Additional Information

1. Setting Coefficient of Performance (COP) Values for Reference Refrigerator

(1) Selection of possible type of cooling systems except project cooling system

- Considering the cooling temperature and the cooling capacity, following systems are identified as the possible type of cooling systems if project cooling system is not installed.
  a) HFC dry expansion system (single loop)
  b) NH_3 flooded, pump system (single loop)
  c) HFC/brine system (secondary loop)
  d) NH_3/brine system (secondary loop)

(2) Collection of COP values of the refrigerator for possible type of cooling systems and identification of reference COP

- For each cooling system identified in the process (1), COP values of the refrigerator are collected from manufacturers' catalogues.
- Among all the possible systems, catalogue values for NH_3/brine system are not found. However, the COP values for NH_3/brine system are always lower than those of NH_3 single loop system[1] and it is assumed not to affect the conservative identification of reference COP.

i) Individual Quick Freezer (-35 deg. C room temperature)

- COP values of refrigerators for possible systems at -35 deg. C (room temperature) are as follows.

[1] Brine system requires lower evaporation temperature of primary refrigerant compared to single loop system since heat exchange from the primary refrigerant to cooling air via brine (secondary refrigerant). For this reason, brine system consumes more energy than single loop system to keep the required temperature therefore, COP value of brine system is always lower than single loop system when primary refrigerant is the same for the both systems.

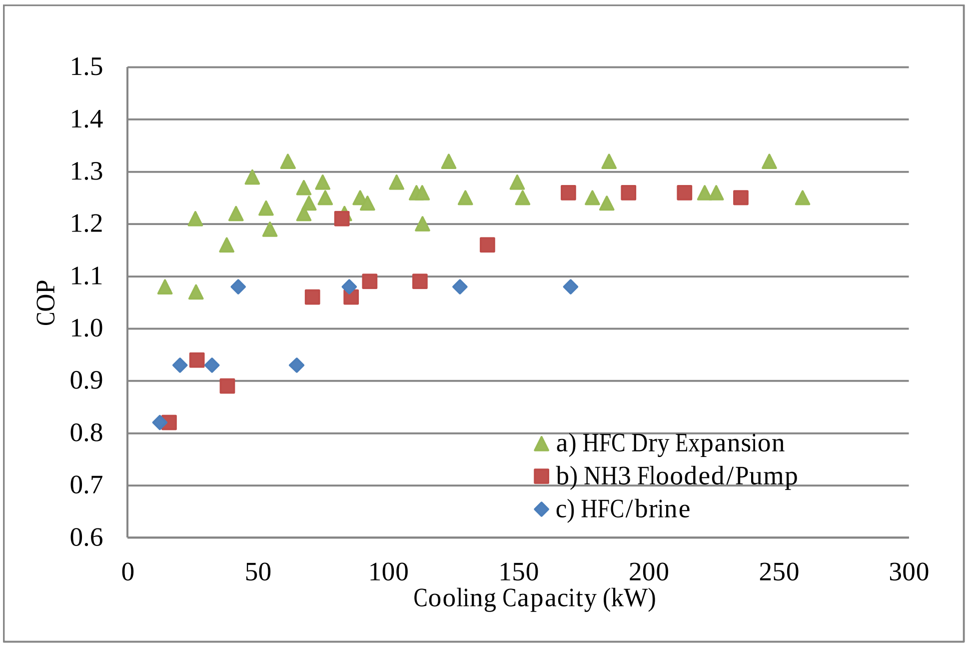


Fig.A1-1 Comparison of COP at room temp. -35 deg. C

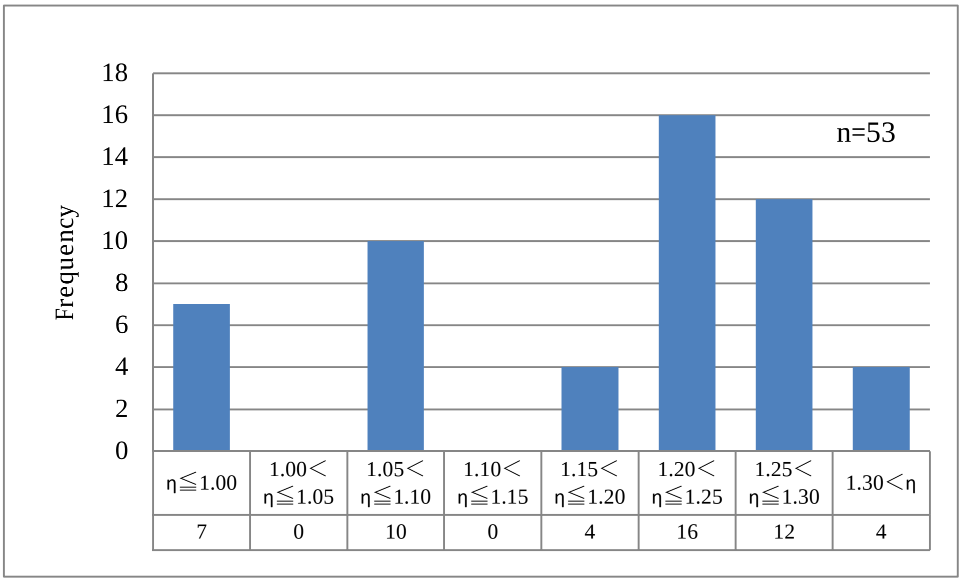


Fig.A1-2 Frequency of COP at room temp. -35 deg. C

- Catalogue COP values are collected from the manufacturers with high market share in Indonesia: manufacturer A, manufacturer B, manufacturer C, manufacturer D, manufacturer E and manufacturer F.
- Range of refrigeration capacity found in the manufacturers' catalogues is 12 to 260 kW.
- The most frequent range of COP values is between 1.20 and 1.25, and the maximum value is 1.32. From the above, the most likely COP values of refrigerators to be installed at BaU basis

are assumed to be between 1.20 and 1.25.

- Considering the conservativeness, the COP value for the reference refrigerator is set as 1.32, applicable for the refrigerators with capacity up to 260 kW.

ii) Cold Storage (-25 deg. C room temperature)

- COP values of refrigerators for possible systems at -25 deg. C (room temperature) are as follows.

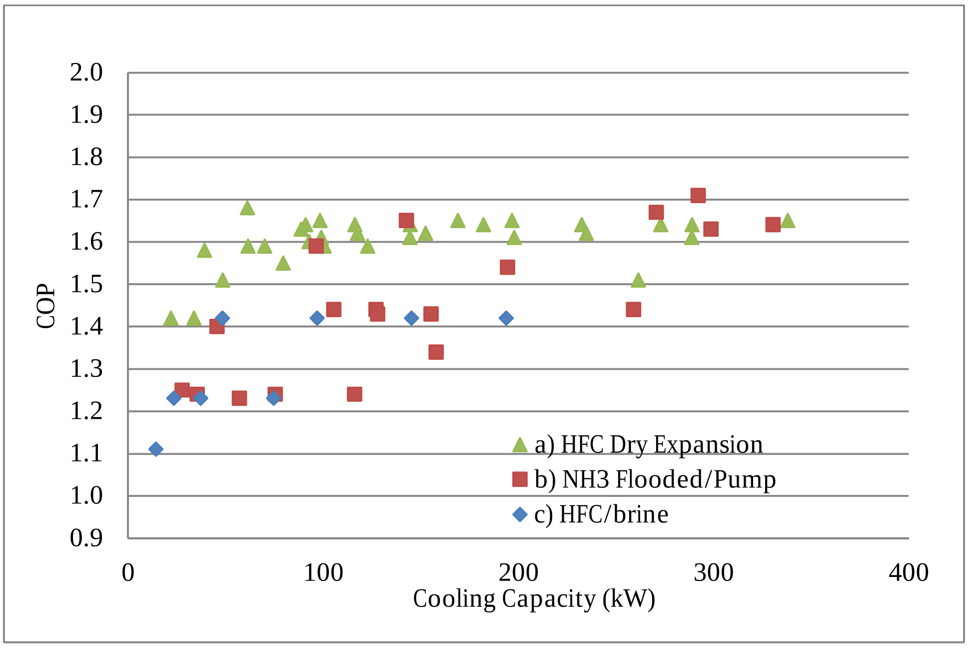
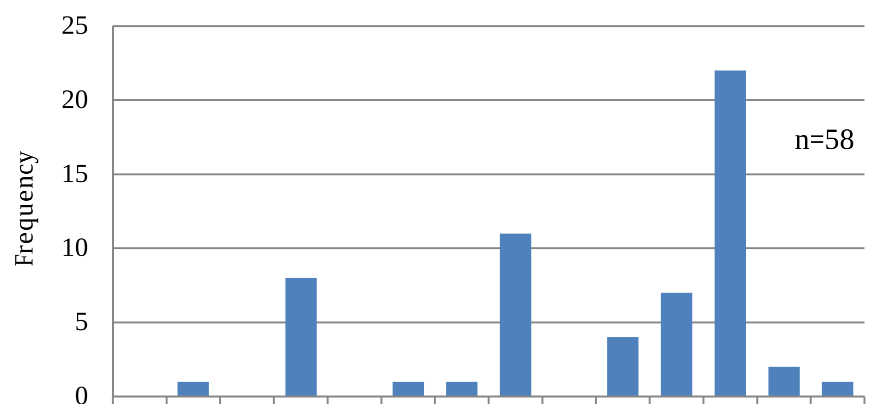


Fig.A2-1 Comparison of COP at room temp. -25 deg. C



η≦1.10	1.10<η≦1.15	1.15<η≦1.20	1.20<η≦1.25	1.25<η≦1.3	1.30<η≦1.35	1.35<η≦1.4	1.40<η≦1.45	1.45<η≦1.50	1.50<η≦1.55	1.55<η≦1.60	1.60<η≦1.65	1.65<η≦1.70	1.70<η
0	1	0	8	0	1	1	11	0	4	7	22	2	1

Fig.A2-2 Frequency of COP at room temp. -25 deg. C

- Catalogue COP values are collected from the manufacturers with high market share in Indonesia: manufacturer A, manufacturer B, manufacturer C, manufacturer D, manufacturer E and manufacturer F.
- Range of refrigeration capacity found in the manufacturers' catalogues is 14 to 340 kW.
- The most frequent range of COP values of all the refrigeration capacity is between 1.60 and 1.65, and the maximum value is 1.71. From the above, the most likely COP values of refrigerators to be installed at BaU basis are assumed to be between 1.60 and 1.65.
- Considering the conservativeness, the COP value for the reference refrigerator is set as 1.71, applicable for the refrigerators with capacity up to 340 kW.

2. Assurance of Net Emission Reductions

- Table A1 shows the comparison of the project cooling system and other possible type of cooling systems.
- Net emission reductions can be assured as follows:
  a) Values higher than BaU COP are selected as the reference COP.
  b) Emissions from power consumption of pumps for the secondary refrigerant or oil are not counted in the emission calculations.

Emissions from HFC leakage is not counted for HFC dry expansion system and HFC/brine system as the reference emissions.

<ANNEX>

1. Calculation of power consumption of pump

Power requirement of pumps for brine and CO_2 are calculated as follows:

Pump power requirement

= gravity × density of fluid × flow capacity × total pump head / *pump efficiency*

where;

gravitational acceleration: 9.8m/s^2,

density of fluid: kg/m^3,

flow capacity: m^3/s,

total pump head: m

Table A1. Comparison of the power consumption between the brine and CO_2 pump

		Cold storage (189kW*1)		Freezer (70kW*1)	
	Secondary refrigerant	Brine*2	CO_2	Brine*2	CO_2
Temperature	deg.C	-34 -> -31	-32	-44 -> -41	-42
Density	kg/m^3	1,115	1,084	1,382	1,124
Specific heat	kJ/kg K	2.7	-	2.58	-
Enthalpy (Liquid)	kJ/kg	-	129	-	193
Enthalpy (Gas)	kJ/kg	-	437	-	435
Flow capacity	m^3/s	0.021	0.0011	0.0065	0.00038
Required heat flow	kJ/s	189.7	189.7	69.5	69.5
Viscosity	mPa*s	118	1 >	118	1 >
Pump head	m	30 - 70	10 >	30 - 70	10 >
Power*3	kW	28.7	0.3	11.0	0.1

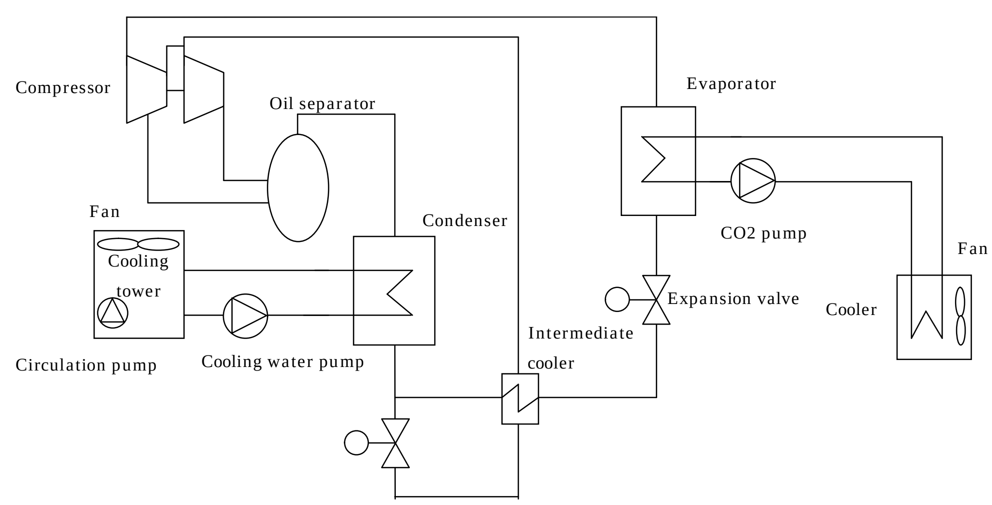
*1: Cooling capacity

*2: Brine is ethylene glycol kind

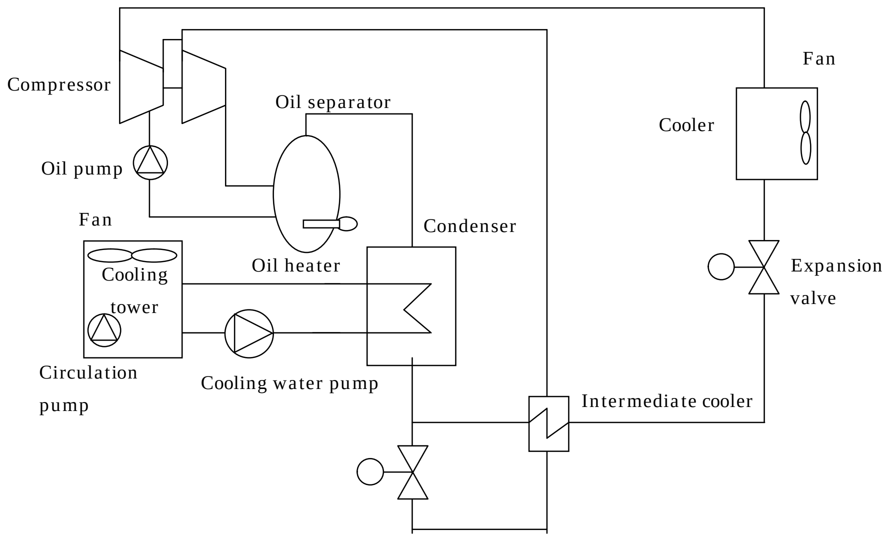
*3: In these calculations, pump efficiency is 0.4.

Table A1. shows comparison of the power consumption between the brine and CO_2 pump for the cold storage and the freezer respectively. The power consumption of the brine pump is much larger than CO_2 pump, reasons are as follows; 1) brine is viscous fluid, 2) CO_2 is low flow capacity because of its high enthalpy.

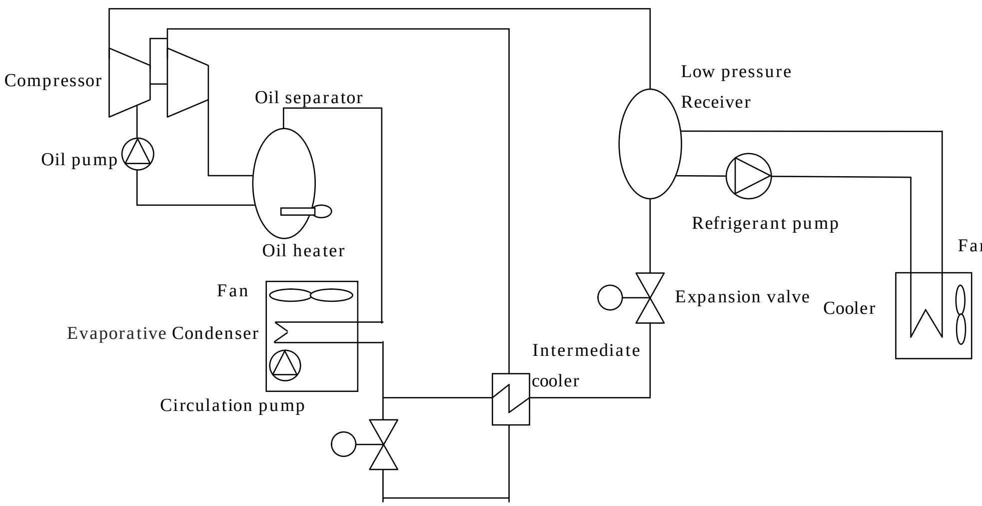
2. Schematic diagrams of cooling systems



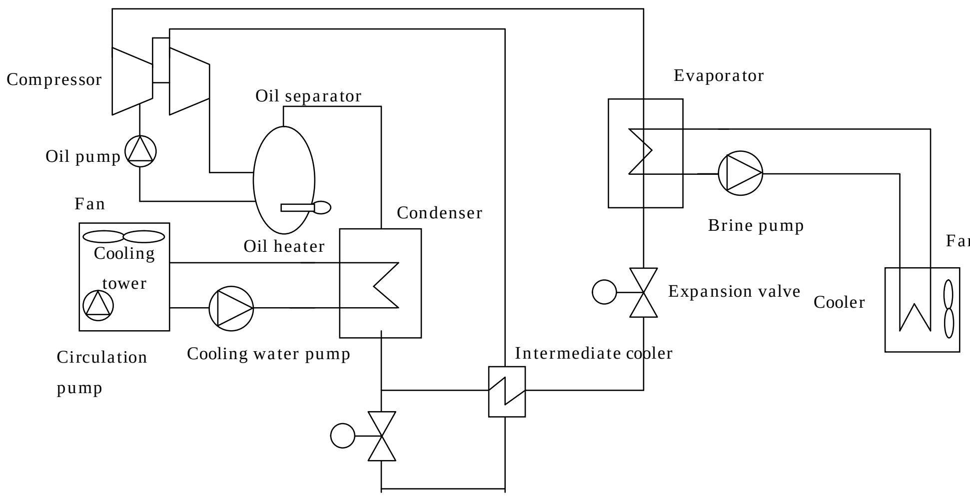
<Project cooling system> NH_3/CO_2 system



HFC dry expansion system



NH_3 pump system



HFC or NH_3/brine system