DESIGN OF AIR CONDITIONING SYSTEM BY USHIG HAP
(Hourly Analysis Program)

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ABSTRACT

To study and evaluate the technical Designing of Heating, Ventilation & Air-conditioning (HVAC) system for a commercial High Rise Building has been designed

HVAC refers to the equipment, distribution network, and terminal that provide either collectively or individually the heating, ventilating, or air-conditioning processes to a building. HVAC system design is a major sub discipline of mechanical engineering, based on the principles of thermodynamics, heat transfer and fluid mechanics [3].

HVAC systems provide:

➢ Heating
➢ Cooling
➢ Air handling, ventilation, and air quality

Every air conditioning application has its own special ‘needs’ and provided its own challenges. Shopping malls, office complexes, hotels, ATM’s, Airports and banks need uniform comfort cooling in every corners of their sprawling spaces and activities involving computers, electronics, aircraft products, precision manufacturing, communication networks and operation in hospitals, infect many areas of programming will come to a halt, so air conditioning is no longer a luxury but an essential part of modern part of modern living.

INTRODUCTION TO HVAC

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HVAC accounts for 40 to 60 percent of the energy used in U.S. commercial and residential buildings. This represents an opportunity for energy savings using proven technologies and design concepts.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) supplies technical information to engineers and other professionals. In addition, ASHRAE writes standards and guidelines in its field of expertise to guide industry in the delivery of goods and services to the public.

HEATING

There are different types of standard heating systems. Central heating is often used in cold climates to heat private houses and public buildings. Such a system contains a boiler, furnace, or heat pump to heat water, steam, or air, all in a central location such as
a furnace room in a home or a mechanical room in a large building. The use of water as the heat transfer medium is known as hedonics.

The system also contains either ductwork, for forced air systems, or piping to distribute a heated fluid and radiators to transfer this heat to the air. The term radiator in this context is misleading since most heat transfer from the heat exchanger is by convection, not radiation. The radiators may be mounted on walls or buried in the floor to give under-floor heat.

VENTILATION

Ventilating is the process of "changing" or replacing air in any space to control temperature or remove moisture, odors, smoke, heat, dust, airborne bacteria, carbon-dioxide, and to replenish oxygen. Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings [6]

Methods for ventilating a building may be divided into mechanical/forced and natural types. Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air.

Mechanical or forced ventilation: A building ventilation system that uses powered fans or blowers to provide free air to rooms and its used to control indoor air quality, excess humidity, odours and contaminants can often be controlled via dilution or replacement with outside air. Kitchens and bathrooms typically have mechanical exhaust to control odour and sometimes humidity.

Natural ventilation: Natural ventilation is the ventilation of a building with outside air without the use of a fan or other mechanical system. It can be achieved with opened windows.

AIR-CONDITIONING

Air-conditioning is the process of removing heat from the space according to the human comfort conditions and its simultaneous control of temperature, humidity, air movement and the quality of air in space.

Early test on refrigeration discussed the application of using ice for preservation of food and the initial development of the concept of mechanical chemical refrigeration in 1978 in Scotland by Dr. William Cullen. It was in 1844 that Dr. John Gorrie (1803-1855), director of the U.S. Marine Hospital and Apalachicola, Florida, described his new refrigeration machine. In the world built and used for refrigeration and air-conditioning. Refrigeration engineering became a recognized profession and in 1904 some 70 members formed ASRE (American Society of Refrigeration Engineers). The real “Father of air-conditioning” was Willis H. Carrier (1876-1950) as noted by many industry professionals and historians.
DUCT
A duct can be described as a device used to provide an isolation path to carry an item from one place to other place without bringing the product in contact with the atmosphere before delivery point.

DUCT DESIGN PROCEDURE AND DUCT LAYOUT DESIGN PROCEDURE:
• Computer-aided duct design and sizing programs are widely used for more precise calculation and optimum sizing of large and more complicated duct systems.
• Designer should verify local customs, local codes, local union agreements
• The designer proposes a preliminary duct layout to connect the supply outlets and return inlets with the fan(s)

DUCT SIZING METHODS
• Equal Friction (Pressure Drop) Method
  • In this method, the size of duct is decided to give equal pressure drop (or friction loss) per meter length in all ducts.
  • If the layout of the ducts is symmetrical giving the same length of the various runs, this method gives equal pressure loss in various branches.

PIPE DESIGNING
• It is a conduit, which carries the water from a boiler or chiller to the heat exchanger, where the heat exchange process is carried out.
• Pipe sizing is calculated from machine to air handling unit and fan coil units.
• For pipe sizing we need to two parameter gpm and velocity

Figure: Pipe Sizing Software
OVER ALL PIPING SYSTEM

EXTERNAL STATIC PRESSURE CALCULATIONS (esp):
ESP For fan selection using ASHRAE duct fitting software

BUILDING SURVEY AND LOAD ESTIMATE
The primary function of air conditioning is to maintain conditions that are (1) Conductive to human comfort or (2) Required by a product, or process within a space. To perform this function equipment of the proper capacity must be installed and controlled throughout the year [2]
Before the load can be estimated, it is imperative that a comprehensive survey be made to assure accurate evaluation of the load components. If the building facilities and the actual instantaneous load with a given mass of the building are carefully studied and economical equipment selection and system design can result, and smooth, trouble free performance is then possible.

The heat gain or loss is the amount of heat instantaneously coming into or going out of the space. The actual load is defined as that amount of heat, which is instantaneously added or removed by the equipment. The instantaneous heat gain and the actual load on the equipment will rarely be equal, because of the thermal inertia or storage effect of the building structures surrounding a conditioned space.

BUILDING SURVEY
Space Characteristics and Heat Load Sources:

An accurate survey of the load components of the space to be air-conditioned is a basic requirement for a realistic estimation of cooling and heating loads, the compel and accuracy of this survey is the very foundation of the estimation, and its importance cannot be over emphasized [1]

Mechanical and architectural drawings, complete fields sketches and in some cases photographs of important aspects are part of a good survey. The following physical aspects must be considered.

Orientation of Building- location of the space to be air-conditioned with respect to
• Compass points- sun and wind effects.
• Nearby permanent structures- shading effects.
• Reflective surfaces- water, sand and parking lots etc.
• Use if Space(s)- Office, Hospital, departmental store, specialty shop, machine shop and factory assembly plant etc.
• Physical Dimensions of spaces (s) - Length, width and height.
• Ceiling Height- Floor to floor height, floor to ceiling, clearance between suspended ceiling and beams.
• Columns and Beams- size, depth also knee braces.
• Construction Materials- Materials and thickness of wall, roof ceiling, floor and partitions and their relative’s position in the structure.
• Surrounding Conditions- Exterior color of walls and roof shaded by adjacent building or sunlight space- invented or vented, gravity or forced ventilation. Surrounding spaces conditioned or unconditioned- temperature of non-conditioned adjacent spaces, such as furnace or boiler room, and kitchens, floors on ground, crawl space and basement.
• Window Sized and Location- wood or material sash, single or double hung, type of glass single or multiple type of shading device. Dimension of reveals and over changes.
• Doors- Location, types, size and frequency of use.
• Stairways, Elevators and Escalators- Location temperature of space if open unconditioned area. Horsepower of machinery, ventilated or not.
• People- Number, duration of occupancy, nature of activity any special concentration. At times, it is required to estimate the number of people on the basis of square feet per person, or on average traffic
• Ventilation- CFM per person, CFM per sq. ft, scheduled ventilation (agreement with purchaser) Excessive smoking orders,
code requirements. Exhaust fans-type size, speed and CFM delivery.

- **Thermal Storage** - includes system operating scheduled (12,16 or 24 hours) per day specially during peak outdoor conditions, permissible temperature swing in space during a design day, rugs on floor, nature of surface, materials, enclosing the space.

- **Continuous or Intermittent Operation** - whether system be required to operate every business day during cooling seasons, or only occasionally, such as churches and ballrooms, if intermittent operation determine duration if time available for pre-cooling or pull down.

### HEATING LOAD ESTIMATE

(a) **Source of Heat:**

1. Outside Heat
2. Inside generated heat
3. Outside source heat
4. A/C Machine Heat
5. Visitors Heat

(b) **Outside Heat:**

1. Solar Heat
2. Machine AHU
3. Visitors Heat
4. Air Leakage
5. Fresh air

(c) **Solar heat load come through radiation & conduction:**

a) Radiation comes through glass window.
b) Conduction through Wall.

Air Conditioning system will be too much affected if we fix it North or East

(d) **Orientation Layout of the building will be in consideration at the time of heat load calculation:**

1. Types of wall used material.
2. Window fixed side & Material.
3. Ground Floor not affected Heat
4. 1st floor & above lower floor’s Condition, roof material, floor Material.
5. Roof: - RCC, Asbestos sheet, false sealing material Leakage
6. Exposed sun
7. Infiltration
   Leakage in side, Ventilation, IAQ [Indoor air quality] fresh air CFM/Person.

(e) **Occupancy:**

- Sensible heat from Visitors+ Latent heat added

(f) **Heat load reduction:**

1. Insulating the wall roof
2. Quality of glass [Double glass pane window reduce 40% to 60% heat load]
3. Ventilation blind
4. Using Sun film
5. Sun Shed
6. Doors leakage
7. Roof [Water spraying, Permanent water storing, Covering by cemented water tank.]
8. False ceiling.

### Principal of Load Estimation

U Factor Value means: - Coefficient of heat transfer from hotter Zone to colder Zone [4]

Conduction method followed for heat transfer “U” Factor.
Heat transfer by conduction = Area X ΔT X U

Outside Design Data

ΔT = Varies from place to place

Inside Design Data

T = 24°C ± 1°C RH: -50% (cooling in Summer)

Inside Design Data

T = 20°C ± 1°C RH: -35% (heating in winter)

(a) Air Movement:

4.5 - 7.5 CM/Min Measured 5’ above ground level

Outside Design: Maximum enriched Temperature

Inside Design: Desired Temperature

Load & Estimate determine size of ACR Equipment to maintain inside design condition during periods of maximum extreme outside temperature.

(b) Heat Gain:

Radiation Maximum through Glass.

Radiation due to solar gain.

Total Heat = Factor on Chart X Area


(c) Conduction:

Thermal Resistance

Conduction = Area X ΔT X U

ΔT = Outside Temperature - Inside Temperature

Radiation = Area X ΔT X U

Heat gain: Add by People: - 1. Sensible Heat

2. Latent heat.

Heat gain: Add by Light: - 1. Incand Lamp,

2. Fluoracent Lamp {Wattage X 3.4}

(d) Infiltration:

Window Leakage - 22 BTU/Hr

Doors Leakage - 65 BTU/Hr/Person X No of customer/Hr

Exhaust Fan = 1000 CFM, 10% Extra will Add Compare with Ventilation & Infiltration.

Specific Humidity = Gm/Kg of Dry Air

Grain X 0.0648 = 1 gm [1 grain = 1/0.0648 gm]

One Man required = 60 Sq Feet, Release = 14 BTU/Hr,

Light Factor = 3.4 BTU/Hr,

Air quantity standard CFM = 400 cfm / Ton

360 CFM outside air carried by the person

Outside air add 20% Extra

Velocity X area of duct air throw = CFM Air Quantity

**CALCULATION FOR HIGH RISE BUILDING**

Heat Load Calculation using HAP (Hourly Analysis Program):
HEAT LOAD CALCULATION SHEET USING HAP SOFTWARE

Air System Information
- Air System Name: R FCU 7,8
- Equipment Class: CW AHU
- Air System Type: SZCAV
- Number of zones: 1
- Floor Area: 1300.0 ft²
- Location: Hyderabad, India

Sizing Calculation Information
- Zone and Space Sizing Method:
- Zone CFM: Sum of space airflow rates
- Space CFM: Individual peak space loads
- Calculation Months: Mar to Jun
- Sizing Data: Calculated

Central Cooling Coil Sizing Data
- Total coil load: 6.9 Tons
- Total coil load: 83.2 MBH
- Sensible coil load: 73.5 MBH
- Coil CFM at Mar 1400: 3640 CFM
- Max block CFM: 3840 CFM
- Sum of peak zone CFM: 3640 CFM
- Sensible heat ratio: 0.884
- ft³/Ton: 187.5
- BTU/(hr·ft³): 64.0
- Water flow: 16.65 gpm
- Load occurs at: Mar 1400
- OA DB / WB: 100.4 / 74.9 °F
- Entering DB / WB: 77.7 / 63.6 °F
- Leaving DB / WB: 56.9 / 55.5 °F
- Coil ADP: 54.5 °F
- Bypass Factor: 0.100
- Resulting RH: 49%
- Design supply temp: 55.0 °F
- Zone T-stat Check: 1 of 1
- Max zone temperature deviation: 0.0 °F

Central Heating Coil Sizing Data
- Max coil load: 6.6 MBH
- Coil CFM at Des Htg: 3640 CFM
- Max coil CFM: 3640 CFM
- Water flow: 0.66 gpm
- Load occurs at: Des Htg
- BTU/(hr·ft³): 5.1
- Ent. DB / Lvg DB: 69.2 / 71.1 °F

Supply Fan Sizing Data
- Actual max CFM: 3640 CFM
- Standard CFM: 3260 CFM
- Actual max CFM/ft²: 2.80 CFM/ft²
- Fan motor BHP: 0.00 BHP
- Fan motor kW: 0.00 kW
- Fan static: 0.00 in wg

Outdoor Ventilation Air Data
- Design airflow CFM: 228 CFM
- CFM/ft²: 0.18 CFM/ft²
- CFM/person: 11.40

Fig: Hap Software
Fig: Software for Weather properties
• From load calculation we get 3640 CFM. & 6.9TR. We divide TR & CFM into two Machines (3.3tr, 1820cfm) & we divide retail shop into 16 diffuser.
• In that there are 8 supply & 8 return. From each diffuser (supply) 455 cfm is supplied

**SIMULATION OF HVAC DESIGNING**

**Air System Information**
- Air System Name: lobby (b&p) FCU1,2,3
- Equipment Class: CW AHU
- Air System Type: SZCAV

**Number of zones**: 1
**Floor Area**: 212.6 ft²
**Location**: Hyderabad, India

**Sizing Calculation Information**
**Zone and Space Sizing Method:**
- Zone CFM: Sum of space airflow rates
- Space CFM: Individual peak space loads

**Central Cooling Coil Sizing Data**
- Total coil load: 1.3 Tons
- Total coil load: 15.9 MBH
- Sensible coil load: 13.1 MBH
- Coil CFM at Jun 1700: 498 CFM
- Max block CFM: 498 CFM
- Sum of peak zone CFM: 498 CFM
- Sensible heat ratio: 0.625
- BTU/(hr-ft²): 74.9
- Water flow @ 10.0 °F rise: 3.18 gpm

**Central Heating Coil Sizing Data**
- Max coil load: 0.6 MBH
- Coil CFM at Des Htg: 498 CFM
- Max coil CFM: 498 CFM
- Water flow @ 20.0 °F drop: 0.06 gpm

**Supply Fan Sizing Data**
- Actual max CFM: 498 CFM
- Standard CFM: 446 CFM
- Actual max CFM/ft²: 2.34 CFM/ft²

**Outdoor Ventilation Air Data**
- Design airflow CFM: 43 CFM
- CFM/ft²: 0.20 CFM/ft²

**ASHRAE Recommended Values**
**Table: Outdoor Air Requirements for ventilation**

<table>
<thead>
<tr>
<th>Application</th>
<th>Estimated Max**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occupancy P/1000 ft²</strong></td>
<td></td>
</tr>
<tr>
<td>Reception Area</td>
<td>30</td>
</tr>
<tr>
<td>Main Entry Lobby</td>
<td>10</td>
</tr>
<tr>
<td>Office Space</td>
<td>5</td>
</tr>
<tr>
<td>Data entry/Telephone</td>
<td>60</td>
</tr>
<tr>
<td>Health club/aerobics room</td>
<td>40</td>
</tr>
<tr>
<td>Supermarket</td>
<td>8</td>
</tr>
</tbody>
</table>
Results

<table>
<thead>
<tr>
<th>Air System Name</th>
<th>Multi.</th>
<th>System Cooling Coil Load (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2- C, OF L, P, IDF, FCU 57</td>
<td>13</td>
<td>4.0</td>
</tr>
<tr>
<td>2 corridor (3)</td>
<td>13</td>
<td>2.1</td>
</tr>
<tr>
<td>2- C OF FCU 55</td>
<td>13</td>
<td>2.6</td>
</tr>
<tr>
<td>2 lobby OFFICE (1)</td>
<td>13</td>
<td>1.0</td>
</tr>
<tr>
<td>2-O FCU 58</td>
<td>13</td>
<td>3.8</td>
</tr>
<tr>
<td>2-O FCU 67</td>
<td>13</td>
<td>4.0</td>
</tr>
<tr>
<td>2-O FCU 68</td>
<td>13</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Conclusion

Based on the inputs & room data sheets and data Summary sheet the projected Ton will be calculated. To offset this load we propose to provide vapor absorption machine with a standby option. Three will be as duty Vapor Absorption Machine while other one will be as standby.

The vapor absorption machine and the pumps will be located in the plant room assigned for the purpose on the Roof Deck floor. The plant room will be duly ventilated. The FCU’s will also be located on the Roof Deck Floor [7]
It is proposed to incorporate a primary water distribution system in the AC system design. The Primary system will comprise of a set of Primary pumps which will circulate the water to the vapor absorption machine and they will circulate the water from the vapor absorption machine to the Various Zone FCU’s are constant speed type. This way the pumps need not run at constant speed always and hence energy is saved.

REFERENCES


[2] CARRIER Air Conditioning Co, Hand


1. Mohammed Dilawar, Assistant Professor of mechanical department, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, T.S

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