High Efficiency Technologies for Small and Medium-Sized Air Conditioning Equipment Using R410A

Hitachi Appliances, Inc.

Introduction

The situation faced by the refrigeration / air conditioning industry has become increasingly severe, because

ODP

- CFCs: abolished in 1995 in developed countries
- HCFCs: must be reduced to practically zero by 2020

GWP

- Must reduce greenhouse gas emissions according to COP3

→ ***What should we do to minimize CO_2 emissions?***

One solution is to develop high-efficiency AC equipment using HFCs

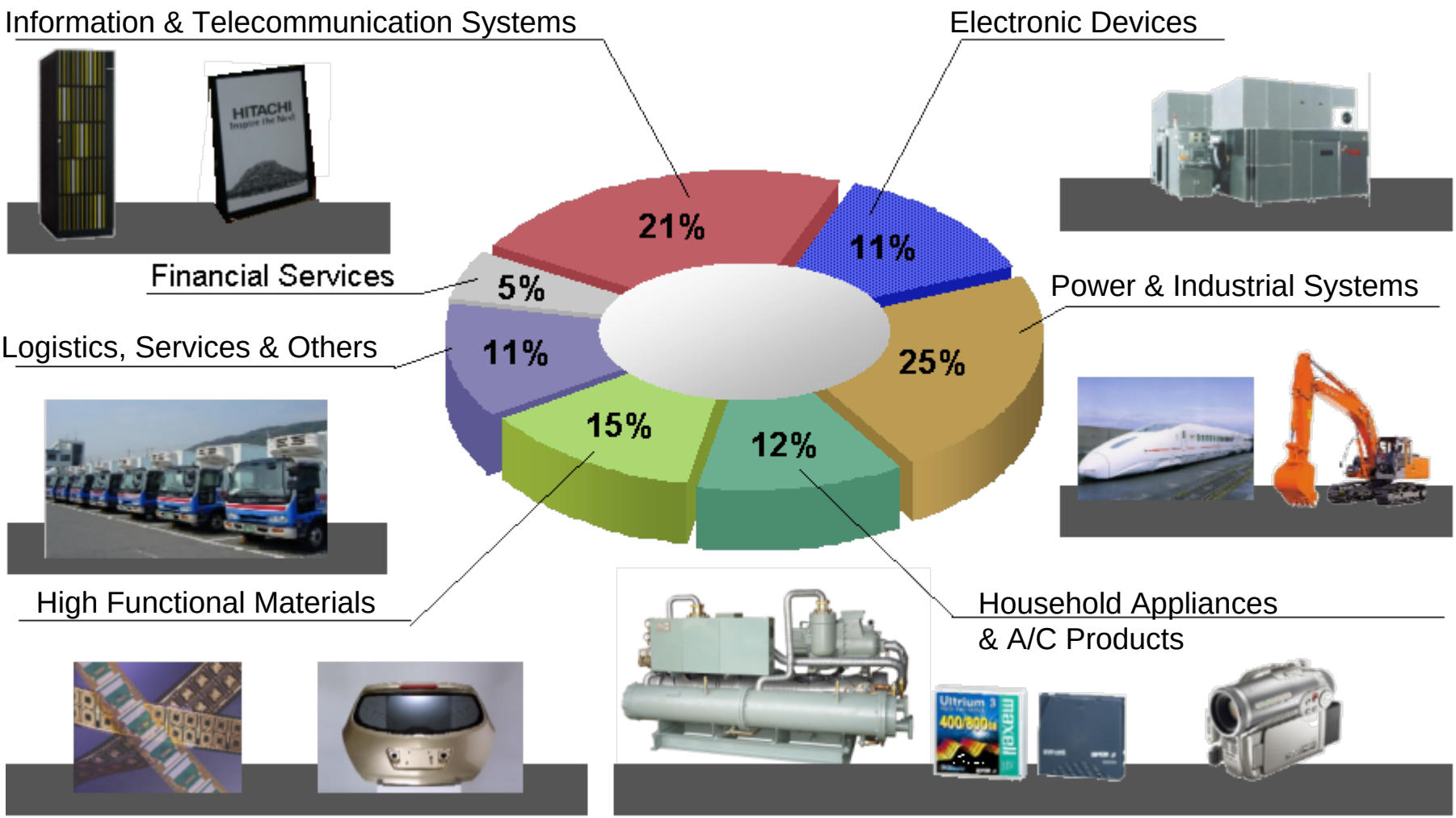
In this presentation, examples of high-efficiency technology used in small and medium-sized air conditioning equipment and lessons for changeover to HFC refrigerants will be shown.

To utilize HFC refrigerants, we have considered

1. Optimization of specifications for each component such as compressors, heat exchangers, refrigeration cycles
2. Assembly line conversions to produce A/C equipment using HFCs
3. Minimization of material costs
4. Training for installation and servicing

Introduction of HITACHI Group

Revenue by Industry Segment

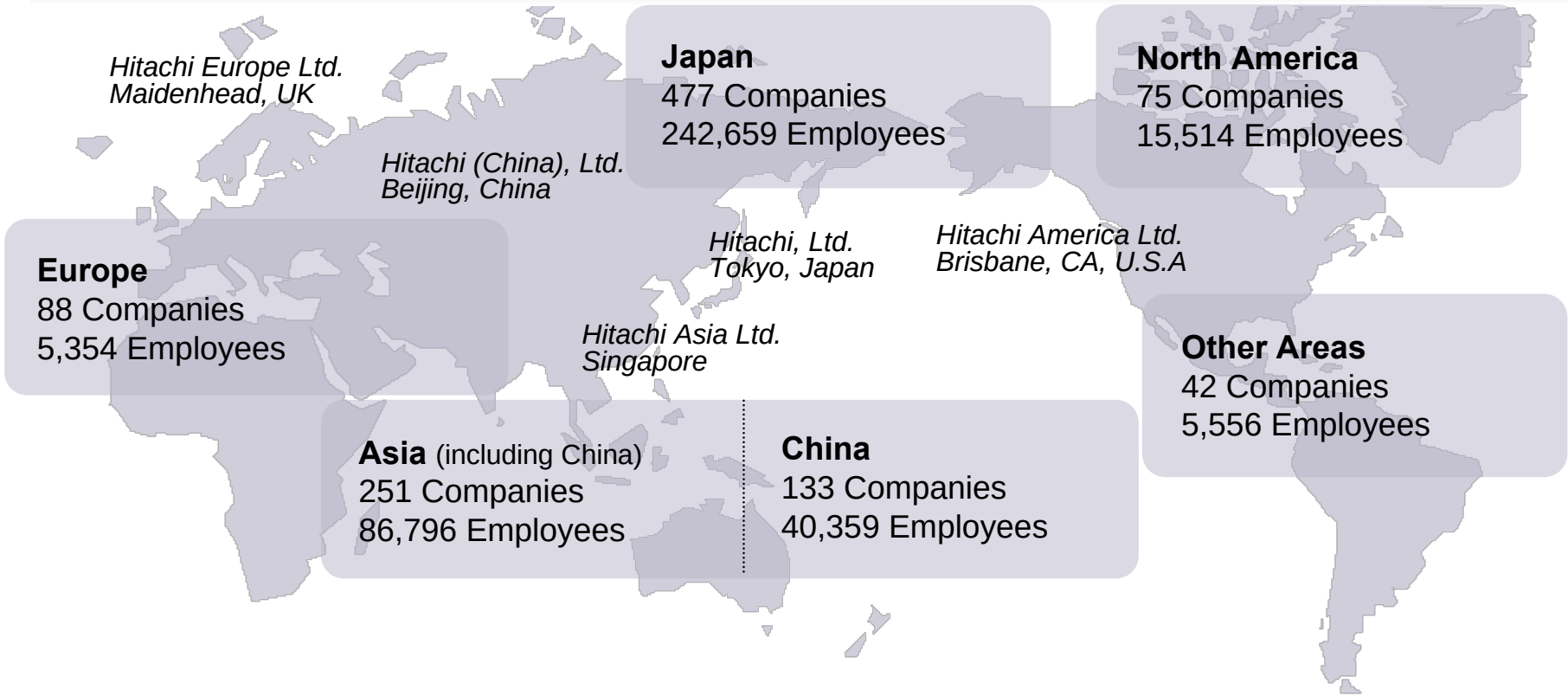


All figures include Eliminations and Corporate items, FY2005/Consolidated basis

HITACHI Worldwide

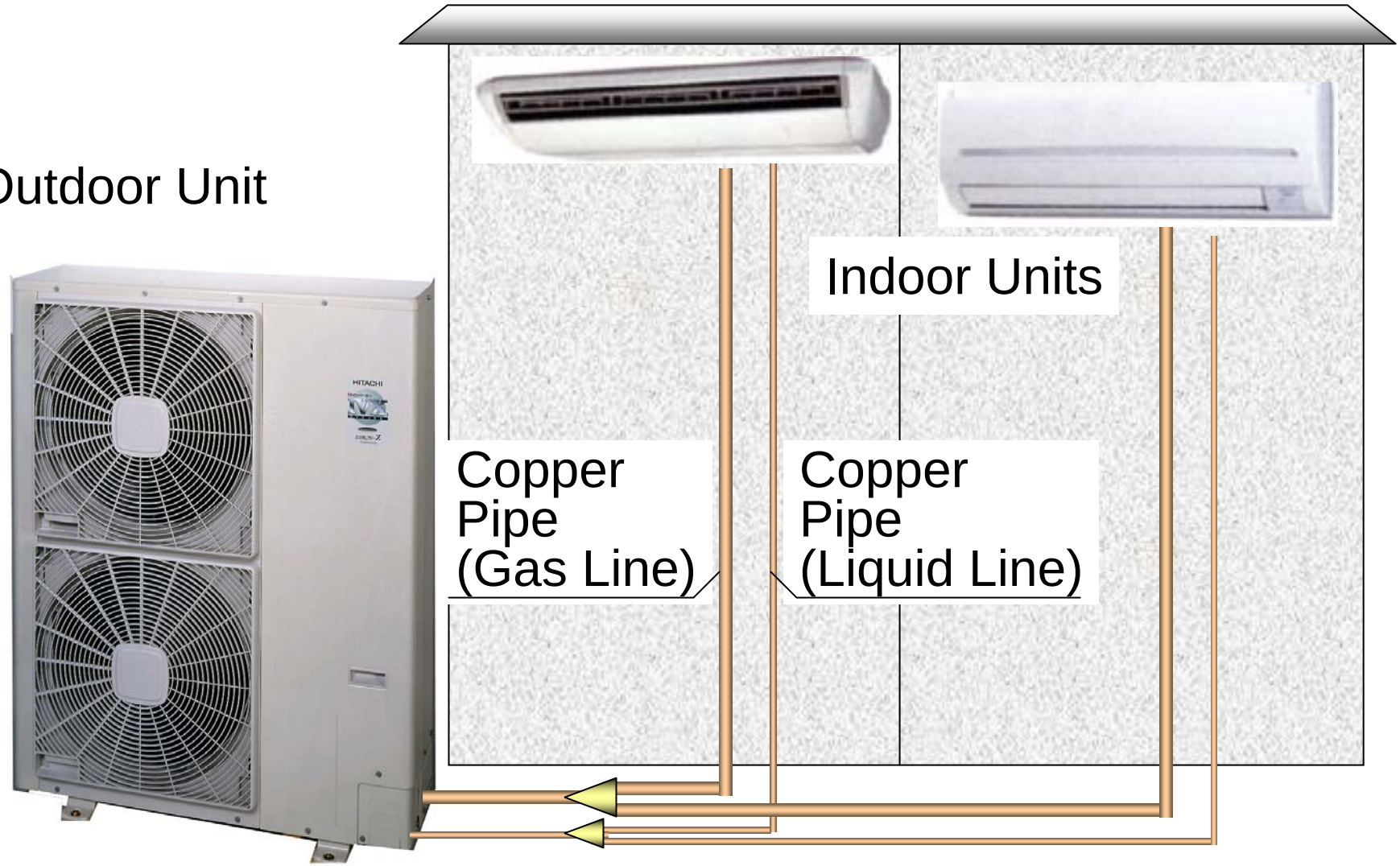
Total **932 Companies**
355,879 Employees

*Including Hitachi, Ltd.



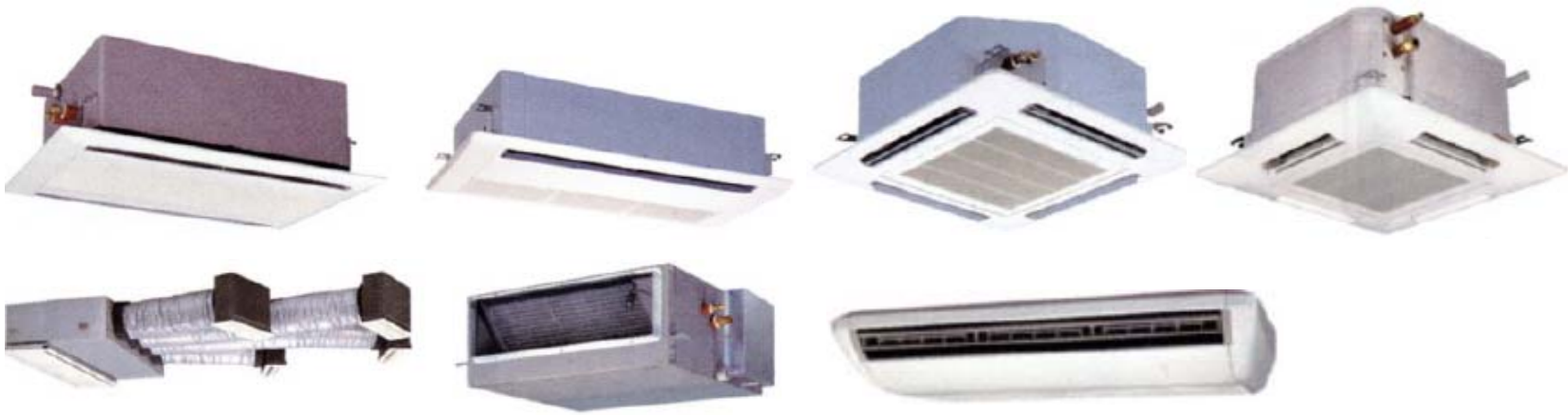
Consolidated figures for FY2005, ended March, 2006

Small and Medium-Sized Air Conditioning Equipment



Variation of A/C units

Indoor Units



Outdoor Units

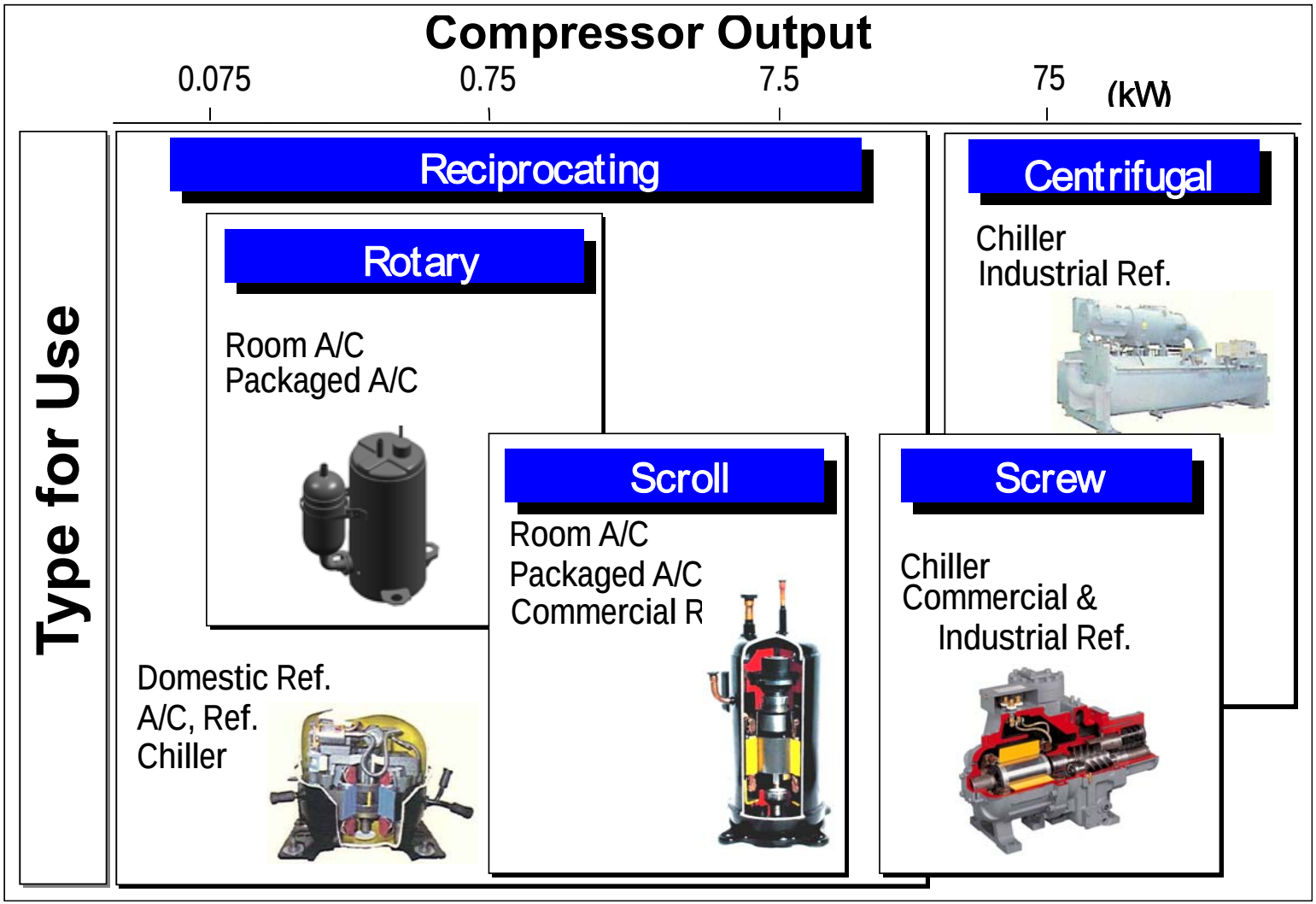
Comparison: HCFCs & HFCs

	HCFC	HFC	
Refrigerant	R22	R407C	R410A
Components	HCFC22 (100%)	HFC32/125/134a (23/25/52wt%)	HFC32/125 (50/50wt%)
ODP*1	0.05	0	0
GWP*2	1810	1770	2090
Pressure at 25°C	1.04MPa	1.19MPa	1.65MPa
at 50°C	1.94MPa	2.21MPa	3.06MPa
Lublication Oil	Mineral	Ether	Ether
		Ester	Ester

*1:Scientific Assessment of Ozone Depletion: 2006, National Oceanic & Atmospheric Administration

*2:IPCC2007 4th Assessment Report

Technology for High Efficiency and Reliability in Compressors



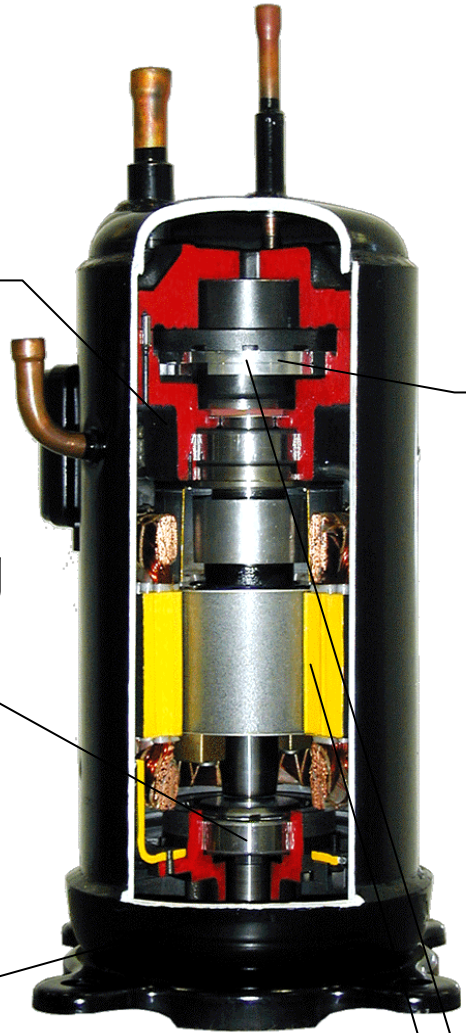
Scroll Compressor

Reliability

New circular
oil supply structure

Putting sub-bearing
below the motor

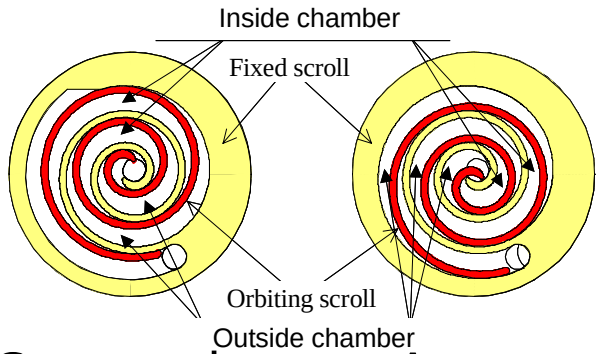
Ether
lubricant oil



Efficiency

Optimizing scroll wrap
profile to reduce leakage &
mechanical loss

→Adopting asymmetric scroll



Symmetric Asymmetric

Optimizing stroke volume
according to refrigerant
characteristics

DC motor

Rotary Compressor

Reliability

Suitable materials
for roller and vane

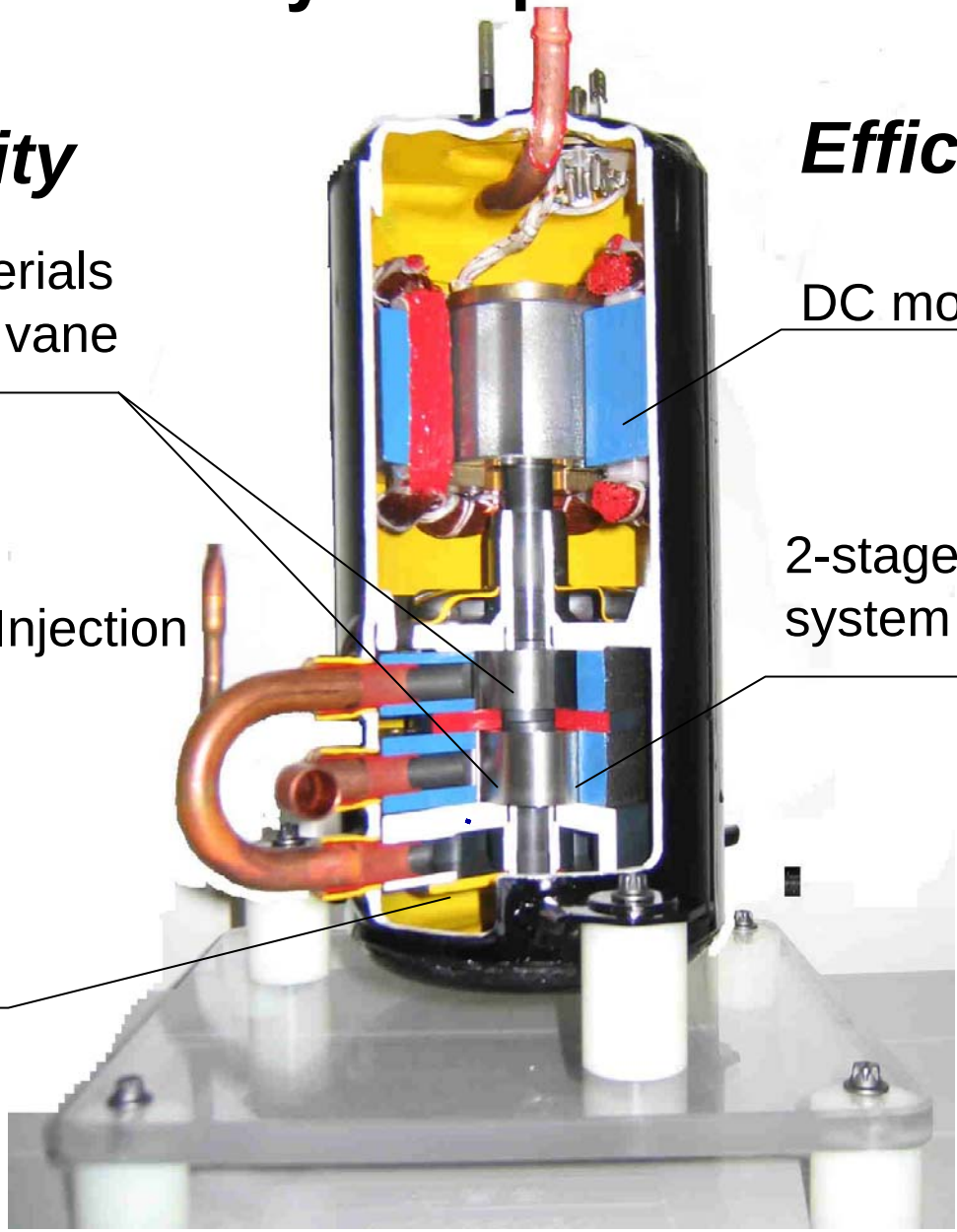
Injection

Ester
lubricant oil

Efficiency

DC motor

2-stage compression
system with injection



Technology for High Efficiency in Heat Exchangers

Purpose

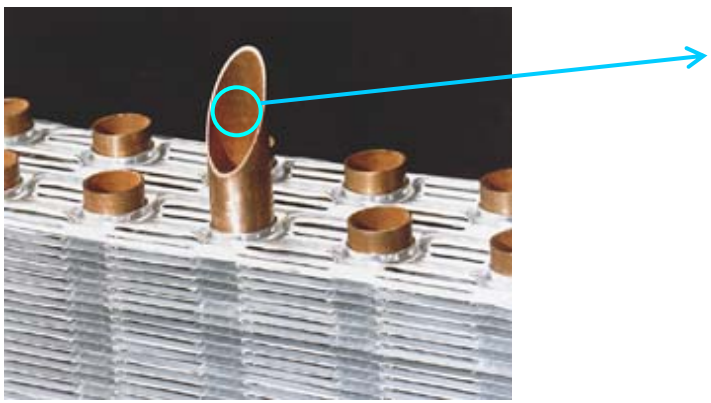
- To increase heat transfer rate
- To reduce pressure loss
- To increase amount of Subcooling

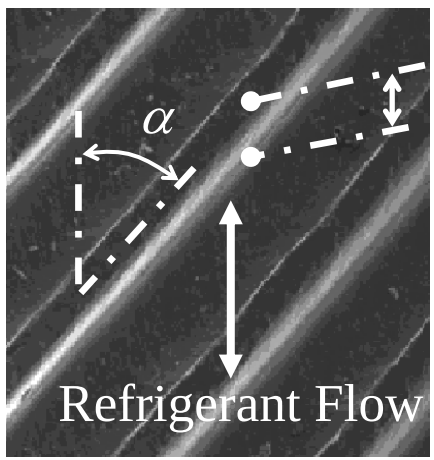
Measures

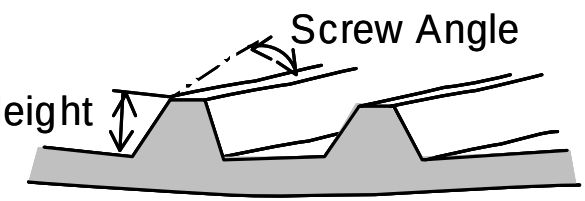
- High angle Micro-fin tubes
- Double-sided louvered fins
- Improvement of refrigerant flow

Heat Transfer Tube

	Conventional	New Type
Height *Hf*	0.23mm	0.20mm
Number of Groove	50	60
Angle *a*	12 deg.	35 deg.
Cooling COP	100%	101.7%
Heating COP	100%	102.4%

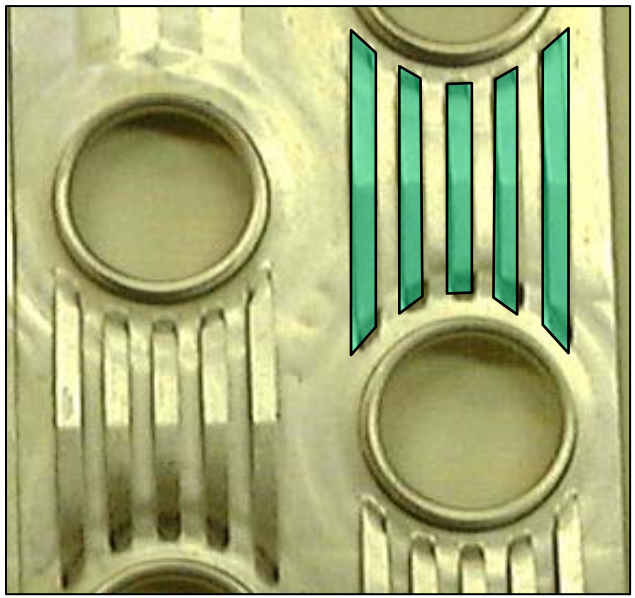


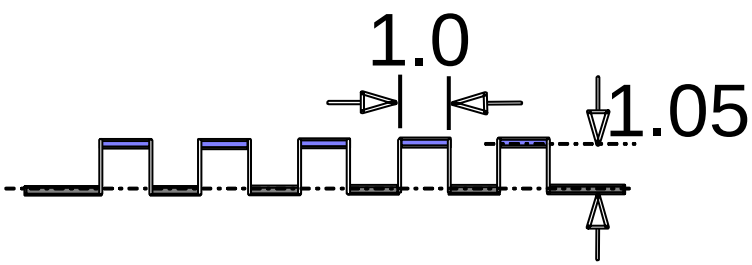




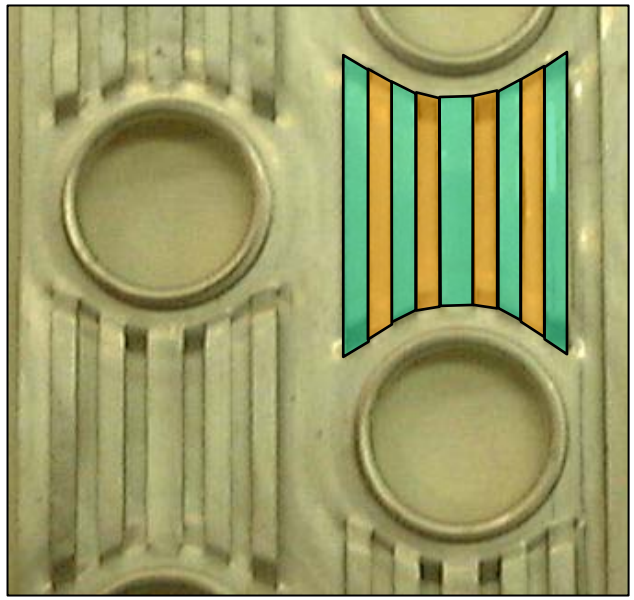
Heat Transfer Fin

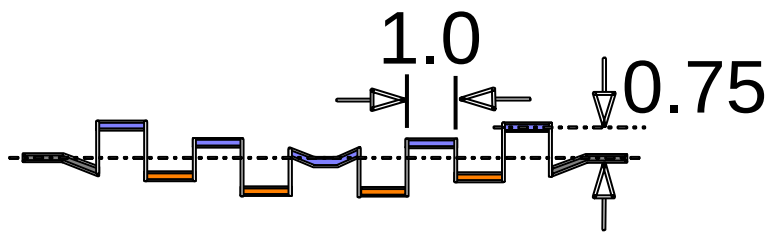
One Side Offset Louver Fin
(Conventional Fin)





Both Side Offset Louver Fin
(Improved Fin)



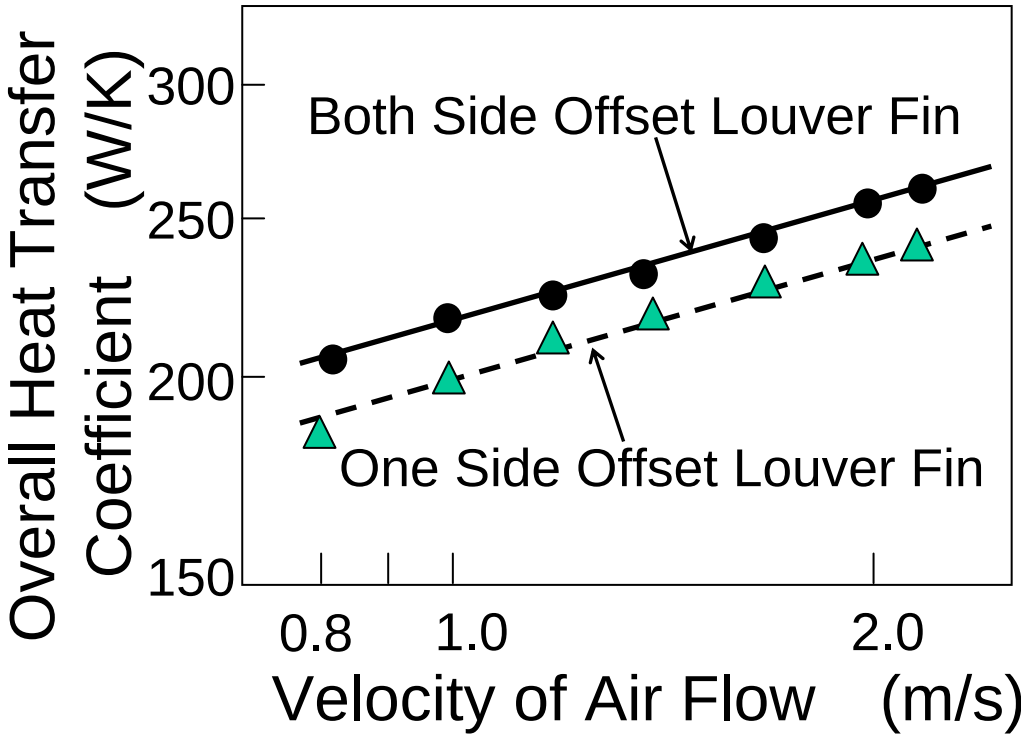


Effect of Both Side Offset Louver Fin

One Side Offset Louver Fin
(Conventional Fin)

Both Side Offset Louver Fin
(Improved Fin)

Leeward fins are not affected by temperature of windward fins



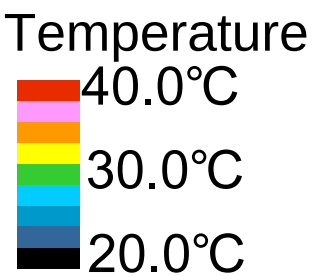


Fig. Effect of Both Side Offset Louver Fin

Overall Heat Transfer Coefficient +10%

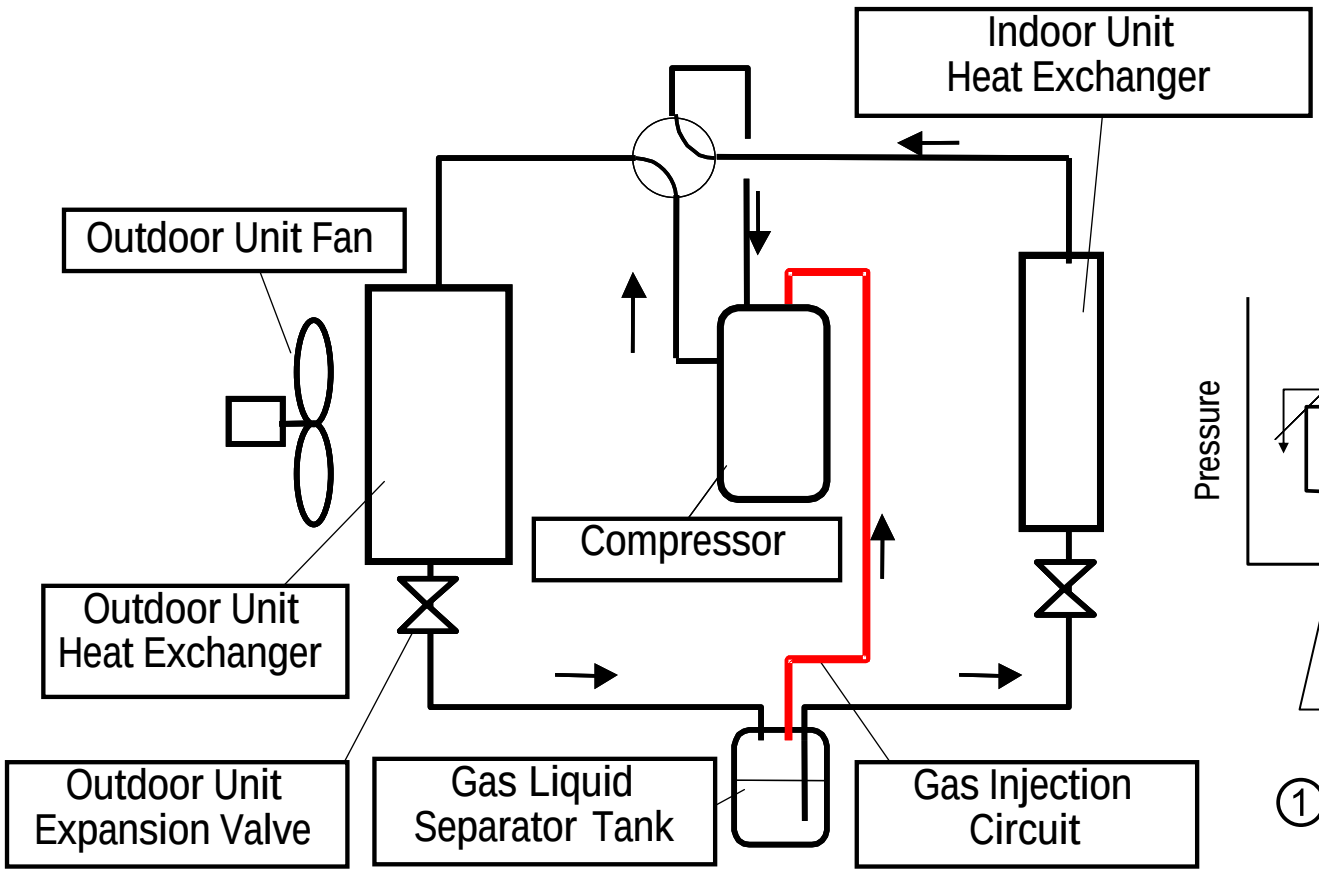
Technology for High Efficiency in Refrigeration Cycle

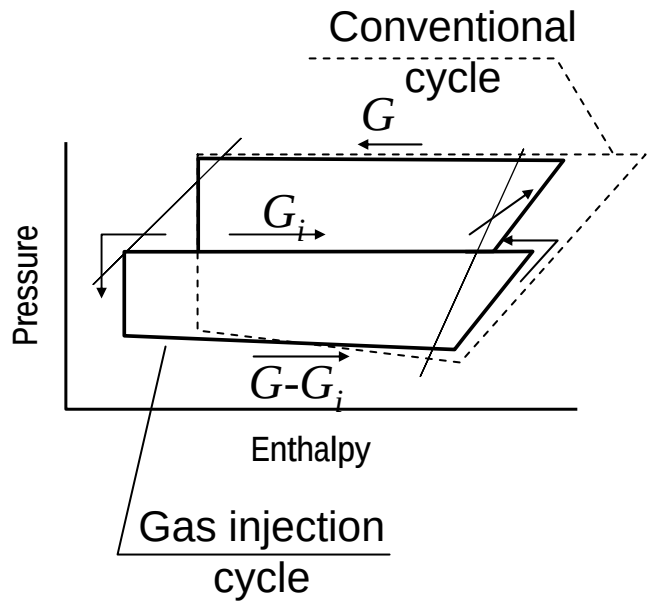
Refrigeration Cycle, which is the combination of components
→ System Optimization

Purpose

- To increase coefficient of performance satisfying its capacity

(1) Gas Injection Cycle

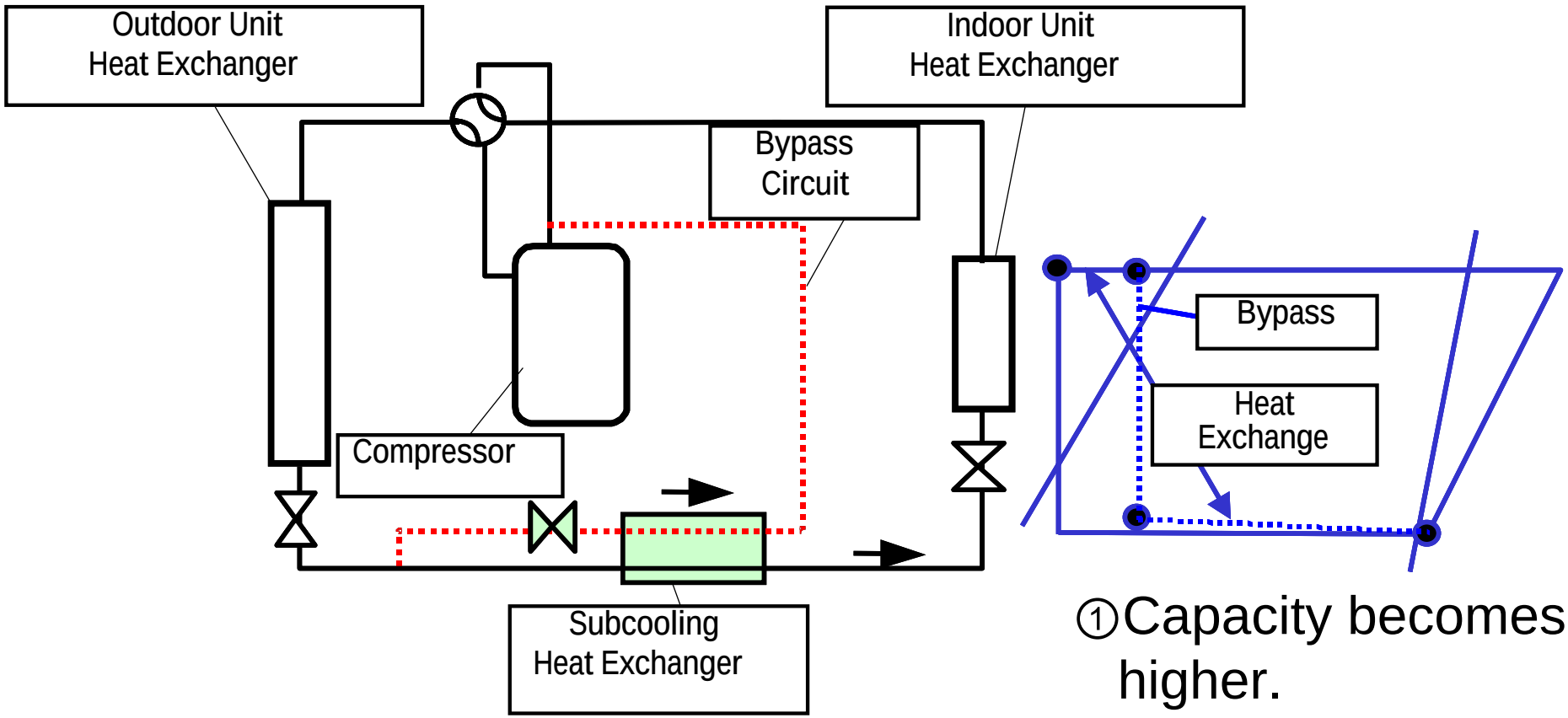




①Compression work is reduced.

②Pressure loss is reduced.

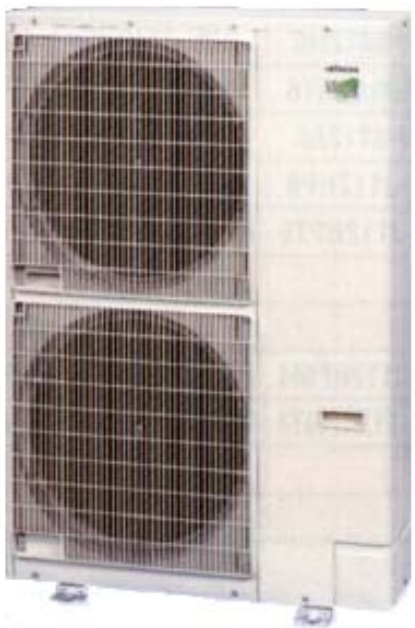
(2) Subcooling Bypass Cycle



①Capacity becomes higher.

(3)(i) COP Improvement Effect

Example of model 140 (Rated Cooling Capacity 12.5kW)



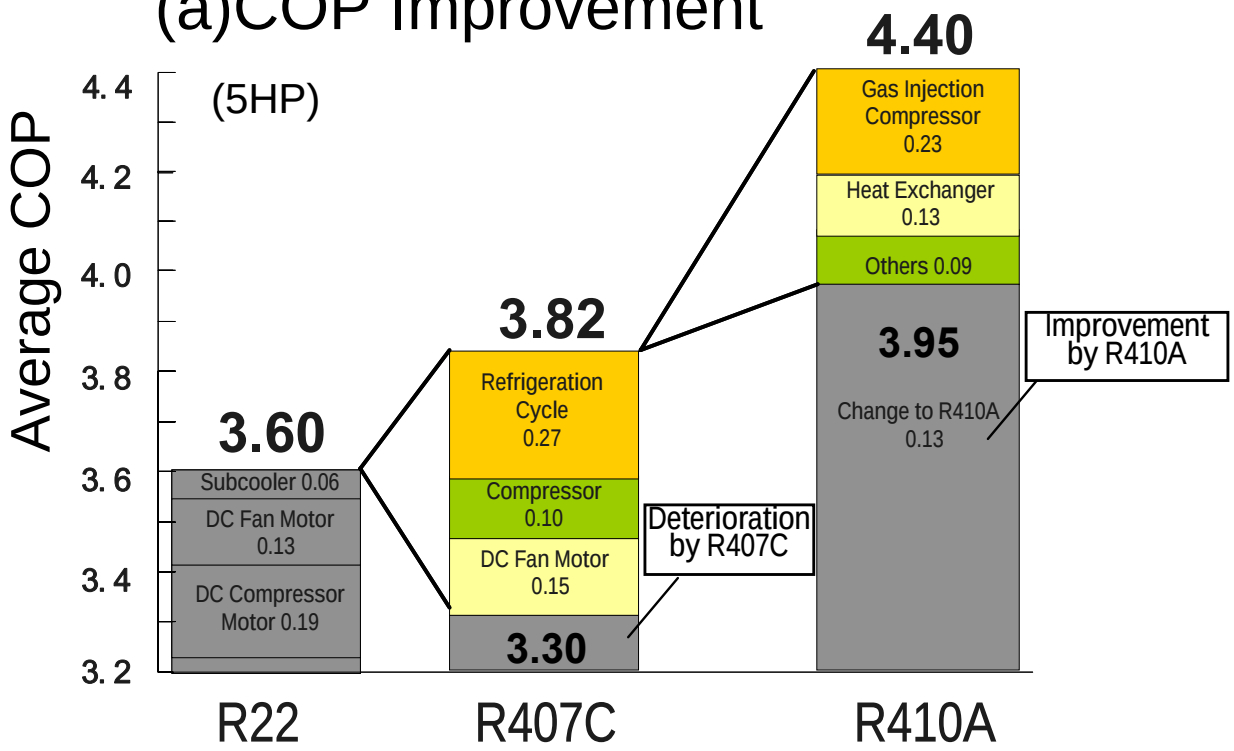
HCFC:
R22 Unit

HFC:
R407C Unit

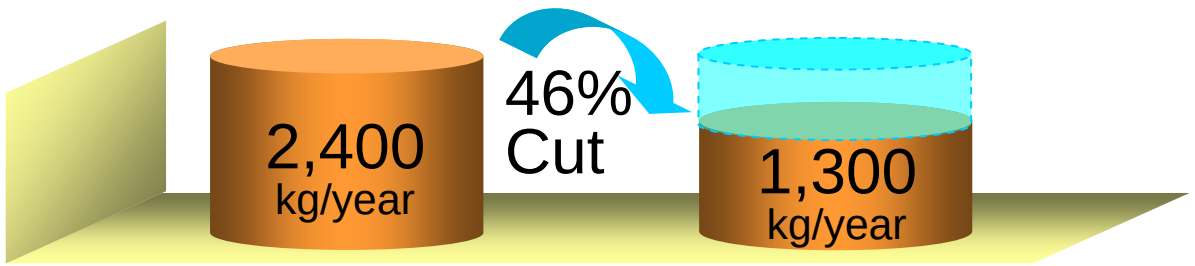
HFC:
R410A Unit

(3)(ii) COP Improvement Effect

(a)COP Improvement



(b)Annual CO_2 Emission Reduction



(4)(i) Leak Tightness

Design Pressure becomes:

R22	R407C	R410A
3.0MPa	3.3MPa	4.15MPa(depends on equipment)

(a)Thickness of some components ... larger

ex.)Pipe according to Japanese Regulation

$$t = \frac{PD_o}{2\sigma_a \eta + 0.8P} + \alpha$$

where

t :minimum thickness of pipe

P :design pressure

D_o :outer diameter of pipe

σ_a :allowable stress of the material

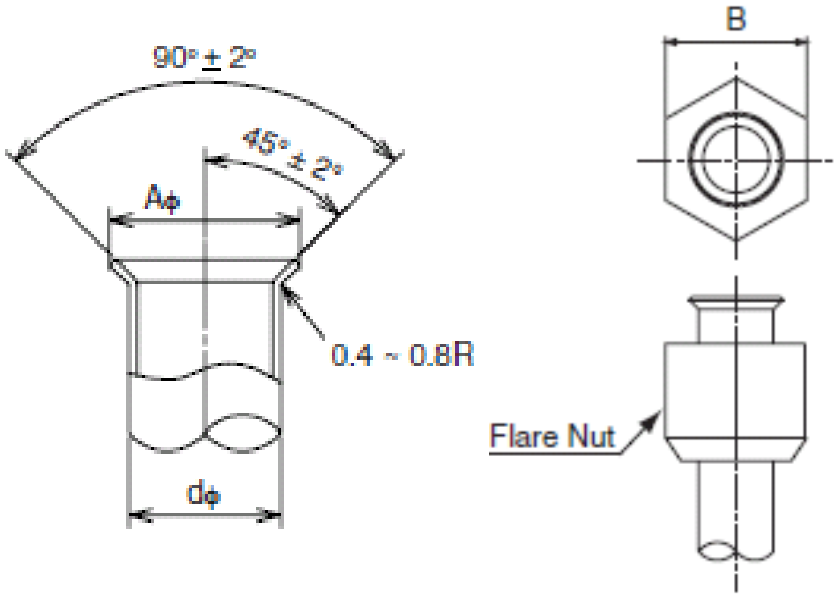
η :efficiency of welding

α :margin against corrode

(for cupper pipe, α=0)

(4)(ii) Leak Tightness

(b)Types of parts (flare nut, etc.) ... changed



Diameter	R22 (HCFC) Type 1		R410A (HFC) Type 2	
	A	B	A	B
φ12.70	16.2	24	16.6	26
φ15.88	19.4	27	19.7	29

JIS B8604:2002

(c) Higher durability of other parts→ for example, expansion valve, solenoid valve, 4-way valve, stop valve, pressure sensor, etc.

(d) Higher pressure for leak test (although detection value of leak test is set the same)

Conversion of Facilities at Assembly Line

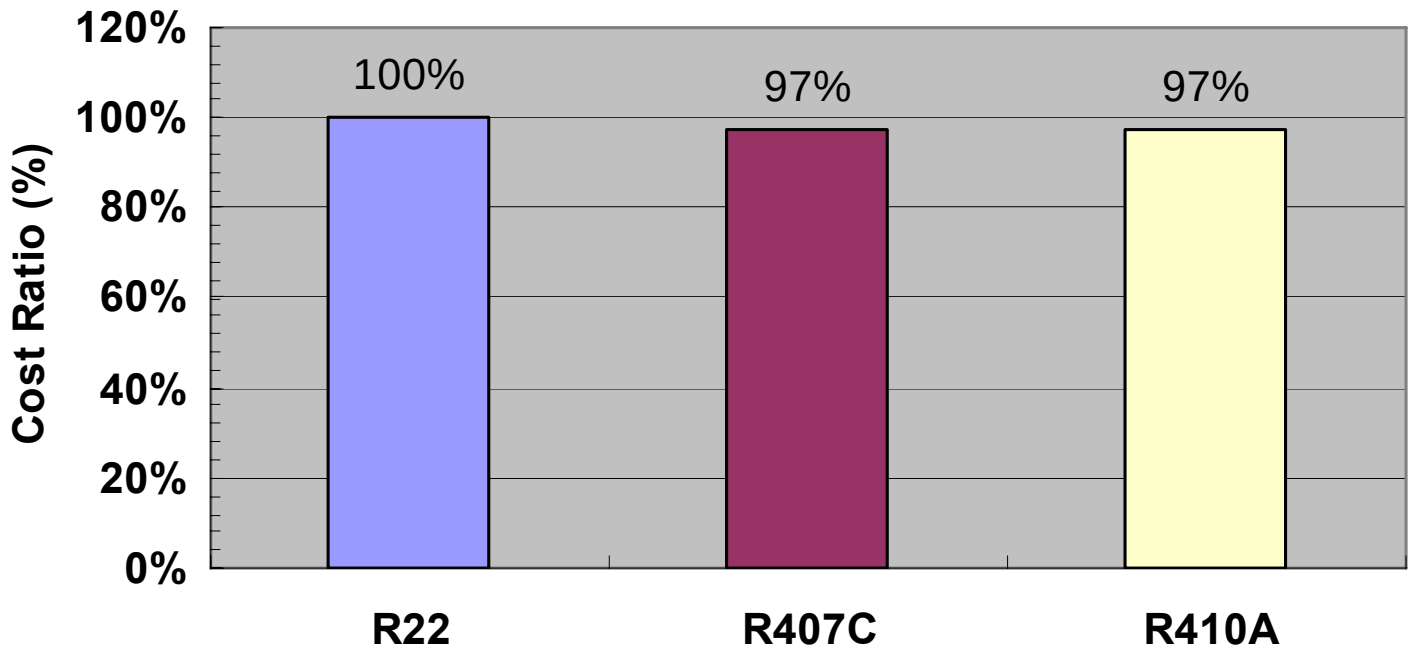
- Oil charger, Refrigerant charger, etc...changed

Material Cost

From characteristics of R410A, some component dimensions can be more compact...cost down

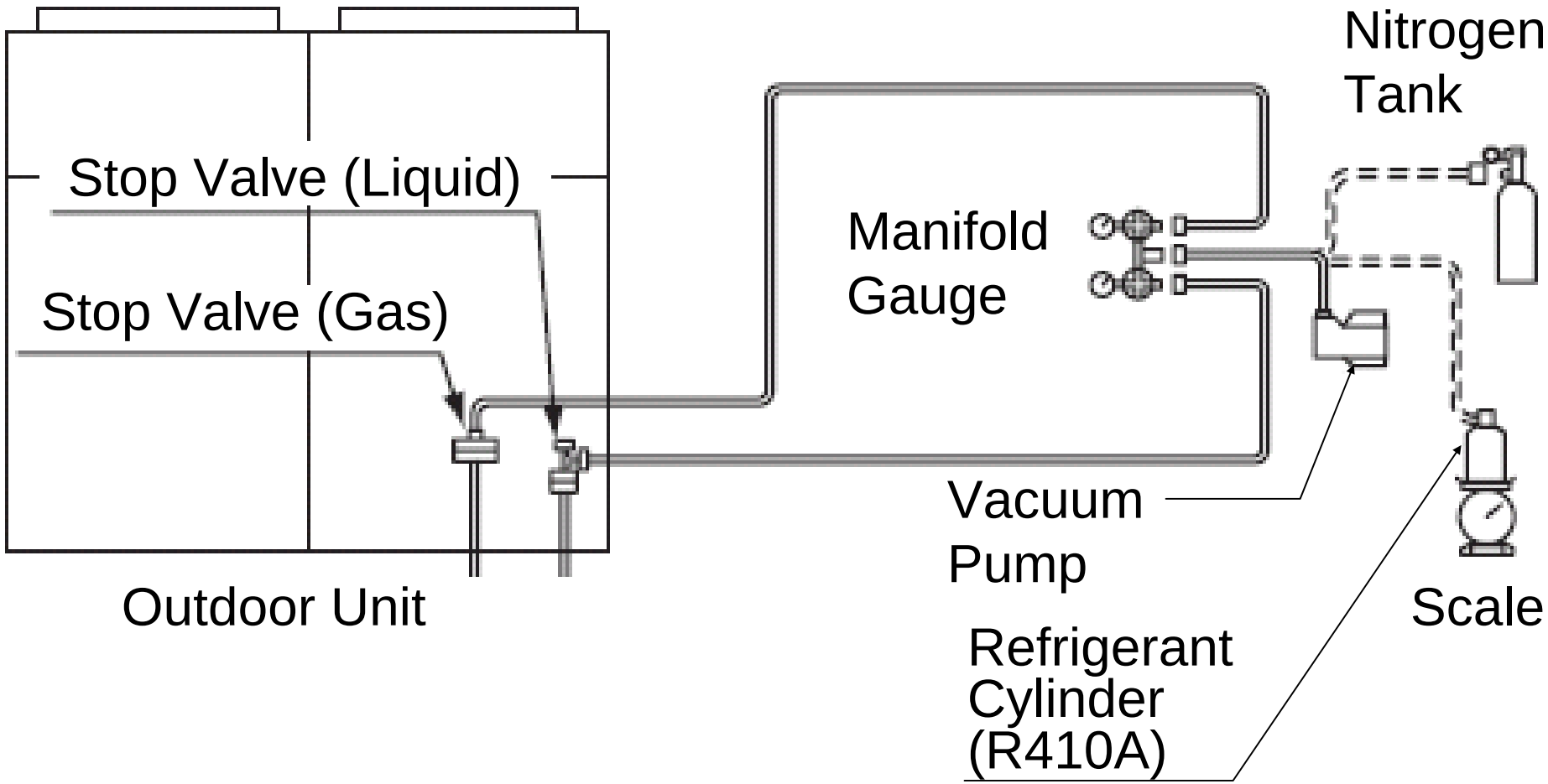
Example of model 140

	R22	R407C	R410A
Cost	100%	97%	97%
COP	100%	106%	122%



Caution at Installation and Servicing

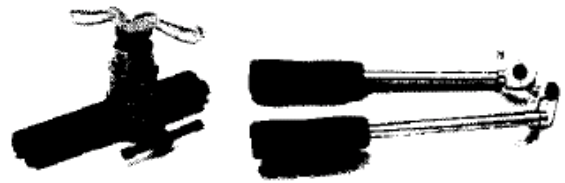
(a) Example of Evacuation and Refrigerant Charge



Caution at Installation and Servicing

(b) Tools for Installation and Servicing

	R407C (HFC)	R410A (HFC)
Pipe cutter,Bender, Flaring tool	◇	◇
Lubricant oil	◆	●
Refrigerant cylinder	◆	●
Vacuum pump	◇	◇
Manifold valve, Charging hose	◆	●



◇:Interchangeability with R22(HCFC)

◆:only for R407C(HFC),●:only for R410A(HFC)

Quality Control of Contamination at Installation

To prevent hydrolysis, content of water and contamination in the refrigeration cycle should be suppressed by sufficient vacuuming as follows:

(example of HITACHI)

R22 :-0.1MPa, 2hours (5 Torr)

R410A:-0.1MPa, 2hours (5 Torr)

} the same

Conclusion

In converting from HCFCs to HFCs…

- Environmental benefits are realized
  - Zero ODP
  - Improved efficiency of A/C equipment
    → reduced CO2 emissions
- Material cost of equipment can be minimized by optimizing each component
- Several specification changes, conversion of facilities, and preparation of tools are required

Together with energy saving technology, the adoption of HFCs are issues of growing importance these days, and will be necessary to continue forging ahead with development of technology.

(reference)

Pipe Thickness and Material for installation

Diameter	R22		R410A	
	Thickness	Material	Thickness	Material
φ6.35	0.6	O	0.8	O
φ9.53	0.8	O	0.8	O
φ12.7	0.8	O	0.8	O
φ15.88	1.0	O	1.0	O
φ19.05	1.0	O	1.0	1/2H
φ22.2	1.2	O	1.0	1/2H
φ25.4	1.2	O	1.0	1/2H
φ28.6	1.4	O	1.0	1/2H
φ31.75	1.4	O	1.1	1/2H
φ38.1	1.65	O	1.35	1/2H

(reference)

LCCP Evaluation (10 years)