Cooling Load Calculation during Summer & Duct Design and Duct Drafting for Commercial Project

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ABSTRACT

Human comfort is essential now a day because of the improvement in life style and increasing central air conditioning is more reliable for easy operation with a lower maintenance cost. With large buildings such as commercial complex, auditorium, office buildings are provided with central air conditioning system. Educational and research institutions also need human comfortness, as the population of student community increase year by year. The effective designing of ducting in central air conditioning can provide human comfort, low power consumption, capital cost and improve aesthetic of building. This project establishes the results of duct designing for air conditioning using ASHRAE for a commercial building. Duct design items such as duct size, CFM each space pressure drop at each diffuser, elbow, T, taper reducer and duct class, duct material. Using ASHRAE and SMACNA fundamental hand book, maintaining ASHRAE and SMACNA standard.

Keywords: Overall heat transfer coefficient, HAP (Hourly analysis program), Duct designing, Duct drafting

I. INTRODUCTION

Heating, ventilation and air conditioning (HVAC) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, or ventilating is dropped as in HACR.

Energy efficiency can be improved more by installing central heating systems which allows more granular application of heat. Zones can be controlled by multiple thermostats. The HVAC industry is a worldwide enterprise, with roles including operation and maintenance, system design and construction, equipment manufacturing and sales, and in education and research. The HVAC industry was historically regulated by the manufacturers of HVAC equipment, but regulating and standards organizations such as HARDI, ASHRAE, SMACNA, ACCA, Uniform Mechanical Code, International Mechanical Code, and AMCA have been established to support the industry and encourage high standards and achievement.

The starting point in carrying out an estimate both for cooling and heating depends on the exterior climate and interior specified conditions. However, before taking up the heat load calculation, it is necessary to find fresh air requirements for each area in detail, as pressurization is a building environment standards. It establishes the general principles of building environment design. It considers the need to provide a healthy indoor environment for the occupants as well as the need to protect the environment for future generations and promote collaboration among the various parties involved in building environmental design for sustainability. ISO16813 is applicable to new construction and the retrofit of existing buildings.

The building environmental design standard aims to:

- Provide the constraints concerning sustainability issues from the initial stage of the design process, with building and plant life cycle to be considered together with owning and operating costs from the beginning of the design process.
• Assess the proposed design with rational criteria for indoor air quality, thermal comfort, acoustical comfort, visual comfort, energy efficiency and HVAC system controls at every stage of the design process.

II. METHODS AND MATERIAL

A. Methodology

• Commercial building plan of 11634.5 square feet
• Calculation of floor, roof, wall and windows areas.
• Calculation of temperature difference (ΔT).
• Thermal resistance of wall, roof and windows.
• H.A.P 4.61.
• Overall heat transfer co – efficient.
• Ton of refrigerant.

B. Psychometric condition during summer in Hyderabad

Dry Bulb Temperature- 105°F
Relative Humidity-70-80%

As the above conditions for the citizens of Hyderabad is not comfortable. So, the air should be dehumidified and should bring the temperature at 72°F-76°F, and relative humidity to 50%-60%. For this cooling is required in a space.

D. Cooling Load Calculation By Using HAP

(heat load calculation  i.e. heat gain through all the sources)

• Application for summer
• Process is directly to cooling and dehumidification (required in wet summer)
• Cooling and humidification (required in dry summer like in desert areas where there is no water available for evaporation).

DEFINITION: The room cooling load is a rate at which the heat must be removed from the room air in order to maintain it at desired temperature and humidity.

E. Civil structure of building

For estimating cooling loads, one must consider the unsteady state processes, as the peak cooling load occurs during the day time and the outside conditions also vary significantly throughout the day due to solar radiation. In addition, all internal sources add on to the cooling loads and neglecting them would lead to underestimation of the required cooling capacity and the possibility of not being able to maintain the required indoor conditions. Thus, cooling load calculations are inherently more complicated as it involves solving unsteady equations with unsteady boundary conditions and internal heat sources.
F. Gathering Data

The second step in the design process is to gather information necessary to model heat transfer processes in the building and to analyze operation of the HVAC equipment which heats and cools the building. This involves gathering data for the building, its environment and its HVAC equipment. Below, gathering of weather data, data for spaces in the building and data for the HVAC system will be discussed.

G. Gathering Weather Data

ASHRAE design weather conditions for Hyderabad will be used for this analysis. In addition to the ASHRAE data, we will use the period Mar through July as the design cooling months. This means cooling sizing calculations will only be performed for this range of months. We could use January through December as the calculation period. However, design weather conditions in Hyderabad are such that peak loads are most likely to occur during the summer or fall months. So we can reduce the set of calculation months to Mar through July to save calculation time without sacrificing reliability.

H. Gathering Space Data

1. Walls
   One common wall construction is used for all exterior walls. The construction, consists of 8-inch lightweight concrete block. The exterior surface absorption is in the “dark” category. The overall U-value is 0.37 BTU/(hr-sqft-F). The overall weight is 87.3 lb/sqft.

2. Roofs
   One uniform horizontal roof construction is used for this portion of the school building. The roof construction consists of half inch cement plaster, 4” Concrete block, half inch cement plaster. The exterior surface absorption is in the “dark” category. The overall U-value is 0.541 BTU/(hr-sqft-F). The overall weight is 43.6 lb/sqft. Note that in HAP the roof assembly must include all material layers from the exterior surface to the interior surface adjacent to the conditioned space.

3. Lighting
   Recessed, unvented fluorescent lighting fixtures are used for all rooms in this portion of the school building. A lighting density of 1.00 W/sqft is used. For offices, storage rooms and practice rooms we will use design day lighting levels of 100% from 0700 through 1700, the standard occupancy period for the offices, and 5% from 1800 through 2100 when lighting is reduced or operated intermittently for custodial work. This lighting profile applies for the days the building is in session. For weekends and holidays lighting levels of 0% are used.

4. Occupants

The maximum number of occupants varies by space and will be discussed later in this section. For all rooms “seated at rest” activity level will be used (230 BTU/hr/person sensible, 120 BTU/hr/person latent). For the music room the “office work” activity level will be used due to the higher level of activity in this room (245 BTU/hr/person sensible, 205 BTU/hr/person latent). For all rooms we will use design day occupancy levels of 100% for 0700 through 1700, the normal hours of operation for the building. Occupancy during the period 1800 through 2100 is very infrequent and will be ignored. Thus, occupancy levels of 0% will be used for all other hours of the day. This occupancy profile applies for days the school is in session. For weekends and holidays 0% occupancy is used for all hours.

5. SPACE DIMENSIONS

Table 1. Space Dimensions
1. Gathering Air System Data

One air handling system will provide cooling and heating to the rooms in this wing of the commercial Building. Therefore, we will define one HAP air system to represent this equipment.

1. Equipment Type

A VAV rooftop unit will be used.

2. Ventilation

Outdoor ventilation airflow will be calculated using the ASHRAE Standard 62.1-2007 method. “Constant” control for ventilation will be used so the system uses the design flow of outdoor air at all times. Ventilation dampers are closed during the unoccupied period and the damper leak rate is 5%.

3. Cooling Coil

The system provides a constant 55 F supply air temperature to zone terminals. The DX cooling coil is permitted to operate in all months. The bypass factor for the cooling coil is 0.038 which is representative of the type of equipment we expect to select.

4. Preheat Coil

The rooftop unit contains a preheat coil to maintain minimum supply duct temperatures during the winter. The preheat coil is located downstream of the point where return air and outdoor ventilation air mix. The preheat set point is 52 F. The gas-fired heat exchanger in the rooftop unit is used for this purpose. The coil is permitted to operate in all months.

5. Supply Fan

The supply fan in the rooftop unit will be forward curved with variable frequency drive. The total static pressure for the system is estimated to be 3 in wg. The overall fan efficiency is 48%. The coil configuration is draw-thru.

6. Zoning

A zone is a region of the building with one thermostatic control. One zone will be created for each classroom.

The music room and its adjacent office, storage room and practice room will all be part of a single zone. Each corridor will also be zone. Therefore, a total of 9 zones will be created: one each for the six classrooms, one for the music room and two for the corridors.

7. Thermostats

Thermostat settings of 75 F occupied cooling, 80 F unoccupied cooling, 70 F occupied heating and 65 F unoccupied heating will be used in all zones. The throttling range will be 1.5 F. The schedule for fan and thermostat operation for the design day will designate 0700 through 2100 as “occupied” hours. This covers both the 0700-1700 operating hours for the school and the 1800-2100 period when custodial staff is present. All other hours will be “unoccupied”. This profile applies for the school year which runs from August through June. During the shutdown month of July all hours will be designated as “unoccupied”.

8. Supply Terminals

All zones use parallel fan powered mixing box terminals with 0.5 in wg total fan static, 50% overall fan efficiency and a 95 F heating supply temperature. Minimum supply airflow for the terminals is based on ASHRAE Standard 62.1-2007 requirements. We will specify minimum zone airflow as zero so the program will automatically use the Standard 62.1-2007 requirement to set the minimum damper position. The heat source for the reheat coils is electric resistance.

9. Sizing Criteria

Required zone airflow rates will be based on the peak sensible load in each zone. Required space airflow rates will be based on peak space loads for the individual spaces. Safety factors will be specified as zero. A margin of safety will be applied later during equipment selection.

After weather, space and HVAC system data has been gathered, it is entered into HAP. This is the third step in the design process. After entering the data into HAP the report will be generated by HAP it self.
III. RESULTS AND DISCUSSION

J. Report

Table 2. Air system sizing summary for AHU-001

Table 3. Zone sizing summary for AHU-001

Table 4. Space load and Airflow for AHU-001

Table 5. Air system sizing summary for AHU-002

Table 6. Zone sizing summary for AHU-002

Table 7. Space load and Airflow for AHU-002

Table 8. Cooling plant sizing summary for CH-001

K. Duct Designing & Terminal Selection of AHU001
1. **Main duct designing of AHU-001**

   **Application**: Commercial

   **Height of Main Duct**: 18’’ & 16’’ (as per clearance above false ceiling).

   **Velocity**: 2500 – 4000 FPM ~3000 FPM.

   For section A to B

   \[
   Q = 10017 \text{ CFM} \\
   V = 3000 \text{ FPM}
   \]

   From the friction chart in ASHRAE Hand Book we get

   \[F = 0.445'\frac{\text{Wg}}{100'}\]

   Round duct size 25’’

   Rectangular duct size from equivalent rectangular duct dimension table 40’’X 14’’.

   For section B to C

   \[
   Q = 5585 \text{ CFM} \\
   V = 2600 \text{ FPM}
   \]

   From the friction chart in ASHRAE Hand Book we get

   \[F = 0.441'\frac{\text{Wg}}{100'}\]

   Total friction for duct B to C

   \[F_p = (0.441'/100') \times 34' = 0.149'' \text{ Wg}\]

   \[P_s = 0.9 \times (\frac{3000}{4000})^2 - (\frac{2600}{4000})^2 = 0.126'' \text{ Wg}\]

   \[P_s\] is less than \[F_p\] so it is not accepted, now chose more less velocity to increase static pressure.

   \[
   Q = 5585 \text{ CFM} \\
   V = 2400 \text{ FPM}
   \]

   From the friction chart in ASHRAE Hand Book we get

   \[F = 0.359'\frac{\text{Wg}}{100'}\]

   Total friction for duct B to C

   \[F_p = (0.359'/100') \times 34' = 0.122'' \text{ Wg}\]

   \[P_s = 0.9 \times (\frac{3000}{4000})^2 - (\frac{2400}{4000})^2 = 0.182'' \text{ Wg}\]

   Now \[P_s\] is greater than \[F_p\], it is accepted so from the friction chart in ASHRAE Hand Book we get the duct dia 21’’

   From equivalent rectangular duct dimension table we get duct size 26’’X 14’’.

   Similarly proceeding further in tabular form below.

2. **Terminal Branch Designing**

   **Branch 1**

   \[
   Q = 1749 \text{ CFM} \\
   H = 14'' - 2'' = 12'' \text{ (height)}
   \]

   \[F = 0.06'\frac{\text{Wg}}{100'}\]

   From the friction chart in ASHRAE Hand Book we get

   \[V = 900 \text{ FPM}\]

   Duct Dia = 19’’ & Duct size = 28’’ X 10’’.

   Similarly proceeding further in tabular form below.

3. **Diffuser Selection**

   **Diffuser 1**

   \[
   Q = 875 \text{ CFM} \\
   V = 450 \text{ FPM (velocity should be taken as branch velocity)}
   \]

   From the duct sizer we get

   Neck Size = 12’’ X 12’’

   Face Size = 15’’X 15’’ (as per manufacturer).

   **Diffuser 2**

   \[
   Q = 875 \text{ CFM} \\
   V = 450 \text{ FPM (velocity should be taken as branch velocity)}
   \]

   From the duct sizer we get

   Neck Size = 12’’ X 12’’

   Face Size = 15’’X 15’’.
Similarly proceeding further in tabular form below.

### Table 11. Diffuser Selection

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1. **Duct Designing & Terminal Selection of AHU-002**

**1. Main duct designing of AHU-002**

Application: Commercial

Height of Main Duct: 18" & 16" (as per clearance above false ceiling).

Velocity: 2500 – 4000 FPM ~ 3000 FPM.

Table 12. Main duct designing of AHU-001

### Table 12. Main duct designing of AHU-001

### Table 13. Branch duct designing

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2. **Terminal Branch Designing**

### Table 14. Diffuser Selection

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2. **Terminal Branch Designing**

### Table 15. Total cooling load of the building

**Figure 3. Double line drawing of AHU-001 & AHU-002**
IV. CONCLUSION

This project briefly explains how to perform cooling load calculation in H.A.P 4.61 for humidifying the air and bring the psychometric properties at a comfort zone for human body in summer season.

V. REFERENCES


[7]. DeWalt’s HVAC/R Professional Reference by Paul Rosenburg 2006.