Refrigerant
R410A

Standard Installation Manual

FUJITSU GENERAL LIMITED

CONTENTS

1. FUNDAMENTALS

2. MATERIALS

3. TOOLS

CONTENTS

4. INSTALLATION WORK

CONTENTS

5. ELECTRICAL WIRING WORK

1. FUNDAMENTALS

1. FUNDAMENTALS

1-1 NEW REFRIGERANT R410A

1-1-1 CHEMICAL PROPERTIES OF REFRIGERANTS

CFC substitutes are being studied in many of the fields where CFCs were used, and two of the first CFC substitutes developed were HCFC and HFC.
However, because HCFC was later sdded to the group of controlled substances, development now centers on HFC.
The molecular design of HCFC and HFC adds a hydrogen atom to the CFC molecule so that the molecules will react with hydroxyl groups in the atmosphere and decompose in the troposphere before reaching the stratosphere, thereby reducing the destruction of the ozone layer.
HCFC contains hydrogen and chlorine atoms inside the molecule and thus most molecules decompose in the troposphere, however, some molecules reach the stratosphere and cause slight ozone destruction. By contrast, HFC does not contain the chlorine atoms that destroy ozone, and thus even if HFC reaches the ozone layer, destruction of the layer does not take place.
However, the life of HFC in the atmosphere is generally longer than HCFC, causing some concern with respect to global warming.

R22 now in wide use is an HCFC type refrigerant, and as R22 is an ozone-destroying substance, it has been decided to substitute the HFC type refrigerants R407C and R410A for R22.
Pipe work procedures for the new refrigerant models are generally the same as for R22, however, due to the properties of the refrigerants and the refrigerator oil, certain points require more caution than for air conditioners that use HCFC refrigerants, and special tools, piping materials, etc. are necessary for installation and service.

1) Performance is almost equivalent to conventional R22.
2) Like conventional R22, the new refrigerants are minimally toxic, chemically stable, and non-combustible.
3) Operating pressure is about 1.6 times that of R22.
4) The refrigerant mixture is pseudo-azeotropic, therefore there are almost no composition control problems.

	Conventional refrigerant (HCFC)	New refrigerant (HFC)	
Refrigerant name	R22	R407C	R410A
Chemical structure/components	$CHC1F_2$	HFC32/HFC125/HFC134a	HFC32/HFC125
Mixture ratio (%)	100	23/25/52	50/50
Composition	Simple refrigerant	Non-azeotropic refrigerant mixture ★2	Pseudo-azeotropic refrigerant mixture ★3
Boiling point (°C) ★1	-40.6	-43.6	-51.6
Saturation pressure 26°C (Mpa)	0.9714	1.126	1.608
Ozone Depletion Potential (ODP) ★1	0.034	0	0
Global Warming Potential (GWP) ★1	1700	1700	2000
Safety class ★1	A1	A1/A1	
Refrigerator oil	Mineral oil (SUNISO)	Synthetic oil (Ether or Ester)	
Features	Compound that includes chlorine, however, hydrogen reduces the level of ozone destruction	New substitute refrigerant with hydrogen but no chlorine; causes no ozone destruction.	

★1 : ASHRAE Refrigerant Data Summary (2000.11.) and values calculated using that data.
★2 : Non-azeotropic refrigerant mixture: mixture of multiple refrigerants with different boiling points.
★3 : Pseudo-azeotropic refrigerant mixture: mixture of multiple refrigerants with boiling points that are relatively close.

1-1-2 Saturation temperature and saturation pressure tables (R410A)

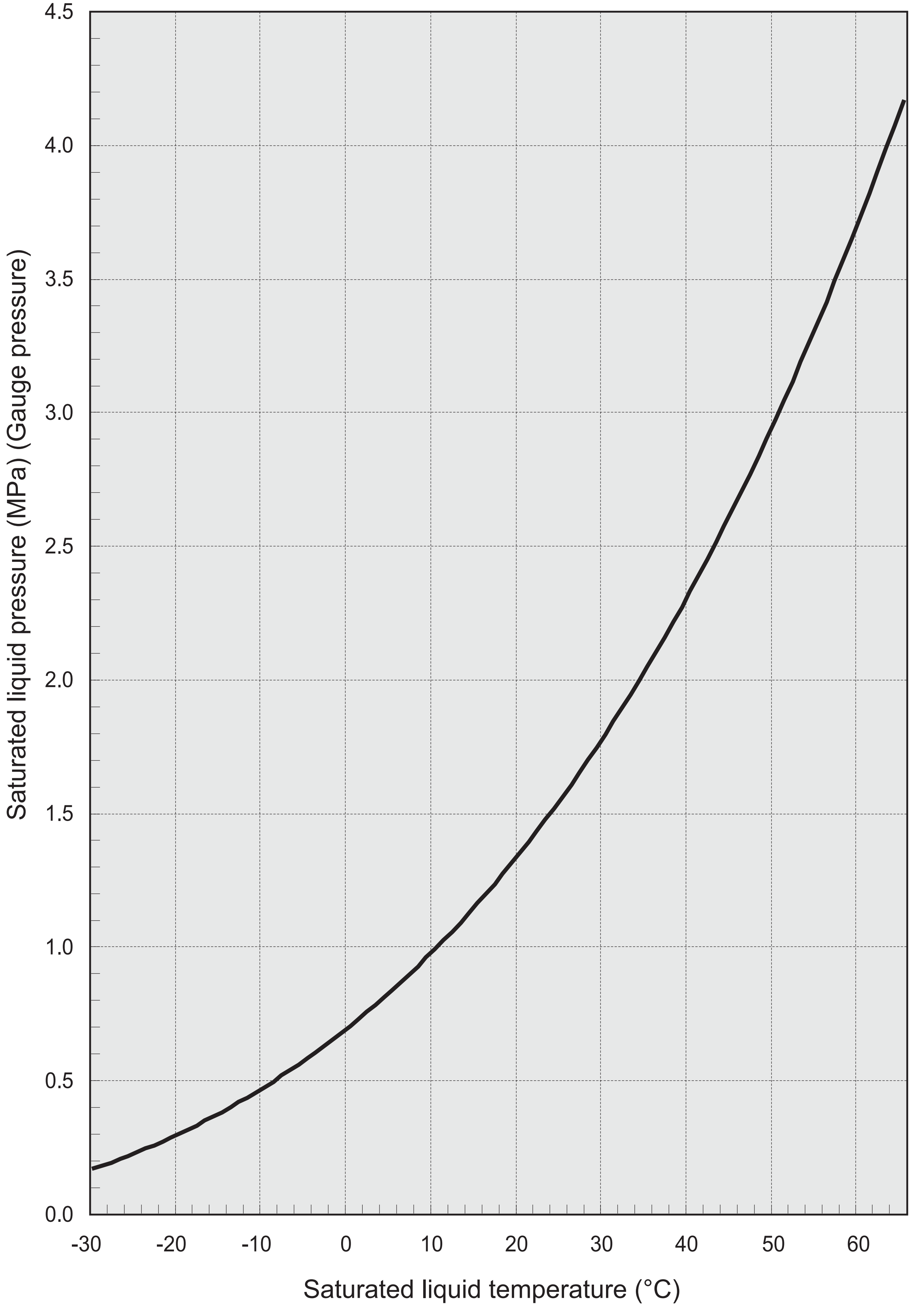
(Pressure: Gauge pressure)

Temp. (°C)	Saturation pressure (Mpa)	
	Saturated liquid	Saturated gas
-30	0.1722	0.1717
-29	0.1836	0.1830
-28	0.1953	0.1947
-27	0.2074	0.2067
-26	0.2199	0.2192
-25	0.2328	0.2320
-24	0.2460	0.2452
-23	0.2597	0.2588
-22	0.2737	0.2728
-21	0.2882	0.2872
-20	0.3031	0.3021
-19	0.3185	0.3174
-18	0.3343	0.3331
-17	0.3505	0.3493
-16	0.3672	0.3659
-15	0.3844	0.3830
-14	0.4021	0.4006
-13	0.4202	0.4187
-12	0.4389	0.4373
-11	0.4580	0.4563
-10	0.4776	0.4759
- 9	0.4978	0.4960
- 8	0.5185	0.5166
- 7	0.5398	0.5377
- 6	0.5616	0.5594
- 5	0.5839	0.5817
- 4	0.6069	0.6045
- 3	0.6304	0.6279
- 2	0.6545	0.6519
- 1	0.6791	0.6765
0	0.7044	0.7017
1	0.7303	0.7274
2	0.7569	0.7539
3	0.7840	0.7809
4	0.8119	0.8086
5	0.8403	0.8369
6	0.8695	0.8659
7	0.9000	0.8956
8	0.930	0.926
9	0.961	0.957
10	0.993	0.989
11	1.026	1.022
12	1.059	1.055
13	1.093	1.089
14	1.128	1.123
15	1.164	1.159
16	1.200	1.195
17	1.237	1.232

Temp. (°C)	Saturation pressure (Mpa)	
	Saturated liquid	Saturated gas
18	1.275	1.270
19	1.314	1.308
20	1.353	1.348
21	1.394	1.388
22	1.435	1.429
23	1.477	1.471
24	1.520	1.513
25	1.563	1.557
26	1.608	1.601
27	1.654	1.647
28	1.700	1.693
29	1.747	1.740
30	1.796	1.788
31	1.845	1.837
32	1.895	1.887
33	1.946	1.938
34	1.998	1.990
35	2.051	2.043
36	2.105	2.097
37	2.160	2.152
38	2.216	2.208
39	2.273	2.265
40	2.332	2.323
41	2.391	2.382
42	2.451	2.442
43	2.513	2.503
44	2.575	2.565
45	2.639	2.629
46	2.703	2.693
47	2.769	2.759
48	2.836	2.826
49	2.904	2.894
50	2.974	2.963
51	3.044	3.034
52	3.116	3.106
53	3.189	3.178
54	3.263	3.253
55	3.338	3.328
56	3.415	3.405
57	3.493	3.483
58	3.572	3.562
59	3.653	3.643
60	3.735	3.725
61	3.818	3.808
62	3.902	3.893
63	3.988	3.979
64	4.075	4.066
65	4.164	4.155

Saturation pressure (Mpa)	Saturation temperature (°C)	
	Saturated liquid	Saturated gas
0.0	-51.85	-51.83
0.1	-37.25	-37.21
0.2	-27.61	-27.55
0.3	-20.21	-20.14
0.4	-14.12	-14.04
0.5	- 8.89	- 8.80
0.6	- 4.30	- 4.20
0.7	- 0.17	- 0.06
0.8	3.58	3.69
0.9	7.02	7.15
1.0	10.22	10.35
1.1	13.21	13.34
1.2	16.01	16.15
1.3	18.66	18.80
1.4	21.17	21.31
1.5	23.55	23.70
1.6	25.83	25.98
1.7	28.01	28.16
1.8	30.10	30.25
1.9	32.11	32.26
2.0	34.04	34.20
2.1	35.91	36.06
2.2	37.72	37.87
2.3	39.46	39.62
2.4	41.16	41.31
2.5	42.80	42.95
2.6	44.40	44.55
2.7	45.95	46.10
2.8	47.47	47.62
2.9	48.94	49.09
3.0	50.38	50.53
3.1	51.78	51.93
3.2	53.16	53.30
3.3	54.50	54.63
3.4	55.81	55.94
3.5	57.09	57.22
3.6	58.35	58.48
3.7	59.58	59.70
3.8	60.79	60.91
3.9	61.98	62.09
4.0	63.14	63.25
4.1	63.99	64.38

1-1-3 Temperature and pressure of refrigerant (Graph)



1-2 REFRIGERANT CYLINDERS

1-2-1 Laws

As a liquefied gas, R410A falls under the scope of the High-Pressure Gas Safety Law. Please refer to this law before using the refrigerant. The law establishes standards necessary for the prevention of accidents.

1-2-2 Types of containers

High-pressure gas containers used for refrigerants include welded containers, seamless containers, non-refillable containers, and service canisters. Welded containers are used for liquefied gas refrigerants. Most fluorocarbon refrigerants are distributed in welded containers. Seamless containers are used for high-pressure refrigerants and high-pressure gas, including fluorocarbon refrigerants such as FC14, CFC13, HFC23, and R503.
Non-refillable containers are disposable and have been used in other countries for some time in the small-container (25 kg or less) sector. With the revision of the High-Pressure Gas Safety Law in April of 1997, non-refillable containers can now be used in Japan. Service canisters are small containers of 1 liter or less, and refilling is prohibited. Previously these containers were only approved for CFC12 and HFC134a, however, the revision of April 1st 1998 now allows filling with R404A, R407C, and R507A .The containable gases were also specified for each container type. (Table 2-1)

Table 2-1: Types of containers and containable refrigerants

Container type	Test pressure	Containable refrigerants
FC 1	3.0MPa	CFC-12, HFC-134a, R500, R401A, R401B, CFC-115, R412A, HFC-218, R407D, HCFC-22, R502
FC 2	4.0MPa	R900JA, R509A, R407C, R402B, R404A, R407A, R901JA, R507A, R402A, R407B, HFC-125, R407E, Gases corresponding to FC-1
FC 3	5.0MPa	R410B, R410JA, R410A, JHFC-32 Gases corresponding to FC-1 and FC-2

1-2-3 Container specifications

The High-Pressure Gas Law requires that high-pressure gas containers be inscribed, labeled, and colored. In addition, the number of mixed refrigerant types is increasing as new refrigerant substitutes are developed. To make identification easier and prevent accidental filling of the wrong refrigerant, the ARI in the United States has established Guideline N for the assignment of colors to refrigerant containers, and U.S. refrigerant manufacturers all use these colors.
In Japan as well, colors equivalent to the ARI colors are used and a label is affixed to part of the container or the container is colored. The Japan Fluorocarbon Manufacturer's Association uses colors equivalent to the ARI colors for the three refrigerants R404A, R407C, and R410A (Figure 2-1).
While not used for single refrigerants (R12, R22, R134a) that are filled as a gas phase, valves consisting of a siphon tube attached to a single valve exist for the purpose of filling mixed refrigerants (R404A, R407C, R401A) that are filled as a liquid phase. A valve with a siphon tube allows the container to be filled with liquid phase without tipping it over (Figure 2-2).

R410A color is pink

Figure 2-1

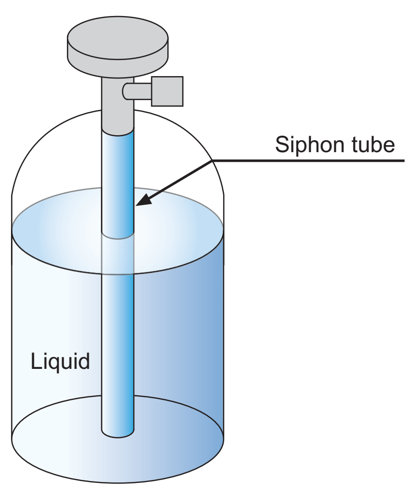


Figure 2-2

1-2-4 Container inscriptions and labels

The following items are inscribed clearly and permanently in the order shown on a clearly visible part of the container where the wall is thick (such as on the shoulder). The container certification was discontinued in the revision of the High-Pressure Gas Control Law of December, 1991.

- Symbol indicating that the container passed inspection and mark indicating the name of the inspector
- Name or mark of container manufacturer
- Type of gas to be filled (see Table 2-1)
- Container symbol and number
- Capacity (symbol V, in liters)
- Weight (symbol W, in kilograms) not including valve and other accessories (detachable items only)
- Year and month inspection passed
- Pressure of pressure test (symbol TP, in Mpa)
- Maximum filling pressure in container filled with compressed gas (symbol FP, in pascals)
- Registered symbol and number of owner of container

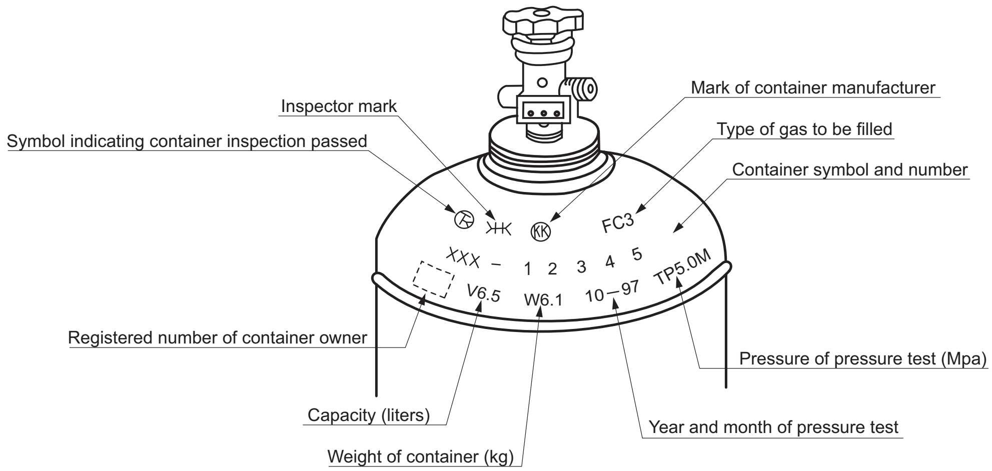


Figure 2-3

1-2-5 Moving containers

The High-Pressure Gas Safety Law calls the transportation of high-pressure gas "moving". When moving high-pressure gas, the following measures stipulated by Ministerial ordinance must be taken to ensure safety.

1) The vehicle that transports the filled container must put up a warning sign in an easily visible location.
2) For containers carried on trucks and other vehicles, measures must be taken to prevent shock and valve damage due to toppling and falling. Containers must not be handled roughly.
3) Filled containers must be kept at a constant temperature of no more than 40°C.
4) Filled containers must not be carried together with dangerous materials stipulated in Section 7, Article 2 of the Fire Services Act.
5) As a basic rule, filled containers should be loaded toward the front of the bed and be securely tied down with a rope, wire rope, luggage holder, or net in order to prevent shock and valve damage due to load scattering, falling, toppling, or vehicle collision.
6) Except when unloading filled containers, the vehicle must not be parked in the vicinity of No. 1 Safety Buildings such as schools and hospitals, or in areas where No. 2 Safety Buildings (residences) are densely built. In addition, a safe parking location with little traffic must be selected. When parked, the driver is not to leave the vehicle except for meals or other situations where leaving the vehicle cannot be avoided.

1-2-6 Storage of containers

When storing 300 m^3 or more of fluorocarbon gas (for liquefied gas, 1 m3 is considered to be 10 kg, and thus this is equivalent to 3 tons), the storage location must be an established high-pressure gas storage area (type 2 storage area) that has been previously reported to the governor of the prefecture or other administrative division. When storing 3000 m^3 or more of fluorocarbon gas (30 tons or more of liquefied gas), the gas must be stored in a type 1 location that has been permitted in advance.

- Storing 1.5 kg to 3 tons

  Reporting is not required, however, certain technical standards must be met:
  <Technical standards>
  1) The container storage location must be clearly marked and a warning sign must be put up that is clearly visible from outside.
  2) Full containers must be kept separate from partially full containers so that the two can be distinguished.
  3) Objects other than gauges or other items required for work must not be placed in the storage location.
  4) Filled containers must be kept at a temperature that never exceeds 40°C.
  5) Measures must be taken to prevent shock and valve damage due to toppling and falling of filled containers, and filled containers must not be handled roughly.

  For 1.5 kg or less, there are no storage regulations.

1-3 REFRIGERATOR OIL

1-3-1 Types of refrigerator oil

The type of refrigerator oil (lubricating oil) used in the compressor varies depending on the use, type, capacity, and refrigerant. The refrigerator oil base can be broadly classified into mineral oil and synthetic oil. The main oil types are described as follows. Mineral oil is generally used when the refrigerant is CFC or HCFC, and is based on naphthene or paraffin, or a blend of paraffin and alkyl benzene. HFC refrigerants will not dissolve into mineral oil, and thus a synthetic oil is generally used to heighten mutual solubility.

- Refrigerator oil
  - Mineral oil
    - Naphthene base
    - Paraffin base
  - Synthetic oil
    - Alkyl benzene (AB)
    - Polyvinyl ether (PVE)
    - Polyphenyl ether (PPE)
    - Polyalkylene glycol (PAG)
    - Poly-ol ester (POE)
    - Polycarbonate (PC)

1-3-2 Mutual solubility of refrigerator oil and refrigerant

Some fluorocarbon refrigerants have a feature of mutual solution with refrigerator oil, however, this depends on the type of oil and the type of refrigerant.
When there is mutual solubility, the refrigerator oil blends together with the refrigerant and circulates with it during the refrigeration cycle, instead of only the refrigerant circulating. The oil collector in the compressor contains some dissolved refrigerant and the liquid refrigerant in the condenser contains a small amount of dissolved oil. When liquid refrigerant evaporates in the evaporator, the oil that was dissolved almost completely separates from the refrigerant. The system design takes care of this by adding a suction tube that returns the separated oil to the compressor. In addition, when the refrigerator is turned off, refrigerator oil collects not only in the compressor but also in suitable locations throughout the refrigerator cycle.
One disadvantage of using mutually soluble oil is foaming phenomenon. When the refrigerator is turned off for a long time and the temperature of the oil in the compressor is lower than in other parts, refrigerant condenses and much of it dissolves into the oil. When the refrigerator is started in this state, the pressure drops and causes the dissolved refrigerant to suddenly evaporate, creating foam. This phenomenon is called foaming. At the same time as foaming occurs, a large amount of oil is spewed out from the discharge side, potentially leading to a compressor lubrication failure. To prevent foaming, some systems have a crankcase heater to warm the oil.

1-3-3 Effects of contaminants

1) Process oil (machining oil, assembly oil)
If a refrigerating system that uses HFC refrigerant becomes contaminated with process oil such as machining or assembly oil, the process oil will separate, create sludge, and cause capillary plugging.

2) Water
If a refrigerating system that uses HFC refrigerant becomes contaminated with a large quantity of water, hydrolysis of the refrigerant and organic materials used in the compressor motor will occur, causing capillary plugging, compressor insulation failure, and other problems.

3) Debris
If a large quantity of debris enters a refrigerating system that uses HFC refrigerant, the refrigerator oil will separate and deteriorate, causing capillary plugging and insulation failure in the compressor and other parts.

4) Air
If a large quantity of air enters a refrigerating system that uses HFC refrigerant, the refrigerator oil will separate and deteriorate, causing capillary plugging and insulation failure in the compressor and other parts.

5) Mixing of other refrigerants
If a large quantity of a different type of refrigerant is mixed into a refrigerating system that uses HFC refrigerant, abnormal operating pressure and temperature will occur, causing damage to the system.

6) Mixing of other refrigerator oils
If a different type of refrigerator oil is mixed into a refrigerating system that uses HFC refrigerant, compressor lubrication failure and capillary plugging will occur, causing damage to the system. Even if a different purity or different grade of the same type of oil is used, or a different additive is used, compressor lubrication failure and capillary plugging may occur and cause damage to the system. For this reason, the refrigerator oil specified by the manufacturer must always be used.

7) Flux
If a chlorine residue from flux forms in the pipes, the pipes will deteriorate, and thus a flux with a low level of chlorine must be used. In addition, the flux should be removed after brazing. If water is added to the flux, use distilled water or other water that does not contain chlorine.

2. MATERIALS

2. MATERIALS

2-1 REFRIGERANT PIPES

2-1-1 Quality of copper pipes

Refrigerant pipes use C1220 phosphorus deoxidized copper as specified in the Japanese Industrial Standard JIS H 3300 "Copper and copper alloy seamless pipes and tubes".

1) No harmful cracks, dents, damage, or other defects.
2) Truly round for practical purposes.
3) Outer and inner pipe surface is clean and there is no harmful chlorine, sulfur, oxides, debris, cutting scraps, oil, or other material.

Refrigerant piping recommended in other contries

- USA	ASTM B280 C12200
- Austraria and New Zealand	AS/NZS 1571
- Europe	BS28712/C106
- China	GB/T1889-1998
- Germany	DIN1787

2-1-2 Types, grades, and codes

Type		Grade	Code	Remarks	
Alloy number	Shape			Name	Characteristics and usage examples
C1220	Pipe	Regular grade	C1220T	Phosphorus deoxidized copper	Good expandability, bendability, restrictability, weldability, corrosion resistance, and thermal conductivity. Even when C1220 is heated to high temperature in a reducing atmosphere, there is no concern that hydrogen embrittlement will occur. Used for heat exchangers, chemical industrial equipment, water supply, hot water supply, and gas pipes, etc.
		Special grade	C1220TS		

★ Dimension tolerance grades in JIS H 3300 are regular grade and the stricter special grade.

Average diameter tolerances

Grade	Code	Outer diameter or inner diameter (mm)						
		4 or more up to 15	More than 15 up to 25	More than 25 up to 50	More than 50 up to 75	More than 75 up to 100	More than 100 up to 125	More than 125 up to 150
Regular grade	C1220T	± 0.08	± 0.09	± 0.12	± 0.15	± 0.20	± 0.27	± 0.35
Special grade	C1220TS	± 0.05	± 0.06	± 0.08	± 0.10	± 0.13	± 0.15	± 0.18

★ Average diameter is defined as the average of the maximum outer diameter and the minimum outer diameter, or the average of the maximum inner diameter and the minimum inner diameter, measured at any cross-section.

2-1-3 Chemical components

Alloy number	Chemical component (%)	
	Cu	P
C1220	99.90 or more	0.015～0.040

2-1-4 Mechanical properties

Grade	Quality classification	Code	Tensile strength (N/mm^2)	Elongation (%)	Hardness			Crystal particle size (mm)
					HR30T	HR15T	HRF	
C1220	0	C1220T-0 C1220TS-0	205 or more	40 or more	-	60 or less	50 or less	0.025 ～ 0.060
	0L	C1220T-0L C1220TS-0L	205 or more	40 or more	-	65 or less	55 or less	0.040 or less
	1/2H	C1220T-1/2H C1220TS-1/2H	245 ～ 325	-	30 ～ 60	-	-	
	H	C1220T-H C1220TS-H	315 or more	-	55 or more	-	-	

Quality classification of copper pipes

Quality classification	Summary
F	As fabricated. No restrictions on mechanical properties. (Fabrication)
0	Completely re-crystallized or annealed. Tensile strength value is lowest. (Zero-0)
0L	Annealed or lightly worked. Same tensile strength as 0. (Abbreviation of "Zero(0)-Light")
1/8H	Hardened to a tensile strength midway between quality classifications 0 and 1/4H. ("H" is an abbreviation of "Hard".)
1/4H	Hardened to a tensile strength midway between quality classifications 1/8H and 1/2H.
1/2H	Hardened to a tensile strength midway between quality classifications 1/4H and 3/4H.
3/4H	Hardened to a tensile strength midway between quality classifications 1/2H and H.
H	Hardened to a tensile strength midway between quality classifications 3/4H and EH.
EH	Hardened to a tensile strength midway between quality classifications H and SH. (EH is an abbreviation of "Extra Hard")
SH	Hardened to the highest tensile strength. (SH is an abbreviation of "Spring Hard")
SR	Heat treated to release stress. (SR is an abbreviation of "Stress Release")

★ There are two types of treatment: heat treatment and cold working.

2-1-5 Classifications

Classifications are based on JIS B 8607-2002 "Flare type and brazing type fittings for refrigerants"
Classifications are type 1, type 2, and type 3 based on the maximum working pressure (design pressure).

Type	Maximum working pressure	Example refrigerants (used at high pressure)
Type 1	3.45MPa	R22, R134a, R404A, R407C, R507A, etc.
Type 2	4.30MPa	R410A, etc.
Type 3	4.80MPa	Refrigerants used at more than 4.30 Mpa but not over 4.80 Mpa.

[Reference]

1) In some cases, codes for the copper pipe wall thickness and compatible refrigerant appear on the surface of the heat insulation material.

< Copper pipe wall thickness >

Wall thickness (mm)	Code
0.8	08
1.0	10

< Compatible refrigerant display >

Compatible refrigerant		Code display
Type 1	R22, R407C	①
Type 2	R410A	②

2) Some are also labeled to enable identification using the outer packaging.

< Example of outer packaging labeling >

(2): Both type 1 and type 2
Compatible refrigerants: R22, R410A, R407C
Copper pipe bore x wall thickness: 6.35 x 0.8 / 9.52 x 0.8

2-1-6 Dimensions

1) Wall thicknesses of copper pipes used for common refrigerants are shown in Table 2-1 and Table 2-2.
These are extracted from JIS B 8607-2002 "Flare type and brazing type fittings for refrigerants".

Important

1) The pressure of substitute refrigerant R410A rises to 1.6 times that of R22. For this reason, be sure to use the appropriate copper pipe as indicated above.
2) For reference, the equation for determining the required copper pipe wall thickness (C1220T) as stipulated in the refrigerant safety rule standards is given below.

[Reference]Equation $t=[P \times DO / (2 \sigma a + 0.8P)] + \alpha$

t :Required wall thickness (mm)

P :Maximum working pressure (design pressure, Mpa)

DO :Standard outer diameter (mm)

σa :Basic allowable stress (N/mm) at 125°C

α :Corrosion allowance (0 mm)

Extracted from JIS B 8607-200

1. Scope of application: This table specifies types, dimensions, and tolerances of copper pipes for common refrigerant piping. However, refrigerant pipes inside factory assembled equipment do not need to conform to these values.
2. Dimensions and tolerances of copper pipes: Dimensions and tolerances of copper pipes must conform to Table 2-1 or Table 2-2.

Table 2-1: Dimensions and tolerances of common copper pipes for refrigerant piping

Type	Standard outer diameter (tolerance) D_0 (mm)	Wall thickness (tolerance) t (mm)	Circularity tolerance (mm)	Type	Reference values	
					Maximum working pressure P (MPa)	Allowable tensile stressa σ (N/mm^2)
0 and 0L	3.17 (± 0.03)	0.70 (± 0.06)	-	Type 3	17.701	33 (Allowable tensile stress at 125°C)
	4.76 (± 0.03)	0.70 (± 0.06)			11.000	
	6.00 (± 0.03)	0.70 (± 0.06)			8.492	
	6.35 (± 0.03)	0.80 (± 0.06)			9.246	
	8.00 (± 0.03)	0.80 (± 0.06)			7.173	
	9.52 (± 0.03)	0.80 (± 0.06)			5.945	
	10.00 (± 0.03)	0.80 (± 0.06)			5.641	
	12.70 (± 0.03)	0.80 (± 0.06)		Type 2	4.378	
	15.88 (± 0.03)	1.00 (± 0.09)			4.376	
	19.05 (± 0.03)	1.00 (± 0.09)		Type 1	3.616	
	22.22 (± 0.03)	1.15 (± 0.09)			3.563	
	25.40 (± 0.04)	1.30 (± 0.09)			3.522	
	28.58 (± 0.04)	1.45 (± 0.10)			3.490	
	31.75 (± 0.04)	1.60 (± 0.10)			3.465	
	34.92 (± 0.04)	1.75 (± 0.10)			3.445	
	38.10 (± 0.05)	1.90 (± 0.10)			3.428	
	41.28 (± 0.05)	2.10 (± 0.13)			3.500	
	44.45 (± 0.05)	2.25 (± 0.13)			3.481	
	50.80 (± 0.05)	2.55 (± 0.18)			3.455	
	53.98 (± 0.05)	2.75 (± 0.18)			3.505	

Remarks
1. The standard outer diameter tolerance is the allowed limit of the difference between the standard outer diameter and the average of the maximum outer diameter and the minimum outer diameter measured at any cross-section of the pipe.
2. The circularity tolerance does not apply to pipes of quality classification 0 and 0L, and coil-wound pipes.
3. Copper pipes not listed in this table are specified by the special class of JIS H 3300.
4. Copper pipes with an outer diameter of 10.00 mm or less can also be used as a type 1 or 2 pipe. Copper pipes with a diameter of 12.70 and 15.88 mm can also be used as a type 1 pipe.

Table 2-2: Dimensions and tolerances of common copper pipes for refrigerant piping

Type	Standard outer diameter (tolerance) D_0 (mm)	Wall thickness (tolerance) t (mm)	Circularity tolerance (mm)	Type	Reference values: Maximum working pressure P (MPa)	Reference values: Allowable tensile stressa σ (N/mm²)
1/2H or H	3.17 (± 0.03)	0.70 (± 0.06)	0.03 or less	Type 3	32.720	61 (Allowable tensile stress at 125°C)
	4.76 (± 0.03)	0.70 (± 0.06)	0.04 or less		20.528	
	6.00 (± 0.03)	0.70 (± 0.06)	0.05 or less		15.698	
	6.35 (± 0.03)	0.80 (± 0.06)	0.05 or less		17.092	
	8.00 (± 0.03)	0.80 (± 0.06)	0.07 or less		13.260	
	9.52 (± 0.03)	0.80 (± 0.06)	0.08 or less		10.990	
	10.00 (± 0.03)	0.80 (± 0.06)	0.08 or less		10.427	
	12.70 (± 0.03)	0.80 (± 0.06)	0.11 or less		8.092	
	15.88 (± 0.03)	1.00 (± 0.09)	0.13 or less		8.090	
	19.05 (± 0.03)	1.00 (± 0.09)	0.16 or less		6.684	
	22.22 (± 0.03)	1.00 (± 0.09)	0.23 or less		5.695	
	25.40 (± 0.04)	1.00 (± 0.09)	0.26 or less		4.959	
	28.58 (± 0.04)	1.00 (± 0.09)	0.29 or less	Type 2	4.391	
	31.75 (± 0.04)	1.10 (± 0.09)	0.32 or less		4.347	
	34.92 (± 0.04)	1.10 (± 0.09)	0.35 or less	Type 1	3.942	
	38.10 (± 0.05)	1.15 (± 0.09)	0.39 or less		3.773	
	41.28 (± 0.05)	1.20 (± 0.09)	0.42 or less		3.630	
	44.45 (± 0.05)	1.25 (± 0.09)	0.45 or less		3.509	
	50.80 (± 0.05)	1.40 (± 0.13)	0.51 or less		3.434	
	53.98 (± 0.05)	1.50 (± 0.15)	0.54 or less		3.467	
	63.50 (± 0.05)	1.75 (± 0.15)	0.64 or less		3.438	
	66.68 (± 0.05)	1.85 (± 0.15)	0.67 or less		3.461	
	76.20 (± 0.05)	2.10 (± 0.18)	0.77 or less		3.438	
	79.38 (± 0.05)	2.20 (± 0.18)	0.80 or less		3.457	

Remarks
1. The standard outer diameter tolerance is the allowed limit of the difference between the standard outer diameter and the average of the maximum outer diameter and the minimum outer diameter measured at any cross-section of the pipe.
2. The circularity tolerance is the difference between the diameter and the shortest diameter measured at any cross-section of the pipe.
3. Copper pipes not listed in this table are specified by the special class of JIS H 3300.
4. Copper pipes with a standard diameter of 25.40 mm or less can also be used as a type 1 and 2 pipe. Copper pipes with a diameter of 28.58 and 31.75 mm can also be used as a type 1 pipe.

2-2 Connection Part

Flare fittings for refrigerants (JIS B 8607-2002)

Flare fittings for copper pipes can be used to connect pipes of nominal diameter 3/4 (outer diameter of copper pipe 19.05 mm) or less.
For pipe diameters larger than the above, a flange fitting or brazing fitting is used. Before using fittings, verify that no contaminants adhere to the inside of the pipes that form the refrigerant circuit.
Refrigerant flare fittings are classified as type 1 (3.45 Mpa) and type 2 (4.30 Mpa) depending on the maximum working pressure (design pressure). Type 1 corresponds to R22 pressure and has been in use for some time. Type 2 corresponds to R410A pressure and thus is a newly established type. Type 2 is approved for use only in locations that are not subject to external forces such as vibrational forces or bending. Table 2-3 indicates the existence or not of applicable standards for each working pressure. Select a suitable fitting for your working pressure (for the refrigerant that will be used).

Table 2-3: Varieties of fittings, types and maximum working pressures (design pressures)

<table>
<tr><th colspan="3" rowspan="2">Fitting variety and type</th><th colspan="3">Maximum working pressure</th></tr>
<tr><th>Type 1
3.45Mpa</th><th>Type 2
4.30Mpa</th><th>Type 3
4.80Mpa</th></tr>
<tr><td rowspan="3">Flare fittings</td><td rowspan="2">Not subject to external forces such as vibrational force or bending</td><td>Non-toxic and non-combustible refrigerants</td><td>Table 2-6</td><td>Table 2-6</td><td>×</td></tr>
<tr><td>Toxic and combustible refrigerants</td><td>Table 2-6</td><td>×</td><td>×</td></tr>
<tr><td colspan="2">Subject to external forces such as external vibrational force or bending. However, cannot be used for toxic and combustible refrigerants.</td><td>Table 2-6</td><td>×</td><td>×</td></tr>
<tr><td colspan="3">Copper alloy brazing fitting</td><td>Same as type 3</td><td>Same as type 3</td><td>Table 2-8</td></tr>
<tr><td rowspan="3">Brazing fitting</td><td colspan="2">Standard outside diameter of copper pipe: 3.17 mm to 22.22 mm</td><td>Same as type 3</td><td>Same as type 3</td><td>Table 2-11</td></tr>
<tr><td colspan="2">Standard outside diameter of copper pipe: 25.40 mm to 28.58 mm</td><td>Same as type 2</td><td>Table 2-11</td><td>×</td></tr>
<tr><td colspan="2">Standard outside diameter of copper pipe: 31.75 mm to 79.38 mm</td><td>Table 2-11</td><td>×</td><td>×</td></tr>
</table>

Remarks
1. "X" in the table indicates that the type cannot be used.
2. Examples of refrigerants classified by maximum working pressure type are shown in the following table.

Type	Maximum working pressure	Refrigerant examples (used at high pressure)
Type 1	3.45MPa	R22, R134a, R404A, R407C, R507A, etc.
Type 2	4.30MPa	R410A, etc.
Type 3	4.80MPa	Refrigerants used at more than 4.30 Mpa but not over 4.80 MPa.

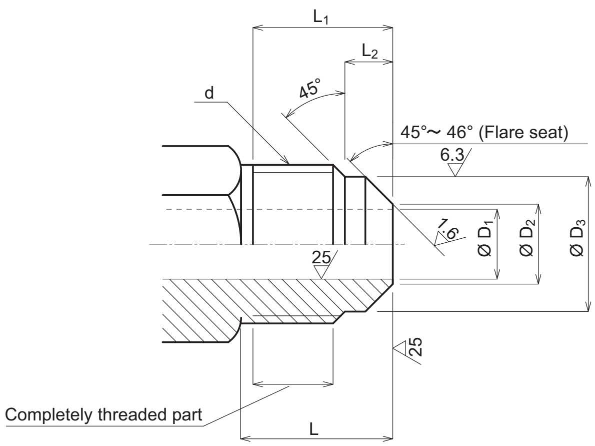
Table of usage of refrigerant flare fittings by working pressure

Nominal	Outer diameter of applicable pipe (mm)	Flare fitting end	Flared pipe end		Flare nut	
		Both type 1 and type 2	Type 1	Type 2	Type 1	Type 2
			3.45MPa	4.30MPa	3.45MPa	4.30MPa
1/4	6.35	○	○	○	○	
3/8	9.52	○	○	○	○	
1/2	12.70	○	○	○	○	○
5/8	15.88	○	○	○	○	○
3/4	19.05	○	○	○	○	

2-2-1 Flare fitting ends

The shape and dimensions of type 1 (3.45 MPa) and type 2 (4.30 MPa) are the same, and thus previously used fitting ends can be used.
The shapes and dimensions are shown in Table 2-4.

Table 2-4: Shape and dimensions of flare fitting end



Units: mm

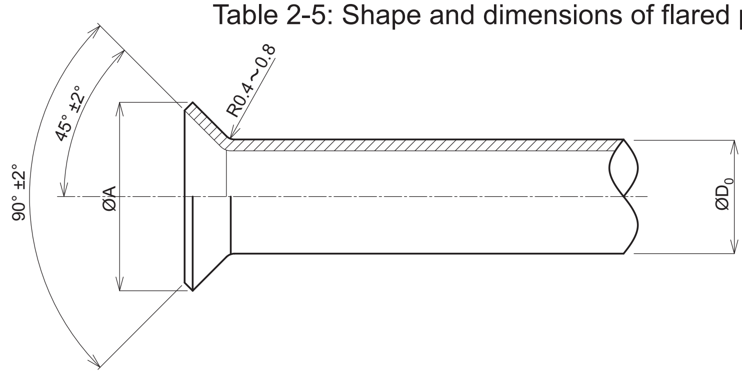
Nominal	Outer diameter of applicable pipe	Nominal screw d	$D_{1\,-0.15}^{\;0}$	D_2	D_3	L	L_1 (minimum)	L_2
1/4	6.35	7/16 - 20UNF	4.8	5.5	9.2	13.5	11.3	3.7
3/8	9.52	5/8 - 18UNF	7.0	8.0	13.5	16.5	14.0	4.8
1/2	12.70	3/4 - 16UNF	10.0	11.0	16.0	19.5	16.8	5.5
5/8	15.88	7/8 - 14UNF	12.5	13.5	19.0	23.0	19.9	6.0
3/4	19.05	1-1/16 - 14UNS	16.0	18.0	24.0	26.5	23.4	6.0

1) The dimensions of the flare fitting end are the same for type 1 and type 2.
2) Screws used for pipe fittings are specified by JIS B 0208 (Unified fine screw threads).
However, 1 1/16 - 14UNS screws are specified by JIS B 8607 4.1h.

2-2-2 Flared pipe ends

Flared pipe ends are classified by working pressure as type 1 (3.45 Mpa) and type 2 (4.30 Mpa). Type 1 flared pipe ends are the same as the conventional flared pipe ends. Each type 2 flared pipe end has a larger diameter and nominal diameter at A (the outer diameter at the trumpet shaped end).
The shape and dimensions are shown in Table 2-5.

Table 2-5: Shape and dimensions of flared pipe ends




Flared pipe ends

Units: mm

Nominal	Outer diameter of pipe	$A^{+0}_{-0.4}$	
	D_0	Type 1	Type 2
1/4	6.35	9.0	9.1
3/8	9.52	13.0	13.2
1/2	12.70	16.2	16.6
5/8	15.88	19.4	19.7
3/4	19.05	23.3	24.0

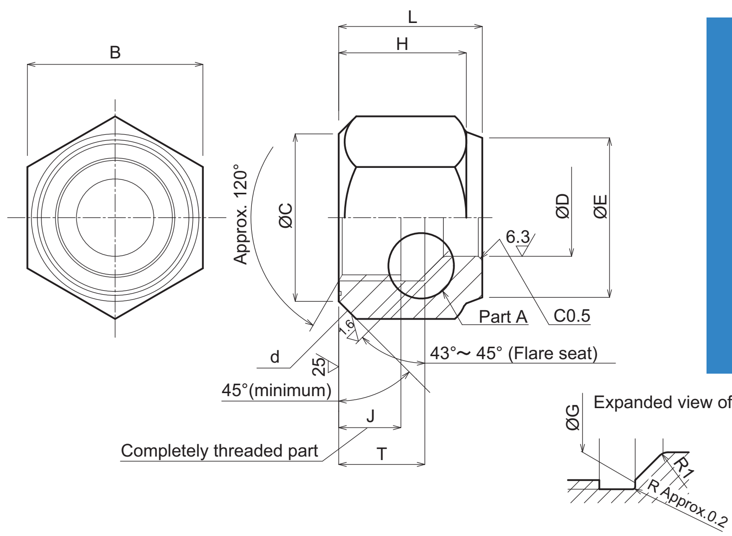
Remarks 1. Flared copper pipes must be made of O or OL material.
2. Deviation of the flared pipe end must be no more than 0.4 mm.
3. A type 1 flared pipe end is used when a type 1 flare nut is used for connection.
A type 2 flared pipe end is used when a type 2 flare nut is used for connection.

2-2-3 Flare nuts

Flare nuts with nominal diameters 1/4, 3/8, and 3/4 are the same for type 1 (3.45 Mpa) and type 2 (4.30 Mpa). Flare nuts with nominal diameters 1/2 and 5/8 are classified by working pressure as type 1 and type 2, and the dimension B spanned by the wrench (distance between the two opposite sides of the nut) is larger on type 2. The shape and dimensions are shown in Table 2.-6.

※ The flare nut should use the specified one by our company or the one attach to the units.

Table 2-6: Shape and dimensions of flare nut



● Type 1 flare nut dimensions

Units: (mm)

Nominal	Outer diameter of applicable pipe	Nominal screw d	B $^{0}_{-0.6}$	D $^{+0.1}_{0}$	E (Minimum)	H ±0.8	J	L ±0.5	T	G	C (Approx.)
1/4	6.35	7/16 - 20UNF	17	6.5	13	12	6.3	15	9.0	9.7	16.5
3/8	9.52	5/8 - 18UNF	22	9.7	20	16	7.8	18	10.8	14.3	21
1/2	12.70	3/4 - 16UNF	24	12.9	20	16	10.0	22	13	17.3	23
5/8	15.88	7/8 - 14UNF	27	16.0	24	20	12.5	26	15.5	20.2	26
3/4	19.05	1-1/16 - 14UNS	36	19.2	28	24	16.0	30	19	25	34

● Type 2 flare nut dimensions

Units: (mm)

Nominal	Outer diameter of applicable pipe	Nominal screw d	B $^{0}_{-0.6}$	D $^{+0.1}_{0}$	E (Minimum)	H ±0.8	J	L ±0.5	T	G	C (Approx.)
1/4	6.35	7/16 - 20UNF	17	6.5	13	12	6.3	15	9.0	9.7	16.5
3/8	9.52	5/8 - 18UNF	22	9.7	20	16	7.8	18	10.8	14.3	21
1/2	12.70	3/4 - 16UNF	26	12.9	23	19	10.0	22	13	17.3	26
5/8	15.88	7/8 - 14UNF	29	16.0	25	22	12.5	26	15.5	20.2	28
3/4	19.05	1-1/16 - 14UNS	36	19.2	28	24	16.0	30	19	25	34

Remarks For both type 1 and type 2, the thread-cutting recess indicated in the enlarged view of part A can be omitted, however, the length J of the completely threaded part must not be shortened.
1) Bolts used for pipe fittings are specified in JIS B 0208 (Unified fine screw threads).
However, 1 1/16 - 14 UNS bolts are specified in JIS B 8607 4.1h.

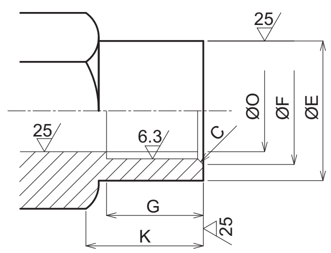
2-2-4 Copper alloy brazing type socket fittings

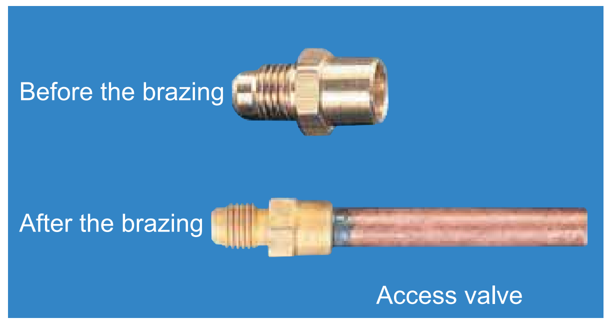
Copper alloy brazing type fittings can be used to connect copper pipes of nominal diameter 7/8 (outer diameter 22.22 mm) or less.
Pipes larger than this are connected with flange fittings or brazing type fittings.
Copper alloy brazing type fittings can be used mutually for any working pressure up to 4.8 Mpa; there are no type classifications by working pressure.
Shape and dimensions are shown in Table 2-8.

Table 2-7: Copper alloy brazing type socket fittings by working pressure list

Nominal	Outer diameter of copper pipe (mm)	Type 3 (4.8 Mpa)	Remarks
1/8～7/8	3.17～22.22	○	Can be used for 4.80 Mpa or less

Table 2-8: Shape and dimensions of flare copper alloy brazing type socket fittings





Units: (mm)

Nominal		Standard outer diameter of connected copper pipe D_0	Standard inner diameter F (allowed tolerance)	Minimum length		Minimum outer diameter E	Bevel C	Inner diameter O
A	B			G	K			
	1/8	3.17	3.27 (±0.03)	5	6	5.6	-	2.4
	3/16	4.76	4.86 (±0.03)	5	6	7.2	-	3.9
6		6.00	6.10 (±0.03)	6	7	8.3	-	5.0
	1/4	6.35	6.45 (±0.03)	6	7	8.7	-	5.3
8		8.00	8.10 (±0.03)	7	8	10.2	0.3	6.8
	3/8	9.52	9.62 (±0.03)	7	8	12.2	0.3	8.2
10		10.00	10.10 (±0.03)	7	8	12.7	0.3	8.6
	1/2	12.70	12.80 (±0.03)	8	9	15.3	0.3	11.0
	5/8	15.88	16.00 (±0.03)	8	9	18.8	0.3	14.0
	3/4	19.05	19.19 (±0.03)	10	11	21.9	0.3	17.0
	7/8	22.22	22.36 (±0.03)	10	11	24.9	0.3	20.0

Remarks
1. The maximum working pressure (design pressure) of the copper alloy brazing type fittings shown in this table is 4.80 Mpa. The fittings are the same for types 1, 2, and 3 .
2. Either an A nominal size or a B nominal size is used. A or B may be added after a dimension as needed to distinguish the nominal size type.
3. When used as a male fitting, outer diameter E can match the inner diameter of the copper pipe.
4. Finish the end surface so that it is smooth.

2-2-5 Brazing type fittings

Types of brazing type fittings

Brazing type fittings are listed in Table 2-10 based on the overall shape and type of connector, and are shown in Figures 2-1 to 2-6.
Brazing type fittings are classified as type 1, type 2, and type 3 based on the working pressure. Useable working pressures and corresponding copper pipe diameters are shown in Table 2-9.

Table 2-9: Brazing type fittings by working pressure list

Standard outer diameter of connected copper pipe (mm)	Type 1	Type 2	Type 3	Remarks
	3.45Mpa	4.30Mpa	4.80Mpa	
3.17～22.22	○	○	○	Can be used at pressures of 4.80 Mpa or less
25.40～28.58	○	○	×	Can be used at pressures of 4.30 Mpa or less
31.75～79.38	○	×	×	Can be used at pressures of 3.45 Mpa or less.

Table 2-10: Types of brazing type fittings

Type	Code	Connector	Example diagram
T	T	Female	Figure 2-1
90° elbow A	90EA	Female	Figure 2-2
90° elbow B	90EB	Female, male	Figure 2-3
45° elbow	45EA	Female	Figure 2-4
Socket	S	Female	Figure 2-5
Reducing socket	RS	Female	Figure 2-6

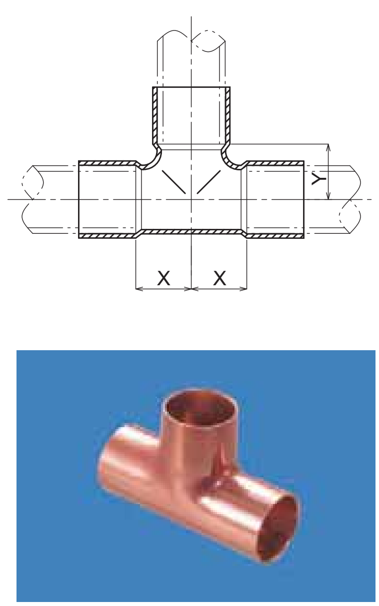


Figure 2-1: T

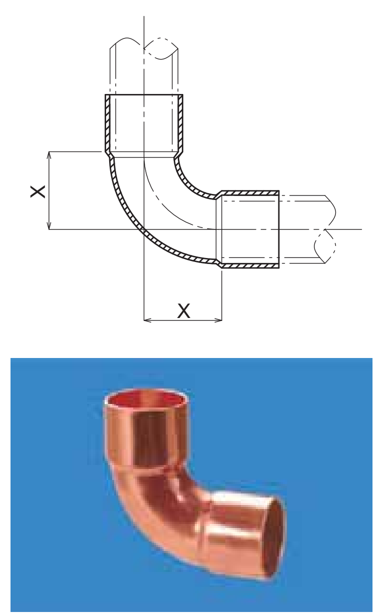


Figure 2-2: 90o elbow A

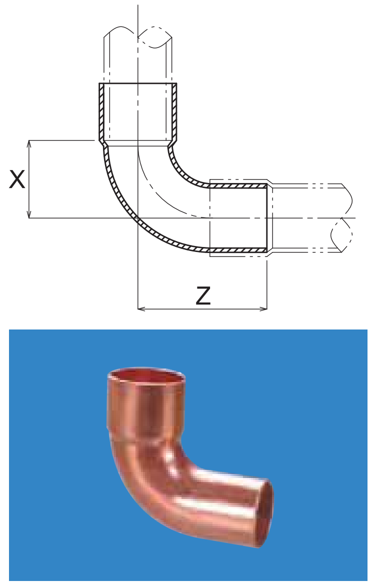


Figure 2-3: 90° elbow B

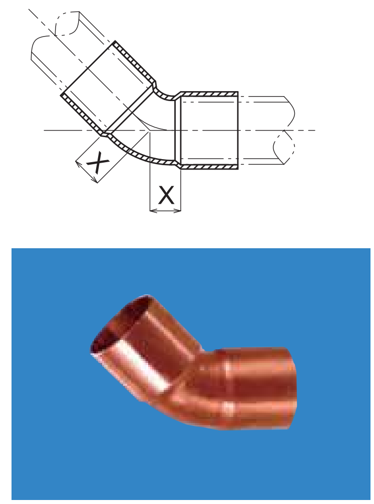


Figure 2-4: 45° elbow

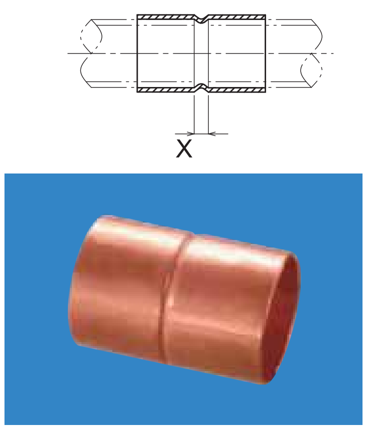


Figure 2-5: Socket

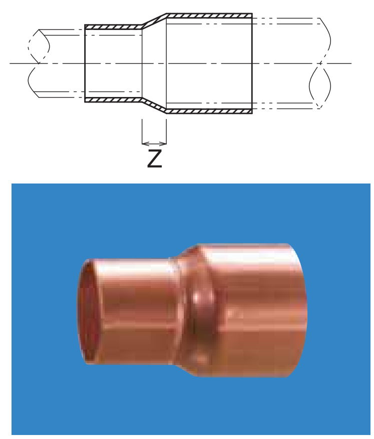


Figure 2-6: Reducing socket

Dimensions and tolerances of brazing type fittings

Brazing type fittings for connected copper pipes with standard outer diameters of 22.22 mm or less can also be used as type 1 and type 2. Brazing type fittings for diameters of 25.40 to 28.58 mm can also be used as type 1. Dimensions and tolerances of brazing type fittings are shown in Table 2-11.

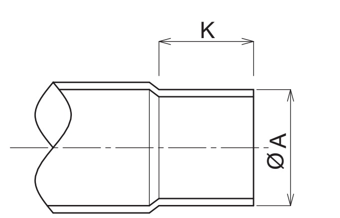
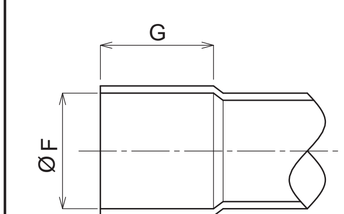
Connector	
Male	Female
	

Figure 2-7

Table 2-11: Dimensions and tolerances of brazing type fittings

Units: (mm)

Standard outer diameter of connected copper pipe D_0	Connector					Minimum connector thickness	Maximum working pressure (design pressure) P Mpa	Type
	Male	Female	Minimum insertion depth		Ellipse value			
	Standard outer diameter (tolerance) A	Standard outer diameter (tolerance) F	K	G				
3.17	3.17 (±0.03)	3.27 (±0.03)	6	5	0.04 or less	0.50	4.80	Type 3
4.76	4.76 (±0.03)	4.86 (±0.03)	6	5	0.05 or less	0.50		
6.00	6.00 (±0.03)	6.10 (±0.03)	7	6	0.05 or less	0.50		
6.35	6.35 (±0.03)	6.45 (±0.03)	7	6	0.06 or less	0.50		
8.00	8.00 (±0.03)	8.10 (±0.03)	8	7	0.06 or less	0.50		
9.52	9.52 (±0.03)	9.62 (±0.03)	8	7	0.08 or less	0.60		
10.00	10.00 (±0.03)	10.10 (±0.03)	8	7	0.08 or less	0.60		
12.70	12.70 (±0.03)	12.81 (±0.03)	9	8	0.10 or less	0.70		
15.88	15.88 (±0.03)	16.00 (±0.03)	9	8	0.13 or less	0.80		
19.05	19.05 (±0.03)	19.19 (±0.03)	11	10	0.15 or less	0.80		
22.22	22.22 (±0.03)	22.36 (±0.03)	11	10	0.16 or less	0.90		
25.40	25.40 (±0.04)	25.56 (±0.04)	13	12	0.18 or less	0.95	4.30	Type 2
28.58	28.58 (±0.04)	28.75 (±0.04)	13	12	0.20 or less	1.00		
31.75	31.75 (±0.04)	31.93 (±0.04)	13	12	0.22 or less	1.05	3.45	Type 1
34.92	34.92 (±0.04)	35.11 (±0.04)	13	12	0.24 or less	1.20		
38.10	38.10 (±0.05)	38.31 (±0.05)	15	14	0.27 or less	1.25		
41.28	41.28 (±0.05)	41.50 (±0.05)	15	14	0.29 or less	1.25		
44.45	44.45 (±0.05)	44.68 (±0.05)	15	14	0.31 or less	1.25		
50.80	50.80 (±0.05)	51.03 (±0.05)	17	16	0.31 or less	1.40		
53.98	53.98 (±0.05)	54.22 (±0.05)	17	16	0.32 or less	1.50		
63.50	63.50 (±0.03)	63.77 (±0.05)	19	18	0.38 or less	1.75		
66.68	66.68 (±0.03)	66.96 (±0.05)	22	21	0.40 or less	1.85		
76.20	76.20 (±0.03)	76.48 (±0.05)	22	21	0.40 or less	2.10		
79.38	79.38 (±0.03)	79.66 (±0.05)	22	21	0.40 or less	2.20		

Remarks

1. The tolerance of standard outer diameter A is the allowed limit of the difference between the standard outer diameter and the average of the maximum diameter and the minimum diameter measured at any cross-section of the connector.
2. The tolerance of standard outer diameter F is the allowed limit of the difference between the standard inner diameter and the average of the maximum diameter and the minimum diameter measured at any cross-section of the connector.
3. The ellipse value here is the difference between the maximum outer diameter (maximum inner diameter) and minimum outer diameter (minimum inner diameter) measured at any cross-section of the connector.
4. A, F, K, and G are the dimensions of the parts in Figure 2-7.
5. The minimum thickness is the thickness of the entire connector wall; in a fitting that combines a large bore diameter and a small bore diameter, the thickness must be larger than the above minimum thickness as appropriate for the bore diameters.
6. Brazing type fittings for connected copper pipes with standard outer diameters of 22.22 mm or less can also be used as type 1 and type 2. Brazing type fittings for diameters of 25.40 to 28.58 are can also be used as type 1.

Table 2-12: Combinations of copper pipes connected using brazing type T fitting

Units: (mm)

Standard outer diameter of copper pipes connecting to connectors on same center line D_0	Standard outer diameter of copper pipe connecting to T connector D_0					
3.17	3.17					
4.76	4.76					
6.00	6.00					
6.35	6.35					
8.00	6.00	6.35	8.00			
9.52	6.35	8.00	9.52			
10.00	10.00					
12.70	6.35	8.00	9.52	12.70		
15.88	6.35	8.00	9.52	12.70	15.88	19.05
19.05	9.52	12.70	15.88	19.05		
22.22	12.70	15.88	19.05	22.22		
25.40	12.70	15.88	19.05	22.22	25.40	
28.58	28.58					
31.75	19.05	25.40	31.75			
34.92	34.92					
38.10	19.05	25.40	31.75	38.10		
41.28	41.28					
44.45	44.45					
50.80	50.80					
53.98	53.98					
63.50	63.50					
66.68	66.68					
76.20	76.20					
79.38	79.38					

Table 2-13: Standard dimensions of brazing type fittings 90EA, 90EB, 45E, S

Standard outer diameter of connected copper pipe D_0 (mm)	90EA	90EB	45E	S
6.35	○			○
9.52	○	○	○	○
10.00	○			○
12.70	○	○	○	○
15.88	○	○	○	○
19.05	○	○	○	○
22.22	○	○	○	○
25.40	○	○	○	○
28.58	○		○	○
31.75	○	○	○	○
34.92	○		○	○
38.10	○	○	○	○
41.28	○		○	○
44.45	○		○	○
50.80	○	○	○	○
53.98	○			○
63.50	○			○
66.68	○			○
76.20	○			○
79.38	○			○

Table 2-14: Copper pipe combinations connected using brazing type fitting RS

Standard outer diameter of copper pipe connecting to large end of connector D_0 (mm)	Standard outer diameter of copper pipe connecting to small end of connector D_0 (mm)		
6.35	3.17	4.76	
8.00	3.17	4.76	6.35
9.52	3.17	4.76	6.35
12.70	6.35	9.52	
15.88	6.35	9.52	12.70
19.05	9.52	12.70	15.88
22.22	12.70	15.88	19.05
25.40	15.88	19.05	22.22
31.75	15.88	19.05	25.40
38.10	25.40	31.75	
44.45	31.75	38.10	
50.80	38.10	44.45	
63.50	44.45	50.80	
76.20	50.80	63.50	
79.38	63.50	76.20	

2-3 Thermal and Cold Insulation Materials

Standard practice for thermal and cold insulation works (JIS A 9501-2001)

1. Scope of application

This standard applies to thermal and cold insulation work on equipment used in the chemical and fuel industries, heat-powered equipment, air conditioning equipment, and water supply and drainage equipment. However, this standard does not apply to thermal and cold insulation work on refrigerators, ships, and train cars.
Note: The applicable temperature range of thermal and cold insulation work subject to this standard is -180 to 1000°C.

2. Definitions

(1) Thermal insulation
Covering an object warmer than room temperature and less than approximately 1000°C to reduce heat radiation, or lowering the surface temperature of a covered object.

(2) Thermal insulation material
Material used for the purpose of thermal insulation. In general a material with a thermal conductivity of 0.065 W/(m-K) or lower at room temperature.

(3) Cold insulation
Covering an object lower than room temperature to prevent heat intrusion, or keeping the surface temperature of a covered object higher than the dew-point temperature to prevent moisture condensation on the surface.

(4) Cold insulation material
Material used for the purpose of cold insulation. In general a material with a low thermal conductivity and a low water vapor permeability.

(5) Condensation proofing
A branch of cold insulation that deals with the prevention of moisture condensation on the surface of an object that is generally at a temperature higher than 0°C and lower than room temperature.

(6) Condensation proof material
Material used for condensation proofing.

(7) Prevention of water freezing in pipes
A branch of thermal insulation that deals with the prevention of freezing for a certain period of time of an internal fluid (usually water) that is in a static state.

2-3-1 Selecting thermal and cold insulation materials

Take the following conditions into consideration when selecting an insulation material for thermal or cold insulation work.

- Temperature range
- Thermal conductivity
- Physical and chemical strength
- Years of use
- Price per unit volume
- Suitability for work site
- Combustibility
- Water vapor permeability

2-3-2 Main thermal and cold insulation materials

The main insulation materials used for thermal and cold insulation work should as a basic rule conform to the following standards or be of equivalent or higher quality.

1. Man made mineral fiber thermal insulation materials JIS A 9504

- At temperatures greater than about 180°C, the binder in man-made mineral fiber thermal insulation materials may occasionally start to decompose and become incapable of form retention (under conditions of strong vibration, performance may no longer be maintained). However the heat tolerance (thermal contraction temperature) of the insulation itself is 400°C for rock wool insulation.
- When form retention is required, the insulation can be reinforced to prevent deformation, or a product with metal lath or wire netting can be used.
- A product that uses a binder may sometimes emit smoke when heated (to about 180°C or higher) during the initial period after work, and thus special caution is required when the insulation is used indoors.

2. Inorganic porous thermal insulation materials JIS A 9510

- The maximum usage temperature of calcium silicate No. 1 is 1000°C, that of water-repellent pearlite No. 3 is 900°C, and that of calcium silicate No 2 and water-repellent pearlite No. 4 is 650°C.
- The water-repellent material used in water-repellent inorganic porous thermal insulation decomposes at 200 to 250°C, and thus water-repellency cannot be maintained at temperatures higher than this.

3. Preformed cellular plastics thermal insulation materials JIS A 9511

- Preformed cellular plastics insulation exhibits considerable deformation at temperatures above 70°C, and thus sufficient care must be exercised with regard to the method of work.

Table 3-1: Types of thermal and cold insulation materials and main properties
(JIS A 9504 Man made mineral fiber thermal insulation materials)

Type			Density range kg/m^3	Thermal contraction temperature °C or higher	Thermal conductivity W/(m-K) or less (average temperature 70°C)	Reference equations for calculating thermal conductivity W/(m-K) θ : Temperature (°C)
Rock wool	Wool		40～150	650	0.044	-
	Thermal insulation board	No. 1	40～100	600	0.044	$0.0337+0.000151\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0395+4.71\times10^{-5}\cdot\theta+5.03\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
		No. 2	101～160	600	0.043	$0.0337+0.000128\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0407+2.52\times10^{-5}\cdot\theta+3.34\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
		No. 3	161～300	600	0.044	$0.0360+0.000116\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0419+3.28\times10^{-5}\cdot\theta+2.63\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
	Felt		20～70	400	0.049	$0.0349+0.000186\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0337+1.63\times10^{-4}\cdot\theta+3.84\times10^{-7}\cdot\theta^2 (100<\theta\leqq400)$
	Blanket	No. 1	40～100	600	0.044	Same as thermal insulation board No. 1
		No. 2	101～160	600	0.043	Same as thermal insulation board No. 2
	Lamella thermal insulation	No. 1	40～100	600	0.052	$0.0349+0.000244\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0407+1.16\times10^{-4}\cdot\theta+7.67\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
		No. 2	101～160	600	0.049	$0.0360+0.000174\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0453+3.58\times10^{-5}\cdot\theta+4.15\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
	Thermal insulation mold		40～200	600	0.044	$0.0314+0.000174\cdot\theta\ (-20\leqq\theta\leqq100)$ $0.0384+7.13\times10^{-5}\cdot\theta+3.51\times10^{-7}\cdot\theta^2 (100<\theta\leqq600)$
Glass wool	Wool		-	400	0.042	$0.0314+1.50\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
	Thermal insulation board	24K	24±2	250	0.049	$0.0357+1.42\times10^{-4}\cdot\theta+8.34\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		32K	32±4	300	0.046	$0.0333+1.21\times10^{-4}\cdot\theta+6.56\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		40K	40+4-3	350	0.044	$0.0328+1.10\times10^{-4}\cdot\theta+5.61\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		48K	48+4-3	350	0.043	$0.0324+1.05\times10^{-4}\cdot\theta+4.62\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		64K	64±6	400	0.042	$0.0320+9.48\times10^{-5}\cdot\theta+3.30\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		80K	80±7	400	0.042	$0.0317+9.39\times10^{-5}\cdot\theta+2.48\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
		96K	96+9-8	400	0.042	$0.0318+9.82\times10^{-5}\cdot\theta+2.44\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$
	Corrugated thermal insulation board		37～105	350	0.050	$0.0331+10.0\times10^{-5}\cdot\theta+7.3\times10^{-7}\cdot\theta^2 (0\leqq\theta\leqq100)$
	Blanket	a	24～40	350	0.048	$0.0337+1.99\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
		b	41～120	400	0.043	$0.0314+1.66\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
Glass wool	Lamella thermal insulation	a	22～36	250	0.052	$0.0384+1.99\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
		b	37～52	350	0.052	$0.0384+1.99\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
		c	58～105	400	0.052	$0.0384+1.99\times10^{-4}\cdot\theta\ (0\leqq\theta\leqq100)$
	Thermal insulation mold		45～90	350	0.043	$0.0324+1.05\times10^{-4}\cdot\theta+4.62\times10^{-7}\cdot\theta^2 (-20\leqq\theta\leqq200)$

Note: See "2-3-2 Main thermal and cold insulation materials" for precautions regarding usage temperature taking into consideration various actual conditions of use. The reference equations for calculating thermal conductivity show the temperature range in which the thermal conductivity was measured.

Table 3-2: Types of thermal and cold insulation materials and main properties
(JIS A 9510 Inorganic porous thermal insulation materials)

Type		Density kg/m^3 or less	Usage temp- erature °C or higher	Thermal conductivity W/(m-K) or less (average tempera- ture °C)		Bending strength N/cm^2 or higher	Compression strength N/cm^2 or higher	Reference equations for calculating thermal conductivity W/(m-K) θ: Temperature (°C)
Calcium silicate thermal insulation material	Thermal insulation board (molding) No. 1 - 13	135	1000	100°C	0.054	20	30	$0.0407+1.28\times10^{-4}\cdot\theta$ $(0\leqq\theta\leqq300)$ $0.0555+2.05\times10^{-5}\cdot\theta+1.93\times10^{-7}\cdot\theta^2$ $(300<\theta\leqq800)$
				200	0.066			
				300	0.079			
				400	0.095			
				500	0.114			
	Thermal insulation board (molding) No. 1 - 22	220	1000	100°C	0.065	30	45	$0.0535+1.16\times10^{-4}\cdot\theta$ $(0\leqq\theta\leqq300)$ $0.0612+3.38\times10^{-5}\cdot\theta+1.95\times10^{-7}\cdot\theta^2$ $(300<\theta\leqq800)$
				200	0.077			
				300	0.088			
				400	0.106			
				500	0.127			
	Thermal insulation board (molding) No. 2 - 17	170	650	100°C	0.058	20	30	$0.0465+1.16\times10^{-4}\cdot\theta$ $(0\leqq\theta\leqq200)$ $0.0570-9.36\times10^{-5}\cdot\theta+3.74\times10^{-7}\cdot\theta^2$ $(200<\theta\leqq800)$
				200	0.070			
				300	0.088			
				400	0.113			
				500	0.146			
	Thermal insulation board (molding) No. 2 - 22	220	650	100°C	0.065	30	45	$0.0535+1.16\times10^{-4}\cdot\theta$ $(0\leqq\theta\leqq300)$ $0.0612+3.38\times10^{-5}\cdot\theta+1.95\times10^{-7}\cdot\theta^2$ $(300<\theta\leqq600)$
				200	0.077			
				300	0.088			
				400	0.106			
				500	0.127			
Water-repellent pearlite thermal insulation material	Thermal insulation board (molding) No. 3 - 25	250	900	70	0.072	25		$0.0632+1.26\times10^{-4}\cdot\theta+2.67\times10^{-8}\cdot\theta^2$ $(0<\theta\leqq800)$
	Thermal insulation board (molding) No. 4 - 18	185	650	70	0.056	20		$0.0483+1.27\times10^{-4}\cdot\theta+3.70\times10^{-8}\cdot\theta^2$ $(0<\theta\leqq600)$

Note: If the thickness of a calcium silicate thermal insulation board No. 1 - 13 and thermal insulation molding No. 1 - 13 is 30 mm or less, the density can be 155 kg/m^3 or less.

Table 3-3: Types of thermal and cold insulation materials and main properties (JIS A 9511 Preformed cellular plastics thermal insulation materials)

Type			Density kg/m^3 or less	Usage temperature °C or higher	Thermal conductivity W/(m-K) or less (average temperature 20°C)	Bending strength N/cm^2 or higher	Moisture permeability coefficient $ng/(m^2\text{-s-Pa})$ or higher	Reference equations for calculating thermal conductivity W/(m-K) θ : Temperature (°C)
Bead-method polystyrene foam	Thermal insulation board	Special	27	80	0.034	35	185	$0.0316+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		No. 1	30	80	0.036	45	145	$0.0336+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		No. 2	25	80	0.037	30	205	$0.0346+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		No. 3	20	80	0.040	22	250	$0.0368+0.00016 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
	Thermal insulation mold	No. 1	35	70	0.036	30	-	$0.0334+0.00013 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
		No. 2	30	70	0.036	25	-	$0.0336+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
		No. 3	25	70	0.037	20	-	$0.0346+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
Extrusion-method polystyrene foam	Thermal insulation board	Type1-a	-	80	0.040	17	205	$0.0360+0.00015 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		Type1-b	-	80	0.040	20	145	$0.0360+0.00015 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		Type2-a,b	-	80	0.034	20	145	$0.0313+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		Type3-a	-	80	0.028	20	145	$0.0270+0.00007 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
		Type3-b	-	80	0.028	25	145	$0.0270+0.00007 \cdot \theta\ (-50 \leqq \theta \leqq 80)$
	Thermal insulation mold	Type1	-	70	0.040	15	-	$0.0360+0.00015 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
		Type2	-	70	0.034	15	-	$0.0313+0.00012 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
		Type3	-	70	0.028	20	-	$0.0270+0.00007 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
Hard urethane foam	Thermal insulation board	Type1-No.1	45	100	0.024	35	145	$0.0294+0.00010 \cdot \theta\ (-200 \leqq 0 \leqq -60)$
		Type1-No.2	35	100	0.024	25	185	$0.0209+3.13 \times 10^{-5} \cdot \theta$
		Type1-No.3	25	100	0.025	15	225	$+3.53 \times 10^{-6} \cdot \theta^2$
		Type2-No.1	45	100	0.023	35	40	$+4.01 \times 10^{-8} \cdot \theta^2 (-60 < \theta \leqq -15)$
		Type2-No.2	35	100	0.023	25	40	$0.0202+0.00014 \cdot \theta\ (15 < \theta \leqq 100)$
		Type2-No.3	25	100	0.024	15	40	
	Thermal insulation mold	No. 1	45	100	0.024	35	145	
		No. 2	35	100	0.024	25	185	
		No. 3	25	100	0.025	15	225	
Polyethylene foam	Thermal insulation mold	Type1	-	70	0.043	-	10	$0.0395+0.00017 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
		Type2	-	120	0.043	-	10	$0.0395+0.00017 \cdot \theta\ (-50 \leqq \theta \leqq 70)$
Phenol foam	Thermal insulation board	Type1-No.1	45	130	0.032	15	145	$0.0300+0.00008 \cdot \theta\ (-100 \leqq \theta \leqq 130)$
		Type1-No.2	30	130	0.030	7	145	$0.0281+0.00007 \cdot \theta\ (-100 \leqq \theta \leqq 130)$
		Type2-No.1	50	130	0.036	20	145	$0.0332+0.00011 \cdot \theta\ (-100 \leqq \theta \leqq 130)$
		Type2-No.2	40	130	0.034	15	145	$0.0311+0.00012 \cdot \theta\ (-100 \leqq \theta \leqq 130)$
	Thermal insulation mold	No. 1	50	130	0.036	20	145	$0.0332+0.00011 \cdot \theta\ (-100 \leqq \theta \leqq 130)$
		No. 2	40	130	0.034	15	145	$0.0311+0.00012 \cdot \theta\ (-100 \leqq \theta \leqq 130)$

3. TOOLS

3. TOOLS

3-1 TOOLS

3-1-1 Required Tools and Points to Keep in Mind During Use

When performing installation work, the tools and parts indicated in the table below are required. When obtaining new tools and/or parts, be sure to obtain the specialized tool or part for the product. The diameter of the service port has been changed on R410A models in order to prevent the accidental charging of other refrigerants.
In addition, in order to increase pressure resistance, the flare work dimensions on refrigerant piping and the width across flats of the flare nuts (1/2", 5/8") have been changed. Sufficient caution must also be exercised to not allow contamination by refrigerator oil.

(1) Newly required tools and parts (cannot be interchanged with conventional tools)

Tool/part	Use	Remarks
Gauge manifold	Vacuuming, refrigerant filling, and operation verification	To prevent accidental R22 charging, the screw diameter has been changed.
Charge hose		
Leak tester	Checking gas leaks	The conventional tester could not detect HFC refrigerants.
Refrigerant tank	Refrigerant filling	Special R410A tank Identification: refrigerant name indicated, pink color band on top of tank
Refrigerant recovery device	Refrigerant recovery	Recovery is necessary in the event that the refrigerant leaks.
Torque wrench	Flare nut tightening	1/2", 5/8" width across flats are different

(2) Tools and parts useable subject to certain conditions

Tool/part	Use	Remarks
Vacuum pump	Vacuum drying	Can be used with a vacuum pump adapter
Bender	Pipe bending	Bend to 4Do for R410A
Flare tool	Pipe flare work	Can be used if pipe protrusion is adjusted.

(3) Conventional tools and parts that can be used (interchangeable)

Tool/part	Use	Remarks
Pipe cutter	Cutting pipes	
Reamer	Removing burrs from cut edges of pipes.	
Expander	Expanding pipe ends	
Welder / nitrogen blower	Pipe welding	
Vacuum pump adapter	Vacuum drying	Includes function that prevents backflow of vacuum pump oil.
Vacuum gauge	Vacuum drying	
Refrigerant filling gauge	Refrigerant filling	

(4) Tools that cannot be used for R410A

Tool/part	Use	Remarks
Charge cylinder	Refrigerant filling	R410A refrigerant is at high pressure and quickly vaporizes, and thus if the charge cylinder is filled with refrigerant, the refrigerant will not remain in the liquid state and vaporized refrigerant foam will rise into the gauge, making it impossible to read.

3-1-2 Copper Pipe Cutting Tools

1. Tube cutters

These are used to cut copper pipes to the required dimensions. Large, medium, small, and other types are available to match the copper pipe diameter and wall thickness.

(1) For small-diameter copper pipes
Applicable outer pipe diameters: 2 to 24 mm (1/8" to 7/8")
Features
- Compact with a small rotation radius for convenient use in work areas with limited space.
- Can also cut capillary tubes.

MODEL: EA202B

(2) For medium-diameter copper pipes
Applicable outer pipe diameters: 4.5 to 28.58 mm (3/16" to 1 1/8")
Features
- Tube cutter for general use

MODEL: EA203
EA203G
EA204G

(3) For large diameter copper pipes
Applicable outer pipe diameters: 6 to 66 mm (1/4" to 2 5/8")
Features
- Suitable for cutting large copper pipes with diameters of 1 inch or more.

MODEL: EA205

2. Reamers

These are used to remove burrs from cut pipe edges and smooth the edges. If cut edges are not smoothed, they may damage the flare surface and cause refrigerant leaks when the flare connection is made.

(1) General purpose copper pipe reamer
Applicable outer pipe diameters: 6 to 38 mm (1/4" to 1 1/2")
Features
- Burnishing can be performed by simply inserting the reamer in the copper pipe and turning it.
- Multiple blades are arranged in a radial pattern, enabling efficient work and resulting in a good finish.

MODEL: EA207BC

(2) Scraper-type reamer
Features
- The blade can move freely, allowing burnishing regardless of the direction of turning.
- A number of shapes can be selected as options, enabling a variety of types of burnishing.

MODEL: EA207S

3-1-3 Copper Pipe Connection Tools

1. Flare tools

A flare tool is used to flare the end of a copper pipe to connect it to another pipe.
The flare tool for type 2 copper pipes was developed for flaring of R410A copper pipes.
The flare dimension standards of type 2 copper pipes are larger than the conventional dimensions and larger than type 1 dimensions. For this reason, in order to use a type 1 flare tool to perform flare work conforming to type 2 standards, the "gauge for copper pipe protrusion adjustment" is required.

(1) Flare tool for R410A copper pipes
Applicable outer pipe diameters: 6.35 to 19.05 mm (1/4" to 3/4")
Features
- The new standard can be met using the same work method as conventionally.
- Can be distinguished from the conventional model by the R410A inscription and the refrigerant color code (pink).

MODEL: EA200B

(2) Gauge for copper pipe protrusion adjustment
Applicable outer pipe diameters: 1/4", 3/8"
Features
- Gauge for adjustment of pipe protrusion when flaring pipes for the new refrigerant (R410A) using the conventional flare tool.
- Gauge thicknesses of 0.5 mm and 1.0 mm each
- Can also be used as a 1/4" and 3/8" copper pipe gauge.

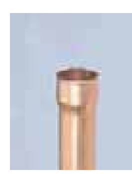
MODEL: EA200-1

2. Expander

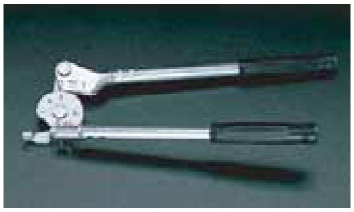
An expander is used to expand one of the pipe ends when joining copper pipes by brazing.

Applicable outer pipe diameters: 9.52 to 25.4 mm (3/8" to 1")
Features
- A two-stage transmission enables pipe expansion with minimal effort.
- Can also be used for correction of joint/pipe diameters.

MODEL: EA208



3-1-4 Copper Pipe Bending Tools



(1) Lever-type bender
Bending ability: To 180° (max.)

Features
- General purpose lever-type bender.
- Bends smoothly to a maximum of 180°

MODEL: EA215A-2
EA215A-3
EA215A-4

(2) Ratchet-type bender
Applicable pipe sizes: 3/8", 1/2", 5/8", 3/4"
Bending ability: To 90° (max.)

Features
- Copper pipe sizes from 3/8" to 3/4" can be bent with a single tool.
- The ratchet mechanism enables bending with minimal effort.
- Reverse bending is possible using an option.

*For use on annealed copper pipes. When bending a straight pipe (hard copper pipe), anneal the straight pipe.

MODEL: EA270

Applicable sizes		Bending radius
3/8"	9.52 mm	32 mm
1/2"	12.70 mm	37.5 mm
5/8"	15.88 mm	58 mm
3/4"	19.05 mm	77 mm

(3) Hydraulic bender
Applicable copper pipe sizes: 1/4", 5/16", 3/8", 1/2", 5/8", 3/4", 7/8"
Bending ability: To 90° (max.)

Features
- Copper pipe sizes from 1/4" to 7/8" can be bent with a single tool.
- Hydraulic system enables easy bending of thick pipes.
- Reverse bending is possible using an option.

*For use on annealed copper pipes. When bending a straight pipe (hard copper pipe), anneal the straight pipe.

MODEL: EA275H

***Note**

When bending pipes for R410A use, use a bender with a bending radius of at least 4Do (four times the outer pipe diameter (Do is the outer diameter of the pipe)).
It will not be possible to satisfy the wall thickness standards of the example standards related to refrigeration safety regulations if a bender of less than 4Do is used.

3-1-5 Flair Joint Tools

Torque wrenches

These wrenches allow the technician to tighten flair nuts to the correct torque, preventing refrigerant leakage due to insufficient tightening and damage to the pipe flair due to over-tightening.

(1) Fixed-type torque wrench
Sizes from 1/4" to 3/4".
Torque wrench for one size and one type.

Features

- The neck bends when the specified torque is reached.

MODEL: EA723A-234

(2) Adjustable torque wrenches
The diameter and torque values of the torque wrench can be changed as desired.

1. Small-diameter torque wrench
   Supported diameters: 10 to 27 (mm)
   Torque values: 15 to 50 (N-m)

   MODEL: EA723ME-50

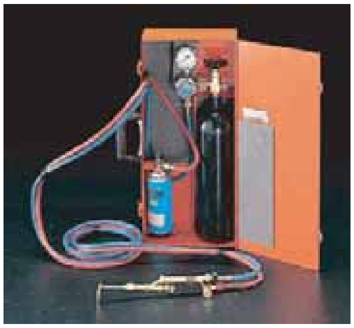
2. Large-diameter torque wrench
   Supported diameters: 17 to 38 (mm)
   Torque values: 50 to 150 (N-m)

   MODEL: EA723ME-150

Flair nut sizes and corresponding torques table

Applicable size		Type 1 and conventional model (for R22 and R407C) Diameter (mm) x Torque (N-m)	Type 2 (for R410A) Diameter (mm) x Torque (N-m)
1/4"	6.35mm	17× 14～18	17× 14～18
3/8"	9.52mm	22× 34～42	22× 34～42
1/2"	12.70mm	24× 49～61	26× 49～61
5/8"	15.88mm	27× 68～82	29× 68～82
3/4"	19.05mm	36× 100～120	36× 100～120

3-1-6 Brazing Tools



(1) Welder (oxygen, propane, butane)

Can be used for medium diameter brazing and compressor replacement.

- Weight: 10.6 kg
- Oxygen tank: 2 L

Features

- Uses a tank cartridge.
- Can be used continuously for up to 2 hours.

MODEL: EA300MB

(2) Welder (oxygen, acetylene)

Capable of large-diameter brazing and can also be used for cutting work.

- Weight: 29 kg
- Oxygen tank: 3.4 L

Features

- Includes a flame arrestor

MODEL: EA300C

(3) Nitrogen blower

During brazing, a nitrogen blower is used to remove air from pipes by blowing in nitrogen. This prevents combustion inside the pipes and the formation of an oxidation layer.

In particular, the HFC refrigerant cycle cannot sustain contamination well and a failure may result if contamination occurs. For this reason, be sure to perform nitrogen blowing during brazing.

- Weight: 9 kg
- Nitrogen tank: 2.1 L

MODEL: EA301

3-1-7 Vacuum Drying Tools

Vacuum drying dries the inside of pipes by using a vacuum pump to vaporize liquid water and discharge it externally.

(1) Vacuum pump
- Rotary type: two-stage
- Vapor exhaust speed (L/min.): 140 (50 Hz), 168 (60 Hz)
- Vacuum attained: 10 microns
- Connection port: 1/4" (UNF7/16-20), 3/8" (UNF5/8-18)
- Weight: 13.6 kg

MODEL: EA112B

(2) Vacuum pump adapter

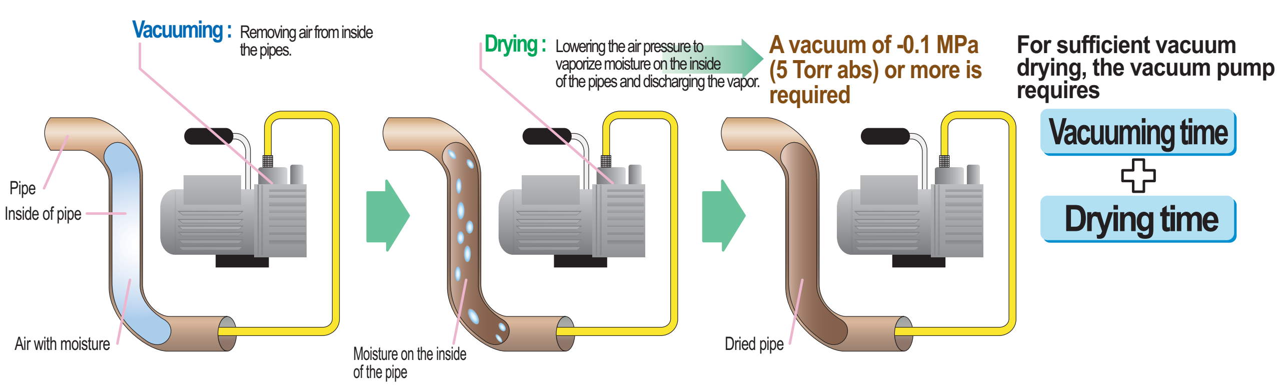
Attaching a backflow prevention mechanism to the vacuum pump prevents vacuum pump oil from entering the refrigerant circuit in the event that the vacuum pump stops for some reason.
The vacuum pump adapter enables use of the conventional R22 vacuum pump.

MODEL: EA112XB

(3) Vacuum gauge

Values in the vacuum region are too small and difficult to read on the pressure gauge of the regular gauge manifold, and thus the vacuum gauge is recommended.
The vacuum gauge allows you to accurately check the vacuum attained and also check for leaks. This makes it possible to work with certitude and to know exactly when vacuum drying is completed.
- Outer diameter: 68 mm
- Vacuum gauge: 0 to -0.1 MPa (0 to -760 mm Hg)
- Connection diameter: 1/4" (UNF7/16-20)

MODEL: EA103E-1



3-1-8 Refrigerant Filling Tools

(1) Gauge manifold
To prevent accidental R22 charging, the screw diameters on each part have been changed. In addition, the tools are color coded pink, making it easy to distinguish them from R22 tools.

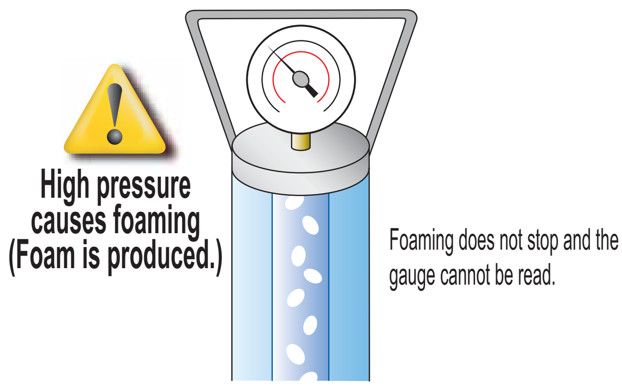
- Low-pressure gauge: -0.1 to 3.8 MPa
- High-pressure gauge: -0.1 to 5.3 MPa
- Connection port diameter: 5/16" flare (UNF1/2-20)

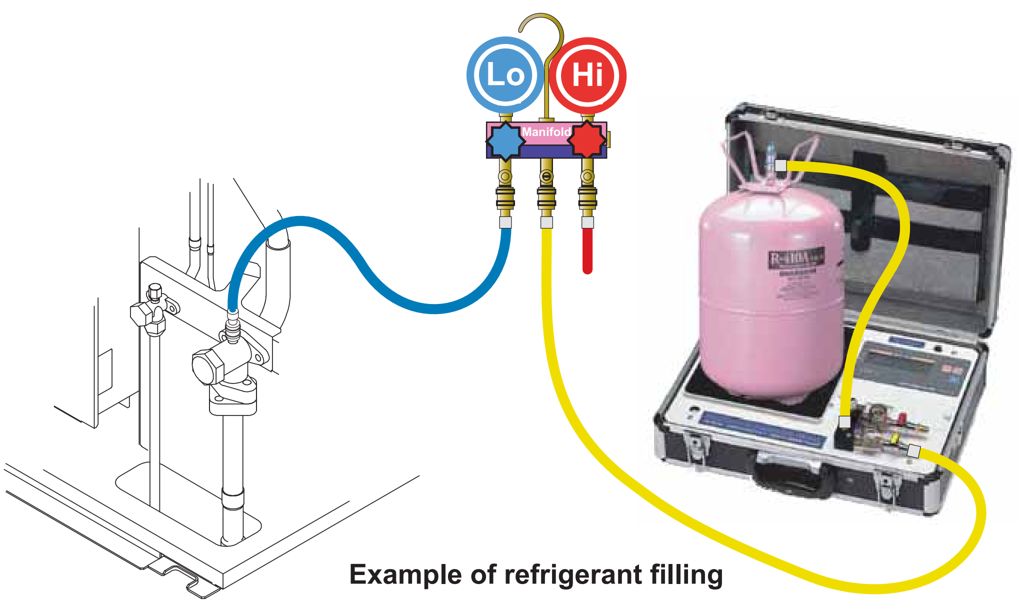
MODEL: EA101TG

(2) Refrigerant filling gauge
R410A refrigerant is at high pressure and quickly vaporizes, and thus if the charge cylinder is used for refrigerant filling, the refrigerant in the cylinder will not remain in the liquid state and vaporized refrigerant foam will rise into the gauge making it difficult to read.
For this reason, use the electronic refrigerant filling gauge.

MODEL: EA113XE-1

The charge cylinder cannot be used.





Example of refrigerant filling

3-1-9 Other Tools

(1) Leak tester

Compared to conventional refrigerants, the molecules that form HFC refrigerants are small and the pressure is higher. For this reason, there is a greater potential for refrigerant to leak from the refrigerating cycle, and thus more care is required to ensure that the system is airtight. In addition, it is difficult to detect HFC refrigerant using a leak tester with a low detection ability; a high-performance leak tester is required.

- Supported refrigerants: R410A, R407C, R404A, R507A, R134a, R12, R22, R502, R500
- Detection sensitivity: Lo: 28 g/year, Hi: 14 g/year
- Auto-balance function

MODEL: EA705A

(2) Refrigerant recovery device

This device is used during servicing to recover refrigerant from inside the product.

MODEL: EA100CA-400

Document reference: ESCO Company Ltd.

4. INSTALLATION WORK

4. Installation Work

4-1 Installation Work and Servicing Safety

There are no special safety precautions for R410A. However, like R22 and R407C, improper installation and servicing can cause serious accidents. Therefore always observe the following safety warnings.

⚠ Warnings
(1) Use only R410A in a package air conditioner designed to use R410A. Otherwise the unit may malfunction and fail.
(2) If the indoor unit is installed in a small room, take measures to prevent the refrigerant gas concentration from exceeding the specified limit if a refrigerant leak should occur. Refrigerant gas concentration exceeding the specified limit may deplete the oxygen in the room.
(3) If the refrigerant gas should leak out during installation, ventilate the room. Contact between the refrigerant gas and open flame may produce a poisonous gas.
(4) When installing or relocating a package air conditioner, do not mix the specified refrigerant with a different refrigerant. Also, do not mix the refrigerant with air or other non-condensable gas. If the specified refrigerant is mixed with a different refrigerant, the refrigeration cycle may malfunction and cause a mechanical failure or injury.
(5) When conducting an air tightness test, use an inert gas such as nitrogen and conduct the test at the specified pressure. Never use oxygen or acetylene gas. They may cause an explosion.
(6) After the end of installation work, verify that there is no refrigerant gas leakage. If refrigerant gas leaks into the room and comes into contact with a fan heater, stove, stove burner, or an open flame, a poisonous gas may be produced.
(7) Perform installation and relocation work in accordance with the instruction manual. Improper installation may cause abnormalities in the refrigeration cycle, water leakage, electrical shock, fire, or other trouble.
(8) Never modify the equipment. Repairs must be made by a qualified technician. Improper repair may cause water leakage, electrical shock, or other trouble.

4-2 Installation Work Procedure and Precautions

Before work

- Decide division of work
- Verify refrigerant to be used
- Draw work diagrams
- Check installation locations
- Preparations before work

Work

- Sleeve/insert work
- Indoor unit installation
- Refrigerant piping work
- Drain piping work
- Duct work
- Insulation work
- Electrical work
- Outdoor unit foundation work
- Outdoor unit installation
- Refrigerant pipe connection
- Air tightness test
- Vacuum drying
- Additional refrigerant charging
- Gas leaks check
- Test operation and adjustment
- Transfer/handling explanation

Work step	Changes/precautions in work procedure for new refrigerant	Reason	Reference page
Verify refrigerant to be used	(1) Verify and clearly understand the special characteristics of the refrigerant used. If refrigerant charging is required, be sure to use the refrigerant specified for the product. (2) Verify the design pressure of the product. R410A: 4.15 MPa	- If a refrigerant other than the specified refrigerant is used, a failure may occur.	1-1
Preparations before work	(1) Use new pipes having the wall thickness specified in Type 2 of JIS B 8607 as the refrigerant piping. (2) The tools used are special R410A tools. Obtain these tools before beginning work. (3) If at all possible, do not use existing piping. If existing piping must be used, be sure to clean the inside of the piping.	- Check the required pressure tolerance. - The size of the service port screw has been changed from 7/16UNF to 1/2UNF. - Use materials suitable for HFC refrigerant.	2-1 3-1
Indoor unit installation	Always use a bubble level to keep the unit horizontal. When tilting the unit toward the scupper, keep the tilt within 10mm. If the unit is tilted too far, water leakage may occur.	- Prevents water leakage.	4-3
Refrigerant piping work	When performing piping work, observe the following precautions to keep the inside of the pipe clean and air tight: (1) Use pipes that are clean on the inside. (2) When leaving pipes unattended, take suitable measures to protect the pipes. (3) Finish flare work precisely. (4) Check the width across flats and the shape of the flare nuts. (5) When brazing, be sure to replace the air in the pipe with nitrogen gas. (6) Be sure to flush out the piping before connecting the unit.	- Foreign matter or moisture inside the piping may cause refrigeration failure and compressor trouble. - Refrigerant leakage may result in poor performance and abnormal stop.	4-4
Drain piping work	(1) Install drain pipe at a downward gradient of more than 1/100 and within 20m of the total horizontal length. (2) Use hard vinyl chloride drain pipe. (3) To support the pipe, keep its length within 1.5m to 2.0m. (4) Use one rank higher pipe for the central piping. (Higher than VP30.)	- Prevents water leakage.	4-14
Insulation work	Select the size of the heat insulation depending on the ambient temperature of the refrigerant piping and the relative humidity. Use heat insulation with a thermal conductivity of less than 0.043 W/(m-k)	- Prevents water leakage.	4-8
Refrigerant pipe connection	Use a torque wrench to make flare connections, and tighten the flare nut to the specified torque.	- Refrigerant leakage may result in poor performance and abnormal stop.	4-4-7
Air tightness test	Pressurize the system to the design pressure using nitrogen gas and conduct a 24 hours air tightness test.	- Refrigerant leakage may result in poor performance and abnormal stop.	4-7
Vacuum drying	(1) Use a vacuum pump with a reverse flow check mechanism, or an ordinary vacuum pump fitted with a reverse flow check adapter. (2) Evacuate the system sufficiently. Evacuate the system for at least 1 hour after attaining a vacuum of -0.1 MPa. Verify that the needle reading does not change when the system is left standing for 1 hour or longer after the vacuum pump is stopped. (3) Never use refrigerant to air purge the system.	- Reverse flow and contamination by the vacuum pump oil may cause the unit to fail. - Completely remove all moisture and air to prevent deterioration of the oil.	4-9
Additional refrigerant charging	(1) Check the instruction manual for the amount of refrigerant that must be additionally charged. (2) Take liquid R410A from the cylinder and charge it in the gaseous state. (A cylinder with a siphon must be turned upside down.) (3) Use the special R410A gauge manifold and charging hose.	- If gaseous refrigerant is taken from the cylinder, the composition of the refrigerant will change, increasing the possibility of poor performance and abnormal stop. - Prevents accidental charging using the wrong refrigerant.	4-10
Gas leaks check	To check for leakage, use the new refrigerant leak tester.	- Conventional leak testers cannot detect R410A.	

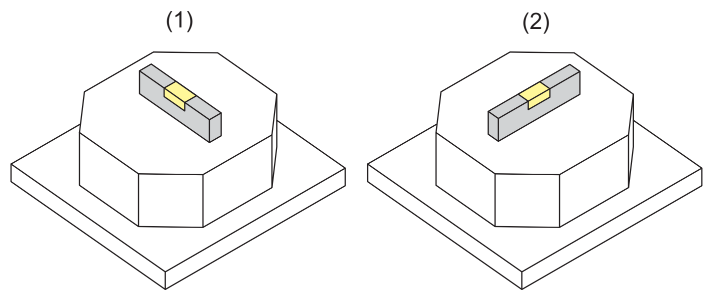
4-3 Important Points When Installing Indoor Units

4-3-1 Indoor Unit Installation Angle

- Always install the unit so that it is horizontal or vertical.
- If you are tilting the unit toward the drain outlet side, keep within 10 mm.
  If tilted too much, water leakage may occur.
- For a unit that can have the drain outlet either on the left or the right, always install the unit so that it is horizontal, or with the drain outlet side lower.

Cassette type

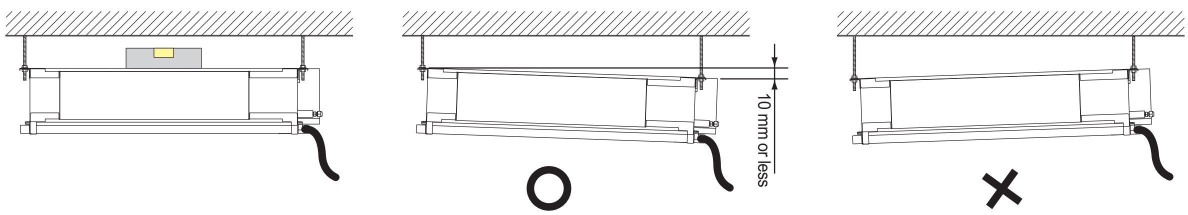
- Use a level gauge to check whether the top face (ceiling face) of the unit is level.
- Check at (1) and then once again at (2) to verify that the surface is level.



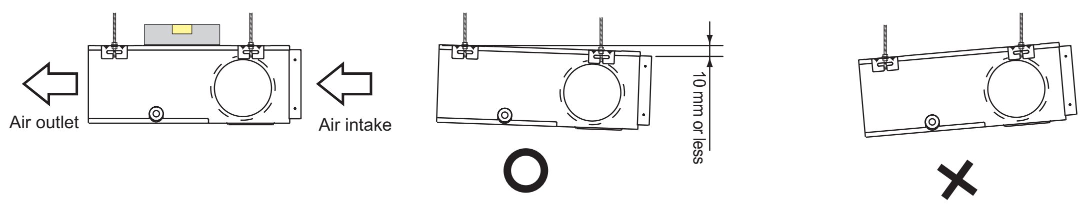
Duct type

- If you are tilting the unit toward the drain outlet side, keep within 10 mm.
- Do not tilt the air outlet down.

View from front

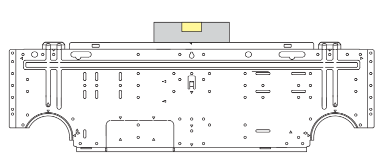


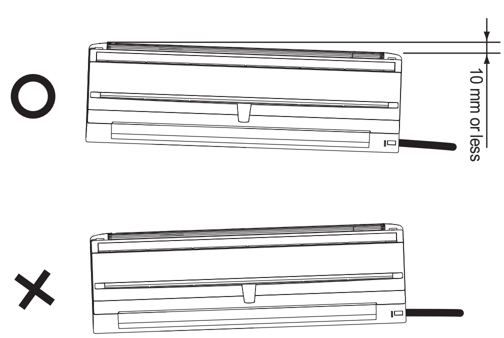
View from side



Wall mounted type

- Always check horizontality at the mounting plate.
- If you are tilting the unit toward the drain outlet side, keep within 10 mm.
- After installing the unit, check horizontality once again with a level gauge.



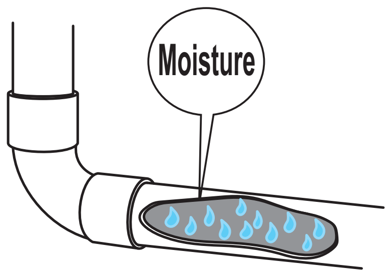
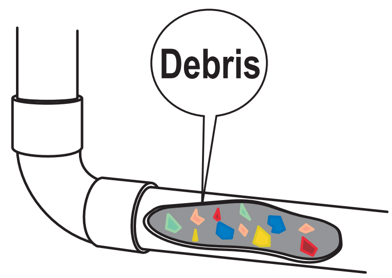
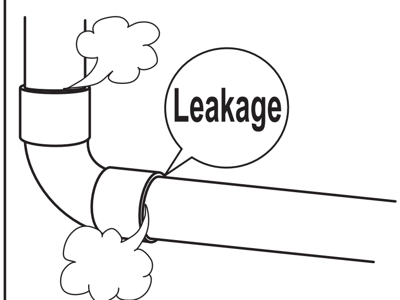


4-4 Refrigerant Piping Work

4-4-1 Three basic principles of refrigerant piping work

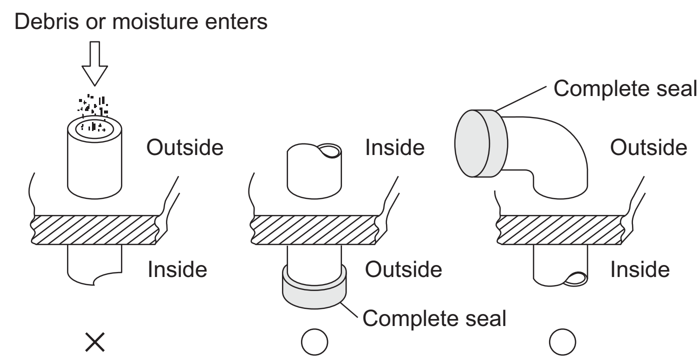
The three basic principles of package air conditioner R410A refrigerant piping work are the same as those for R22 and R407C (DRY, CLEAN, and TIGHT). However, R410A refrigerant requires stricter moisture and contaminant control because of the properties of the refrigerant and refrigerator oil. For this reason, more specific material selection, installation, storage, and brazing work and control procedures must be followed.

Refrigerant piping requires specific precautions that are unnecessary with general piping. Failure to observe these precautions may result in system trouble. When performing refrigerant piping work, be sure to keep the pipe dry, clean, and tight. These are called the "Three basic principles of refrigerant piping work".

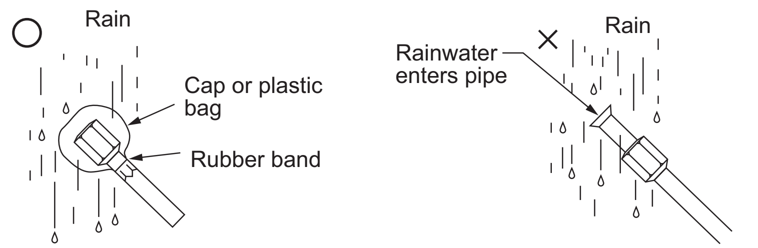
	DRY	CLEAN	TIGHT
	No moisture inside	No dirt or debris inside	No refrigerant leakage
ITEM	 	 	
DESCRIPTION	Verify that the inside of the pipe is dry. If the inside of the pipe is wet, remove the moisture. Even the smallest amount of moisture will interfere with circulation and impair performance, and may eventually cause compressor insulation failure by accelerating hydrolysis and deterioration of the refrigerator oil. Air leaking into the system will be accompanied by water and cause the same problem. If at all possible, avoid performing piping work when it is raining. Be sure to seal the end of the pipe during storage.	The refrigerant system uses precision devices and parts. Dirt or foreign matter in the system will interfere with their operation. Cutting, oxidized flakes of brazing filler metal and flux, and fragments of thread from clothes can easily enter pipe during piping work; thus caution must be exercised.	Since refrigerant pipes are charged with high-pressure gas, a basic rule is that the system must be air tight. Be sure to inspect pipe joints especially carefully to verify that there are no leaks.
CAUSES OF FAILURE	- Hydrolysis of refrigerator oil - Deterioration of refrigerator oil - Compressor insulation failure - No cooling, no heating - Expanded valves, clogged capillary tubes	- Deterioration of refrigerator oil - Compressor insulation failure - No cooling, no heating - Expanded valves, clogged capillary tubes	- Gas shortage - Deterioration of refrigerator oil - Compressor insulation failure - No cooling, no heating - Change in refrigerant composition
PREVENTATIVE MEASURES	- Do not allow moisture to get inside pipes (Fig. a) - Always seal all pipe openings until joining of pipes is completed. - Do not perform piping work when it is raining. (Fig. b) - Keep pipe openings horizontal or pointing downward as far as possible. - When inserting pipes through openings in walls, be sure to cap the ends of the pipe. (Fig. e)	- Do not allow foreign matter to enter pipes. (Fig. a) - Always seal all pipe openings until joining of pipes is completed. - Keep pipe openings horizontal or pointing downward as far as possible. - Do not place pipes directly on the ground. - Do not let pipes scrape the ground. (Fig. c) - When removing burrs after cutting pipe, keep the pipe pointed downward. (Fig. d) - When inserting pipes through openings in walls, be sure to cap both ends of the pipe. (Fig. e)	- Always conduct an air tightness test (gas leakage). - Follow the basic procedures for brazing. - Follow the basic procedures for flare work.

4-4-2 Precautions for refrigerant pipe work

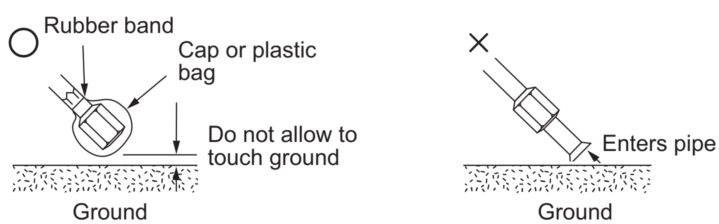
(a)



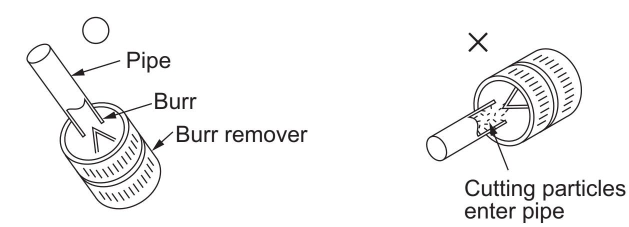
(b)



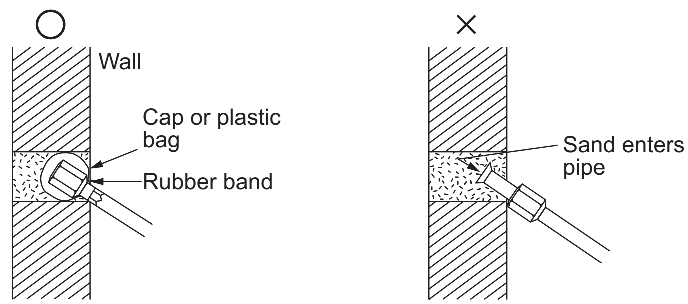
(c)



(d)



(e)



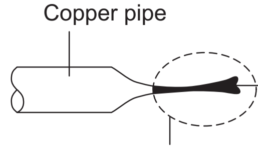
4-4-3 Refrigerant pipe protection

Pipe protection is an important factor in preventing moisture, debris, dust, and other contaminants from entering pipes. The entry of water into the system has caused major problems on numerous occasions in the past; thus caution must be exercised to prevent this kind of trouble from occurring.
All pipe ends must be protected. One of the best protection methods is the "pinch method". The simple "taping method" can also be used, depending on the location and duration of the work.

Location	Duration of work	Protection method
Outdoors	1 month or longer	Pinch
	Less than 1 month	Pinch or taping
Indoors	Does not matter	

(1) Pinch method

The end of the pipe is pinched shut and brazed.
Greater protection can be obtained by charging the pipe with nitrogen gas to 0.2 to 0.5 MPa.

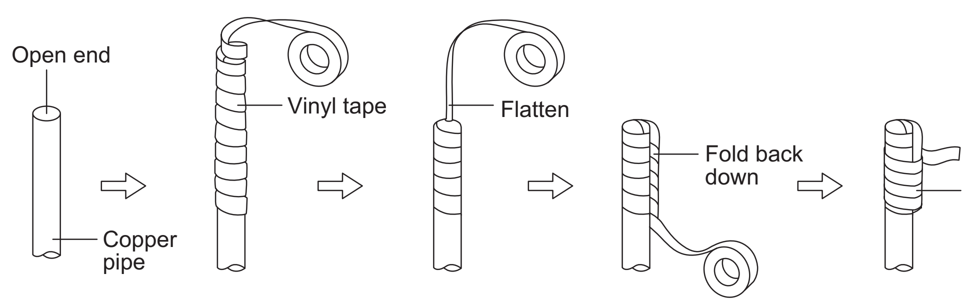



Pinch off pliers

(2) Taping method

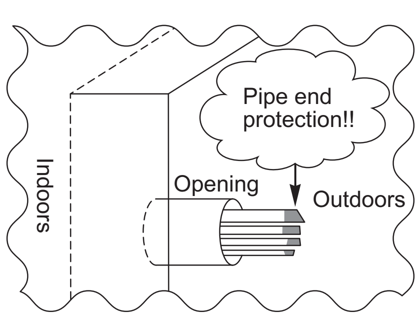
The end of the pipe is covered with vinyl tape.

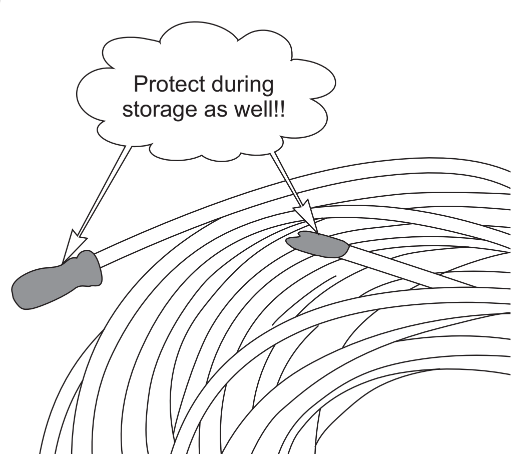
<Taping method>



<At these times, extra care is required>

- When inserting a pipe through an opening (debris can easily enter)
- When one end of the pipe is outside (rain may enter)
  (Outside vertical pipes require special attention)



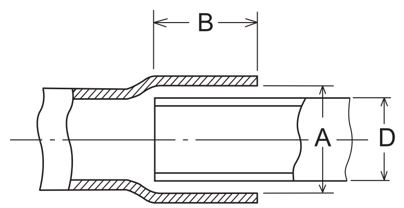


4-4-4 Brazing

(1) Brazing parts

Brazed connections are made by overlapping the surfaces to be joined, closing the gap between the surfaces with brazing filler metal, and using the adhesive strength of the brazing filler metal to hold the connection. Therefore, it is important to have a sufficiently large joining area and a suitable gap between the surfaces. The table below shows the minimum insertion depth, the outer diameter of the pipe inside the joint, and the gap between the surfaces for a copper pipe joint. For copper phosphorous brazing filler metal, a gap of about 0.05 mm to 0.1 mm will provide the strongest joint.

Minimum insertion depth and gap for copper pipe joints (Units: mm)

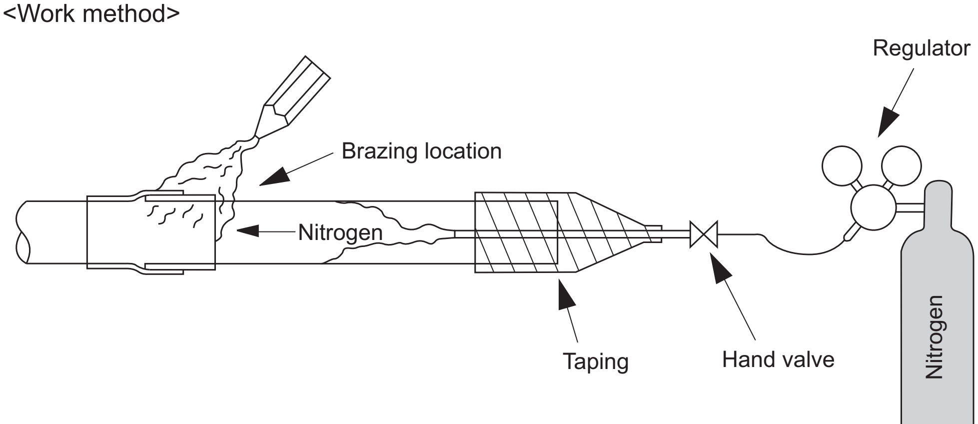


Outer pipe diameter D	Minimum insertion depth B	Gap (A-D) X 1/2
5 to 8 8 to 12	6 7	0.05～0.35
12 to 16 16 to 25	8 10	0.05～0.45
25 to 35 35 to 45	12 14	0.05～0.55
45 to 53	16	0.05～0.55

(2) Nitrogen replacement method (nitrogen blow)

If brazing is performed without blowing nitrogen through the pipe, a large amount of oxidization scale will form on the inside wall of the pipe. This oxidation scale may clog the solenoid valve, capillary tubes, accumulator oil return port, compressor oil pump intake, and other parts and hinder normal operation.
To prevent this, when brazing, the air in the pipes must be replaced with nitrogen. This is known as "nitrogen replacement" and is very important when brazing refrigerant pipe.

<Work method>



Effect of nitrogen replacement (nitrogen blow)

Copper pipe after brazing

Nitrogen blow performed
(No oxidation scale)

Nitrogen blow not performed
(Oxidation scale)

(3) Nitrogen Source of information: JIS K 1107: 2005

1. Outline

Chemical formula is N_2. It exists as a gas with no color/smell under a normal temperature and normal pressure.
Melting point: 210degC, Boiling point -195.8degC, Relative gravity 0.808(-195.8degC).
This gas consists in atmosphere most, and its potency is approx. 78% on the ground.
Nitrogen is classified in the following 2 kinds.

- **Liquefied Nitrogen:** Liquefied Nitrogen is completely vaporized with evaporator, etc., and then set to room temperature.
- **Pressurized Nitrogen:** It is reduced pressure and then set to room temperature.

For Air Conditioner installation, use Nitrogen with [Pressurized Nitrogen of or over Class 2]. Liquefied Nitrogen must not be used.

2. Quality

The quality of Nitrogen shall meet the following specifications.

Item		Class and Quality	
		Class 1	Class 2
Purity	% (volume)	Higher than 99.9995	Higher than 99.995
Oxygen	ppm (volume)	Less than 5	Less than 50
Dew point	degC	Less than -65	Less than -60

Remarks: The dew points of -65degC and -60degC are equivalent to the moisture level of 5.3ppm(volume) and 10.7ppm(volume).

3. Safety Cautions

Protection against deficiency of oxygen: If nitrogen is discharged into the closed room, the density of oxygen in the air drops and may cause the deficiency of oxygen. Under the regulation, it is necessary to adopt ventilation or equivalent so that the density of oxygen does not become below 18%.
Pressurized Nitrogen is usually supplied in the cylinder that is charged with a high pressure of either approx. 15MPa or approx. 20MPa. Handle it under the regulation with using a reduced pressure valve, opening and closing the valve slowly.

(4) Brazing filler metal

Silver brazing filler metal and copper phosphorous brazing filler metal are generally used for refrigerant pipe brazing. Silver brazing filler metal is used to join iron, copper and copper alloy. Phosphorous brazing filler metal is generally used to join copper and copper alloy. Use the "BcuP-3" copper phosphorus brazing filler metal specified in JIS Z 2364. When brazing copper using copper phosphorous brazing filler metal, flux does not have to be used.

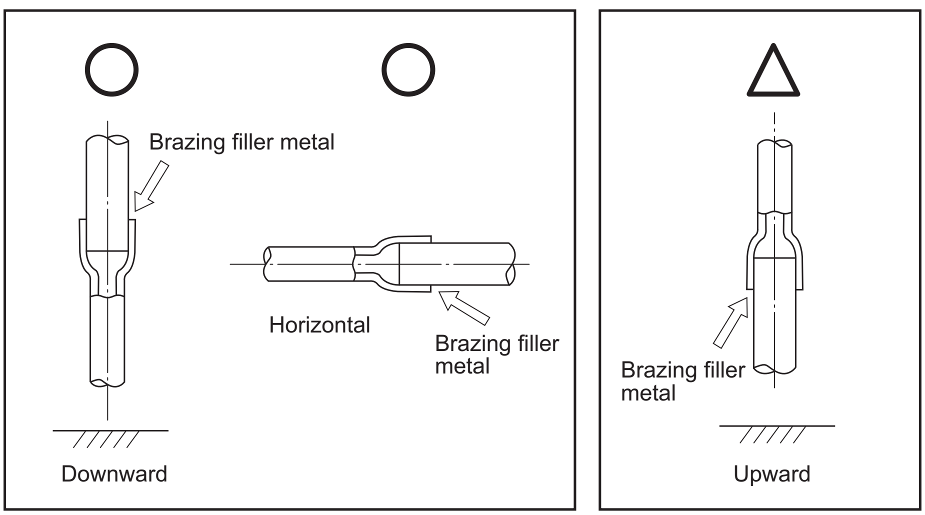
(5) Flux

Flux (1) removes oxidation scale and foreign matter from the base metal and improves the flow of the brazing filler metal, (2) prevents oxidation of the surface of the base metal, and (3) is necessary to reduce the surface tension of the brazing filler metal and help it join with the base metal. A flux suitable for the type and shape of the base metal, the type of brazing filler metal, and the brazing method must be selected.

- Flux is required when brazing copper and copper alloy, and copper and iron.
- Flux is not required when brazing copper and copper.

(6) Brazing work

(1) Fit a regulator and flow meter to the nitrogen cylinder.
(2) Use a small copper tube to deliver the nitrogen to the piping and connect the tube to the cylinder flow meter.
(3) To prevent reverse flow of nitrogen gas, seal the gap between the piping and the inserted nitrogen delivery tube.
(4) When the nitrogen gas is flowing, make sure that the piping side end of the delivery tube is open.
(5) Use the regulator to regulate the nitrogen flow at 0.05 m3/hour, or 0.02 MPa or less.
(6) Perform brazing at humidity suitable for the brazing filler metal.
(7) Perform brazing pointing downward or horizontally. Do not braze upward, if possible (to prevent leaking).



(8) Use only the specified branch of liquid pipes and gas pipes. Install the pipes in the proper direction and at the proper angle (to prevent oil return and side-flow).
(9) After brazing work is completed, continue to blow nitrogen gas through the pipe until the pipe has cooled to the point where it can be touched by hand. Be careful not to burn yourself.
(10) After you have finished brazing, remove all the flux. If any flux remains in the pipe, the chorine in the flux will cause the refrigerator oil to deteriorate.

⚠ CAUTION

1. Use only nitrogen as the replacement gas. Oxygen, carbon dioxide, and Freon gas cannot be used for the following reasons:
Oxygen: Danger of explosion. Oxygen accelerates oxidation and degradation of the refrigerator oil.
Carbon dioxide: Degrades the characteristics of the dryer.
Freon gas: Contact with open flame will produce a poisonous gas.
2. Always use a regulator for replacement.
3. Take measures to prevent fire. (Protect the area around the brazing site; have a fire extinguisher and water close at hand.)
4. Be careful not to burn yourself.
5. Verify that the gap between the pipe and coupling is suitable. (To prevent leakage)

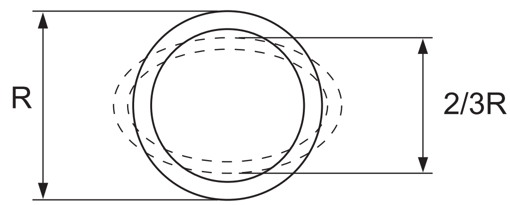
4-4-5 Bending

Avoid bends and vertical traps because they can impair performance.
Run piping so that it is as short as possible and in a straight line. If the pipe must be bent, bend it in accordance with the bending radius shown in the table below.
Use a manual bender to bend refrigerant pipe. Try to avoid stretching the pipe; causing the walls to become thinner.

<Minimum bend radii> (Units: mm)

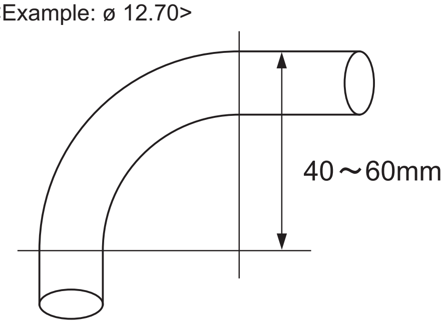
Pipe size	Minimum bend radius
ø 6.35	30～40
ø 9.52	30～40
ø 12.70	40～60
ø 15.88	40～60

<Stretching guideline>



Do not stretch to less than 2/3 R

<Example: ø 12.70>



The maximum usable pressure is for straight pipe (bend radius R≧4Do). If a pipe is bent to less than 4Do, reinforcement for the loss of wall thickness (given by Expression 1-1) that accompanies bending is required. According to JIS B 8607, creases and loss of wall thickness accompanying bending will cause such problems as increased resistance to refrigerant flow; thus R>3Do is recommended. When using a pipe bender, use a tool that is at least R>3Do. Use Expression 1-2 to calculate the decrease in the maximum usable pressure due to bending. Note that the design pressure of pipes used in local regions (local pipes) varies with the product; therefore, when selecting the pipes, refer to the design information and other documentation for the product.

$$t = \frac{P \cdot D_0}{2\sigma_a \cdot \eta + 0.8P}\left[1 + \frac{D_0}{4R}\right] + \alpha$$ ·································· Expression 1-1

$$Pa = \frac{2\sigma_a \cdot \eta \cdot (t - \alpha)}{\left(1 + \frac{D_0}{4R}\right) \cdot D0 - 0.8(t - \alpha)}$$ ·································· Expression 1-2

t	: Minimum pipe thickness mm	σ_a	: Allowable tensile stress of pipe material N/mm^2
P	: Design pressure MPa	η	: Welding efficiency of welded joint (1 when joint is not copper pipe)
P_a	: Allowable pressure MPa	R	: Bending radius at centerline of pipe mm
D_0	: Outer diameter of pipe mm	α	: Corrosion allowance mm

According to the revision of "Example standards related to refrigerant safety regulations 23.6.6", the corrosion allowance α in this expression does not have to be considered for copper pipes.

<Example: When a copper pipe (ø12.70 Type O) is bent by 3 times of pipe outer diameter.>

$$Pa = \frac{2\sigma_a \cdot \eta \cdot (t - \alpha)}{\left(1 + \frac{D_0}{4R}\right) \cdot D0 - 0.8(t - \alpha)}$$

See page 02-04.

$$Pa = \frac{2 \cdot 33 \cdot 1 \cdot (0.8 - 0)}{\left(1 + \frac{12.7}{4 \cdot (3 \cdot 12.7)}\right) \cdot 12.7 - 0.8(0.8 - 0)}$$

3 times of outer diameter of a copper pipe

$$Pa = \frac{52.8}{\left(1 + \frac{12.7}{152.4}\right) \cdot 12.7 - 0.64}$$

$$Pa = \frac{52.8}{(1.0833) \cdot 12.7 - 0.64}$$

$$Pa = \frac{52.8}{13.118}$$

Pa = 4.025 MPa

<Example: When a copper pipe (ø12.70 Type O) is bent by 4 times of pipe outer diameter.>

$$Pa = \frac{2\sigma_a \cdot \eta \cdot (t - \alpha)}{\left(1 + \frac{D_0}{4R}\right) \cdot D0 - 0.8(t - \alpha)}$$

See page 02-04.

$$Pa = \frac{2 \cdot 33 \cdot 1 \cdot (0.8 - 0)}{\left(1 + \frac{12.7}{4 \cdot (4 \cdot 12.7)}\right) \cdot 12.7 - 0.8(0.8 - 0)}$$

4 times of outer diameter of a copper pipe

$$Pa = \frac{52.8}{\left(1 + \frac{12.7}{203.2}\right) \cdot 12.7 - 0.64}$$

$$Pa = \frac{52.8}{(1.0625) \cdot 12.7 - 0.64}$$

$$Pa = \frac{52.8}{12.853}$$

Pa = 4.107 MPa

4-4-6 Refrigerant pipe flushing

Flushing is the removal of foreign matter from the inside of pipes using gas pressure.

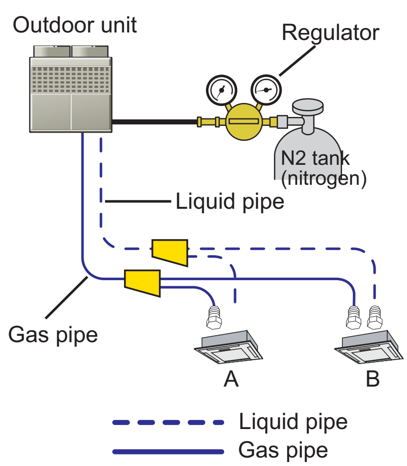
<3 major benefits>

1. **Removal of oxidation scales that form on the inside of pipes due to insufficient nitrogen gas replacement during brazing.**
2. **Removal of foreign matter and moisture from the inside of pipes caused by insufficient protection.**
3. **Verification of connections between indoor and outdoor piping systems (both liquid and gas)**

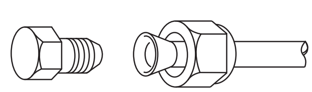
<Example procedure>

(1) Attach the regulator to the nitrogen tank.
*Use only nitrogen gas.
(Freon gas and carbon dioxide may cause condensation, oxygen may cause an explosion)

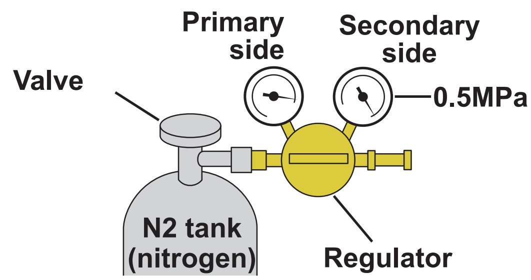
(2) Connect the charge hose to the regulator and to the service port of a liquid pipe of the outdoor unit.



(3) Attach a flare plug in indoor units (unit B) other than unit A.
*The indoor units are not connected.

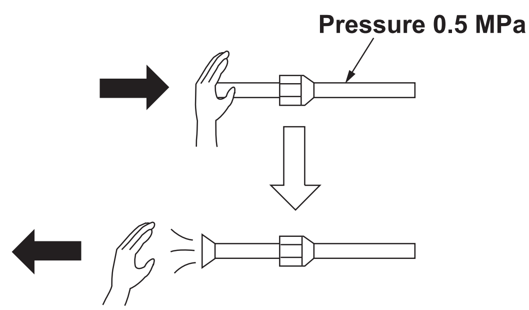


(4) Open the valve on the nitrogen tank and raise the secondary side of the regulator to **0.5 MPa**.



(5) Verify that nitrogen gas is coming out from the liquid pipe of unit A.

(6) Flushing
- Cover the end of the pipe with the palm of your hand.
- When the pressure becomes so high that you cannot continue covering the pipe end, quickly remove your hand from the pipe. (First flushing)
- Cover the pipe end with your hand again. (Perform the second flushing.)



***During flushing, place a cloth lightly on the end of the pipe and see what and how much foreign matter was in the pipe. In the event that water is discovered, completely wipe all water off the inside of the pipe.**
Action (1) Flush the inside of the pipe with nitrogen gas. (Until no more water comes out!)
(2) Thoroughly vacuum dry the pipe.

(7) Close the valve on the nitrogen tank.

(8) Repeat the above procedure on unit B.

(9) When you have finished the liquid pipes, flush the gas pipes.

4-4-7 Flare work

<Flare work procedure>

(1) Cut the pipe to the necessary length with a pipe cutter.

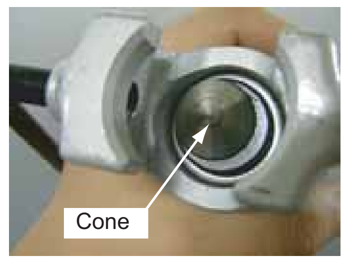
(2) There will be burrs on the cut edge of the pipe. (The larger the pipe wall thickness, the larger the burrs.)

(3) Remove the burrs. (Be careful that the cuttings do not enter the pipe. When deburring, keep the end of the pipe facing downward.)

(4) File the end of the pipe smooth. (Be careful that the filings do not enter the pipe. When filing, keep the end of the pipe facing downward.)

(5) Clean the inside of the pipe. (Use a cloth wrapped around the end of a thin stick.)

(6) Before flaring, clean the cone of the flare tool.



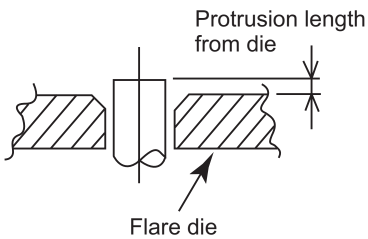
(7) Flare work.
The shape and dimensions of the flared end of copper pipe used with air conditioners that use R410A have been changed from those for R22 in order to increase the pressure resistance. For this reason, it is recommended that a special R410A clutch-type flare tool be used. If a conventional clutch-type flare tool is used, set the protrusion from the flare die surface correctly using a "protrusion adjustment gauge".

<Procedure>

Insert flare nut
↓
Protrusion length
↓
Flaring
↓
Check flare

<Protrusion length>

- Set the length of protrusion from the flare die correctly.



Length from surface of die to end of copper pipe (Units: mm)

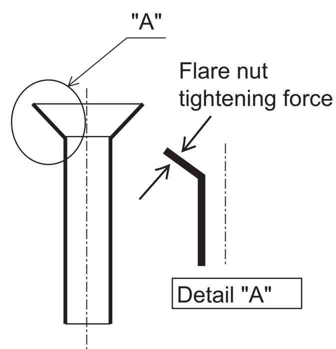
Flare tool type	Applicable copper pipe	ø 6.35	ø 9.52	ø12.70	ø 15.88	ø 19.05
Clutch type (for R410A)	For R22	0～0.5	0～0.5	0～0.5	0～0.5	0～0.5
	For R410A	0～0.5	0～0.5	0～0.5	0～0.5	0～0.5
Clutch type (conventional)	For R22	0～0.5	0～0.5	0～0.5	0～0.5	0～0.5
	For R410A	0.7～1.3	0.7～1.3	0.7～1.3	0.7～1.3	0.7～1.3

<Flare work>

- Flare uniformly to a true circle with a shiny and smooth inner surface (no damage).

After the flare nut makes a "click" sound, continue to turn it 3 or 4 turns to attain a good flare surface finish.

Principle of flare connections



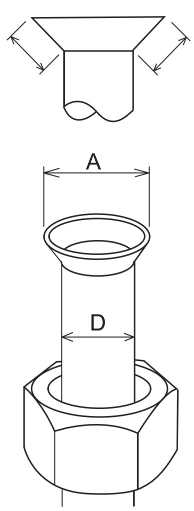
<<Principle>>

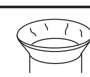
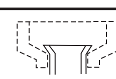
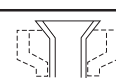
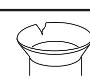
(1) An air tight seal is obtained using a metal packing based on the elasticity of metal (copper).
(2) The correct elastic force is obtained using the specified torque wrench torque value.
(3) If tightened to a value higher than the specified torque, the plastic will be deformed and the metal packing effect will be lost. (Gas leakage)

<Flare inspection>

(1) The width of the flare should be uniform and the inner surface shiny.
(2) The thickness of the flared edge should be uniform.
(3) The size of the flare should be suitable.

Outer diameter of pipe (D mm)		ø 6.35 (1/4")	ø 9.52 (3/8")	ø 12.70 (1/2")	ø 15.88 (5/8")	ø 19.05 (3/4")
Outer diameter of flare (A mm) Tolerances $^{+0}_{-0.4}$	R22	9.0	13.0	16.2	19.4	23.3
	R410A	9.1	13.2	16.6	19.7	24.0



Examples of bad flares	
Connecting a defectively flared pipe will result in gas leakage. If the flare is defective, repeat the flare work.	
Insufficient burnishing	
Inner surface damage due to cuttings	
Flare too small	
Flare too large	
Cracking	

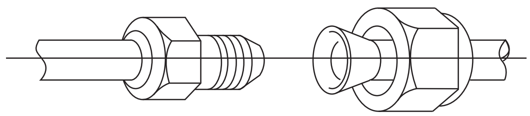
(8) Flare nut tightening

The shape and dimensions of flare nuts used for R410A are different from those for R22; thus a special torque wrench is required.

⚠ CAUTION

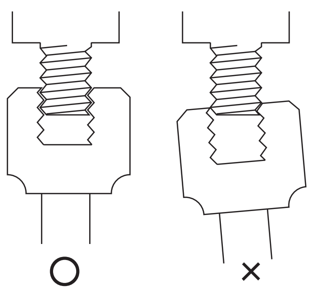
If refrigerator oil is applied to the flare surface, the rubbing friction of the threads will decrease. Therefore, tightening the flare nut to the specified torque will result in the axial component of force being higher than that without the oil and this may cause stress cracks in the flare. For this reason, the application of refrigerator oil to the flare surface is not recommended.

(1) Align the centers of the flare joint and the flared surface in a straight line.

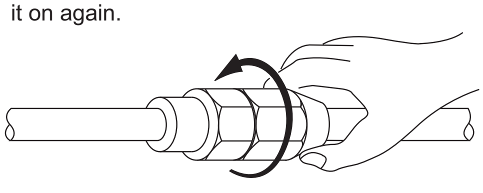


Align the centers

(2) Be careful not to screw the flare nut on at an angle, as this will damage the threads and cause a gas leak.

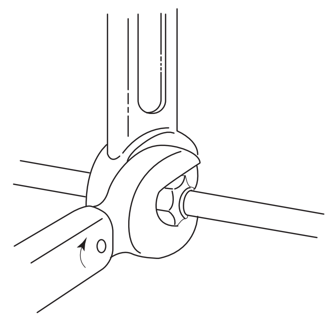


(3) Tighten the flare nut by hand. If the flare nut does not tighten smoothly, the threads are not aligned. Remove the flare nut and screw it on again.



Align the centers of the flare joint and flared pipe in a straight line and tighten 3 to 5 turns by hand.

(4) After the flare nut has been sufficiently tightened by hand, finish tightening it with a torque wrench. To prevent excessive force from being applied to the flare joint pipe, hold the flare joint with another wrench while tightening the flare nut (double wrench method).



Double wrench method.

(5) Tighten the connecting part correctly. see the tightening torque value in the table below.

Flare nut size and tightening torque corresponding table

Applicable size		Type 2 (for R410A) Diameter (mm) × Torque (N-m)
1/4"	6.35 mm	17 × 14 ～ 18
3/8"	9.52 mm	22 × 34 ～ 42
1/2"	12.70 mm	26 × 49 ～ 61
5/8"	15.88 mm	29 × 68 ～ 82
3/4"	19.05 mm	36 × 100 ～ 120

4-5 Important Points When Installing Separation tube

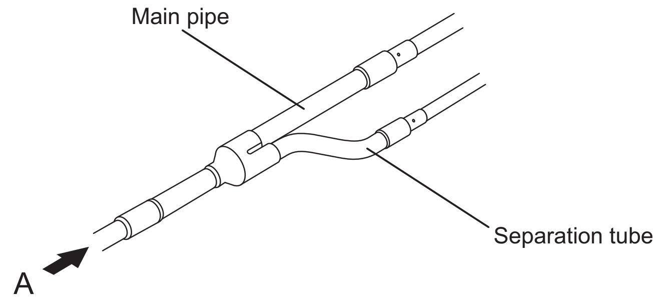
Total of indoor unit model codes	Model (flow dividing pipe)
Less than 90	UTR-BP090L
91 to 180	UTR-BP180L
181 or more	UTR-BP567L

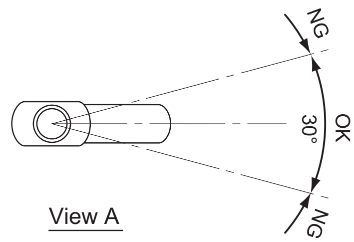
*90, 91, 180 and 181 are indoor unit model code totals.

<Example>
AS14 + AR30 + AU25 → 14 + 30 + 25 = 69≦90

4-5-1 Separation tube angle

1. Horizontal

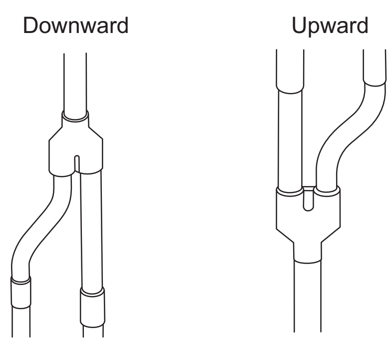




⚠ CAUTION

- Separation tube must be installed at an angle within -15° to +15°.
- Separation tube must be horizontal and must be higher than the main pipe (for oil collection prevention).

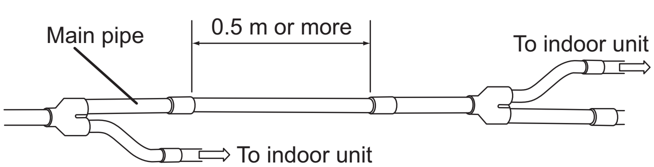
2. Vertical

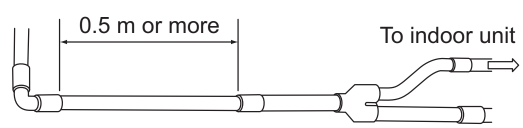


⚠ CAUTION

- The tubes can point downward or upward, however, they must be vertical.

4-5-2 Interval between separation tubes





⚠ CAUTION

- The interval between separation tubes must be at least 0.5 m (to prevent refrigerant noise).

4-6 Important Points When Installing Headers

If the header installation angle is not suitable, poor indoor unit performance may result.
Headers must be installed as indicated below. Always observe the rules below when installing headers.

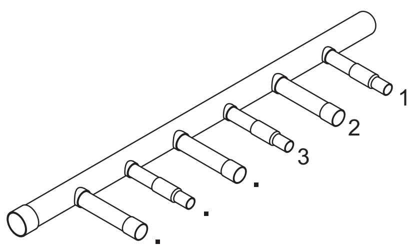
1. Applicable models

For the S Series: UTR-HD908R, UTR-HD906R, UTR-HD908A, UTR-HD906A
For the J Series: UTR-HD546U
For the V Series: UTR-H0906L, UTR-H0908L, UTR-H1806L, UTR-H1808L

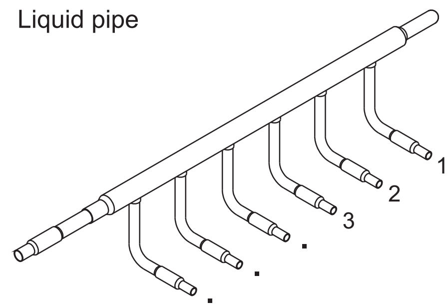
2. Rules

(1) Design pipe connections to the indoor unit so that welding is performed from the leading end of the header.
(In the following diagram, connect in the order 1, 2, 3, ...)

Gas pipe (gas supply pipe, gas intake pipe)

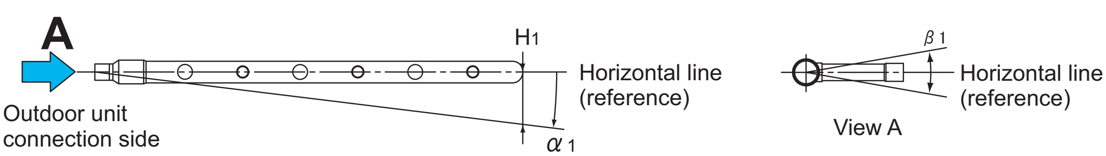


Liquid pipe



(2) Install the header so that it is horizontal.
The tolerance for the leading end of the header with respect to the base is 10 mm downward (1°).
Always use the level gauge to verify the header is completely level.

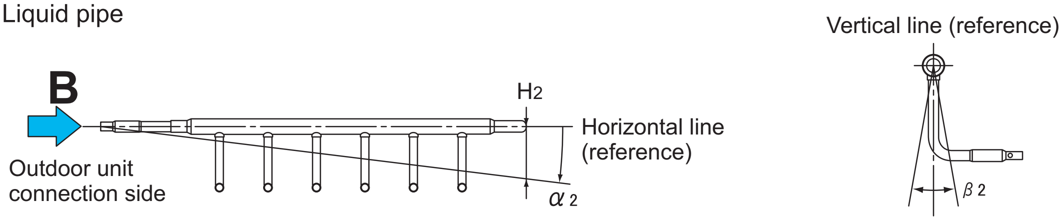
Gas pipe (gas supply pipe, gas intake pipe)



H_1 : 0～10mm
(α_1 : 0～1°)

β_1 : -10～10°

Liquid pipe



H_2 : 0～10mm
(α_2: 0～1°)

β_2 : -10～10°

(3) After connecting the piping for the indoor unit and insulating the header, verify once again with the level gauge that the header is level to within the angle in (2), and then secure the header.

4-7 Pressure test

Pressure test is one of the three basic principles of refrigerant piping work. When refrigerant piping work has been completed and before heat insulation is installed, the entire piping system must be carefully checked for leaks and pressure sealing must be verified. This is known as "Pressure test".

⚠ CAUTION

(1) Use only nitrogen gas.
Never use refrigerant gas, oxygen, inflammable gas, or poisonous gas to pressurize the system. (If oxygen is used, there is the danger of an explosion.)
(2) Indoor units have a built-in electronic expansion valve. (Fully open when shipped from the factory.) Do not turn on the indoor unit power because the expansion valve fully closes when the power is turned on. If the expansion valve closes, switch to the "Cool" mode with the remote controller to trip the circuit breaker and break the circuit.
(3) The design pressure of R410A refrigerant is higher than that of R22 and R407C. Check the design pressure before conducting an air tightness test.
(4) Use a pressure gauge with an effective scale of 1.25 to 2 times the design pressure. (For R410A, a scale that goes up to 7MPa.)
(5) After the pressur test is completed, purge the nitrogen gas before advancing to the next task.

<Typical procedure>

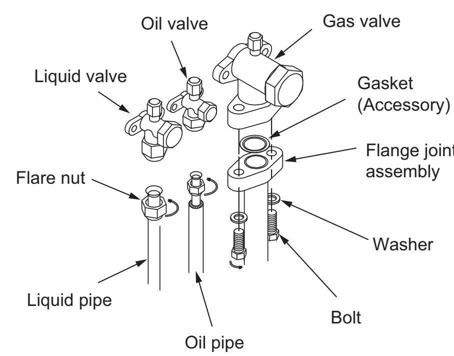
(1) Recheck that the spindles of the 3-way valve are closed before performing the pressure test.

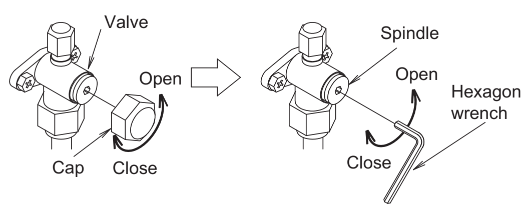
(2) After connecting the pipe, perform the pressure test.

(3) Pressurize from either service port of liquid pipe or gas pipe.

(4) Be sure to use the regulator on the nitrogen cylinder.

(5) Pressurize the system to the specified pressure in stages gradually.





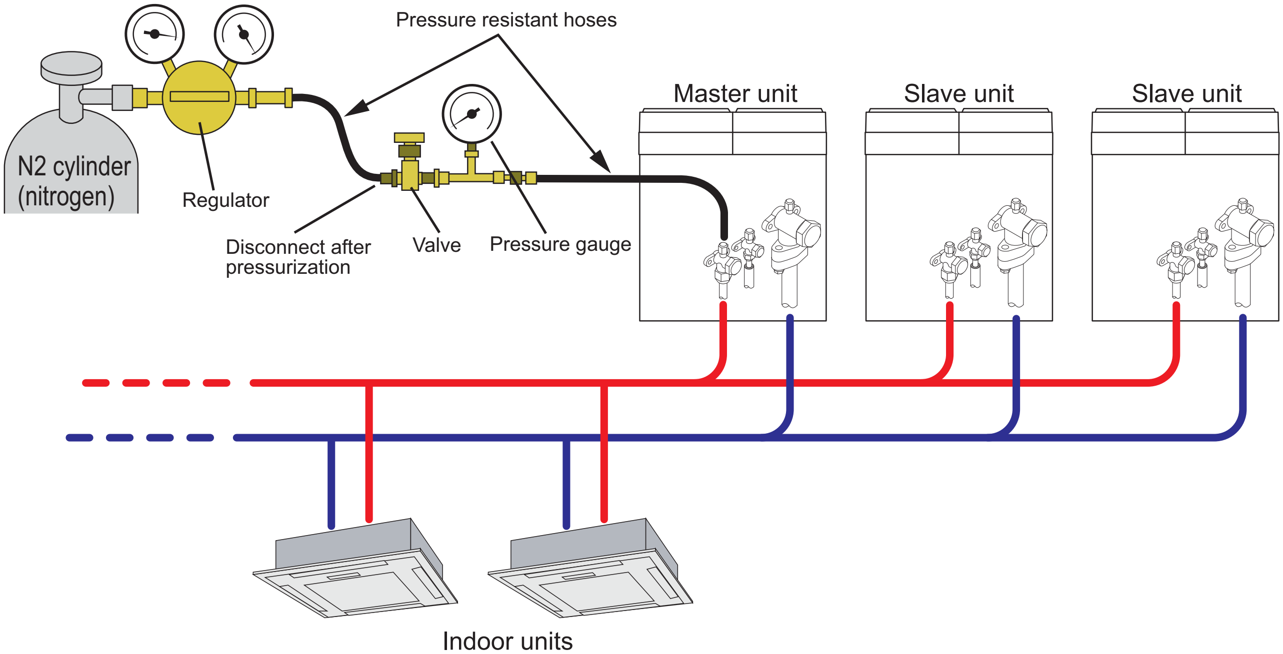
Pipe	Spindle	Cap
Liquid valve	60 to 80 kgf-cm (6.0 to 8.0 N-m)	280 to 320 kgf-cm (28.0 to 32.0 N-m)
Gas valve	250 to 300 kgf-cm (25.4 to 29.4 N-m)	600 to 650 kgf-cm (60.0 to 65.0 N-m)
Oil valve	50 to 70 kgf-cm (5.0 to 7.0 N-m)	200 to 250 kgf-cm (20.0 to 25.0 N-m)

<Step 1>
When the pressure reaches 0.5 MPa (gauge pressure), stop pressurizing and wait for at least 5 minutes, and then verify that the pressure did not drop.

<Step 2>
Pressurize the system to 1.5 MPa (gauge pressure) and wait for at least 5 minutes, and then verify that the pressure did not drop.

<Step 3>
Pressurize the system to the specified pressure (design pressure for R410A; 4.15 MPa) and make a note of the ambient temperature and pressure.
Next, close the valve so that the nitrogen gas cylinder is isolated from the system as shown on the following page. Let the system stand for 24 hours, and then verify that the pressure did not drop.

<Connection example>



(6) Let the pressurized system stand for about 1 day. If the pressure does not drop, the system passes.
- If the ambient temperature changes by 1°C, the pressure will change by about 0.01 MPa (gauge pressure). In this case, correct the pressure for the temperature difference.

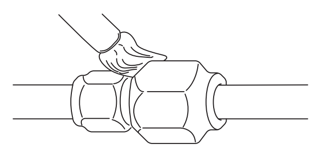
Correction value = (temperature when pressure checked - temperature during pressurization) x 0.01

(7) If the pressure dropped at steps 1 to 3, there are one or more leaks in the system. Locate and fix the leaks.

<Lead detection>

Check method: When the pressure drops at steps 1 to 3.

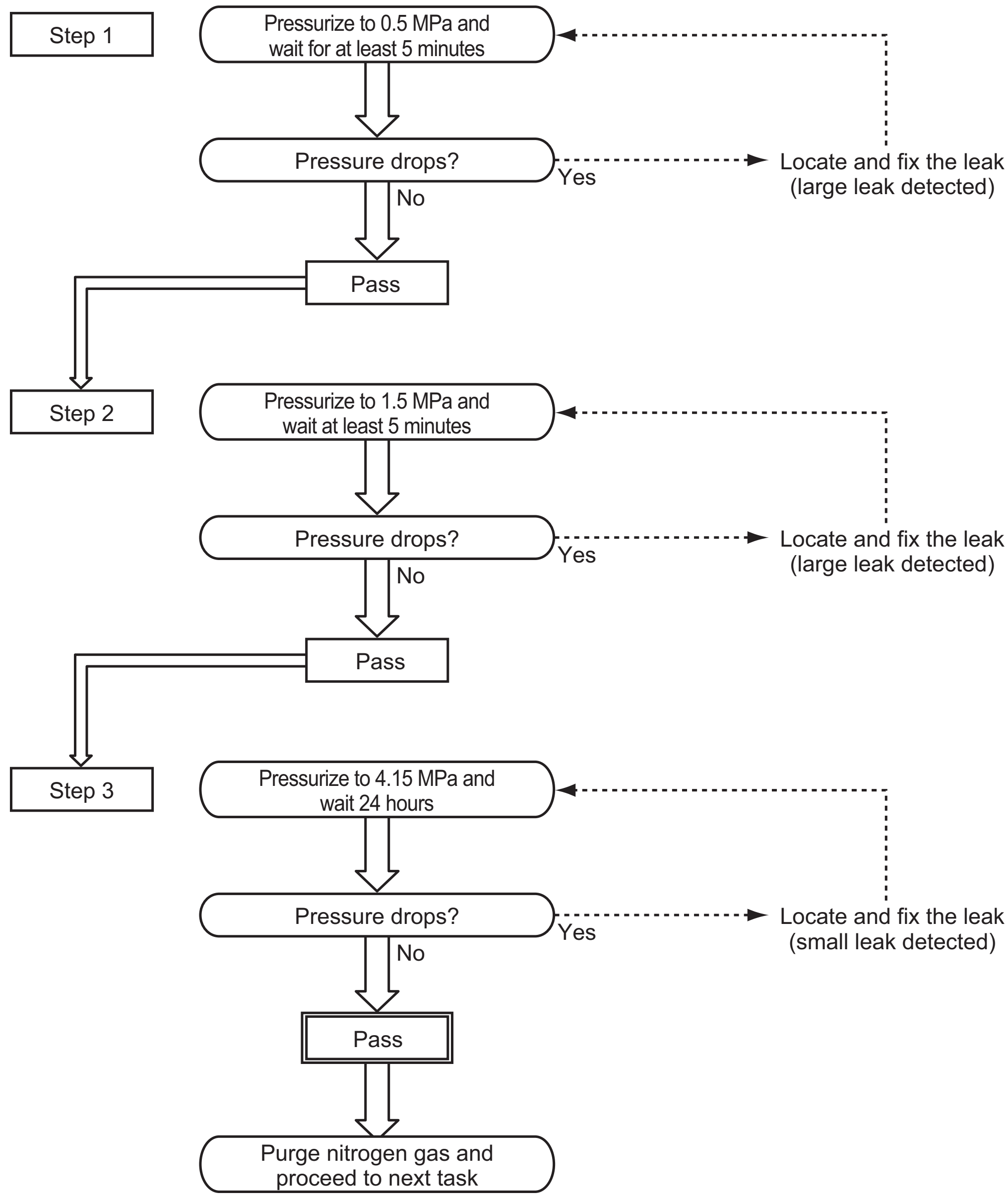
- Auditory check: Listen for a large leak.
- Tactile check: Place your hand on welded parts and connections and see if you feel a large leak.
- Soap and water check: Bubbles will form where there is a leak.



Note: After using soap and water, wipe off all the soapy water.
Soapy water may corrode the flare nut.

If the piping is long, it is recommended that you break it up into blocks and conduct an air tightness test on each block to make it easier to locate leaks.

<Flow chart>

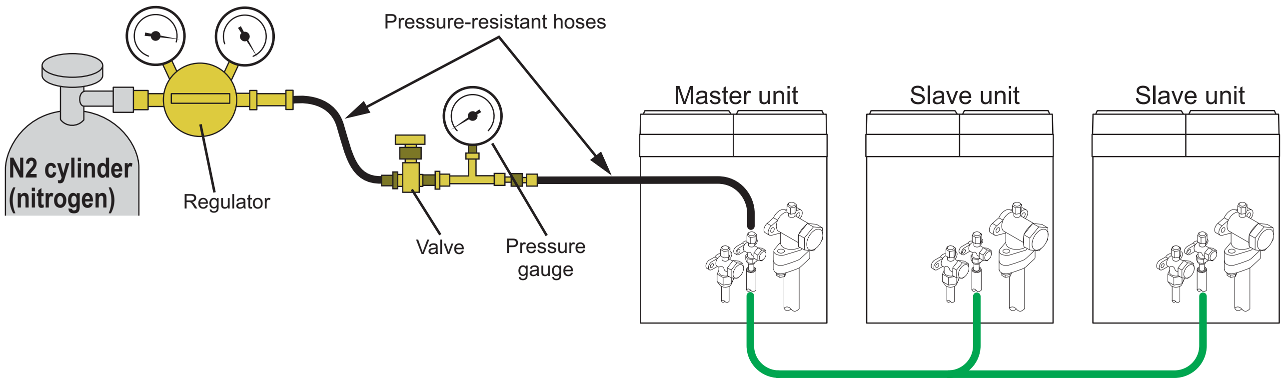


Step 1
Pressurize to 0.5 MPa and wait for at least 5 minutes
Pressure drops?
Yes
Locate and fix the leak (large leak detected)
No
Pass
Step 2
Pressurize to 1.5 MPa and wait at least 5 minutes
Pressure drops?
Yes
Locate and fix the leak (large leak detected)
No
Pass
Step 3
Pressurize to 4.15 MPa and wait 24 hours
Pressure drops?
Yes
Locate and fix the leak (small leak detected)
No
Pass
Purge nitrogen gas and proceed to next task

(8) Complete the leak location check and verify that there are no leaks. Next, purge the nitrogen gas.
If the system will not be run immediately, keep nitrogen in the unit.

(9) To test the air tightness of oil pipes (when 2 or more outdoor units are connected), refer to the connection example shown below and perform steps 5 through 7.

<Example of connection for air tightness testing of oil pipes>



(10) Remove the valve plate, flare union, and flare plug, and connect the pipe to the 3 way valve of the outdoor unit.

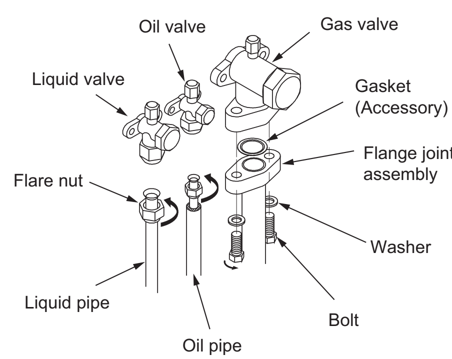
(11) Tighten the pipe to the valve connection port of the outdoor unit using the flare nut on the pipe. Refer to the table below for the tightening torque.

	Flare nut	Valve rod	Cap	Charge inlet cap
Gas pipe (3-way valve)	-	27.0 to 30.0 N-m (270 to 300 kgf-cm)	60.0 to 65.0 N-m (600 to 650 kgf-cm)	12.5 to 16.0 N-m (125 to 160 kgf-cm)
Liquid pipe (3-way valve)	49.0 to 61.0 N-m (490 to 610 kgf-cm)	-	28.0 to 32.0 N-m (280 to 320 kgf-cm)	12.5 to 16.0 N-m (125 to 160 kgf-cm)
Oil pipe (3-way valve)	16.0 to 18.0 N-m (160 to 180 kgf-cm)	-	20.0 to 25.0 N-m (200 to 250 kgf-cm)	12.5 to 16.0 N-m (125 to 160 kgf-cm)

(12) Connect the piping to the outdoor unit as shown in the diagram.

(13) When connecting the flange joint, use the gasket supplied.

(14) Connect the flange joint by brazing it togetyer with the reducer.



4-8 Pipe Insulation Work

4-8-1 Thickness of insulation material

1. Always insulate refrigerant pipes.
2. Refer to the minimum recommended thicknesses shown below to decide the thickness of the insulation material.
3. If the outdoor unit is installed in a higher position than the indoor unit, use putty or other material to fill in the gap between the pipe and the insulation at the connection to prevent water produced by condensation on the outdoor unit valve from flowing inside the building.
4. Completely insulate liquid pipes and gas pipes using the same specifications for each.
5. If refrigerant pipes are not completely insulated, water leakage may occur.

Minimum recommended insulation thickness by refrigerant pipe size
(When using insulation with a thermal conductivity of 0.043 W/(m-k) or less)

Installation conditions ambient temperature: 30°C (DB)

		Minimum recommended insulation thickness (mm)			
Relative humidity		≦70%	≦75%	≦80%	≦85%
Outer diameter of refrigerant pipe mm (in)	6.35 (1/4")	8	10	13	17
	9.53 (3/8")	9	11	14	18
	12.70 (1/2")	10	12	15	19
	15.88 (5/8")	10	12	16	20
	19.05 (3/4")	10	13	16	21
	22.22 (7/8")	11	13	17	22
	25.40 (1")	11	13	17	22
	28.58 (1-1/8")	11	14	18	23
	31.75 (1-1/4")	11	14	18	23
	34.92 (1-3/8")	11	14	18	24
	38.10 (1-1/2")	12	14	19	24

* If the ambient temperature and relative humidity are respectively higher than 30°C (DB) and 85%, use more insulation on the refrigerant pipes. Otherwise, condensation may form on the surface of the insulation.

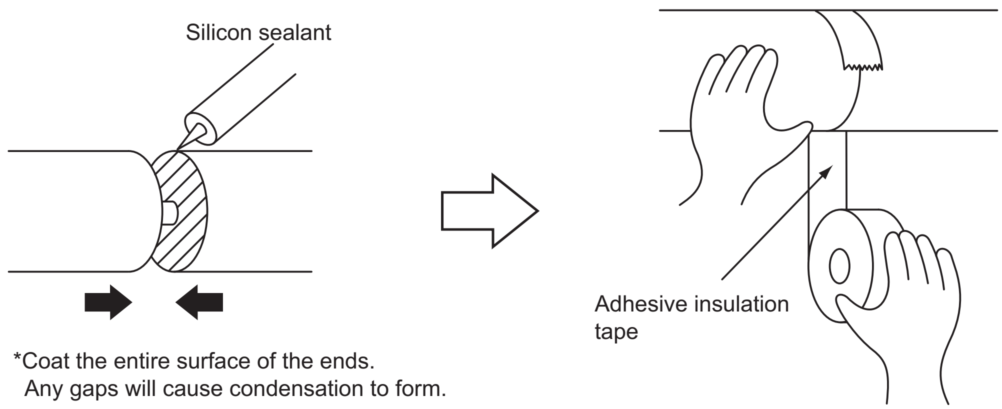
* Heat pump type gas pipes become very hot during heating operation.
For this type of pipe, select an insulation material with a heat resistance temperature of 120°C or higher.

4-8-2 Recommended Insulation performance

- Thermal conductivity: 0.043 w/m-k (kcal/m-h-°C)   Average temperature: 20°C
- Heat resistance temperature: -40 to 120°C
  (Conforming to JIS A9511 PE-C-P2)

4-8-3 Treatment of Joints

Always cut the insulation at a 90o angle and coat the entire surface of the joining ends with silicon, urethane, or other sealant. Fill in any gaps between the insulation and pipe with sealant. When fully coated, joint the ends of the insulation. Wipe off all dust and dirt from the joint with a dry, clean cloth and then tape the circumference of the joint with adhesive insulation tape, providing an overlap of at least 10 mm. Work the tape onto the surface well.
*If this work is not performed properly, condensation will form at the joint.



*Coat the entire surface of the ends.
Any gaps will cause condensation to form.

4-9 Vacuum Drying

1. Purpose

Vacuum drying refers to the use of a vacuum pump to vaporize (change to a gaseous state) moisture inside the pipes. The vaporized moisture is discharged outside the pipe; thereby drying the inside of the pipes. An additional objective is the discharge of nitrogen gas during air tightness testing.

- The boiling point of water at 1 atmosphere (760 mmHg) is 100oC. However, a vacuum pump is used to reduce the air pressure inside the pipe to nearly a vacuum, which causes the boiling point of the water inside the pipes to drop. Decreasing the boiling point below the outside temperature causes the water to vaporize so it can be discharged to the outside of the pipes.

2. If vacuum drying is not performed sufficiently...

(1) If air is mixed in the refrigerant, the high-side pressure will rise abnormally and may cause the compressor to fail.
(2) If microscopic quantities of water (moisture in the air) enter the refrigeration cycle, the air conditioner may fail.
(3) If moisture remains in the refrigerant, condensation may form in the expansion valve and cause the air conditioner to fail.

Boiling temperature of water vs. degree of vacuum

		100°C	90°C	80°C	70°C	60°C	50°C	40°C	30°C	20°C	10°C	0°C	-19°C	-68°C
Absolute pressure	mmHg abs (Torr abs)	760 (Atmospheric pressure)	525	355	234	149	92	55	32	17	9	4.5	1	0
Gauge pressure	MPa gauge	0	-0.0312	-0.0540	-0.0702	-0.0814	-0.0890	-0.0939	-0.0971	-0.0990	-0.1001	-0.1007	-0.1012	-0.1013

3. Vacuum pressure units

SI units of pressure recognized by the New Measurement Law are Pa (Pascal), N/m^2 (Newton per square meter), and bars. Non-SI units recognized are Torr for measuring the pressure inside living bodies and mmHg (mercury column millimeters) for measuring blood pressure.

The two methods shown below are used to indicate a vacuum. The vacuum industry uses absolute pressure, but other industries often use gauge pressure. Therefore, it is necessary to check which method is being used when reading catalogs and other literature.

(1) Absolute pressure units, for which "0" is an absolute vacuum, are often followed by "a" or "abs".
(2) Gauge pressure units, for which "0" is atmospheric pressure, are often followed by "G" or "Gauge".

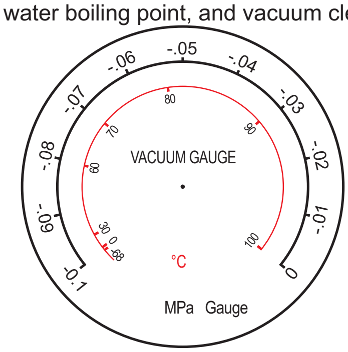
■ Unit conversion table

	atm	bar	Pa	kPa	MPa	Torr(mmHg)
atm	1 (Atmosphere pressure)	1.0133	101330	101.33	0.10133	760
bar	0.9869	1	100000	100	0.1	750.06
Pa	9.869×10^{-6}	0.01×10^{-3}	1	0.001	1×10^{-6}	7.501×10^{-3}
kPa	9.869×10^{-3}	0.01	1000	1	0.001	7.501
MPa	9.869	10	1×106	1000	1	7501
Torr(mmHg)	1.316×10^{-3}	1.333×10^{-3}	133.3	0.1333	133.3×10^{-6}	1

*The table above is based on absolute pressure such that an absolute vacuum is 0 Pa and the standard atmospheric pressure is 1 atm.

Vacuum gauge (Gauge pressure unit)

- Pressure range: 0 to - 0.1 MPa (0 to -760 mmHg)
  (Vacuum region) (With water boiling point scale)
- The water boiling point scale makes the relation between the external temperature, water boiling point, and vacuum clear at a glance.



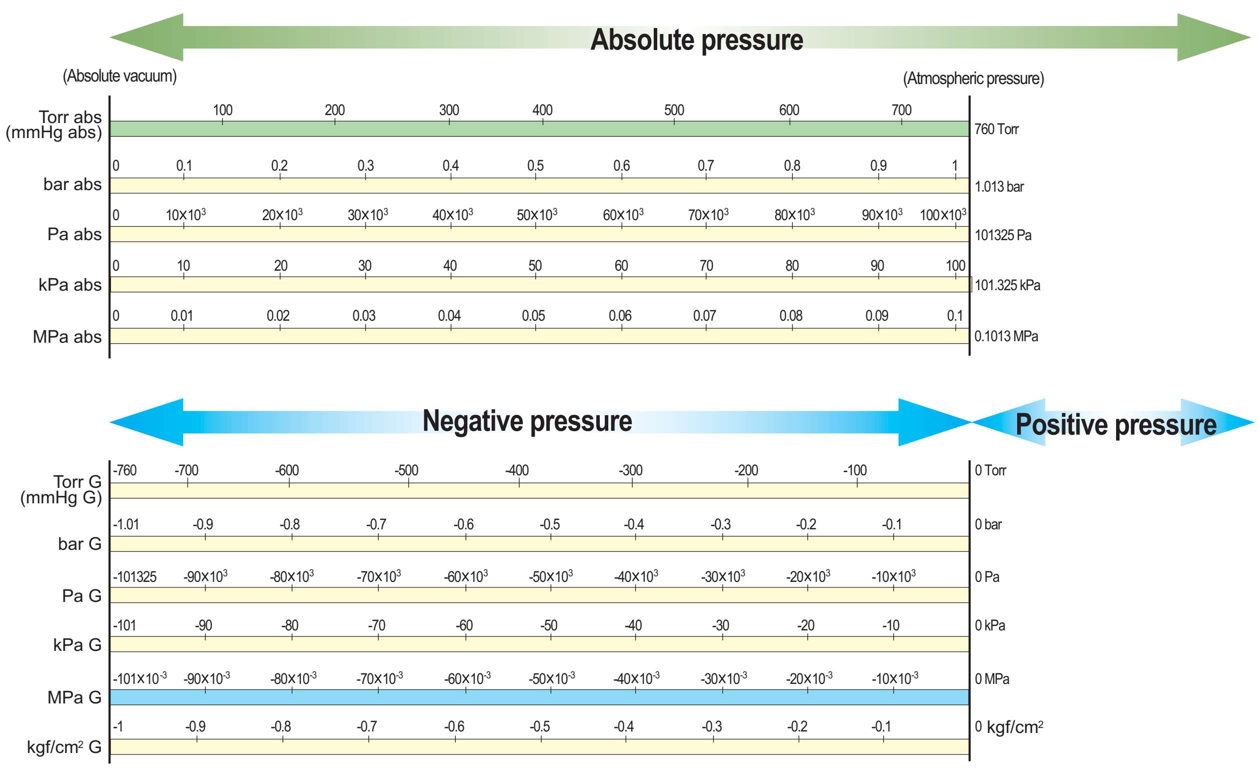
***Do not subject the vacuum gauge to positive pressure. This will damage the gauge. Either close the vacuum gauge valve completely or release or add gas after removal.**

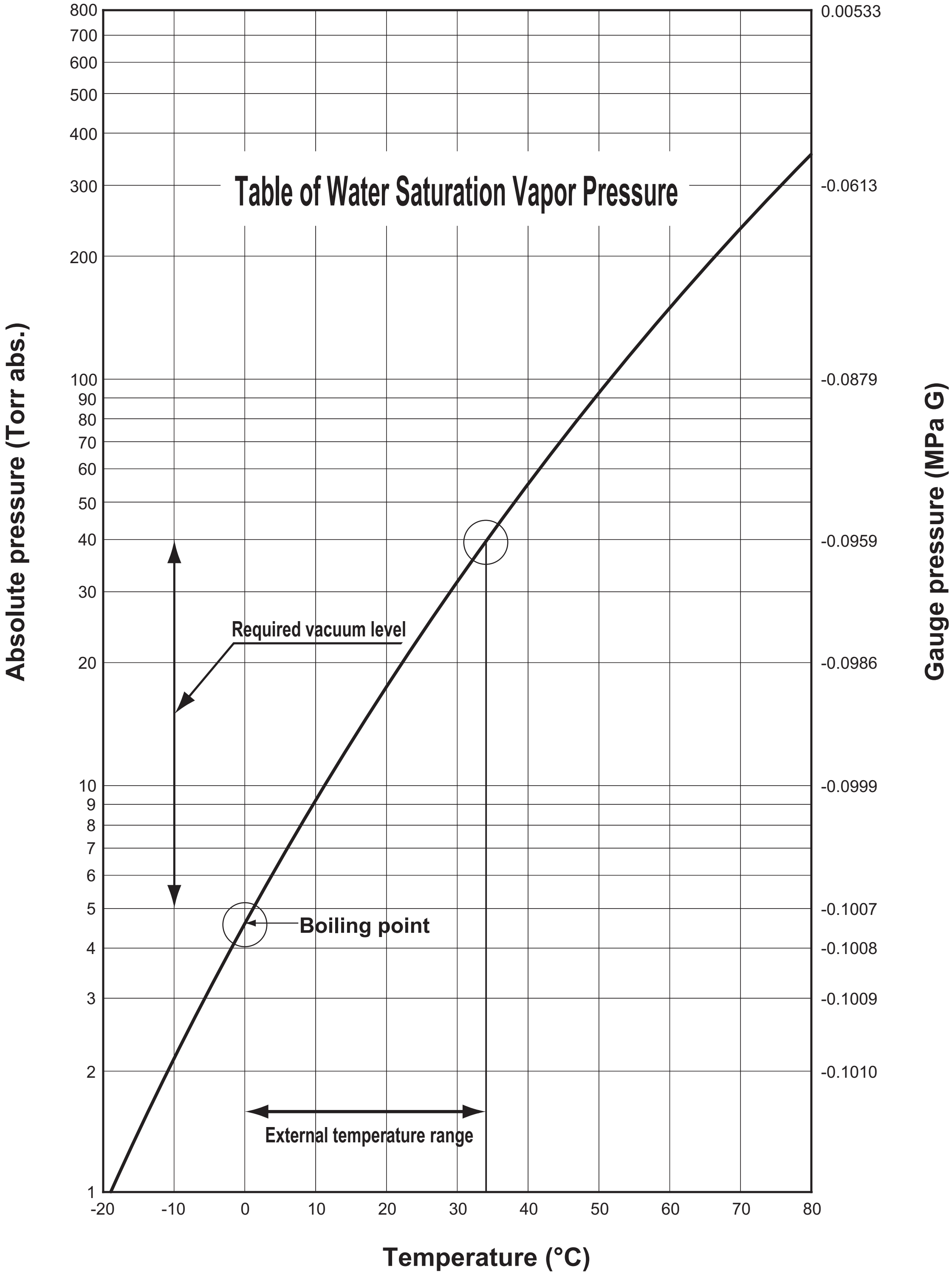
Vacuum gauge (Absolute pressure units)

- Measurement range: 200 to 500, 000 microns
- Size: 330 x 230 x 44 mm
- The pressure can be read to 1 micron on the LCD digital display.
- High-performance sensor enables immediate analysis response even to changes in temperature.

1mmHg = 1,000Micron

■ Comparison of units





—— Key Point When Working ——

**A vacuum level of -0.1 MPa G (5 Torr abs) or less must be obtained.
Thorough work control (more than previously) is required.**

4. Selecting a vacuum pump

The following two items generally determine vacuum performance:

(1) Pumping speed

Pumping speed is typically measured in units of L/min or m2/h. The higher the pumping speed, the quicker a vacuum is attained. Generally, a larger and heavier vacuum pump is required to obtain a higher pumping speed. Commonly sold vacuum pumps (pumping speeds of 20 to 30 L/min) take a very long time to attain a vacuum.

(2) Vacuum level

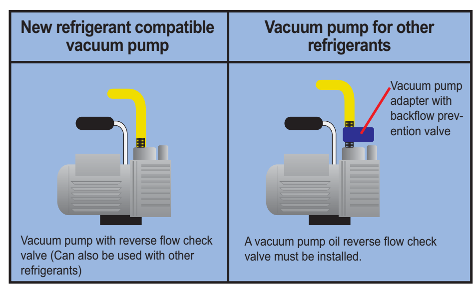
Vacuum level is the vacuum drying (moisture removal) ability. Vacuum level is primarily measured in Torr or microns. The lower the vacuum level, the higher the performance. Moisture is especially bad for new refrigerant devices and freezing/refrigeration machines with a low vaporization temperature setting. A vacuum pump capable of attaining a high vacuum level (0.5Torr or less) is necessary.

<Work Procedure>

⚠ CAUTION

(1) If vacuum pump oil becomes mixed in the refrigeration cycle due to reverse flow, the equipment may fail. Therefore, it is necessary to install a reverse flow check device to prevent reverse flow of the oil from the vacuum pump.
(2) The refrigerating machine oil used in an HFC refrigeration cycle easily absorbs moisture, and if even a little moisture becomes mixed in the refrigerating machine oil, acidic materials will form. For this reason, a vacuum pump capable of attaining a high vacuum level (0.5 Torr or less) is necessary to sufficiently remove the moisture.
(3) Use a special R410A gauge manifold and charging hose.
If a gauge manifold and charging hose that were used with R22 or R407C are used, the R22/R407C refrigerating machine oil (mineral oil), which is not compatible with R410A, will cause the refrigerating machine oil to deteriorate and lead to equipment failure.

(1) Connect the gauge manifold, vacuum gauge, and vacuum pump as shown on the following page.
*If you are using a vacuum pump previously used with other refrigerants, a vacuum pump adapter with reverse flow check flow is necessary.
(2) Fully open the gauge manifold and vacuum pump valve and turn on the vacuum pump.
(3) Use a high-performance vacuum pump to evacuate and maintain the vacuum state for a sufficiently long time.

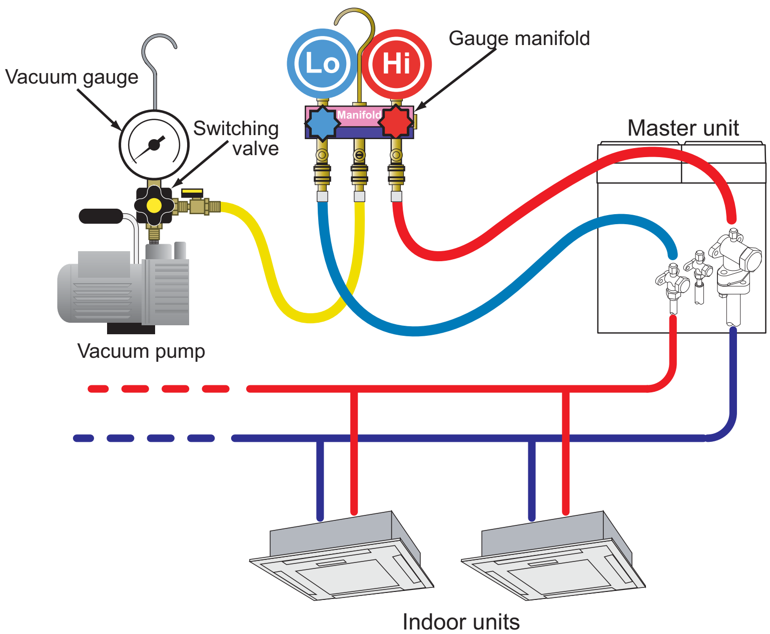


Gauge pressure gauge: -0.1 MPa or less
Absolute pressure gauge: 1 Torr or 1,000 microns or less
Once the values above have been reached, continue to operate the pump for the time show below.

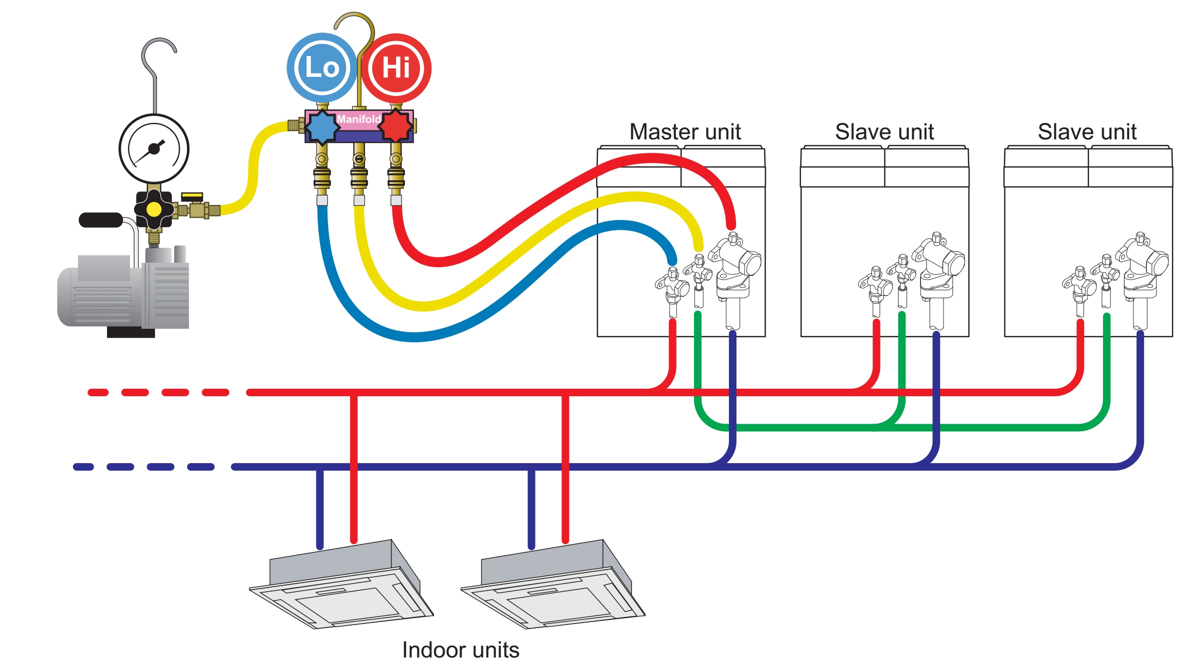
- Multi-air conditioner system for buildings: 2 hours or longer
- Package air conditioner: 1 hour or longer
- Small air conditioner: 15 minutes or longer

(4) Cllose the vacuum gauge valve (keeping the gauge manifold Hi/Lo valve fully open) and stop the vacuum pump.
(5) Let the system stand for 1 hour, and then verify that the vacuum gauge needle or display does not drop. If the pressure rises, there is a leak. Conduct a leak test, fix the leak, and evacuate the system again.
(6) Once you have verified that there are no leaks, fully close the gauge manifold and vacuum gauge valves. This ends vacuum drying.
(7) Add refrigerant, as required.
*At this time do not subject the vacuum gauge to positive pressure. Positive pressure will damage the gauge. Either fully close the vacuum gauge valve or purge or add gas after removing the gauge.

(A) Connection to one outdoor unit



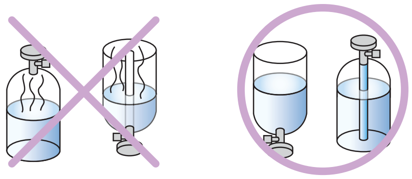
(B) Connection to multiple outdoor units



4-10 Charging Refrigerant

4-10-1 Preventing Component Alteration

Before charging refrigerant, check whether the refrigerant tank has a siphon pipe.

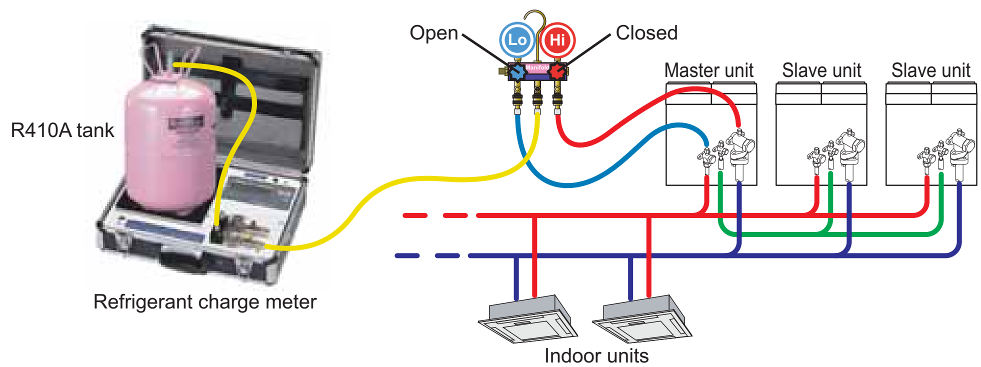


If the tank has a siphon pipe, the tank must be placed vertically right side up.
If the tank does not have a siphon pipe, the tank must be placed upside down.

R410A is a refrigerant blend. When charging, make sure that the refrigerant is in a liquid state to prevent component alteration.

4-10-2 Charging refrigerant using a vacuum

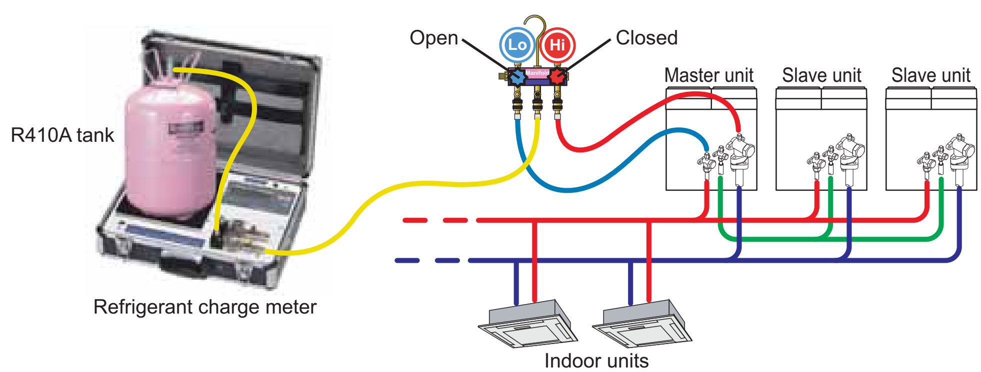
Verify that the 3-way valve is closed. (Never charge refrigerant through a gas pipe.)
After evacuation is completed, charge refrigerant (in a liquid state) through a liquid pipe.



4-10-3 Charging refrigerants during operation

If it was not possible to charge the specified amount of refrigerant in the method of 4-10-2, open the three-way valve, run the unit in cooling mode, and then charge refrigerant through a gas pipe. (This must be done in trial operation mode.)

- To prevent damage to the compressor, wait at least 12 hours before starting operation after turning on the supply power.
- To prevent fluid return, add the refrigerant a little at a time.
- The temperature of the supply gas must be kept at least 10°C higher than the saturation temperature.
- Open each valve of the three-way valve.



4-10-4 Preparing for operation

- After charging refrigerant, verify that all three-way valves are open.
  However, if the system only has one outdoor unit, the three-way valve of the oil pipe must remain closed.
- Verify that the amount of added refrigerant has been recorded on the service plate on the cover of the control box.

⚠ CAUTION

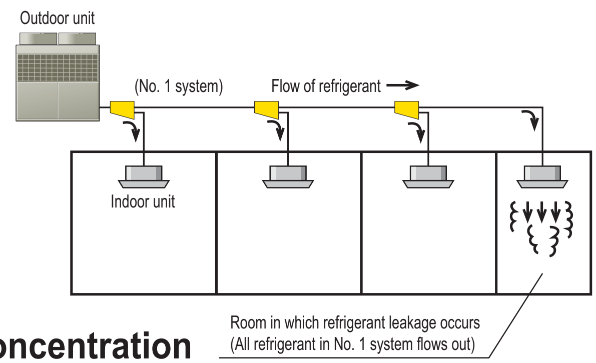
The refrigerant pressure and refrigeration oil are different, and thus the same installation tools cannot be used for both R22 and R410A.

4-11 Refrigerant Leakage Amount Cautions

1 Introduction

Multi air conditioner systems and almost all other air conditioners use R22 or R410A refrigerant.
Although these refrigerants are safe (non-toxic and non-flammable) the room in which the air conditioner is installed must be large enough so that the concentration of refrigerant gas does not exceed the concentration limit in the unlikely event that refrigerant gas leaks into the room.

> ⚠
>
> The limit concentration is the concentration of chlorofluorocarbon gas at which emergency measures can be taken in the event that refrigerant leaks into the air without the occurrence of injury to the human body. The limit concentration is normally given in units of kg/m^3 (weight of chlorofluorocarbon gas in one cubic meter of air) for easy calculation.
>
> **Limit concentration of R22: 0.3 kg/m^3**
>
> Base the limit concentration of R410A on the above limit concentration for R22.



2 Procedure for checking refrigerant concentration

Follow steps (1) through (3) to calculate the refrigerant concentration.

(1) Calculate the total quantity of refrigerant charged in each refrigerant system.

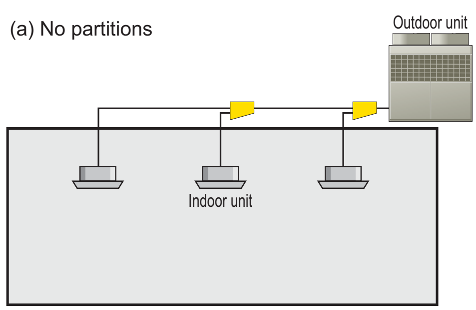
Quantity of refrigerant charged in outdoor unit system No. 1 (Amount of refrigerant charged at factory) + **Quantity of additionally charged refrigerant** (Amount of refrigerant added on-site due to length or diameter of piping) = **Total quantity of refrigerant charged in refrigerant equipment (kg)**

> ⚠
>
> **If the refrigerant equipment is separated into two or more independent systems, use the quantity of refrigerant filled in each system.**

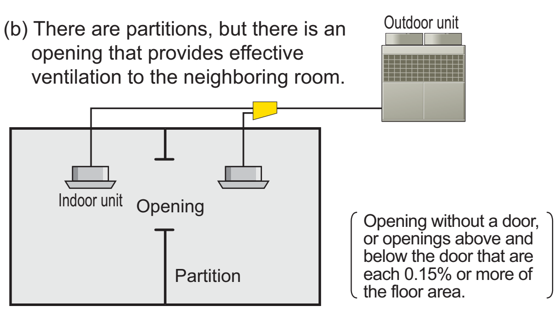
(2) Calculate the cubic space (m^3) of the room with the smallest capacity.

In the following cases, calculate the ☐ region as one room, or as the capacity of the smallest room.

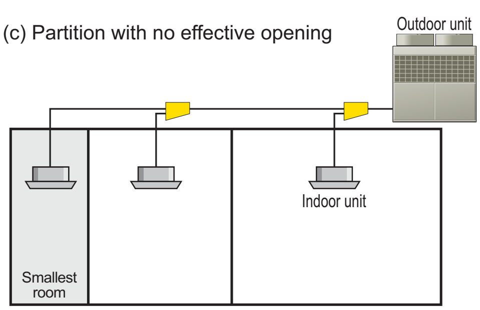
(a) No partitions



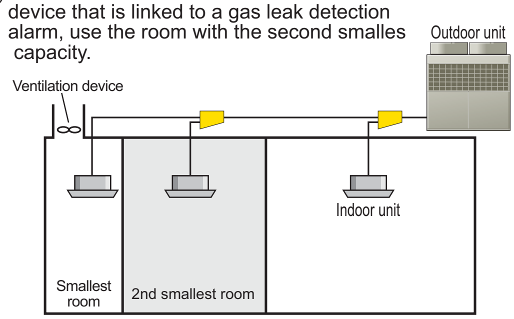
(b) There are partitions, but there is an opening that provides effective ventilation to the neighboring room.



(c) Partition with no effective opening



(d) If the smallest room has a mechanical ventilation device that is linked to a gas leak detection alarm, use the room with the second smalles capacity.



(3) Calculate the refrigerant concentration based on the results of (1) and (2).

$$\frac{\text{Total quantity of refrigerant filled in refrigerant equipment (kg)}}{\text{Capacity of smallest room with installed equipment containing refrigerant } (m^3)} \leqq \text{Refrigerant concentration } (kg/m^3)$$

If the refrigerant concentration is higher than the limit concentration, perform the same calculation for the second smallest room, the third smallest room, and so-forth up to large-capacity rooms to identify all rooms for which the concentration limit is exceeded.

3 Measures to be taken if the limit concentration is exceeded

If the refrigerant concentration exceeds the limit concentration for a particular room capacity, take the measures described below.

Measure 1 Create an opening that provides effective ventilation

Create openings above and below the door that are each at least 0.15% of the room area, or create an opening with no door.

Measure 2 Reduce the total quantity of refrigerant in the refrigerant equipment

(1) Shorten the refrigerant pipes.
Move the outdoor unit to a position that is closer to the indoor units to shorten the pipes and reduce the total amount of refrigerant.

(2) Reduce the capacity of the outdoor unit.
Use multiple outdoor units so that the outdoor unit capacity per refrigerant system is smaller, reducing the total amount of refrigerant in the system.

> For example, changing a 20 HP x 1 unit system to 10 HP x 2 units will allow the quantity of refrigerant per system to be cut approximately in half.

Measure 3 Install a ventilation system

A ventilation system can be installed to prevent an excessive increase of refrigerant concentration in the event that a refrigerant leak occurs. Ventilation methods include outside air introduction and air exhaust; however, due to the characteristics of the refrigerant, the outside air introduction method is recommended.

(1) Exhaust capacity
The exhaust capacity must be at least as large as indicated in Figure 1, based on the total quantity of refrigerant in the refrigerant equipment and the room capacity.

(2) Link to sensor
As a basic rule, the ventilation system should always run regardless of whether or not the air conditioner is being used or there are people present. If this is not possible, install a sensor system that will automatically start the ventilation system when a refrigerant leak occurs. An always-on ventilation system is shown in Figure 2, and a sensor linked system is shown in Figure 3.

Cautionary points

a) Even if a ventilation system is to be installed, the conditions indicated by the shaded area of Figure 1 should be avoided due to the possibility, even if remote, of the ventilation system failing. If actual conditions fall into this area, openings that provide effective ventilation should be created as described in **Measure 1** and **Measure 2** in order to increase the capacity of the room, or the total quantity of refrigerant should be reduced by changing the capacity of the outdoor unit or the length of the pipes.

b) If **Measure 1** **Measure 2** cannot be implemented when a ventilation system is installed and actual conditions fall under the shaded area of Figure 1, implement another means of ensuring safety that is independent of the ventilation system. For example, install a refrigerant shut-off valve that is activated by a sensor when a refrigerant leak occurs, or a reliable alarm system that will alert people in the room to danger. The sensor for this system should be different from the sensor that activates the ventilation system. Figure 4 shows the system when a refrigerant shut-off valve is installed.

c) When installing a ventilation system, be sure to create a gap that provides effective ventilation at the lowest point of the room (such as the gap under a door).

d) Exercise particular caution regarding pipe joints in areas where people will be present. Perform the work carefully in compliance with JIS rules, and conduct thorough leak testing after the work is completed. In addition, provide complete anti-vibration support for pipes to prevent breakage in the event of an earthquake or other external shock (however, allow for movement along the direction of the pipes to prevent stress due to temperature changes).

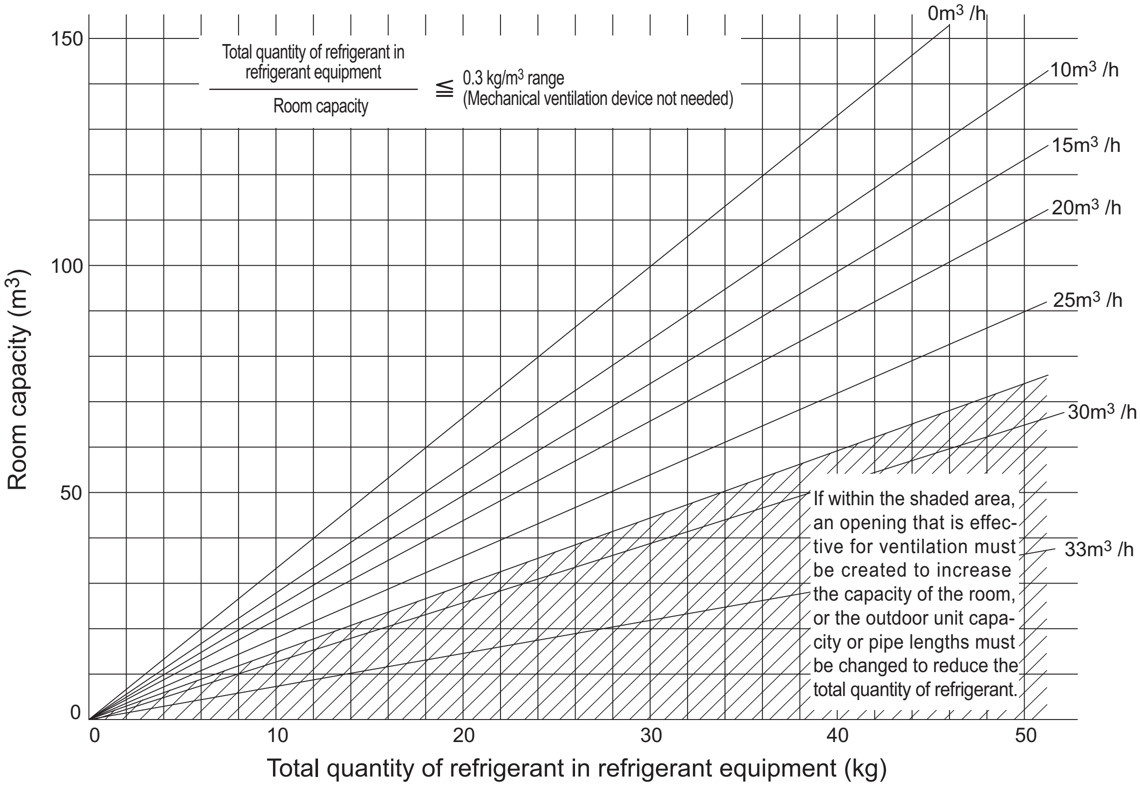


Figure 1: Selecting the system based on ventilation capacity

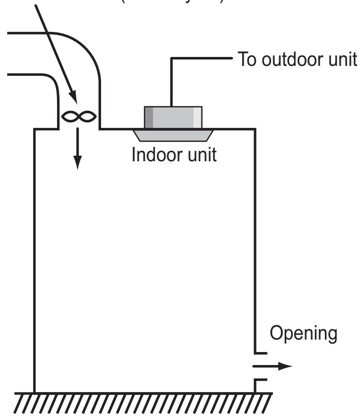


Figure 2: Always-on ventilation system (Example of outside air introduction)

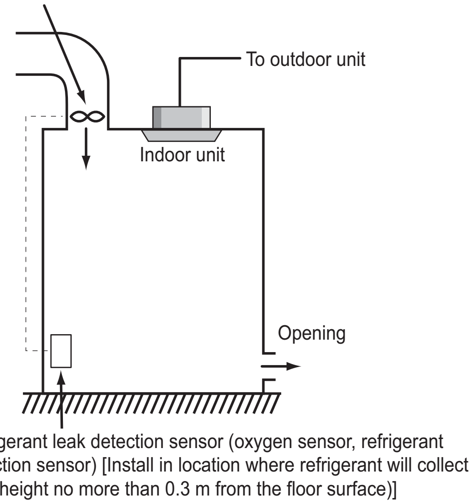


Figure 3: Sensor-linked system (Example of outside air introduction)

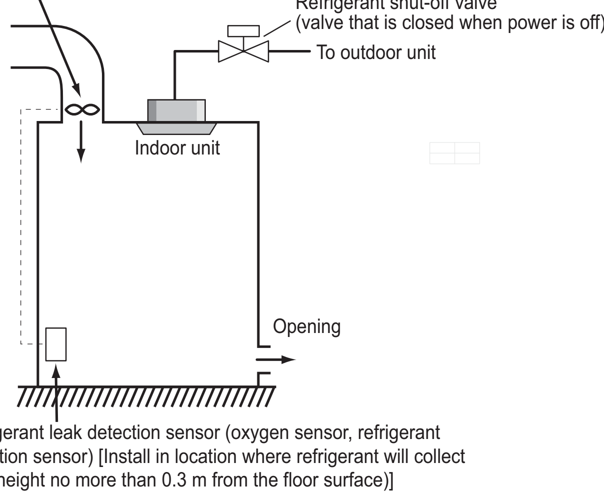


Figure 4: Always-on ventilation system and refrigerant shut-off valve

4-12 Refrigerant Recovery

Follow the procedures below to recover refrigerant when performing repair work.
Up to approximately 20 kg can be recovered per outdoor unit.

4-12-1 When repairing indoor unit parts and pipe joint leaks

Table 1
Connected number of outdoor unit.

1 unit	20.0kg
2 unit	40.0kg
3 unit	60.0kg

1. When the total quantity of refrigerant used in the system exceeds the amount shown in Table 1
   (1) Checking the weight of the recovery tank, use a refrigerant recovery unit to remove refrigerant until the total quantity is less than the quantity indicated in Table 1. To prevent alteration of the refrigerant components, continue removing liquid refrigerant from the refrigeration unit using the service port on the liquid line.
   (2) Perform pump-down as explained on the next page. (See page 04-32.)
   (3) When the repair work is finished, check for leaks and evacuate, and add the same quantity of new refrigerant as was recovered. (See page 04-27.)
   (4) Open the three-way valve, run the air conditioner, and verify that it operates normally.

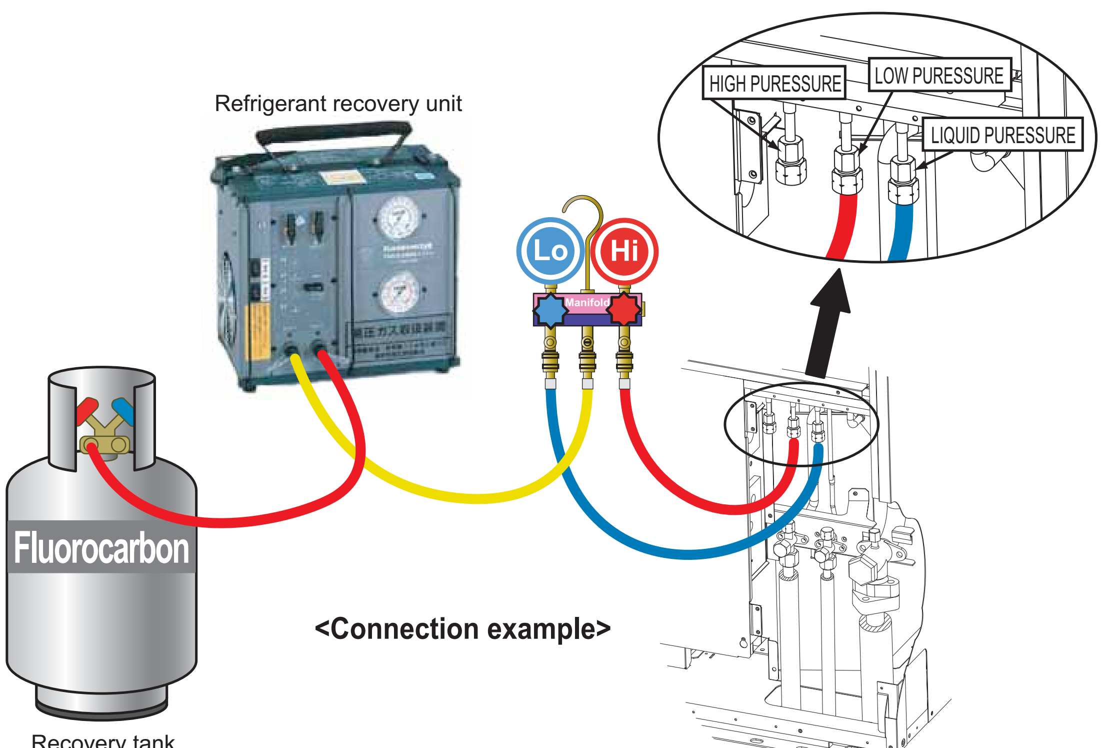
2. When the total quantity of refrigerant used in the system is less than the quantity shown in the table
   (1) Perform pump-down as explained on the next page. (See page 04-32.)
   (2) When the repair work is finished, check for leaks and evacuate. (See pages 04-22 to 04-26.)
   (3) Open the three-way valve, run the air conditioner, and verify that it operates normally.

4-12-2 When repairing refrigeration cycle parts of outdoor unit

(1) Close the three-way valve of the outdoor unit. Run the indoor unit in cooling mode and make the EEV (electronic expansion valve of the outdoor unit) open. Next, break the circuit with the power breaker (to prevent fluid inflow).
(2) Using a refrigerant recovery unit, recover as much as possible of the refrigerant in the outdoor unit through the service port.
(3) When the repair work is finished, check for leaks and evacuate, and add the same quantity of new refrigerant as was recovered.
(4) Open the three-way valve, run the air conditioner, and verify that it operates normally.

⚠ CAUTION

When recovering refrigerant, follow the instructions of the recovery unit manufacturer.



<Connection example>

4-13 Pump-Down

To prevent the discharge of the refrigerant into the atmosphere, Follow the procedure indicated below to recover the refrgerant from an outdoor unit before moving or discarding the unit. Up to approximately 20 kg can be recovered per outdoor unit. If the volume of the refrigerant to be recovered is large, recover it into a refrigerant recovery cylinder while measuring the weight of the refrigerant.

4-13-1 Procedure for Pump-down

Single unit Installation

Pump down method 1 (DIP switch method)

1. Fully close the 3-way valve at the liquid pipe.
2. Set the DIP switch 1-3 on the outdoor unit board "OFF→ON". The unit will start automatically.
3. When the pump down is completed, the LED lamps will flash at LED 2 to 6.
4. After the LED lamps flash, fully close the 3-way valve at the gas pipe promptly.
5. Restore the DIP switch to the original setup (ON→OFF)

Pump down method 2 (manual method)

1. Connect the charge hose of the manifold gauge to the charge port of the 3-way valve at the gas pipe. Open the pressure reduction valve slightly to purge the air from the charge hose.
2. Fully close the 3-way valve at the liquid pipe.
3. Perform a test run in the cooling mode. Set the DIP switch SW1-1 to "OFF→ON".
4. When the pressure gauge reads between 0.05 and 0 MPa, fully close the 3-way valve at the gas pipe.
5. Stop the run. Set the DIP switch SW1-1 to "ON→OFF".

Multiple connections

Pump down method 1 (DIP switch method)

1. Fully close all the liquid pipe.
2. Set the DIP switch 1-3 on the outdoor unit board "OFF→ON". The unit will start automatically.
3. When the pump down is completed, the LED lamps will flash at LED 2 to 6.
4. After the LED lamps flash, fully close the 3-way valve at the gas pipe and the 3-way valve at the oil pipe on all units promptly.
5. Restore the DIP switch to the original setup (ON→OFF)

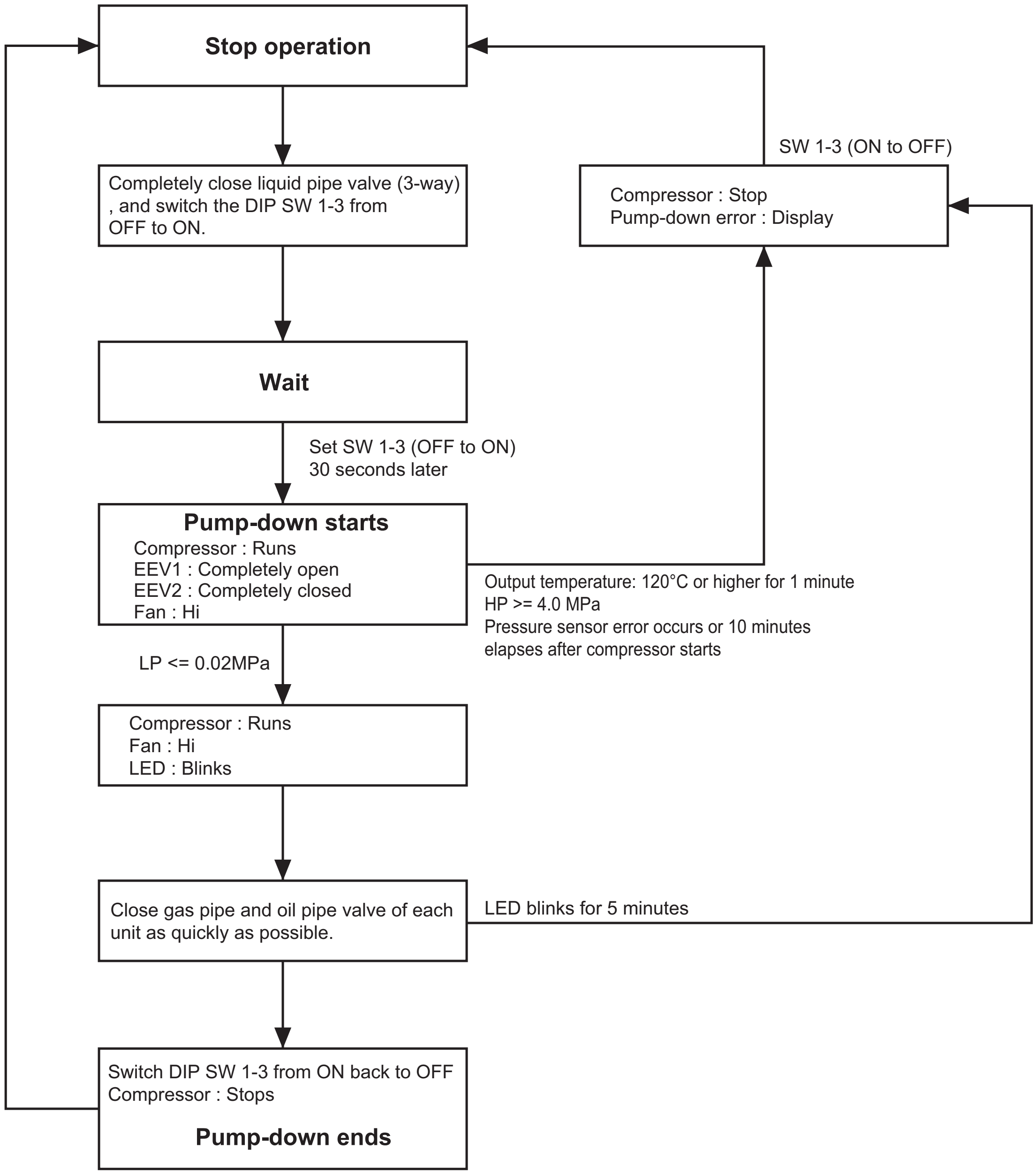
Pump down method 2 (manual method)

1. Connect the charge hose of the manifold gauge to the charge port of the 3-way valve at the gas pipe. Open the pressure reduction valve slightly to purge the air from the charge hose.
2. Fully close the 3-way valve at the liquid pipe on all units.
3. Perform a test run in the cooling mode. Set the DIP switch SW1-1 to "OFF→ON".
4. When the pressure gauge reads between 0.05 and 0 MPa, fully close the 3-way valve at the gas pipe and the 3-way valve at the oil pipe on all units.
5. Stop the run. Set the DIP switch SW1-1 to "ON→OFF".

⚠ CAUTION

Do not reuse the refrigerant that has been recovered by the recovery pump.

4-13-2 Pump-down Flowchart

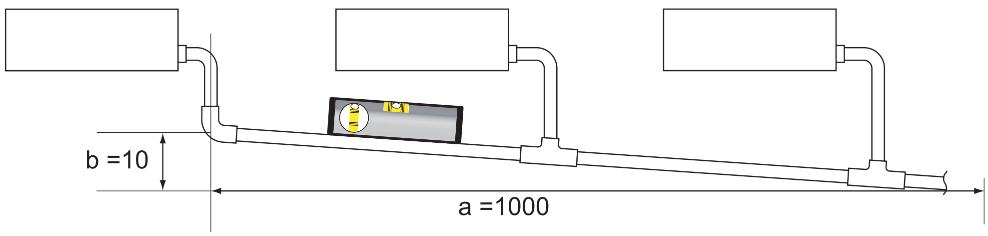


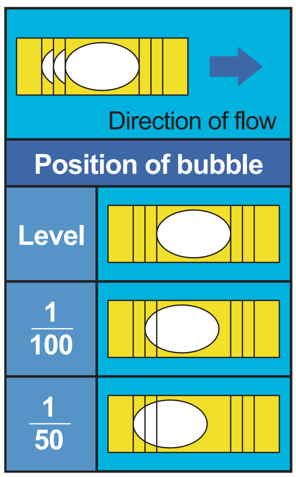
*To check operation, attach a pressure gauge to the service port and monitor the pressure. Do not leave the premises during operation.

4-14 Drain Pipe Work

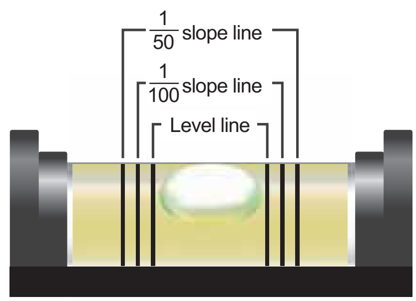
4-14-1 Overview of Spirit Level

Drain pipes are generally installed so that the pipe slopes down toward the drain outlet.
The slope is indicated by b/a. For example, if a = 1000 mm and b = 10 mm, the slope is 1/100.





When the bubble is between the two innermost indicator lines, the surface being measured is level. When the bubble is at the second indicator line, a slope of 1/100 is indicated. When the bubble is at the third indicator line, a slope of 2/100 (1/50) is indicated.



4-14-2 General Precautions for Drain Pipe Work

(1) Drain pipe work

- Install drain pipes at a slope of at least 1/100 with a horizontal run of no more than 20 m.
- Use hard vinyl chloride piping (commercially available) for drain pipes. To join pipes, use a vinyl chloride based adhesive so that there are no leaks.
- Always wrap drain pipes with commercially available insulation material (polyethylene foam with a thermal conductivity of 0.043 (W/m-k) and a thickness of 9 mm or more).
- Provide drain pipe supports at an interval of 1.5 m to 2.0 m.

(2) Centralized piping

- Position centralized piping about 10 cm lower than the drain outlet on the unit. Use a higher grade of vinyl chloride pipe (VP30 or higher).

Figure 1 Drain pipe work

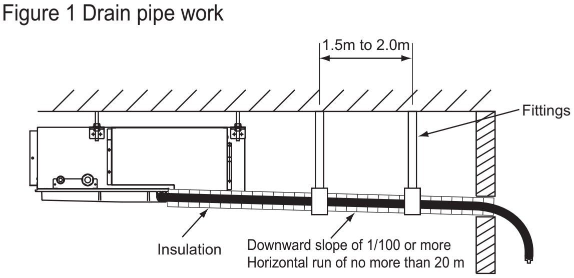
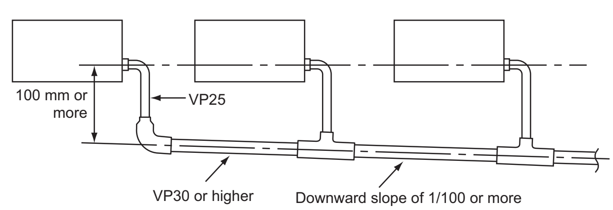


Figure 2 Centralized piping



(3) Drain pump

- The height from the ceiling of units with a built-in drain pump varies by model. Check the installation instructions.
- Even when there is a built-in drain pump, rises and drops are prohibited.

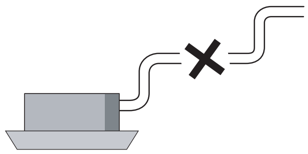
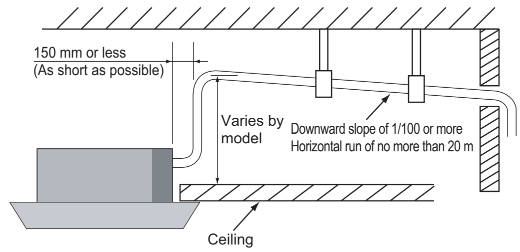


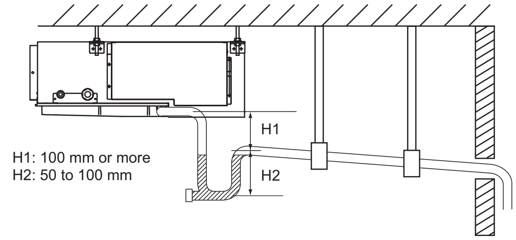
Figure 3: Drain pump



(4) Drain pump installation standards
Applicable models: High static pressure ducts

- Always install a drain trap on indoor units that have a large negative pressure at the drain pan outlet.
- Install one trap per indoor unit. Installing a single trap for multiple units below the merging point will have no effect.
- Install the trap so that it can be cleaned.

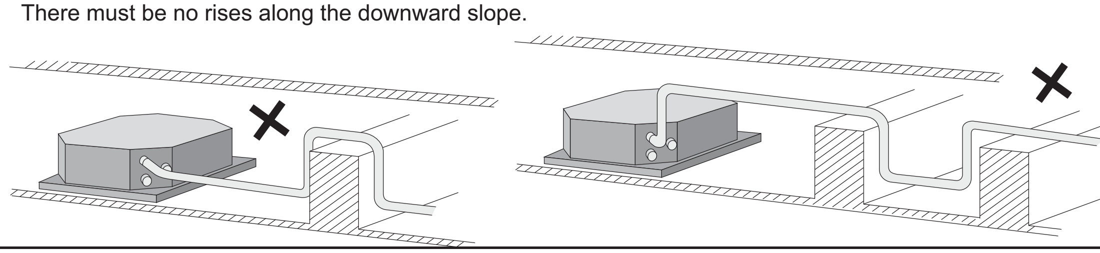
Figure 4: Drain trap



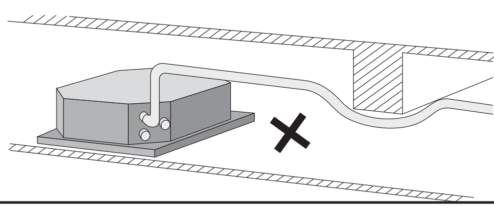
(5) Drainage test

- Conduct a drainage test. While conducting the test, verify that there are no leaks at joints. For a unit with a built-in drain pump, check whether or not the drain pump operates by executing trial operation in cooling mode.
- Even when installing during the heating season, execute trial operation in cooling mode.

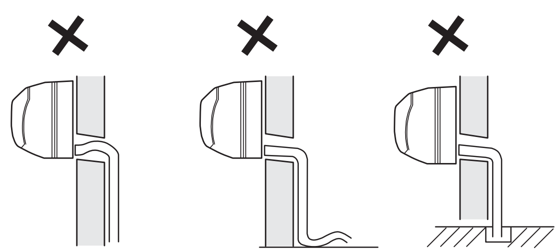
Rises There must be no rises along the downward slope.



Traps A traps along the horizontal run of the piping will cause retention of the water flow.

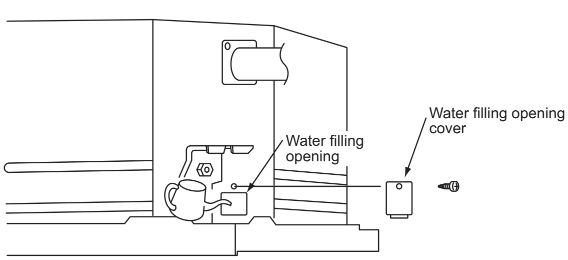


Wall mounted type

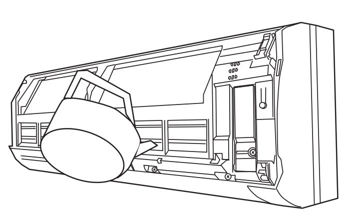


Drainage test

Duct type

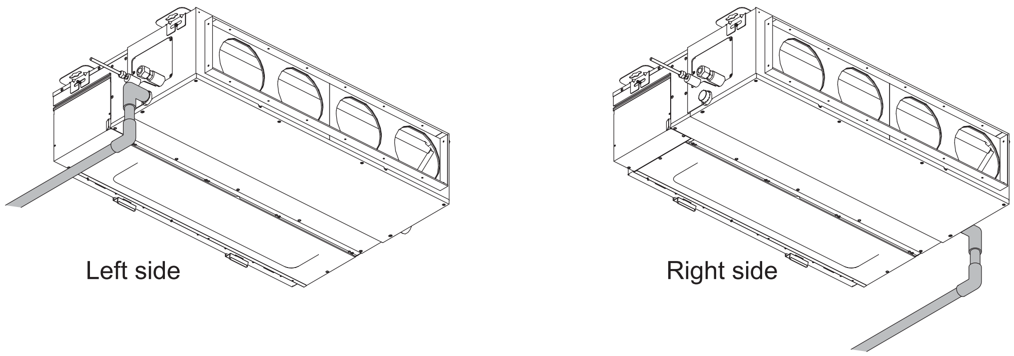


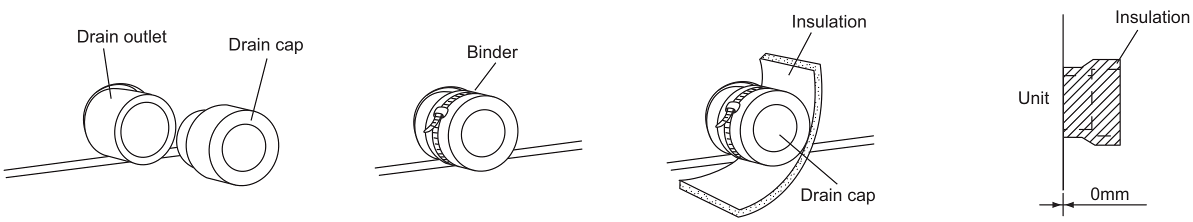
Wall mounted type



4-14-3 Selecting the Drain Cap Position

- There are drain outlets on both the right and left sides of the unit. Select the outlet that is most suitable for your site.
- In the factory shipping state, the drain outlet on the left side (the side with the electrical box) is ready for use.
- If you need to use the drain outlet on the right side, attach the drain cap to the drain outlet on the left side.





⚠ CAUTION

- **Verify that the drain cap is attached to the unused drain outlet and is secured firmly with a binder.**
- **If the drain cap is not attached or is not firmly secured with the binder, water may leak during cooling operation.**

5. ELECTRICAL WIRING WORK

5. Electrical Wiring Work

5-1 Precautions When Wiring Communication Lines

5-1-1 Countermeasures for Static Electricity

When working on the control board to configure address settings and other settings, an electrostatic charge on your body may damage the control board. For this reason, observe the following precautions when working with communication wiring and remote control wiring.

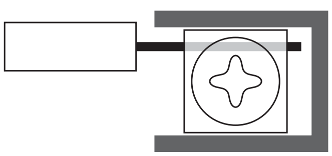
(1) Indoors units, outdoor units, and peripheral devices must be grounded.
(2) The power must be shut off at the breaker.
*This does not apply to some devices. Devices such as UTR-YLLA and UTR-YRPC on which settings are configured with the power on are excluded.
(3) **Touch a metal part of the indoor/outdoor unit for at least 10 seconds to discharge any electrostatic charge on your body.**
(4) Never touch a terminal plate, pattern, or component on a board.

5-1-2 Precautions When Performing Wiring Work

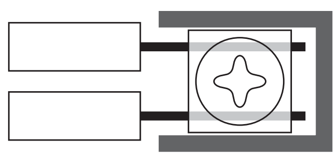
Verify the following items before wiring communication lines.

(1) The countermeasures for static electricity must be taken. (See 5-1-1)
(2) Use a wire stripper to remove the jacket from leads. If a wire stripper is not available, use nippers or a similar tool to carefully remove the jacket, exercising caution not to damage the conductors. Any damage to conductors may lead to a broken circuit and interfere with communication.
(3) Connecting wires to a terminal plate
Connect wires as shown in Figures (a) to (c). Take care not to overtighten screws. Overtightening may cause a circuit break. Insufficient tightening may cause a poor connection and interfere with communication.

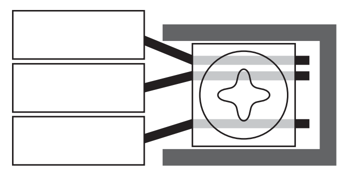
(a) Connecting one lead



(b) Connecting two leads

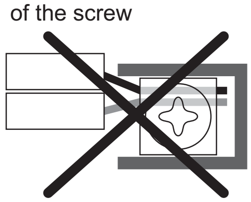


(c) Connecting three leads

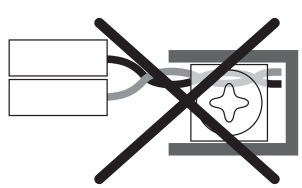


Never connect leads as shown below.
Circuit breaks or short circuiting may occur, causing failures and interfering with communication.
(d) Multiple leads inserted on one side of the screw
(e) Twisting leads together
(f) Crossing leads over each other
(g), (h) Leads protruding from terminal plate

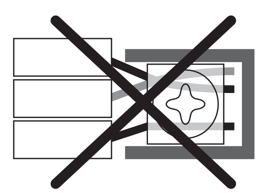
(d) Two leads inserted on one side of the screw



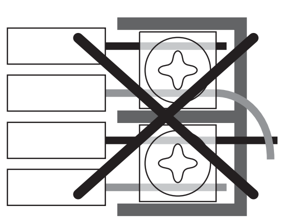
(e) Leads twisted together



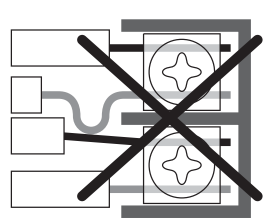
(f) Leads crossed over each other



(g) Short circuit at end of leads

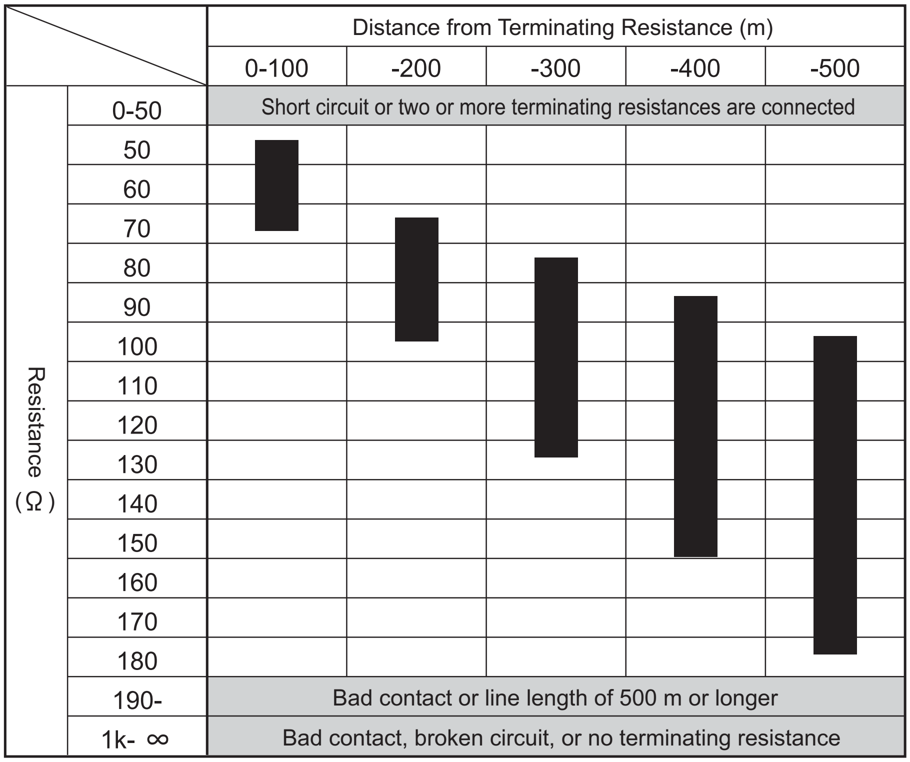


(h) Short circuit near terminal plate



5-1-3 Measuring the Resistance of the Communication Line (Measure with Breaker OFF)

When you have finished wiring the communication line, measure the resistance at both ends of the communication line, from the device with the attached terminating resistance (outdoor unit or signal amp) to the most distant device.
The resistance changes as shown below in relation to the distance from the terminating resistance. The indicated values are approximate.



⚠ CAUTION

If the resistance is not normal, do not under any circumstances turn on the power.
This may damage the communication board.

Communication line protection

Use the body ground screw on each device to secure both ends of the shield wire of the communication line.
Take care not to overtighten the screws. Overtightening may cause a circuit break or damage the terminal plate.

Remote control wiring

(1) Take static electricity countermeasures. (see 5-1-1)
(2) The breaker of the indoor unit must be OFF.
(3) Connect the terminal plate wires in the order GND - power - signal (on both the indoor unit and the remote control).
(4) Verify that the GND, power, and signal wires are connected correctly. Turning on the power with incorrect connections may damage the unit.
(5) Take care not to overtighten the screws. Overtightening may cause a circuit break or damage the terminal plate.
Insufficiently tightened screws may cause a bad contact and interfere with remote control communication.
(6) Never touch the terminal plate, pattern, or components on the board.

5-1-4 Precautions When Configuring Settings

When configuring addresses and other settings in the indoor unit, outdoor unit, and remote control, observe the ollowing precautions.

(1) Take countermeasures for static electricity (see 5-1-1)
(2) Never touch the terminal plate, pattern, or components on the board.
(3) Use an insulated screwdriver for DIP SW settings.
(4) Settings on the UTR-YLLA, UTR-YRP, and similar models must be configured with the power ON. Exercise caution to avoid electrical shock as an AC voltage is present at the power board and terminal plate.

5-1-5 Precautions When Turning on the Power

Verify the following before turning on the power.

(1) All pipes are connected properly.
(2) Indoor units, outdoor units, and peripheral equipment are grounded properly.
(3) The power line is connected correctly.
(4) The communication line is connected correctly (resistances are within specifications).
(5) If there are wired remote controls or similar peripheral devices, verify that they are connected correctly. Do not turn on the power if any devices are not connected correctly. (If a peripheral device is not connected, do not strip the jacket from the cable. Wrap conductor ends in electrician's tape to prevent short-circuiting.)

5-2 Guidelines for Selecting VRF Communication Cable

1. Introduction

This section gives guidelines for selecting communication cable used for the VRF Series.
Following these guidelines will help ensure stable communication. However, note that these guidelines do not guarantee any communication cable products.

2. Communication cable standards and precautions

Communication cables for the VRF Series (based on "NEMA Level 4 Cables" of the National Electrical Manufacturers Association (NEMA)) require the following electrical characteristics and precautions.

(1) Electrical specifications

No.	Item		Unit	Specification
1	Wire type		mm	ø0.65 (AWG22 equivalent) Shielded twisted pair cable
2	Pairs (twisted pair cable)*1		----	One-pair or two-pair
3	Loop DC resistance (20°C)		Ω/Km	118 or less
4	Degree of DC resistance non-equilibrium (20°C)		%	5 or higher
5	Withstand voltage (between conductors)		V/1Min	AC 350
6	Insulation resistance (between conductors) (20°C)		MΩ/Km	500 or higher (500 V DC, after charging for 1 min.)
7	Electrostatic capacitance between conductors	1KHz	nF/Km	56 or less
8	Non-equilibrium electrostatic capacitance (pair to ground)	1KHz	nF/Km	3.28 or less
9	Characteristic impedance	772KHz	Ω	102 ±15% (87 to 117)
		1MHz		100 ±15% (85 to 115)
		4MHz		100 ±15% (85 to 115)
		8MHz		100 ±15% (85 to 115)
		10MHz		100 ±15% (85 to 115)
		16MHz		100 ±15% (85 to 115)
		20MHz		100 ±15% (85 to 115)
10	Attenuation	772KHz	dB/Km	15 or less
		1MHz		18 or less
		4MHz		36 or less
		8MHz		49 or less
		10MHz		56 or less
		16MHz		72 or less
		20MHz		79 or less
11	Near crosstalk attenuation (*2)	772KHz	dB/Km	58 or higher
		1MHz		56 or higher
		4MHz		47 or higher
		8MHz		42 or higher
		10MHz		41 or higher
		16MHz		38 or higher
		20MHz		36 or higher

*1 Twist frequency is not specified. However, characteristic impedance, attenuation, and other electrical specifications must be satisfied. (Example: 40 twists/meter or higher)
*2 Near crosstalk attenuation applies only to two-pair twisted pair cable.

(2) Precautions
(1) Materials are not specified. However, materials must be selected with consideration given to the ambient environment (temperature, humidity) and local environmental regulations (RoHS, etc.).
(2) Mechanical specifications are not stipulated. However, consideration should be given to the ambient environment.

<Reference>

Major manufacturers of Lonworks cables, a typical cable type, and their products are shown below.

(1) BICCGeneral (BICC Cable, Brand-Rex, General Cable, Carol Cable)

Corporate	4 Tesseneer Drive Highland Heights, Kentucky 41076-9753 Phone : +1-606-572-8000 Phone : 1-800-424-5666 Fax : +1-606-572-8458 Web : www.biccgeneral.com
Europe Head Office	Stewarts Road Finedon Road Industrial Estate Wellingborough Northants, NN8 4RJ United Kingdom Phone : +44(0) 1933-277700 Fax : +44(0) 1933-273696
Asia / Pacific Head Office	435 Orchard Road #17-02 Wisma Atria Singapore 238877 Phone : +65-734 1151 Fax : +65-734

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	C8611
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	C8651

(2) The Cable Company

498 Bonnie Lane
Elk Grove, Illinois 60007 U.S.A
Phone : 1-847-437-5267
Fax : +1-847-437-8820
Web : www.thecableco.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	5202ECH
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	5204ECH

(3) Calvert Wire and Cable Corporation

5091 West 164th Street Brook Park, OH. 44142 U.S.A
Phone : +1-216-433-7600
Fax : +1-216-433-7614
Web : www.calvert-wire.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Non-plenum U.L. Type CMR	RD3011-LON
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Non-plenum U.L. Type CMR	RD2P3011-LON
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Plenum U.L. Type CMP	DMC3011-LON
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Plenum U.L. Type CMP	DMC2P3011-LON

(4) Communication Supply Corporation (CSC)

Low Voltage Division Headquarters 5950 Office Boulevard, N.E.
Albuquerque, NM 87108 U.S.A
Phone : 1-505-344-3400, 1-800-334-2150
Fax : +1-505-345-3862
Web : www.gocsc.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Non-plenum U.L. Type CM	CSC 588549
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Non-plenum U.L. Type CM	CSC 588550
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Plenum U.L. Type CMP	CSC 588545

(5) ConnectAir International

4240 B Street N.W. Auburn, Washington 98001
Phone : +1-253-813-5599
Phone : 1-800-247-1978
Fax : +1-253-813-5699
Web : www.connect-air.com

Direct burial and aerial messenger cables also available.

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	W221P-2002
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	W222P-2004
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	P221P-1003
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum U.L. Type CM	P222P-1005

(6) Eastman Wire & Cable

International Sales Office
1085 Thomas Busch Highway Pennsauken, New Jersey 08110
Phone : +1-609-488-8800
Phone : 1-800-257-7940
Fax : +1-609-488-8899
Web : www.eastmanwire.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum	LEV4221PSJ725
Level 4 22AWG (0.65mm)	2	Shielded Plenum	LEV4222PSJ725
Level 4 22AWG (0.65mm)	1	Shielded PVC jacket Non-plenum	LEV4221PSJ
Level 4 22AWG (0.65mm)	2	Shielded PVC jacket Non-plenum	LEV4222PSJ

(7) General Wire Products

International Sales Office
425 Shrewsbury Street Worcester, Massachusetts 01604
Phone : +1-508-752-8260
Fax : +1-508-753-2173
Web : www.generalwireproducts.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Solid Plenum	030-42701
Level 4 22AWG (0.65mm)	2	Shielded Stranded Plenum	030-21891
Level 4 22AWG (0.65mm)	1	Shielded Stranded Plenum	030-21892
Level 4 22AWG (0.65mm)	2	Shielded Solid Plenum	030-42702

(8) Great Lakes Wire and Cable, Incorportated

International & Domestic Sales Office
32400 Howard Street Madison Heights, MI 48071
Phone : +1-248-616-0022
Phone : 1-888-833-4592
Fax : +1-248-616-9118
Web : www.greatwire.co

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1 Solid	Shielded Plenum U.L. Type CMP	70004
Level 4 22AWG (0.65mm)	2 Solid	Shielded Plenum U.L. Type CMP	70005
Level 4 22AWG (0.65mm)	1 Stranded	Shielded Plenum U.L. Type CMP	70008
Level 4 22AWG (0.65mm)	2 Stranded	Shielded Plenum U.L. Type CMP	70009

(9) Lake Cable, LLC

2020 North Austin Avenue Chicago, IL. 60639 U.S.A
Phone : +1-773-385-8700
Fax : +1-773-385-8770
Web : www.lakecable.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	PFF222PRCS-ECH
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	PFF222CS-ECH
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	222CSFPP-ECH

(10) Magnum Cable Corporation

International Sales Office
5250 Naiman Parkway Solon, Ohio 44139 U.S.A
Phone : +1-440-519-3333
Fax : +1-440-519-3334
Web : www.magnumcable.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum	A30016LON
Level 4 22AWG (0.65mm)	2	Shielded Plenum	A30018LON
Level 4 22AWG (0.65mm)	1	Shielded PVC jacket Non-plenum	A20050LON
Level 4 22AWG (0.65mm)	2	Shielded PVC jacket Non-plenum	A20052LON

(11) Metro Wire and Cable Corporation

36625 Metro Court Sterling Heights, MI 48321 U.S.A
Phone : +1-586-264-3050
Fax : +1-586-264-7390
E-mail : metrowire@Earthlink.net

Norcross, GA 30093 U.S.A
1275-A Oakbrook Drive
Phone : +1-770-449-6327
Phone : +1-800-633-1432
Fax : +1-770-263-6504
E-mai l: mwcatl@att.net

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	MWC-1002
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	MWC-1003

(12) Showa Electric Wire and Cable Co. Ltd. (Japan)

No. 26 Chuo Building 29-5, Nishi-Shinbashi 2-chome
Minato-ku Tokyo
Phone : +81-03-3437-7301
Fax : +81-03-3437-7323
Web : www.asiansources.com/showa.co
Web : www.swcc.co.jp

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum	LW221S
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum	LW222S

(13) Windy City Wire

4250 Madison Street Hillside, Illinois 60162
Phone : +1-708-493-1191
Phone : 1-800-379-1191
Fax : +1-708-493-1390
Web : www.smartwire.com

Cable Type	Number of Pairs	Details	Catalog Number
Level 4 22AWG (0.65mm)	1	Shielded Plenum U.L. Type CMP	106500 - Blue jacket 106502 - Orange jacket 106503 - Yellow jacket 106540 - Purple jacket
Level 4 22AWG (0.65mm)	2	Shielded Plenum U.L. Type CMP	106600 - Blue jacket
Level 4 22AWG (0.65mm)	1	Shielded Non-plenum U.L. Type CM	108500 - Blue jacke
Level 4 22AWG (0.65mm)	2	Shielded Non-plenum U.L. Type CM	108600 - Blue jacket

5-3 Methods for Detecting Incorrect Connections (J-Series)

A method for detecting incorrect connections using a tester (diode measurement function) is explained below.
Testing should be performed before turning on the power following the completion of wiring.
However, in a system to which an MIII is connected, a complete determination is not possible, and thus caution is equired. In addition, with this method, if the ground wire is not connected correctly, detection will not be possible.

1. Measurement points

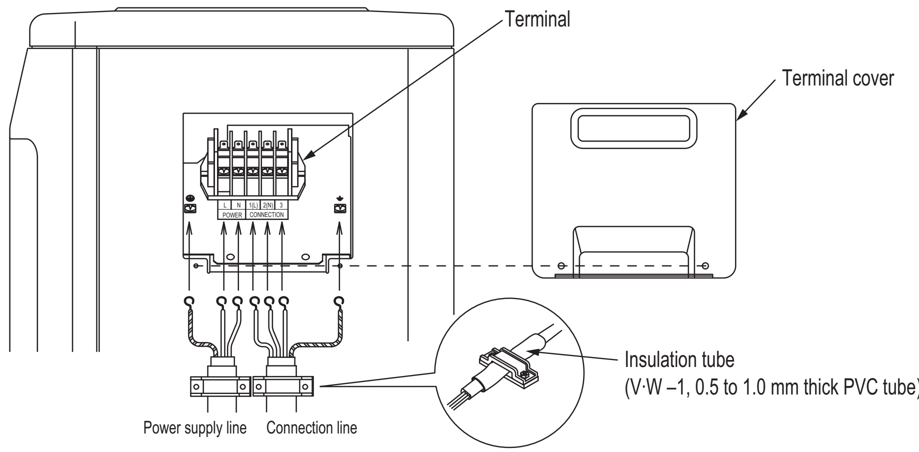


Figure 1: Terminal plate of outdoor unit

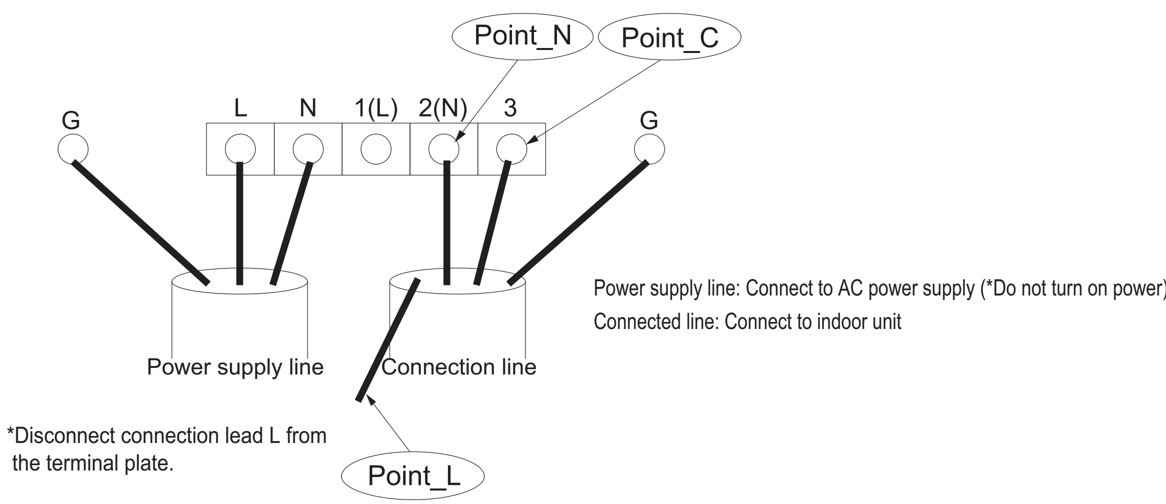
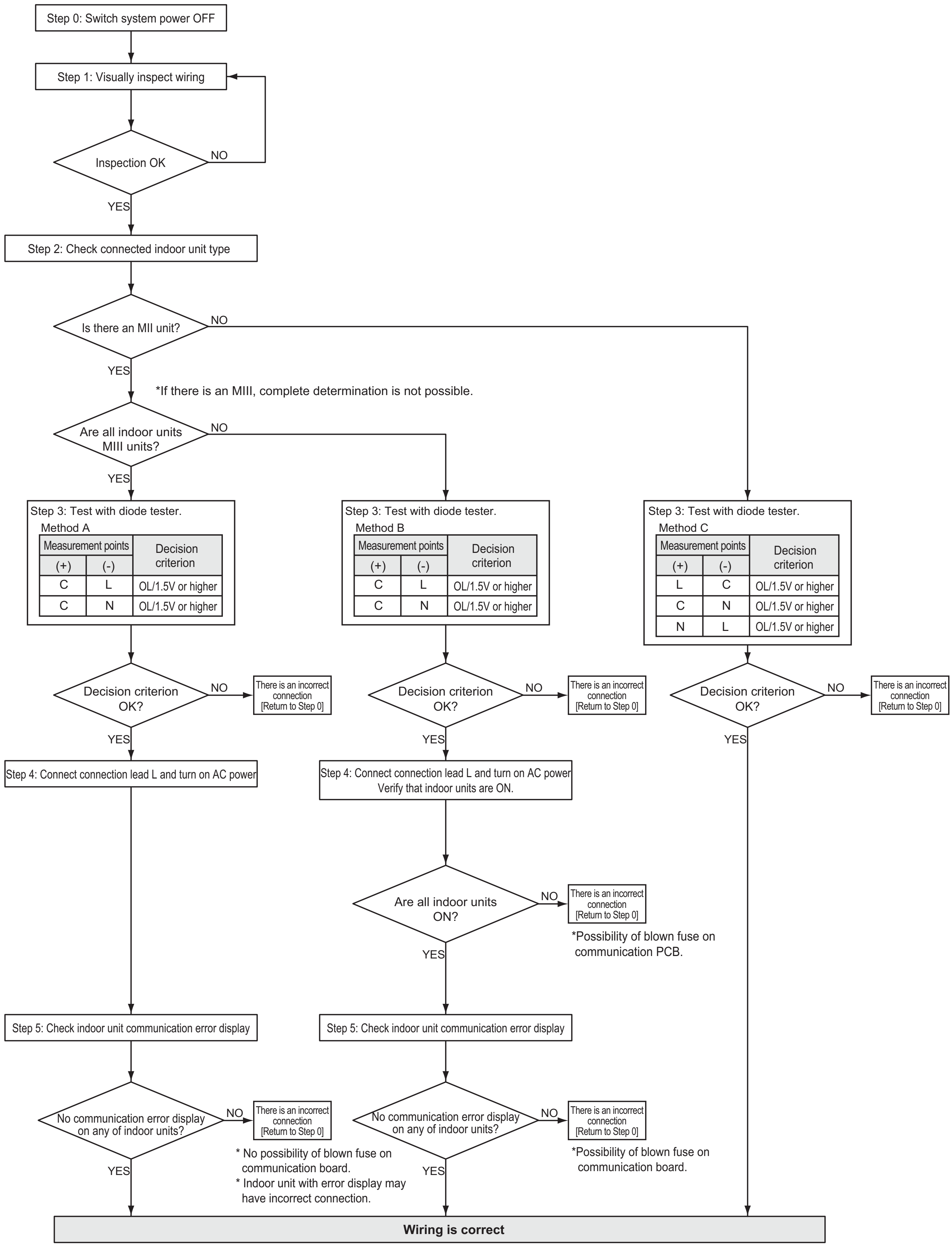


Figure 2: Wiring method and measurement points

2. Measurement flowchart and decision criteria



Method A

Measurement points (+)	Measurement points (-)	Decision criterion
C	L	OL/1.5V or higher
C	N	OL/1.5V or higher

Method B

Measurement points (+)	Measurement points (-)	Decision criterion
C	L	OL/1.5V or higher
C	N	OL/1.5V or higher

Method C

Measurement points (+)	Measurement points (-)	Decision criterion
L	C	OL/1.5V or higher
C	N	OL/1.5V or higher
N	L	OL/1.5V or higher

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