DESIGN OF HVAC SYSTEM ON COMMERCIAL BUILDING USING WATER COOLED CHILLERS

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Abstract: *The objective to design Heating, Ventilation & Air conditioning (HVAC) system for a commercial school Building, with simultaneously controls its temperature, humidity, cleanliness, proper distribution, noise level, heat load calculation, fresh air, exhaust, duct design, pipe design, equipment selection and layout of accessories such as indoor and outdoor unit of the project. Cooling load will be calculated on E20 form. Indeed, today the emphasis is no more on understanding air conditioning 'products' but on creating 'solutions' and not just solutions, but 'customized solutions' that suit specific cooling needs of specific business and establishments. Every air-conditioning application has its own special needs and provides its own challenges. Airports, hotels, shopping malls, office complexes and banks need uniform comfort cooling in every corner of their sprawling spaces and activities involving computers, electronics, aircraft products, precision manufacturing, communication networks and operation in hospitals. In fact many areas of programming will come to halt, so air-conditioning is no longer a luxury but an essential part of modern living. With reference to the building plan and requirement of the case problem air-conditioning load is estimated for seasonal conditioning. The project is carried out on "Designing the HVAC system for a Commercial Building". To provide human comfort, it is very essential to maintain steady temperature at public places like schools.*

I- INTRODUCTION

HVAC (heating, ventilating, and air conditioning; also heating, ventilation, and air conditioning) 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 (such as the designation of HACR-rated circuit breakers).

HVAC is important in the design of medium to large industrial and office buildings such as skyscrapers and in marine environments such as aquariums, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Ventilating or Ventilation (the V in HVAC) is the process of "changing" or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air. 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. Methods for ventilating a building may be divided into mechanical/forced and natural types.

1.1Definitionof A/C:

The American society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) defines air conditioning as: “The process of treating the air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space”.

Air conditioning is a field of work that never stagnates. Air-conditioning is commonly used to ease men’s environmental problems on earth and in space. The very adverse problems of space environment are also successfully solved with the advanced knowledge of air-conditioning that has made the successful space travel. The refrigeration and air-conditioning industry in India got the impetus to progress with the dawn of independence in India. This industry has achieved phenomenal growth in less than two decades in our country. The annual output has increased from 800 tons in the early fifties and to about 80,000 tons in 1970. This industry now produces a wide range of light and heavy equipment that has reduced in the import from 50.5% Air-Conditioning Systems.

II - LITERATURE SURVEY

Commercial Air-Conditioning According To Application
Industrial Air-Conditioning

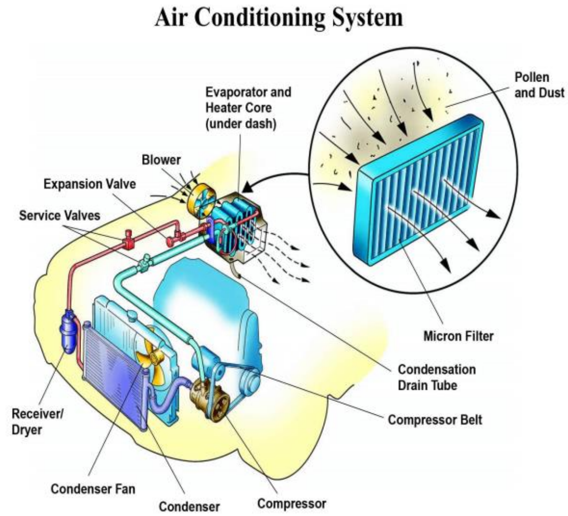

Fig 2.1:-Basis Air-Conditioning system

2.2 Commercial Air-Conditioning According To Application:

This includes air-conditioning of multi room structure like apartments, hotels, office buildings and hospitals. Although treatment varies somewhat for these applications, the basic problems are the same.

Individual control of room temperature is desirable.

Cooling system should also be suitable for winter heating to eliminate duplication of risers and equipment.

Unusual heat loads should be considered.

Fan noise, air noise and cross talk between rooms through ductwork are undesirable

When these requirements are considered in conjunction with loads and equipment, it is not difficult to understand why quality air-conditioning for multi room buildings are more costly per unit capacity than many other types of comfort installation.

2.3 Industrial Air-Conditioning

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There has some tendency to draw a sharp line of demarcation between systems designed for personnel comfort and those designed for process control. The distinction hardly warranted because the procedure in both instances must necessarily be identical.

Special treatment may be necessary in some industrial application due to requirement of continues operation, 24 hrs a day & 7 days a week, or due to peculiar conditions of corrosion, contamination hazards, concentrated heat load or other adverse operating conditions.

It is necessary for the designer to understand the industrial process in order to minimize hazards. Furthermore since conditions must be maintained regardless of outside weather conditions particular attention should be directed to adequate installation of roof and walls.

Adequate moisture barriers kin building construction, particularly when high Double glass, block or no windows where high humidity is necessary for process during winter weather.

The use of shading screen, Venetian blinds or other means of preventing the entrance of direct sunlight.

Adequate ceiling weights to provide space for ventilation hood, air duct and pipes. The evaluation of the storage effect of structure, equipment and materials in process if operation is on 24 hrs bases.

Many industrial air-conditioning installations are just as necessary for providing productive working conditions for employees as for the product or process. In fact it is often desirable to depart somewhat from optimum process conditions to provide comfortable working conditions.

2.4 Unit of Refrigeration

Unit of refrigeration is “Ton”. A ton here doesn’t mean mass it is a measure of rate of heat transfer. We know that latent heat of fusion of ice is 336 KJ/Kg. When one ton that is 1000 kg of ice melt in 24 hrs it produces cooling effect at the rate of 233 KJ/min. In other words, if heat is removed from water at the rate of 233 KJ/min we get 1000 kg (I tone) of ice per day.

2.5 Types of Refrigeration Systems
Vapor Compression system
Vapor Absorption System

2.5.1 Vapor Compression system:

A schematic flow diagram showing the basic components of vapor compress refrigeration system is shown in figure below some typical temperatures for air-conditioning applications are indicated. Refrigerant fluid circulates through the piping and equipment to the direction shown. There are four processes that occur it flows through the system they are as follows:

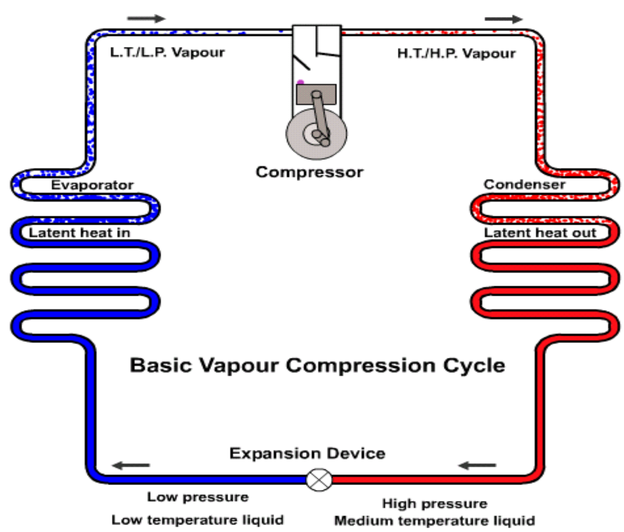

Fig.2.2: Vapor Compression Cycle

2.5.2Vapor Absorption System:

The absorption refrigeration system is quite similar to the vapor compression refrigeration system. In the absorption refrigeration system, refrigerant is produce by evaporation of a liquid (refrigerant) in the evaporator. The difference between the two systems lies in the method of converting the refrigerant vapor back to liquid. In vapor compression system compressor and condenser are used to the conversion of refrigerant vapor (coming from the evaporator) into liquid. In the absorption system also, the condenser is used but the compressor is replaced by the combination of absorber generator.

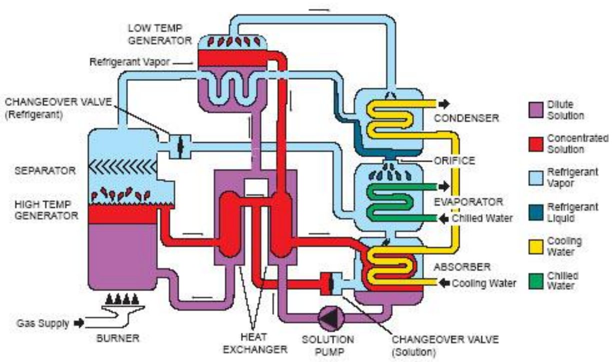

Fig.2.3: Vapor Absorption Cycle

In vapor compression system, the refrigerant vaporizes in the evaporator, absorbing its latent heat from the surrounding, the suction side of the compressor draws the refrigerant vapor from the evaporator compresses it an delivers it to the condenser were the high pressure vapor is condensed into a liquid. So we have the three components viz. evaporator, compressor and condenser. The compressor sucks vapor compresses and discharges it into the condenser. So we can say that the compressor has suction side as well as a discharge side. In the absorption system also we have the evaporator and condenser doing the same function as in the vapor compression system. The absorber does the suction function of the compressor and the generator replaces the discharge side of the compressor.

As shown in figure, the absorbent and refrigerant circulating pattern differ. The refrigerant part is generator to condenser, condenser to evaporator and evaporator to absorber and from the absorber to the generator mixed with the solution.

3. Equipments of Air-Conditioning System

3.1Compressors

The function of compressor is to compress the low-pressure refrigerant vapor from the evaporator to high-pressure temperature, which the refrigerant vapor can be conveniently condensed to a liquid with the aid of in expensive cooling media, such as atmospheric air or water at normal temperature. Two stage reciprocating compressor and multi stage centrifugal compressor also available for serving scientific application.

3.2 CONDENSER

The function of the condenser is to superheat the high-pressure gas, condensate it and also sub cools the liquid. Heat from the hot refrigerant gas is rejected in the condenser to the condensing medium (air or water). Air and water are chosen because they are naturally available. Their normal temperatures range in satisfactory for condensing refrigerants.

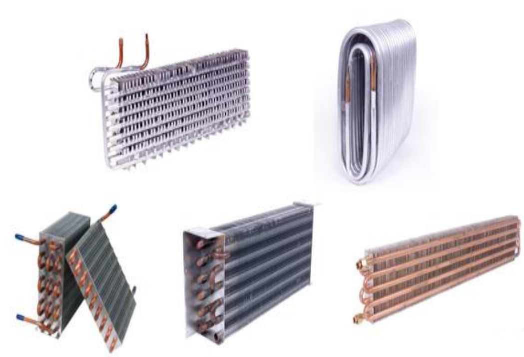

Fig 3.2: Condenser

3.4 REFIGERENT

A refrigerant is a substance or mixture, usually a fluid, used in a cycle. In most cycles it undergoes phase transitions from a liquid to a gas and back again. Fluorocarbons, especially chlorofluorocarbons, became commonplace in the 20th century, but they are being phased out because of their ozone depletion effects. Other common refrigerants used in various applications are ammonia, sulfur dioxide, and non-halogenated hydrocarbons such as propane. The ideal refrigerant would have favorable thermodynamic properties,
be noncorrosive to mechanical components, and be safe, including free from toxicity and flammability. It would not cause ozone depletion or climate change. Since different fluids have the desired traits in different degree, choice is a matter of trade-off. The desired thermodynamic properties are a boiling point somewhat below the target temperature, a high heat of vaporization, a moderate density in liquid form, a relatively high density in gaseous form, and a high critical temperature. Since boiling point and gas density are affected by pressure, refrigerants may be made more suitable for a particular application by choice of operating pressures.

3.5 Requirement for Refrigerants:

The generally requirement for any refrigerant are
It should be non-poisonous
It should be non-explosive
It should be non-corrosive
It should be non-inflammable
Leaks should be easy to detect
It should be operated under low pressure (low boiling point)
It should be non-toxic (not harmful if inhaled or if spilled on skin)

3.6 Important Refrigerants:

1. Ammonia (NH_3) – R717:

It is the only refrigerant form inorganic group, which was used universally for many applications and still used to great, extends at the present time. Few properties for ammonia are listed below

It is toxic, flammable, irritating and food destroying.
Ammonia attacks on non-ferrous metals in the presence of water therefore copper and brass are never used with ammonia refrigeration system.
Ammonia can be used economically for 70˚C evaporator temperature and its application for further low temperature becomes highly uneconomical and difficult vacuum required in the evaporator.

2. Freon – 12 (CCL_2F_2) – R 12:
This is most widely used and most popular refrigerant. It is commonly used for all refrigeration purpose (low, medium and high temperature). It is colorless and odorless liquid. It is non-toxic, non-flammable and non-corrosive. It condenses at moderate atmospheric pressure. It simplifies the problem of oil return as it has good oil miscibility. This refrigerant is commercially available in different cylinder sizes. General 0.7 Kg or refrigerants is required in refrigeration system per cubic meter of air-conditioned space.

4. PSYCHOMETRY

4.1 Psychometric

It is science and practice associated with atmospheric air, method of control of its temperature/moisture content and its effect on material and human comfort.

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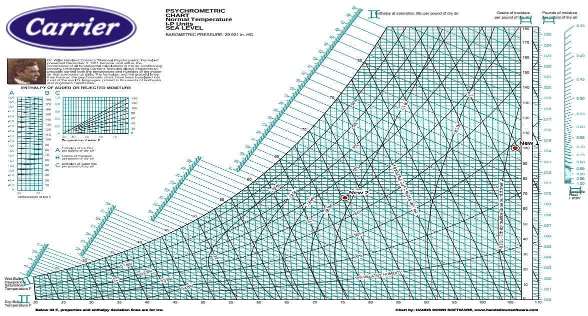

Fig 4.1:-psychometric chart

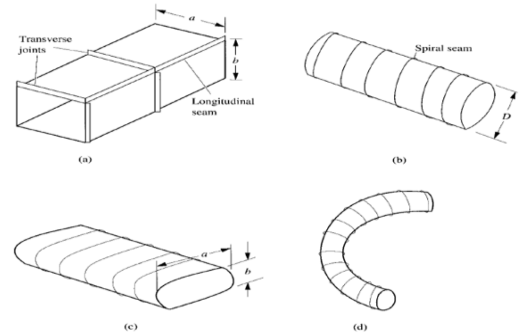

Fig 7.2: Various type of air duct: (a) Rectangular duct; (b) round duct with spiral beam; (c) Flat oval duct; (d) flexible duct.

Duct Material

The ducts are usually made from galvanized iron sheet metal, aluminum sheet metal or black steel. The most commonly used duct material in air conditioning system is galvanized sheet metal, because the zinc coating of this metal prevents rusting and avoids the cost of painting. The sheet thickness of galvanized iron (G.I) duct varies from 26 gauges (0.55 mm) to 16 gauges (1.6 mm). The aluminum is used because if it's lighter weight and resistance to moisture. The black sheet metal is always painted unless they withstand high temperature.

Now-a-days, the use of non-metal ducts has increased. The resin bonded glass fiber ducts are used because they are quite strong and easy to manufacture according to the desired shape and size. They are used in low velocity applications less than 600 m/min and for static pressure below 5mm gauge. The cement asbestos ducts may be used for underground air distribution and for exhausting corrosive materials. The wooden ducts may be used in places where moisture content in the air is not very large.

The objective of duct design is to determine the dimension of all ducts in the given space. The duct should carry the necessary volume of conditioned air from the fan outlet to the conditioned space with minimum frictional and dynamic losses. The duct layout must be made so as to reach the outlet without least number of bends, obstruction and area changes. The area changes must be gradual where possible and limited to not more than 20^0 for diverging area and 60^0 for converging area. For rectangular duct, the aspect ratio of 4 and less is desirable but it should not be greater than 8 in any case. The minimum sheet metal is required with square cross-section for given cross section.

III - SOFTWARE IMPLEMENTATION

There are numerous software's involved in our HVAC designing and detailing project on a commercial / Offices Tower, for calculation purposes. They are as follows:

HAP SOFTWARE

HAP (Hourly analysis program) soft ware is used to calculate heat load calculation of the system. By this system total tonnage of the machine that to be installed is known, by giving the inputs such as exposures present in the space, occupancy density, lighting and electrical load of the space.

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Procedure for calculation is as follows:

Step1: A weather property of the location where the building is located is entered.
Step2: Schedules such as lighting, people, electrical should be prepared in project libraries.
Step3: Exposures and u values are given for wall, window and roof in project libraries.
Step4: In spaces according to the orientation of the individual room exposure of walls, windows and roofs are entered.
Step5: In system, type of machine to be installed is given in which spaces are added to each machine depending upon the requirement

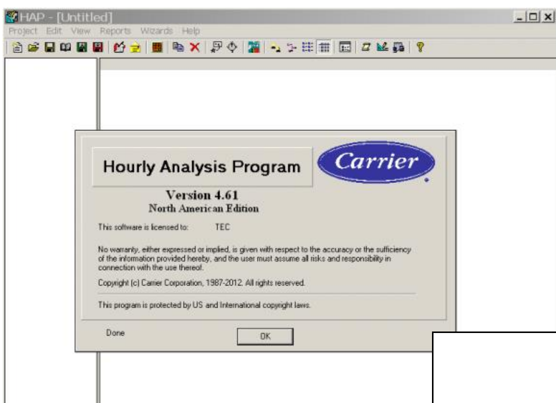

Fig. 3.1: Hap Software

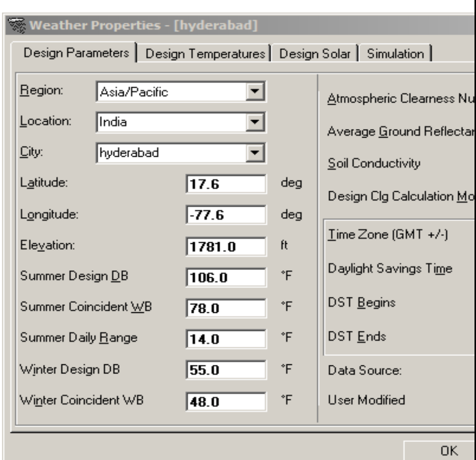

Fig. 3.2: Weather condition entr

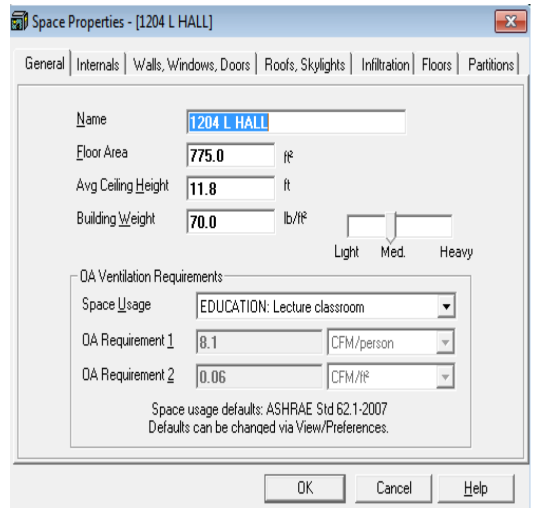

Fig 3.3: Dialog Box for Space Properties-General

IV - CALCULATED DATA

ASHRAE RECOMMENDED VALUES
Outdoor Air Requirements for Ventilation

Table 1: Outdoor Air Requirements for Ventilation

APPLICATION	CFM/ PERSON	CFM/S
Lecture class room	7.5	0.0
Science laboratories	10	0.1
Computer lab	10	0.1
Multipurpose assembly	5	0.0
Office space	5	0.0
Libraries	5	0.1

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Lighting Load:

Enter the lighting load in WATTS/SQ FT. This value will be multiplied with the zone area in get the lightening load, see table below:

Table 2: Lighting Load

CLASSIFICATION	LIGHTS(WATTS/SQ.FT)		
	Lo	Av	Hi
Apartment, High Rise	1.0	2.0	4.0
Auditoriums, Churches, Theatres	1.0	2.0	3.0
Schools, Colleges, Factories, Assembly Areas	3.0	4.5	6.0
Light Manufacturing	9.0	10.0	12.0
Heavy Manufacturing*	15.0	45.0	60.0
Hospitals, Patient Rooms	1.0	1.5	2.0
Public Areas	1.0	1.5	2.0
Hotels, Motels, Dormitories	1.0	2.0	3.0
Libraries and Museums	1.0	1.5	3.0
Office Buildings (General)	4.0	6.0	9.0
Private Offices	2.0	5.8	8.0
Stenographic Department	5.0	7.5	10.0
Residential Large	1.0	2.0	4.0
Residential Medium	0.7	1.5	3.0
Restaurants Large	1.5	1.7	2.0
Restaurants Medium	--	--	--
Shopping Centers, Beauty and Barber Shops	3.0	5.0	9.0
Department Stores	2.0	3.0	4.0
Basement			
Main Floors	3.5	6.0	9.0
Upper Floors	2.0	2.5	3.5
Drug Stores	1.0	2.0	3.0
5c and 10c Stores	1.5	3.0	5.0
Hat Shops	1.0	2.0	3.0
Shoe Shops	1.0	2.0	3.0
Malls	1.0	1.5	2.0
Dress Shops	1.0	2.0	4.0

U Factor Glass

Enter the corresponding U values. For details refer ASHRAE Fundamentals Manual/glass manufacturers' information catalogs.

VENTILATION

Ventilation air, as defined in ASHRAE standard 62.1 and the ASHRAE handbook, is that air used for providing acceptable indoor air quality.

When people or animals are present in buildings, ventilation air is necessary to dilute odours and limit the concentration of carbon dioxide and airborne pollutants such as dust, smoke, volatile organic compounds (VOC's).

Ventilation air is often delivered to spaces by mechanical systems which may also heat, cool, humidify the space.

V - HAP ANALYSIS RESULTS

Air System Sizing Summary for Project

Project Name: Project
Prepared by:
13-06-2021
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Air System Information

Air System Name	Project	Number of zones	1
Equipment Class	CW AHU	Floor Area	387[illegible] ft²
Air System Type	SZCAV	Location	Bangalore, India

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	Sum of space airflow rates	Calculation Months	Jan to Dec
Space CFM	Individual peak space loads	Sizing Data	Calculated

Central Cooling Coil Sizing Data

Total coil load	13.4	Tons	Load occurs at	Jun 1600	
Total coil load	160.6	MBH	OA DB / WB	92.4 / [illegible]	°F
Sensible coil load	149.6	MBH	Entering DB / WB	77.7 / 63.2	°F
Coil CFM at Jun 1600	8909	CFM	Leaving DB / WB	60.3 / 59.1	°F
Max block CFM	8909	CFM	Coil ADP	58.4	°F
Sum of peak zone CFM	8909	CFM	Bypass Factor	[illegible]	
Sensible heat ratio	0.932		Resulting RH	56	%
ft²/Ton	289.7		Design supply temp.	[illegible]	°F
BTU/(hr-ft²)	41.4		Zone T-stat Check	0 of 1	OK
Water flow @ 10.0 °F rise	32.13	gpm	Max zone temperature deviation	0.1	°F

Central Heating Coil Sizing Data

Max coil load	15.8	MBH	Load occurs at	Des Htg	
Coil CFM at Des Htg	8909	CFM	BTU/(hr-ft²)	4.1	
Max coil CFM	8909	CFM	Ent. DB / Lvg DB	[illegible]	°F
Water flow @ 20.0 °F drop	1.58	gpm			

Supply Fan Sizing Data

Actual max CFM	8909	CFM	Fan motor BHP	0.00	BHP
Standard CFM	7978	CFM	Fan motor kW	0.00	kW
Actual max CFM/ft²	2.30	CFM/ft²	Fan static	0.00	in wg

Outdoor Ventilation Air Data

Design airflow CFM	628	CFM	CFM/person	[illegible]	CFM/person
CFM/ft²	0.16	CFM/ft²			

VI - CONCLUSION

Based on the inputs & room data sheets and data Summary sheet the projected TONS will be calculated. To offset this load we propose to provide Water Cooled Chillers with a standby option. Three will be as duty chiller while other one will be as standby.

The Water Cooled Chillers and the pumps will be located in the Chiller plant room assigned for the purpose on the Roof Deck floor. The plant room will be duly ventilated. The FAN COIL UNITS' will also be located on the Roof Deck Floor.

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 chillers and they will circulate the water from the chillers to the Various Zone AIR HANDLING UNITS are constant speed type. This way the pumps need not run at constant speed always and hence energy is saved.

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