flow velocity Vs at air-in opening is 1.5m/s or below

Height of flow blew off air duct is H_D=H-h'

When layout in two-row or three-row, the above shall be item 2 and 3 for reference consult I.

(2) When it is impossible for set opening





Set rack with a height between 500 and 1000mm.

Height of blow off conduit is HD=H-h'

When layout in two-row or three-row, the above shall be item 2 and 3 for reference consult I.

(7) Layout in each floor (below 10 floors)

Key design points:

Set blow off conduit at each air-outlet (shall be closely connected with split grid when there is split grid).

Demolish covering net of fan

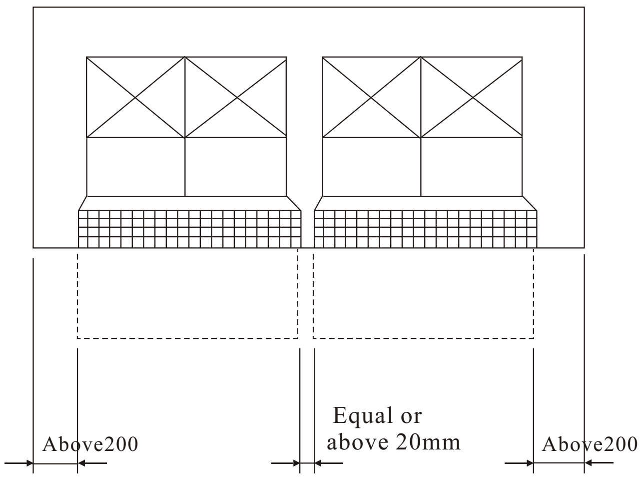
Air resistance shall be under 1.5mmAq at blow off conduit and splits.

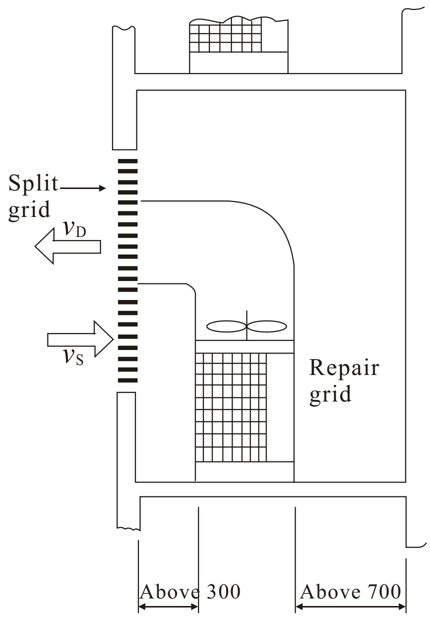
Angle of split grid shall be horizontal ~20 with downward splits.

Flow velocity is: velocity of blow in flow Vs 1.5m/s, that of blow off flow V_D=4-5m/s

There shall be noise proof measures on each floor.

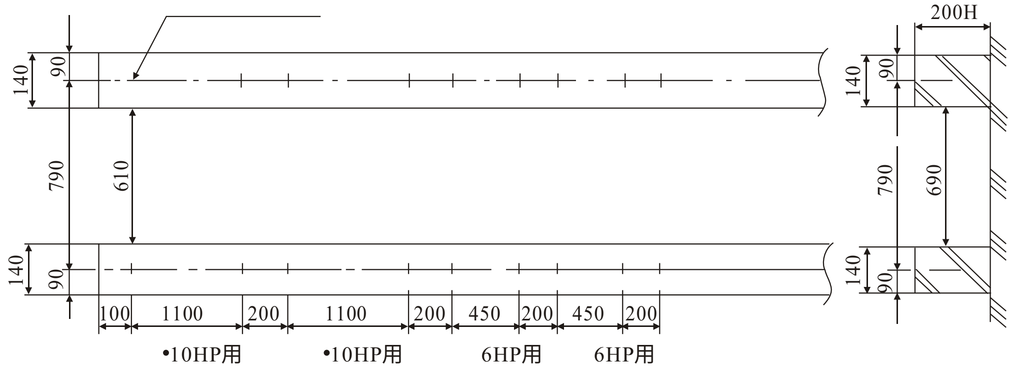
Space for air-in, service, tubing, wiring and construction shall be left.





(8) Foundation

Example of two-span concrete foundation is as the following drawing.

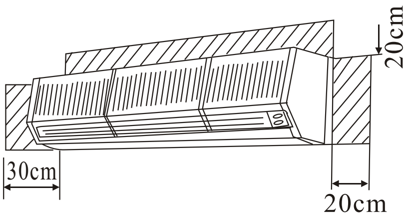


Section 2 Installation and Construction of indoor unit

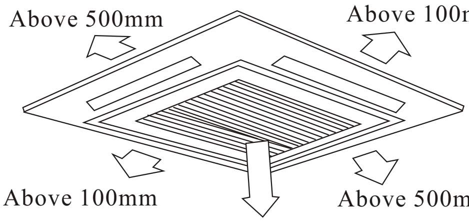
The following listed shall be taken into consideration and you shall have an installation plan:

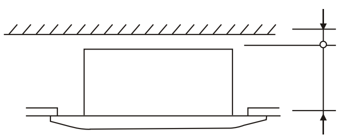
1. When indoor units are installed inside ceiling, you shall consider cooperating with construction material and proper layout with structure, lighting fixtures, and fireproofing water spray pipes.

2. Make sure unit vibration shall not be spread to places beyond ceiling.



Hanging indoor air conditioner





Embedded height of apparatus is 10 to 20mm.

Drawing 4-4 Space left during indoor air conditioner installation

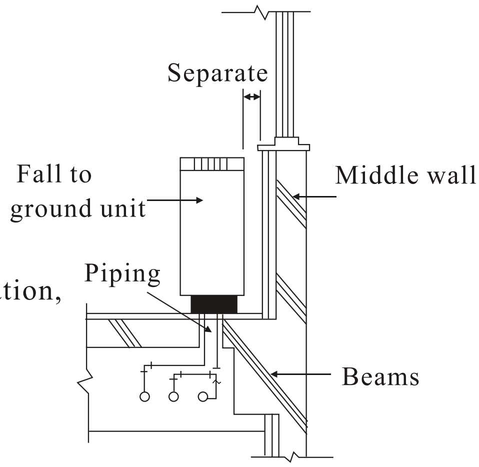
3.Discuss if shape and color of indoor air conditioner match color of building materials such as ceiling, and direction of power supply wire and control wire shall unisonous.

4.Indoor air conditioner shall not be installed at entrance or exit. For instance, indoor air condition in floor-type installation shall be installed at the bottom of windowsill and be in harmony with indoor furniture and decoration.

5.There shall be enough space around unit to ensure service and circulation of flow. Refer to drawing 4-4.

1 Plan prior to installation of indoor unit

1 When indoor unit is installed near windowsill, installation shall be affected by under floor beams and location of pipes. Therefore enough space shall be left between the unit and wall as shown in drawing 4-5. Special care has to be taken when curtains are installed and flow velocity is affected.



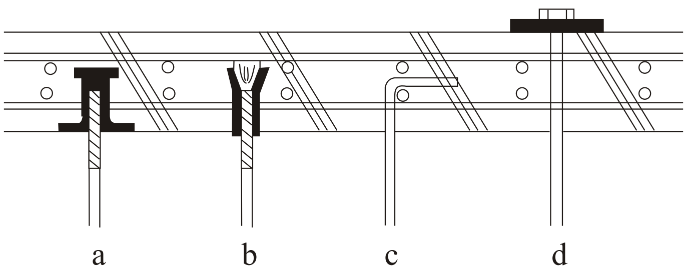
Drawing 4—5

2 When indoor unit is installed in concealed location, you shall confirm dimension of blow off conduit, jointing method of free area and short pipe, dimension of service opening, opening of control switch zone, location for air filter to discharge. All the above factors shall be well considered in plan.

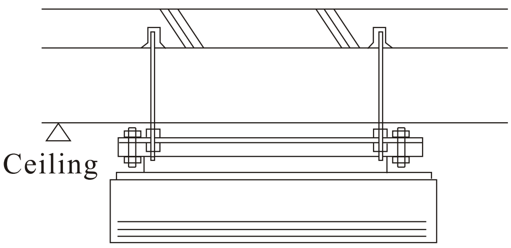
3 To air-cooling unitary machine, as part of the unit is exposed to outside wall, you shall consider if leaked rainfall enters indoor space. And also you shall consider fireproofing performance.

2 Ceiling -typed indoor unit installation

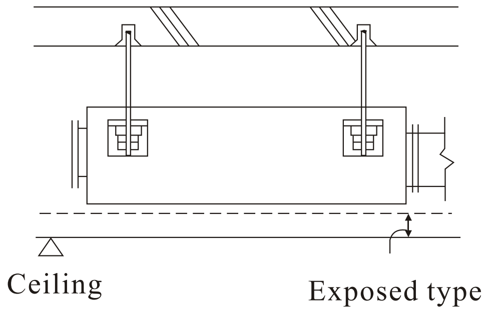
There are three main types of indoor unit hanging in ceiling---exposed type, concealed type and box type, which use similar installation method. Usually hanging bolts are first set, and then units are lifted as shown in drawing 4-6, 4-7, 4-8, and 4-9.



Drawing 4-6 Forms of different hanging bolts (hanging bar).

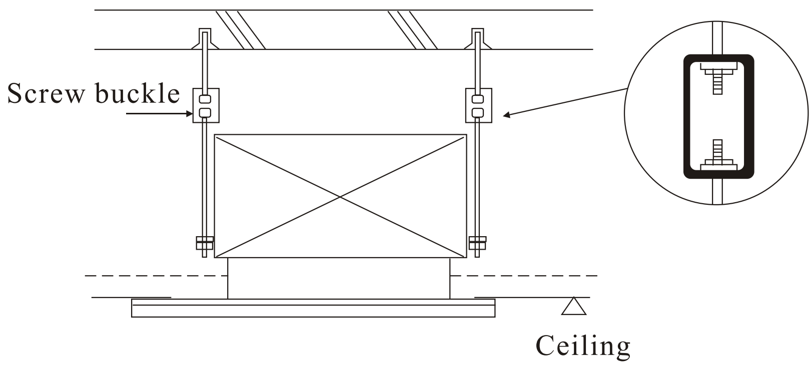


Drawing 4-7 Exposed type



Drawing 4-8 Concealed type

Space of ceiling foundation



Drawing 4-9 Box type

1 Installation approaches:

1. Pre-embedding pieces or expansion bolts to top beams and floor and insert hanging bolts in.

2. Lift indoor unit to its location on ceiling, tightly lock and fix hanging bolts.

3. Adjust level of indoor unit by screw buckle, which hangs bolts

4. Mark on bolts by painting after installation of ceiling, make sure it is fixed, and make sure there is no displacement after operation.

5. After testing (including control test) without mistake, install shell or panel.

(2 Cautions during installation

1. Combination of hanging bolts and pre-embedded pieces is dimension of screw twisted in. Strength must be guaranteed. It is forbidden to twist into screw thread by force or only screw into one or two circle in case buckle loosening occurs.

2. Adopt two bolt caps and tightly lock them after orientation.

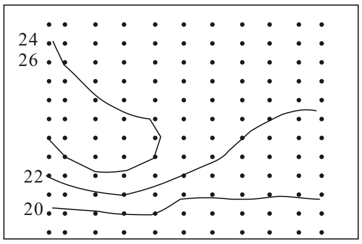
3.Pre-embedded straining bar and hanging bolts shall be with bearing capacity of two times self-gravity of indoor unit.

3 Installation of hanging indoor unit

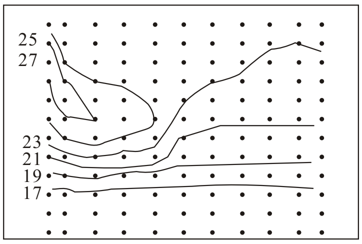
The most important factor in laying hanging indoor unit is to confirm strength of wall. Mark on wall according to installation location and nail hanging plate on wall by steel nails. And then hang indoor unit on it and check if it is horizontal. If it is acclivitous, you shall not carry out piping engineering until you have adjusted it to level station. The following listed shall be taken into consideration for installation of hanging indoor unit (including hanging ceiling unit).

1 Distribution of indoor temperature

Flow, temperature distribution and ventilation shall be chiefly considered. Temperature of blew off cooled wind is lower than that of indoor air during refrigeration. Therefore blowing downwards or levelly and decreasing velocity of flow shall prevent you from feeling ventilation. Blew off heated flow shall settle in top indoor space and thus temperature difference rises between the top part and bottom part in indoor space. Drawing 4-10 demonstrates indoor flow distribution in isotherm drawing at blew off temperature 40 and 50 separately when other conditions such as flow velocity, blew off outlet are the same. It is obvious that indoor air temperature varies a lot when blew off air temperature is 50 and thus causes uncomfortable feeling. Drawing 4-11 is indoor air isotherm drawing at the same temperature only with changes of blew off flow velocity, which shows under higher blew off flow velocity, indoor temperature distributes more evenly.



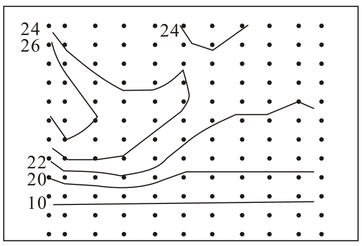
Blew off temperature 40℃



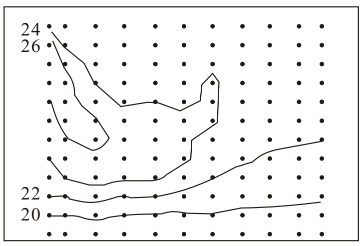
Blew off temperature 50℃

Drawing 4-10 Relationship between temperature distribution and ventilation

(under different blew off temperature)



Blew off temperature 45℃



Blew off temperature 45℃

Drawing 4-11 Relationship between temperature distribution and ventilation

(under one same blew off temperature)

Therefore window-blinds with changeable blowing rate and blowing direction are set on air conditioners. Heat exchange or clearance wind shall be felt at doors or windows during heat production. To prevent the above said station occurs, most units shall blow towards window side.

2 Regularly check and clean air filter net or change adsorption apparatus. De-dusting technique shall be referred to section 4 chapter 3.

3 Please pay attention to noise after installing indoor units. There are two main reasons for noise generating----one is vibration caused by unit itself, wind vane run up against wall or shaft friction loss. The other is sympathetic vibration, which was caused by improper fixing during installation.

Section 3 Noises and Vibration

As air compressor, fan motor, and wind vane shall bring noise and vibration, noise and vibration are concomitant. As output power of air compressor and fan of commercial air conditioners is larger, its blowing rate is higher and fan diameter is larger. Therefore noise and vibration of commercial air conditioner is larger than common family air conditioners.

As commercial units are usually with multi-units, low operation noise shall be chosen in office buildings. Therefore it is more necessary to disperse sound source and reduce vibration noise.

1 Noises

Noises sent out by site we located and air conditioners are called noise value at sound caught point. We could use the following formula to calculate noise value of each sound source and distance from each sound source to sound caught point. The formula is:

$$SPL = 10\log\{10\ PWL1/10\left(\frac{Q1}{4\pi r i^2}+\frac{4}{R}\right)+\cdots\cdots 10\ PWL$$

$$/10\left(\frac{Q}{4\pi r i^2}+\frac{4}{R}\right)\cdots\cdots\}$$

SPL:sound pressure grade value $R=\frac{Sa}{1-2}$

Qa average adsorption rate

PWL power rank

S surface area of room

Q orientation coefficient (R: constant of room)

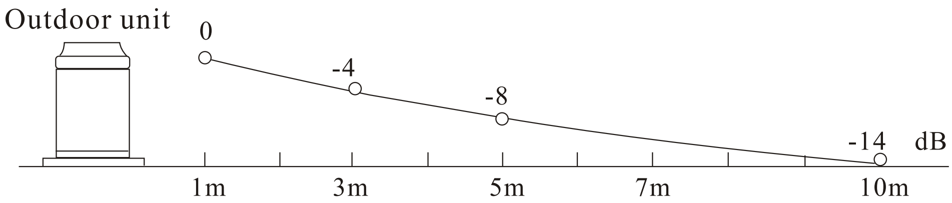
Sound pressure grade value R of audio frequency zone of different frequency summed using the secondary formula to get answer of noise voltage (SPL).

$$SPL[dBA]=10\log(10^{spl_1/10}+10^{spl_2/10}+\cdots\cdots+10^{spl_n/10})$$

1 Noise control measures

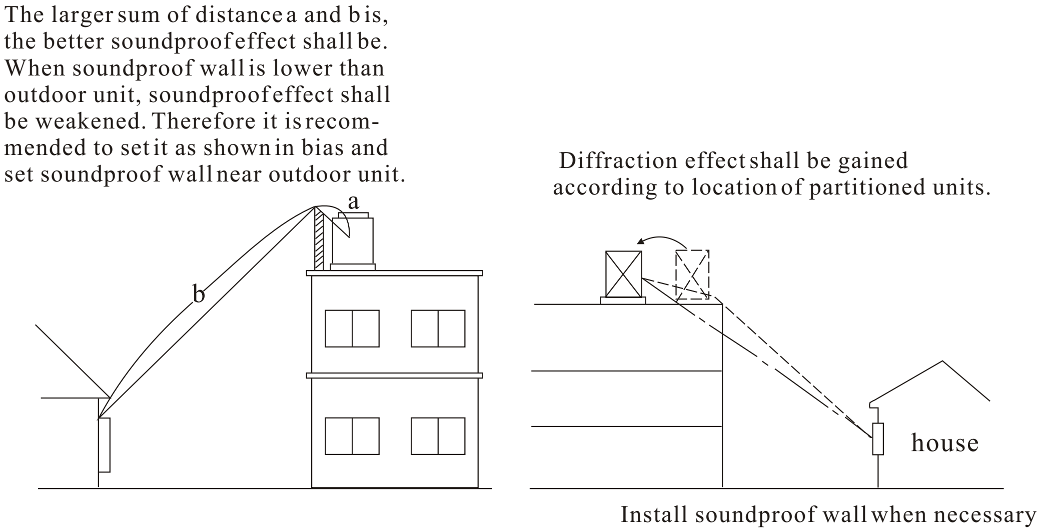
Low noise outdoor unit shall be chosen and the following items shall be cared:

1. To adopt distance attenuation effect and try to keep distance between each unit location as long as possible. Relationship between noise strength and distance attenuation is as shown in drawing 4-12.



Drawing 4-12 Relationship between noise strength and distance attenuation

2.To adopt diffraction attenuation effect and use sound-proof wall to obstruct and diffract its noises. In this way noises shall be attenuated. Layout shall be referred to the following drawing 4-13.



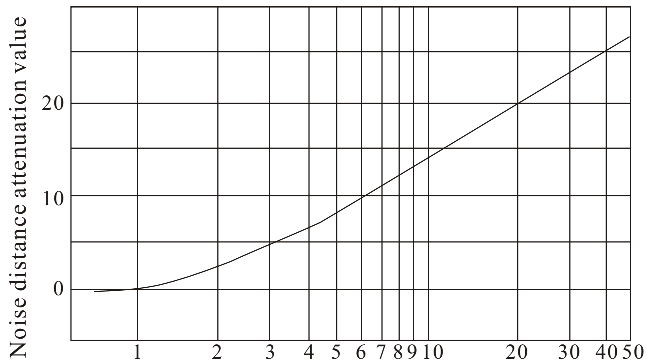
Drawing 4-13 Effect of soundproof wall

3. If noise can not be decreased by taking above listed measures, sound elimination pipe shall be set on air-inlet and air-outlet of outdoor unit, or to build sound adsorption and insulation board to decrease outdoor unit noise.

(2) Calculation of noise value

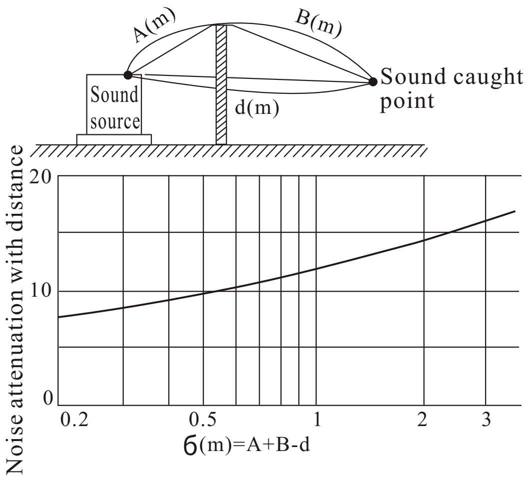
1. Sound distance attenuation

Sound distance attenuation is calculated as 20log (r: distance) when sound source spreads to each direction as point sound source. When distance doubles, noise shall be decreased to 6dB (decibel). In actual situation outdoor units are not point sound source, therefore attenuation is smaller than theoretically calculated. Attenuation character is shown in drawing 4-14.



Drawing 4-14. Attenuation character with changes of noise distance

(3) Diffraction attenuation value of soundproof wall



Drawing 4-15. Noise diffraction attenuation character on top of units

Wall with quality could prevent sound. But there is still part of sound, which turns over from top of wall and reach sound caught point. The higher sound frequency is, the larger diffraction attenuation is. To noise with low frequency it is just on the contrary. Therefore it is necessary to calculate correct attenuation value according to frequency of each outdoor unit. Under restrained conditions, attenuation effect similar to what was shown in drawing 4-15 shall be gained. Though value of σ shall be got form formula A+B-d. The larger σ is, the larger attenuation value shall be.

Drawing 4-12 lists allowable maximum noise value in city (use Tokyo as an example)

2 Vibration

Vibration points in air conditioner system are air compressor, fan and fan motor, Vibration shall be spread to floor and wall through shell and pipes, and even cause fluttering sound of resonance of some parts. Though manufacture has taken the above listed into consideration, improper installation shall enhance vibration.

There are a lot of physical measures for estimating vibration effect. Vibration transmission rate T is commonly used for estimating vibration effect. We also call it vibration isolation coefficient or vibration isolation efficiency, which shows the proportion of force passing vibration isolation system and reaching structure to total force implied on unit by vibration action. The smaller T value is, the better vibration isolation effect is. T is as the following formula shows:

$$T = \frac{1}{(f/fo)^2 - 1}$$

f— — vibration frequency of vibration source (units) in Hz.

fo connatural frequency of elastic shock absorption supports in Hz.

It is clear that the larger ratio of f to fo is, the smaller T value is, the better vibration isolation effect is. When f equals fo, T value is infinite and resonance occurs in system.

Chart 4-2 General standard for noise

<table>
<tr><th colspan="2" rowspan="3">Condition / Zone</th><th colspan="8">Time period</th><th>Special standard</th></tr>
<tr><th colspan="2">In the morning</th><th colspan="2">In the afternoon</th><th colspan="2">Dusk</th><th colspan="2">Night</th><th rowspan="2">Adjacent to schools and hospitals (about 500 meter's distance)</th></tr>
<tr><th>Volume</th><th>Time</th><th>Volume</th><th>Time</th><th>Volume</th><th>Time</th><th>Volume</th><th>Time</th></tr>
<tr><td>1st grade</td><td>Dwelling house Special zone</td><td>40</td><td rowspan="4">6 am to 8 pm</td><td>45</td><td rowspan="2">8 am to 7 pm</td><td>40</td><td rowspan="2">7 pm to 11 pm</td><td>40</td><td rowspan="4">11 pm to 6 am in the following day</td><td>Same to the left standard</td></tr>
<tr><td>2nd grade</td><td>Dwelling house zone Without appointed zone</td><td>45</td><td>50</td><td>45</td><td>45</td><td rowspan="3">Minus 5 on the basis of left standard</td></tr>
<tr><td>3rd grade</td><td>Commercial zoneRatified industrial zone Industrial zone</td><td>55</td><td>60</td><td rowspan="2">8 am to 8 am</td><td>55</td><td rowspan="2">8 am to 11 pm</td><td>50</td></tr>
<tr><td>4th grade</td><td>Special appointed zone in central city area</td><td>60</td><td>70</td><td>60</td><td>55</td></tr>
</table>

Vibration proof measures

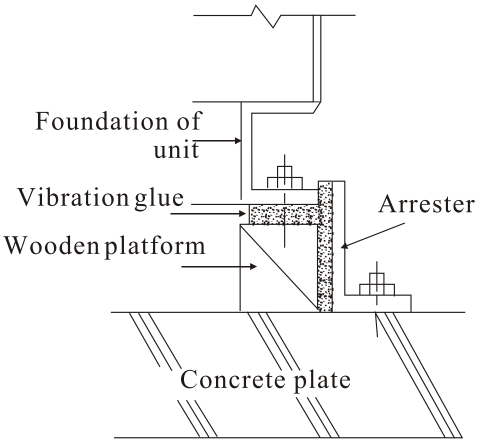
Different methods of fixing such as ground supporting, ceiling hanging, supporting by sloped frame shall be adopted in indoor and outdoor unit installation according to different type of air conditioner. All these methods shall be taken into consideration as an integral part of vibration proof engineering. Presently adopted foundation and vibration methods shall be referred to chart 4-3 according to shape of indoor and outdoor unit, weight, dimension, and installation site. Meanwhile allowable vibration degree, equipment expenditure, and different methods shall be considered.

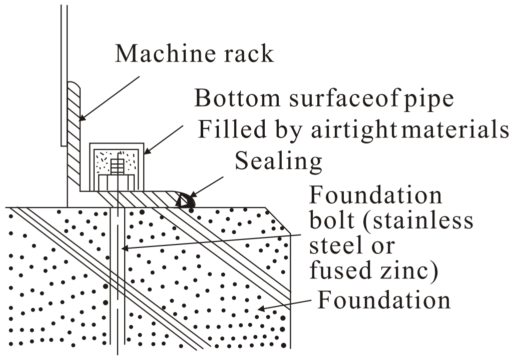
1 There shall be enough strength and rigidity.

2 Foundation and rack platform shall be with adequate strength to bear equipment weight, implied forces (such as outdoor typhoon etc) and be with enough resistance to prevent distortion and displacement. It is forbidden for outdoor unit to drop off.

3 There shall be no settlement

4 There shall be no reverse running, displacement and fluctuation. As air condition is a kind of machine with rotation, vibration shall be produced and spread to floor, walls. Thus causes uncomfortable feeling of human body and larger noise brought by resonance of indoor articles. Proper measures shall be taken to adsorb unit vibration, especially to unit with large power, referring to drawing 4-16.





The following listed are process for unit to move into foundation

1 Mark installation location with painting.

2 Place unit on top of foundation aiming installation location, and make the unit aerial.

3 Laying of vibration glue.

4 Install bolts for fixing and aim them to fixing holes of unit, twist into bolt caps for orientation (not tightly twisted).

5 Fill bolt holes with concrete mortar, which shall be filled in batch, and with tight vibration.

6 Tightly twist into bolts after enough curing of mortar and adequate strength, and adjust unit to level.

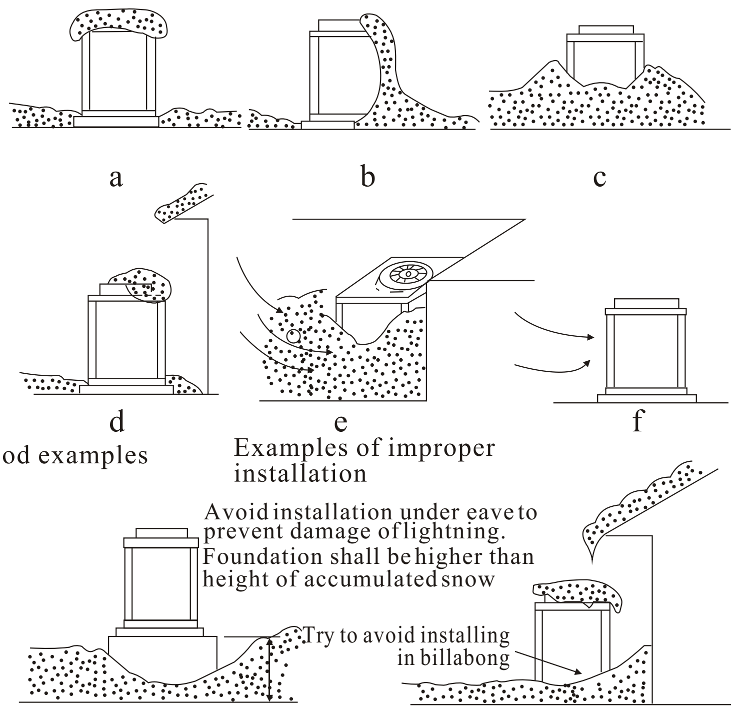
7 Unit and foundation shall be well sealed to prevent rust. Top of fixing bolts shall be with aluminum cap and sealing materials.

3 Snow proof

In northern areas snowfall in winter has great effect on outdoor unit. Snow accumulation may block air-outlet, air-inlet and heat exchanger, thus cause reduction of flow rate and failure in heat production. To prevent the above said situation occurring, we shall take some measures in advance in snow accumulation areas as shown in drawing 4-17. It includes: 1.
Pay attention to snow accumulation on top of unit. 2 Pay attention to snow accumulation on fan. 3.Pay attention to snow accumulation status. 4. Pay attention to snowfall status. 5. Pay attention to snow formed in pile. 6. Pay attention to seasonal wind.

Chart 4-3 Equipment foundation and vibration proof material

Vibration equipment	Shape of foundation	Installed location	Vibration proof materials: Spring	Vibtation glue	Glue plate	Soft wood	Suitable machine type
Without vibration equipment	Rack	On floor	—	—	—	—	Fission cabinet type and wall hanging type family use air conditioner Commercial air conditioner Outdoor air cooled unit
		Inside ceiling (hanging ceiling)	—	—	—	—	Ceiling of commercial unit Indoor unit and air duct fan
		Hanging on wall	—	—	—	—	Family use fission type air conditioner
	Concrete foundation	On floor	O	O	O	O	Integral type air conditioner Outdoor unit of commercial air conditioner
With vibration equipment	Rack	On floor	O	O	O	O	Outdoor unit of commercial air conditioner
		Inside ceiling	O	O	O	—	Small type integral air conditioner
		Wall hanging	O	O	O	—	Small type integral air conditioner
	Concrete foundation	On floor: On ground	O	O	O	—	Outdoor unit of integral type air conditioner General refrigeration equipment
		On floor: Strengthening foundation	O	O	—	—	Screw type refrigeration equipment and other refrigeration equipment
		On floor: With vibration proof material	—	—	O	O	Turbine type refrigeration equipment



Drawing 4-17

Section 4 Tubing engineering

Tubing engineering is a very important part in air condition engineering from design to construction. If failures in design are not corrected in construction, efficiency of air conditioner shall decrease. Therefore special care shall be taken to tubing engineering.

4-1 General items during construction

Construction drawing and operation instruction shall be finished in advance according to design drawing and construction instruction before carrying out tubing engineering. Please pay attention to the following listed:

1 Items relating the building

Please check the structure and confirm if there is any collision with elements including ventilation holes of each room, partition of machine room, height of ceiling, structural steel bar, and beams.

2 Relationship with other equipment

Please check if there is any collusion with other pipes such as pipes of water supply and drainage, fireproofing, water spray, and gas conduit. Please check power supply cable, power supply bridge, telephone and optical cable with design drawing. Special attention shall be paid to concealed power supply circuit.

3 Items relating tubing engineering

1 Expansion caused by heat and shrinkage caused by coldness shall be taken into consideration when choosing dimension of tubes. Drawing 4-4 lists changes in mm for every 100 -meter-long pipe when temperature varies under the supposition that corresponding value at 10 is 0.

Chart 4-4

Temperature ( )	Cast ion	Cast copper	Copper	Brass and copper
-46	-58.5	-63.5	-61.0	-92.0
-32	-44.2	-48.4	-47.4	-71.0
-18	-30.0	-33.4	-31.8	-47.6
-4	-15.0	-16.7	-15.9	-24.2
+10	0	0	0	0
+38	+30.0	+32.6	+31.7	+48.4
+66	+61.7	+67.5	+64.3	+98.6
+83	+95.3	+104.4	+99.5	+151.0
+121	+130.0	+143.0	+136.0	+205.0
+145	+156.0	+182.0	+175.0	+259.0

2 Check if layout of pipe shall disturb operation and maintenance of equipment, and vibration measures.

3 Check if up-bent gas store and generating section shall be formed in tubing engineering, and if relationship with supporting rack is proper.

4-2 Tubing of heat pump system

There are two tubing methods---refrigerant tubing and water tubing.

1 Refrigerant tubing

This information is only for middle and small type commercial use air conditioner. This type of machine is with low cold-producing (heat-producing) capacity. Chlorine fluorohydrocabon materials are used as its refrigerant. Copper materials are used as basic material for tubing. Deoxidized copper (TP1) and common red copper pipes (TP2) are commonly used at present.

Choice of tubing dimension shall refer to the following two conditions:

1. Gasify refrigerant and refrigerant oil given off by air compressor shall be back to air compressor simultaneously after circulation. Refrigerant gas has minimum flowing capacity with oil.

2. Dimension of pipes shall be large enough to ensure resistance for refrigerant gas or liquid flowing as smaller as possible. In other words pressure drop shall be small. Otherwise refrigeration efficiency of the system shall drop.

2 Water tubing

It is applied to cold and warm water system or cooled water system. First check its usage before choosing pipes, including temperature, pressure, corrosion character etc. The principle for choosing pipe dimensions are as following listed:

1. Single friction loss on water tubing (30-60mmHg/m)

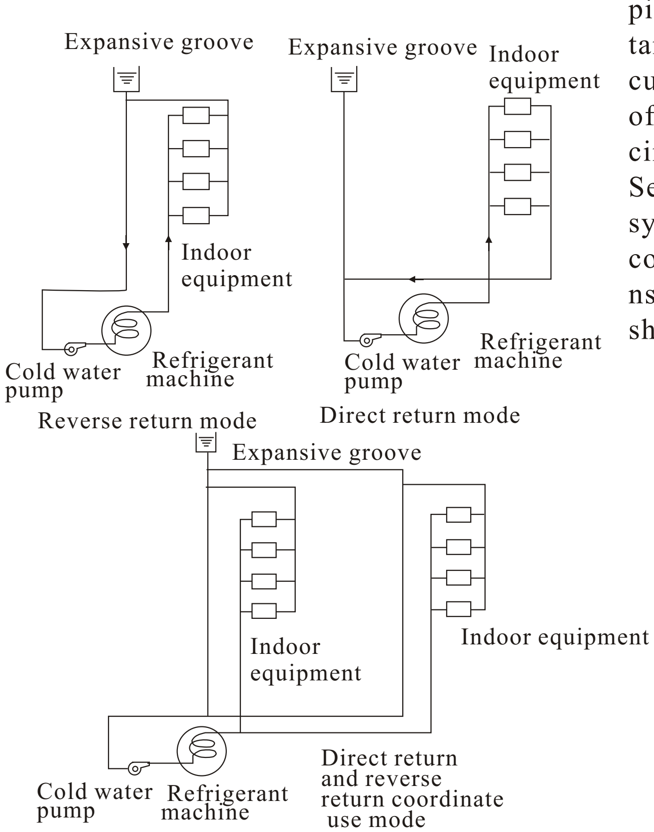
2.Velocity of water current inside tube.

3 .Water current rate needed.

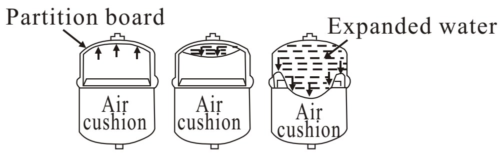
Recommended velocity of current			Allowable maximum current velocity considering corrosion action	
Diameter of pipe		Velocity of current (m/s)	Operation time (hour/year)	Velocity of speed (m/s)
A (mm)	B (in)			
Above 125	Above 5	2～3.6	1500 2000	3.6 3.45
60～100	2～4	1～2	3000 4000	3.3 3.0
About 25	About 1	0.5～1	6000 8000	2.7 2.4

Materials for water pipes are mainly low carbon seamless steel pipes with hot-galvanized coating inside and on outside surface. Common used pressure is 16Mpa and test pressure is 2.5 Mpa.

When water tubing is applied in cold and warm water system, expansion crack or air divorce shall occur inside pipe system caused by water expansion or shrinkage as cold and warm water system is a sealed system. Therefore expansion tank is equipped in such water system. Expanded water shall enter expansion tank when water temperature in pipe rises and water shall be supplied to pipe from tank when in pipe water temperature goes down. Water tank shall also supply some water to circulating pump for keeping inner pressure of water system when leakage occurs in circulating pump as shown in drawing 4-18. Several indoor cold and warm water supply systems. Generally small type cold-water air conditioner shall be installed airtight expansive groove (container) with partitions as shownin drawing 4-19.



Drawing 4-18 Several indoor cold and warm water supply systems



Drawing 4-19 Partition board type expansive groove

Calculation of expansive groove when warm water temperature is 70 is as following listed:

$$Vt = \frac{E \times Vs}{\frac{Pa}{Pf} - \frac{Pa}{Po}} \quad (m^3)$$

Vt----minimum capacity of expansive groove (m^3)

E-----water expansion rate in equipment (%)

Vs----full water volume in equipment (m^3)

Pa----absolute atmosphere pressure (Mpa)

Pf-----minimum allowable pressure of equipment (absolute pressure) (Mpa)

Po-----maximum allowable pressure of equipment (absolute pressure) (Mpa)

4-3 Construction methods

After checking with construction drawing and technique instruction at site without mistake, construction shall be carried out. Tubing of indoor unit, outdoor unit, and relative auxiliary equipment (such as fresh air disposal, air filtration equipment, fan and so on) shall not be carried out only after orientation and siting.

1 Construction sequence of pipes:

Design of construction drawing---siting and placing into perforated sheath and embedded pieces---move in cleaned pipe materials---lay scaffolding simultaneously---lay lifting and supporting tools---processing of pipes (incision, welding and so on)---hanging in tubing---locate level center (vertical line shall be located for vertical pipes)---water pressure test or air pressure test for ensuring without leakage---heat insulation---painting.

2 Key points in construction Water tubing

1.If hanging and supporting tools are with adequate strength to support total water weight in tubing and pipes: check if they are with enough resistance to earthquake or outside vibration, concussion. Shrinkage of pipes caused by temperature changes shall not be transferred to building structure. Lay supports or hanging tools in proper space, and make it convenient to prefabricate holes for pipe heat insulation work. Space shall be kept between pipes as listed in chart 4-6.

2. Slope of pipes: a slope from 1/15 to 1/100 shall be kept to ensure water current in pipes, flow discharge, refrigerant gas or liquid current flowing. Shrinkage value shall be cared when jointing with vertical pipes. Horizontal support space shall be referred to drawing 4-7. Tubing and supporting method shall be referred to drawing 4-8.

3. Discharge pipe: Air stored in tubing shall cause improper circulation and even prevent water pump from operating. Therefore discharge branch shall be laid on protuberant part of tubing to prevent stop valve from giving off air

Drawing 4-6. Spacing between tube (mm)

Diameter of pipes (mm)	15	20	25	32	40	50	65	80	100
100	230	235	240	255	255	265	270	285	300
80	215	220	225	240	240	250	255	270	
65	200	205	210	225	225	235	240		
50	195	200	205	220	220	230			
40	185	190	195	210	210				
32	185	190	195	210					
25	170	175	180						
20	165	170							
10	160								

Drawing 4-7. Maximum spacing between horizontal pipes (mm)

Diameter of pipes	25	40	50	65	75	80	100	125	150	200	250	300
Maximum space	2100	2700	3000	3300	3600	3900	4200	4800	5100	5700	6600	6900

4. Discharge water pipe: Discharge pipes and valves shall be laid on lowest level pipe in entire water circulation system to ensure water drainage and pollutions such as furring when changing circulation. (at valve mouth of cold and warm water system).

5. Tubes passing through walls and floor: it shall be strictly following construction drawing and pay attention to vibration proof, heat insulation and water proof. It is forbidden to cause inundation accident by pipe passing through.

6. Shrinkage of tubes: Water pipe shall shrink with temperature changes and dilapidation, bend, distortion may occur. Therefore shrinkable joints, buffer, and corrugated pipes are adopted to reduce shrinkage.

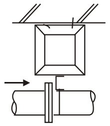
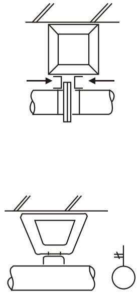
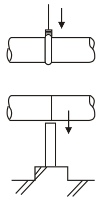
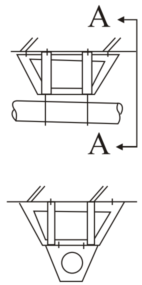
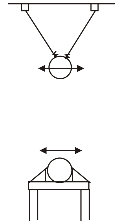
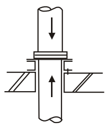
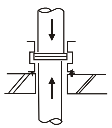
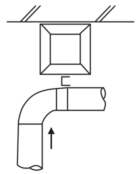
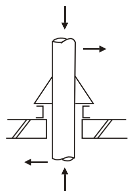
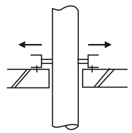
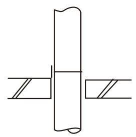
7. Vibration proof and noise proof: Bent area with flexibility shall be left at where tubing connects with unit, pumps. And vibration proof material or heat insulation materials shall be wrapped around supports, racks, and passing through situation on wall to decrease vibration and noises. Several construction examples are shown on drawing 4-21.

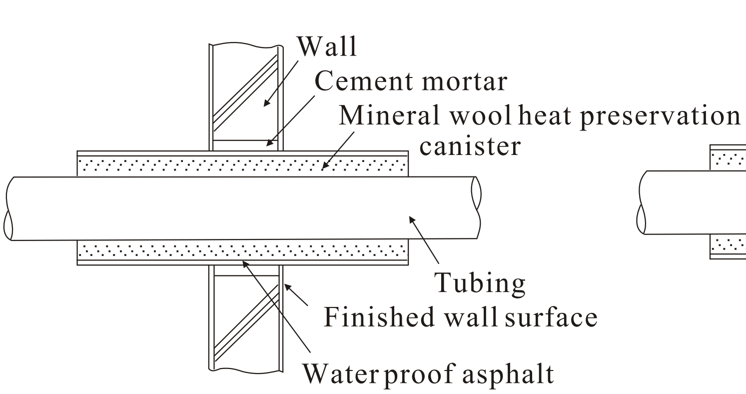
8. In order to control actual operation status, there is pressure gauge, thermometer on certain situation of pipe to show medium status as shown in drawing 4-21.

9.As tubes are very long with welded joints, screw jointing or flange connection, there may be leakage gap or leakage caused by un-tightly fixed bolts. Therefore water pressure test and air- tight test shall be taken.

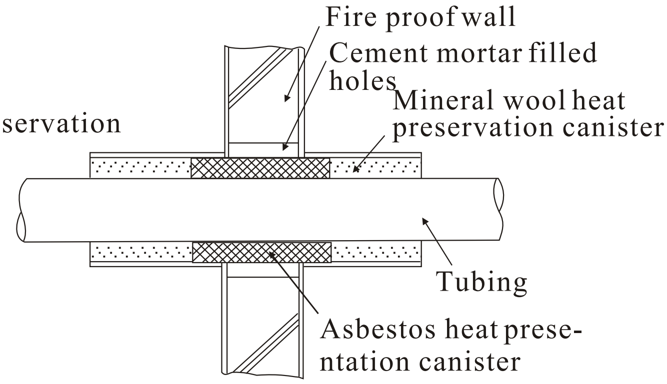
Water pressure test:Inpouring water into pipe and discharge all air in pipes. Add pressure to stipulated value and keep it for 30 minutes to check if there is any leakage or distortion. Designated pressure of water tubing system usually is about two times from test pressure to use pressure with minimum pressure of above 0.8 Mpa.

Drawing 4-8 Supporting method of pipes

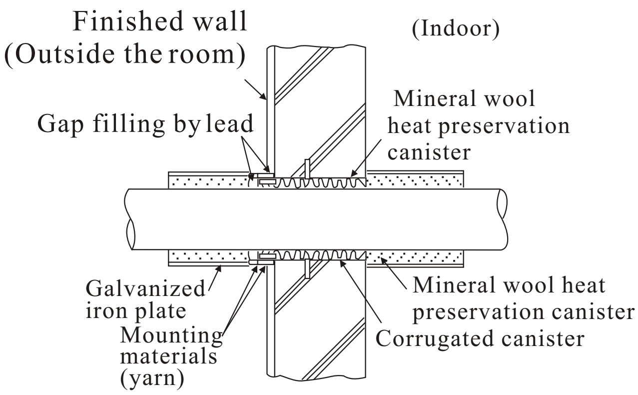
Classification	Supporting				Fixing	Vibration proof	
Direction of loading / Direction of pipes	Along pipe axis				All-way	Along pipe axis	
	Lean to one direction	Two directions	Downwards	Upwards		Horizontal	Downwards
Horizontal pipes	Alternative name stop unit 	Alternative name stop unit 	Hanging or supports 		 A-A section	Alternative name stop unit 	
Vertical pipes	Alternative name bearing 			Press Upward force 			Alternative name support 



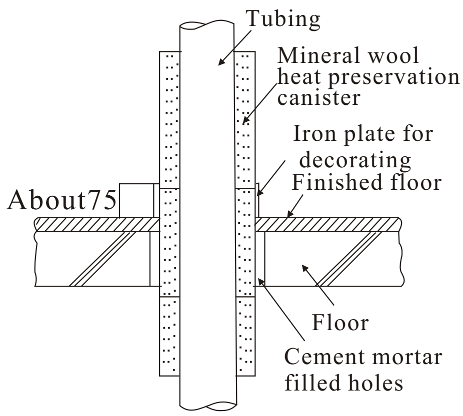
(a)Example of passing through common wall



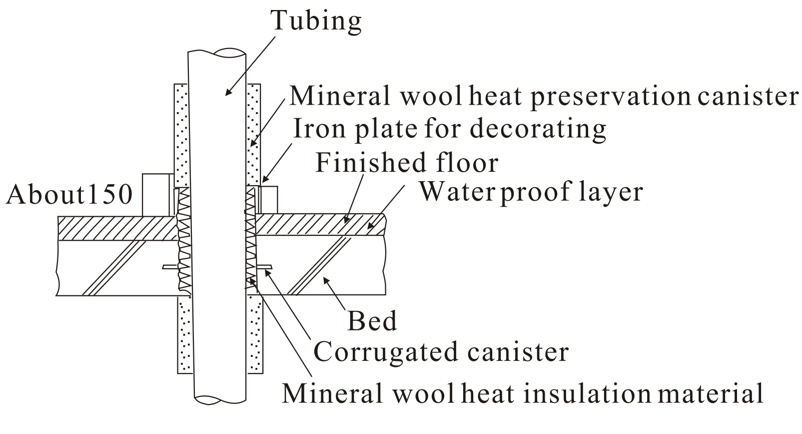
(b) Example of passing through fire proof wall



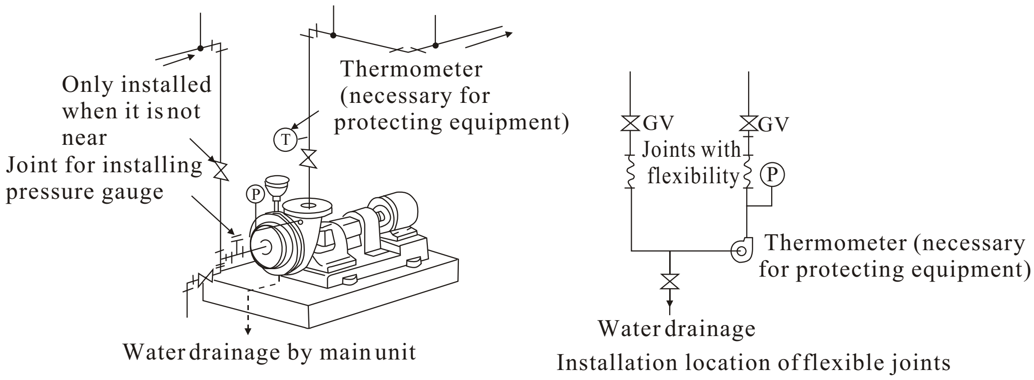
(c)Example of passing through outer surface of wall



(d)Example of passing through common floor



Drawing 4-20 Construction examples of heat insulation, vibration proof and heat shrinkage



Drawing 4-21 Layout around pump

Airtight inspection:Input inflammable gases such as nitrogen gas or compressed air into tubing and force pressure to designated value status, continue for more than 30 minutes, and then paint with soap-suds, check if soap bubble is produced to make sure if there is leakage of gas. Large changes of surrounding air shall cause changes of pressure inside pipes and make it difficult to judge if there is leakage or not. Designated (test) pressure is about 1.2 times of common use pressure and shall not be lower than 0.2 Mpa.4.3.2.

10 .Heat insulation: Heat insulation engineering is for preventing heat loss of cooled and warm water, accumulation of dew. Therefore heat insulation material with good performance, heat resistance, damp absorbing, cheap price and convenient for construction. At present super glass wool plate, super glass wool plate with or sprayed by resin binding admixture, and strip materials are adopted. Their heat-conducting rate is about 0.046 W/m· . At present on some occasions epispastic polystyrene half-circle cask shaped material or PEF foam as heat insulation layer.

Drawing 4-22 shows construction station of heat insulation indoor and outdoor

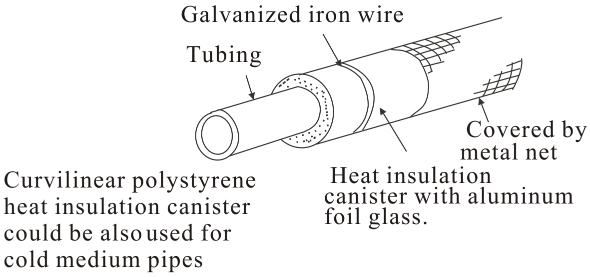
Tubing of refrigerant

1. When height difference between indoor and outdoor is not large:Usually height difference shall be below 10 m. If height difference is above 10 meters, hoist height shall be too large and refrigerant shall be gasified when it reaches the highest point. Under oil concave bent is set on pipe to collect oil and prevent oil from counter flowing as shown in drawing 4-21.

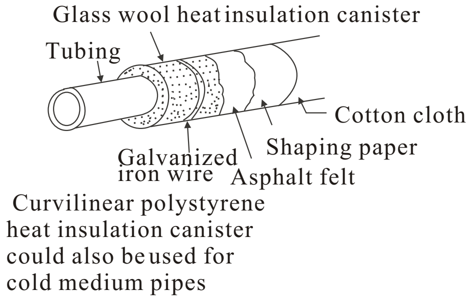
2. Length of tubing: Pipes shall be as short as possible. Over long tubing shall cause pressure drop (large pressure difference) and reduce heat-producing or coldproducing efficiency, thus frozen machine oil shall settle in pipe and air compressor may be burnt down due to lack of oil. Drawing 4-24 lists relationship between tubing length and capacity.

3. Supporting space between tubes: Copper tubes are usually adopted and there shall be one support every 1 meter for good appearance.

4. Cautions in tubing engineering: Fused connection shall be with cleanness-disposed pipes. Helium or nitrogen gas shall be filled into pipes for protection and preventing oxidation or producing of copper oxide. You could also cut off tube materials and use screwed joints at flaring (alternative name horn flaring, bolt cap, two joints as instructed in following parts).

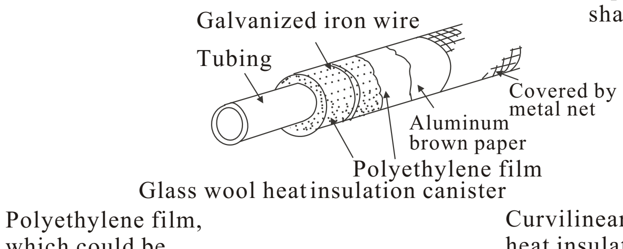


(a) Concealed indoor

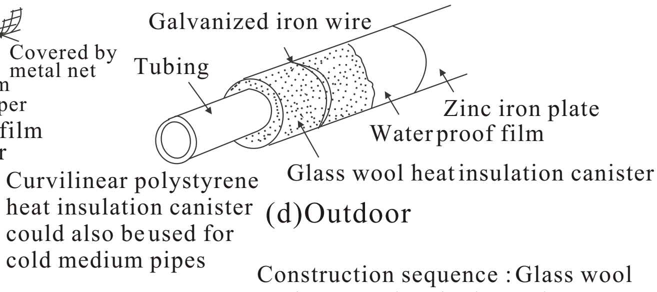


(c) Exposed indoor

Construction sequence: Glass wool heat insulation canister----cast wire---asphalt felt (polyethylene film)---shaping paper and cotton paper



(b) Concealed indoor



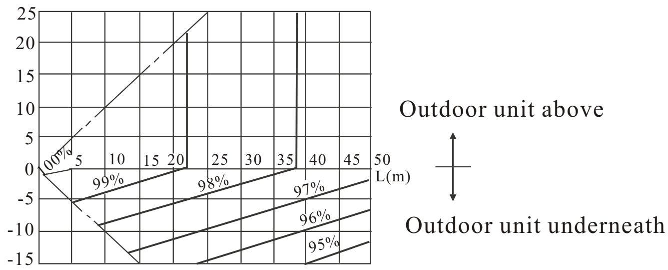
(d)Outdoor

Construction sequence : Glass wool canister + galvanize iron wire + water proof film + galvanize iron plate.

Curvilinear polystyrene heat insulation canister could also be used for cold medium pipes
Construction sequence 1: Aluminum foil glass canister+ adhesive tape+ metal net for covering
Construction sequence 2: Glass wool canister + zinc wool + metal net + polyethylene film +aluminum brown paper + metal net for covering

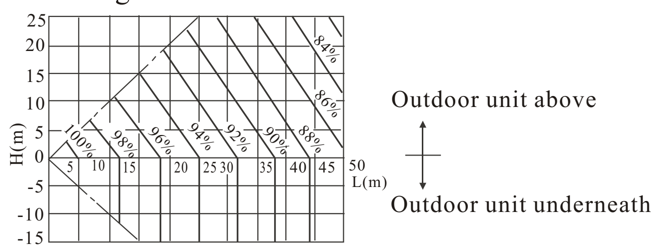
Drawing 4-22. Construction example of heat insulation

L: comparative length of tubing
H: height difference



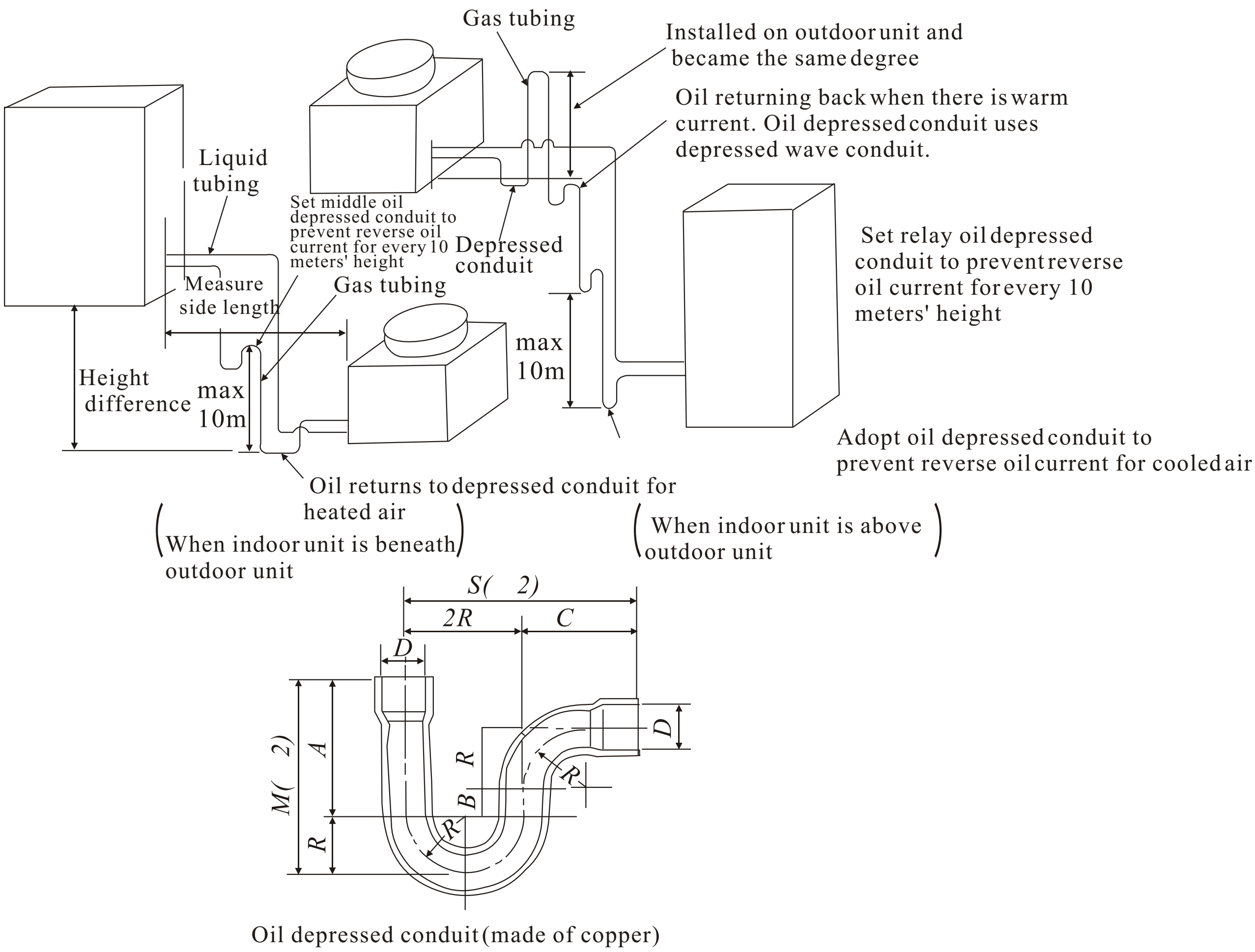
(a)Change rate of heat-producing capacity

L: comparative length of tubing
H: height difference



(b)Change rate of cold-producing capacity

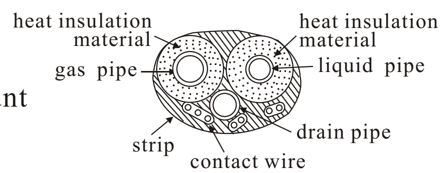
Drawing 4-24. Relationship between tubing length and capacity



Drawing 4-23. Height of oil concave bent

5.Thickness of heat insulation layer shall be enlarged to current return pipe and liquid supply pipe of heat pump air conditioner as shown in drawing 4-25.

6. Airtight check: Inpouring nitrogen gas to pipe and add pressure to 2~3 Mpa. And then place for more than 2 hours and paint soap suds on joints. Observe if bubble rises and it must be confirmed that there is no leakage.



7.Vacuumize: Use vacuum pump to discharge air and moisture inside pipes after completion of refrigerant engineering. This is a key operation. Failure shall occur if there is moisture and air in cold-producing system.

Vacuum grade shall reach value under 200 Pa when vacuuming. When it has reached this value, you shall stop vacuuming for more than 1 hour and then start to vacuumize for a while. Surrounding temperature during above operation shall be 20 . Vacuuming shall be prolonged for 30 minutes to every 5 temperature drop. After stop vacuuming, upper valve of vacuumed pipes shall be turned off to prevent oil from vacuum pump entering system.

8. Supplement of refrigerant: when tubing length exceeds designated length by manufacturer, refrigerant shall be supplemented to ensure proper operation of cold-producing system. The supplement shall be referred to chart 4-19, values of which are for every one-meter long pipe.

Chart 4-9 Supplementary quantity of refrigerant to prolonged tubing (kg/m)

Outer diameter of copper pipe (mm)	Air return pipe	Liquid supply pipe
Φ9.52	0.00335	0.0493
Φ12.7	0.0068	0.0997
Φ15.88	0.0107	0.1581
Φ19.05	0.0164	0.2415
Φ22.2	0.0224	0.3287
Φ25.4	0.0291	0.4292
Φ31.8	0.0468	0.6396
Φ33.1	0.0687	1.0120
Φ44.5	0.0968	1.4241
Φ50.8	0.1294	1.9073

4-4 Choice of pipe diameter of refrigerant tubing

1. Choice of refrigerant tubing

(1) Outdoor unit---tubing within first divergence part (main)

Tubing dimension of this part shall be same as that of outdoor unit tubing (refer to chart 4-10). For 6 Hp units, gas pipe length shall be enlarged to that of the next one dimension grade when tubing exceeds 25 meters.

(2) Divergence part---tubing between each divergence part

Choice shall be chosen on the basis of sum of indoor unit capacity, which connects to backward position (refer to chart 4-11). When it is larger than outdoor unit capacity, choice shall be on the basis of outdoor unit capacity.

(3) Divergence part---tubing between each indoor unit

Dimension shall be same as tubing dimension of indoor unit (refer to chart 4-12). Gas pipe length from the first divergence part shall be enlarged to that of the next one dimension grade when tubing exceeds 30 meters.

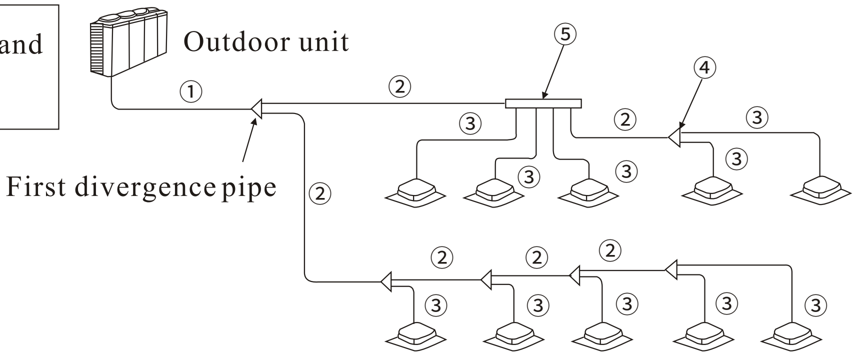
2. Choice of Y-shaped divergence pipe

Y-shaped divergence pipe shall be chosen on the basis of capacity sum of indoor units, which connect to backward position (refer to chart 4-13). When it is larger than outdoor unit capacity, choice shall be on the basis of outdoor unit capacity.

3. Choice of pectinate shape divergence pipe

Pectinate shape divergence pipe shall be chosen on the basis of quantity of divergence pipes connected (refer to drawing 4-14).

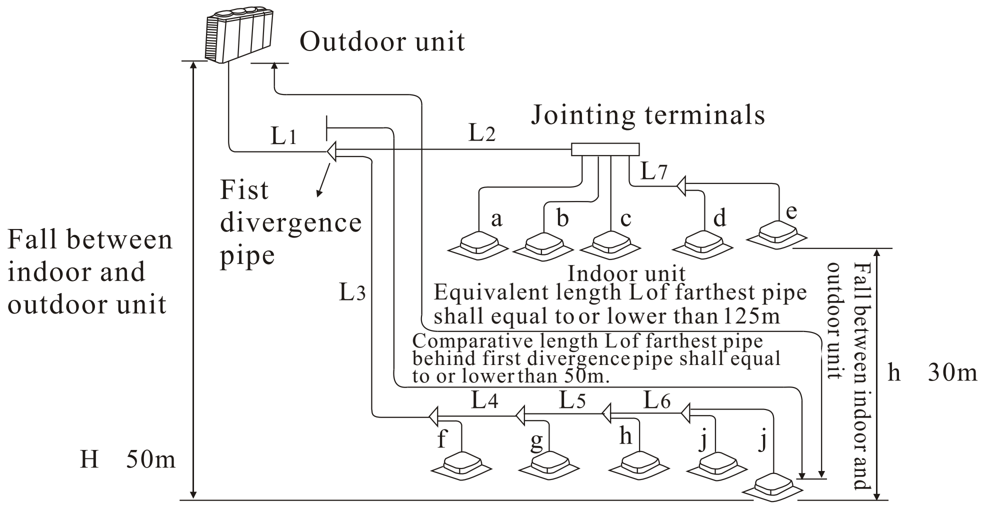
Dimension of tubing and jointing method



4. Allowable length of refrigerant and fall

<table>
<tr><th colspan="3"></th><th colspan="2">Allowable value</th><th>Tubing parts</th></tr>
<tr><td rowspan="4">Length of tubing</td><td colspan="2" rowspan="2">Total length of tubing (actual length)</td><td>AU55NFUAHA</td><td>AU96NFTAHA</td><td rowspan="2">$L_1+L_2+L_3+L_4+L_5+L_6+L_7+a+b+c+d+e+f+g+h+i+j$</td></tr>
<tr><td>220m</td><td>250m</td></tr>
<tr><td>Length of farthest tubes</td><td>Actual length
Comparative length</td><td colspan="2">100m
125m</td><td>$L_1+L_3+L_4+L_5+L_6+j$</td></tr>
<tr><td colspan="2">Comparative length L form first divergence pipe to farthest indoor unit ※</td><td colspan="2">50m</td><td>$L_3+L_4+L_5+L_6+j$</td></tr>
<tr><td rowspan="3">Fall</td><td rowspan="2">Fall H between indoor unit and outdoor unit</td><td>Above outdoor unit</td><td colspan="2">50m</td><td>—</td></tr>
<tr><td>Below outdoor unit</td><td colspan="2">50m</td><td>—</td></tr>
<tr><td colspan="2">Fall h between indoor unit and outdoor</td><td colspan="2">30m</td><td>—</td></tr>
</table>

※ Farthest indoor unit from first divergence pipe is indoor unit j.



※ Conversion of comparative length

When calculating, to Y-shaped divergence pipes it is one for each 0.5m length and one for each 1 meter to pectinate shape divergence pipe.

(1) Drawing 4-15 Tubing dimension of outdoor units

Type	To gas pipes	To liquid pipes
AU55NFUAHA	Φ22.2 (hard-solder welding) ※ 1	9.52 (bell mouthing)
AU96NFTAHA	Φ28.58 (hard-solder welding) ※ 1	12.7 (bell mouthing)

※ 1 Use connecting pipes of accessories.

(2) Drawing 4-16Tubing dimension and connecting method between divergence pipes

Sum of indoor unit capacity code	To gas pipes	To liquid pipes
Lower than 38220Btu/h	Φ15.88 (hard-solder welding)	Φ9.52 (hard-solder welding)
38220~61157 Btu/h	Φ19.05 (hard-solder welding)	Φ9.52 (hard-solder welding)
※ 61157~126137Btu/h	Φ25.4 (hard-solder welding)	Φ12.7 (hard-solder welding)

※ 1 It shall use outdoor unit capacity for calculation when it is larger than outdoor unit capacity.

(3) Drawing 4-17 Tubing dimension of indoor units

Capacity grade	To gas pipes	To liquid pipes
Type 07 to 16	Φ12.7 (bell mouthing)	Φ6.35 (bell mouthing)
Type 18 to 32	Φ15.88 (bell mouthing)	Φ9.52 (bell mouthing)
Type 36 to 45	Φ19.05 (bell mouthing)	Φ9.52 (bell mouthing)

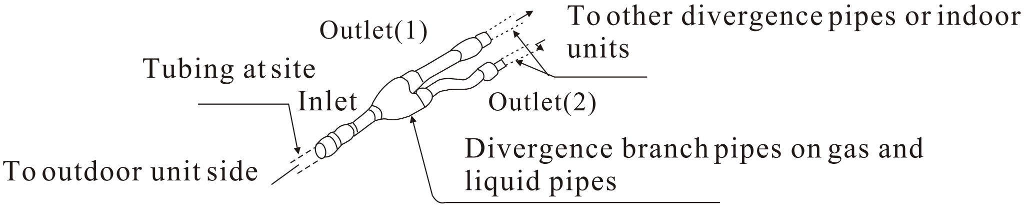
(4) Drawing 4-18 Choice for divergence pipes

	Sum of indoor unit capacity code Type	
Y-type manifold pipe	Lower than 61 KBtu/h	FQG-B180
	※ 1 Equal to or higher than 61KBtu/h lower than 126KBtu/h	FQG-B370
※ Comb-shaped pipe	For branch 4	FQG-H3704
	For branch 8	FQG-H3708

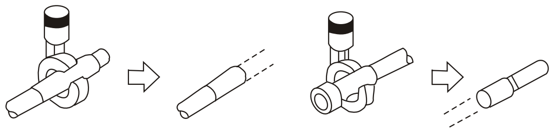
※ 1 Calculation shall be on the basis of outdoor unit capacity when it is larger than outdoor unit capacity.
※ 2 Maximum capacity code of last system behind pectinate shape divergence pipes could be connected to 6.0.

4-5 Jointing of divergence parts

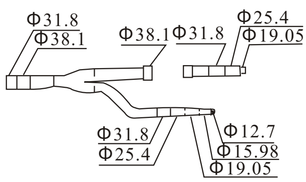
1. Y-shaped divergence pipes (on gas side and liquid side)



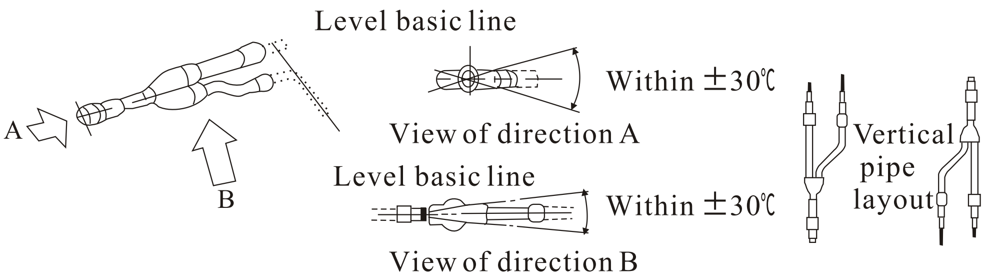
(1) When chosen dimension for site tubing is different from dimension of divergence branch pipes, please cut off at central part of joints by pipe cutting knife (small type knife) as following drawing.



(2)Auxiliary pipe for adjusting pipe diameter when using divergence pipes on gas side of FQG-B740. Welding shall be carried out after diverged pipes and auxiliary pipes cut into required pipes.

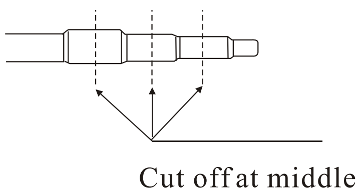


(3) Please pay attention to level and erection when installing Y-shaped divergence pipes

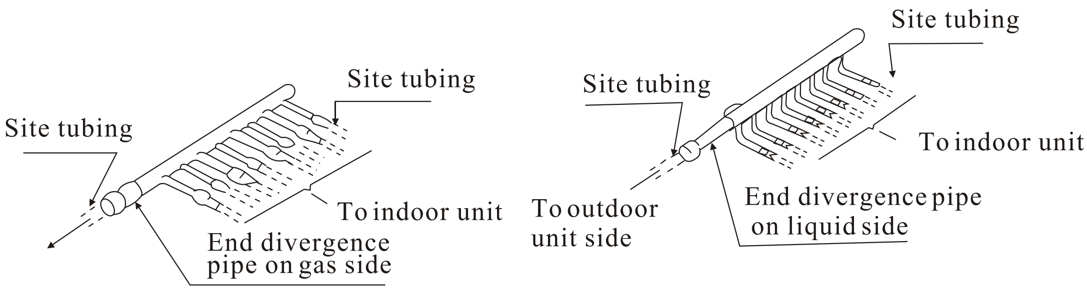


(4) Heat insulation of Y-shaped divergence pipes shall be following instructions attached in it.

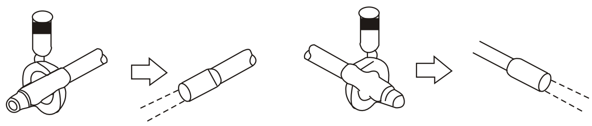
(5) Location for cutting off: cut off at the middle part of each joint and remove burr.



2.Pectinate shape divergence pipes (on gas side and liquid side)



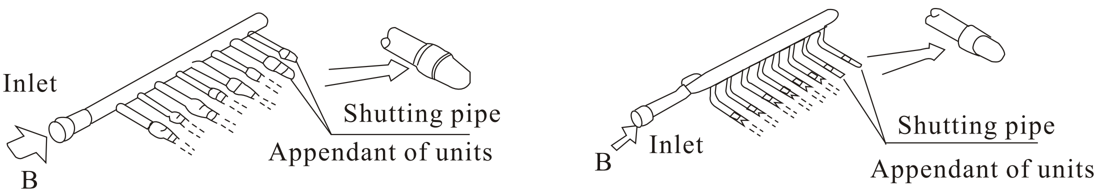
(1) When chosen dimension for site tubing is different from dimension of divergence branch pipes, please cut off at central part of joints by pipe cutting knife (small type knife) as following drawing.



(2) Shutting pipe shall not be installed when connected indoor unit quantity is lower than its capacity.

Main divergence pipe on gas side

Main divergence pipe on liquid side



(3) End divergence pipe shall be horizontal diverged. If is forbidden to use vertically.

Main divergence pipe on gas side

Main divergence pipe on liquid side

View from B direction

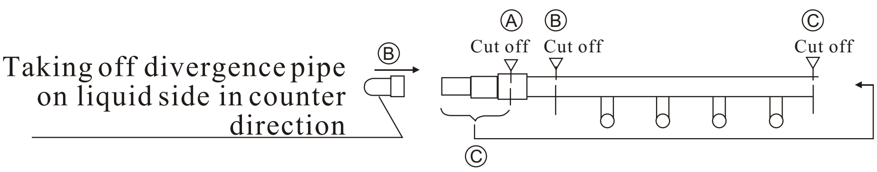
On gas side

View from B direction

On liquid side

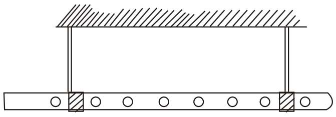
(4) Heat insulation of divergence pipes shall be following instructions attached in it.

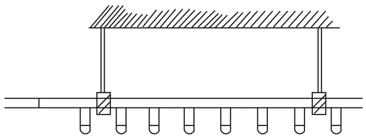
(5) When taking off divergence pipe on liquid side in counter direction please cut off both sides as following drawing and use counter shutting pipe on gas side.



(6) Supporting of pectinate shape divergence pipes

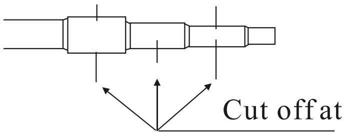
Supporting of pectinate shape divergence pipes shall be after heat insulation construction and adopt hanging metal pieces (prepared at site). Supporting pieces shall be laid.





. (7) Location for cutting off

Location for cutting off: cut off at the middle part of each joint and remove burr.



Small type knife shall be adopted for cutting pectinate shape divergence pipes off. (capable for cutting pipes under Φ22.2).

Cautions:	① Direct pipe with a length of more than 300 mm shall be left on inlet side of y-shaped and pectinate divergence pipes ② Y-shaped divergence pipes shall be installed horizontally or vertically. When it is installed horizontally, its level shall be within ±30°. ③ Pectinate divergence pipes shall be installed as horizontal divergence pipe. ④ T-shaped pipe shall not be adopted in divergence parts.

Cautions:	Nameplate shall be tied inside tube sleeve in longitudinal pipes and at outlets of roof pipe sleeve to demonstrate name of system. Measures shall be taken to prevent wrong jointing as refrigerant pipes centralized here.

3. Shape drawing of divergence parts

(1) Demonstrate identification mark for each pipe.

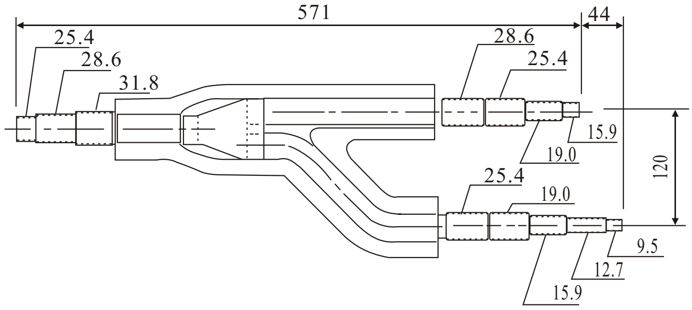
(2) External shape shall be marked as the following:

Type	Identification mark
FQG-B180	A
FQG-B370	B
FQG-H3704	C
FQG-H3708	D
FQG-B760	E
FQG-H7604	F
FQG-H7608	G

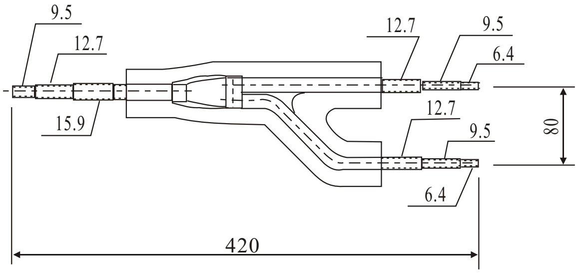
Shape drawing of Y-shaped divergence pipes

FQG-B370

on gas side

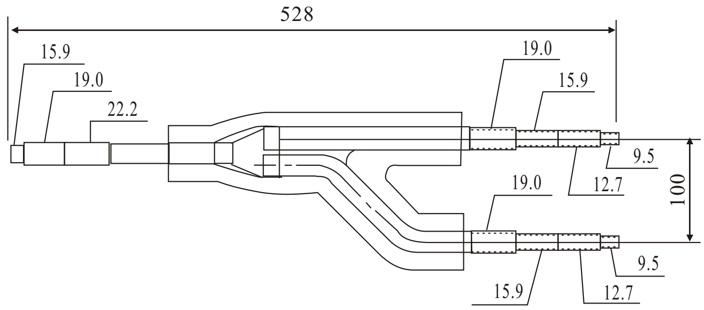


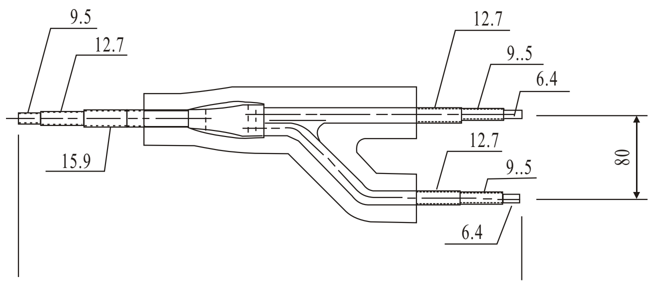
On liquid side
on gas side



FQG-B180

On liquid side

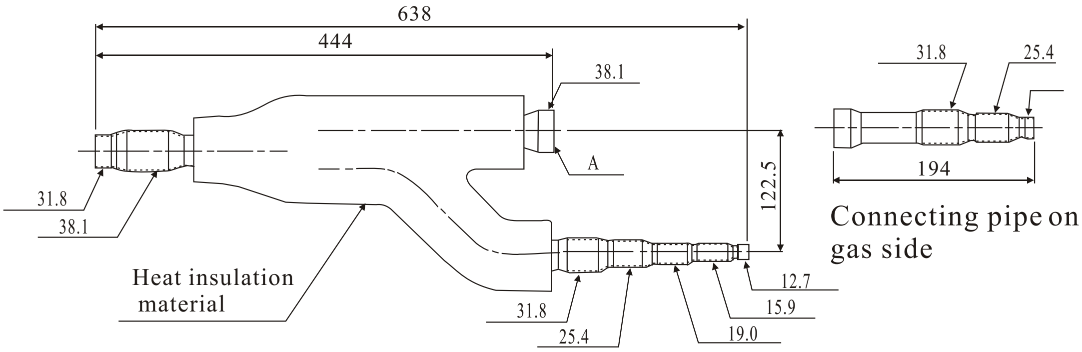




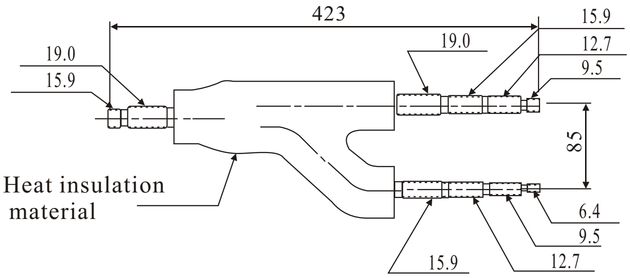
P.S. Dimension of pipes listed above is corresponding pipe dimension (inner diameter)

Shape drawing of Y-shaped divergence pipes

FQG-B760
on gas side



On liquid side

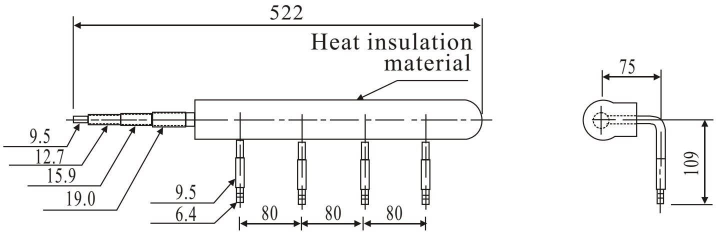


P.S. 1. Dimension of pipes listed above are connected pipe dimension.
2. Pipe on gas side is used in connecting with pipe on A side when connecting with pipe which dimensin is under ∅31.8.

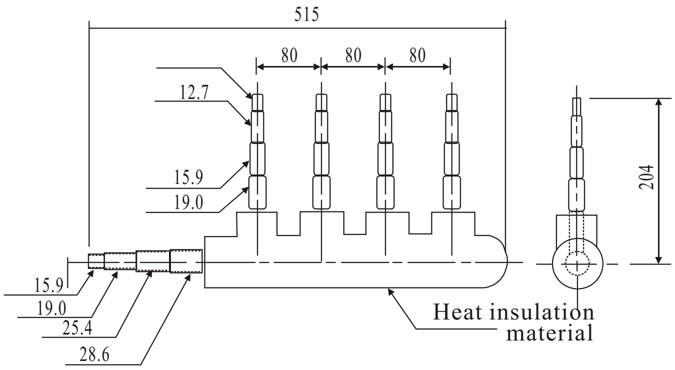
Shape drawing of pectinate divergences

FQG－H3704

on gas side

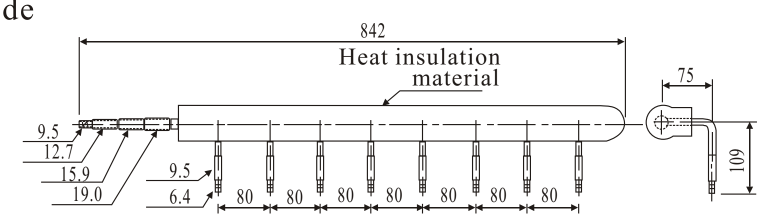


On liquid side

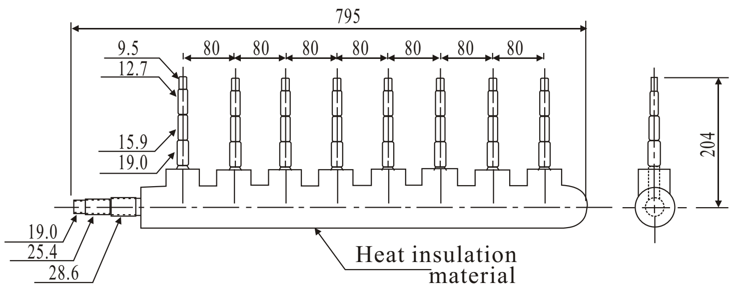


FQG－H3708

on gas side



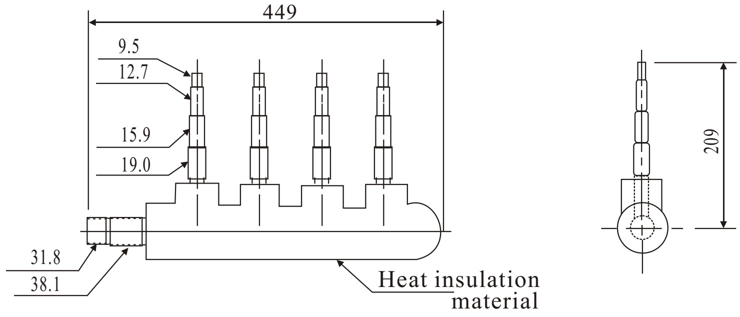
On liquid side



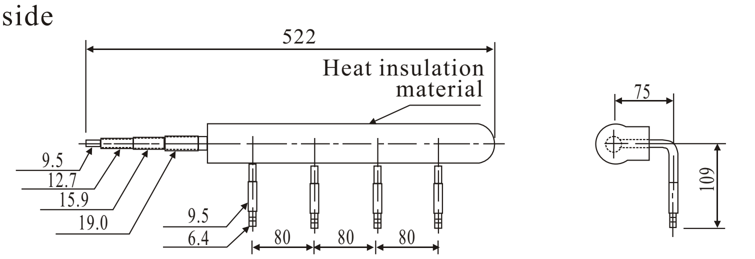
P.S. Dimension of pipes listed above is corresponding pipe dimension (inner diameter)

FQG－H7604

On gas side

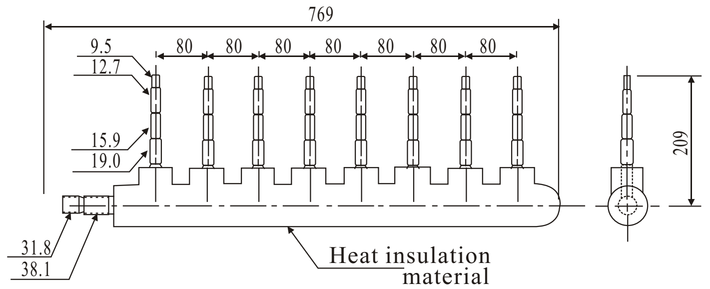


On liquid side

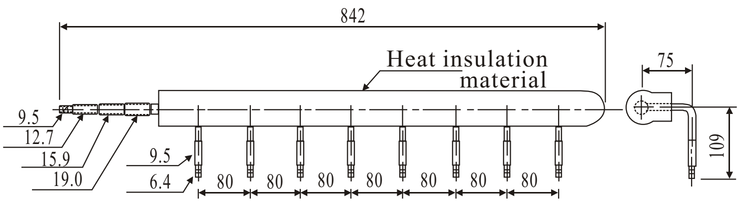


FQG－H7608

On gas side



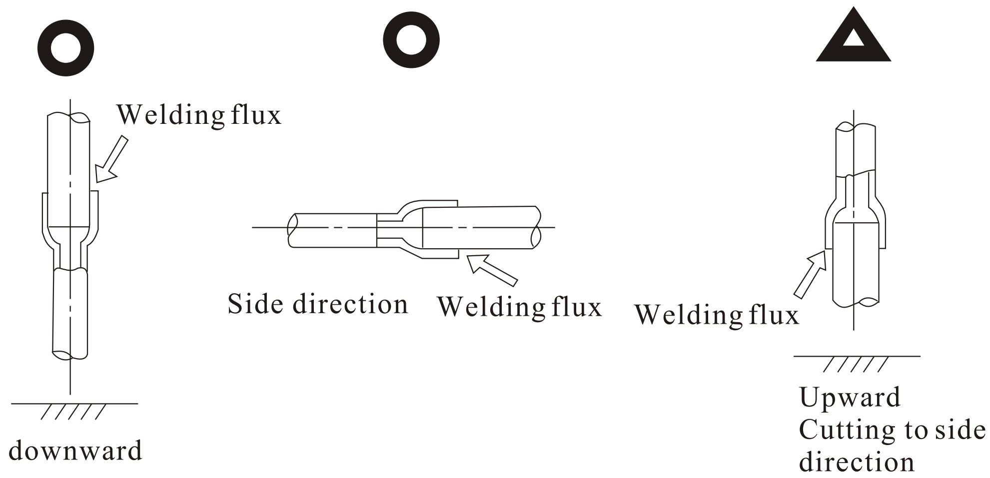
On liquid side



P.S. Dimension of pipes listed above is corresponding pipe dimension (inner diameter)

4-6 Welding operation

(1) Welding should be operated downwards in vertical direction or to side direction in horizontal plane. Avoid overhead welding as possible.



(2) Fitting directions and angle for ends of liquid tube and gas tube must be correct to avoid return or accumulation of oil.

(3) The standard welding method is to injecting nitrogen for replacement.

Note:

① Preparation for fire protection (Keep away from open flame and operate in clean area with fire fighting device and water available for emergency use).

② Prevent from being scalded.

③ Pay attention to clearance between hose and joint (to avoid leakage).

④ Ensure the extension tubes are supported enough.

● Standards of intervals between supports for horizontal pipe (copper tube) are as the following:

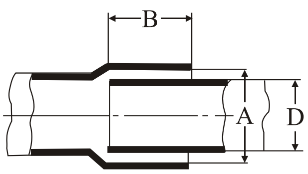
Copper tube

Nominal	Below 20	25-40	50
Maximum clearance (m)	1.0	1.5	2.9

Copper tube should not be clamped by metal bracket.

Minimum inlaid depth and clearance for joints to copper tube.

Unit : mm

	External diameter D	Minimum inlaid depth B	Clearance A~D
	Less than 8 for those below 5 Less than 12 for those below 8	6 7	0.05~0.21
	Less than 16 for those below 11 Less than 25 for those below 16	8 10	0.05~0.27
	Less than 35 for those below 25 Less than 45 for those below 35	12 14	0.05~0.35

4-7 Scouring and cleaning for extension refrigerant tubes

Using compressed gas to scour is one of ways to clean dust out of the tubing.

3 main functions

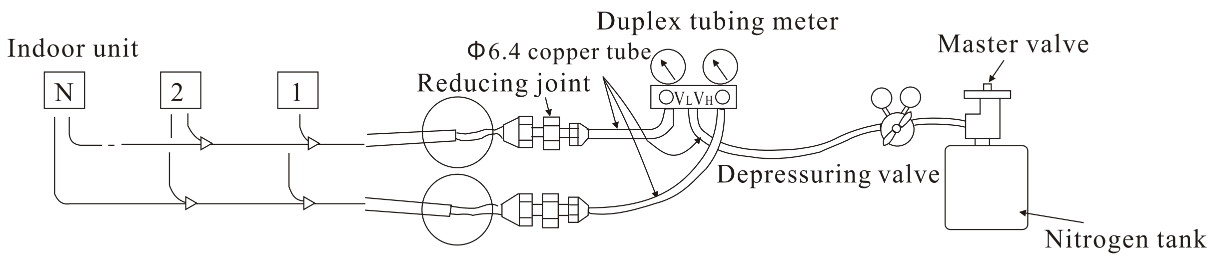
① Remove oxide bubble out of the copper tube when the nitrogen gas is not enough to replace.

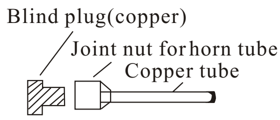
② Remove dirt and humidity out of the tube which is not tightly sealed or covered.

③ Check connections between indoor and outdoor tubing (for both liquid and air tubes).

Example for process

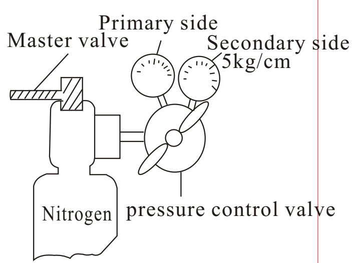
① Fit pressure control valve on the nitrogen tank. Ensure the gas used is nitrogen (Using poly-tetraethylene or carbon dioxide may cause risk of condensation while using oxygen may cause hazard of explosion).





② Connect entry to liquid tube of outdoor unit on the pressure control valve with charging hose.

③ Connect entries to B of all the indoor units except A with charging hoses.



④ Open the valve of nitrogen tank and set the pressure control valve to 5kg/cm².

⑤ Check whether nitrogen gas is passing through liquid tube of indoor unit A.

⑥ Scour:

- Sustain the nozzle with an insulator in hand.

↓

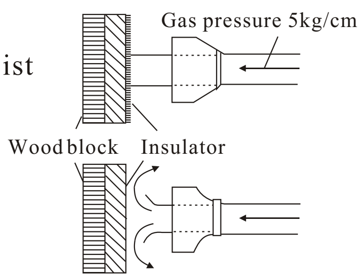
- Rapidly release the insulator when the pressure is too high to resist (for the first scouring)

↓

- Sustain the nozzle again with an insulator in hand.

↓

(make the second scouring).



The dirt scoured can be detected by loosely placing a piece of rag near the nozzle. Some humidity may be found occasionally. If that occur, the tubing should be totally dried.

How to dry:

A. Scouring inside of the tube with nitrogen (until humidity no more appear).

B. Carrying on full vacuum drying operation (as seen on Page 96)

⑦ Close master valve of nitrogen.

⑧ Repeat the above operation to indoor unit.

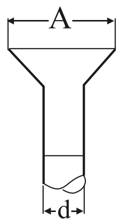
⑨ Carrying the above scouring operation to gas tube after finishing operations to liquid tube.

4-8 Joint for bellmouth

(1) Before expanding operation, the reinforced tube should be annealed.

(2) Use a tube cutter to cut tubes (Use large cutter to cut tubes of big size. Or use metal saw when the tube size is too big to be cut with a tube cutter, and avoid sawdust entering inside the tube).

(3) Use expanding tool and keep size of bellmouth as the following:



standard diameter	external diameter	expanding tube dimension A
3/8	9.52	12.2~12.8
4/8	12.7	15.6~16.2
5/8	15.88	18.8~19.4
3/4	19.05	23.1~23.7

(4) Coat internal and external sides of the expanded area with air conditioner lubricant (to let expanding nut smoothly through and avoid distortion of the tube).

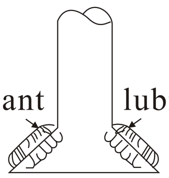
Note:

① Remove burrs carefully.

② Use two wrenches to hold the tube.

③ Before expanding the tube, the expanding nuts should be fitted on the tube.

④ Use proper torsional force to fasten the nuts.



Standard torsion for fastening the expanding nuts ±10%

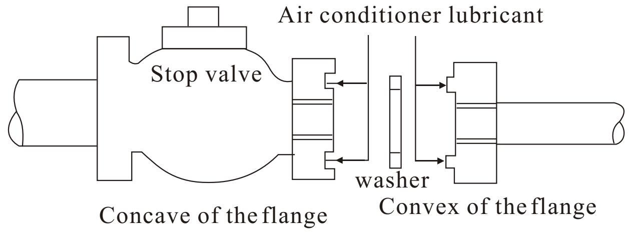
size	torsion	
	(kgf·cm)	(N·cm)
1/4"(Ø 6.35)	144~176	1420~1720
3/8"(Ø 9.52)	333~407	3270~3990
1/2"(Ø 12.7)	504~616	4950~6030
5/8"(Ø 15.88)	630~770	6180~7540
3/4"(Ø 19.05)	990~1210	9270~11860

⑤ Check whether the expansion surface is damaged.

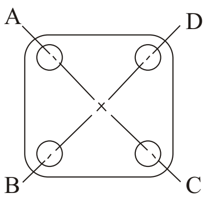
4-9 Flange connection

(1) Flange surface should be clean without any damage (clean dust off it with a cloth and then check whether it is damaged).

(2) Coat flange surface with air conditioner lubricant before connecting.



(3) Diagonally fasten bolts and then confirm whether the connection is reliable.



e.g. :
Sequence: A→ B→ C→ D→ : According to such directions, the bolts will be fastened gradually. Apply torsions of the same angle to each corner.

Note:

① The flange surface should only be coated with clean air conditioner lubricant (to avoid dirt and moisture)

② Apply proper torsion to fasten flange bolts.
bolt standard torsion:

ISO hexagon bolt

torsion / size	5.8(5T)		10.9(10T)	
	kgf·cm ±15%	N·cm ±15%	kgf·cm ±15%	N·cm ±15%
M8	125	1230	302	2960
M10	257	2520	620	6080
M12	436	4280	1050	10300
M16	1030	10100	2480	24300
M20	2050	20100	4950	48500

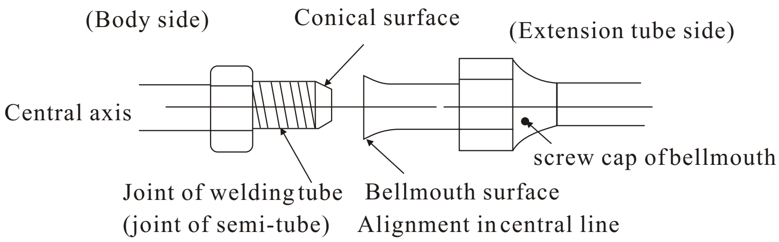
4-10 Connections for extension refrigerant tubes of indoor & outdoor units

1. Connections for extension tubes of indoor unit

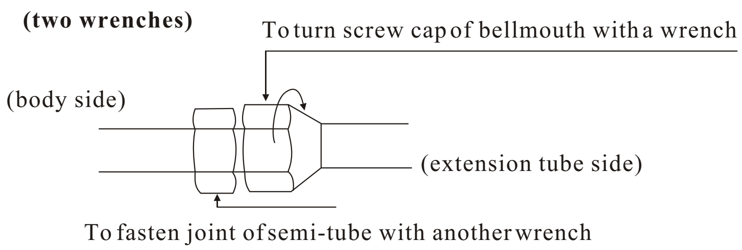
(1) Screw the cap off the bellmouth of the extension tube of the indoor unit body (MUST apply two wrenches). There will be no problem if there's slight noise for leakage of gas, which is sealed for protection.

(2) Expand bellmouth of the extension tube. (As aforesaid)

(3) Make the conical surface of the joint and the bellmouth surface full contact and in alignment.



(4) Fastening screw cap of the bellmouth.
First fasten lightly using fingers, then using two wrenches.



(5) Fastening torsion for bellmouth bolt.

Tube diameter (mm)	6.35	9.52	12.7	15.88	19.05
Fastening torsion (kg · cm)	160	300	500	800	1000
Reinforcing torsion (kg · cm)	200	350	550	1000	1200

- Avoid initially fastening with wrench.
- While fastening Φ6.35 extension tube, apply two wrenches and fasten for 90° ~120° (1.5~2 teeth of the screw cap) from positions where fastening with wrench starts.

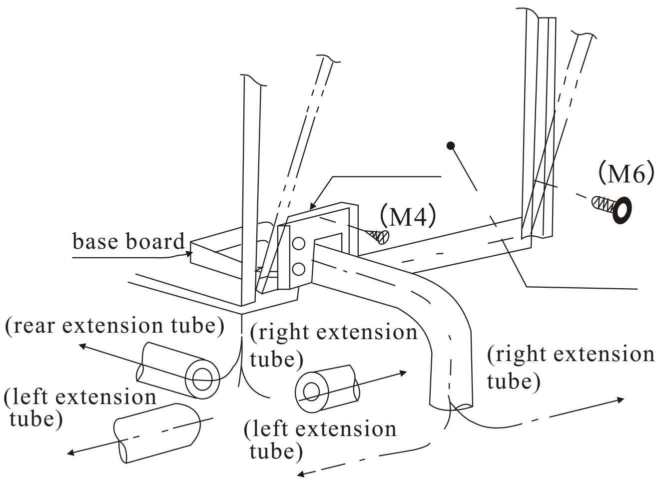
2. Connections for extension tubes of outdoor unit

Compare with extension refrigerant tubing system diagram and confirm whether they coincide with each other. Connect extension refrigerant tubes to outdoor unit according to system number. After finishing connection, write system name on the surface of outdoor unit.

(1) The connection part of extension refrigerant tubes are inside the outdoor unit. Dismount its front maintenance panel.

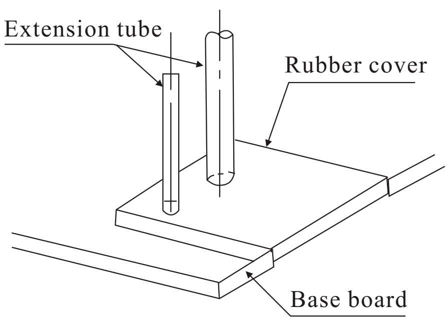
(2) The extension tube can be taken out from the front or blow of the outdoor unit.

(3) While taking the extension tube out from the front, take it forward with the panel separated by tubing wires. For consideration of after service, pull the right or left extension tube after the tubing system is at lower position of the outdoor unit.



(4) While taking the extension tube out from the below, connect tubes to external of the outdoor unit from square hole of the base board, connecting left, right or rear extension tube.

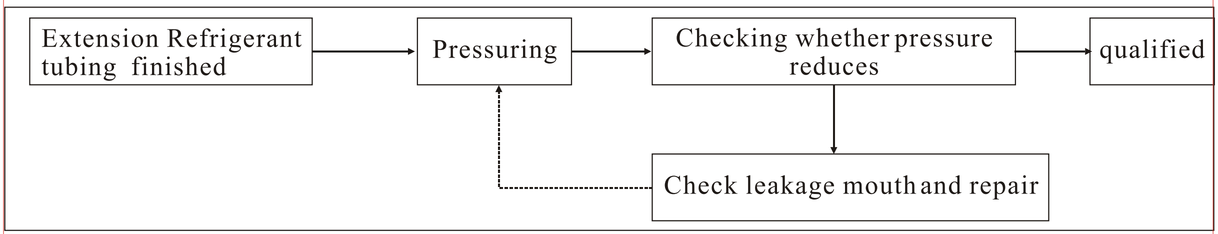
(5) Connect the tube through round holes of the rubber cover equipped on square hole in the base board of the outdoor unit. After finishing connection, PLUG the square hole with the rubber cover.Before taking out the extension tube forward, the rubber cover should be dismounted off the square hole. The rubber cover is mainly used to prevent rubbish, dust or dirt.



Note: For heat insulation, the rubber cover should be cut into proper size to plug the square hole tightly.

4-11 Air tightness test

1. Operation sequence:



2. Setting for pressuring (test method)

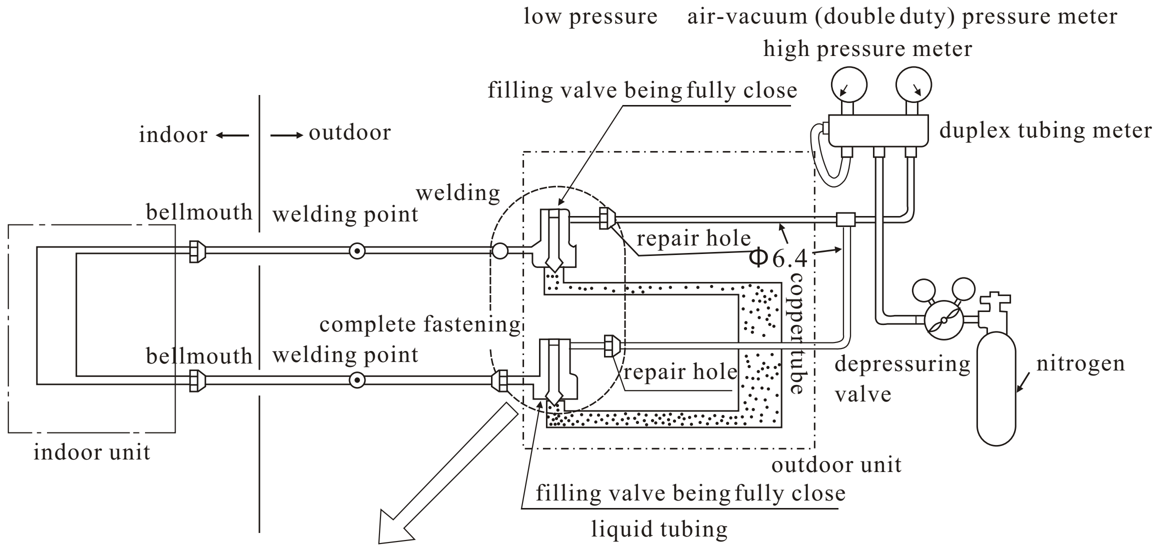
During air tightness test, the nitrogen tank should be connected to extension tubes and pressured as shown in the following chart.

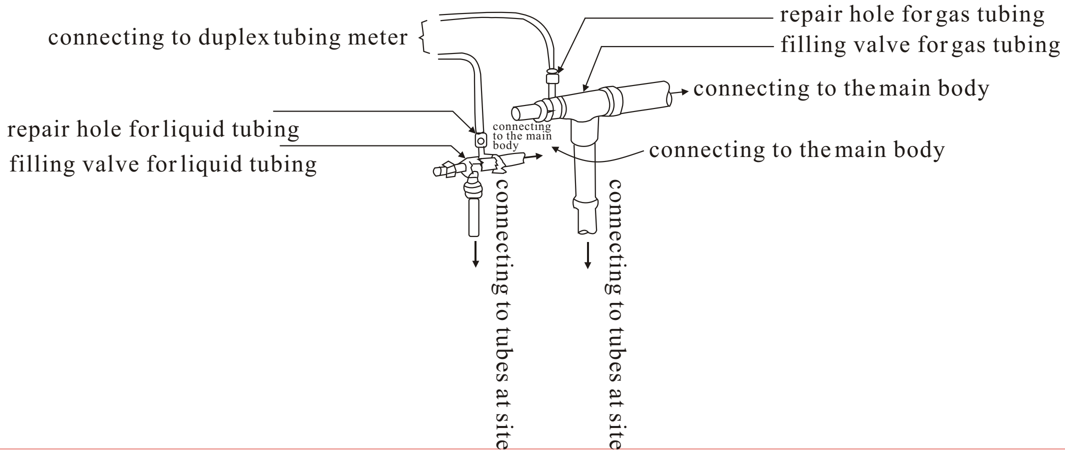
Front seats of valves for gas and liquid tubes should be in fully close status.

Since it is possible for nitrogen to enter cycle system of the outdoor unit, reinforce valves (bars) before pressuring. (Both gas and liquid tubes should be reinforced)

Note: Oxygen , flammable gas or toxic gas is absolutely forbidden to use for air tightness test or checkup of gas leakage.

Each refrigerant system should and MUST be pressured slowly according to sequence from both gas and liquid sides.





3. Checking whether the pressure reduces

a. • The first stage: 3.0kg/cm², pressuring for more than 3 minutes   may cause big gap

• The second stage: 15.0kg/cm², pressuring for more than 3 minutes

• The third stage: 30.0kg/cm², pressuring for 24 hours   may cause small gap

Even under the pressure of 30.0kg/cm², if the time is too short, small gap still cannot appear. Thus why in the third stage the time requires 24 hours.

b. Observing whether pressure reduces

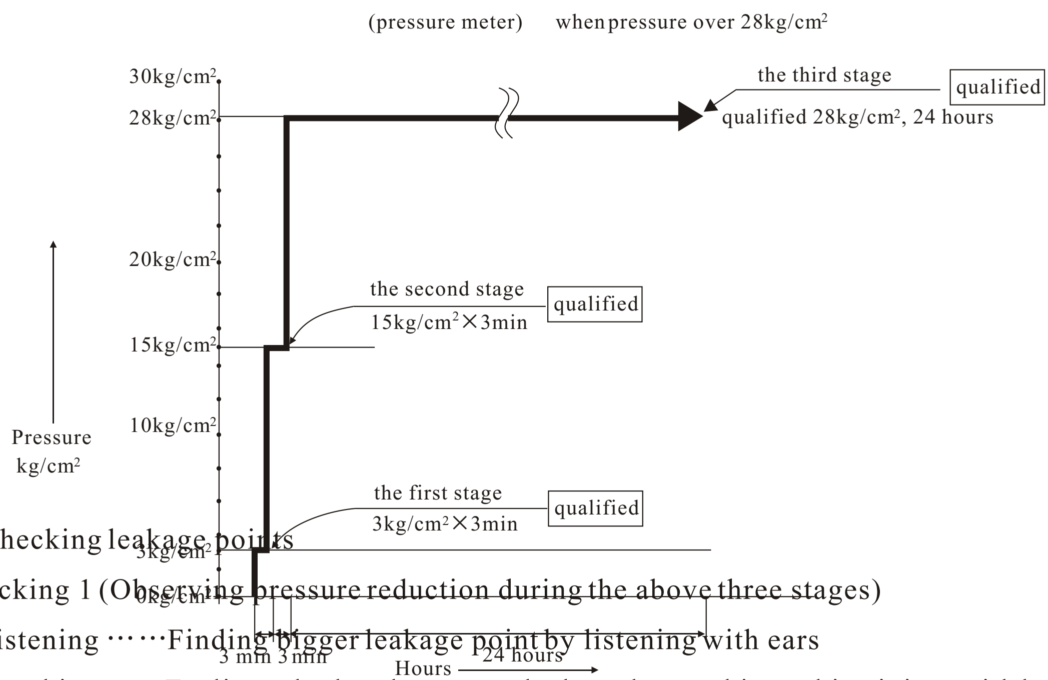
It is qualified if the pressure doesn't reduce.

Referring to 4-11.4, find leakage points if the pressure reduces.

Since pressure changes with environmental temperature, it should be amended with correction value (temperature while pressuring temperature while observing) 0.1kg/cm² .

(for instance) while pressuring: 28.kg/cm², 25

24 hours later: 27.5kg/cm², 25



4. Checking leakage points

Checking 1 (Observing pressure reduction during the above three stages)

- Listening ……Finding bigger leakage point by listening with ears
- Touching ……Feeling whether there's gas leakage by touching tubing joints with hand
- Suds ……Finding bubbles coming out from leakage points

Checking 2 (in cases that expecting to find small leakage points or no leakage point being found while pressure reduces in pressuring test)

(1) Adjust the pressure of nitrogen to 3.0kg/cm^2.

(2) Adjust the pressure of fluorine gas to 5.0kg/cm^2 (mixed status of nitrogen & fluorine gas)

(3) Check with detection machines for halogen, alkane gas (petroleum gas), or electricity etc.

(4) If no leakage point is found, keep on pressuring to 28kg/cm^2 and check again (the maximum pressure is 30kg/cm^2).

Note:

Check in sections if the tube is too long.

(e.g.) ① indoor side

② indoor side + vertical tube

③ indoor side + vertical tube + outdoor side

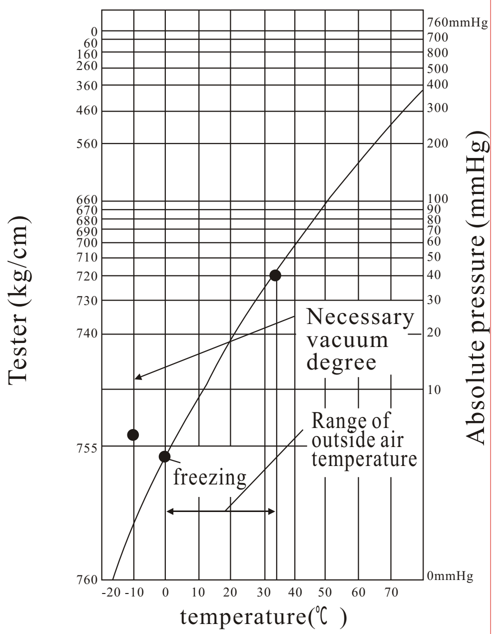
4-12 Vacuum drying

1. What is vacuum drying

Vacuum drying means using vacuum pump to change moisture (liquid)inside the tube into vapor (gas) and discharge it out to dry the inside of the tube. The boiling point of water is 100℃ under one unit atmospheric pressure and will reduce relatively in vacuum. Therefore, when reducing the pressure inside the tube nearly to vacuum with the pump and the temperature inside under outside air temperature, the moisture inside the tube will be evaporated.

(e.g.) Vacuum drying can only be carried on under-752mmHg if the outside air temperature is lower than 7.2℃ .

In addition, it is recommended to know how to select and repair vacuum pump before vacuum drying operation.



2. Selection of vacuum pump.

Note the following two points while selecting vacuum pump:

(1) Choose the pump that can meet required vacuum degree (i.e. to-755 mmHg)

(2) Choose the pump of big air output (more than 40L/min or so). Besides, ensure whether it can reach pressure below -755 mmHg with adoption of vacuum measurement.

Boiling point of water( )	Nitrogen (mmHg)	Vacuum degree (mmHg)
40	55	-705
30	36	-724
26.7	25	-735
24.4	23	-737
22.2	20	-740
20.6	18	-742
17.8	15	-745
15.0	13	-747
11.7	10	-750
7.2	8	-752
0	5	-755

For rotating oil vacuum pump, change lubricant and check vacuum degree every 1~2 months.

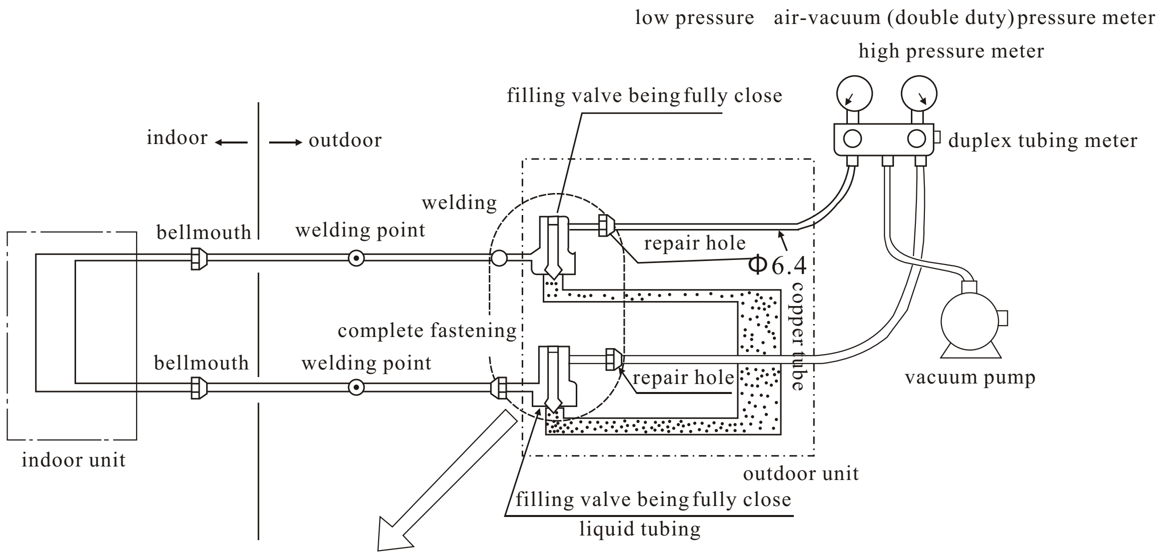
Type and vacuum degree of vacuum pump (for reference)

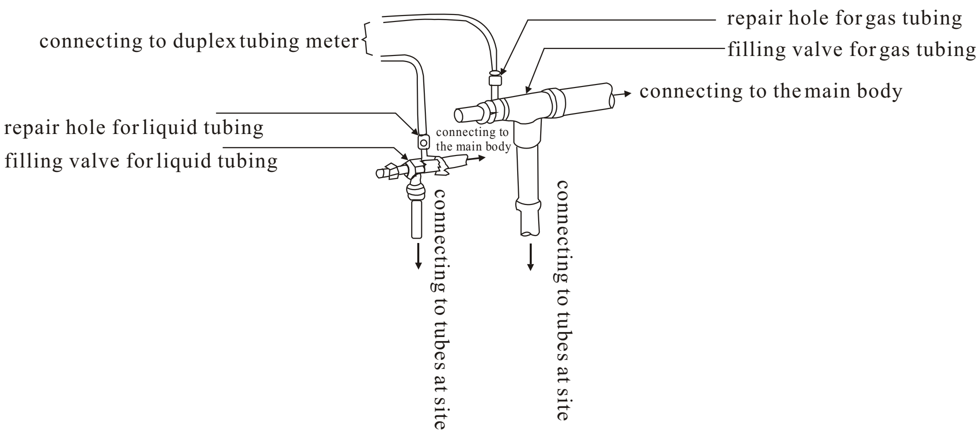
Type	Air output after reaching vacuum degree	Purpose	
		For vacuum drying	For air discharging
Rotating oil pump (with oil)	0.02mmHg 100L/min	Proper	Improper
Rotating oil less pump(without oil)	10mmHg 50L/min	Improper	Improper
	0.02mmHg 40L/min	Proper	Proper

← Note: Normally, hand pumps belong to such type.

3. Operation sequence of vacuum drying

After finishing air tightness test and releasing nitrogen, connect duplex tubing meter to repair holes of filling valves at both ends, and connect vacuum pump as the following chart.





There are two ways for vacuum drying for selection according to different conditions.

(1) Common vacuum drying ……………………………………………………common method

Operation sequence

① Vacuum drying (for the first time) ……Connect a multimeter to entries of liquid and gas tubes and run the vacuum pump for more than 2 hours. (the vacuum degree should be -755mmHg below)

After 2 hours' pumping, if the vacuum degree still cannot reach-755 mmHg below, or there's moisture or leakage point(s), continue pumping for 1 hours.

Check whether there's leakage point(s) if the vacuum degree still cannot reach-755 mmHg after 3 hours' pumping.

② Vacuum sustaining test

Keep the system for 1 hour after vacuum degree reaches-755 mmHg below. 1 hour later, if the vacuum meter has no ascension, it means the system qualified. Ascension implies there's moisture or leakage point(s).

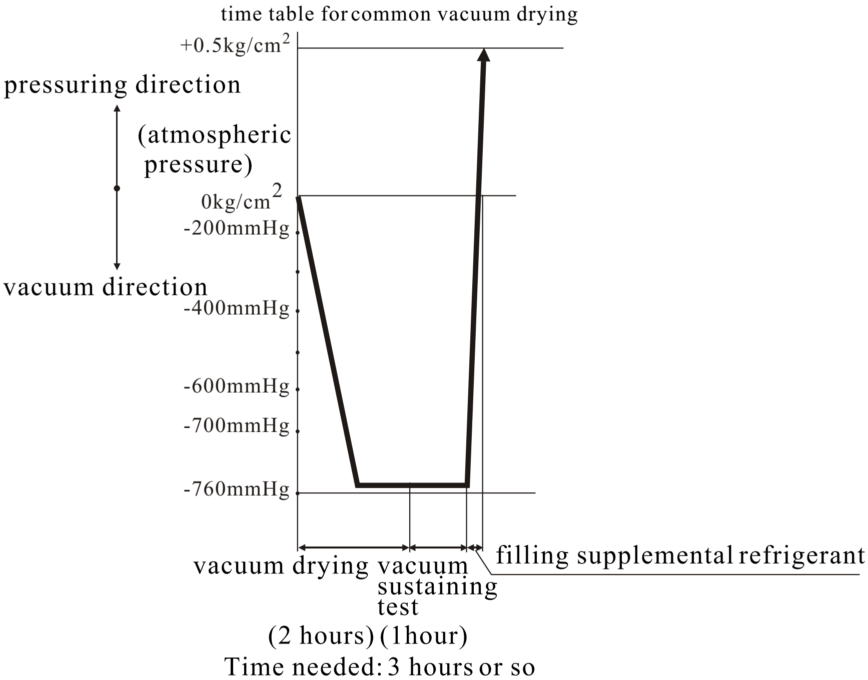
③ Filling supplemental of refrigerant

Fill in refrigerant of necessary quantity from the entry of liquid tube with an injector.

④ Opening all switch valves

Open switch valves of both liquid and gas tubes.

(Note) Vacuum operation should be carried on by pumping from both sides of liquid and gas tubes (because pumping may be blocked during operation due to attached components inside the indoor unit)



(2) Special vacuum drying

This special method is used when there may be moisture inside the tubing. E.g.:

Moisture is found while scouring refrigerant tube.

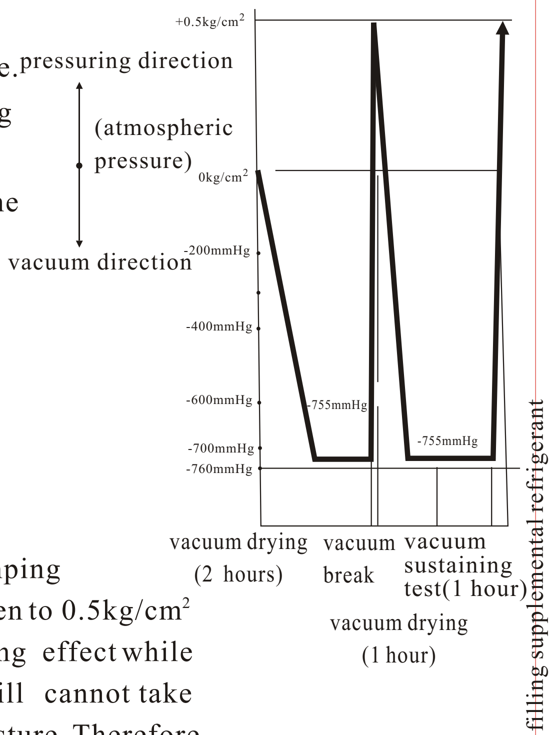
There may be water inside while constructing in raining season.

There may be water inside if the construction time is long.

Rains may enter inside during construction.

The method is inserting time vacuum break procedure with nitrogen more than once.

time table for special vacuum drying



Operation sequence:

①Vacuum drying (the first time) ……2 hours' pumping

②Vacuum break (the first time) ……filling nitrogen to 0.5kg/cm^2

As nitrogen belongs to dry gas, it can take drying effect while vacuum breaking. However, this method still cannot take complete drying effect when there's too much moisture. Therefore, water entrance and condensation should be strictly avoided during construction of refrigerant tubing.

③Vacuum drying (the second time) ……pumping for more than 1 hour

Determination: ⓐThe system is qualified if it can reach-755 mmHg. Repeat operation if the system cannot reach such degree in 2 hours.

ⓑ Vacuum breaking

ⓒ Vacuum drying

④Vacuum sustaining test ……1 hour

⑤Filling supplemental refrigerant

⑥Opening switch valves

※ Only nitrogen can be used for vacuum break. Misuse of oxygen can cause hazard of explosion.

4-13 Filling supplemental refrigerant

After finishing vacuum pumping, replace the vacuum pump to the refrigerant tank for refrigerant filling operation.

1. Calculation for supplemental refrigerant

(1) Filled quantity by manufacturer

Outdoor unit	AU55NFUAHA	AU96NFTAHA
Filled quantity	10.0kg	18kg

Filled quantity of refrigerant by manufacturer not includes that inside extension tubes for local construction. Thus why local quantity should be calculated before filling operation.

(2) Supplemental quantity, calculated according to size and actual length of local extension liquid tube.

Quantity of local supplemental refrigerant = actual length * supplement quantity for per meter liquid tube

Supplemental quantity: $R(kg)=(L_1\quad 0.030kg/m)+(L_2\quad 0.065kg/m)+(L_3\quad 0.115kg/m)+(L_4\quad 0.190kg/m)+(L_5\quad 0.290kg/m)$

In the above formula:

L1: total length of Φ6.35 liquid tube (m)

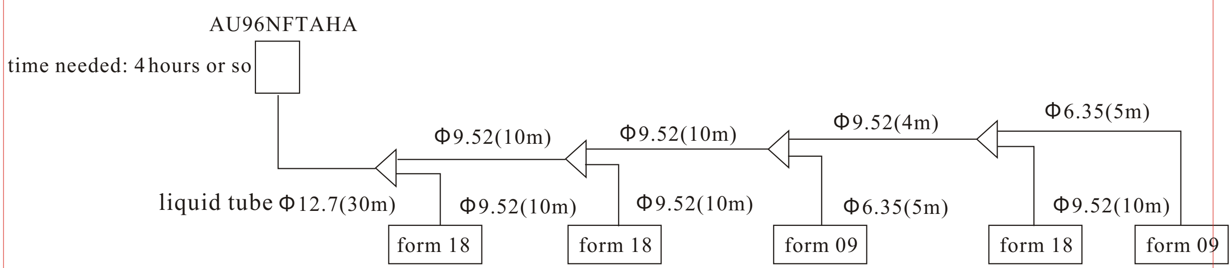
L2: total length of Φ9.52 liquid tube (m)

L3: total length of Φ12.7 liquid tube (m)

L4: total length of Φ15.88 liquid tube (m)

L5: total length of Φ19.05 liquid tube (m)

Example for calculation:



liquid tube 6.35=5+5=10m

9.52=10+10+10+10+4+10=54m

12.7=30m

$R=(10m\quad 0.030kg/m)+(54m\quad 0.065kg/m)+(30m\quad 0.115kg/m)=7.26kg$

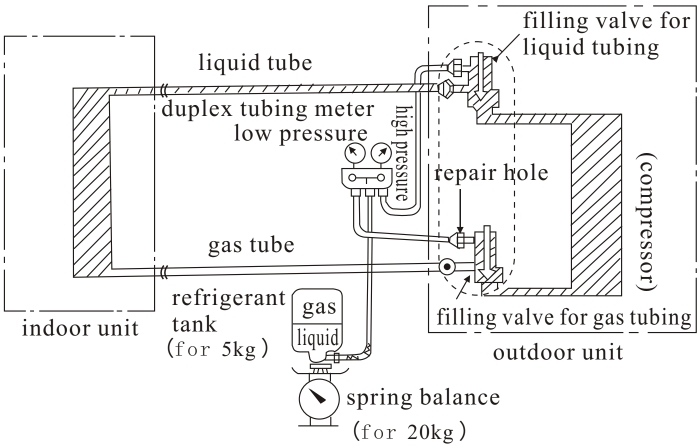
2. Filling method for supplemental refrigerant:

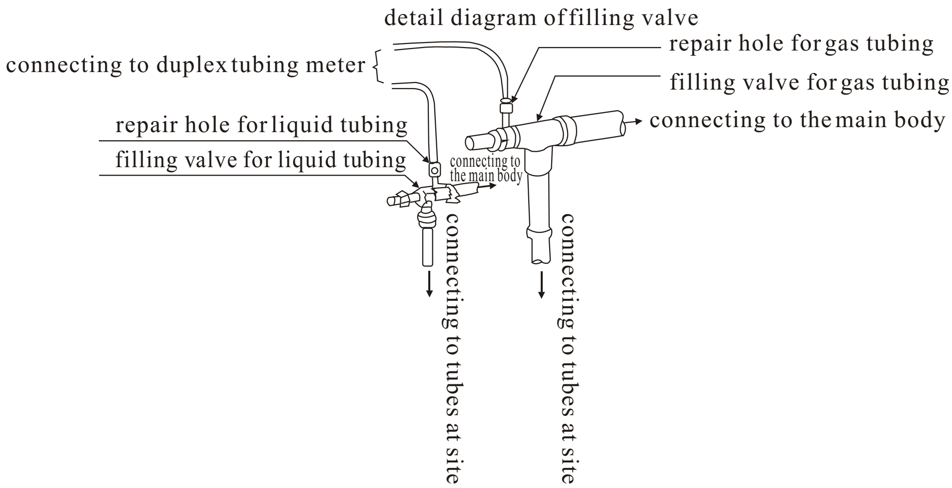
(1) Slightly fit the hose of refrigerant tank to the duplex tubing meter, open Va, the master valve of the tank to repel remaining air out of the hose, then fasten Va.

(2) As shown in the chart on next page, place the tank upside down and open Vh valve of the duplex tubing meter, filling the refrigerant in liquid state to the liquid tube. (Note: For siphonic refrigerant tank, the refrigerant will flow out if the tank is placed normally.) If the filling quantity is still not enough, close Vh valve, place the refrigerant tank normally, fully open filling valve of the liquid tube and set filling valve of the gas tube to medium position (between fully close and fully open). Then run cooling operation, open valve Vℓ, filling to gas tube in gas state.

(3) Watching dial gauge of the spring balance. Once it reaches required supplemental quantity, immediately close valve Ve and master valve Va of the tank and fully open filling valve of the gas tube.

(4) Supplemental quantity should be written on label plate of the outdoor unit.



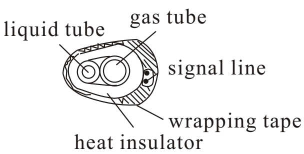
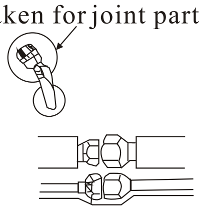
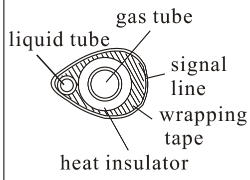
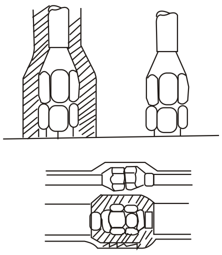
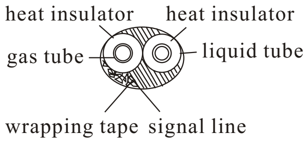
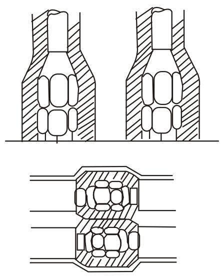
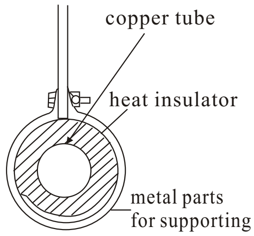


4-14 Heat insulation processing for extension refrigerant tubes

Operation sequence:

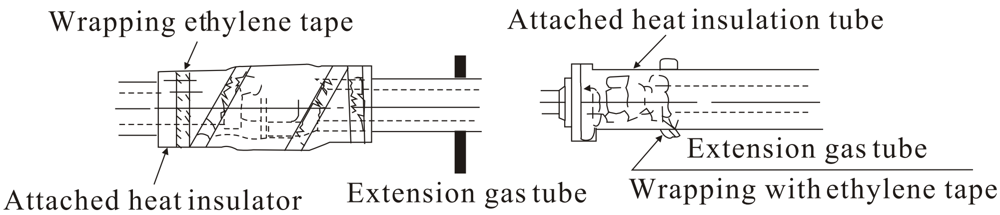
Construction of extension refrigerant tubes → Heat insulation processing (excluding joint parts) → Air tightness test → Heat insulation processing (for joint parts)

1. Material: Select materials that can endure tubing temperature for heat insulation. E.g.: polythene foaming materials (endurable temperature over 120).
2. Heat insulation and key points: Heat insulation processing for all joint parts such as welding parts, bellmouths etc. should only be carried on after passing air tightness test. For multiple air conditioners sharing one compressor, heat insulation processing for all gas and liquid tubes should be carried on respectively.

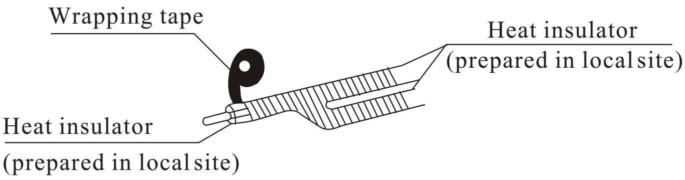
Example for incorrect processing		Example for correct processing	
Mixing heat insulation processing for gas and liquid tubes together.  ⬮ Heat insulation measure should be taken for joint part. No heat insulation measure has been taken for joint part 	[heat insulation processing only done for gas tube]  	[heat insulation processing should be done for both gas and liquid tubes]  	[heat insulation processing for supporting parts] 

Note:

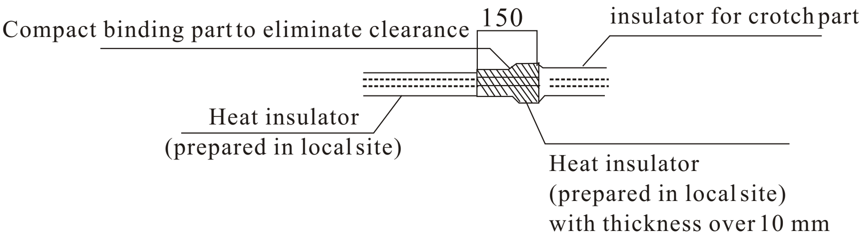
① Heat insulation processing should be done to joint parts (tube joints, screw caps of bellmouths) of extension tubes of indoor unit.



② Heat insulation processing for crotch parts. Use tapes to wrap the crotch parts with local extension tube (where construction is carried on) and attached heat insulators altogether.



Compact binding part of heat insulators attached and that locally prepared for extension tubes to make it firm without any clearance. Process the shown in the following chart after placing insulators.



Coat a layer of glass wool (16-20kg/m^2 with thickness over 10mm) on the common heat insulator(8-10mm) while taking heat insulation measures to extension refrigerant tubes inside ceilings in environment of high temperature to get a better effect.

Key points:

Thickness of heat insulator is decided according to tube size.

Tube size	Thickness of heat insulator
6.4mm~25.4mm	10mm or more
28.6mm~38.1mm	15mm or more

Recommended values in the above table should be increased in hot and humid environment.

These should be also attached even if the client provides materials by himself.

Since the air conditioner is expected to use when the outside temperature is below 10 ,
heat insulation measures should be also taken to liquid tubes.

Section 5 Electric wiring and Trial run

5-1 Basic attention points

1. Common items:

⚠ Warning

Comply with regulations for electrical appliance & technology.
After connecting a wire to terminal block, make a bow and fix it with a pressing clip to avoid forces applied to the wire transmitting to the pressing terminal.
DON'T power through the indoor unit before finishing vacuuming the extension refrigerant tubes.

⚠ Note

> Electric leakage breaker should be installed on the power supply according to basic requirement for electric appliances.
>
> The earth line MUST be installed.

2. Other details for attention

(1) Power supplies for indoor and outdoor units are mutually independent.

(2) The power supplies are from special branch circuit. Electric leakage protector and air breaker MUST be installed. Earthing construction is necessary. Power supply for outdoor unit and indoor unit is 3-phase 380~418V and single phase 220~230V respectively.

(3) Power supplies, electric leakage protectors and air breakers for indoor units connecting to the same outdoor unit should be out of the same source (For indoor units of the same system, there should be two power supplies at the most).

(4) Each indoor unit should be equipped with a power supply for auxiliary electrical heater. And so is electric leakage protector and air breaker.

(5) DON'T bind systems for extension refrigerant tubes and control transmission (communication wires between indoor-outdoor units, and indoor-indoor units) together.

(6) It is recommended to adopt 2-core shielding wire (BVVD1.25mm^2 for control transmission to avoid interference. DON'T adopt multi-core wires (more than 3 cores).

(7) Specifications for wire size, electric leakage protector, manual switch and earthing line are as shown in Table 2 on next page.

(8) Size and length of wire. Wires for MRV commercial air conditioners should be much thicker than those for power equipment like common motors. The current for commercial air conditioners should be calculated as 1.25 times of the rated when total current 50A and as 1.1 times when the total current > 50A.In addition to such calculation,calculating current of the compressor should be estimated as 1.2 times of that marked on its label (leaving surplus).

Because MRV commercial air conditioner has electrical properties of freezer whose rated values are the input properties under standard conditions (as required by GB, national standards of China), the machine is equipped with a motor (compressor) that can endure overload (such as ascension of indoor temperature and condensate pressure etc.) for freezer.

Select according to specifications of each machine.Wire size can be selected according to Table 1.

Since the current through wires is different with that of common motors and to keep voltage of power supply stable during start procedure, the length of the wire should be selected with consideration of holding voltage drop from starting end of the power supply within 2%.

5-2 Wiring for power supply
[for outdoor units (independent of indoor units)]

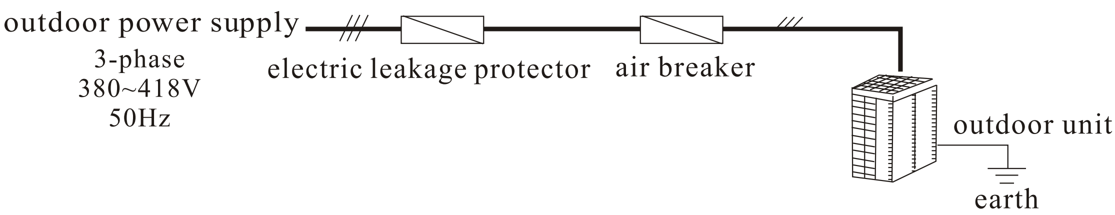
Connections of power supply should be in compliance with local regulation, and, in China with concerning content of technical standards specified in Installation of electrical facilities: Construction, checkup & acceptance criteria for low voltage electrical appliances of GB 5024-96. Carefully consider the following:

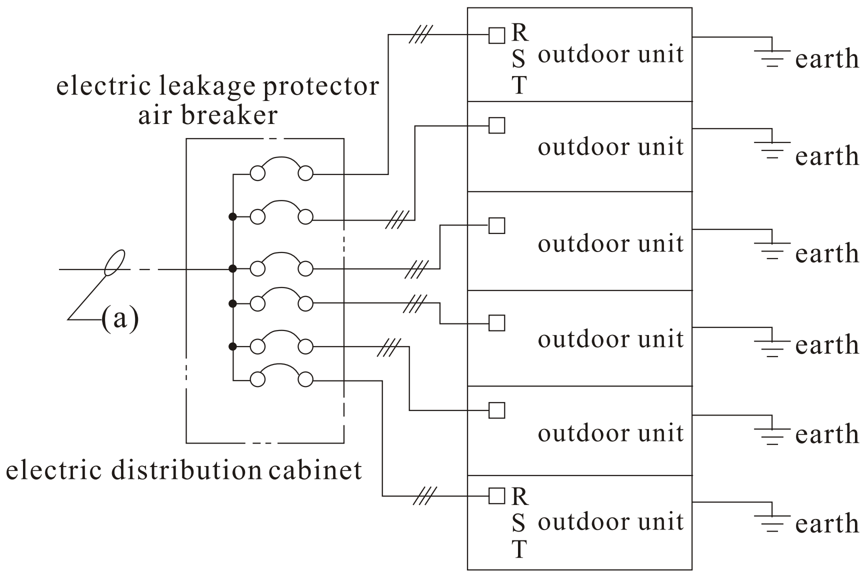
1. Individual power supply

Table 1

Item / Type	Power supply	Minimum thickness of wire (mm^2) (wiring with metal tube or PVC tube)			Air breaker (A)	Electric leakage protector (capacity, leakage current, start time)
		Size (length 20mm)	Size (20mm < length 50mm)	Earthing line (mm^2)	Capacity (A)	
AU55NFUAHA	3-phase 380~418V 50Hz	5.5	14	3.5	30	30A, 30mA 0.1Sec below
AU96NFTAHA	3-phase 380~418V 50Hz	14	38	5.5	60	60A, 60mA 0.1Sec below

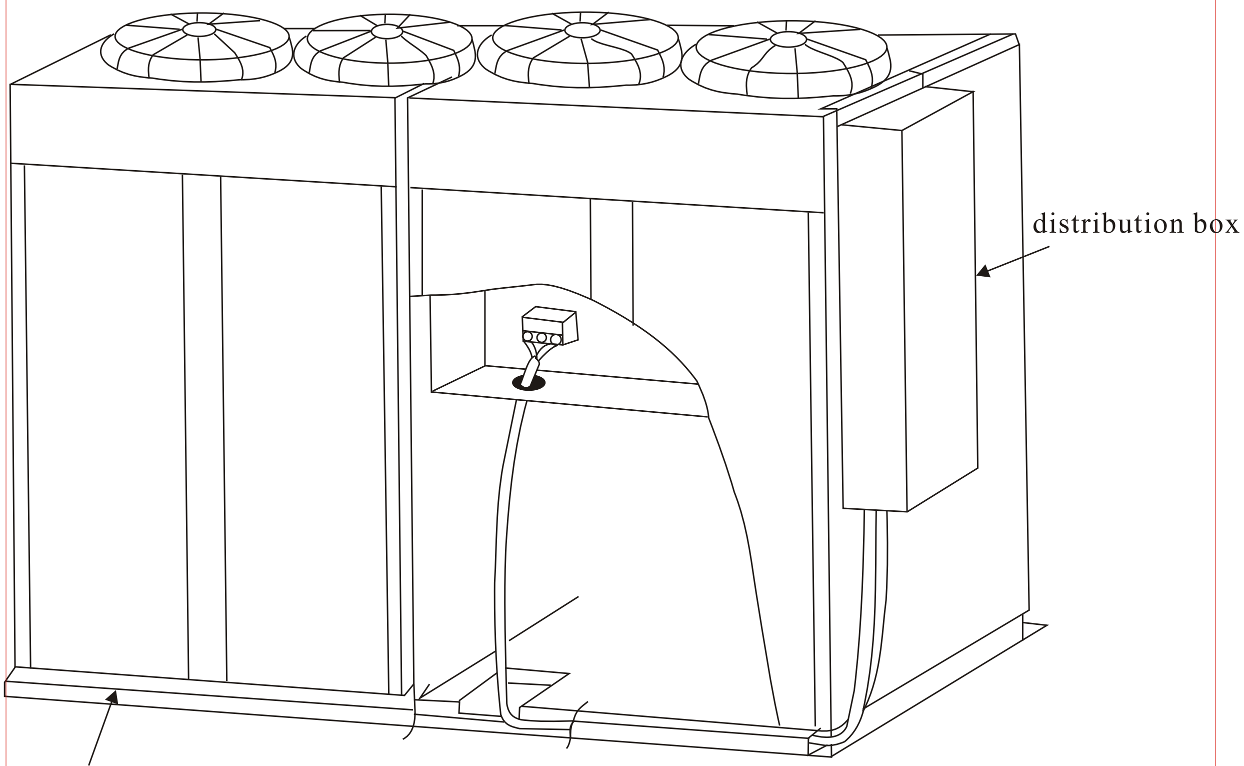
Note: All sizes in the above table can control voltage drop within 2%. If the wire length exceeds that in the table, choose its thickness according to Collection of general diagrams for installation of electrical facilities: Typical technique specifications .





For individual power supply

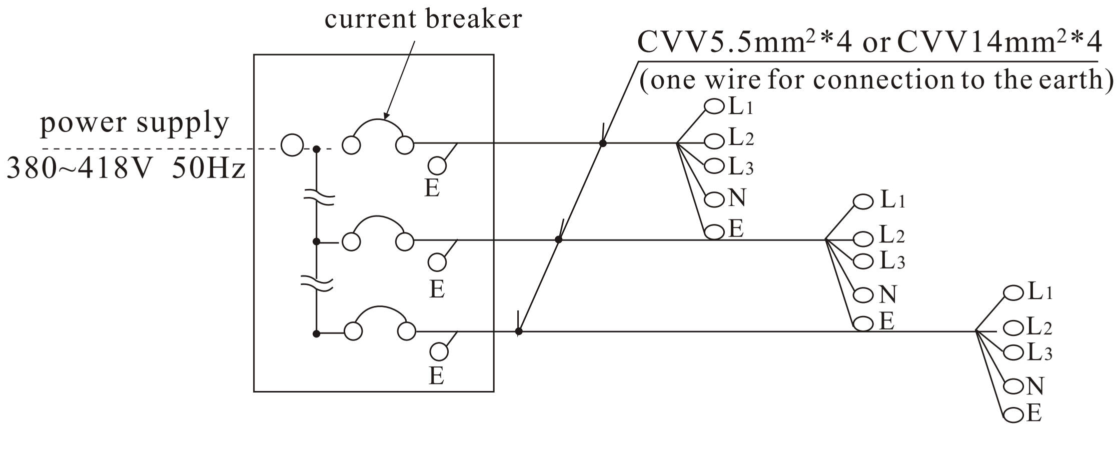
2. Wiring surrounding the outdoor unit (installation of distribution box and wiring)



Distribution box: for power supplying to outdoor unit (with air breaker and electric leakage protector)

(1) Composition of distribution box

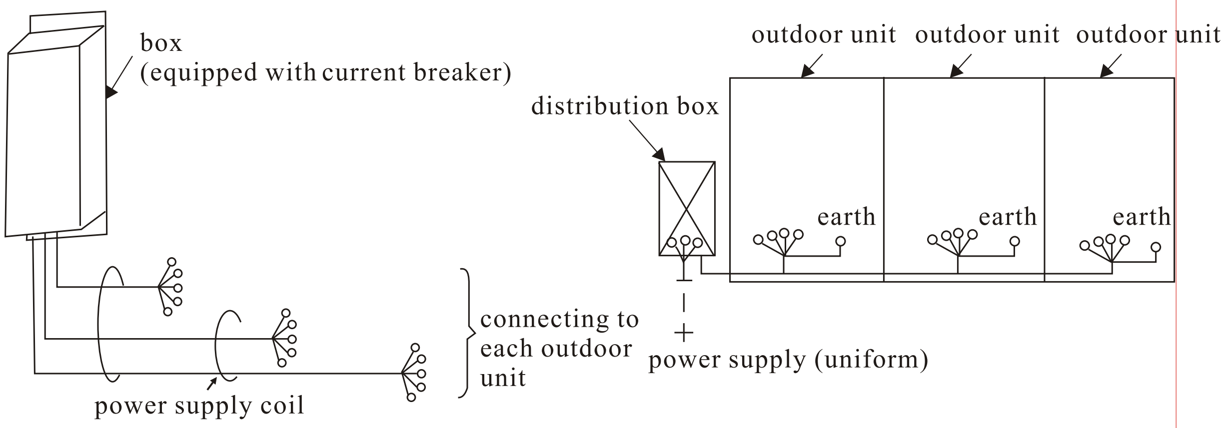
<distribution box: FO-EOOOO or FO-OOOOE>



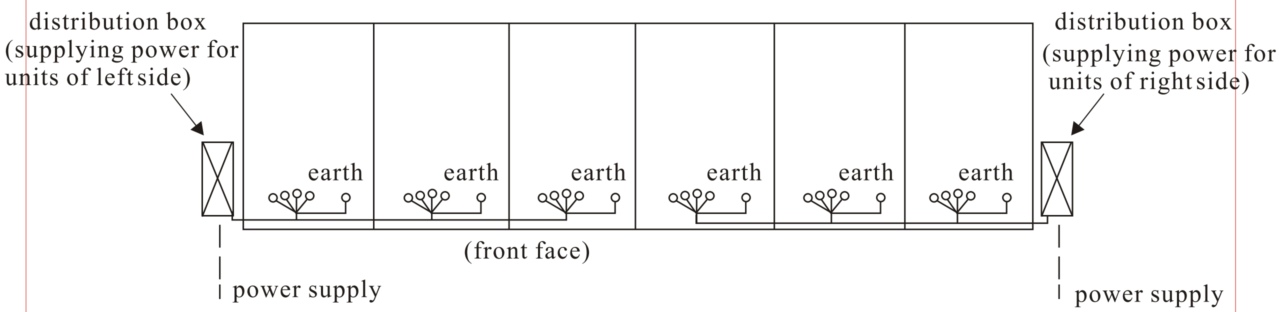
(2) Connection between distribution box and outdoor unit

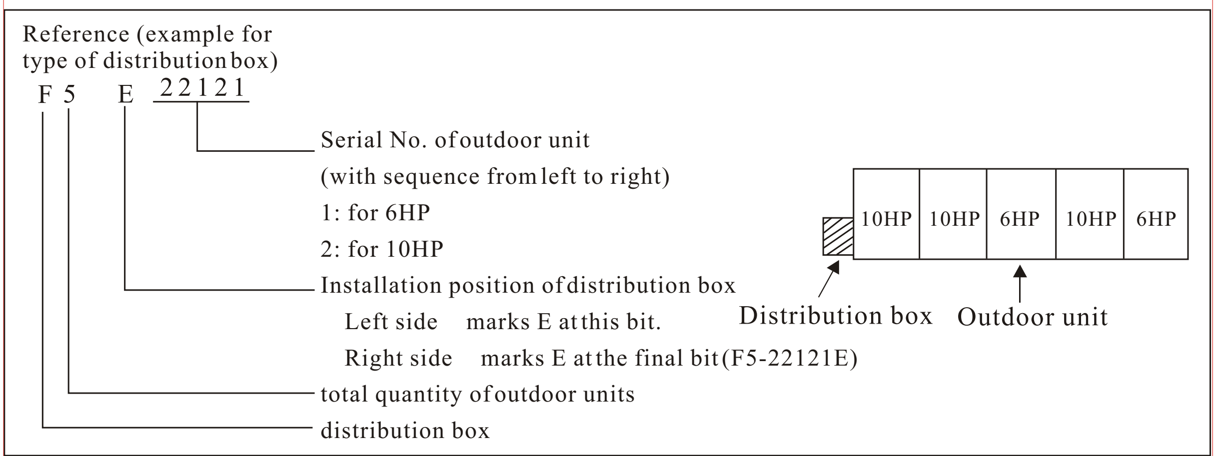
<in case of 5 outdoor units or below>

The distribution box is installed on right or left side of the outdoor unit (according to types)



<in case of 6 outdoor units or more>
Distribution boxes are installed on left and right side respectively.





(3) Installation of distribution box and confirmation of outdoor unit

Install distribution box on right or left side (either side respectively in case of 6 units or more) of outdoor unit. Dismount the external cover, pull the attached wire of the power supply forward and connect to the outdoor unit.

(4) Connecting power supply to distribution box

Power line should be connected through the hole on rubber insulation gasket below the distribution box.

Drill holes on left, right or bottom side as required diameter since no hole for power supply is originally available on distribution box.

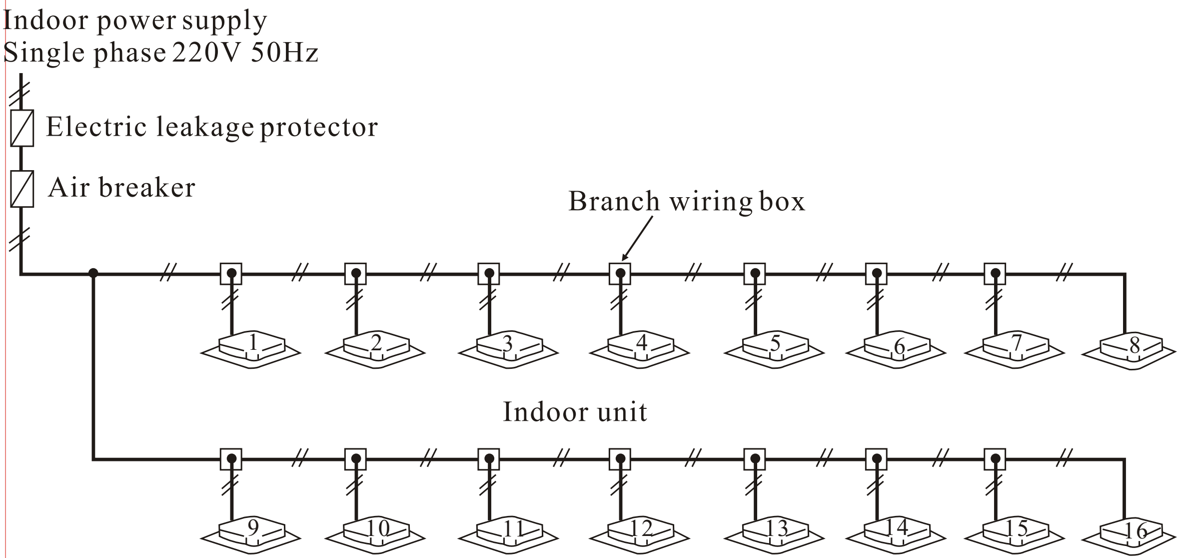
The length of power line attached with the distribution box is preset according to standard placement conditions of outdoor unit. During actual installation, prepare wire of proper length according to spot conditions other than the standard.

5-3 Wiring for power supply

[for indoor units (independent of outdoor units)]

Item / Type	Power supply	Minimum thickness of wire (wiring with metal tube or PVC tube)			Air breaker (A)	Electric leakage protector
		Size (length 20mm)	Size (length 50mm)	Earthing line	Capacity	
All types of indoor units	Single phase 220~230V 50Hz	3.5	5.5	1.6mm	30	20A, 30mA 0.1 sec below

Note: All sizes in the above table can control voltage drop within 2%. If the wire length exceeds that in the table, choose its thickness according to Collection of general diagrams for installation of electrical facilities:Typical technique specifications .Wires are parallelly connected in power supply circuit as shown in the following diagram.



Note

The extension refrigerant tube system and control transmission lines for indoor-indoor units and indoor-outdoor units are of the same system.

Power supply wires and control wires should be inlaid in different wiring tubes respectively or keep proper interval distance(30mm while current capacity below 10A, 500mm while below 50A) when they are wired parallelly.

Size of power supply wire and Rated current valve for indoor unit

	Model No.	Rated current(A)		Model No.	Rated current(A)
Four-direction air out cassette type	AB092FEAIA	0.28/0.35	Wall mounted type	AS072FAAHA	0.28/0.3
	AB122FEAIA	0.28/0.35		AS092FAAHA	0.28/0.3
	AB142FEAIA	0.48/0.54		AS122FAAHA	0.48/0.5
	AB162FEAIA	0.48/0.54		AS162FAAHA	0.48/0.5
	AB182FEAIA	0.55/0.61		AS182FAAHA	0.55/0.6
	AB242FEAIA	0.55/0.61		AS242FAAHA	0.55/0.6
	AB282FEAIA	0.70/0.80	High static pressare air duct type	AD322FIAHA	1.32
	AB322FEAIA	1.06/1.22		AD362FIAHA	1.32
	AB362FEAIA	1.06/1.22		AD452FIAHA	1.32
	AB452FEAIA	1.06/1.22			
Two-direction airout cassette type	AB072FDAHA	0.40/0.42			
	AB092FDAHA	0.40/0.42			
	AB122FDAHA	0.40/0.42			
	AB142FDAHA	0.50/0.53			
	AB162FDAHA	0.50/0.53			
	AB182FDAHA	0.55/0.61			
	AB242FDAHA	0.62/0.64			
	AB282FDAHA	0.62/0.64			
Convertible type	AC092FEAHA	0.48/0.54			
	AC162FEAHA	0.48/0.54			
	AC182FEAHA	0.48/0.54			
	AC242FEAHA				

Total current value = Rated current value x total quantity

Allowable current for wiring = 1.25xtotal current value

Calculate minimum thickness of power wire (at least 2.5mm^2) according to Table 1 -- allowable current value (referring to concerning manuals of electrical equipment).

Control the voltage drop within 2% (within 0~4.4V), calculate allowable current value and wire size or maximum connection length of wire.

e.g.: AB362FEAIAx5 sets connection length of wire 30m

AB452FEAIAx1 sets

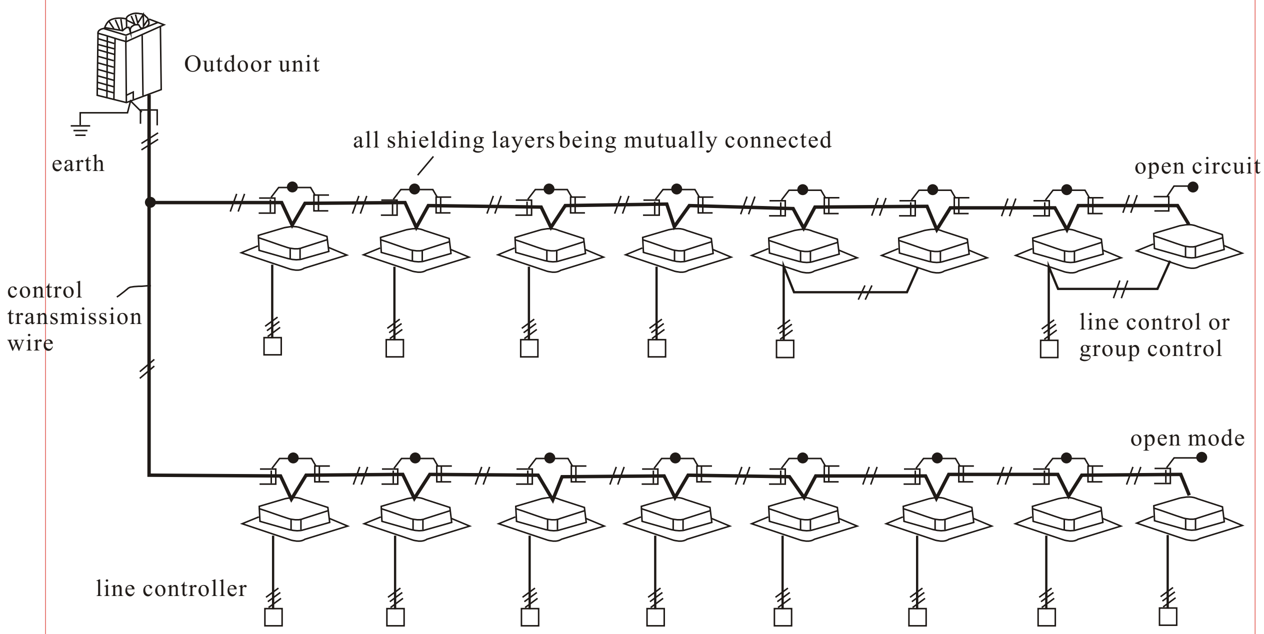
According to the above table: 1.06Ax5 sets + 1.06Ax1 set = 6.36A

6.36Ax1.25 = 7.95A

Result checked out from technical manual: When the voltage drop is 4V, thickness of power supply wire is 2.5mm^2

8A 16mx2 times = 32m, wire size 2.5mm^2.

5-4 Wiring of control transmission circuit and remote controller



1. Size, type and specification of wire

table 14

Name	Type	Size	Specification
Control transmission wire	2 core	$1.25mm^2$ $\ell \leq 500m$	BVVD
Remote control wire	3 core	$0.3mm^2$ $\ell \leq$ 200m $0.75mm^2$ 200m$\leq \ell \leq$500m	RVV

(1) Adopt 2-core nonpolar shielding transmission wire for control transmission to avoid electromagnetic interference. In such conditions, the earhing connection of the system is to connect close ends of shielding layers of the wires and set to open mode (insulating process) at the end. (connect one point of the outdoor unit to the earth)

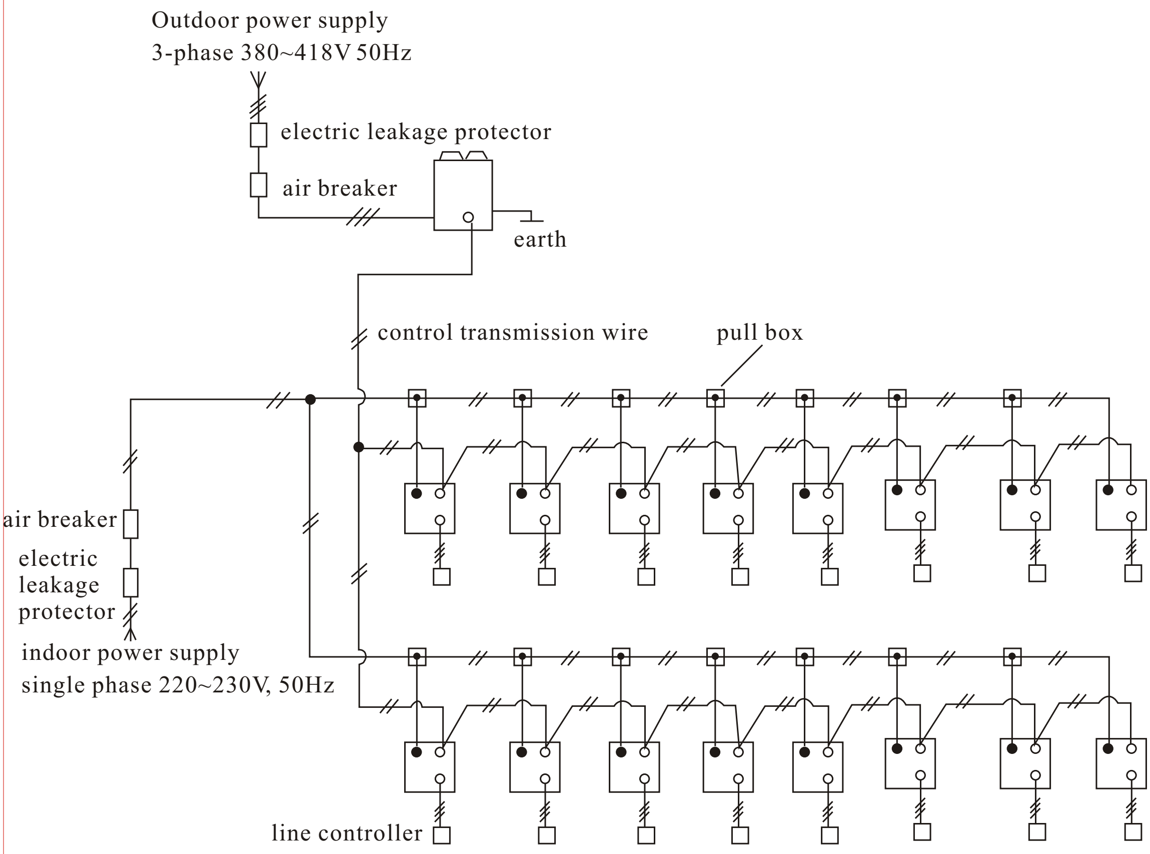
(2) Adopt 3-core wire for line controller. (terminal A, B, C)
Adopt 2-core polar wires for line controller group.

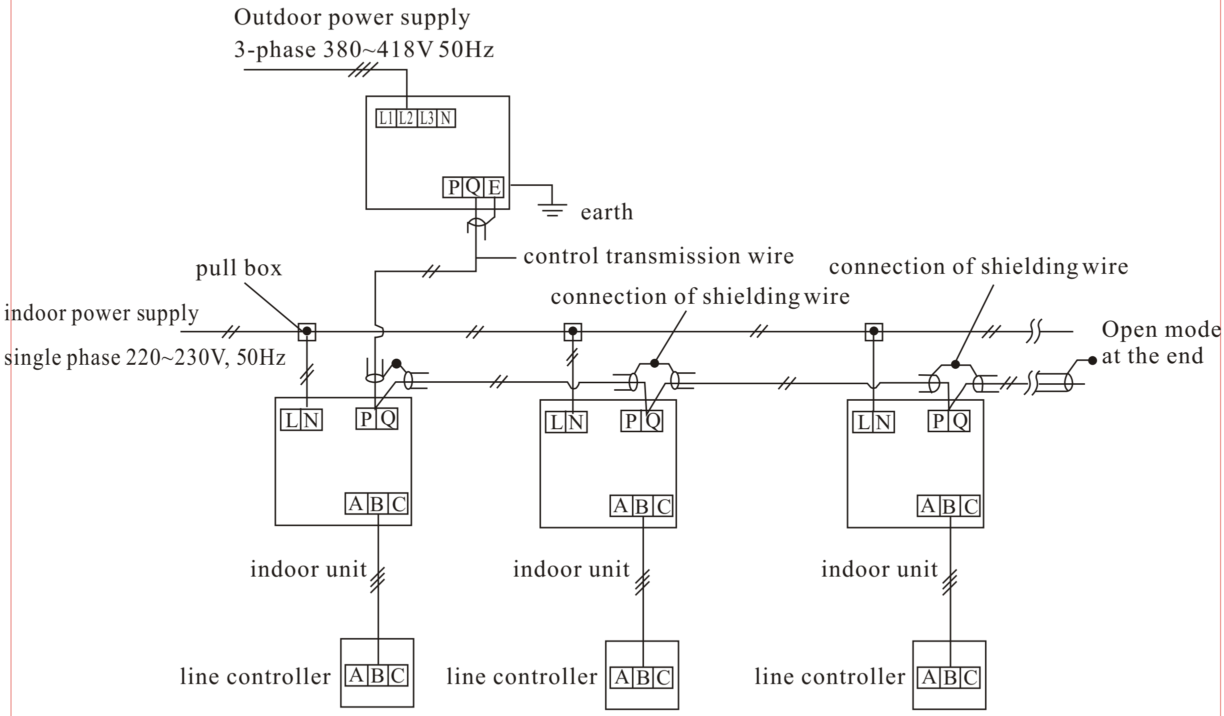
(3) Control method between indoor-indoor units is of bus communication and the control addresses are automatically set..

⚠ Note

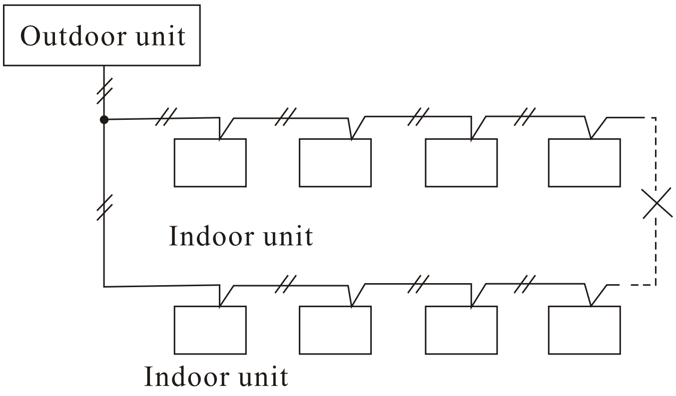
Wirings for control transmission and remote control are all of slight current and cannot directly contact with power supplies of AC220V or AC380V, and not be inlaid in the same wiring tube either.

Wiring system diagram

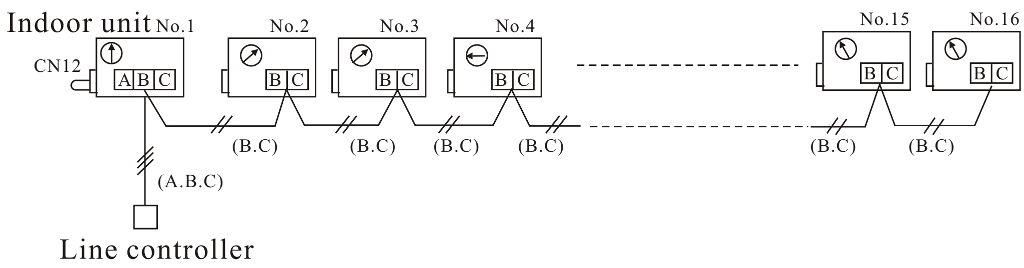




Attention points: Loop wiring mode is absolutely forbidden for control transmission



2. Group operation of controller switches
   Control severial indoor units using one line controller (maxium 16)



Settings for control circuit board of indoor unit

Indoor unit No.	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8
Setting of rotary switch (SW01)	1	2	3	4	5	6	7	8
CN12 short connection wire	available	open	open	open	open	open	open	open
Line control terminal	A B C	B C	B C	B C	B C	B C	B C	B C

Indoor unit No.	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16
Setting of rotary switch (SW01)	9	10	11	12	13	14	15	16
CN12 short connection wire	open	open	open	open	open	open	open	open
Line control terminal	B C	B C	B C	B C	B C	B C	B C	B C

Rotary switch (SW01) (on control circuit board of indoor unit)

3. Installation of line controller

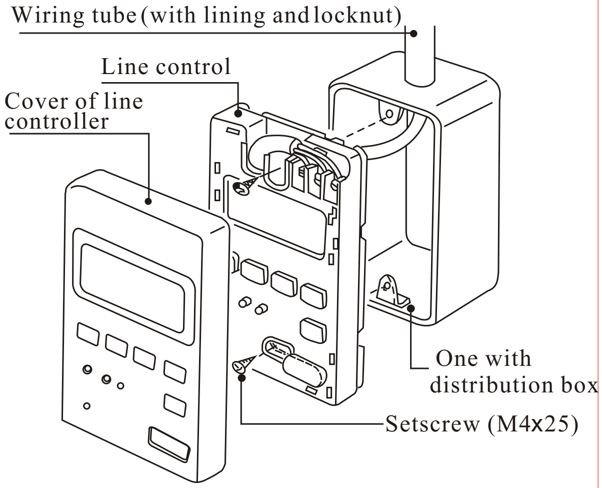
YR-F01

While inlaying in the wall (installing switch box)

The wiring should be carried on in place convenient for operation.

The thickness of wire for line control varies with length. Use wiring tubes of proper thickness (with lining and locknut).

To dismount the cover of line controller, extend a flat screwdriver into concaved part as shown in the diagram and screw off.



⚠ Note

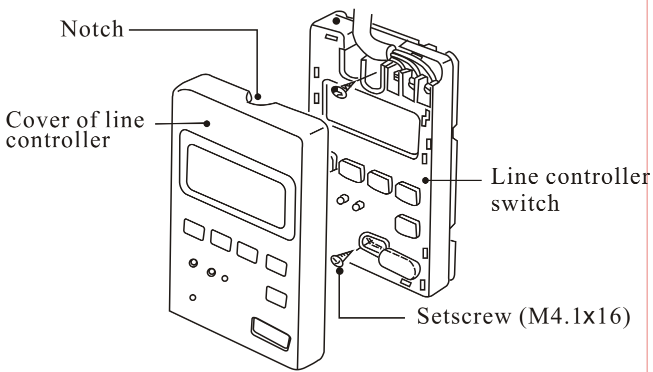
Fastening screw too tightly can cause the box distorting and LED breaking.
DON'T get any wire stuck while installing
Horizontally press the cover of line controller in. Otherwise press buttons on the controller may get stuck resulting in disabled operation.

While installing on the wall

Connect soft 3-core wire coated with polyethylene insulator (RVV wire) through U-shape hole on central top of the line controller cover.

Final processing

- After installation of line controller cover, seal it with oil loam to prevent against water, dust and dirt.



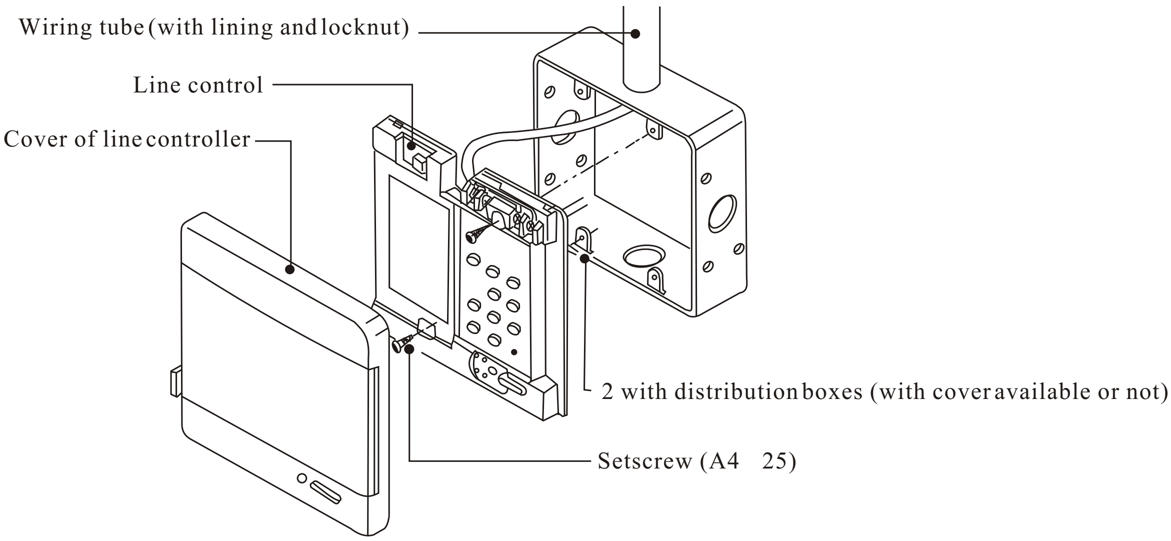
⚠ Note

Line control circuits are all of slight current and cannot directly contact with power supplies of AC220V or AC380V, and not be inlaid in the same wiring tube either.

YR-E02

While inlaying in the wall (installing switch box)

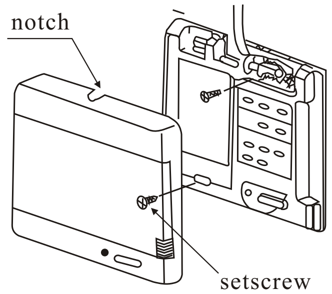
The maximum length of line controller wire is 500m and the wiring should be carried on in place convenient for operation.



Use flat screwdriver prying the arrow to dismount the decoration cover.

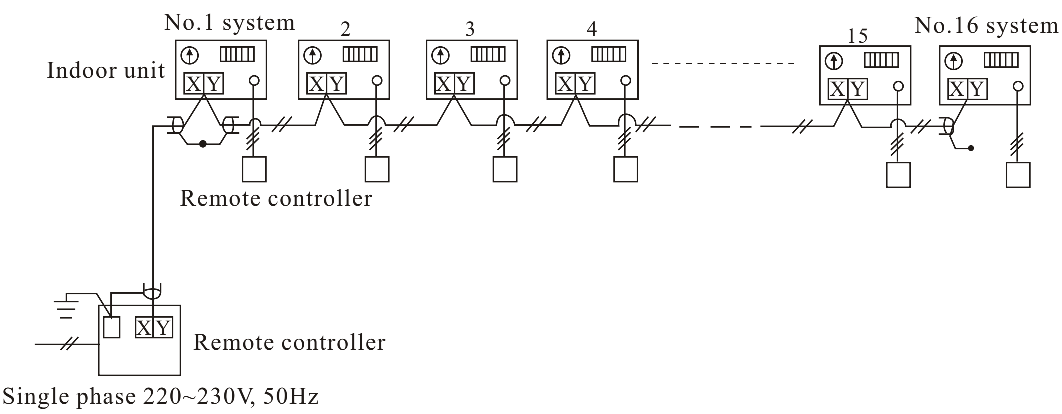
While installing on the wall

Connect soft 3-core wire coated with polyethylene insulator through U-shape hole on central top of the decoration cover.



5-5 Centralized operation management for centralized controller (Centralized control of 16 systems)

Signal lines of centralized controller should be 2-core and nonpolar. To avoid interference of electromagnetic noise, adopt 2-core shielding wire for YR-E01.

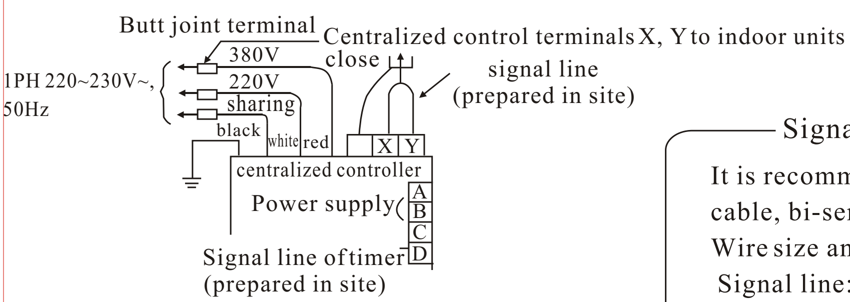


1. Settings for control circuit boards of indoor units

Indoor unit system	No.1 system	No.2 system	No.3 system	No.4 system	No.5 system	No.6 system	No.7 system	No.8 system
Setting of centralized control address No. (SW02)	01	02	03	04	05	06	07	08
Setting of rotary switch (SW01)	1	1	1	1	1	1	1	1
Centralized control terminals	X Y	X Y	X Y	X Y	X Y	X Y	X Y	X Y

Indoor unit system	No.9 system	No.10 system	No.11 system	No.12 system	No.13 system	No.14 system	No.15 system	No.16 system
Setting of centralized control address No. (SW02)	09	10	11	12	13	14	15	16
Setting of rotary switch (SW01)	1	1	1	1	1	1	1	1
Centralized control terminals	X Y	X Y	X Y	X Y	X Y	X Y	X Y	X Y

2. Wiring connection



Signal line

It is recommended to adopt 2-core electric cable, bi-serial cable or mike line.
Wire size and allowable length
Signal line: 1.25mm^2 500m below
2.00mm^2 1000m below
polarity: nonpolar

Signal line

It is recommended to adopt 2-core shielding wire

Size and allowable length (total length of signal lines should comply the following)

1.25mm^2, 500m below

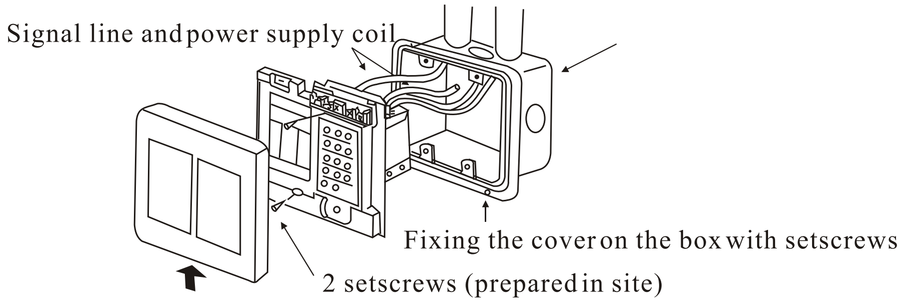
2.00mm^2,500m~1000m

Polarity: nonpolar

3. Installation of controllers

The centralized controller is installed in the way of inlaying in the wall.

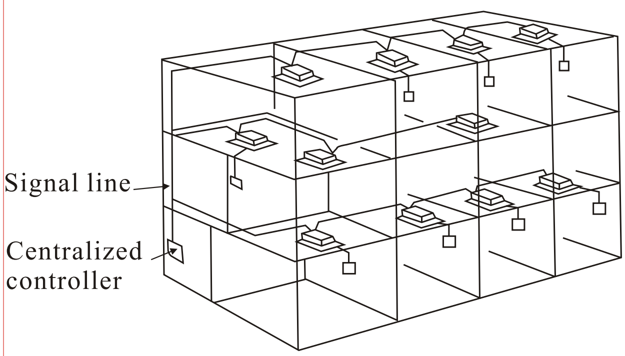
Wiring and tubing should be carried on in places convenient for operation.



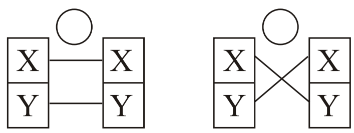
⚠ Note

Confirm power supply voltage and connect to 220~230V properly.
Signal line circuits are all of slight current and cannot directly contact with AC220~230V wires, and not be inlaid in the same wiring tube either.

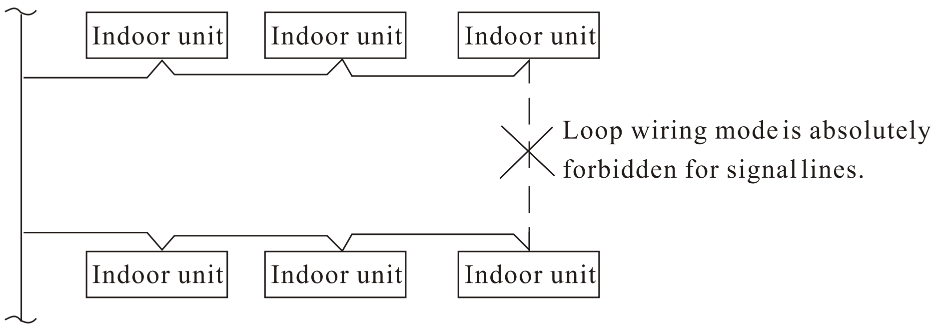
4. Wires connected to indoor units

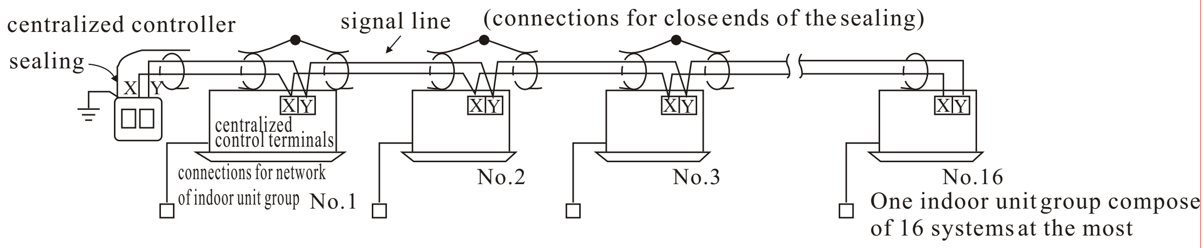


Connections can be as either of the following for signal line is nonpolar.



Connection between centralized remote controller and control circuit board of indoor units which are controlled in a group should be on the one whose group address No.(rotary switch SW01) is set to 1.





- Earhing connections for the system: Mutually connect shielding layers of shielding lines together and set to open mode (insulation process) at the end. And, connect one point of the centralized controller to the earth.

5. Settings for centralized control address number (network address number) of indoor unit:

- Settings for centralized control address number (originally preset to “ 1 ” by manufacture) is necessary while wiring for multiple indoor units not over 16 sets.
- Set the centralized control address number coinciding with centralized controller.

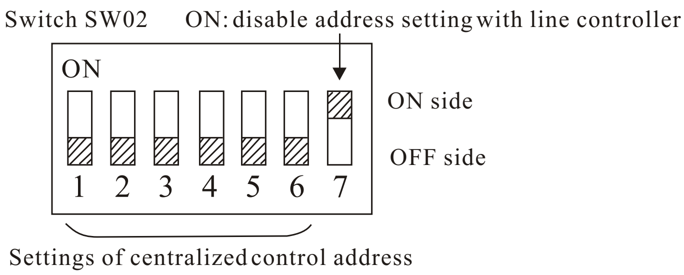
Two setting ways:

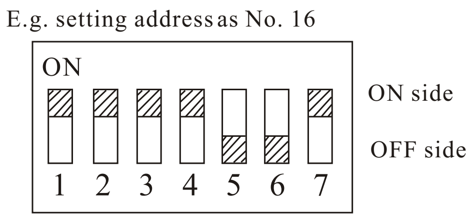
(1) Setting with switches on control circuit board of indoor unit

a. Switch off power supply to the indoor unit

b. Set bit 7 of centralized control address number switch SW02 to “ ON ” to disable address setting with line controller.

c. Set centralized control address number by combining “ ON/OFF ” of bit 1-6 of SW02. Relations between address number and combination of ON/OFF are as shown in the table on the next page.





Setting table for centralized control address No. (by dial switch SW02)

Address No.	1	2	3	4	5	6
01	X	X	X	X	X	X
02	O	X	X	X	X	X
03	X	O	X	X	X	X
04	O	O	X	X	X	X
05	X	X	O	X	X	X
06	O	X	O	X	X	X
07	X	O	O	X	X	X
08	O	O	O	X	X	X
09	X	X	X	O	X	X
10	O	X	X	O	X	X
11	X	O	X	O	X	X
12	O	O	X	O	X	X
13	X	X	O	O	X	X
14	O	X	O	O	X	X
15	X	O	O	O	X	X
16	O	O	O	O	X	X

O: ON side X : OFF side (bit 5, 6 should be set to OFF side)

(2) Setting with line controller

<limits>

a. The line controller can only set No.1 indoor unit of one unit group.

b. Bit 7 on dial switch SW02 (setting switch for centralized control address No.) on the control circuit board of indoor unit is set to OFF.

<sequence>

a. Switch on the power supply.

b. Hold pressing reset filter screen button for 5 seconds to enter setting mode for centralized control address, the line controller will display as shown on the right.

Unit group
01
01 address

c. Change address number by pressing forward ○ / backward ○ . The right chart is the example for setting address number as 03. Press ○ / ○ on the auxiliary line controller while using auxiliary line controller to set address.

Unit group
01
03 address

d. Press reset filter screen button again to return to normal display to finish the setting. Or the controller will automatically go back to normal display 15 seconds to finish the setting.

Note: Line controller with weekly timer cannot be used to set centralized control address.

5-6 Sequence of trial run

Trial run is carried on as the following procedure including pre-confirmations to avoid defects and troubles after sales.

	Item	Content	Checkup points	Reference pages	Remark
1 day ago	Confirmation before trial run	Confirmation of installation	Circuits and connections of power supply Capacities of indoor & outdoor electric leakage protectors Connection & wiring mode for indoor & outdoor controls Earthing connection method Quantity record of supplemental filling refrigerant Confirmation of insulation resistance	P38~53 electrical wiring P34 filling supplemental refrigerant	Confirm with power supply wire to the earth before connection
	Preparation	Diagrams for test Checkup details before trial run Checkup details for trial run	Extension refrigerant tube system diagram Power supply wiring system diagram Control system diagram (List of wiring system diagrams)	P71 confirmations before trial run P/2~76 recording paper for system diagrams (Examples P77-81) P80~81 checkup details for trial run (examples P83~84)	Recording paper of the same day
		Switching on all outdoor units	Confirmation of power supply voltage		Avoid too much refrigerant dissolving in freezing oil and ensure the compressor heating with power (180~220V) (being powered on for over 12 hours before running)
The very day	Trial run starts	Switch off all outdoor power supplies other than the one of trial run system Switch on indoor power supply of trial run system Indoor & outdoor control addresses are auto set Clear trouble shooting code 95 -- abnormal	Confirmation of outdoor power supply Confirmation of indoor power supply	P90 clear malfunctions	Reconfirm the status of power supply 198V~242V (single phase) 342V~418V (3-phase) auto address setting needs 20 in maximum Trouble shooting code 95 may display due to switch-on time difference between indoor & outdoor power supplies
	Trial run of blowing machine	Compare with system diagram	Confirmation of connections to indoor unit Confirmation of connections to remote controller Auto setting for refrigerant control address	P87 trial run function of outdoor unit P92 determination function of outdoor unit P91 determination function of remote controller P85 confirmation function for connections of transmission line for extension refrigerant tube control	Records of auto setting for refrigerant control address (note 6)
	Trial run of cooling program	Running current (indoor) Indoor blowing temperature Pressure of the cooling system (outdoor) Temperature of the cooling system	Confirmation of cool wind	P88 cooling trial run function of outdoor unit P94~95 checkup details for trial run	Checkup lists for indoor and outdoor systems respectively (lists)
	Trial run of heating program	Running current (indoor) Indoor blowing temperature Pressure of the cooling system (outdoor) Temperature of the cooling system	Confirmation of hot wind	P89 heating trial run function of outdoor unit P94~96 checkup details for trial run	DON'T switch on power supply for AINETWORK system of the centralized controller
	Ending (for one system)	Switch off indoor & outdoor power supplies			Avoid on/off control transmitted from remote interface as possible
	Switch on power supplies of indoor & outdoor units for next trial run				

After finishing trial run for the whole system, switch on all indoor & outdoor power supplies, and confirm connections for transmission control line of centralized management. Like refrigerant trial run, switch on power for systems one by one to confirm actions. In this case, confirm on/off status sent from remote control interface.

The above sequence is applied for common sequential example . As a system to be confirmed with blowing trial run, it can jump to trial run of the next system while cooling trial run starting.

Transcribe the recorded data to checkup table for trial run (statistic table for different system) and make notes as the following: Submit the aforesaid system diagrams of extension tubing, power supply wiring control wiring (lists of wiring system) and checkup table before trial run to manager of the building to keep as a part of completion book for rapid reference in case of after service.

Measurement instruments applied:

- multimeter
- pressure meter
- tong tester
- insulation testing set (DC, 500V megohm meter)
- 2 thermometers of constant temperature

While applying auto determination function of outdoor unit, sensing data inside the outdoor unit can be read on LED on I/F (interface) PC board of it. Use this data to enhance trial run precision and determine whether freezing cycle status is normal.

Auto address number of refrigerant control is used for outdoor unit to detect number of indoor unit, normally it has no relations with air conditioner operation by line controller or centralized controller. But it is convenient to use this number in after service, thus why it is recommended to record it in checkup lists.

Confirmations before trial run

Before trial run, the following diagrams should be finished and submitted to building manager to keep as part of complete diagrams. It will be helpful for after service.

Extension refrigerant tubing system diagram

Control wiring system diagram (together with lists of wiring system)

Power supply wiring system diagram

Checkup table before preparation

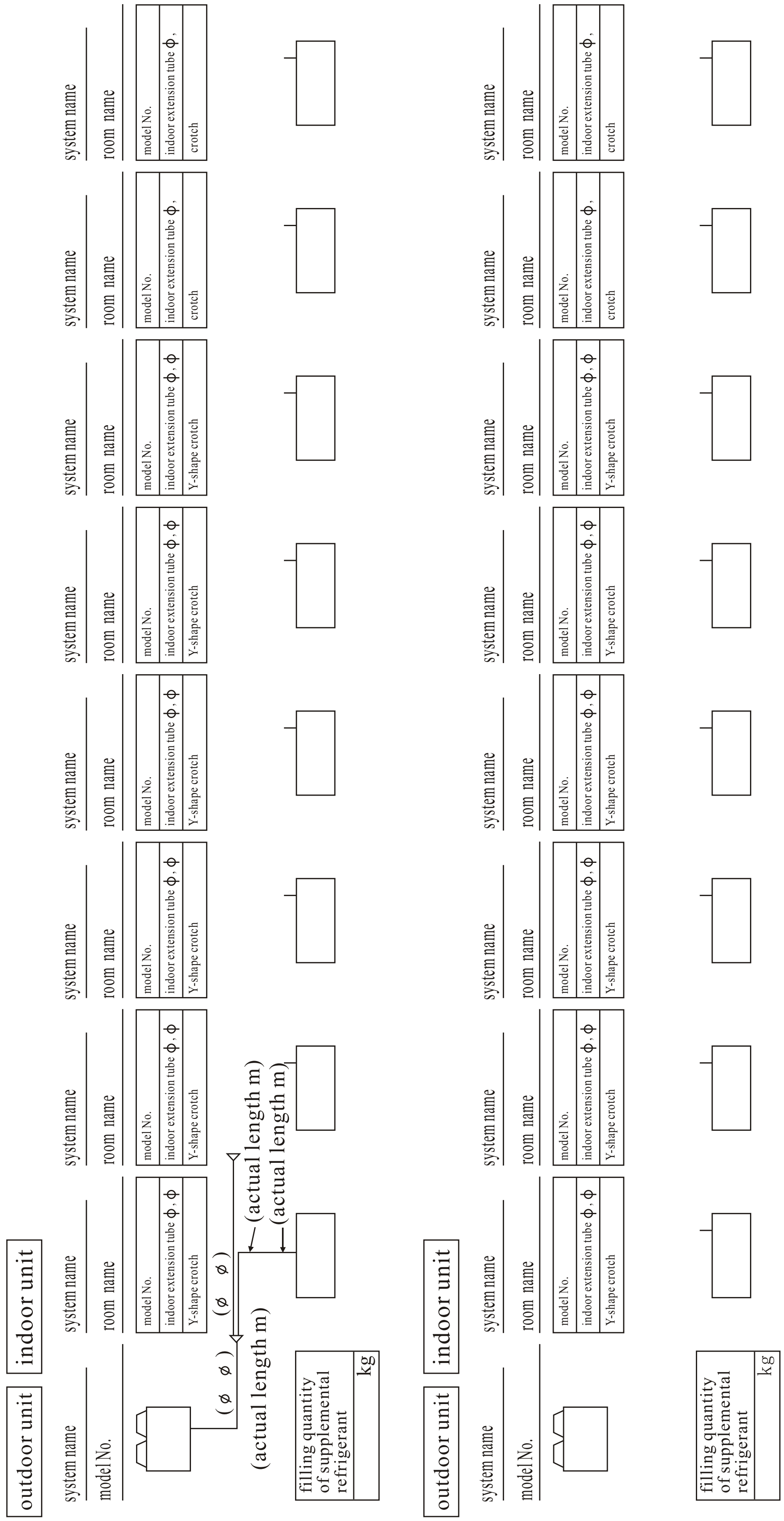
Refer to (recording diagrams, attached tables and examples)

Settle all system diagrams and mark system names uniformly.

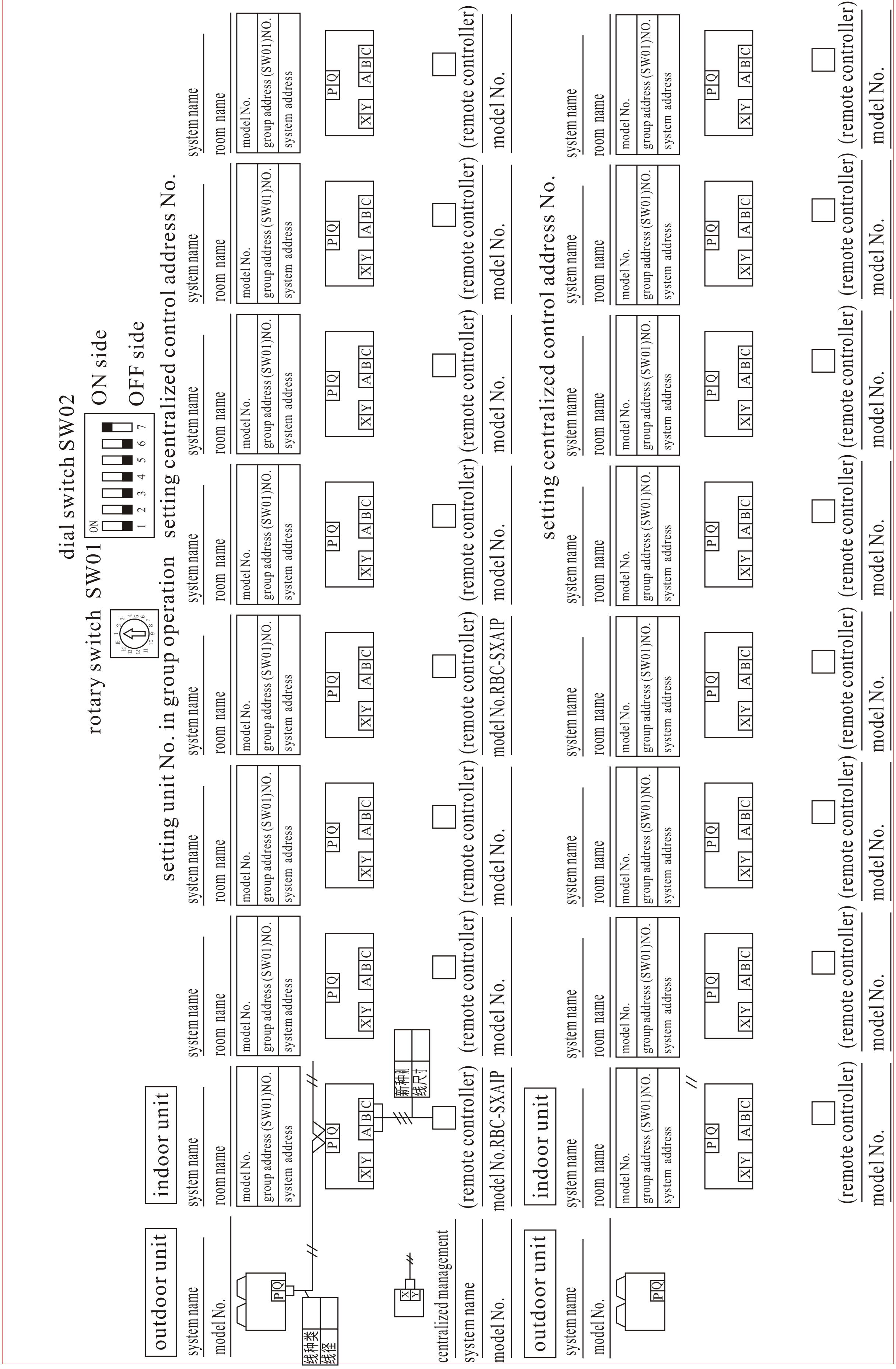
Before trial run, prepare the above diagrams and check the following items

Checkup item	Checkup method
1) Confirmation for connections of extension refrigerant tubing	Whether as same as tubing system diagram?
2) Supplemental refrigerant filling for all outdoor units	Record length of extension tube and filling quantity of supplemental refrigerant on label plate of outdoor unit
3) Confirmation for control wiring connection and all setting switches.	Whether as same as control wiring diagram?
4) Confirmation for the system and capacity of power supply switch blade	Whether as same as power supply wiring system diagram?

1. Extension refrigerant tubing system diagram



2. Control wiring system diagram



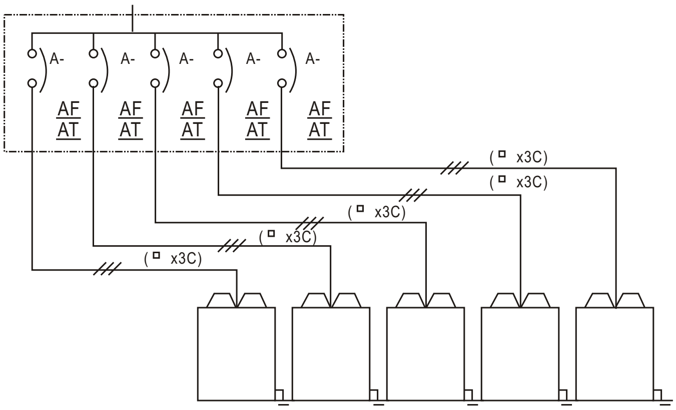
List of control wiring system

Model number of outdoor unit (system name)	Indoor unit			Switch of line controller		System address for centralized control
	Model number	System name	Room name	group	Group number	

3. Power supply wiring system diagram

System of outdoor units

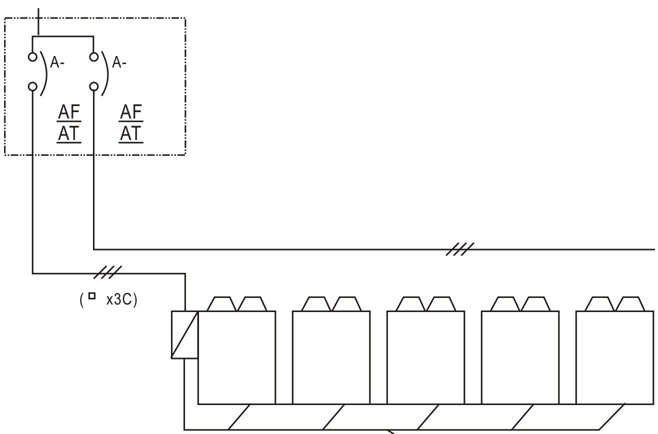
(1) Supplying according to quantity of outdoor units
Branch distribution panel (prepared at sited)



System name

Model number

(2) One-off power supplying
(adopting power supply equipment)

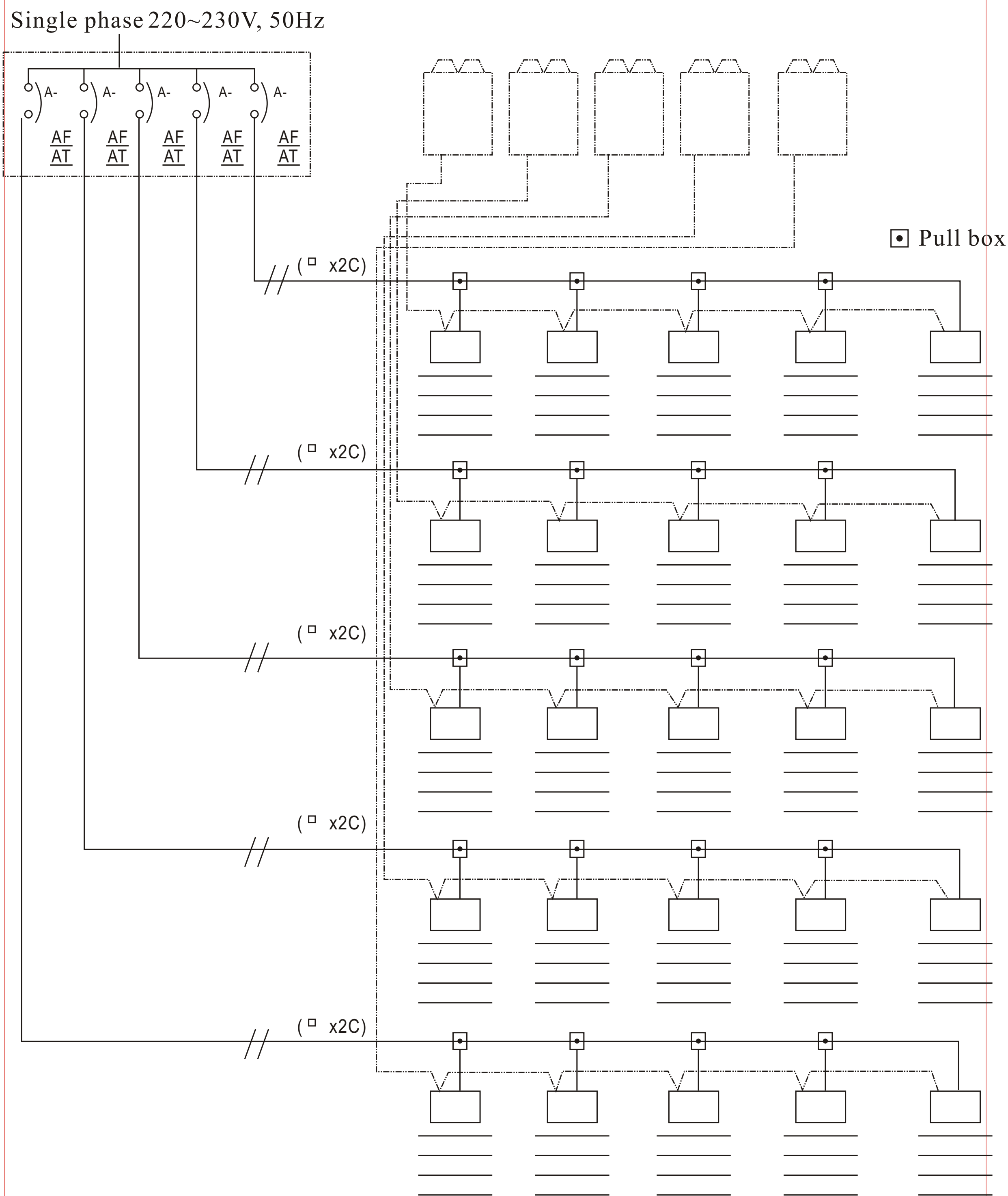


System name

Model number

System of indoor units

Indoor units connected to the same outdoor unit are of the same system and their power supplies, electric leakage breakers and manual switches are applicable to each other.



4.Checkup table before trial run

Checkup table before trial run

Date: Year Month Day

Checking department:

Checker:

User	Mr./Ms.

(outdoor unit) setting site ( )

System name	Model No.	Serial No.	Nitrogen tightness test Pressure • time	Filling quantity of supplemental refrigerant	Valve switch	
					Gas tube	Liquid tube
		NO.		kg		
		NO.		kg		
		NO.		kg		
		NO.		kg		
		NO.		kg		
		NO.		kg		

System name	Insulation resistance 500V megohm Power supply wire --- Earth (body)			Power supply wire Wire No.or color			Control line			Wire (mm^2)		Capacity of electric leakage breaker			Free load voltage		
	L1-earth	L2-earth	L3-earth	L1	L2	L3	N	P	Q	Power supply	holding	Body (A)	Trip (A)	Induced current	L1-L2	L2-L3	L1-L3

Checkup table before trial run

(indoor unit) SW01: setting switch for unit number SW02: setting switch for system address

System name	Setting site	Model No.	Unit No.	Insulation resistance 500V megohm Power supply wire ---- Earth (body)		Power supply wire		Control line		Remote control wire			Centralized management line		Setting of switch	
				L-earth	L-earth	L	N	P	Q	A	B	C	X	Y	SW01	SW02
			NO.													
			NO.													
			NO.													
			NO.													
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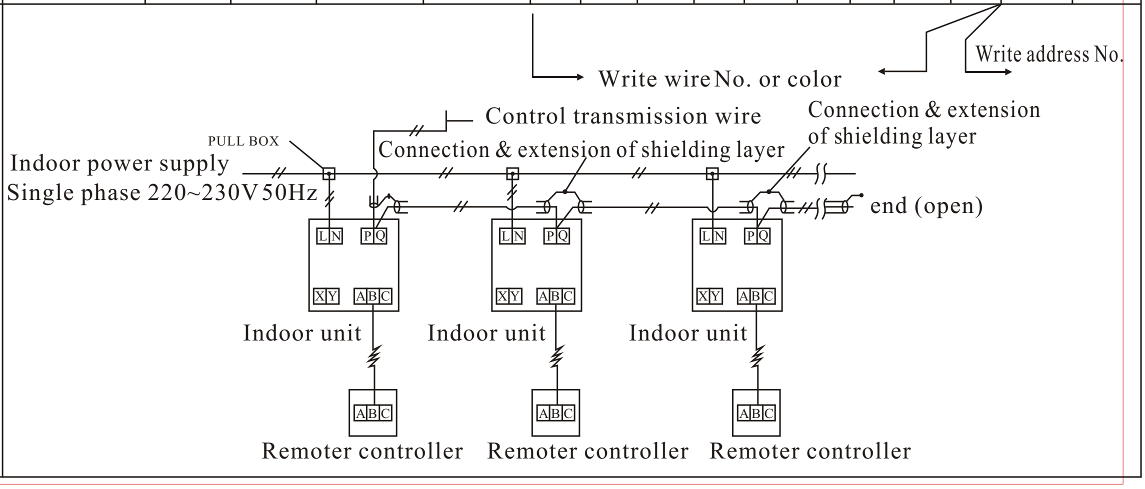
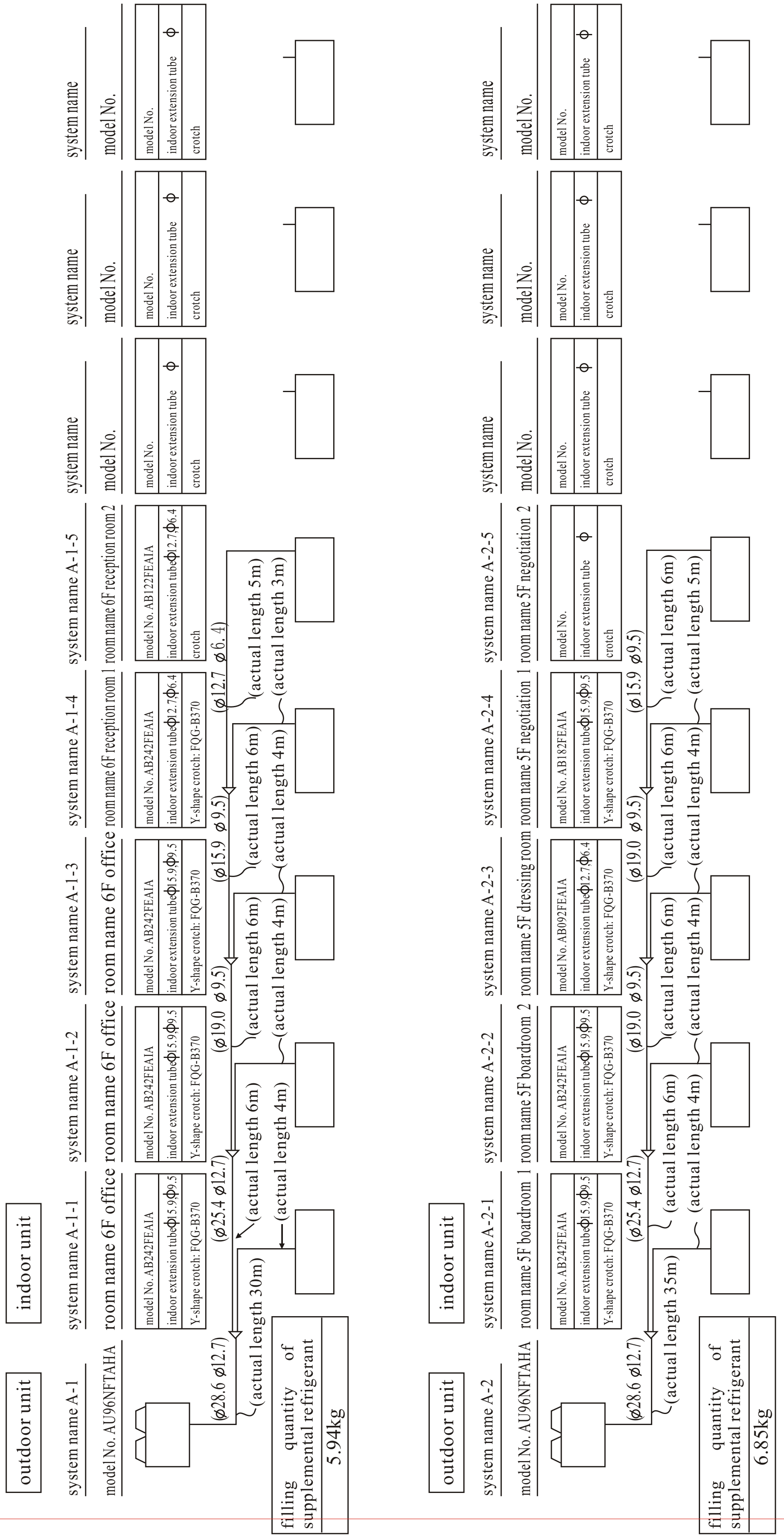
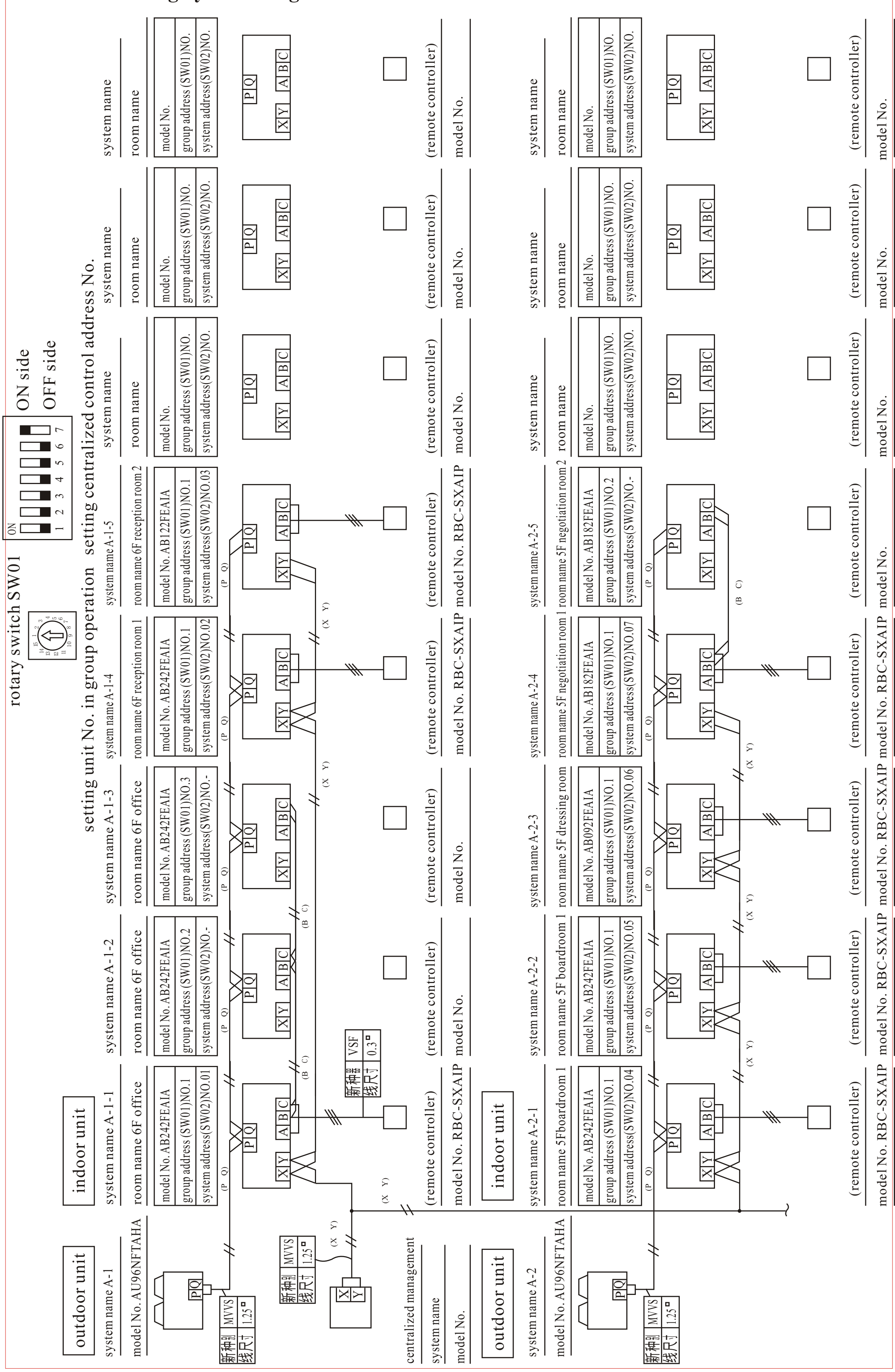


1. Extension refrigerant tubing system diagram



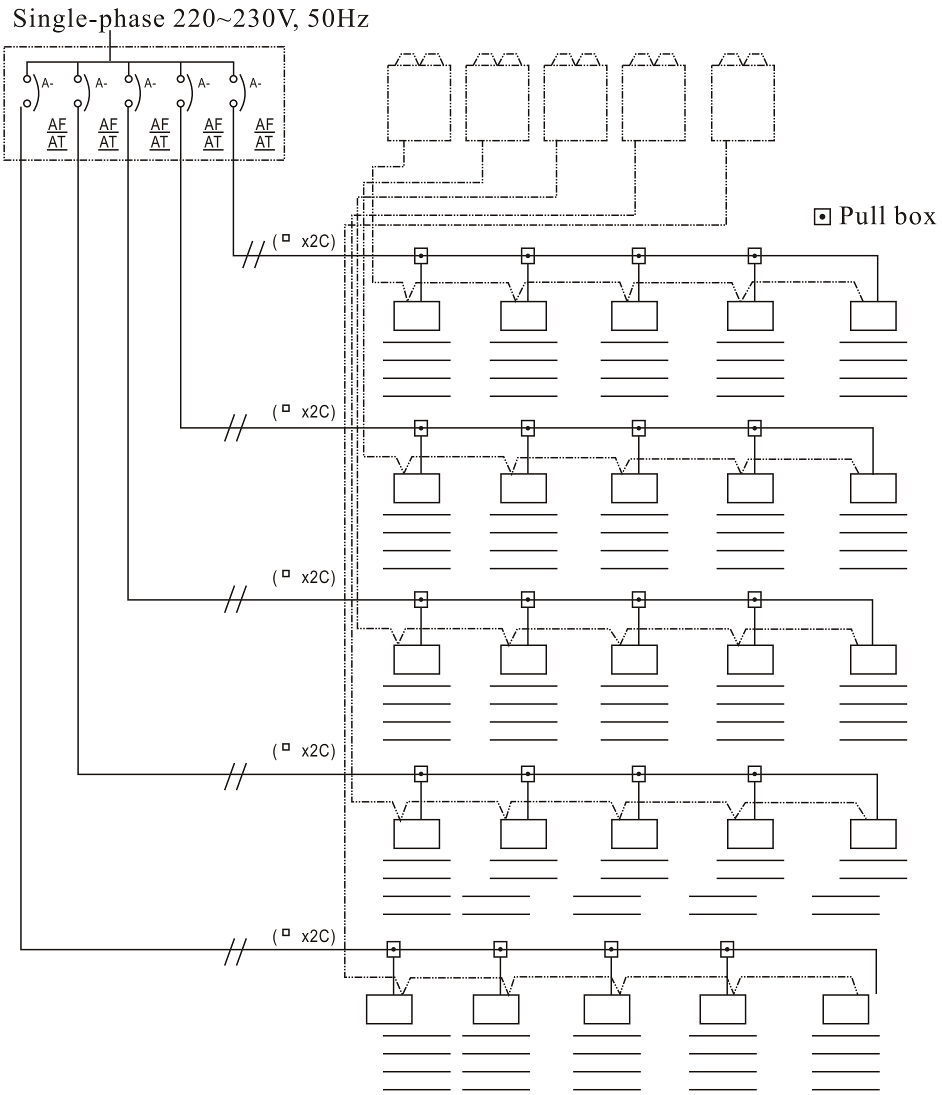
2. Control wiring system diagram

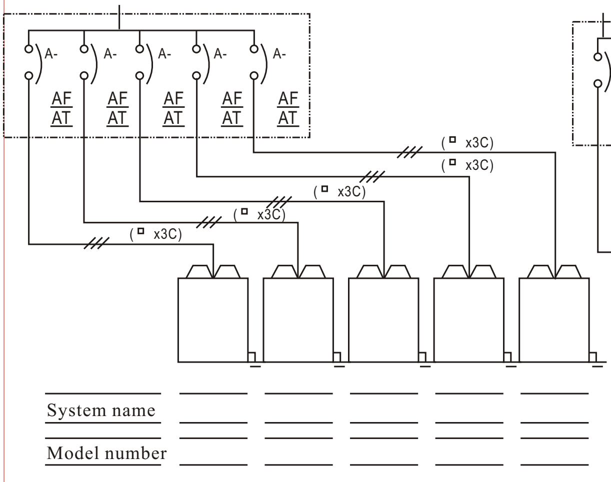


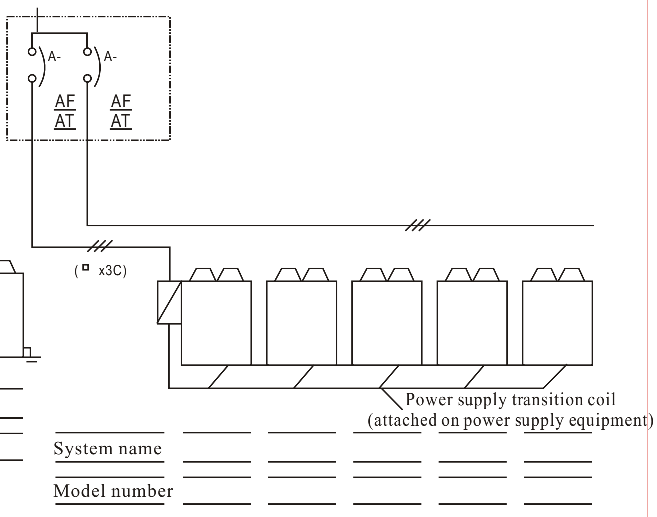
List of control wiring system

Model number of outdoor unit (system name)	Indoor unit			Switch of line controller		System address for centralized control
	Model number	System name	Room name	group	Group number	
AU96NFTAHA (A-1)	AB242FEAIA	A-1-1	6F office	A	1	01
	AB242FEAIA	A-1-2	6F office	A	2	—
	AB242FEAIA	A-1-3	6F office	A	3	—
	AB242FEAIA	A-1-4	6F reception room 1	individual	1	02
	AB122FEAIA	A-1-5	6F reception room 2	individual	1	03
AU96NFTAHA (A-2)	AB242FEAIA	A-2-1	5F boardroom 1	Individual	1	04
	AB242FEAIA	A-2-2	5F boardroom 2	Individual	1	05
	AB092FEAIA	A-2-3	5F dressing room	Individual	1	06
	AB182FEAIA	A-2-4	5F negotiation room 1	B	1	07
	AB182FEAIA	A-2-5	6F negotiation room 2	B	2	—

3. Power supply wiring system diagram







4. Checkup table before trial run

Checkup table before trial run

Date: Year Month Day

Checking department:

Checker:

User	Mr./Ms.

(outdoor unit) setting site ( )

System name	Model No.	Serial No.	Nitrogen tightness test Pressure • time	Filling quantity of supplemental refrigerant	Valve switch	
					Gas tube	Liquid tube
A-1	AU96NFTAHA	NO.50100005	OK after 30kg/cm^{2}G · 24 hours	5.94kg	open	open
A-2	AU96NFTAHA	NO.50100007	OK after 30kg/cm^{2}G · 24 hours	6.85kg	open	open

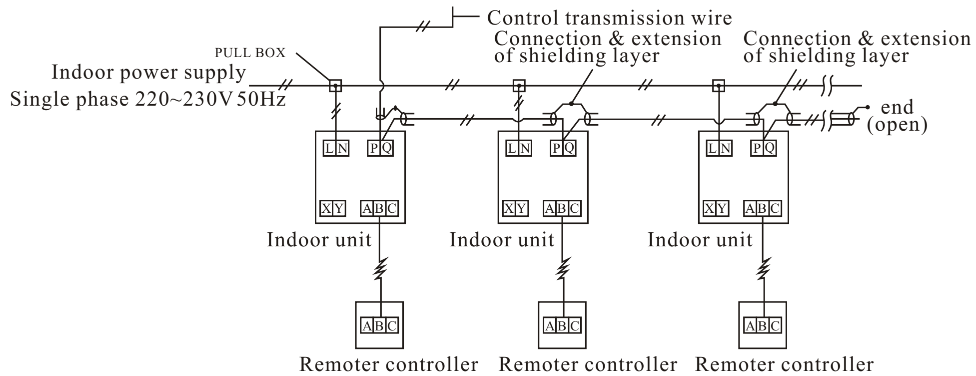
System name	Insulation resistance 500V megohm Power supply wire -Earth (body)			Power supply wire WireNo. or color			Control line			Wire (mm^2)		Capacity of electric leakage breaker			Free load voltage		
	L1-earth	L2-earth	L3-earth	L1	L2	L3	N	P	Q	Power supply	holding	Body (A)	Trip (A)	Induced current (mmA)	R-S	S-T	R-T
A-1	∞	∞	∞	Red	White	Black		Black	White	38	1.25	60	60	100	380	380	380
A-2	∞	∞	∞	Red	White	Black		Black	White	38	1.25	60	60	100	380	380	380

Checkup table before trial run

(indoor unit) SW01: setting switch for unit number SW02: setting switch for system address

System name	Setting site	Model No.	Unit No.	Insulation resistance 500V megohm Power supply wire ---- Earth(body)		Power supply wire		Control line		Remote control wire			Centralized management line		Setting of switch	
				L-earth	N-earth	L	N	P	Q	A	B	C	X	Y	SW01	SW02
A-1-1	6F office	AB242FEAIA	NO.50100050	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	01
A-1-2	6F office	AB242FEAIA	NO.50100051	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	2	—
A-1-3	6F office	AB242FEAIA	NO.50100055	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	3	—
A-1-4	6F reception room 1	AB242FEAIA	NO.50100070	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	02
A-1-5	6F reception room 2	AB122FEAIA	NO.50100071	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	03
A-2-1	6F boardroom 1	AB242FEAIA	NO.50100052	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	04
A-2-2	6F boardroom2	AB242FEAIA	NO.50100053	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	05
A-2-3	5F dressing room	AB092FEAIA	NO.50100080	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	06
A-2-4	5F negotiation room 1	AB182FEAIA	NO.50100091	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black		1	07
A-2-5	5F negotiation room 2	AB182FEAIA	NO.50100092	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	2	—
A-3-1	4F office	AB182FEAIA	NO.50100093	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	08
A-3-2	4F office	AB182FEAIA	NO.50100095	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	2	—
A-3-3	4F office	AB162FEAIA	NO.50100041	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	3	—
A-3-4	4FOA room	AB122FEAIA	NO.50100073	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	09
A-3-5	4F negotiation room	AB092FEAIA	NO.50100081	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	10
A-4-1	3F office	AB242FEAIA	NO.50100054	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	11
A-4-2	3F office	AB162FEAIA	NO.50100043	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	2	—
A-4-3	3F office	AB122FEAIA	NO.50100072	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	3	—
A-4-4	3F OA room 1	AB122FEAIA	NO.50100074	∞	∞	Red	White	Black	White	Red	Yellow	Brown	Black	White	1	12
A-4-5	3F OA room 2	AB122FEAIA	NO.50100075	∞	∞	Red	White	Black	White	/	Yellow	Brown	/	/	1	13

Wirte wire No. or color Wirte address No.



5-7 Adjustment of trial run (setting with switches)

(1) Auto address setting [auto address setting (between indoor units & outdoor units)]

The air conditioner can automatically set addresses while first switch-on after installation. The procedure normally takes 3~5 minutes since power-on and 20 minutes at most according to different conditions.

Attention points for auto address setting

(1) The air conditioner is not running

While auto address setting, pressing running switch will enter the following state:

a. Running indicator lamp on the remote controller lights

b. Indoor blowing fan enters blowing mode or stops according to running signals

c. Since the outdoor unit is in stop mode, cooling or heating operation cannot be run.

After finishing auto address setting, the system will release the above state and automatically start running.

(2) Detection for wiring mistakes may cause false determination

Once the control unit address of an indoor unit is confirmed, the system cannot run auto address setting any more except for the following case:

a. While first switch-on after changing PC board of indoor unit.

b. While first switch-on after adding new indoor unit(s).

(2) Switchin of power supply

[trouble shooting code 95 after power switch-on (communication loop between indoor & outdoor units)]

In such case, trouble shooting code 95 will display even the system is normal (communication loop between indoor & outdoor units)

After power switch-on to indoor unit, press ON/OFF button on the line controller before switching on power for outdoor unit

↓

Trouble shooting code 95 displays even the system is normal

In such case, clear trouble shooting code as the following procedure:

Hold pressing trouble shooting button on line controller for more than 10 seconds.

If the code 95 displays again, that means there's some problem with signal loop between indoor & outdoor units. Check the loop.

In addition, switch on according to the following sequence to avoid false dtermination.

Firstly switch on power supply for outdoor unit, then switch for indoor unit.

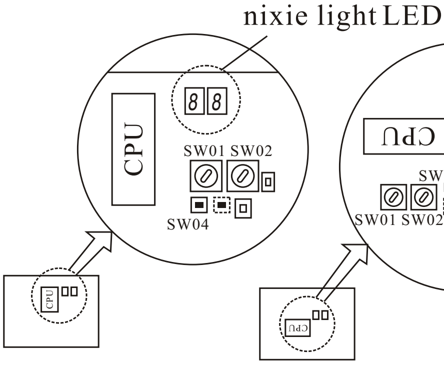
(3) Detection function for wire connections of extension refrigerant tubing and control transmission

This 1-X air conditioner has the function to detect mistake wire connections (wiring jumping over outdoor units) of extension refrigerant tubing and control transmission between indoor & outdoor units. Before performance test, the following content MUST be checked.

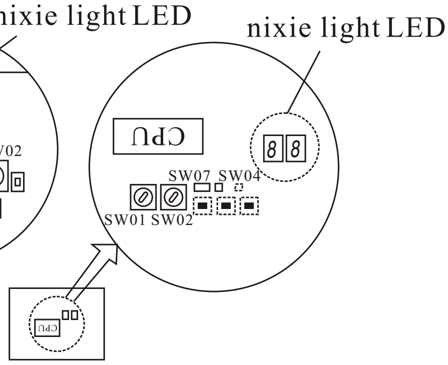
(1) Confirmation cannot be completed if line controllers are running in groups jumping over outdoor units. (2) The confirmation should be done to each unit individually. Confirming multiple units at the same time may cause false determination. (3) Switch on power for indoor and outdoor units that need to test or may wired with mistakes.

(Detection sequence)

Switching on ········ Switch on both indoor and outdoor units



layout chart for I/F PC boards of 5HP~10HP outdoor units



layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

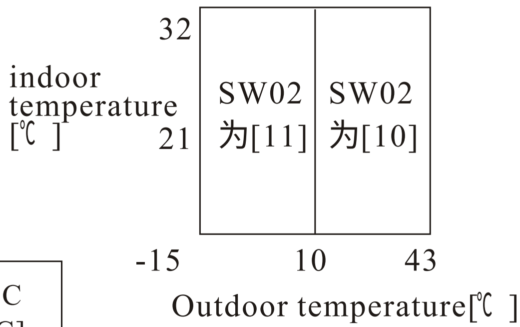
↓

Set SW01 on I/F PC board of outdoor unit to [1] and SW02 to [7], confirm connected quantity of indoor units consistent with the preset value via LED

↓

Set switches on I/F PC board of out unit to one of the following modes according to indoor temperature.
Cooling: SW01 [1], SW02 [10]
Heating: SW01 [1], SW02 [11].

······ cooling → SW01, 02······rotary switches
SW04······press switches
SW03.05.06 nonuse
SW07dial switch∗2



↓

Hold pressing switch SW04 on I/F PC board over 2 seconds. Confirm [CC] displaying for cooling and [HH] for heating.

······ Running

↓

15 minutes later, confirm quantity of indoor units shown by LED. [00]*1 means none. During confirmation, SW01[6], SW02 should be set according to address sequence. Confirm trouble shooting code, 9A means mistake connection.

······ check whether there's mistake wiring, taking 15 minutes for each system.

*1 Unit quantity shown by LED only include indoor units sending trouble shooting codes other than those of mistake wiring. Confirm trouble shooting code.

*2 in the case outdoor unit over 10 HP and connected indoor units more than 16

SW02	SW07	
1~16	OFF	1~16
1~4	ON	17~20

↓

Reset SW01, SW02 on I/F PC board of outdoor unit to [1] after confirmation

(4) Trial run function of outdoor unit

The function of running connected indoor units according to each outdoor unit.

Set connection method as the following way:

All ON/OFF   setting SW01 to [1], SW02 to [15] C Run all connected indoor units.

Individual ON/OFF   setting SW01 to [16]

Setting SW02, SW07 of the expected indoor unit (as below*) --- only running the set indoor unit. (indoor unit whose rotary switch (SW01) is set to 2~16 , running under group control, cannot be individually controlled. In such case, LED on I/F PC board shows   .)

(Running sequence)

Switch on

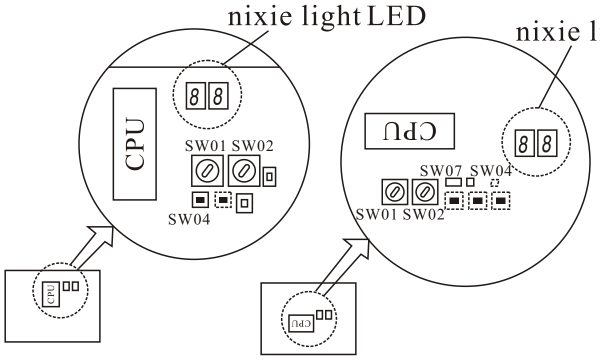
↓

If there's abnormal display while SW01, SW02 setting to [1], go back to the normal mode according to trouble shooting methods. Carry on trial run when all things are normal.

Setting operation mode for remote controller. (Or keep the present running mode) (blowing, cooling, heating) ······Select cooling/heating running mode with heating program owning priority. Unit not owning priority cannot run.
Besides, group controlled indoor units cannot run during individual control.

↓

Setting switches on I/F PC board of indoor unit as notes hereunder



layout chart for I/F PC boards of 5HP~10HP outdoor units

layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

SW01,02······rotary switches
SW04,05······press switches
SW03,06 nonuse

↓

Hold pressing SW04 over 2 seconds ······running

↓

Run the expected indoor unit ······ running confirmation (there may be mistake wiring if the blowing temperature has no change even cooling/heating program is set with line controller)

↓

Hold pressing SW05 over 2 seconds ······stop

↓

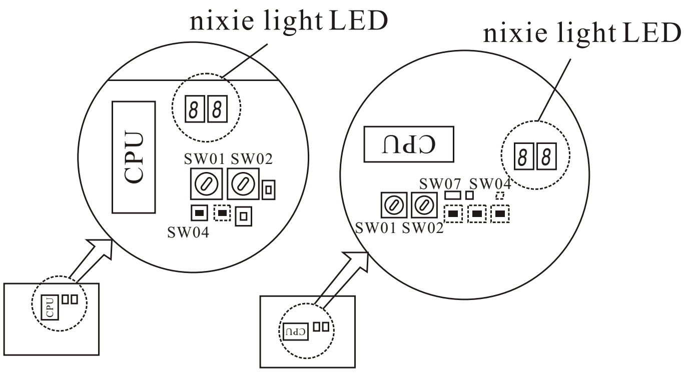
Reset SW01, SW02 on I/F PC board of outdoor unit to [1] after the test ······ending

※

SW01	SW02	SW07	Expected unit	
1	15		All connected indoor units	······ON/OFF at the same time
16	1~16	OFF	Address 1 ~ Address 16 } Individual	······ON/OFF idividually
16	1~4	ON	Address 17 ~ Address 20 } Individual	

(5) Cooling trial run of outdoor unit

The function of converting all connected indoor units to cooling trial run mode according to each outdoor unit.(Running sequence)



layout chart for I/F PC boards of 5HP~10HP outdoor units

layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

SW01, 02 rotary switches
SW04, 05 press switches
SW03, 07, 06 nonuse

Switch on

↓

Set SW01 on I/F PC board of outdoor unit to [1] and SW02 to [12]

↓

Hold pressing SW04 over 2 seconds — running

↓

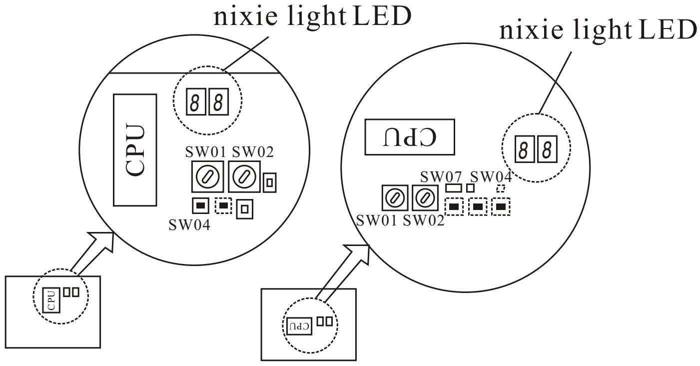
Confirm the line controller connected to the expected indoor unit converting to cooling mode (showing L) and LED on I/F PC board of outdoor unit showing -C — running confirmation

↓

Reset SW01, SW02 on I/F PC board of outdoor unit to [1] after the test — stop, ending

(6) Warmhouse trial run for outdoor unit

The function of converting all connected indoor units to warmhourse trial run mode according to each outdoor unit.



layout chart for I/F PC boards of 5HP~10HP outdoor units

layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

SW01, 02 rotary switches
SW04, 05 press switches
SW03, 07, 06 nonuse

Switch on

↓

Set SW01 on I/F PC board of outdoor unit to [1] and SW02 to [13]

↓

Hold pressing SW04 over 2 seconds — running

↓

Confirm the remote controller connected to the expected indoor unit converting to heating mode (showing H) and LED on I/F PC board of outdoor unit showing -H — running confirmation

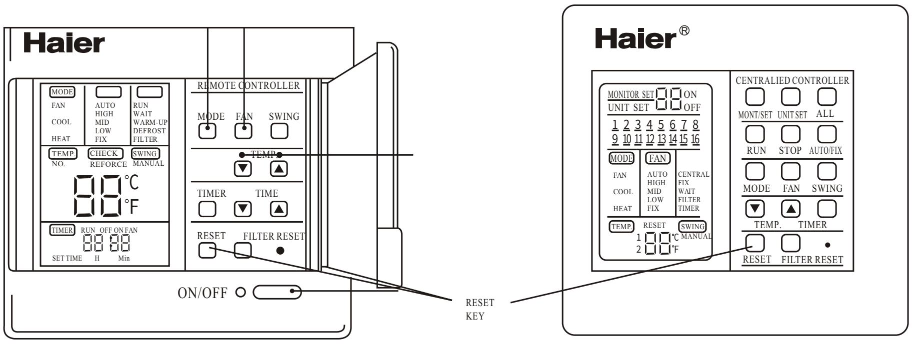
↓

Reset SW01, SW02 on I/F PC board of outdoor unit to [1] after the test — stop, ending

(7) Eliminating disorders

(1) Eliminating trouble shooting codes shown on remote controller / centralized controller

Release fully locked OFF mode of connected indoor units (of the whole group) with the line controller. Indoor units released with such operation can automatically start running (or new trouble shooting) while those not operated stop running (with running indicator lamp off).



Hold pressing trouble shooting button of the line controller over 5 seconds. (holding over 10 seconds also can eliminate trouble shooting code (only for this controller)

(2) Eliminating with I/F PC board of outdoor unit

This method can eliminate trouble shooting codes and restart running without shutting power down on base of each outdoor unit. But trouble shooting codes in memory of the line controller cannot be cleared with this method. (Such memory should be cleared as described in (1) or pressing RESET hole on the remote controller).

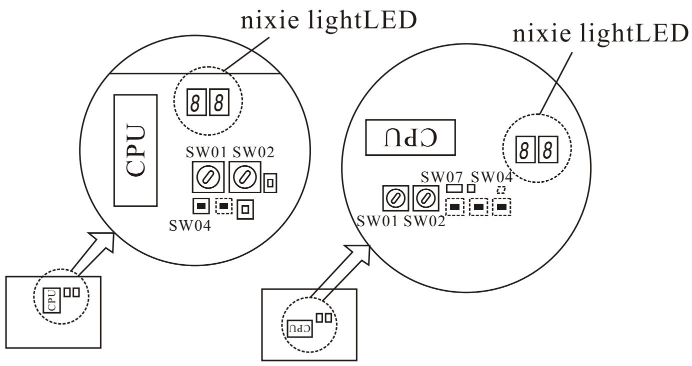
Set SW01 on I/F PC board of outdoor unit to [1] and SW02 to [16]

↓

Hold pressing SW05 over 5 seconds

↓

LED on PC board changes to showing CL for 5 seconds …… Also releasing abnormal lock mode of indoor unit (but there's still trouble shooting in memory of the remote controller). Make normal trouble shooting after such operation.



layout chart for I/F PC boards of 5HP~10HP outdoor units

layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

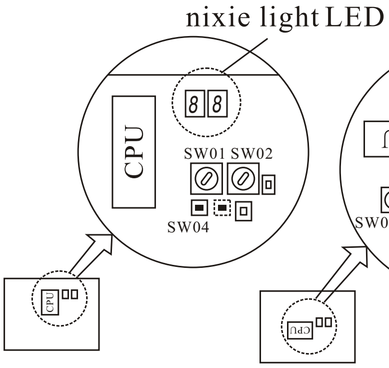
SW01, 02 rotary switches
SW04, 05 press switches
SW03, 07, 06 nonuse

(3) Eliminating abnormal trouble shooting code by reenergizing
(Also use this method to eliminate trouble code -- BD -- Mg-Sw contacts abnormally stuck)
Note: Only reenergizing outdoor unit cannot release fully stop lock mode of the whole system
in the case that indoor unit is abnormally locked.

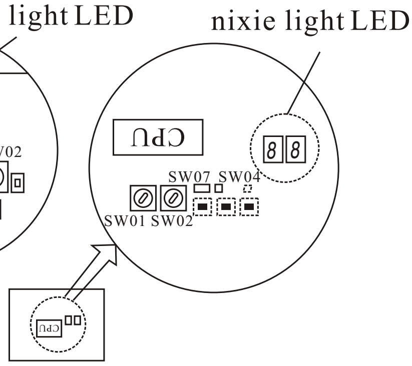
Indoor and outdoor units MUST be all reenergized. Power the both supplies OFF ⟶ Note: For reenergizing, firstly switch on power for outdoor unit then for indoor.

(8) Determination function of remote controller

The function of determining from remote controller connected to outdoor unit according to each outdoor unit.
(Deter mination sequence)



layout chart for I/F PC boards of 5HP~10HP outdoor units



layout chart for I/F PC boards of 13HP~20HP outdoor units (series 1)

SW01, 02 rotary switches
SW04, 05 press switches
SW03, 07, 06 nonuse

Switch on
↓
Set SW01 on I/F PC board of outdoor unit to [1] and SW02 to [16]
↓
Hold pressing SW04 over 2 seconds
↓
The non-priority indicating lamp on connected remote controller flashes and LED on I/F PC board shows [11] — confirmation of connected remote controller
↓
Hold pressing SW05 on I/F PC board over 2 seconds — ending

Other ending conditions:
1. 10 minutes has passed since signal sending
2. SW01 and SW02 are set to other positions

(9) Determination of outdoor unit

To determine connected outdoor units from the remote controller

(Determination sequence)

Operation:

1. Switch on
2. ↓ Dismount remote controller cover off
3. ↓ Setting blowing mode and shorting the timer circuit*

Confirmed by outdoor unit:

4. ↓ Bi-way electromagnetic valve connected to outdoor unit sounds click, click every 2 seconds, repeating OPEN/CLOSE for 5 minutes.

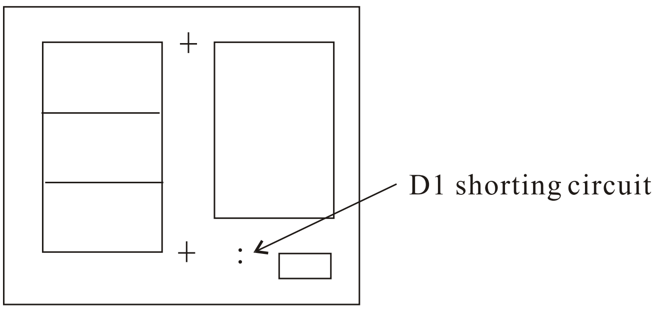
ending:

5. ↓ The timer ending remote controller open circuit (remove the shorting pin)

* Shorting the timer circuit

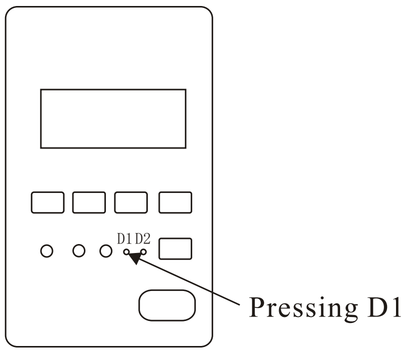
for YR-E02

State when the remote controller cover is dismounted off



For YR-F01

State when the remote controller cover is dismounted off



Short-circuit running of timer:
Besides initial installation, in repairing, shorting the circuit of timer and keeping the state after running can cause disorders as defined in trouble shooting code occurring with concerning protectors. It MUST be paid great attention during such case.

(10) The forced all open function of electronic expand value PMV of the indoors machine.

It is by opening the switch on the outdoor machine to force all the electronic expand valve of indoors machine to all open.

General when powering the indoors machine at the first time the PMV of indoors machine becomes all open, but after this, when powering the machine next time the following method must be used for the PMV all open.

[operating Method].

Set sw01 for " 1 ", sw02 for " 9 ", push sw04 more than 2 seconds . (after this, in two minutes the light LED show " FF ")

[remove].

Tow minutes later, PMV comes back to general opening. (by indoors controlling system, for the outdoor signal, the PMV all open only two minutes)

(11) The electronic expand valve PMV forced all open/all close function of the outdoor machine .

The electronic expand valve PMV forced all open/all close of the outdoor machine can be realized for two minutes.

[all open]

Short the CN30 on the I/F base plate of outdoor machine.

[all close].

Short the CN31 on the I/F base plate of outdoor machine.

[remove].

All open/all close the PMV come back to general two minutes later become opening.

confirm the wire used during short and must be removed.

(12) Indication of telecontrol unit when running power not reach 0.8HP.

When running power of indoors machine is less than 0.8HP(temperature sensor ON), temperature sensor of outdoor machine OFF.

After this , remote controller shows [wait].

When running power of indoors machine reaches 0.8HP(temperature sensor ON), this controlling is released and comes back to usual running.

Test run check form (indoors machine)
[run pattern: refrigerate/ warm]

User										
system name										
room name										
indoors-machine model										
indoors-machine number NO.										
check item	check means	judge standard								
power voltage	multimeter	220V±10%	L N	L N	L N	L N	L N	L N	L N	L N
sucked air temperature	thermometer	difference in temperature refrigerate more than 8 warm more than 15								
blown air temperature	thermometer									
operation sound • vibration	sense of hearing	no abnormal sound • vibration								
system name										
room name										
indoors-machine model										
indoors-machine number NO.										
check item	check means	judge standard								
power voltage	multimeter	220V±10%	R S	R S	R S	R S	R S	R S	R S	R S
sucked air temperature	thermometer	difference in temperature cold room more than 8 warm room more than 15								
blown air temperature	thermometer									
operation sound • vibration	sense of hearing	no abnormal sound • vibration								
measure condition			run for 30 minutes later in the steady condition(wind strong , set temperature :refrigerate 18 warm 29)							

Test run check form (outdoor machine)
[run pattern: refrigerate/warm]

User																	
system name																	
outdoor machine model																	
outdoor machine number																	
check item	check means	judge standard															
power voltage	Multimeter	power end line 380V 10%	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3
operating current	clamp current meter	power wire	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
release pressure	pressure meter	15~21(kg/cm^{2}G)															
inhale pressure	pressure meter	3.0~5.5(kg/cm^{2}G)															
sucked air temperature	Thermometer	out air temperature															
Blown air temperature	Thermometer																
pressure machine frequency (commer-cial ON or OFF	clamp current meter with frequency	30~120Hz (pressure machine wire)	INV Hz commercial ON, OFF			INV Hz commercial ON, OFF			INV Hz commercial ON, OFF			INV Hz commercial ON, OFF			INV Hz commercial ON, OFF		
sound operation	sense of hearing	no abnormal sound															
operation vibration	sense of look	no abnormal vibration															
measure condition			run for 30minutes later, In the steady condition (wind strong , set temperature: refrigerate 18 warm29														

Test running check form

(system selection count form)

check date:

check unit:

check unit:

user		system name	
Outdoor-machine model		Outdoor-machine model	NO.

[run pattern: refrigerate/warm]

<table>
<tr><th></th><th>check item</th><th>check means</th><th>judge standard (objective)</th><th colspan="6">measurement</th><th>Judge -ment</th></tr>
<tr><td rowspan="9">outdoor machine</td><td>power voltage</td><td>multimeter</td><td>380V±10%</td><td>R−S</td><td>V</td><td>S−T</td><td>V</td><td>R−T</td><td>V</td><td></td></tr>
<tr><td>operating current</td><td>clamp current meter</td><td>power wire</td><td>R phase</td><td>A</td><td>S phase</td><td>A</td><td>T phase</td><td>A</td><td></td></tr>
<tr><td>release pressure</td><td>pressure meter</td><td>15~21(kg/cm²G)</td><td colspan="6">kg/cm²G</td><td></td></tr>
<tr><td>inhale pressure</td><td>pressure meter</td><td>3.0~5.5(kg/cm²G)</td><td colspan="6">kg/cm²G</td><td></td></tr>
<tr><td>sucked air temperature</td><td>thermometer</td><td>outside air temperature</td><td colspan="6">℃</td><td></td></tr>
<tr><td>blown air temperature</td><td>thermometer</td><td></td><td colspan="6">℃</td><td></td></tr>
<tr><td>compressor frequency (commercial ONor OFF)</td><td>clamp current meter with frequency</td><td>30~120Hz (compressor wire)</td><td colspan="6">INV Hz
Commercial ON middle, OFF middle</td><td></td></tr>
<tr><td>operation sound</td><td>sense of hearing</td><td>no abnormal sound</td><td colspan="6"></td><td></td></tr>
<tr><td>operation vibration</td><td>sense of look</td><td>no abnormal vibration</td><td colspan="6"></td><td></td></tr>
<tr><td rowspan="20">indoor machine</td><td colspan="3" rowspan="4">indoors machine system name</td><td>1.</td><td>2.</td><td>3.</td><td colspan="3">4.</td><td rowspan="4"></td></tr>
<tr><td>5.</td><td>6.</td><td>7.</td><td colspan="3">8.</td></tr>
<tr><td>9.</td><td>10.</td><td>11.</td><td colspan="3">12.</td></tr>
<tr><td>13.</td><td>14.</td><td>15.</td><td colspan="3">16.</td></tr>
<tr><td rowspan="4">power voltage</td><td rowspan="4">multimeter</td><td rowspan="4">220V±10%</td><td>1.</td><td>2.</td><td>3.</td><td colspan="3">4.</td><td rowspan="4"></td></tr>
<tr><td>5.</td><td>6.</td><td>7.</td><td colspan="3">8.</td></tr>
<tr><td>9.</td><td>10.</td><td>11.</td><td colspan="3">12.</td></tr>
<tr><td>13.</td><td>14.</td><td>15.</td><td colspan="3">16.</td></tr>
<tr><td rowspan="4">sucked air temperature</td><td rowspan="4">thermometer</td><td rowspan="8">difference in temperature refrigerate more than 8 warm more than 15</td><td>1.</td><td>2.</td><td>3.</td><td colspan="3">4.</td><td rowspan="4"></td></tr>
<tr><td>5.</td><td>6.</td><td>7.</td><td colspan="3">8.</td></tr>
<tr><td>9.</td><td>10.</td><td>11.</td><td colspan="3">12.</td></tr>
<tr><td>13.</td><td>14.</td><td>15.</td><td colspan="3">16.</td></tr>
<tr><td rowspan="4">blown air temperature</td><td rowspan="4">thermometer</td><td>1.</td><td>2.</td><td>3.</td><td colspan="3">4.</td><td rowspan="4"></td></tr>
<tr><td>5.</td><td>6.</td><td>7.</td><td colspan="3">8.</td></tr>
<tr><td>9.</td><td>10.</td><td>11.</td><td colspan="3">12.</td></tr>
<tr><td>13.</td><td>14.</td><td>15.</td><td colspan="3">16.</td></tr>
<tr><td rowspan="4">running sound/ vibration</td><td rowspan="4">sense of hearing</td><td rowspan="4">no abnormal sound /vibration</td><td>1.</td><td>2.</td><td>3.</td><td colspan="3">4.</td><td rowspan="4"></td></tr>
<tr><td>5.</td><td>6.</td><td>7.</td><td colspan="3">8.</td></tr>
<tr><td>9.</td><td>10.</td><td>11.</td><td colspan="3">12.</td></tr>
<tr><td>13.</td><td>14.</td><td>15.</td><td colspan="3">16.</td></tr>
</table>

Test run check form (indoors machine)
[run pattern :refrigerate warm]

user										
system name			A-1-1	A-1-2	A-1-3	A-1-4	A-1-5	A-2-1	A-2-2	A-2-3
room name			6F office room	6F office room	6F office room	6F reception room 1	6F reception room 2	5F meeting room 1	5F meeting room 2	5F dressing room
indoors-machine model			AB242FEAIA	AB242FEAIA	AB242FEAIA	AB242FEAIA	AB122FEAIA	AB242FEAIA	AB242FEAIA	AB092FEAIA
indoors-machine number NO.			NO.50100050	NO.50100051	NO.50100055	NO.50100070	NO.50100071	NO.50100052	NO.50100053	NO.50100080
Check item	Check means	judge standard								
power voltage	multimeter	220V±10%	L - N	L - N	L - N	L - N	L - N	L - N	L - N	L - N
			222	222	222	222	222	222	220	220
sucked air temperature	thermometer	difference in temperature refrigerate more 8 warm more than 15	27.0	27.2	27.1	26.8	27.0	26.7	26.6	27.0
blown air temperature	thermometer		17.0	17.3	17.0	16.9	16.0	16.7	16.7	16.9
operation sound • vibration	sense of hearing	no abnormal sound • vibration	no	no	no	no	no	no	no	no
system name			A-2-4	A-2-5	A-3-1	A-3-2	A-3-3	A-3-4	A-3-5	
room name			5F negotiation room 1	5F negotiation room 2	4F office room	4F office room	4F office room	4FOA room	4F negotiation room	
indoors-machine model			AB182FEAIA	AB182FEAIA	AB182FEAIA	AB182FEAIA	AB162FEAIA	AB122FEAIA	AB092FEAIA	
indoors-machine number NO.			NO.50100091	NO.50100092	NO.50100093	NO.50100095	NO.50100041	NO.50100073	NO.50100081	
Check item	Check means	judge standard								
power voltage	multimeter	220V±10%	L - N	L - N	L - N	L - N	L - N	L - N	L - N	L - N
			222	222	220	220	220	220	220	
sucked air temperature	thermometer	difference in temperature cold room more than 8 warm room more than 15	26.9	27.0	27.1	27.0	27.2	27.0	27.1	
blown air temperature	thermometer		17.0	17.0	17.0	16.9	17.2	16.5	17.0	
operation sound • vibration	sense of hearing	no abnormal sound • vibration	no	no	no	no	no	no	no	no
measure condition			run for 30 minutes later in the steady condition(wind strong , set temperature : refrigerate 18 warm 29)							

Test run check form (outdoor machine)
[run pattern: warm]

user																	
system name			A-1			A-2			A-3			A-4			A-5		
outdoor machine model			AU96NFTAHA			AU96NFTAHA			AU96NFTAHA			AU96NFTAHA			AU96NFTAHA		
outdoor machine number			NO.50100005			NO.50100007			NO.50100020			NO.50100021			NO.50100030		
check item	check means	judge standard	MEASURE VALUE			MEASURE VALUE			MEASURE VALUE			MEASURE VALUE			MEASURE VALUE		
power voltage	Multimeter	power end line 380V 10%	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3	L1-L2	L2-L3	L1-L3
			222	223	224	222	222	222	220	220	218	220	220	220	220	220	220
operating current	clamp current meter	power wire	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
			28	28	27	27	27	26	28	28	27	27	27	26	28	28	27
release pressure	pressure meter	15~21(kg/cm²G)	19.5			19.0			18.8			19.2			19.5		
inhale pressure	pressure meter	3.0~5.5(kg/cm²G)	4.5			4.2			4.5			4.2			4.3		
sucked air temperature	thermometer	out air temperature(℃)	30.0			30.0			30.0			30.2			30.2		
blown air temperature	thermometer	(℃)	41.0			40.0			39.5.			39.5			40.0		
compressor frequency (commercial ON or OFF)	clamp current meter with frequency	30~120Hz (compressor wire)	INV 75 Hz commercial OFF			INV 70 Hz commercial OFF			INV 80 Hz commercial OFF			INV 83 Hz commercial OFF			INV 90 Hz commercial OFF		
operation sound	sense of hearing	no abnormal sound	no abnormal			no abnormal			no abnormal			no abnormal			no abnormal		
operation vibration	sense of look	no abnormal vibration	no abnormal			no abnormal			no abnormal			no abnormal			no abnormal		
measure condition			run for 30minutes later, in the steady condition (wind strong , set temperature:refrigerate18 warm 29)														

Test running check form

(system selection count form)

check date:

check unit:

check unit:

User		system name	A-1
Outdoor-machine model	AU96NFTAHA	Outdoor-machine model	NO.50100005

[run pattern:warm]

	check item	check means	judge standard (objective)	measurement						Judge -ment
outdoor machine	power voltage	multimeter	380V±10%	L1-L2	220V	L2-L3	222V	L1-L3	220V	OK
	operating current	clamp current meter	power wire	L1phase	28A	L2phase	29A	L3phase	28A	OK
	release pressure	pressure meter	15~21(kg/cm²G)	19.5kg/cm²G						OK
	inhale pressure	pressure meter	3.0~5.5(kg/cm²G)	4.5kg/cm²G						OK
	sucked air temperature	thermometer	outside air temperature	30.0℃						OK
	blown air temperature	thermometer		41.0℃						OK
	pressure machine frequency (commercial ONor OFF)	clamp current meter with frequency	30~120Hz (compressor wire)	INV >5 Hz commercial OFF middle						OK
	operation sound	sense of hearing	no abnormal sound	NO						
	operation vibration	sense of look	no abnormal vibration	NO						

	check item	check means	judge standard	measurement				Judge -ment
indoor machine	indoors machine system name			1. A-1-1	2. A-1-2	3. A-1-3	4. A-1-4	
				5. A-1-5	6.	7.	8.	
				9.	10.	11.	12.	
				13.	14.	15.	16.	
	power voltage	multimeter	220V±10%	1. 220	2. 220	3. 220	4. 220	
				5. 220	6.	7.	8.	
				9.	10.	11.	12.	
				13.	14.	15.	16.	
	sucked air temperature	thermometer	difference in temperature refrigerate more than 8 warm more than 15	1. 27.0	2. 27.2	3. 27.1	4. 26.8	
				5. 27.0	6.	7.	8.	
				9.	10.	11.	12.	
				13.	14.	15.	16.	
	blown air temperature	thermometer		1. 17.0	2. 17.3	3. 17.0	4. 16.9	
				5. 16.9	6.	7.	8.	
				9.	10.	11.	12.	
				13.	14.	15.	16.	
	operation sound/ vibration	sense of hearing	no abnormal sound /vibration	1. NO	2. NO	3. NO	4. NO	
				5. NO	6.	7.	8.	
				9.	10.	11.	12.	
				13.	14.	15.	16.	

5-8 Pay attention to the refrigerant leakage

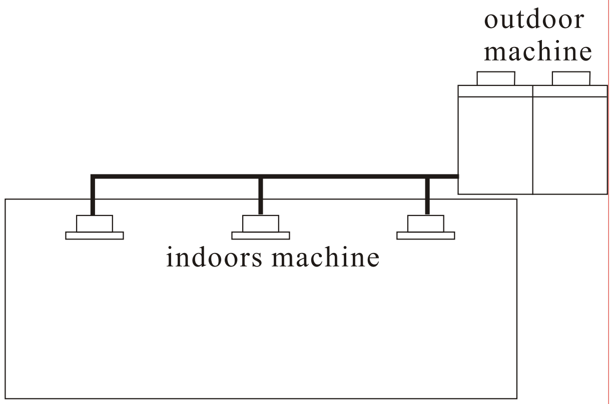
Note item for refrigerant leakage:

Introduction:

Like other air conditioning system the MRV system use the R-22 for refrigerant R-22 is no poison, no ignition and is safe refrigerant. But the care must be taken, the air conditioning equipment shall not be too big. In abnormal condition the density of refrigerant leaking from system shall conform with local rules and standard.

*Maximum density

Maximum leaking quantity and maximum density of refrigerant are relative to allowable leaky quantity of the room with the person. The unit of density is Kg/m^2 (refrigerant weight per cubic meter volume) or conform with local rules and standard. The maximum density of refrigerant R22in space with person is limited as $0.3Kg/m^2$.



Steps to check dangerous density

Check dangerous density according to the following steps 1 - 4

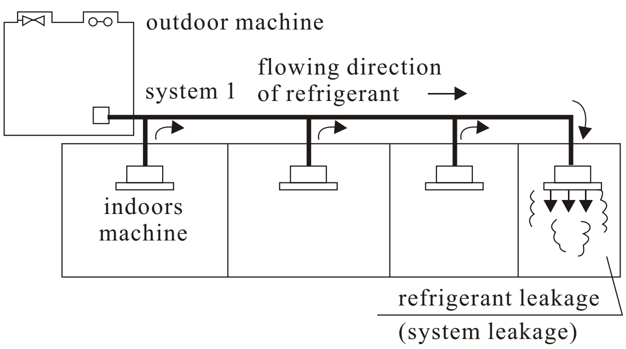
(1) Calculate the adding quantity of refrigerant independently for every system. (refrigerant quantity of single indoors machine)+(additional quantity)=total refrigerant quantity(Kg) in the system (including added quantity of refrigerant before come out from factory and supplementary quantity of refrigerant according laying cold medium tube)

Note :only when the single refrigerant equipment be divided as independent system it is can be added as a single system.

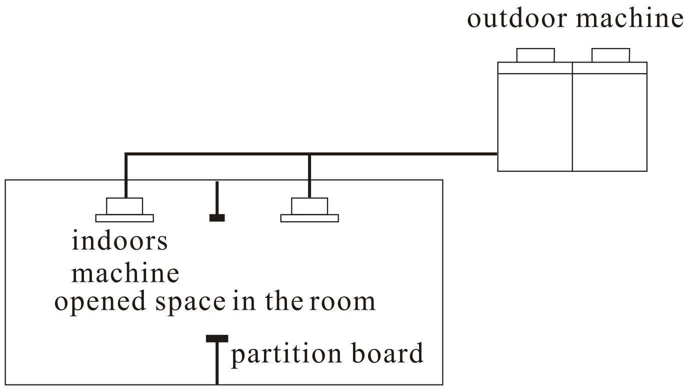
(2)Calculate the volume of minimum room

when calculate the volume in the following condition(a)(b)can be calculated as a independent room or minimum room.

(a)No minimum room divided



(b)Room be divided, but there are no enough opening allowing air to flow



(There is no door but there is opening ,or the opening orient upward or downward, it is can be calculated as 15% of the room volume)

(3)Calculate the density of refrigerant by the outcome of step (1)(2):

Total quantity of refrigerant/volume(m^3) of the minimum room with indoors machine dangerous density(Kg/m^3)

If the calculating result according this form exceeds the dangerous density , it shall be calculate for the second /third minor room in order , until the calculating result is less than dangerous density.

(4)Handing method for the result exceeding maximum value

when the density of refrigerant exceeds the maximum value the design can be revised, please consult with Haier provider

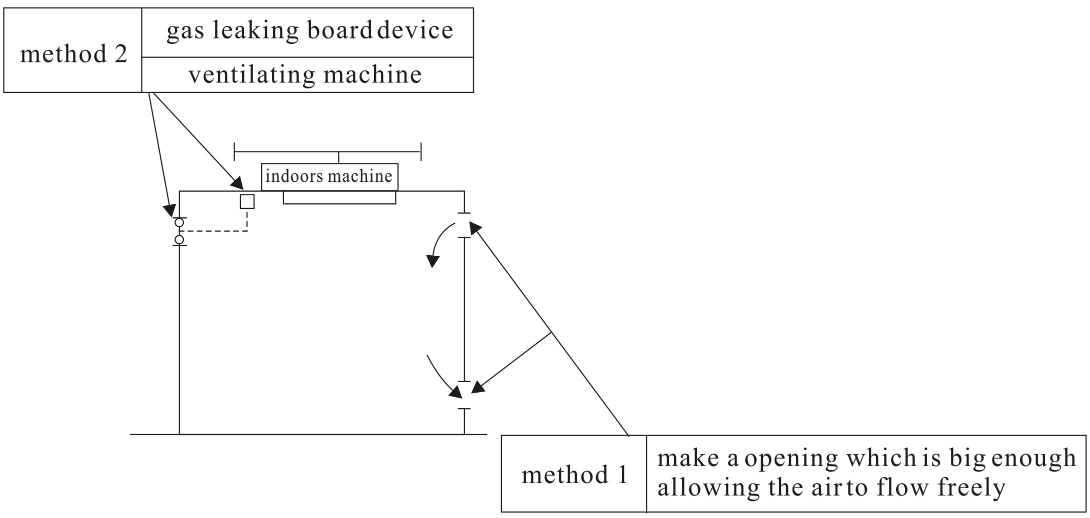
(5)Handling method for the result exceeding dangerous value

When the density of refrigerant exceeds the dangerous value, the design must be revised or handle according to following methods:

Method1: Make a opening allowing air to flow freely

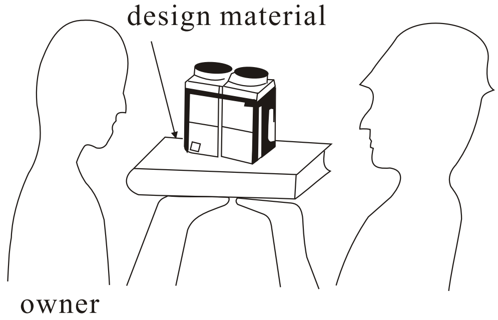
On upper or lower part of the door make some openings which area is 15%of the door or make some openings which are not doors on the wall.

Method2:install a ventilating machine which links up with the air leaking warning unit.



5-9 Deliver the machine to owner

● operating step	Test run in good condition →	final report (test run check report) →	explain how to operate the machine →	deliver the related printing material

(1) main point	a. Note the measurement value of test run in test report. b .Do not forget to note the length of the cold media tube and the supplementary quantity of the refrigerant on the note board on back of the system for using to check and repair the system. c. Tell the owner how to operate the equipment and let him to practice. d. Bind up the chart, diagram and data of the system as a book, and hand over it to the owner and tell him to preserve properly. detailed list of delivered system listed blueprint ……it is necessary to prepare a set of operating chart for using to comprehend the operating system of refrigerant system. a set of operating guide name of the principal (address for affiliation in urgent condition) A written pledge of the system e. Write the serve address clearly. 

TECHNICAL PARAMETER FORM

Technical parameter form for four-direction air out cassette air conditioner.

Indoors machine model		specification									
MRV-network frequency-conversion central air condition system		AB092FEAIA	AB122FEAIA	AB142FEAIA	AB162FEAIA	AB182FEAIA	AB242FEAIA	AB282FEAIA	AB322FEAIA	AB362FEAIA	AB452FEAIA
refrigeration capacity (BTU/h)		9000	12000	14000	16000	18000	24000	28000	32000	36000	45000
warming capacity (BTU/h)		11000	14000	16000	17000	21000	28000	32000	34000	43000	55000
electric charac-teristic	electric power	single phase 220V, 50Hz									
	operating current(A)	0.26	0.26	0.26	0.26	0.5	0.5	0.6	1.0	1.0	1.0
	consume power (KW)	0.053	0.053	0.053	0.053	0.1	0.1	0.12	0.2	0.2	0.2
	power element%	94	94	94	94	93	93	93	94	94	94
	starting current (A)	0.6	0.6	0.6	0.6	0.8	0.8	0.8	1.8	1.8	1.8
exterior	body	Zn-plating steel plate with heat-preservation material									
	color of face plate	milky white									
exterior measurement	body (mm)	660 270 660				840 240 840			840 280 1230		
	face plate (mm)	750 80 750				950 80 950			950 80 1340		
total mass(Kg)	body	27				30			48.4		
	face plate	3.5				6.0			8.4		
fashion to deliver wind		direct									
thermo-exchanger		bend slice tube									
sound-insulation heat-preservation material		polyprene									
device to deliver wind	deliver-wind machine	eddy wind-machine									
	flow(m^3/h)	870				1020			1920		
	out pover of motor(W)	42								90	
dust filter		enclosed in the face-plate									
run-regulating device		wire-control device									
diameter of matching tube	gas side (mm)	ϕ 12.7				ϕ 15.88				ϕ 19.05	
	liquid side(mm)	ϕ 6.35				ϕ 9.52				ϕ 9.52	
	exit for water draining(mm)	ϕ 32									
noise value dB(A)		36/34/32				36/34/32		38/35/32	42/37		

Technical parameter form for convertible air conditioner

Indoors machine model		specification				
MRV-network frequency-conversion central air condition system		AC092FEAHA	AC122FEAHA	AC162FEAHA	AC182FEAHA	AC242FEAHA
refrigeration capacity (BTU/h)		9000	12000	16000	18000	24000
warming capacity (BTU/h)		11000	14000	17000	21000	28000
electric charac-teristic	electric power	single phase 220V, 50Hz				
	operating curret(A)	0.26	0.26	0.26	0.5	0.5
	consuming power (KW)	0.055	0.055	0.055	0.1	0.1
	power element%	94	94	94		94
	starting current (A)	0.6	0.6	0.6	0.8	0.8
exterior	body	Zn-plating steel plate with heat-preservation material				
	color of face plate	milky white				
exterior measurement	body (mm)	990 199 655			1320 235 715	
	total mass (Kg)	29	29	29	48	48
fashion to deliver wind		direct				
thermo-exchanger		bend slice tube				
sound-insulation heat-preservation material		polyprene				
device to deliver wind	deliver-wind machine	two head centrifugal air machine				
	flow(m^3/h)	830	830	830	1000	1000
	out power of motor (W)	34	34	34	34	34
dust filter		enclosed in the aircloset				
run-regulating device		wire-control device				
diameter of matching tube	gas side (mm)	ϕ 12.7	ϕ 12.7	ϕ 12.7	ϕ 15.88	ϕ 15.88
	liquid side (mm)	ϕ 6.35	ϕ 6.35	ϕ 6.35	ϕ 9.52	ϕ 9.52
	exit for water draining (mm)	ϕ 21	ϕ 21	ϕ 21	ϕ 26	ϕ 26
noise value dB(A)		42/38/36	42/38/36	41/37/35	42/38/36	42/38/36

■ These parameter only for reference, when there is difference comply with practice machine.

TECHNICAL PARAMETER FORM

Technical parameter form for cassette hind air conditioner

Technical parameter form for high static pressure air duct air conditioner

Indoors machine model		Specification		
MRV-networkfrequency-conversion central air condition system		AD322FIAHA	AD362FIAHA	AD452FIAHA
refrigeration capacity (BTU/h)		32000	36000	45000
warming capacity (BTU/h)		34000	43000	55000
electric charac-teristic	electric power	single phase 220V, 50Hz		
	operating current (A)	1.48	1.48	1.64
	consuming power (KW)	0.26	0.32	0.36
	power element%	96	98	98
	starting current (A)	3.5	4.1	4.8
exterior exterior measurement	body	Zn-plating steel plate withheat-preservation material		
	body(mm)			1200 830 360
total mass (Kg)		62	62	62
fashion to deliver wind		delivery air by tube		
thermo-exchanger		bend slice tube		
device to deliver wind	sound-insulation heat-preservation material	Polyprene		
	deliver-wind machine	two head centrifugal airmachine		
	flow(m^3/h)	1560	1600	2100
	out power of motor (W)	260	260	260
run-regulating device		wire-control device		
diameter of matching tube	gas side (mm)	ϕ 19.05	ϕ 19.05	ϕ 19.05
	liquid side (mm)	ϕ 9.52	ϕ 9.52	ϕ 9.52
	exit for water draining (mm)	ϕ 32	ϕ 32	ϕ 32
noise value dB (A)		40	40	40

Technical parameter form for wall mounted air conditioner

Indoors machine model		Specification					
MRV-networkfrequency-conversion central air condition system		AS072FAAHA	AS092FAAHA	AS122FAAHA	AS142FAAHA	AS162FAAHA	AS182FAAHA
refrigeration capacity (BTU/h)		7000	9000	12000	14000	16000	18000
warming capacity (BTU/h)		9000	11000	14000	16000	17000	21000
electric charac-teristic	electric power			single phase 220V, 50Hz			
	operating current (A)	0.26	0.26	0.26	0.26	0.46	0.46
	consuming power (KW)	0.053	0.053	0.053	0.053	0.09	0.09
	power element%	94	94	94	94	94	94
	starting current (A)	0.6	0.6	0.6	0.6	0.8	0.8
exterior exterior measurement	body	Zn-plating steel plate withheat-preservation material					
	color of face plate	milky white					
	body (mm)	938 182 265				1155 308 224	
	total mass(Kg)	11	11	11	11	16	16
fashion to deliver wind		delivery air by tube					
thermo-exchanger		bend slice tube					
sound-insulation heat-preservation material			polyprene				
device to deliver wind	deliver-wind machine	flow through wind machine					
	flow(m^3/h)	600	600	600	600	1150	1150
	out power of motor (W)	30	30	30	30	30	30
dust filter			enclosed in the aircloset				
run-regulating device	dust filter	wire-control device					
diameter of matching tube	gas side (mm)		ϕ 12.7				ϕ 15.88
	liquid side (mm)		ϕ 6.35				ϕ 9.52
	exit for water draining (mm)	ϕ 20					
noise value dB (A)			41 33			42/35	43/35

■ These parameter only for reference, when there is difference comply with practice machine.

TECHNICAL PARAMETER FORM

Technical parameter form for two-direction airout cassette air conditioner

Indoors machine model		specification			
MRV-networkfrequency-conversion central air condition system		AB072FDAHA	AB092FDAHA	AB122FDAHA	AB142FDAHA
refrigeration capacity (BTU/h)		7000	9000	12000	14000
warming capacity (BTU/h)		9000	11000	14000	16000
electric charac-teristic	electric power	single phase 220V, 50Hz			
	operating current (A)	0.35	0.35	0.35	0.35
	consuming power (KW)	0.07	0.07	0.07	0.07
	power element%	88	88	88	88
	starting current (A)	0.6	0.6	0.6	0.8
exterior	body	Zh-plating steel plate withheat-preservation material			
	color of face plate	milky white			
exterior measurement	body (mm)	550 398 830			
	face plate (mm)	1000 620 75			
total mass(Kg)	body	33			
	face plate	8			
fashion to deliver wind		Direct			
thermo-exchanger		bend slice tube			
sound-insulation heat-preservation material		Polyprene			
device to deliver wind	deliver-wind machine	two head centrifugal air machine			
	flow(m^3/h)	570		780	
	out power of motor (W)	75			
dust filter		enclosed in the face-plate			
run-regulating device		wire-control device			
diameter of matching tube	gas side (mm)	ϕ 12.7			
	liquid side (mm)	ϕ 6.35			
	exit for water draining (mm)	ϕ 25			
noise value dB (A)		34/32/30			

Technical parameter form for outdoor-machine

Indoors machine model		specification	
MRV-networkfrequency-conversion central air condition system		AU96NFTAHA	AU55NFUAHA
refrigeration capacity (BTU/h)		85000(96000)	48000(55000)
warming capacity (BTU/h)		89000(107500)	48000(55000)
electric charac-teristic	electric power	three phase 380V, 50Hz	
	operating current (A)	17.0(26.5)	9.2(11.0)
	consuming power (KW)	10.6(16.5)	5.5(7.0)
	power element%	96(97)	91(96)
	operating current (A)	16(20.0)	9.1(11.1)
	consuming power (KW)	10.0(12.9)	5.4(7.0)
	power element%	97(98)	91(95)
exterior color		ivory white	
esterior measurement (mm)		1290 750 1580	640 750 1500
total mass (Kg)		304	173
compressor	type	type closed completely	type closed completely
	out power of motor (KW)	7.5	4.1
	Cooling method	Wind cooling type	
device to deliver wind	deliver-wind machine	axial flow wind machine	
	flow (m^3/h)	10000	5000
	out power of motor (W)	0.15 2	0.15
	Refrigerant and its quantity	R22(18.0)	R22(10.0)
	Maximum number of thelinked indoors machine	16	9
	Heating power of the crankshaft box (W)	74	40
diameter of matching tube	gas side (mm)	ϕ 28.6	ϕ 22.2
	liquid side (mm)	ϕ 12.7	ϕ 9.52
	link fashion	liquid side: enlargediameter, gas side: weld	
	maximum commensurate length (m)	125	125
	maximum (m)	100	100
	maximum drop (m)	50	50
	maximum (m)	250	220
noise value dB (A)		60	58
Protection device		meltable embolism, thermo-switch compressorexhaust, back-air temperature sensor, high/low pressure sensor, highpressure press-switch, overloading protectdevice, over current sensor.	

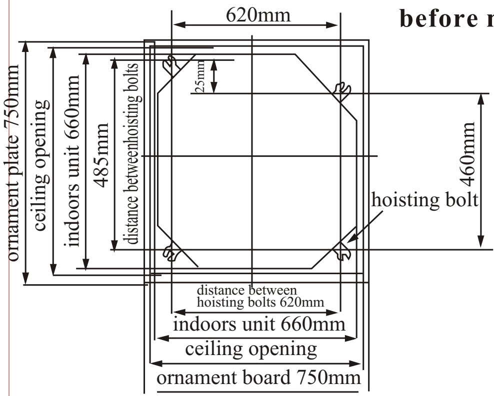
① mounting engineering practice for cassette air conditioner

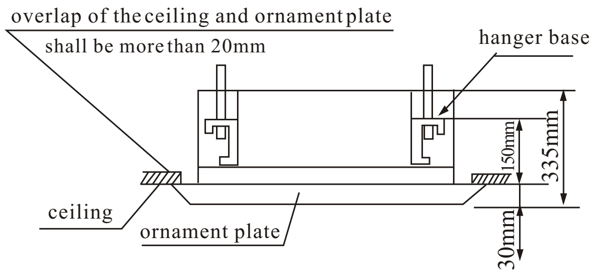
mounting engineering practice

mounting schematic diagram
for cassette type

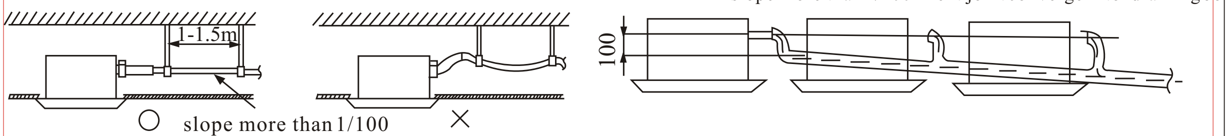
match with building before mounting

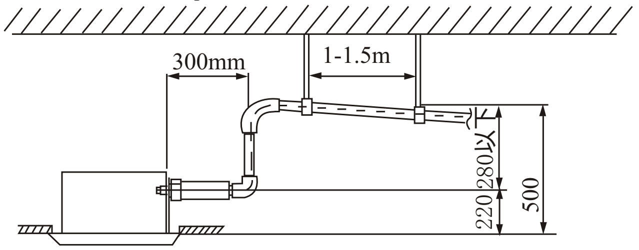
special power wire must be used for air conditioner
special switch (20A-30A) is prepared by the user
parameter of power wire :3 2.5mm²

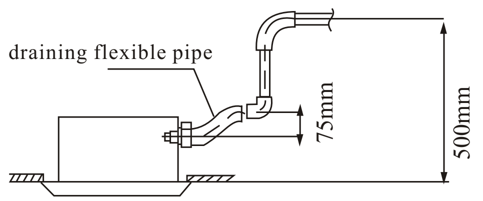




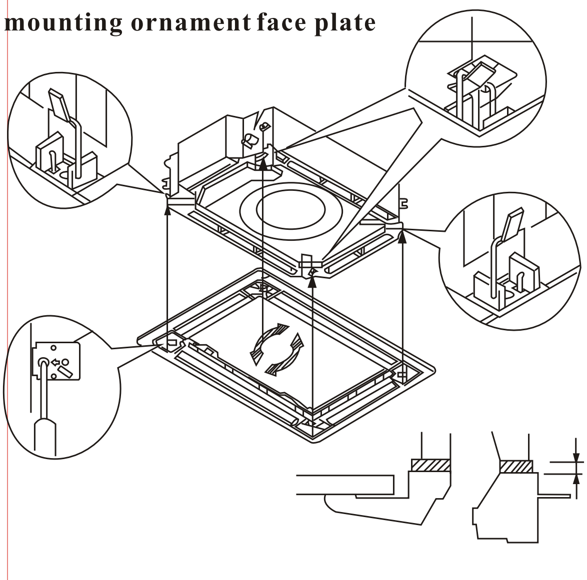
mount water draining tube



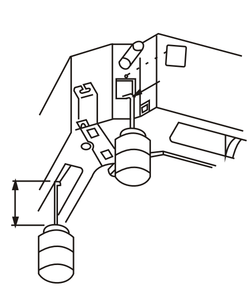




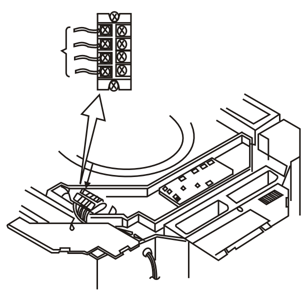
mounting ornament face plate



draining test

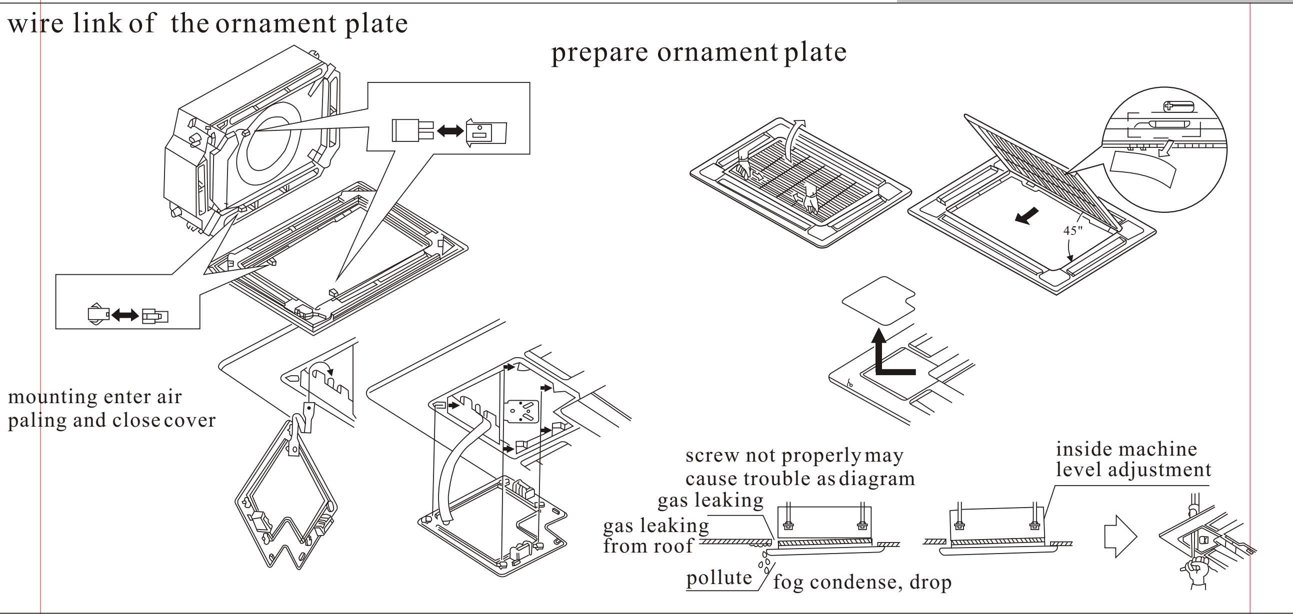


mounting electric section



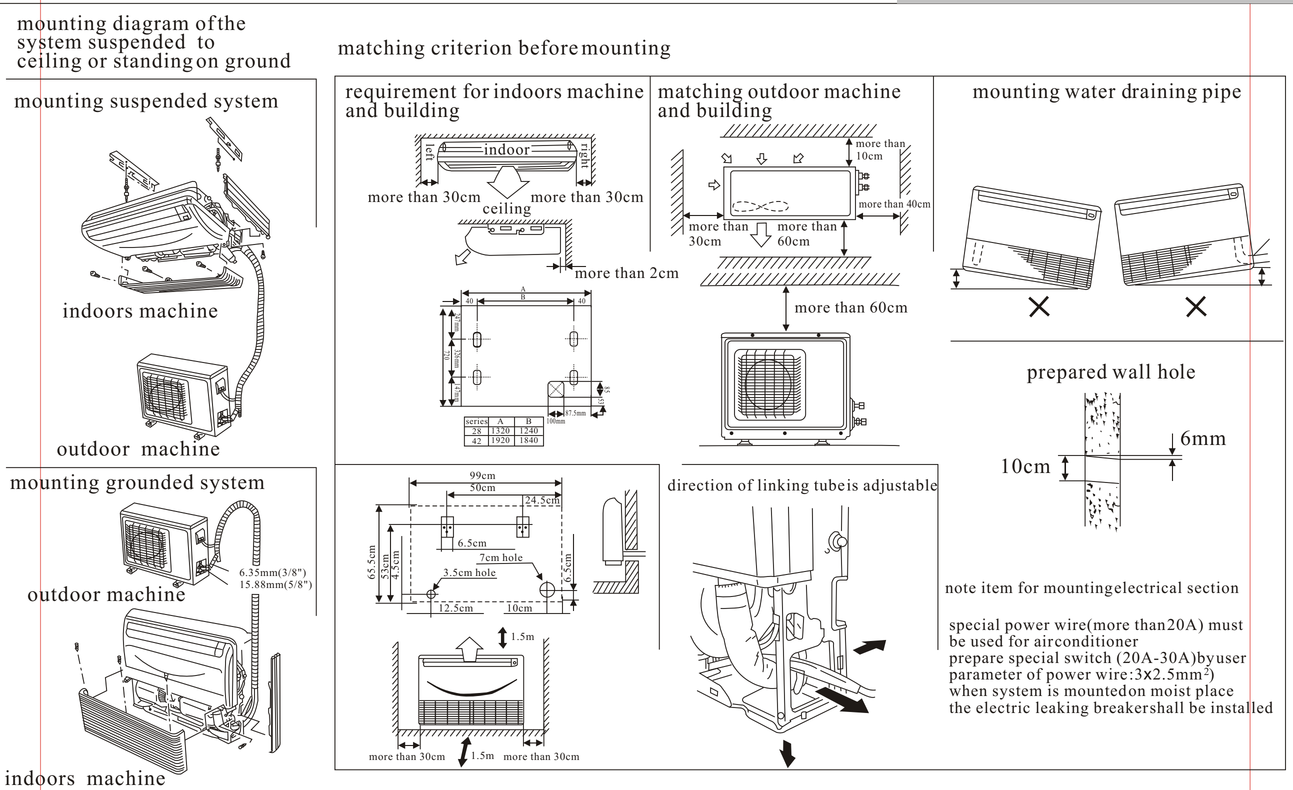
② mounting matching on worksite for cassette air conditioner

mounting engineering practice

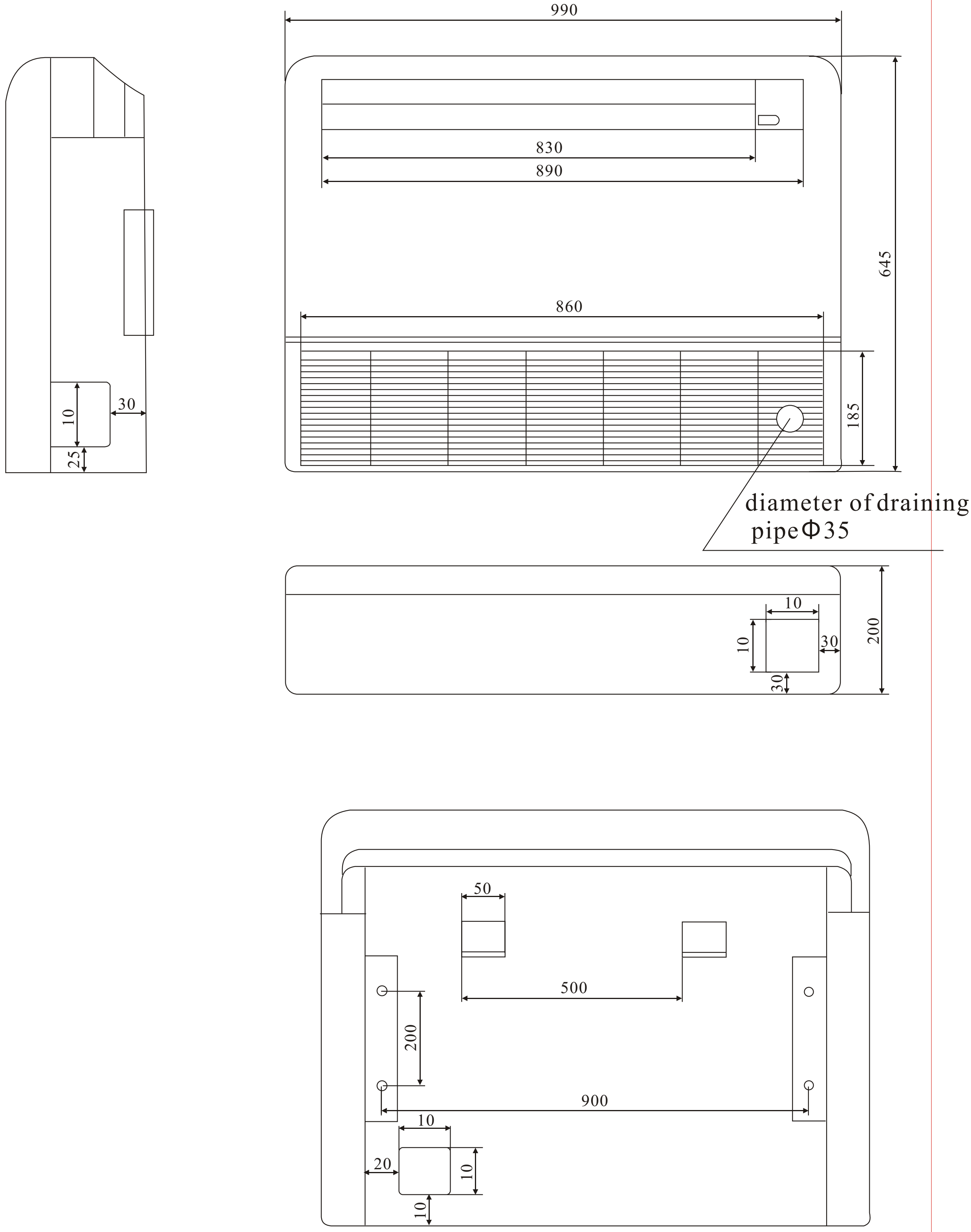


③ mounting matching on work site for convertible air conditioner

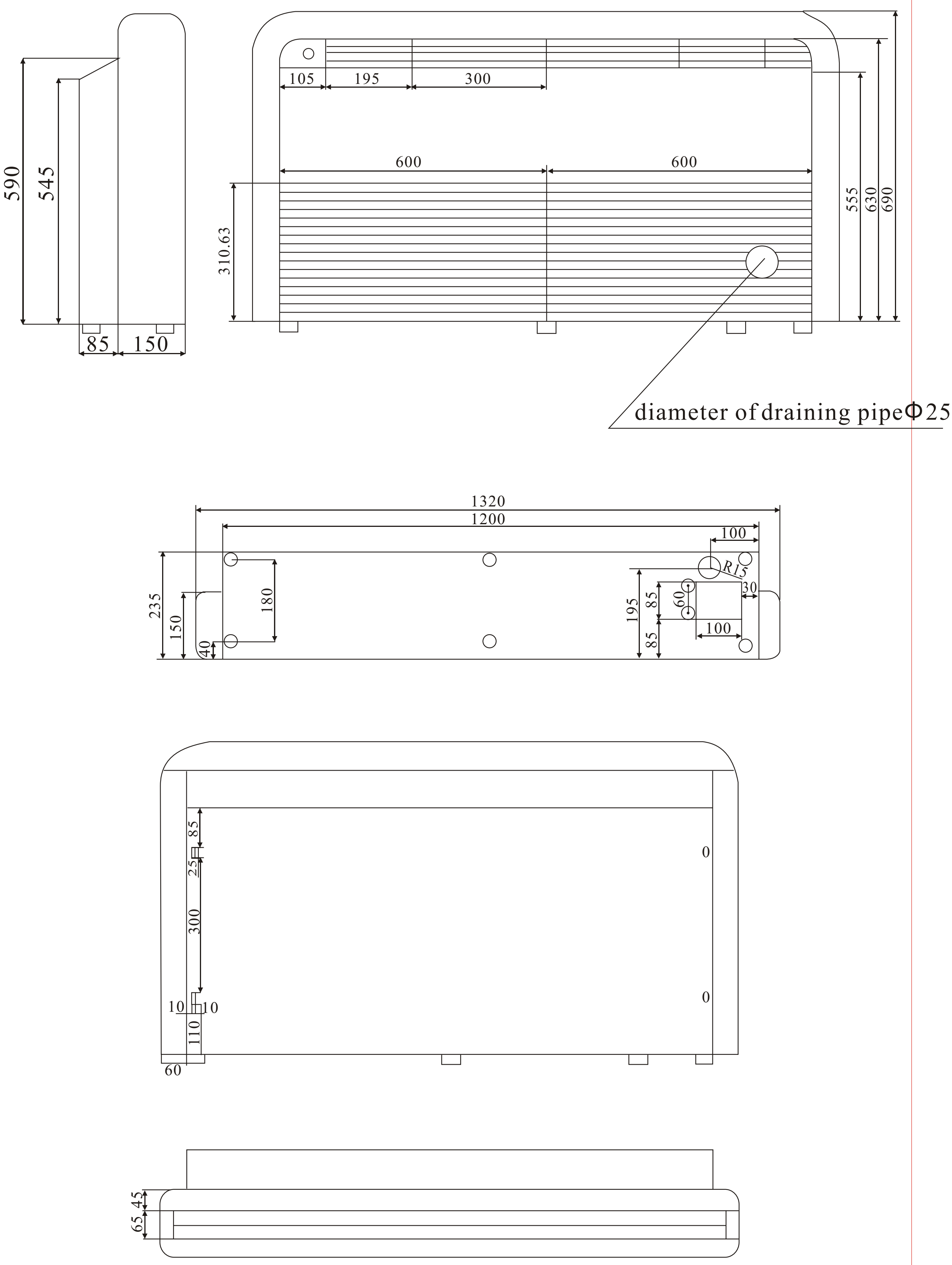
mounting engineering practice



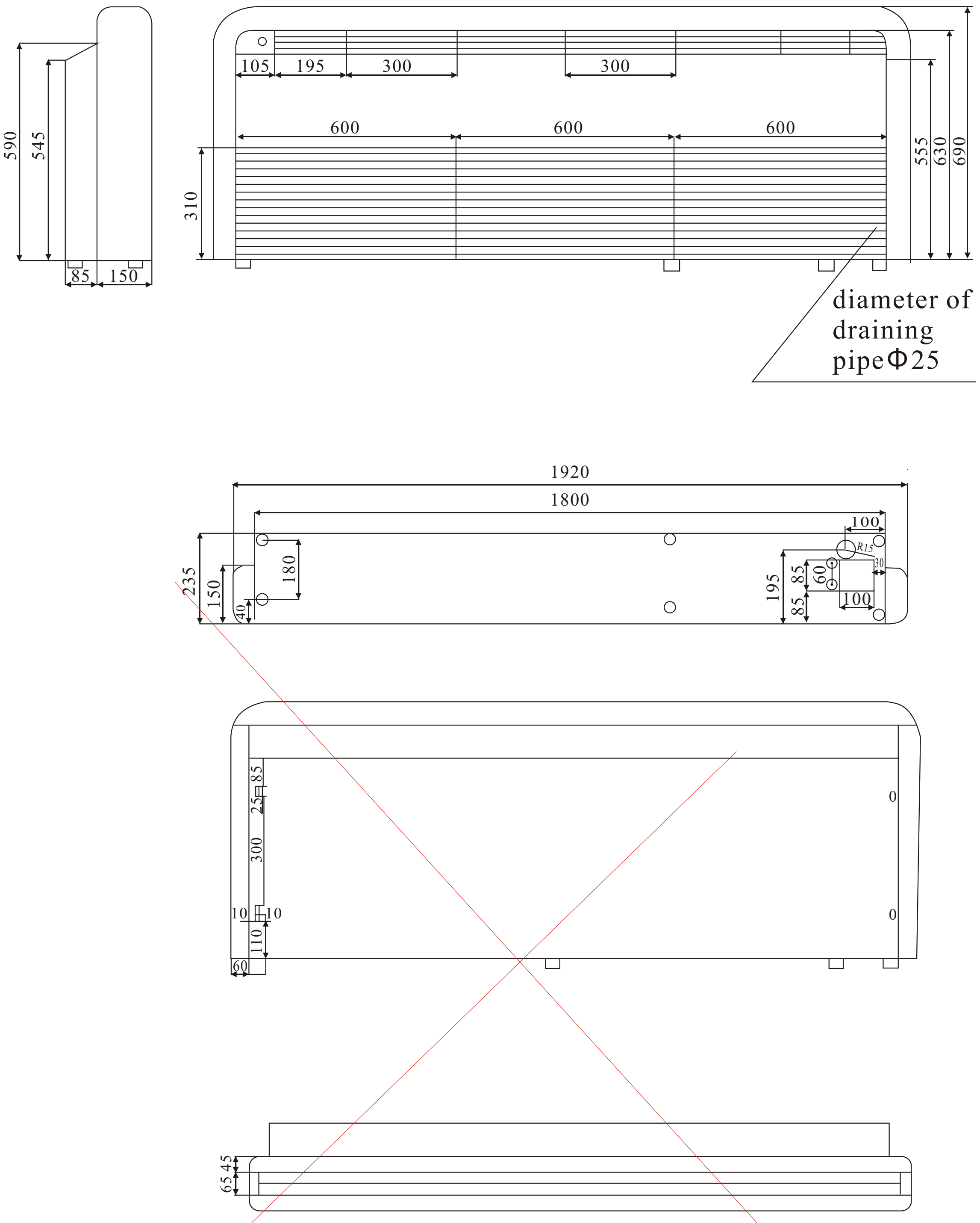
mounting dimension diagram for convertible air conditioner 2HP:



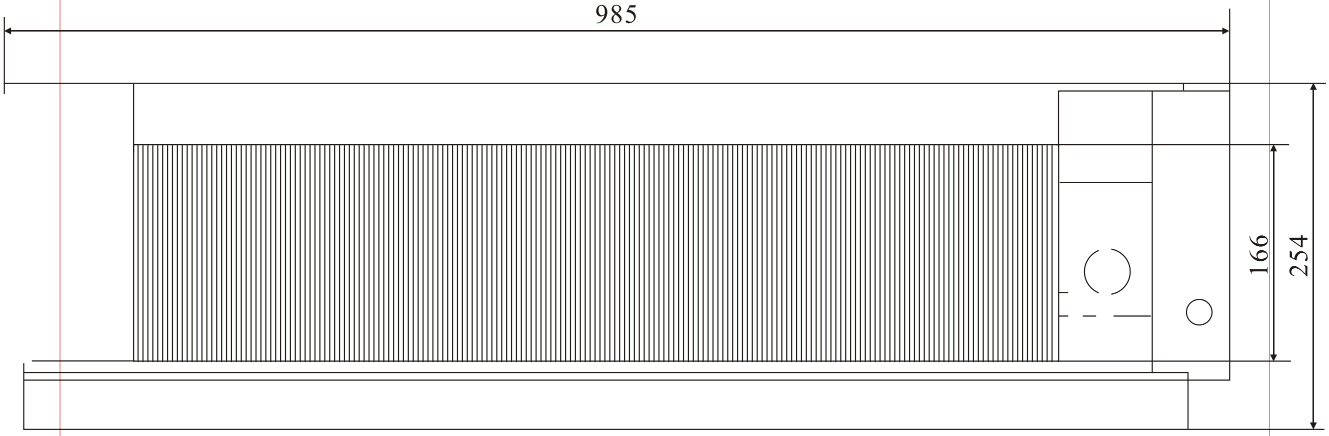
mounting dimension diagram for convertible air conditioner 3HP:

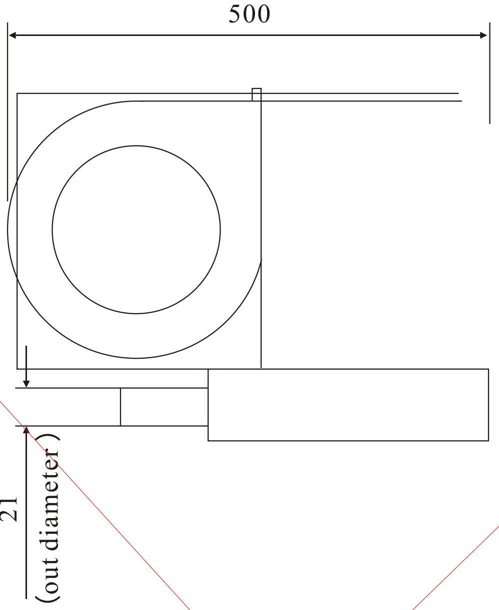


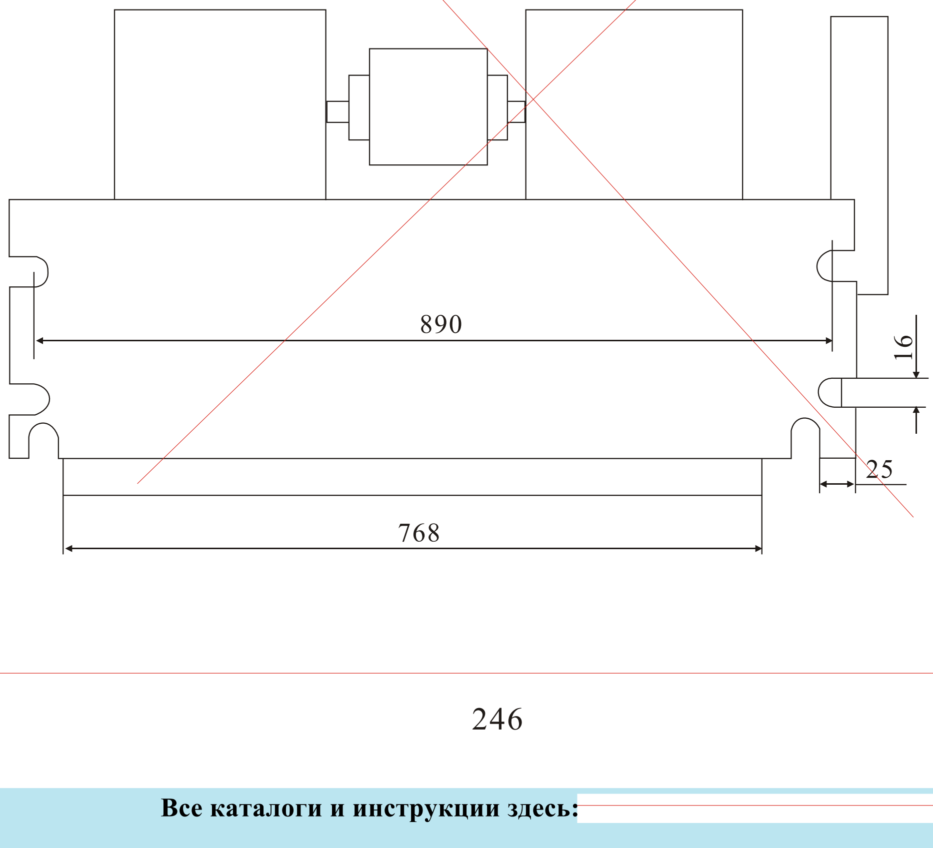
mounting dimension diagram for convertible air conditioner 5HP:



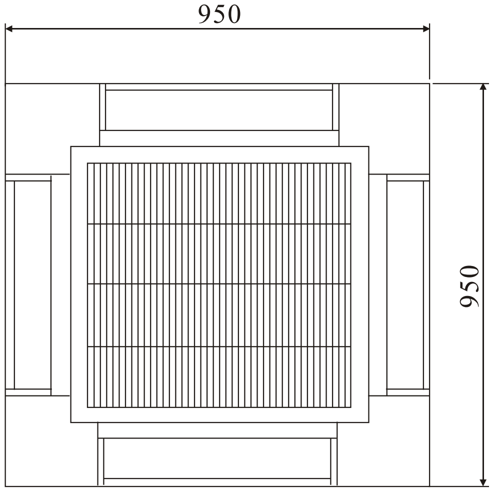
mounting dimension diagram cassette hind air conditioner:

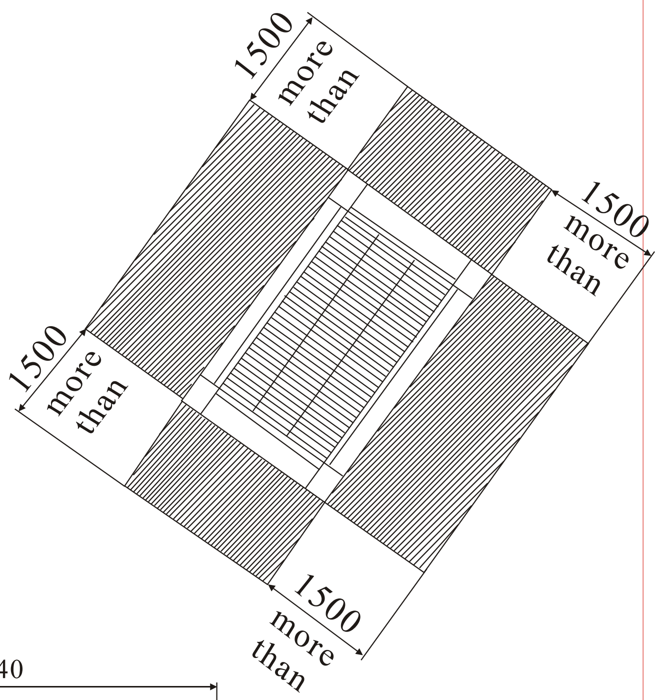


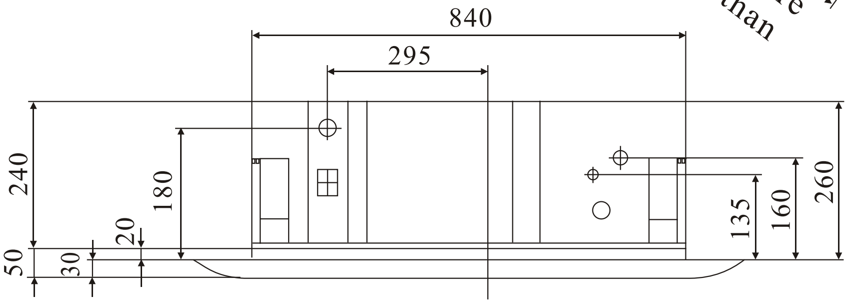


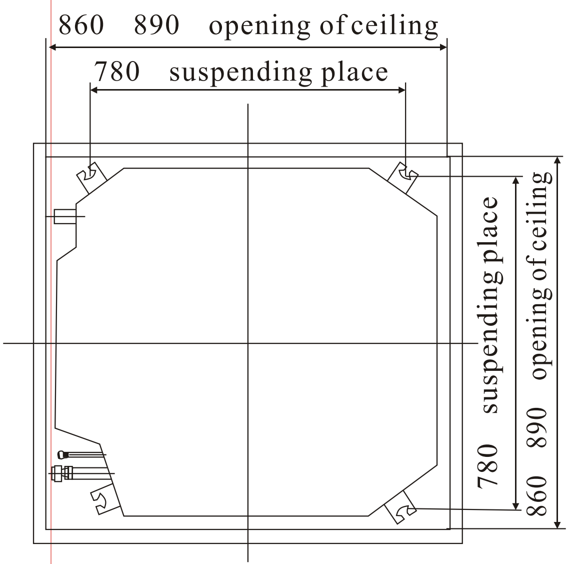


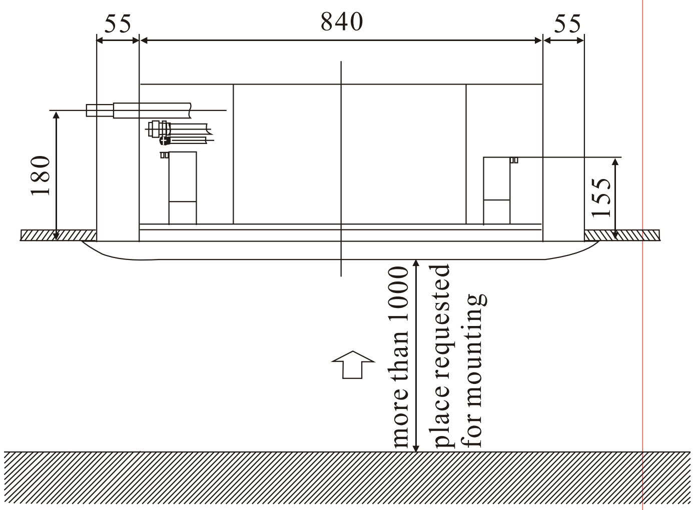
mounting dimension for cassette air conditioner 3HP:



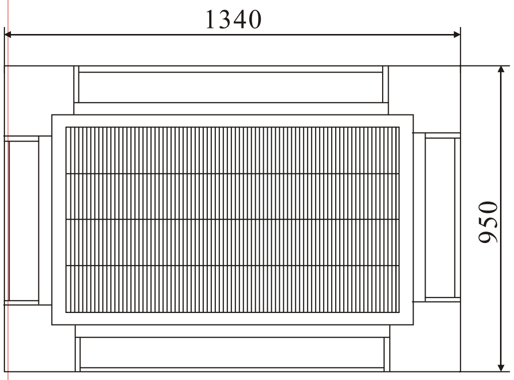


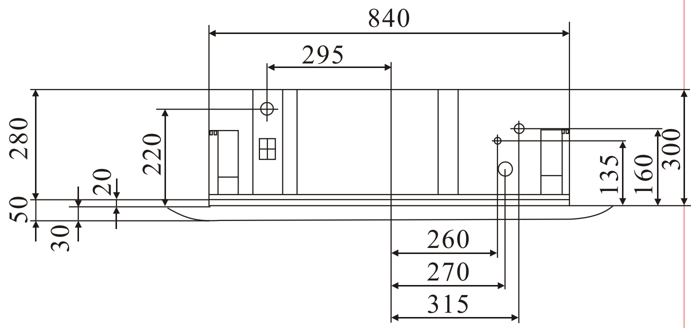


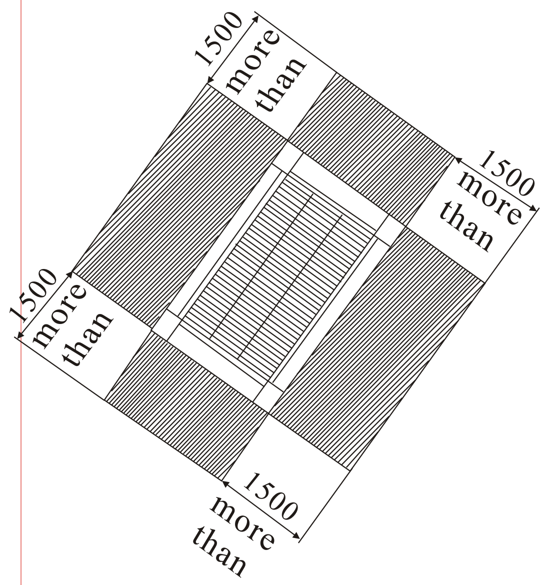


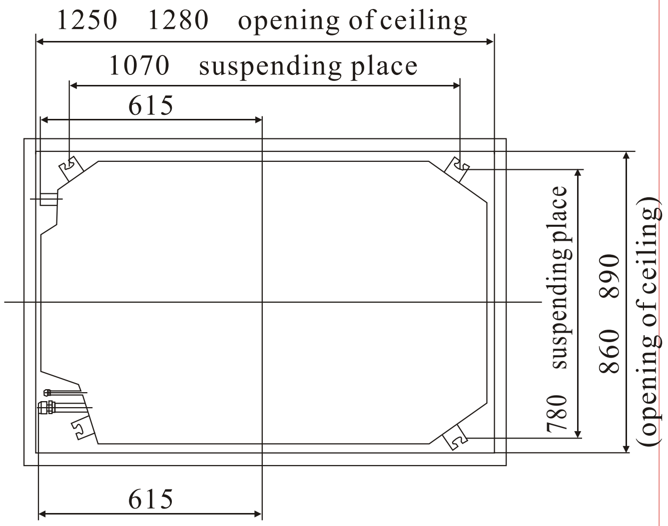


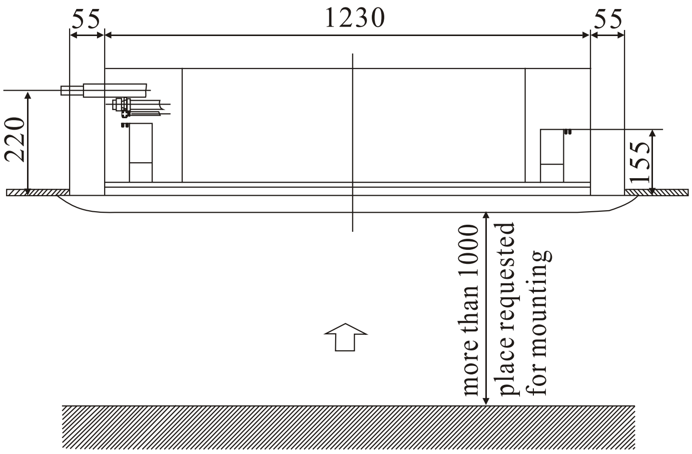
mounting dimension for cassette air conditioner 5HP:











t ℃	P bar	v' dm³/kg	v dm³/kg	rho' kg/dm³	rho kg/m³	h' kJ/kg	h kJ/kg	r kJ/kg	s' kJ/kgk	s kJ/kgk
-60	0.38	0.683	537.90	1.464	1.860	132.40	378.06	245.66	0.7227	1.8752
-59	0.40	0.684	510.19	1.461	1.960	133.45	378.56	245.11	0.7276	1.8722
-58	0.42	0.686	484.18	1.458	2.070	134.51	379.06	244.56	0.7326	1.8692
-57	0.45	0.687	459.75	1.456	2.180	135.57	379.57	244.00	0.7375	1.8663
-56	0.47	0.688	436.79	1.453	2.290	136.63	380.07	243.43	0.7424	1.8634
-55	0.50	0.690	415.19	1.450	2.410	137.70	380.57	242.87	0.7473	1.8606
-54	0.52	0.691	394.87	1.447	2.530	138.77	381.07	242.29	0.7522	1.8578
-53	0.55	0.692	375.73	1.445	2.660	139.84	381.56	241.72	0.7570	1.8550
-52	0.58	0.694	357.71	1.442	2.800	140.92	382.06	241.14	0.7619	1.8523
-51	0.61	0.695	340.72	1.439	2.940	142.00	382.56	240.55	0.7668	1.8496
-50	0.65	0.696	324.69	1.436	3.080	143.08	383.05	239.97	0.7716	1.8470
-49	0.68	0.698	309.57	1.433	3.230	144.17	383.54	239.37	0.7765	1.8444
-48	0.72	0.699	295.29	1.431	3.390	145.26	384.03	238.78	0.7813	1.8418
-47	0.75	0.700	281.80	1.428	3.550	146.35	384.52	238.17	0.7861	1.8393
-46	0.79	0.702	269.05	1.425	3.720	147.44	385.01	237.57	0.7909	1.8368
-45	0.83	0.703	257.24	1.422	3.890	148.34	385.52	237.18	0.7949	1.8344
-44	0.87	0.705	245.82	1.419	4.070	149.44	386.00	236.57	0.7997	1.8320
-43	0.91	0.706	235.01	1.416	4.260	150.54	386.49	235.95	0.8044	1.8296
-42	0.96	0.707	224.78	1.414	4.450	151.65	386.97	235.32	0.8092	1.8273
-41	1.01	0.709	215.08	1.411	4.650	152.75	387.45	234.70	0.8140	1.8250
-40	1.05	0.710	205.88	1.408	4.860	153.86	387.93	234.07	0.8187	1.8227
-39	1.10	0.712	197.17	1.405	5.070	154.97	388.40	233.43	0.8235	1.8204
-38	1.15	0.713	188.89	1.402	5.290	156.09	388.88	232.79	0.8282	1.8182
-37	1.21	0.715	181.04	1.399	5.520	157.21	389.35	232.15	0.8329	1.8160
-36	1.26	0.716	173.58	1.396	5.760	158.32	389.82	231.50	0.8376	1.8138
-35	1.32	0.718	166.54	1.393	6.000	159.38	390.30	230.92	0.8421	1.8117
-34	1.38	0.719	159.80	1.390	6.260	160.50	390.76	230.26	0.8468	1.8096
-33	1.44	0.721	153.39	1.387	6.520	161.63	391.23	229.60	0.8514	1.8075
-32	1.51	0.722	147.29	1.385	6.790	162.75	391.69	228.94	0.8561	1.8054
-31	1.57	0.724	141.49	1.382	7.070	163.88	392.15	228.27	0.8607	1.8034
-30	1.64	0.725	135.96	1.379	7.360	165.01	392.61	227.59	0.8654	1.8014
-29	1.71	0.727	130.69	1.376	7.650	166.14	393.06	226.92	0.8700	1.7994
-28	1.78	0.728	125.68	1.373	7.960	167.28	393.51	226.24	0.8746	1.7975
-27	1.86	0.730	120.89	1.370	8.270	168.41	393.96	225.55	0.8792	1.7955
-26	1.94	0.732	116.33	1.367	8.600	169.55	394.41	224.86	0.8838	1.7936
-25	2.02	0.733	111.97	1.364	8.930	170.69	394.85	224.17	0.8884	1.7917
-24	2.10	0.735	107.82	1.361	9.280	171.82	395.30	223.47	0.8929	1.7899
-23	2.18	0.737	103.85	1.358	9.630	172.96	395.74	222.77	0.8975	1.7880
-22	2.27	0.738	100.06	1.355	9.990	174.11	396.17	222.07	0.9020	1.7862
-21	2.36	0.740	96.40	1.352	10.370	175.31	396.60	221.29	0.9067	1.7843
-20	2.45	0.742	92.94	1.348	10.760	176.46	397.03	220.57	0.9112	1.7826
-19	2.55	0.743	89.63	1.345	11.160	177.60	397.46	219.86	0.9157	1.7808
-18	2.65	0.745	86.46	1.342	11.570	178.75	397.88	219.13	0.9202	1.7791
-17	2.75	0.747	83.43	1.339	11.990	179.90	398.30	218.41	0.9247	1.7773
-16	2.86	0.748	80.53	1.336	12.420	181.04	398.72	217.68	0.9291	1.7756
-15	2.96	0.750	77.72	1.333	12.870	182.25	399.13	216.88	0.9338	1.7739
-14	3.07	0.752	75.06	1.330	13.320	183.40	399.54	216.14	0.9382	1.7722
-13	3.19	0.754	72.49	1.327	13.800	184.62	399.94	215.33	0.9428	1.7705
-12	3.30	0.756	70.04	1.324	14.280	185.77	400.35	214.58	0.9472	1.7689
-11	3.42	0.757	67.70	1.320	14.770	186.92	400.75	213.83	0.9516	1.7673
-10	3.55	0.759	65.43	1.317	15.280	188.13	401.14	213.01	0.9562	1.7656
-9	3.68	0.761	63.27	1.314	15.810	189.29	401.54	212.25	0.9605	1.7640
-8	3.81	0.763	61.18	1.311	16.350	190.50	401.93	211.42	0.9651	1.7624
-7	3.94	0.765	59.19	1.308	16.900	191.66	402.31	210.66	0.9694	1.7609
-6	4.08	0.767	57.26	1.304	17.460	192.87	402.69	209.82	0.9739	1.7593
-5	4.22	0.769	55.42	1.301	18.040	194.03	403.07	209.04	0.9782	1.7577
-4	4.36	0.771	53.64	1.298	18.640	195.25	403.44	208.20	0.9827	1.7562
-3	4.51	0.772	51.95	1.295	19.250	196.41	403.82	207.41	0.9869	1.7547
-2	4.66	0.774	50.30	1.291	19.880	197.62	404.18	206.56	0.9914	1.7531
-1	4.82	0.776	48.73	1.288	20.520	198.80	404.54	205.74	0.9957	1.7517
0	4.98	0.778	47.21	1.285	21.180	200.00	404.90	204.90	1.0000	1.7502
1	5.14	0.781	45.74	1.281	21.860	201.22	405.25	204.03	1.0044	1.7487
2	5.31	0.783	44.35	1.278	22.550	202.38	405.61	203.23	1.0086	1.7472
3	5.48	0.785	42.99	1.274	23.260	203.60	405.95	202.35	1.0130	1.7457
4	5.66	0.787	41.69	1.271	23.990	204.78	406.30	201.51	1.0172	1.7443
5	5.84	0.789	40.42	1.268	24.740	206.00	406.63	200.63	1.0215	1.7428
6	6.02	0.791	39.21	1.264	25.500	207.20	406.96	199.76	1.0258	1.7414
7	6.21	0.793	38.04	1.261	26.290	208.43	407.29	198.86	1.0301	1.7400
8	6.40	0.795	36.92	1.257	27.090	209.61	407.62	198.01	1.0343	1.7385
9	6.60	0.798	35.83	1.254	27.910	210.81	407.94	197.12	1.0385	1.7371
10	6.80	0.800	34.78	1.250	28.760	212.04	408.25	196.21	1.0428	1.7357
11	7.01	0.802	33.76	1.247	29.620	213.26	408.56	195.30	1.0470	1.7343
12	7.22	0.804	32.79	1.243	30.500	214.45	408.86	194.42	1.0511	1.7329
13	7.43	0.807	31.84	1.240	31.410	215.67	409.16	193.49	1.0554	1.7315
14	7.65	0.809	30.93	1.236	32.330	216.88	409.46	192.58	1.0595	1.7302
15	7.88	0.811	30.04	1.232	33.280	218.10	409.75	191.65	1.0637	1.7288
16	8.11	0.814	29.19	1.229	34.260	219.33	410.03	190.70	1.0679	1.7274
17	8.34	0.816	28.37	1.225	35.250	220.54	410.31	189.78	1.0720	1.7261
18	8.58	0.819	27.57	1.221	36.270	221.75	410.59	188.84	1.0761	1.7247
19	8.83	0.821	26.80	1.218	37.310	222.98	410.86	187.88	1.0802	1.7233

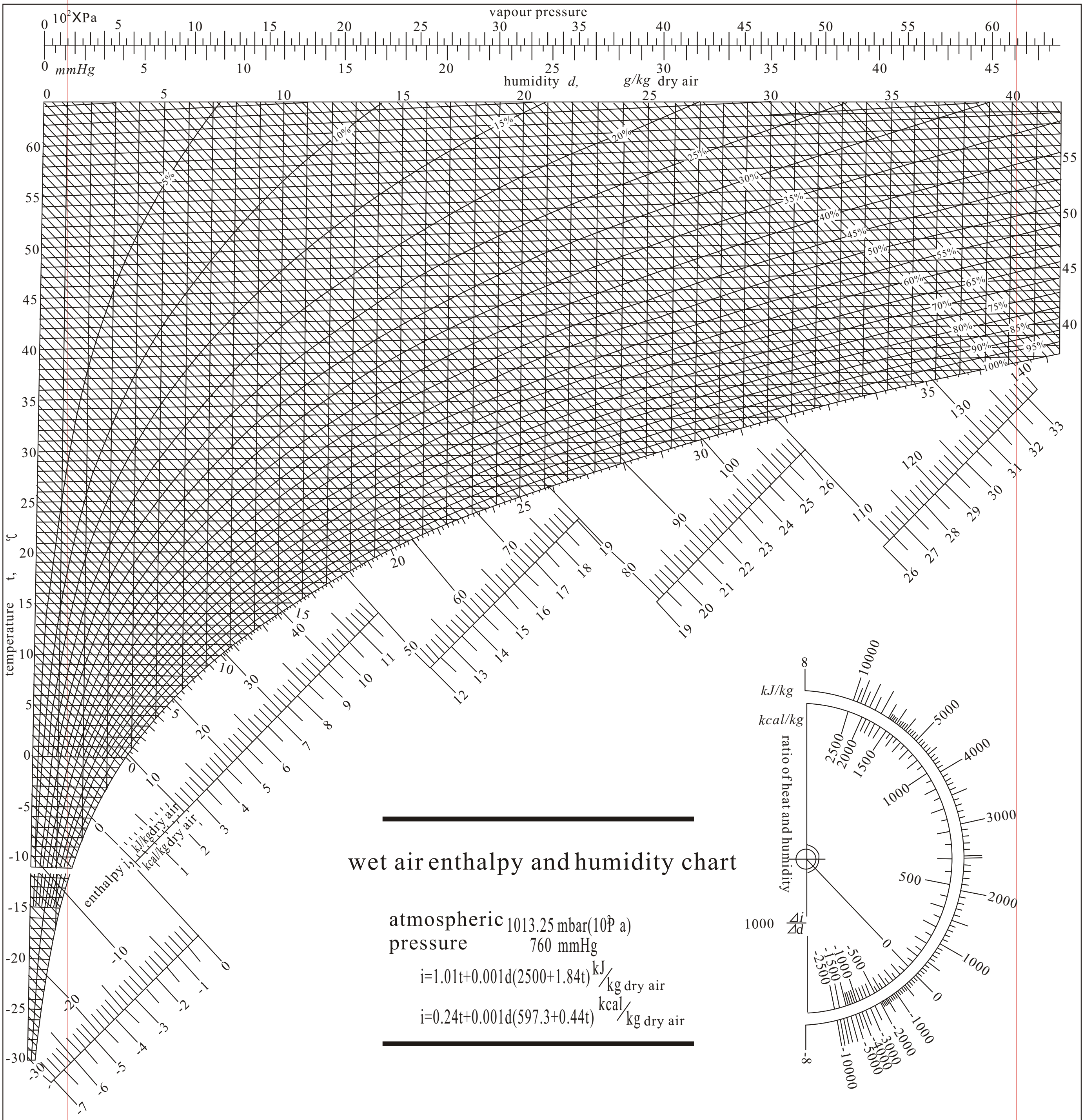
t ℃	P bar	v' dm³/kg	v dm³/kg	rho' kg/dm³	rho kg/m³	h' kJ/kg	h kJ/kg	r kJ/kg	s' kJ/kgk	s kJ/kgk
20	9.08	0.824	26.06	1.214	38.380	224.19	411.13	186.94	1.0843	1.7220
21	9.33	0.826	25.33	1.210	39.470	225.42	411.39	185.96	1.0884	1.7206
22	9.59	0.829	24.63	1.206	40.590	226.65	411.64	184.99	1.0925	1.7193
23	9.86	0.832	23.96	1.203	41.740	227.87	411.89	184.02	1.0966	1.7179
24	10.13	0.834	23.31	1.199	42.910	229.10	412.13	183.03	1.1007	1.7166
25	10.41	0.837	22.67	1.195	44.110	230.34	412.37	182.03	1.1047	1.7153
26	10.69	0.840	22.06	1.191	45.330	231.56	412.60	181.04	1.1087	1.7139
27	10.98	0.842	21.46	1.187	46.590	232.79	412.83	180.03	1.1128	1.7126
28	11.27	0.845	20.89	1.183	47.880	234.03	413.04	179.01	1.1168	1.7112
29	11.57	0.848	20.33	1.179	49.200	235.27	413.26	177.98	1.1208	1.7099
30	11.88	0.851	19.79	1.175	50.540	236.50	413.47	176.97	1.1248	1.7086
31	12.19	0.854	19.26	1.171	51.920	237.74	413.67	175.93	1.1288	1.7072
32	12.51	0.857	18.75	1.167	53.330	238.99	413.86	174.87	1.1328	1.7059
33	12.83	0.860	18.25	1.163	54.780	240.23	414.05	173.82	1.1368	1.7045
34	13.16	0.863	17.77	1.159	56.260	241.48	414.23	172.75	1.1408	1.7032
35	13.49	0.866	17.31	1.155	57.780	242.73	414.40	171.67	1.1447	1.7018
36	13.84	0.869	16.86	1.150	59.330	243.98	414.57	170.59	1.1487	1.7005
37	14.18	0.873	16.42	1.146	60.920	245.23	414.73	169.50	1.1526	1.6991
38	14.54	0.876	15.99	1.142	62.540	246.49	414.88	168.39	1.1566	1.6978
39	14.90	0.879	15.57	1.137	64.210	247.75	415.03	167.28	1.1605	1.6964
40	15.27	0.883	15.17	1.133	65.910	249.01	415.17	166.16	1.1644	1.6951
41	15.64	0.886	14.78	1.129	67.660	250.27	415.30	165.02	1.1684	1.6937
42	16.02	0.890	14.40	1.124	69.450	251.55	415.42	163.87	1.1723	1.6923
43	16.41	0.893	14.03	1.120	71.280	252.82	415.53	162.72	1.1762	1.6909
44	16.81	0.897	13.67	1.115	73.160	254.10	415.63	161.54	1.1802	1.6895
45	17.21	0.901	13.32	1.110	75.080	255.38	415.73	160.36	1.1841	1.6881
46	17.62	0.904	12.98	1.106	77.060	256.66	415.82	159.16	1.1880	1.6867
47	18.04	0.908	12.65	1.101	79.080	257.95	415.90	157.95	1.1919	1.6853
48	18.46	0.912	12.32	1.096	81.150	259.24	415.97	156.72	1.1958	1.6838
49	18.89	0.916	12.01	1.091	83.280	260.55	416.03	155.48	1.1997	1.6824
50	19.33	0.920	11.70	1.087	85.460	261.85	416.08	154.22	1.2037	1.6809
51	19.78	0.925	11.40	1.082	87.700	263.17	416.11	152.94	1.2076	1.6794
52	20.23	0.929	11.11	1.077	90.000	264.49	416.14	151.65	1.2115	1.6780
53	20.69	0.933	10.83	1.072	92.360	265.81	416.16	150.35	1.2155	1.6765
54	21.16	0.938	10.55	1.066	94.770	267.13	416.17	149.03	1.2194	1.6749
55	21.64	0.942	10.28	1.061	97.260	268.48	416.16	147.69	1.2233	1.6734
56	22.13	0.947	10.02	1.056	99.810	269.82	416.14	146.32	1.2273	1.6718
57	22.62	0.952	9.76	1.051	102.440	271.18	416.11	144.93	1.2313	1.6703
58	23.12	0.957	9.51	1.045	105.140	272.54	416.07	143.53	1.2353	1.6687
59	23.63	0.962	9.27	1.040	107.910	273.91	416.01	142.10	1.2392	1.6671
60	24.15	0.967	9.03	1.034	110.770	275.30	415.94	140.64	1.2433	1.6654
61	24.68	0.972	8.79	1.028	113.700	276.69	415.86	139.16	1.2473	1.6637
62	25.22	0.978	8.57	1.022	116.730	278.10	415.75	137.65	1.2513	1.6620
63	25.76	0.984	8.34	1.017	119.850	279.51	415.64	136.12	1.2554	1.6603
64	26.32	0.990	8.13	1.011	123.060	280.95	415.50	134.56	1.2595	1.6586
65	26.88	0.996	7.91	1.004	126.370	282.39	415.35	132.96	1.2636	1.6568
66	27.46	1.002	7.70	0.998	129.790	283.84	415.18	131.34	1.2677	1.6550
67	28.04	1.008	7.50	0.992	133.320	285.32	414.99	129.67	1.2719	1.6531
68	28.63	1.015	7.30	0.985	136.960	286.81	414.78	127.97	1.2761	1.6512
69	29.23	1.022	7.11	0.979	140.740	288.32	414.55	126.23	1.2803	1.6492
70	29.84	1.029	6.91	0.972	144.650	289.84	414.29	124.45	1.2846	1.6472
71	30.46	1.036	6.73	0.965	148.700	291.39	414.01	122.62	1.2889	1.6452
72	31.10	1.044	6.54	0.958	152.890	292.96	413.71	120.74	1.2933	1.6431
73	31.74	1.052	6.36	0.951	157.250	294.56	413.37	118.82	1.2977	1.6409
74	32.39	1.060	6.18	0.943	161.780	296.18	413.01	116.83	1.3022	1.6387
75	33.05	1.069	6.01	0.936	166.490	297.83	412.61	114.79	1.3067	1.6364
76	33.73	1.078	5.83	0.928	171.410	299.51	412.18	112.67	1.3113	1.6340
77	34.41	1.087	5.66	0.920	176.540	301.22	411.72	110.50	1.3160	1.6316
78	35.10	1.097	5.50	0.911	181.900	302.96	411.21	108.25	1.3208	1.6290
79	35.81	1.108	5.33	0.903	187.510	304.75	410.67	105.91	1.3256	1.6264
80	36.53	1.119	5.17	0.894	193.410	306.58	410.07	103.49	1.3306	1.6236
81	37.26	1.131	5.01	0.884	199.620	308.46	409.42	100.96	1.3357	1.6207
82	38.00	1.143	4.85	0.875	206.180	310.39	408.71	98.32	1.3409	1.6177
83	38.75	1.157	4.69	0.865	213.110	312.38	407.94	95.56	1.3462	1.6145
84	39.52	1.171	4.54	0.854	220.490	314.44	407.10	92.66	1.3517	1.6112
85	40.29	1.186	4.38	0.843	228.370	316.57	406.17	89.60	1.3574	1.6076
86	41.08	1.203	4.22	0.831	236.800	318.79	405.15	86.36	1.3634	1.6038
87	41.89	1.221	4.07	0.819	245.930	321.11	404.02	82.91	1.3695	1.5998
88	42.70	1.242	3.91	0.805	255.850	323.54	402.75	79.21	1.3760	1.5953
89	43.53	1.264	3.75	0.791	266.730	326.11	401.34	75.22	1.3828	1.5905
90	44.37	1.289	3.59	0.776	278.820	328.86	399.72	70.86	1.3901	1.5853
91	45.23	1.319	3.42	0.758	292.500	331.82	397.86	66.04	1.3980	1.5793
92	46.10	1.353	3.24	0.739	308.290	335.07	395.67	60.60	1.4065	1.5725
93	46.99	1.395	3.06	0.717	327.150	338.72	393.00	54.28	1.4162	1.5644
94	47.88	1.451	2.85	0.689	350.930	342.98	389.59	46.61	1.4275	1.5544
95	48.80	1.531	2.60	0.653	384.380	348.40	384.76	36.36	1.4418	1.5406
96.18	49.90	1.949	1.95	0.513	513.110	366.80	366.80	0.00	1.4912	1.4912

saturation R407C thermodynamic property

R407C release 1.02

t ℃	P' bar	P bar	v' dm³/kg	v dm³/kg	rho kg/dm³	rho kg/m³	h' kJ/kg	h kJ/kg	r kJ/kg	s' kJ/kgk	s kJ/kgk
-50	0.75	0.51	1.402	2.40	0.713	416.20	132.74	380.81	248.07	0.7300	1.8614
-49	0.79	0.53	1.399	2.53	0.715	394.95	134.02	381.42	247.41	0.7357	1.8589
-48	0.83	0.56	1.396	2.67	0.716	375.01	135.29	382.04	246.74	0.7415	1.8564
-47	0.87	0.60	1.393	2.81	0.718	356.27	136.57	382.65	246.08	0.7473	1.8540
-46	0.91	0.63	1.391	2.95	0.719	338.65	137.85	383.26	245.41	0.7530	1.8516
-45	0.96	0.66	1.388	3.11	0.721	322.05	139.13	383.87	244.74	0.7587	1.8493
-44	1.00	0.70	1.385	3.26	0.722	306.43	140.42	384.48	244.06	0.7644	1.8470
-43	1.05	0.74	1.382	3.43	0.724	291.72	141.71	385.08	243.38	0.7701	1.8447
-42	1.10	0.78	1.379	3.60	0.725	277.84	143.00	385.69	242.69	0.7758	1.8425
-41	1.16	0.82	1.376	3.78	0.727	264.76	144.29	386.29	242.00	0.7814	1.8403
-40	1.21	0.86	1.373	3.96	0.729	252.41	145.58	386.89	241.31	0.7871	1.8381
-39	1.27	0.91	1.370	4.15	0.730	240.75	146.88	387.49	240.61	0.7927	1.8360
-38	1.33	0.95	1.366	4.35	0.732	229.73	148.18	388.09	239.91	0.7983	1.8339
-37	1.39	1.00	1.363	4.56	0.733	219.32	149.49	388.69	239.20	0.8039	1.8319
-36	1.45	1.05	1.360	4.77	0.735	209.47	150.80	389.28	238.49	0.8095	1.8299
-35	1.52	1.10	1.357	5.00	0.737	200.15	152.11	389.88	237.77	0.8150	1.8279
-34	1.58	1.16	1.354	5.23	0.739	191.33	153.42	390.47	237.05	0.8206	1.8260
-33	1.66	1.21	1.351	5.47	0.740	182.97	154.74	391.06	236.32	0.8261	1.8241
-32	1.73	1.27	1.348	5.71	0.742	175.05	156.06	391.64	235.59	0.8316	1.8222
-31	1.80	1.33	1.345	5.97	0.744	167.54	157.38	392.23	234.85	0.8371	1.8203
-30	1.88	1.39	1.341	6.23	0.745	160.42	158.71	392.81	234.10	0.8426	1.8185
-29	1.96	1.46	1.338	6.51	0.747	153.66	160.04	393.39	233.36	0.8480	1.8167
-28	2.04	1.52	1.335	6.79	0.749	147.24	161.37	393.97	232.60	0.8535	1.8150
-27	2.13	1.59	1.332	7.09	0.751	141.14	162.71	394.55	231.84	0.8589	1.8132
-26	2.22	1.67	1.329	7.39	0.753	135.35	164.05	395.12	231.08	0.8643	1.8115
-25	2.31	1.74	1.325	7.70	0.755	129.84	165.39	395.69	230.30	0.8697	1.8098
-24	2.40	1.82	1.322	8.03	0.756	124.60	166.73	396.26	229.53	0.8751	1.8082
-23	2.50	1.90	1.319	8.36	0.758	119.61	168.08	396.83	228.74	0.8805	1.8066
-22	2.60	1.98	1.315	8.71	0.760	114.86	169.43	397.39	227.96	0.8858	1.8049
-21	2.70	2.06	1.312	9.06	0.762	110.34	170.79	397.95	227.16	0.8911	1.8034
-20	2.81	2.15	1.309	9.43	0.764	106.03	172.15	398.51	226.36	0.8965	1.8018
-19	2.92	2.24	1.305	9.81	0.766	101.92	173.51	399.06	225.56	0.9018	1.8003
-18	3.03	2.34	1.302	10.20	0.768	98.00	174.87	399.61	224.74	0.9070	1.7987
-17	3.14	2.43	1.298	10.61	0.770	94.26	176.24	400.16	223.92	0.9123	1.7972
-16	3.26	2.53	1.295	11.03	0.772	90.70	177.61	400.71	223.10	0.9176	1.7958
-15	3.39	2.64	1.292	11.46	0.774	87.29	178.98	401.25	222.27	0.9228	1.7943
-14	3.51	2.74	1.288	11.90	0.776	84.04	180.36	401.79	221.43	0.9281	1.7929
-13	3.64	2.85	1.285	12.36	0.778	80.93	181.74	402.33	220.59	0.9333	1.7914
-12	3.77	2.97	1.281	12.83	0.781	77.96	183.12	402.86	219.74	0.9385	1.7900
-11	3.91	3.08	1.278	13.31	0.783	75.12	184.50	403.39	218.89	0.9437	1.7887
-10	4.05	3.20	1.274	13.81	0.785	72.40	185.89	403.91	218.02	0.9489	1.7873
-9	4.20	3.33	1.271	14.33	0.787	69.80	187.28	404.43	217.15	0.9540	1.7859
-8	4.34	3.45	1.267	14.86	0.789	67.31	188.67	404.95	216.28	0.9592	1.7846
-7	4.50	3.58	1.263	15.40	0.792	64.93	190.07	405.47	215.40	0.9643	1.7833
-6	4.65	3.72	1.260	15.96	0.794	62.65	191.47	405.98	214.51	0.9694	1.7820
-5	4.81	3.86	1.256	16.54	0.796	60.46	192.87	406.49	213.62	0.9746	1.7807
-4	4.98	4.00	1.252	17.13	0.798	58.36	194.28	406.99	212.71	0.9797	1.7794
-3	5.15	4.15	1.249	17.75	0.801	56.35	195.68	407.49	211.81	0.9848	1.7782
-2	5.32	4.30	1.245	18.38	0.803	54.42	197.09	407.98	210.89	0.9899	1.7769
-1	5.50	4.45	1.241	19.02	0.806	52.57	198.51	408.47	209.97	0.9949	1.7757
0	5.68	4.61	1.238	19.69	0.808	50.79	200.00	408.96	208.96	1.0000	1.7744
1	5.86	4.77	1.234	20.37	0.811	49.09	201.34	409.44	208.10	1.0051	1.7732
2	6.06	4.94	1.230	21.07	0.813	47.45	202.76	409.92	207.16	1.0101	1.7720
3	6.25	5.11	1.226	21.80	0.816	45.88	204.19	410.39	206.21	1.0152	1.7708
4	6.45	5.29	1.222	22.54	0.818	44.37	205.61	410.86	205.25	1.0203	1.7696
5	6.66	5.47	1.218	23.30	0.821	42.91	207.04	411.33	204.28	1.0254	1.7685
6	6.87	5.66	1.215	24.09	0.823	41.51	208.48	411.79	203.31	1.0306	1.7673
7	7.08	5.85	1.211	24.89	0.826	40.17	209.91	412.24	202.33	1.0357	1.7661
8	7.30	6.04	1.207	25.72	0.829	38.88	211.35	412.69	201.34	1.0408	1.7650
9	7.53	6.24	1.203	26.57	0.831	37.63	212.79	413.14	200.35	1.0460	1.7639
10	7.76	6.45	1.199	27.45	0.834	36.43	214.24	413.58	199.34	1.0511	1.7627
11	7.99	6.66	1.195	28.34	0.837	35.28	215.68	414.01	198.33	1.0563	1.7616
12	8.23	6.88	1.191	29.27	0.840	34.17	217.14	414.44	197.31	1.0615	1.7605
13	8.48	7.10	1.187	30.21	0.843	33.10	218.59	414.87	196.28	1.0667	1.7594
14	8.73	7.32	1.182	31.19	0.846	32.07	220.05	415.29	195.24	1.0719	1.7582
15	8.99	7.55	1.178	32.19	0.849	31.07	221.51	415.70	194.19	1.0772	1.7571
16	9.25	7.79	1.174	33.21	0.852	30.11	222.98	416.11	193.13	1.0824	1.7560
17	9.52	8.03	1.170	34.26	0.855	29.19	224.44	416.51	192.07	1.0877	1.7549
18	9.79	8.28	1.166	35.34	0.858	28.29	225.92	416.91	190.99	1.0930	1.7539
19	10.07	8.54	1.162	36.46	0.861	27.43	227.39	417.30	189.90	1.0982	1.7528
20	10.36	8.80	1.157	37.60	0.864	26.60	228.88	417.68	188.81	1.1035	1.7517
21	10.65	9.06	1.153	38.77	0.867	25.80	230.36	418.06	187.70	1.1089	1.7506
22	10.95	9.34	1.149	39.97	0.871	25.02	231.85	418.44	186.59	1.1142	1.7495
23	11.25	9.62	1.144	41.20	0.874	24.27	233.34	418.80	185.46	1.1195	1.7484
24	11.56	9.90	1.140	42.47	0.877	23.55	234.84	419.16	184.32	1.1249	1.7473
25	11.88	10.19	1.135	43.77	0.881	22.85	236.35	419.52	183.17	1.1303	1.7463
26	12.20	10.49	1.131	45.10	0.884	22.17	237.86	419.86	182.01	1.1357	1.7452
27	12.53	10.79	1.126	46.48	0.888	21.52	239.37	420.20	180.83	1.1411	1.7441
28	12.87	11.10	1.122	47.88	0.891	20.88	240.89	420.53	179.65	1.1465	1.7430
29	13.21	11.42	1.117	49.33	0.895	20.27	242.41	420.86	178.45	1.1520	1.7419
30	13.56	11.75	1.113	50.82	0.899	19.68	243.95	421.18	177.23	1.1574	1.7408
31	13.92	12.08	1.108	52.34	0.903	19.11	245.48	421.49	176.01	1.1629	1.7397
32	14.28	12.42	1.103	53.91	0.906	18.55	247.03	421.79	174.76	1.1684	1.7386
33	14.65	12.76	1.099	55.52	0.910	18.01	248.58	422.09	173.51	1.1739	1.7375
34	15.03	13.11	1.094	57.17	0.914	17.49	250.14	422.37	172.24	1.1794	1.7364
35	15.41	13.48	1.089	58.87	0.918	16.99	251.70	422.65	170.95	1.1850	1.7353
36	15.80	13.84	1.084	60.62	0.922	16.50	253.28	422.92	169.65	1.1905	1.7342
37	16.20	14.22	1.079	62.41	0.927	16.02	254.86	423.18	168.33	1.1961	1.7331
38	16.61	14.60	1.074	64.26	0.931	15.56	256.45	423.44	166.99	1.2017	1.7319
39	17.02	14.99	1.069	66.16	0.935	15.12	258.05	423.68	165.63	1.2073	1.7308
40	17.45	15.39	1.064	68.11	0.940	14.68	259.65	423.91	164.26	1.2129	1.7296
41	17.88	15.80	1.059	70.11	0.944	14.26	261.27	424.13	162.86	1.2186	1.7285
42	18.31	16.21	1.054	72.18	0.949	13.85	262.90	424.34	161.44	1.2242	1.7273
43	18.76	16.64	1.049	74.30	0.954	13.46	264.54	424.54	160.01	1.2299	1.7261
44	19.21	17.07	1.043	76.49	0.958	13.07	266.19	424.73	158.55	1.2356	1.7249
45	19.67	17.51	1.038	78.74	0.963	12.70	267.84	424.91	157.07	1.2413	1.7236
46	20.14	17.96	1.033	81.06	0.968	12.34	269.52	425.08	155.56	1.2470	1.7224
47	20.62	18.42	1.027	83.45	0.973	11.98	271.20	425.23	154.03	1.2527	1.7211
48	21.11	18.88	1.022	85.92	0.979	11.64	272.90	425.37	152.47	1.2585	1.7198
49	21.60	19.36	1.016	88.45	0.984	11.31	274.61	425.49	150.89	1.2643	1.7185
50	22.10	19.85	1.011	91.07	0.990	10.98	276.33	425.60	149.28	1.2700	1.7172
51	22.62	20.34	1.005	93.78	0.995	10.66	278.07	425.70	147.63	1.2758	1.7158
52	23.44	20.85	0.999	96.57	1.001	10.36	279.82	425.78	145.96	1.2817	1.7145
53	23.67	21.36	0.993	99.45	1.007	10.06	281.59	425.84	144.26	1.2875	1.7130
54	24.20	21.88	0.987	102.43	1.013	9.76	283.37	425.89	142.52	1.2933	1.7116
55	24.75	22.42	0.981	105.51	1.019	9.48	285.17	425.91	140.74	1.2992	1.7101
56	25.31	22.96	0.975	108.69	1.026	9.20	286.99	425.92	138.93	1.3051	1.7086
57	25.87	23.52	0.969	111.99	1.032	8.93	288.82	425.90	137.08	1.3110	1.7070
58	26.45	24.08	0.963	115.40	1.039	8.67	290.68	425.87	135.19	1.3169	1.7054
59	27.03	24.66	0.956	118.94	1.046	8.41	292.55	425.81	133.26	1.3228	1.7037
60	27.63	25.24	0.950	122.61	1.053	8.16	294.45	425.72	131.28	1.3287	1.7020
61	28.23	25.84	0.943	126.42	1.061	7.91	296.36	425.61	129.25	1.3347	1.7002
62	28.85	26.45	0.936	130.38	1.068	7.67	298.30	425.48	127.18	1.3406	1.6984
63	29.47	27.07	0.929	134.49	1.076	7.44	300.26	425.31	125.05	1.3466	1.6965
64	30.10	27.71	0.922	138.78	1.084	7.21	302.24	425.11	122.87	1.3526	1.6945
65	30.75	28.35	0.915	143.24	1.093	6.98	304.24	424.88	120.63	1.3586	1.6925
66	31.40	29.01	0.908	147.89	1.102	6.76	306.27	424.61	118.34	1.3646	1.6904
67	32.07	29.68	0.900	152.75	1.111	6.55	308.33	424.30	115.97	1.3706	1.6882
68	32.74	30.36	0.892	157.82	1.121	6.34	310.41	423.95	113.54	1.3767	1.6858
69	33.42	31.06	0.884	163.13	1.131	6.13	312.52	423.56	111.04	1.3827	1.6834
70	34.12	31.77	0.876	168.70	1.141	5.93	314.66	423.12	108.46	1.3888	1.6809
71	34.83	32.49	0.868	174.54	1.152	5.73	316.83	422.63	105.80	1.3949	1.6782
72	35.54	33.23	0.859	180.69	1.164	5.53	319.03	422.08	103.05	1.4009	1.6754
73	36.27	33.98	0.850	187.15	1.176	5.34	321.26	421.48	100.22	1.4070	1.6725
74	37.01	34.75	0.841	193.97	1.190	5.16	323.52	420.80	97.28	1.4131	1.6694
75	37.76	35.53	0.831	201.18	1.204	4.97	325.82	420.06	94.24	1.4193	1.6661
76	38.52	36.34	0.821	208.82	1.219	4.79	328.15	419.24	91.09	1.4254	1.6626
77	39.30	37.15	0.810	216.93	1.235	4.61	330.51	418.33	87.81	1.4315	1.6589
78	40.08	37.99	0.798	225.56	1.253	4.43	332.92	417.32	84.41	1.4376	1.6550
79	40.87	38.85	0.786	234.78	1.272	4.26	335.36	416.22	80.86	1.4438	1.6508
80	41.68	39.72	0.773	244.65	1.294	4.09	337.84	414.99	77.15	1.4499	1.6463
81	42.50	40.62	0.758	255.28	1.319	3.92	340.36	413.63	73.28	1.4561	1.6414
82	43.33	41.54	0.742	266.78	1.347	3.75	342.92	412.12	69.20	1.4623	1.6362
83	44.17	42.49	0.724	279.31	1.382	3.58	345.52	410.43	64.91	1.4684	1.6304
84	45.03	43.47	0.701	293.10	1.426	3.41	348.17	408.53	60.35	1.4746	1.6241
85	45.89	44.48	0.671	308.52	1.490	3.24	350.87	406.33	55.47	1.4808	1.6171
86.4	46.20	46.20	0.510	510.00	1.961	1.96	368.89	368.89	0.00	1.5113	1.5113

mix R32, R125, 134a with weight ratio of 23, 25, 52 percent


vapour pressure
10^2 XPa
mmHg
humidity d, g/kg dry air
temperature t, ℃
enthalpy i, kJ/kg dry air
kcal/kg dry air
wet air enthalpy and humidity chart
atmospheric pressure 1013.25 mbar(10^5 Pa)
760 mmHg
$i=1.01t+0.001d(2500+1.84t)$ kJ/kg dry air
$i=0.24t+0.001d(597.3+0.44t)$ kcal/kg dry air
kJ/kg
kcal/kg
ratio of heat and humidity
$\frac{\Delta i}{\Delta d}$

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