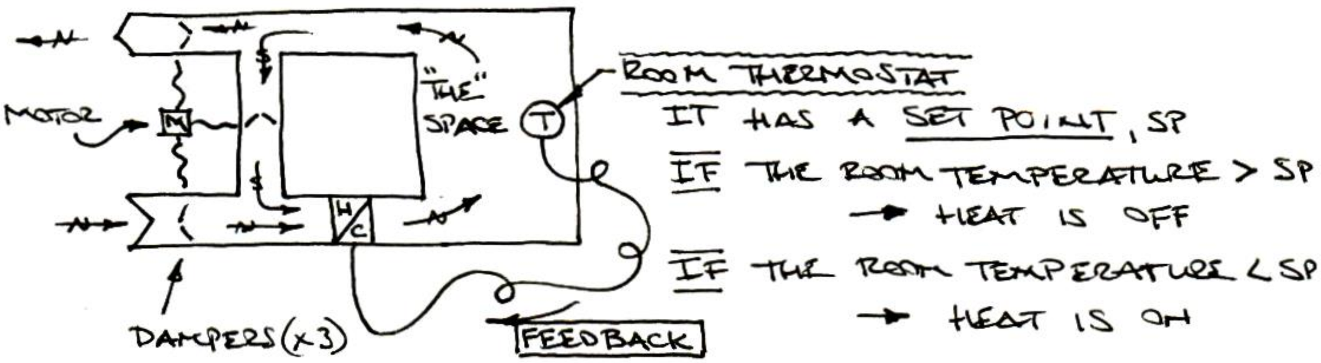
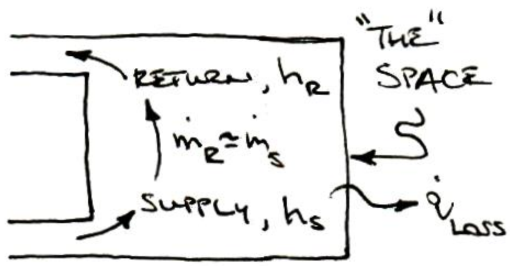
Introduction to HVAC Controls

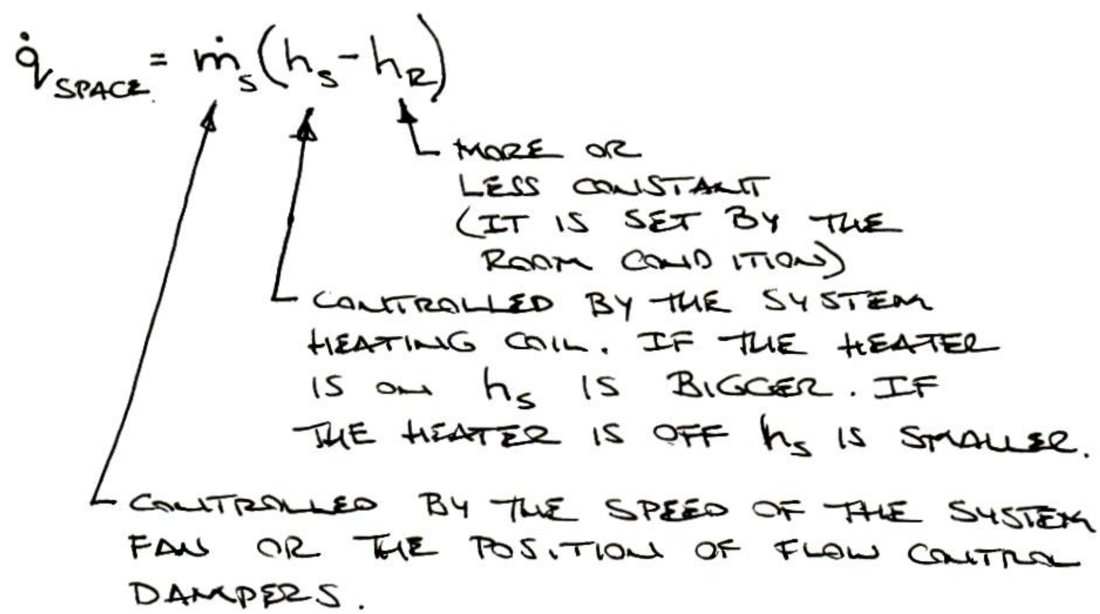


In the HVAC schematic above, there is a connection between the Room Thermostat and the Heating Coil. This connection between Thermostat and Heater is called FEEDBACK and it forms part of an information loop called a CONTROL LOOP.

In this case the Thermostat controls the action of the Heater. IF it is cold in the room the heater comes on and the supply air becomes warmer. IF the room is warm the heat is held off and the supply air becomes cooler.



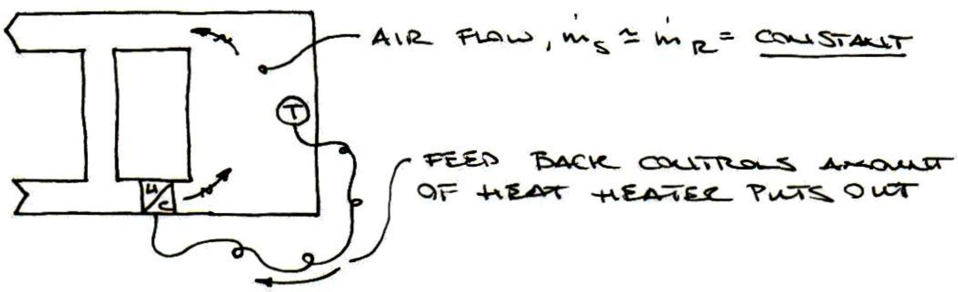
Is this the only way?
What are your choices?
The equation below helps.



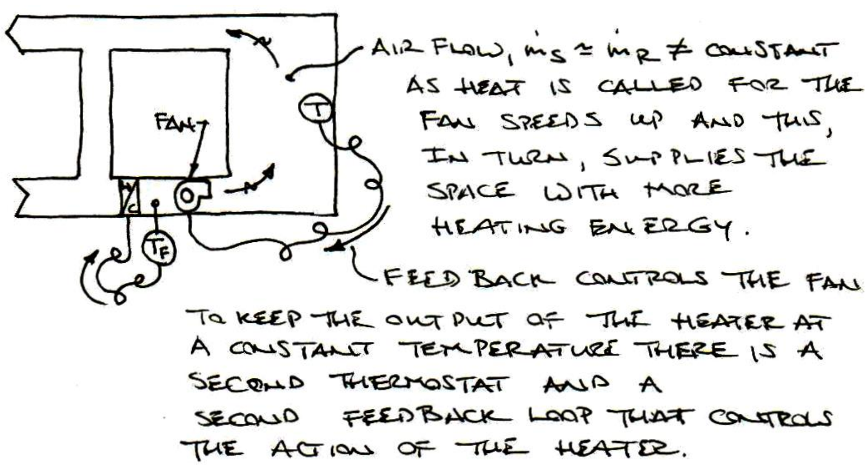
Let's say you want more heat in the space.
This equation dictates your choices as to how to do it.

1. Heater ON → Bigger h_S → $\dot{q}_{SPACE}$ = Bigger
2. Turn UP fan → Bigger $\dot{m}_S$ → $\dot{q}_{SPACE}$ = Bigger
3. Do Both … Heater ON & Turn UP fan → $\dot{q}_{SPACE}$ = Bigger

Option 1: Constant Volume, Variable Temperature (CVVT)

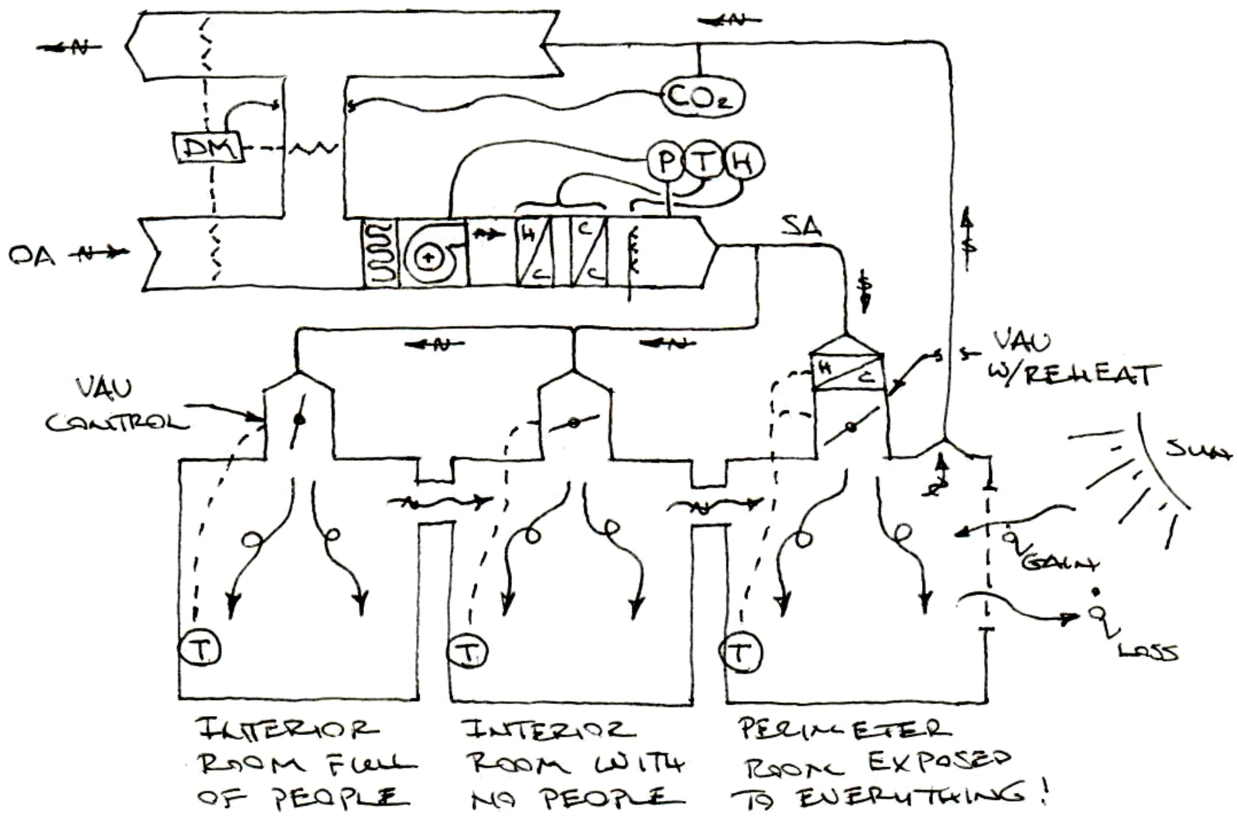


Option 2: Variable Volume, Constant Temperature (VVCT)



The systems pictured so far, will work for single-zone environment such as a car, a bus or homes. For commercial and industrial buildings, however, MULTI-ZONE environments are very NORMAL. The ventilation system, you design, has to be able to handle a diversity of conditions easily and smoothly, from space to space.

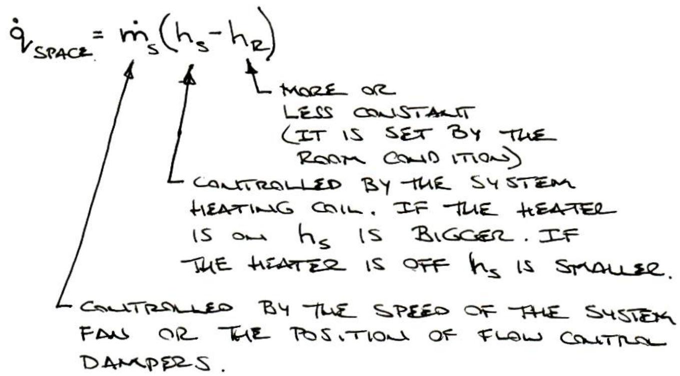
Take this school, for example, some classrooms are full and some are empty. The ones that are full and active put demands on the ventilation system to keep the space cool and keep the air fresh. At that same time, the empty rooms have no people-heat and people-pollutants. These empty rooms must be kept warm enough so they are ready for occupation at a moment's notice. It is up to the HVAC system to keep all these spaces comfortable at all times. To accomplish this apparently difficult task, a slightly more complex system arrangement is required.



Take a look at the system schematic above. Notice that there is a 'central system' supplying three occupied spaces with clean, conditioned air. The three occupied spaces are all quite different.

A. One is full of people.
   All those people give off lots of heat (sensible heat) and lots of humidity (latent heat), and they demand fresh air, giving off CO_2 and other polluting gasses as they breath and function.
   This room requires the supply air (SA), produced by the central cooling coil, to be cold and dry.
B. One has no people in it at all.
   In this empty room the lights are off as well. No heat or humidity is generated in the space and no polluting gases are generated. This room has to be kept at 'Room Temperature' so that, in the event that people come in and start to do what they do, they don't feel the space is cold or uncomfortable. This room is supplied with the same cold supply air (SA) that the first room demands.
C. One is connected to the outdoor and has a window.
   This room can have big heat losses to the outdoors in the winter, it can have bright sunlight shining in, delivering a big solar gain and it can have lots of people occupying the space or no one at all. Yet it is supplied with the same supply air (SA) as the other spaces.

To figure out how to make each of these very different spaces comfortable, all one has to do is consult this equation.



Here is a brief description of how each of these three occupied spaces is controlled.

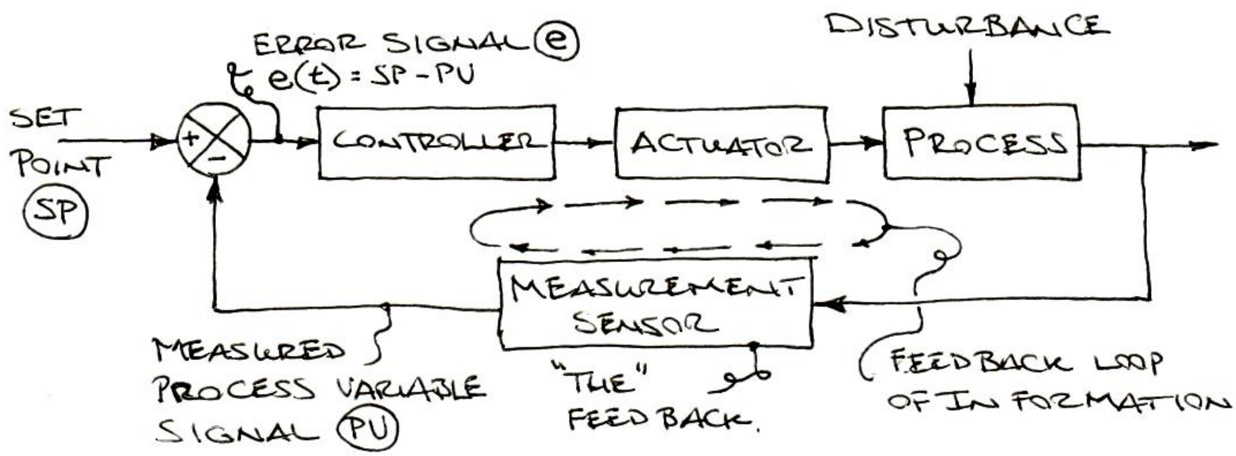
A. When the room thermostat detects that the room is getting warm it opens the VAV damper (VAV = Variable Air Volume) and lets more air in (increases the mass flowrate of air entering the space). If the VAV damper is at 100% open and the room continues to warm, then the temperature of the central system supply air (SA) is lowered. These things are done in succession (one after the other) until the set-point of the room thermostat is satisfied.

B. When the room thermostat detects that the room is getting cold (because the central system supply air (SA) is coming in cold and there are no heat gains given off in the space to offset the effect of that cold air) the VAV damper is gradually closed until the thermostat set-point is happy. The VAV damper is only allowed to close to some sort of minimum position (usually about 20% open). This type of control uses the mass flowrate of cold air entering the space as the primary control variable. If the room continues to cool below the thermostat's set-point, even with the VAV damper closed to its minimum … well then, that's life. The room gets cold. That is until people come in and warm it up.

C. This room has an extra way of controlling the temperature of the space. The VAV control housing is fitted with a hot water or electric heater. Its function is to take the cold supply air (SA), provided by the central system and, if required, re-heat it (warm it up). I think you can imagine why this might be needed. This room is, after all, connected to the great outdoors. On some days, it will be very cold out there and, without people in the room, this room might get quite cold. The re-heat coil serves to heat up the incoming supply air (SA) and keeps the room above some minimum temperature.

Control Feedback Loops

This whole arrangement may seem a bit complex and you might be wondering how all the elements work in a coordinated fashion. Does it require some complex computer program for it all to work properly? The answer is no. A computer is used often to centralize the control but a computer isn't really required to get this system to work. The reason this system can be controlled in a low-level, not so intelligent way, is that the overall control has been broken down and organized into a set of quite simple CONTROL LOOPs. A control loop is a loop of control INFORMATION that goes round and round. Here is a general illustration of a control loop.



In this diagram, notice that there is a SET-POINT, SP and measurement taken as to how the 'Process' is doing. The 'Process' in our case is the heating or cooling of a room. The Measurement Sensor measures the room temperature and supplies that data to a comparator. The comparator simply compares the Room Temperature with the desired Set-Point by numerically subtracting the two. The results of this comparative subtraction is called the ERROR, e. If the error is zero, then everyone is happy. If the Error is positive the room is cold (PV < SP … room temperature is below the thermostat set-point) and the VAV damper is gradually closed (Actuator). If the Error is negative (PV > SP … room temperature is larger than the thermostat set-point) then the VAV damper gradually opens letting in more cool supply air. This is an INFORMATION LOOP that provides feedback to the controller and enables it to take action.

Identify the Feedback Information/Action Loops in the VAV control system illustrated above:

- Room Thermostat → VAV Damper
- Room Thermostat → VAV Damper & Reheat Coil
- Duct Pressure → Fan Speed
  (Controls the overall air volume flowrate in the system as the VAV Dampers open and close throughout the system and through the day.)
- Central System Supply Air (SA) Temperature → Heating & Cooling Coil operation
- Central System Supply Air (SA) Humidity → Humidifier water valve
- Central System Return Air CO_2 Sensor → Outdoor Air (OA) Damper Motor (DM)
  (When the CO_2 levels in the Return Air are too high more outdoor air is let into the building to freshen the air. On the other hand, when the building is only occupied by only a few people, the Outdoor Air (OA) damper is closed to a minimum position, saving huge amounts of energy.)

Notice that the entire control system is organized into many smaller Control Loops. The key thing in identifying these Control Loops is to track the control INFORMATION. Information about temperature can be transmitted via electricity once it is measured, but temperature information also travels with the air as it moves around the space. Information travels with every physical quantity. Think of it as two things traveling around at once – the thing (air, cars, birds, whatever) and information about the thing (temperature, chemical make-up, species, etc.). They are bundled together … in everything.

Understanding that the 'the-thing' and 'information about the-thing' travel together but are different from each other, is central to the understanding how control system work.