Kshitij 2014

the techno-management fest

KRYOTECH

TUTORIAL

Indian Institute Of Technology, Kharagpur

Introduction

The goal of the heating, ventilating, and air conditioning (HVAC) system is to create and maintain a comfortable environment within a building. A comfortable environment, however, is broader than just temperature and humidity.

Comfort requirements that are typically impacted by the HVAC system include:

• Dry-bulb temperature

• Humidity

• Air movement

• Fresh air

• Cleanliness of the air

• Noise levels

Any HVAC system can be dissected into basic subsystems. These subsystems will be referred to as "loops/" There are five primary loops that can describe virtually any type of HVAC system.

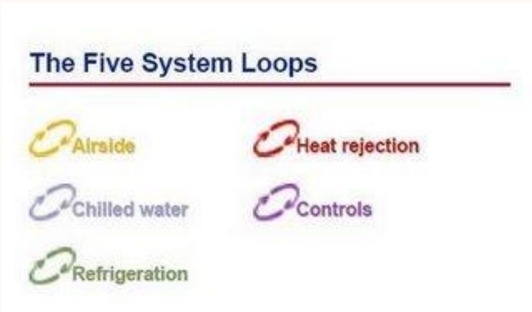
• Airside loop (yellow)

• Chilled-water loop (blue)

• Refrigeration loop (green)

• Heat-rejection loop (red)

• Controls loop (purple)



Why HVAC

- Air conditioning already uses more than 16% of the total electrical energy produce in India
- Average HVAC system running constantly uses its capital cost in electricity in just few months.
- Typical retrofit ROI is recoverable in less than 24 months.
- Reduction in Capex for backup power and connected switchgear improves the payback period
- Due to High humidity and temperature combination IAQ improvement cost are extremely high.

List of considerations

- Infection control practices to minimize airborne contaminants
- Air distribution effectiveness within spaces served by the ventilation/HVAC systems
- Air quality requirements in the healthcare facilities
- Room pressure relationships of isolation rooms
- Temperature and humidity design criteria
- Filtration practices
- Selection of HVAC equipment including chillers, air-handling systems and distribution systems
- Energy-conservative design practices for the healthcare environment
- Heat Transfer and Load Calculation -- Conduction; convection; radiation; thermal capacitance; and sensible and latent heat transfer.
- Temperature Design Conditions and Weather Data - Inside and outside design conditions; winter outdoor design temperature; wind and annual extremes data; summer outdoor design conditions; and other sources of climatic information.

8 Basic HVAC Parts Found in Every HVAC System

The acronym HVAC stands for "heating, ventilation, and air conditioning." An HVAC system is responsible for moderating the temperature of a building's interior and maintaining it at a comfortable level for the inhabitants. During the hot days of summer, the air conditioning kicks in, providing much-needed cool air. In the frigid days of winter, the system supplies heat.

When all the parts of an HVAC system are functioning correctly, the system is more efficient. An efficient system uses less power to accomplish its necessary heating and cooling functions, and therefore it costs the owner less money in electric bills or gas bills. It is important for owners to conduct regular maintenance on their HVAC systems to keep them functioning optimally.

- **The Furnace**
  The furnace unit is typically fairly large, requiring its own space within a building. It is often installed in the basement, in the attic, or in a closet. The furnace pushes the cold or hot air outward into the ducts that run through every room in the building. Throughout the ducts, there are vents that allow the warm or cool air to pass into rooms and change their interior temperature.

- **The Heat Exchanger**
  Heat exchangers reside in the housing of every furnace unit. When the furnace is activated by the thermostat, the heat exchanger begins to function as well. Air is sucked into the heat exchanger, either from the outside or from a separate duct that pulls cool air out of the building's rooms. This type of duct is called a cold air return chase. When the cool air comes into the heat exchanger, it is quickly heated and blown out through the ducts to be dispersed into the building. If the furnace operates on gas, the heating is accomplished by gas burners. If it uses electricity, it is done via electric coils.
- **The Evaporator Coil**
  Like heat exchangers, evaporator coils are also part of the furnace unit. However, they serve the opposite function to that of heat exchangers. They are also attached to a different part of the furnace. Instead of being within the furnace housing, they are installed inside a metal enclosure that is affixed to the side or the top of the furnace.
  Evaporator coils are activated when cool air is needed. When triggered, the evaporator coil supplies chilled air, which is then picked up by the furnace blower and forced along the ducts and out through the vents. The internal design of an evaporator coil resembles that of a car's radiator. Evaporator coils are connected to the HVAC system's condensing unit, which is typically located on the exterior of the building.
- **The Condensing Unit**
  The condensing unit is installed outside the building, separate from the furnace. Inside the condensing unit, a special kind of refrigerant gas is cooled through the exchange of heat with the air outside. Then, it is compressed and condensed into liquid form and sent through a tube or a line made of metal. This tube runs straight to the evaporator coil. When the liquid reaches the coil, a series of small nozzles spray the liquid, lowering its pressure and allowing it to resolve back into gaseous form. During the evaporation of liquid to gas, heat is absorbed, causing a sudden drop in temperature and supplying cold air for the furnace blowers. The refrigerant gas is then sent back outside to the condensing unit, and the process is repeated again to generate additional cold air.
- **The Refrigerant Lines**
  The refrigerant lines are the metal tubes that carry the liquid to the evaporating coil and return the gas to the condensing unit. Refrigerant lines are usually made from aluminum or copper. They are designed to be durable and functional under extreme temperatures.
- **The Thermostat**
  The thermostat controls the function of the furnace. It is directly connected to the furnace and includes temperature-sensing technology as well as user controls. A thermostat is usually positioned somewhere within the building where it can easily discern temperature and remain accessible to users. A large building may have more than one thermostat to control different areas of the structure. The inhabitants of the building can manually set the thermostat to a certain temperature. If the air in the room or building is too cold, the heat exchanger kicks in and blows heat through the vents. If the room is too warm, the condensing unit and evaporator coil start to

function, and the air conditioning system sends cool air throughout the building or to one particular section of the building.

- **The Ducts**

  Heating ducts are put in during the construction of a home or a building. They are often run through the ceiling. In each room, at least one rectangular opening is cut into the duct so that a vent or vents can be installed.

- **The Vents**

  Vents are usually rectangular in shape. They are placed in the ceiling, with their edges corresponding to the opening in the duct above. As warm or cool air pours through the ducts, vents allow it to disperse into the rooms below. Vents are usually made of metal, which can handle a wide range of temperatures. The vent is comprised of a rectangular edge or frame, within which is a series of thin metal slats. The slats are angled to channel the air downward. Some vents also include a manual control that lets users angle the air toward a different part of the room depending on their preference.

Terms that might be useful in the report submission

- DBT- The dry-bulb temperature (DBT) is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture.
- DPT- The dew point temperature (DPT) is the temperature at which the air must become cooled to in order to become completely saturated with water vapor.
- U factor- U-factor is the rate at which a window, door, or skylight conducts non-solar heat flow. It's usually expressed in units of Btu/hr-ft2-oF.
- AIR CHANGE RATES -Ventilation supply rates for health care facilities require large expenditure of fresh air to dilute and remove the contaminants generated in the space. The ventilation rates for healthcare facilities is expresses as air changes air per hour (ACH), which is a measure of how quickly the air in an interior space is replaced by outside (or conditioned) air. For example, if the amount of air that enters and exits in one hour equals the total volume of the space, the space is said to undergo one air change per hour. Air flow rate is measured in appropriate units such as cubic feet per minute (CFM) and is given by: Q= ACH*ROOM VOLUME/ 60 Min/hr. In this equation, Q is the volume flow rate of air being calculated, and ACH is the number of air changes per hour.

Technical terms:-

- Sensible Heat Gain – is the energy added to the space by conduction, convection and/or radiation.
- Latent Heat Gain – is the energy added to the space when moisture is added to the space by means of vapor emitted by the occupants, generated by a process or through air infiltration from outside or adjacent areas.
- Radiant Heat Gain – the rate at which heat absorbed is by the surfaces enclosing the space and the objects within the space.
- Space Heat Gain – is the rate at which heat enters into and/or is generated within the conditioned space during a given time interval.
- Space Cooling Load – is the rate at which energy must be removed from a space to maintain a constant space air temperature.
- Space Heat Extraction Rate - the rate at which heat is removed from the conditioned space and is equal to the space cooling load if the room temperature remains constant.
- Relative humidity - describes how far the air is from saturation. It is a useful term for expressing the amount of water vapor when discussing the amount and rate of evaporation.
- Air handling unit (AHU) – a central unit consisting of a blower, heating and cooling elements, filters, etc. that is in direct contact with the airflow

- Chiller – a device that removes heat from a liquid. The cooled liquid flows through pipes and passes through coils in air handling units, FCUs, etc.
- Coil – equipment that performs heat transfer inside AHU etc.
- Damper – a plate or gate placed in a duct to control Airflow
- Fan coil unit (FCU) – a small terminal unit that is often composed of only a blower and a cooling coil
- Variable air volume (VAV) – an HVAC system that has a stable supply air temperature and varies the airflow rate with dampers and adjusting fan speeds to meet the temperature requirements.

Heating

- Small spaces such as homes use heating systems that contains a boiler or furnace, so to heat water, steam, or air in a central location such as a furnace room in a home or a mechanical room. The use of water as the heat transfer medium is known as hydronics.
- The large structure such as a hospital have systems that contain either ductwork for forced air systems or piping to distribute a heated fluid and radiators to transfer this heat to the air. The radiators may be mounted on walls or buried in the floor to give under-floor heat.
- All but the simplest boiler-fed or radiant heating systems have a pump to circulate the water and ensure an equal supply of heat to all the radiators. The heated water can also be fed through another (secondary) heat exchanger inside a storage cylinder to provide hot running water.
- Forced-air systems send heated air through ductwork. During warm weather the same ductwork can be used for air conditioning. The forced air can also be filtered or passed through air cleaners.

Heat Transfer Concepts

- Conduction
- Convection
- Radiation
- Resistance
- U=1/R
- U value is the rate of heat in Btu/hr through a one cubic ft area when one side is 1DEGREE F Warmer
- Q=U x A(T2-T1)

Conduction Through Roofs, External Walls & Glass

Q=U*A*(CLTD)

Where:

Q=Heat conducted

U=Thermal Transmittance for roof or wall or glass

A=Area of building, wall or glass calculated from building plans

CLTD=Cooling Load Temperature Sunlit Surfaces

Most Exterior surfaces of a building are exposed during some portion of day. Light and radiant heat can pass through a transparent surface, neither pass through an opaque or non-transparent surface. Certain amount of radiant energy is transferred to roof, when it strike's its surface, resulting in increase in surface temperature.

Solar Load Through Glass

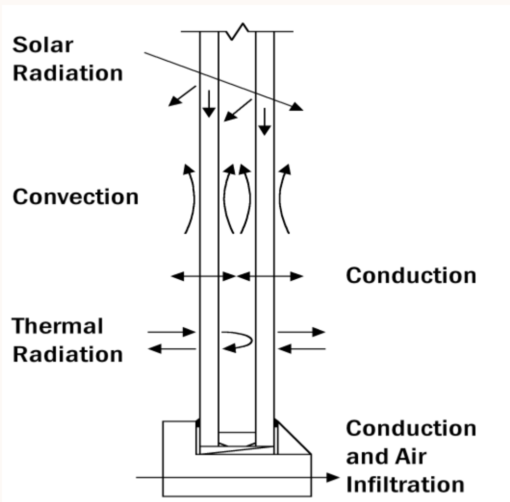
•Q = A * (SHGC) * (CLF)

•A = area of roof, wall or glass calculated from building plans

• SHGC= Solar Heat Gain Coefficient.

• CLF = Solar Cooling Load Factor.

Energy flow through a window glass



Energy flows through a window

Ventilation

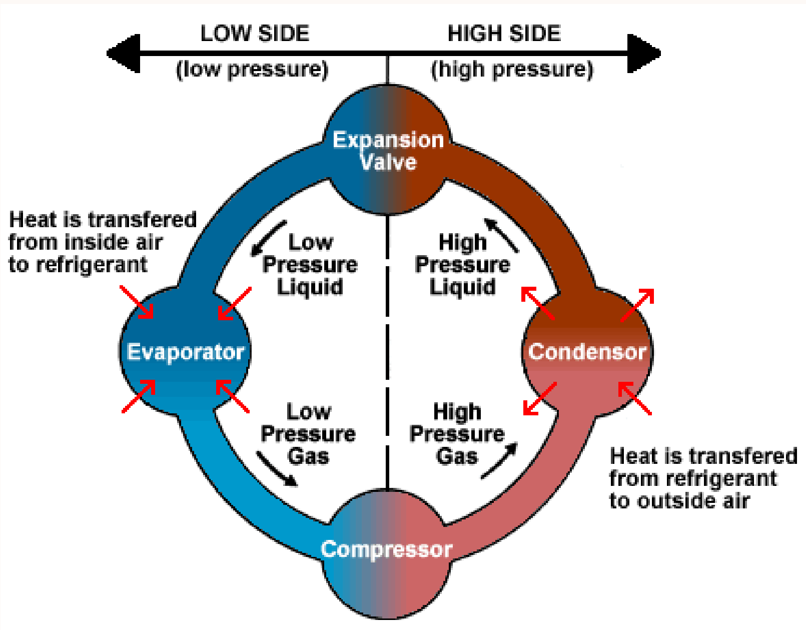
Ventilating (the V in HVAC) is the process of "changing" or replacing air in any space to provide high indoor air quality (i.e. to control temperature, replenish oxygen, or remove moisture, odors, smoke,heat, dust, airborne bacteria, and carbon dioxide). Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air.

- It's calculated from tables depending on the number of people or on the area of the roam in general.
- Fans provide the mechanical energy to move air through an HVAC system and to building spaces. But these spread contamination
- Due to the contaminants presents in inside air, ASHRAE has set ventilation standards as a guide for maintaining proper indoor air quality
- A carbon filter uses an activated carbon-filtering medium to remove most odors, gases, smoke, and smog from the air by means of an adsorption process.
- Enthalpy economizers use temperature and humidity levels of the outside air to control the operation of HVAC system.
- Ultraviolet air-cleaner systems kill biological contaminants using a specific light-wavelength (approximately 450 nanometers) not visible to the human eye.
- When water is present, even a small collection of dirt and dust provides a breeding ground for microbial contaminants in HVAC equipment such as drip pans, humidifiers, ducts, and coils.
- Drain pans must be pitched to allow drainage and must be periodically checked for blockages in the pan and drain pipes
- All pan and floor drain traps must be filled with water to prevent sewer gases from entering a building or HVAC system
- Even though variable-air-volume terminal boxes can throttle airflow from 100% to 0% of design flow, all VAV terminal boxes have a minimum flow settling to maintain ventilation standards.

Air conditioning

- Refers to the cooling and dehumidification of indoor air for thermal comfort
- Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favourable conditions.
- Air conditioning systems are designed to stabilise the air temperature and humidity within an area. Excess heat from the circulating air is usually removed by a cooling coil that is supplied with cold water
- To decrease relative humidity the circulating air needs to be cooled to a temperature below the dew point and then heated back to meet the requirement.
- Air conditioners are rated by the number of British Thermal Units (Btu) of heat they can remove per hour. Another common rating term for air conditioning size is the "ton," which is 12,000 Btu per hour.

Basic principle of Air conditioning



Assessment of Air Conditioning

- Airflow Q (m3/s) at Fan Coil Units (FCU) or Air Handling Units (AHU): anemometer.
- Air density ρ (kg/m3)
- Dry bulb and wet bulb temperature: psychomotor
- Enthalpy (kCal/kg) of inlet air (hin) and outlet air (Hout): psychometric charts

Indicative TR load profile

- Small wards : 0.1 TR/m2
- Medium size wards (10 – 30 people occupancy) with central A/C: 0.06 TR/m2
- Large common wards with central A/C: 0.04 TR/m2

Considerations for Assessment

- Accuracy of measurements
    - Inlet/outlet temp of chilled and condenser water
    - Flow of chilled and condenser water
- Integrated Part Load Value (IPLV)
    - kW/TR for 100% load but most equipment operate between 50-75% of full load
    - IPLV calculates kW/TR with partial loads
    - Four points in cycle: 100%, 75%, 50%, 25%

SOME TIPS TO REDUCE ENERGY CONSUMPTION AND COSTS IN BUILDINGS

- **Assess how your building consumes and wastes energy**.Conduct regular energy audits to determine what condition your equipment is in and how it is performing. These audits will show where and how energy is being wasted and prioritize energy improvement measures.
- **Use more energy efficient equipment.** Install new energy efficient equipment and replace or eliminate outdated, inefficient equipment. Look for Energy Star labels for equipment and appliances.

- **Match HVAC and lighting output to occupancy.** Install programmable building controls that enable systems to provide light, heat and cooling to building spaces only when they are occupied.
- **Maintain equipment for maximum efficiency.** Make sure that your equipment is properly serviced and maintained so that it runs as efficiently as possible. Increase operating efficiency of chillers, boilers and packaged cooling equipment through proactive service and maintenance.
- **Maximize lighting efficiency.** Upgrade lighting to high efficiency bulbs and fixtures. Energy efficient lighting uses less energy and generates less heat, reducing your costs and easing the strain on your HVAC systems.
- **Measure water usage and waste.** Conduct water audit in your facilities, campus, or geography to determine where water is being used and wasted. Reduce water consumption by installing low-flow equipment and fixing leaks.
- **Schedule cleaning during regular work hours.** Experiment with different "day cleaning" schedules. Arrange cleaning schedules to overlap with work hours instead of having cleaning done after hours and keeping the lights, heating and air conditioning on at night. That will reduce energy consumption.
- **Insulate thoroughly.** Insulate exterior walls, outlets, pipes, radiators, etc to reduce heat and cooling loss.
- **Meet LEED standards.** Build, renovate, and operate your facilities according to Leadership in Energy and Environmental Design (LEED) standards. That will benefit your bottom line by lowering operating costs and increasing asset value. It will benefit the environment by conserving energy and water, reducing waste sent to landfills, creating healthier, safer occupant environments, and reducing harmful greenhouse gas emissions.
- **Make building occupants more informed.** Educate and engage building occupants to promote energy conservation and reward wise energy decisions and behaviours.

INPUT CONDITIONS BASED ON WHICH THE HVAC SYSTEM HAS TO BE DESIGNED:

AREA TO BE AIR CONDITIONED: The building consists of 5 floors, each floor having area (required to be conditioned) of 20,000 sqft. Hence total area required to be conditioned is 1,00,000 sqft.

Orientation: The 4 walls of the building are on a perfect North, South, East, West orientation. Please consider a rectangular building having 200 ft length along the North and South direction and 100 ft length along East and West direction. Consider a total height of 14 feet for each floor, of which 10 ft is below false ceiling and 4 ft is above false ceiling.

Building Construction and heat load parameters: All the exposed walls shall be of standard 10 inch brick construction having ½ inch inside and outside plaster resulting in an overall U factor of 0.36 BTU/Hr/Deg. F sqft. Each of the exposed wall area shall have 30% exposed glass (30% of wall area below false ceiling). Glass shall have a U value of 0.5 BTU/Hr/ Deg. F sq. ft. and Solar Heat Gain Factor (SHGF) of 0.35.

Consider floor below and upper as air conditioned, except for the top most floor, for which consider a U value of 0.1 BTU/Hr/Deg. F sqft. for the exposed roof. No heat gain is required to be considered from the ground below the ground floor.

Occupancy: 50 sq ft per person occupancy for each floor (i.e. 400 persons per floor). Consider 100% occupancy from 09:00 hrs to 18:00 hrs. and 50% occupancy (distributed equally for all floors) from 18:00 hrs to 09:00 hrs. Consider normal office working activity for all occupants.

Light & Equipment Load: Total consider 3 watt / sqft during 09:00 hrs to 18:00 hrs, and 50% or 1.5 watt / sqft for all floors (from 18:00 hrs to 9:00 hrs).

Building operation: 24 x 7

Location & Ambient Condition for design (Deg. F): KOLKATA – West Bengal India, 100 / 83 DBT / WBT for summer and 90 / 84 DBT / WBT for Monsoon. No separate provision for heating / humidity control is required to be considered. In side conditions to be maintained at 72 Deg. F DBT +/- 2 Deg. F and RH 55% (without any specific control). For year round variation of weather data, please refer attached annexure.

Design Fresh air: As per ASHRAE Std 62.1 (2007) (which can be varied with occupancy).

Electricity Tariff Structure: 2 options are available: a) Fixed tariff rate of Rs 5.00/- KwHr throughout the day b) Variable tariff rate of Rs 5.00/- from 6:00 to 17:00 hrs, Rs 7.5/- from 17:00 hrs to 22:00 hrs and Rs 3.5/- from 22:00 to 6:00 hrs.

It is important to note that only a single tariff structure a) or b) as mentioned above can be considered for the entire building as a whole.

Service water availability: Available in good quality and quantity.

Piped LPG or oil or waste heat is not available at site.

Content of the report to be submitted by each group of engineers participating in the contest:

a) Summary of heat load calculation for all floors with internal loadings worked out at peak condition.

b) Estimated variation of cooling load for the building considering seasonal variation, occupancy and internal load variation as per data furnished in the problem statement.

c) Detailed description of the AC system considered for the building with capacities and types of cooling system, pumping system and Air Handling system considered. Logic for sizing and each type of equipment must be clearly spelt out.

d) Detailed analysis of year round energy consumption needs to be furnished with as much back-up data as possible.

e) Schematic layout of the AC system considered needs to be furnished. f) A technical report on innovative ideas that have been considered in your design.

Use the data given in Statistics for IND_Calcutta_IWEC in the report to be submitted

Click on the link http://ktj.in/static/eventdocs/Kryotech_IND_Calcutta_IWEC_stat.htm to download Statistics for IND_Calcutta_IWEC.