Brief Notes on Air Conditioning System Design

1. Basic Concepts

- *Comfort Air-conditioning* – a process of controlling the air temperature, relative humidity, ventilation, air movement and air cleanliness of a given space in order to provide the occupants with a comfortable indoor temperature.
- *Air-conditioning System* – consists of a group of components or equipment connected in series to control the environmental parameters.

2. Classification of Air Conditioning Systems

The purpose of classifying air conditioning systems is to distinguish one type from another and to provide a background for selecting the optimum air conditioning system based on building requirements. A classification of air conditioning systems should include the classification of air and refrigeration systems in order to define a more specific system.

Air conditioning systems can be classified into three categories corresponding to their related equipment as follows:

- *Individual Systems* – use a self-contained , factory-made air conditioner to serve one or two rooms (e.g. room/ window air conditioner and split-type units).
- *Unitary Packaged Systems* – similar in nature to individual systems but serve more rooms or even more than one floor, have an air system consisting of fans, coils, filters, ductwork and outlets (e.g. in small restaurants, small shops and small cold storage rooms).
- *Central (Hydronic) Systems* – basically consists of three major parts:
    - Air system – air handling units (AHU), air distribution (air duct) system and terminals.
    - Water system – chilled water system, hot water system, condenser water system.
    - Central plant – refrigeration (chiller) plant, boiler plant.

An air-handling unit (AHU) is the basic piece of equipment used in an air system. It can be either a field-assembled built-up system or a factory-made unit. Because a central system always has a chilled water system, the type of coil installed in an AHU is a water cooling coil, which is different from an air handler in a packaged system, which uses a DX (direct expansion) coil.

3. Air and Refrigeration Systems Designation

Classification of air conditioning systems also involves classification of refrigeration system.

- An individual system uses a small, self- contained factory-assembled refrigeration system that uses a DX-coil to cool air.
- A packaged system always has a refrigeration system that uses a DX-coil to cool air directly.
- A central system has a refrigeration system that uses chilled water as a cooling medium to cool air indirectly.

In addition, in order to designate an air conditioning system more clearly and correctly, the main characteristics of its air system may be added to the description of its basic category (that is, individual, packaged, or central). More clearly specified terminology for an air conditioning system with a designated air system and primary cooling and heating plant is a combination of items from two or three of the following columns:

Air system	Refrigeration	Air conditioning system
• Constant volume • Fan-coil • Single-zone VAV • Perimeter-heating VAV • VAV reheat • Dual-duct VAV • Fan-powered VAV	• Centrifugal • Reciprocating • Screw • Scroll • Absorption • Gas cooling • Desiccant evaporative	• Central system • Rooftop packaged system • Indoor packaged system • Split packaged system • Rooftop heat pump system • Split heat pump system • Water-loop heat pump system • Ice storage system • Chilled water storage system • Heat recovery central system

Some air systems are always central systems and some refrigeration systems are usually packaged systems. Fan-coil systems are always central systems and centrifugal or absorption refrigeration system are usually central systems. The refrigeration systems of a package system is usually a reciprocating, screw, or scroll system. A thermal storage system is always a central system.

A variable air volume (VAV) reheat screw central system, or simply VAV reheat central system, is a central air conditioning system that has a VAV reheat air system and a screw chiller plant to cool air in various AHUs. A fan-powered VAV, centrifugal, ice storage central system, is a central air conditioning system that has a fan-powered VAV system for cold air distribution and an ice storage system that uses a centrifugal chiller to reduce peak electricity costs. Ice storage systems are always central systems that use brine to provide cooling.

Occasionally, an air conditioning system may exist without an air system, such as a reciprocating water-loop heat pump system, or simply water-loop heat pump system, whose water-source heat pumps may be installed in individual rooms. Note that a heat pump is always a packaged system.

If the distinctions between centrifugal, reciprocating, scroll, and screw compression are not important for an air conditioning system (for example, for a water-loop heat pump system or a single-zone VAV rooftop packaged system), just omit them.

For central systems, most primary heating plants in commercial buildings use gas-fired, electric, and heat-recovery heating. Direct gas-fired and electric heaters are the most widely used. For simplicity, the designations of primary heating plants are not included in classification. In areas where the type of primary heating plant is important, gas heating, electric heating, and oil heating can be added after centrifugal, reciprocating, or screw compression, or the designation of refrigeration systems may be omitted.

4. The Goal of Air Conditioning System Design

The goal of an air conditioning system design is to achieve a highly quality system that functions effectively and is energy-efficient and cost-effective. The following are essential for a system to function effectively:

- All design criteria are fulfilled, and the requirements of the owner and the user are satisfied.
- A good indoor air quality is provided.
- The system is reliable and has adequate fire protection level (e.g. smoke management).

5. Air Conditioning System Selection

When considering and selecting an air conditioning system, the designer must understand the building and the client's requirements and try to study and evaluate the following factors:

- Building location, surrounding environment and external climate
- Uses and functional requirements of the building
- Client's budget, investment policy and expected quality of service

The designer should consider various system options and recommend one or several that will be likely to perform as desired. Some of the selection criteria include:

- *Performance requirements* – on comfort, noise, control options, flexibility and meeting requirements of local regulations/codes
- *Capacity requirements* – range of capacity, multiple units, zoning, etc.
- *Spatial requirement* – plant room space, space for ducting and piping (vertical shafts), space for terminal equipment
- *Costs* – initial cost, operating cost and maintenance cost
- *Energy consumption* – for both economic and environment reasons
- *System qualities* – e.g. aesthetics, life, reliability and maintainability

Useful References

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Table 1. Comparison between individual room, unitary packaged, and central hydronic air conditioning systems

Characteristics	Individual room systems	Unitary packaged systems	Central hydronic systems
Area served	Small	Medium to large	Large
Capacity of refrigeration system (ton of refrig, TR)	Mostly < 2 TR	3-220 TR	Often greater than 100 TR
Amount of outdoor air supply	Influenced by wind direction and velocity	Positive outdoor air supply Providing modulation of volume low	Positive and guaranteed outdoor air supply
Space temperature control	Greater temperature fluctuation	Temperature may fluctuate as a result of step control of DX control	Better control quality
Air cleanliness	Not satisfactory owing to low-efficiency air filters installed	Satisfactory because of installation of medium-efficiency air filters	Meet any requirement because of the possibility of installing medium- or high-efficiency air filters
Space sound level	Higher space noise criteria NC curve	Lower space NC curve	Lower space NC curve because of better sound attenuation
Load diversity	No diversity	Lower diversity	Lower diversity
System component efficiency	Low	Medium	Higher
Equipment life	Shorter	Longer	Longest
Maintenance	More maintenance work Maintenance at conditioned space	Less maintenance work Maintenance at the packaged unit	Less maintenance work Maintenance at fan room and plant room
Heat rejection	Easier for premier zone	Easier for low-rise building	Easy for any building
Smoke control	Cannot coordinate with smoke control system	May be integrated as part of smoke control system	Can be integrated as part of smoke control system
Operator	No operator	Operator may be required	Operator is required
Characteristics	Individual DX room air conditioner	DX packaged system	Central hydronic system
Initial cost	Lower	Medium	Higher
Operating cost	Lower	Medium	Higher
Plant room	No equipment room is required	Separate equipment room is required	Fan room and central plant room
Flexibility of operation	More flexible	Comparatively flexible	Less flexible
Installation	Simple and fast	Simpler compared with central hydronic systems	More complex
Energy metering for individual tenants	Simple	Simpler compared with central hydronic systems	Difficult
Future expansion	Flexible	Less flexible compared with individual room systems	Less flexibility
System characteristic	Individual	Central	Central
Cooling	Direct expansion DX control	Direct expansion DX control	Water cooling coil