MEBS6006 Environmental Services I

http://www.hku.hk/bse/MEBS6006

Cooling

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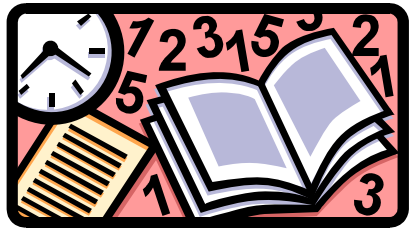
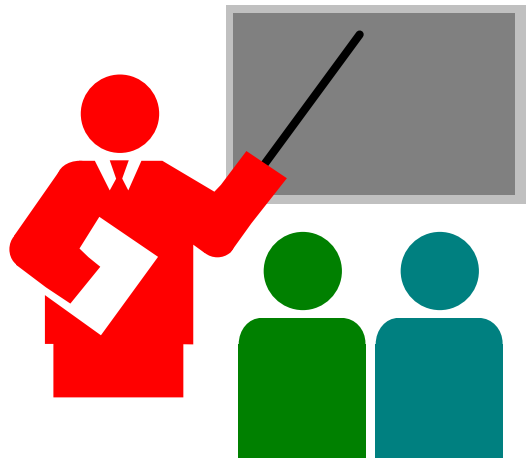
Background



- MEBS6006 Environmental services I

  Part II
  - Cooling system
  - Heating system
  - Ventilation system
  - Air side system
  - Water side system
  - Refrigeration and Heat Rejection



- Assessment: 100% by examination

Basics - Unit Conversion

The Units

- 1Btu/hr = 0.2931W
- 12,000 Btu/hr = 1 refrigerant ton (TR) = 3.516kW
- 1gallon per minute (gpm) = 0.0631L/s
- 1ft/s (fps) = 0.3048m/s
- 1ft/min (fpm) = 0.00508m/s
- $1ft^3$/min (cfm) = 0.4719L/s
- 1psi = 0.068948 bar = 6894.8 pascal(Pa) or 6.89kPa
- 1atm = 14.696psi = 29.92mmHg = 1.013 bar = 101.325kPa
- $x^{\circ}C = (1.8x + 32)^{\circ}F$ (deg. Celsius vs deg. Fahrenheit)

Basics - Design Condition

Indoor Design Conditions

Summer

Office and Classroom

Minimum dry bulb temperature	23°C
Minimum relative humidity	50%

Other Applications except Office and Classroom

Minimum dry bulb temperature	22°C
Minimum relative humidity	50%

Winter

Hotel

Maximum dry bulb temperature	24°C
Maximum relative humidity	50%

Other Applications except Hotel

Maximum dry bulb temperature	22°C
Maximum relative humidity	50%

Outdoor Design Conditions

Summer

Maximum dry bulb temperature	33.5°C
Maximum relative humidity	68%

Winter

Minimum dry bulb temperature	7°C
Minimum relative humidity	40%

Remember the recommended outdoor and indoor design conditions for Hong Kong by Dr. Sam Hui?
(Lecture on 'Load Estimation')

Basics – COP

$$\text{Coefficient of Performance} = \frac{\text{Refrigeration Effect}}{\text{Power input of Compressor, Ancilliary Motor, Control}}$$

Minimum COP for Water-Cooled Water Chiller with Centrifugal Compressors

Capacity Range (kW)	Below 500	500 to 1000	Above 1000
Minimum COP (Cooling)	4	4.5	5.7

Minimum COP for Air-Cooled Water Chiller with Centrifugal Compressors

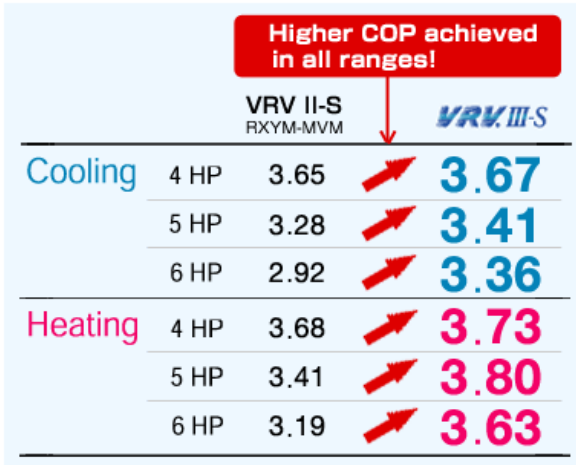
Capacity Range (kW)	All Ratings
Minimum COP (Cooling)	2.8

Minimum COP for Air-Cooled Water Chiller with Screw Compressors

Capacity Range (kW)	All Ratings
Minimum COP (Cooling)	2.9

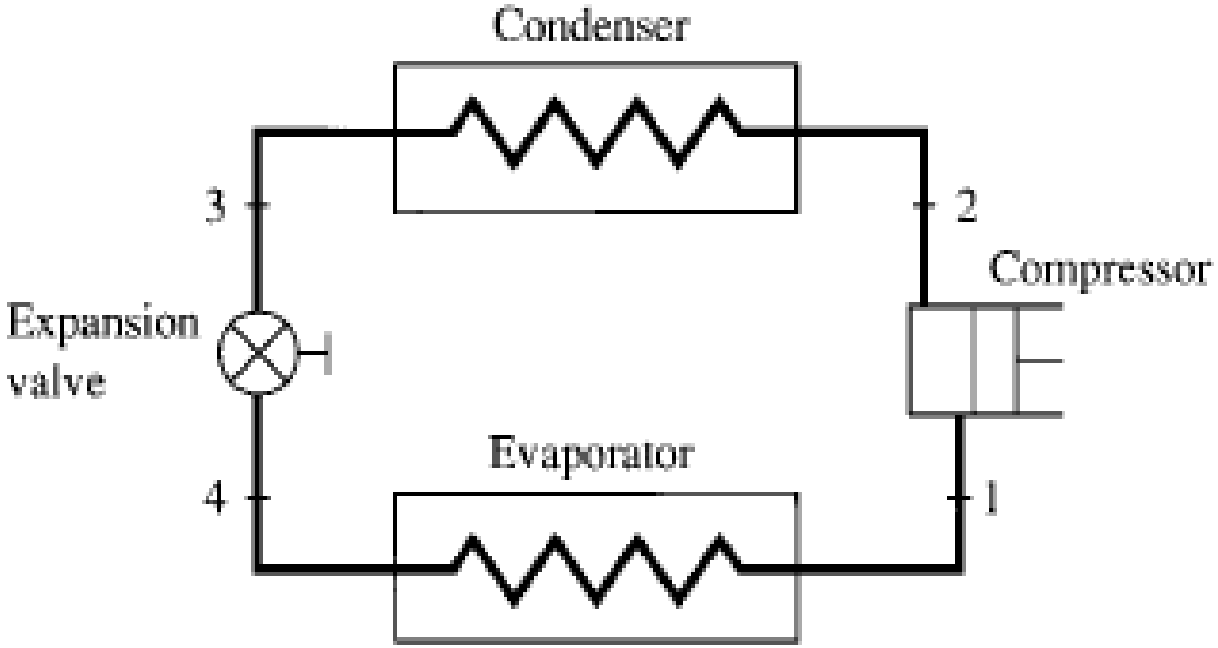
Minimum COP for Water-Cooled Water Chiller with Screw Compressors

Capacity Range (kW)	Below 500	500 to 1000	Above 1000
Minimum COP (Cooling)	4.6	4.6	5.5



Methods to Produce Cooling

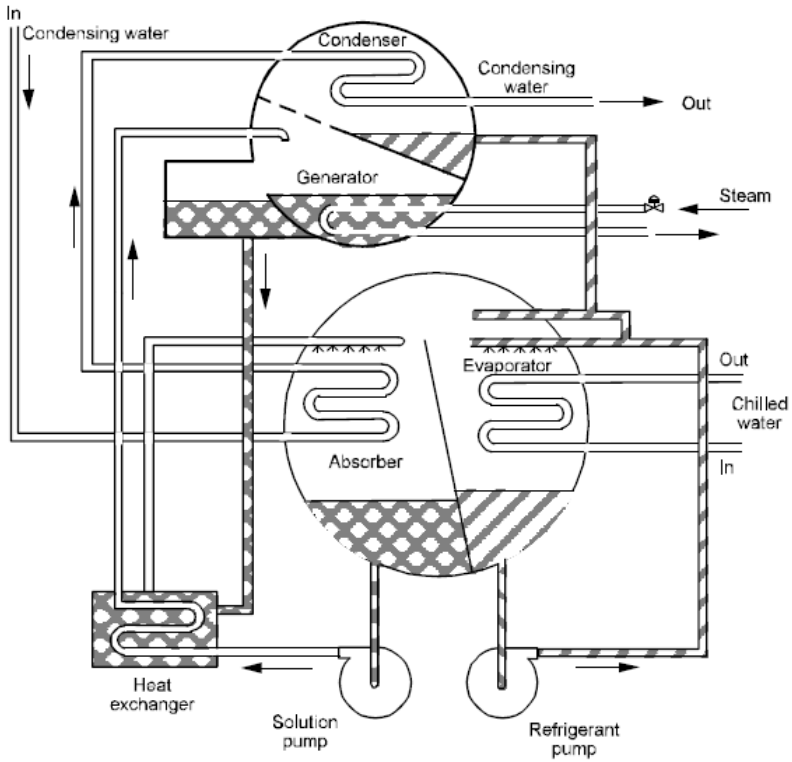
- Methods of producing cooling effect
  - 1) Vapour Compression Refrigeration



1. **Low Pressure Vapour**
2. **High Pressure Vapour**
3. **High Pressure Liquid**
4. **Low Pressure Vapour / Liquid Mixture**

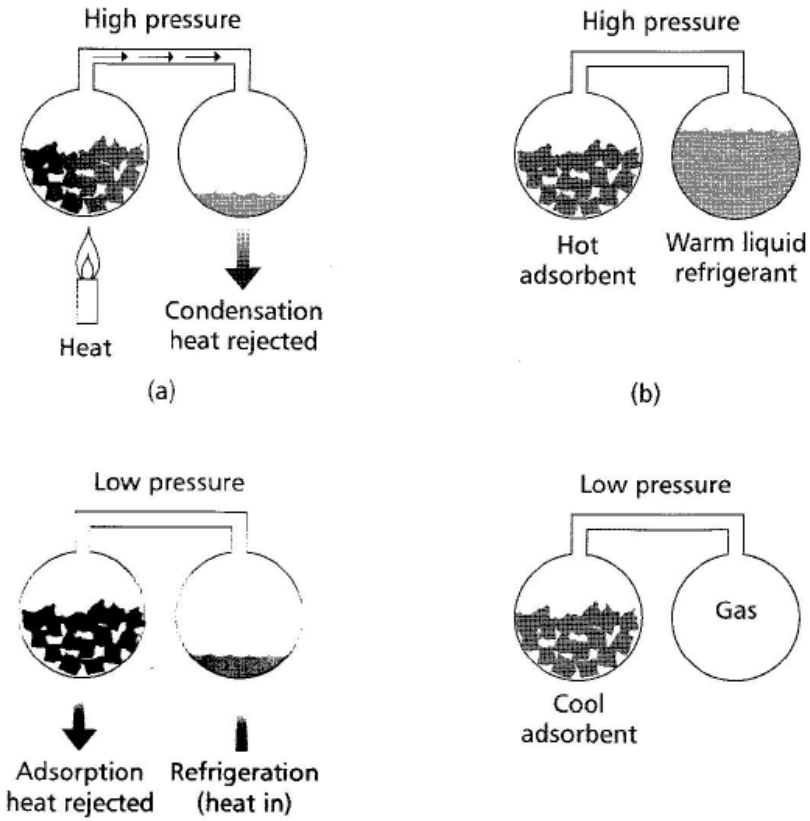
Methods to Produce Cooling

- Methods of producing cooling effect
  - 2) Absorption Refrigeration



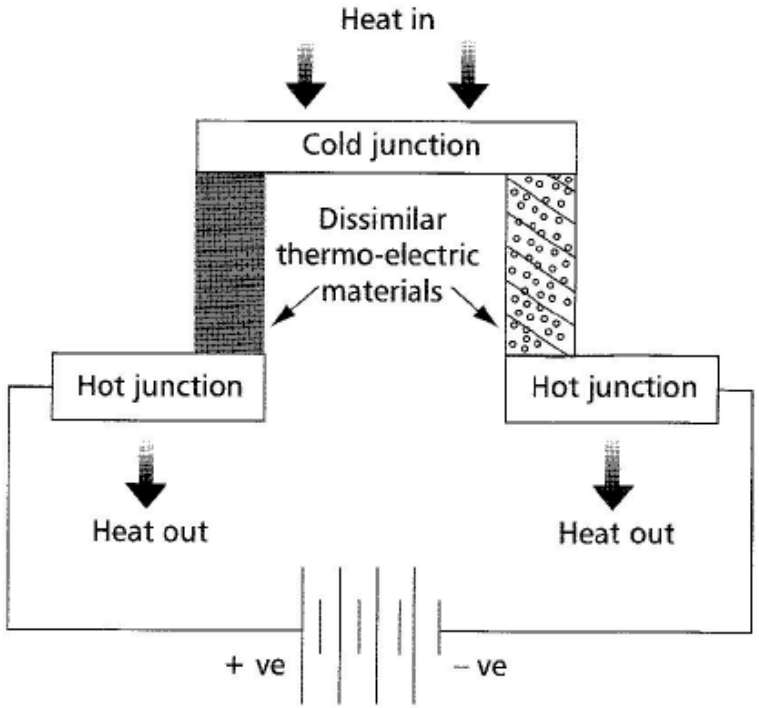
Methods to Produce Cooling

- Methods of producing cooling effect
  - 3) Solid Absorption System



Methods to Produce Cooling

- Methods of producing cooling effect
  - 4) Thermoelectric Cooling



  - 5) Others

Heat Absorption and Rejection

Vapour Compression System

Classification on Heat Absorption at Evaporator

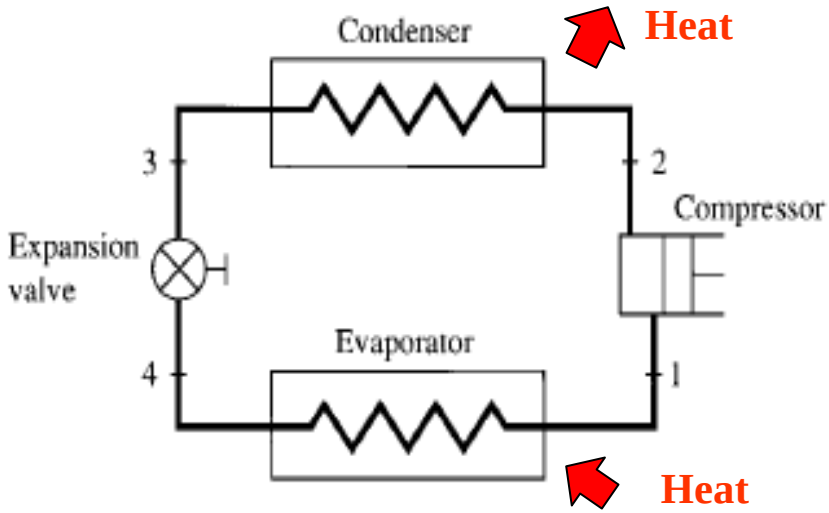
a) Direct heat absorption by the refrigerant

b) Heat absorbed by the water which is subsequently cooled by the refrigerant

Classification on Heat Rejection at the Condenser

a) Direct heat rejection by air cooling of the Condenser

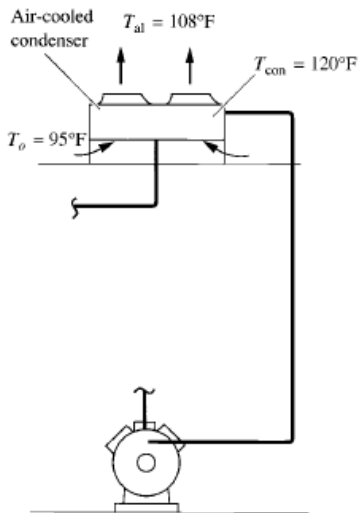
b) Heat is absorbed by water at the condenser and then water to the ambient air

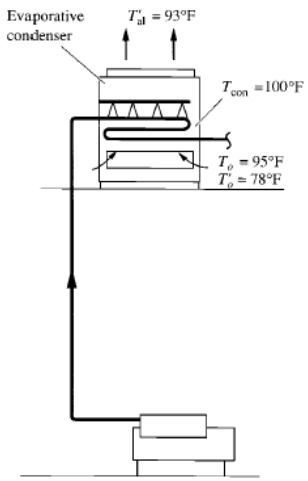


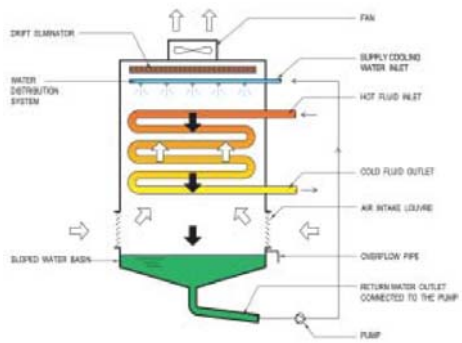
Heat Rejection System

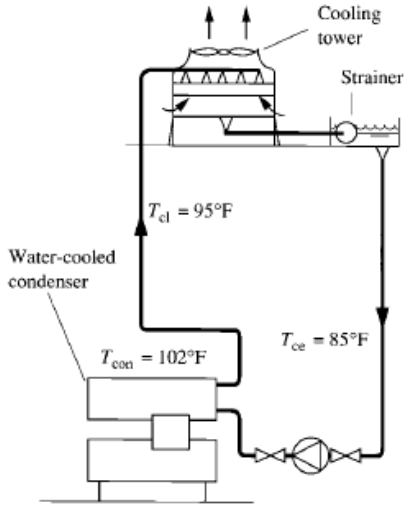
Six types of heat rejection system as follows: -

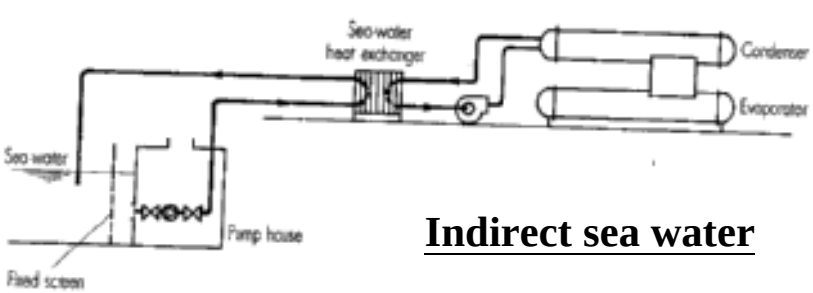
Air cooled condensers **Evaporative condensers** **closed-circuit cooling tower** **cooling towers**



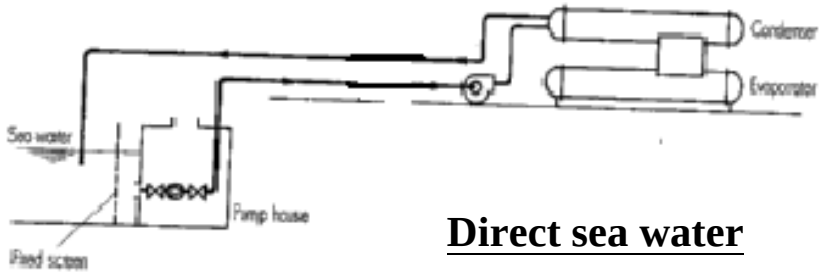








Indirect sea water



Direct sea water

Common Air Conditioning System

Types of Common Air Conditioning System

a) Individual Room Air Conditioning System
b) Package Air Conditioning Systems
c) Central Hydronic Air Conditioning System

Common Air Conditioning System

a) Individual Room Air Conditioning System

Window AC Units

- Window air conditioning unit or through-the-wall unit.
- Controlled by thermostat (compressor on/off) and fan speed control
- For single space cooling (e.g. living room, classroom)
- Supply fan, cooling cool, air filter, compressor, condenser…(all-in-one)
- Cooling capacity usually in kW or Btu/hr (or hp)
- Additional features: Timer for the automatic shutting off of the unit
- Some models can provide warm air during heating season (use of reverse cycle)
- Newer models adopt the use of variable frequency drives

Common Air Conditioning System

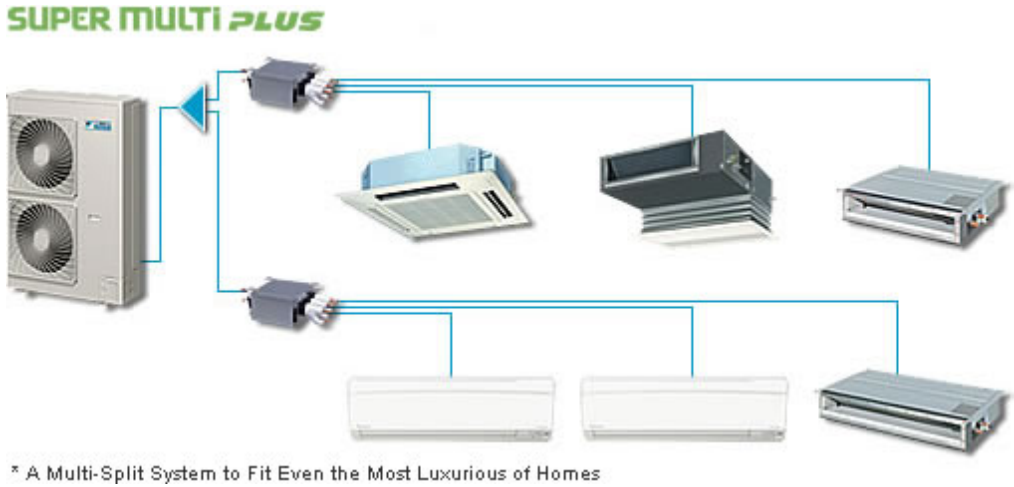
b) Unitary Package Air Conditioning Systems

Indoor Unit –
Split AC system

Outdoor Unit – Split AC system

Common Air Conditioning System

b) **Unitary Package Air Conditioning Systems**



Split AC Units

Common Air Conditioning System

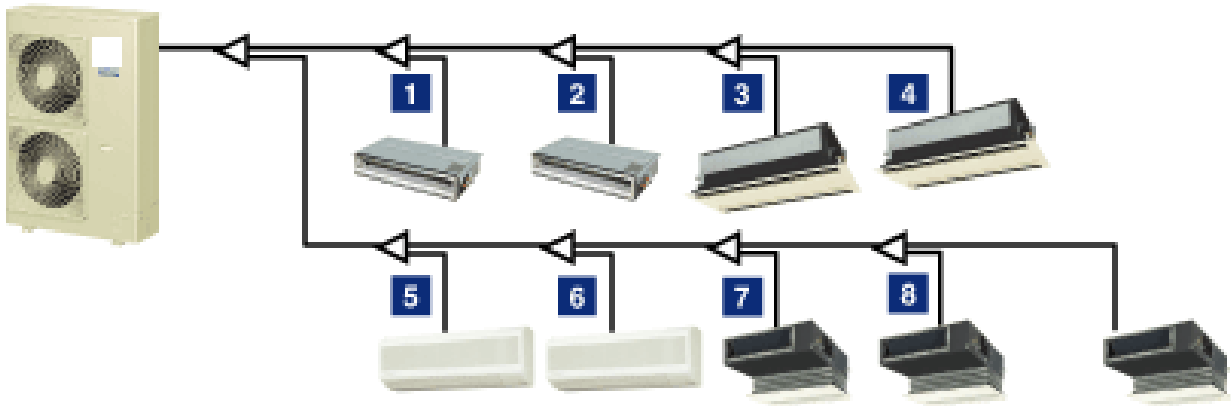
b) **Unitary Package Air Conditioning Systems**

Model No. / Item		
Indoor Unit / Outdoor Unit		
Rank		
Capacity	Cooling	kW
	Heating	
	Cooling	BTU/h
	Heating	
Moisture Removal		l/h
Room Air Circulation (High)	Inner	m³/h
	Outer	
Input Power		V/ø/Hz
Running Current	Cooling	A
	Heating	
Power Consumption	Cooling	kW
	Heating	
Dimensions H x W x D	Inner	mm
Net Weight		kg(lbs)
Dimensions H x W x D	Outer	mm
Net Weight		kg(lbs)
Connection Method		
Connection Pipe Size (Small/Largea)		mm
Max Pipe Length /Height Difference		m
Permissible Range of Outdoor Temp.	Cooling	°C
	Heating	
Refrigerant		

Typical Data on an Split AC unit

Common Air Conditioning System

b) **Unitary Package Air Conditioning Systems**



VRV System

- Slim, compact and sufficient capacity
- High COP
- Low operation sound / Nighttime quiet operation function
- Connectable to up to 9 indoor units / Long piping design possible
- Simple wiring and piping connection / Wide operating temperature range

Common Air Conditioning System

b) **Unitary Package Air Conditioning Systems**

Air-cooled packaged air conditioners

Common Air Conditioning System

b) **Unitary Package Air Conditioning Systems**

Water-cooled packaged air conditioners

Common Air Conditioning System

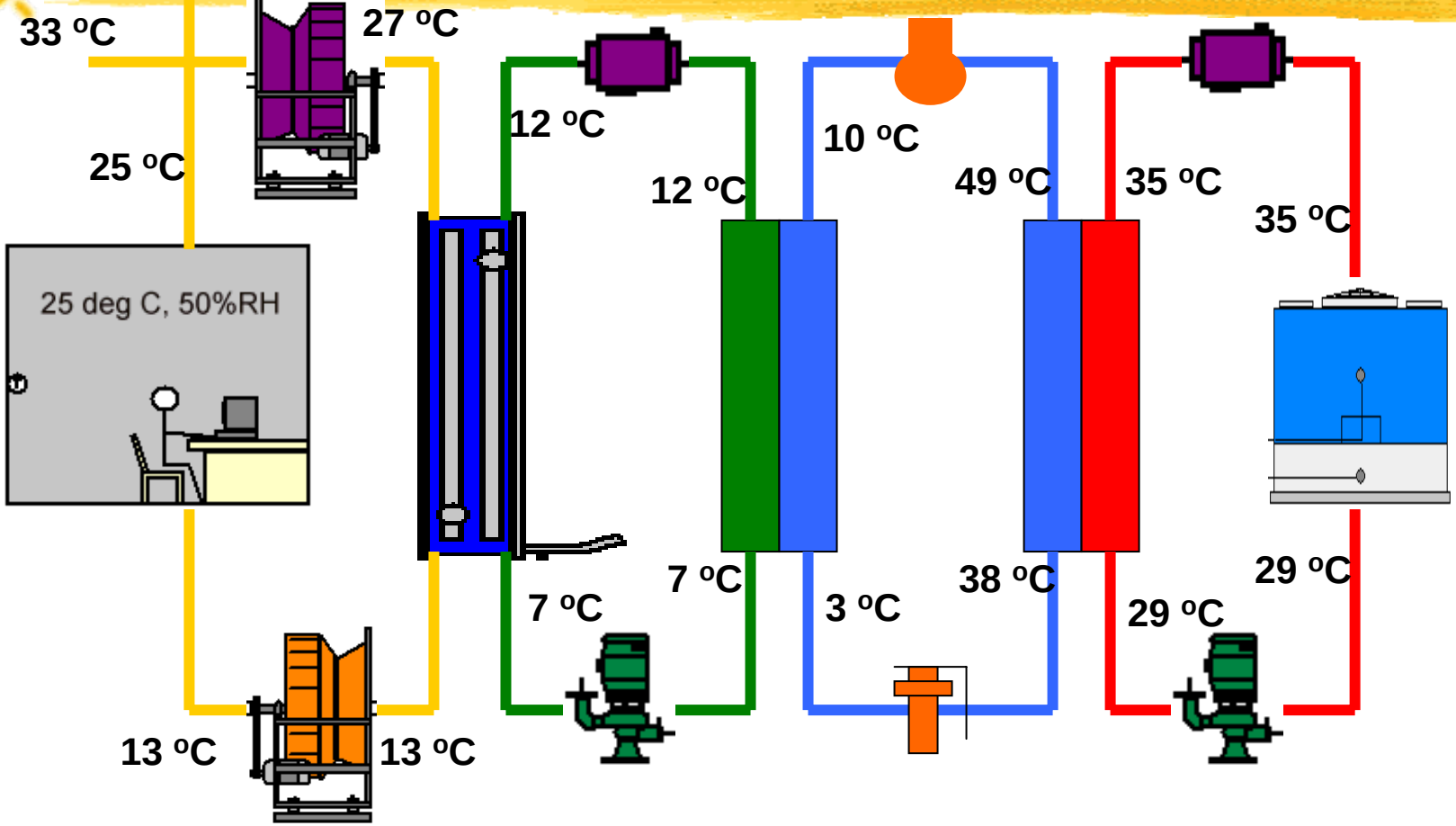
b) **Unitary Package Air Conditioning Systems**

From the previous examples,

- Single, self-contained package units or split systems.
- It may be a split A/C system with indoor unit with fan, filter, and DX-coils and the outdoor condensing unit
- It may be a central system with supply air duct with diffuser and DX-coil for cooling

Common Air Conditioning System

c) Central Hydronic Air Conditioning System



Air Circulation | **Chilled Water Circuit** | Refrigerant Circuit | Condenser Water Circuit

Common Air Conditioning System

c) Central Hydronic Air Conditioning System

Product Name	: Air Cooled Screw Chiller
Model	: ERTAC
Country of Origin	: France
Cooling Capacity	: 400 - 1,500 kW

Product Name	: Water Cooled Screw Chiller
Model	: RTHD
Country of Origin	: USA
Cooling Capacity	: 439.5 - 1,582.2 kW

Common Air Conditioning System

c) Central Hydronic Air Conditioning System

•Chilled water cooling coils in air handling equipment like AHUs / FCUs

•Chilled water, with high specific heat capacity, absorbs the heat and cools the space air

•Involve complicated system arrangement and expensive equipment

•Use of ‘Direct digital control’ (DDC) for overall system control: Electronic sensors send signals to microprocessor operated and control modules which actuates dampers, valves and relays.

Common Air Conditioning System

c) Central Hydronic Air Conditioning System

District Cooling System (DCS)

•It distributes chilled water from a central chiller plant to a number of buildings, whose building owners / operators have subscribed the DCS service.

•After connection with DCS, these service purchasers would no longer require to keep or use their own existing chiller plants.

•The absorbed heat from the user buildings is rejected by either sea water cooling or evaporative cooling towers.

•Any example in Hong Kong?

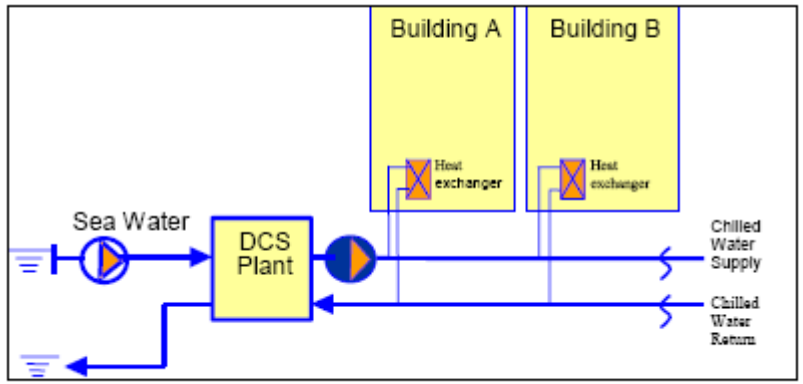


Figure 1.1 Schematic Diagram of DCS with Seawater for Heat Rejection

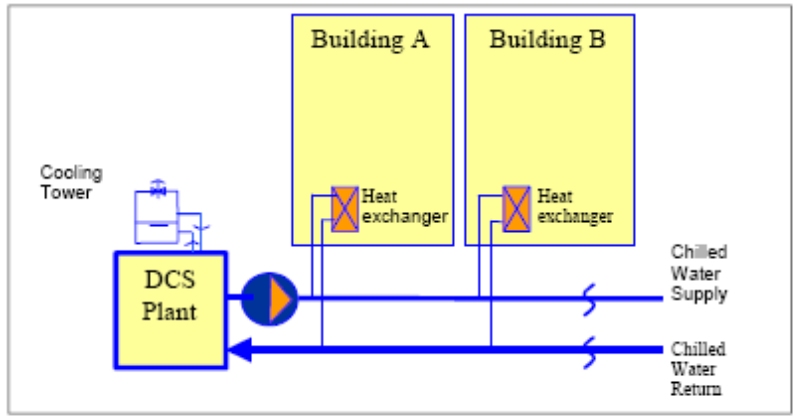


Figure 1.2 Schematic Diagram of DCS with Cooling Tower for Heat Rejection

Common Air Conditioning System

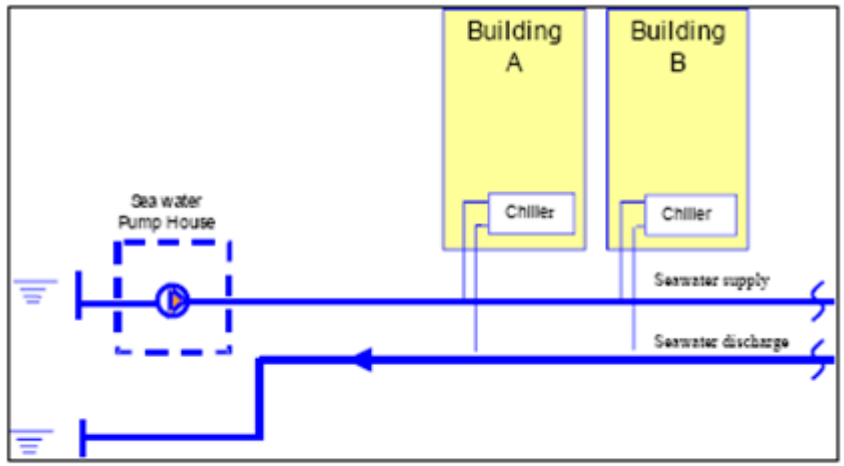
c) Central Hydronic Air Conditioning System

Centralized Piped Supply System for Condenser Cooling (CPSSCC)

•The centralized piped supply system for condenser cooling (CPSSCC) is a large scale central sea water pumping system

•It supplies sea water via the distribution piping network to a number of potential users within the district for heat rejection of their air conditioning systems.

•Any examples in Hong Kong?

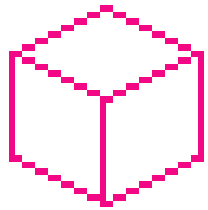


Schematic Diagram for CPSSCC

Common Air Conditioning System

c) Central Hydronic Air Conditioning System

- Subscription of CPSSCC service requires the customer building to be installed with seawater cooled chiller plant.
- Current air-cooled chillers not potential customers for CPSSCC. (space issue?)
- When compared with CPSSCC, DCS is simple, more energy efficient and environmentally friendly.
- As both schemes involve substantial capital investment and public road space for pipes laying, it would not be practical to allow two systems to co-exist in the same district.
- Buildings installed with air-cooled chiller plants likely subscribe for DCS service
- CPSSCC would only be considered under special cases such as re-provision of sea water cooling system for existing seawater cooled buildings when their existing sea water cooling plants become affected by reclamation.



Q & A