



Air Systems Design

Introduction



What you will Learn in this Lesson

- Short history of air conditioning
- A description of the practice of air conditioning design
 - Design-Bid-Build
 - Design Build
 - Integrated Project Delivery (IPD)
- Contract options for design firms

What you will Learn in this Lesson

Overview of the rest of the school

- Psychrometrics
- Duct Design
- Coils
- Air conditioning Fans
- Acoustic Fundamentals
- Building Loads
- Air handling units
- Distribution Systems
- High Performance Buildings

(cont.)

- DOAS
- Heat Recovery
- Computer Simulation of Energy Use in Buildings
- Air System Options by Building Type
- Codes and Standards

Engineering is the art of directing the great sources of power in nature for the use and convenience of man.

-Thomas Tredgold, 1828

History of Air Conditioning

- ***Indoor Air Quality***

- In 1775, French Chemist Antoine Lavoisier identified the “unknown particle” that was assumed to be the cause of “bad air”: carbon dioxide. His study of oxygen and carbon dioxide helped explain why mice died when put in air tight spaces with burning candles

British Thermal Unit

- Nineteenth century English chemist and physicist Michael Faraday is credited with giving us the first definition of a British thermal unit. Faraday, who was a bookbinder before he turned to science, is also credited with the discovery of electromagnetic rotations, electromagnetic induction, diamagnetism and the magneto-optical effect

- **British thermal unit (Btu)**, a measure of the quantity of heat, defined since 1956 as approximately equal to 1,055 [joules](#), or 252 gram calories. It was defined formerly as the amount of heat required to raise the temperature of one pound of water 1° F. The definition was changed because it was dependent on the initial temperature of the water. Gas utilities frequently use a larger unit, the therm, defined as 100,000 Btu, as a measure of gas consumption.

therm

\[?thərm

**Definition of : a unit for quantity of heat that equals
100,000 British thermal units**

Origin of Greek heat, from hot; akin to Latin warm,
Sanskrit heat

First Known Use: 1888

Joule

Energy also can be measured in joules. Joules sounds exactly like the word jewels, as in diamonds and emeralds. A thousand joules is equal to a British thermal unit.

1,000 joules = 1 Btu (roughly)

Joule

- The term "joule" is named after an English scientist [James Prescott Joule](#) who lived from 1818 to 1889. He discovered that heat is a type of energy.
- One joule is the amount of energy needed to lift something weighing one pound to a height of nine inches. So, if you lifted a five-pound sack of sugar from the floor to the top of a counter (27 inches), you would use about 15 joules of energy.

Rule of Thumb: Q delta T for air

- What is the formula for heat transfer in air?

$$Q = m \cdot c_p (T_2 - T_1)$$

$$m \cdot c_p = ?$$

$$m \cdot c_p = 60 * 0.075 * \text{CFM}$$

$$Q = 4.5 * \text{CFM} * (T_2 - T_1)$$

Rule of Thumb: 20 F ΔT

- Why 20 F?
- What is the formula for heat transfer in clear water?

$$Q = m \cdot c_p (T_2 - T_1)$$

$$m \cdot c_p = 8.338 \text{ lb/US gal} \times 60 \text{ min/hr} \times 1.0099 \text{ Btu/lb} \cdot \text{F}$$

$$m \cdot c_p = \mathbf{505.24} \text{ Btu} \cdot \text{min/h} \cdot \text{USgal} \cdot \text{F}$$

(roughly 500) so $500 \times 20 = 10,000$

$$\text{IF } Q = 125,000 \text{ THEN gpm} = 12.5$$

$$\text{IF } Q = 200,000 \text{ THEN gpm} = 20.0!$$

Dr. John Gorrie

- The act of cooling air for the benefit of the occupants was tried as early as 1842 when Dr. John Gorrie attempted to treat his fever stricken sailor patients who suffered from yellow fever and malaria by blowing air over buckets of imported ice into the sick rooms. When one recalls that the worlds first electric power plant opened some forty years after this time it is amazing to imagine how the air was moved across the ice. Even more amazing was the location of this experiment for Dr. Gorrie received his ice by ship sailing from Boston and New York and delivered to his practice in *Apalachicola, Florida!*

Father of Air Conditioning?

“If air were highly compressed, it would heat up by the energy of compression. If this compressed air were run through metal pipes cooled with water, and if this air cooled to the water temperature was expanded down to atmospheric pressure again, very low temperature could be obtained, even low enough to freeze water in pans in a refrigerator box.”

Dr. John Gorrie

- US Patent No. 8080 in 1851 for the “first machine ever to be used for mechanical refrigeration and air-conditioning”

The Practice of Air Conditioning Design

- HVAC designers have many choices for system selection
 - Natural ventilation through double hung windows and steam radiators
 - Unit ventilators with boilers and chillers
 - Unit ventilators with self contained AC and electric heat
 - Unit ventilators with electric heat pumps
 - Water source heat pumps – boiler/tower or geothermal & DOAS
 - Fan Coils with boilers, chillers and DOAS
 - Variable Refrigerant Volume with DOAS
 - PTAC-PTHP with DOAS

System Choices

- Central AHU options
 - Constant volume with reheat
 - Variable volume with reheat
 - Variable volume with parallel fan powered boxes
 - Variable volume with series fan powered boxes
 - Single zone RTU with DX and gas furnace
 - Dual duct constant volume
 - Dual duct variable volume
 - Multi-zone with DX or chilled water

Designers have Specialties

- Ventilation design
- Plumbing
- Fire protection
- Hydronic
- Central plant
- District cooling/heating
- Laboratories
- Healthcare
- Schools
- Office

Design-Bid-Build

- The traditional method of project delivery
- Up to nine different phases
 - Studies
 - Master Plan
 - Block Schematics
 - Schematic Design (SD)
 - Design Development (DD)
 - Construction Documents (CD)
 - Bidding and Negotiating
 - Construction
 - Post Construction

Who works for whom?

- HVAC designers may be hampered by the contractual arrangement
 - Engineering contracted to architect
 - Engineer and architect in same firm
 - Owner hires engineer directly

Design-Build

- Sometimes referred to as “Build-Fix” 😊
- DB industry is growing
- DBIA has changed how buildings get built
 - Design-Build Institute of America (DBIA) defines it this way:
 - “Design-build is a method of project delivery in which one entity - the design-build team - works under a single contract with the project owner to provide design and construction services.”
 - Owners like this for having a sole point of contact for all things related to the project. The theory is to stop “finger pointing”.
 - DB promises: faster delivery, cost savings, better quality, reduced risk

Design-Build: What is your perspective?

- Budget focus
- Schedule focus
- Quality focus
- The old axiom said “pick two”
- DB promises to do all three but your results may vary.....

Integrated Project Delivery ≠ DB

- “There are reasons to acknowledge that highest and best sustainable results in meeting increasingly aggressive goals for energy and carbon reduction are best achieved through collaborative processes. The AIA’s experience with the American Society of Heating, Refrigerating and Air-Conditioning Engineers’ (ASHRAE’s) Advanced Energy Design Guides suggest that although some reductions are prescriptively achievable (i.e., through the use of a checklist), as one exceeds a 30% reduction and moves toward even greater reductions, complex interactions of systems and context must be taken into account. Integrated processes are being acknowledged and encouraged in sustainable ratings systems such as LEED®. New energy codes, such as ASHRAE’s Standard 189, include recommendations regarding integrated processes.” *(From AIA)*

Integrated Project Delivery $\neq$ DB

- Owners must be intelligent for IPD to work
- All stakeholder must work together from the very start
- Contractors, designers, and owners must find solutions that:
 - Work across all disciplines
 - Are complete systematic solutions
 - Are proven, reliable, buildable, understandable, and durable

What is the Role of the Manufacture's REP?

- Be there when they need you!
- Understand the process
- Understand the contractual relationships
- Be prepared with the tools they need
- Spend the time UP FRONT to get a sale well down the road
- Be attuned to your customer's mission, reputation, skill sets
- Your reputation takes years to build and hours to kill

Project Deliverables

- Studies:
 - Paper and electronic reports with lots of tables and graphs
 - Some sketches and diagrams
- Master Plans:
 - Site drawings with new building outlines
 - Building shell space with walls, rooms and equipment
 - Schedules with equipment capacities and physical sizes
- Block Schematics:
 - Bubble diagrams of functions in general areas of a floor plan
- Schematic Design:
 - Line drawings of walls, systems, flows
 - Tables of data for equipment

Project Deliverables

- Design development:
 - Full floor plans with space names
 - One line drawings of all systems
 - All equipment locations with correct sizes and capacities
 - Flow diagrams showing all components with sizes
 - Narrative specification or basis of design
- Construction documents
 - All details of construction
 - All schedules completely filled out
 - A complete three part specification

Project Specifications

- Construction Specifying Institute (CSI)
 - Produces MasterFormat™
- Some clients will use the stock spec
- Some clients will create their own custom spec

MasterFormat 2010 Structure

Procurement and Contracting Requirements Group

Procurement and Contracting

Requirements: Division 00

Specifications Group

General Requirements Subgroup: Division 01

Facility Construction Subgroup: Divisions 02 - 19

Facility Services Subgroup: Divisions 20 - 29

Site and Infrastructure Subgroup: Divisions 30 - 39

Process Equipment Subgroup: Divisions 40 - 49

MasterFormat 2010 Structure

Facility Services Subgroup:

20 Reserved

21 Fire Suppression

22 Plumbing

23 Heating, Ventilating and Air
Conditioning

24 Reserved

25 Integrated Automation

26 Electrical

27 Communications

28 Electronic Safety and Security

29 Reserved

23 00 00 Heating, Ventilating, and Air Conditioning (HVAC)

- **23 73 00 Indoor Central-Station Air-Handling Units**
 - 23 73 13 Modular Indoor Central-Station Air-Handling Units
 - 23 73 23 Custom Indoor Central-Station Air-Handling Units
 - 23 73 33 Indoor Indirect Fuel-Fired Heating and Ventilating Units
 - 23 73 33.13 Indoor Indirect Oil-Fired Heating and Ventilating Units
 - 23 73 33.16 Indoor Indirect Gas-Fired Heating and Ventilating Units
 - 23 73 39 Indoor, Direct Gas-Fired Heating and Ventilating Units

23 00 00 Heating, Ventilating, and Air Conditioning (HVAC)

- **23 74 00 Packaged Outdoor HVAC Equipment**
 - 23 74 13 Packaged, Outdoor, Central-Station Air-Handling Units
 - 23 74 23 Packaged, Outdoor, Heating-Only Makeup-Air Units
 - 23 74 23.13 Packaged, Direct-Fired, Outdoor, Heating-Only Makeup-Air Units
 - 23 74 23.16 Packaged, Indirect-Fired, Outdoor, Heating-Only Makeup-Air Units
 - 23 74 33 Dedicated Outdoor-Air Units

23 00 00 Heating, Ventilating, and Air Conditioning (HVAC)

- **23 75 00 Custom-Packaged Outdoor HVAC Equipment**

- 23 75 13 Custom-Packaged, Outdoor, Central-Station Air-Handling Units
- 23 75 23 Custom-Packaged, Outdoor, Heating and Ventilating Makeup-Air Units
- 23 75 33 Custom-Packaged, Outdoor, Heating and Cooling Makeup Air-Conditioners

End of Lesson

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