# Control Strategies for OTs and Critical Areas

**By**

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# Control Systems for OTs and Critical Areas

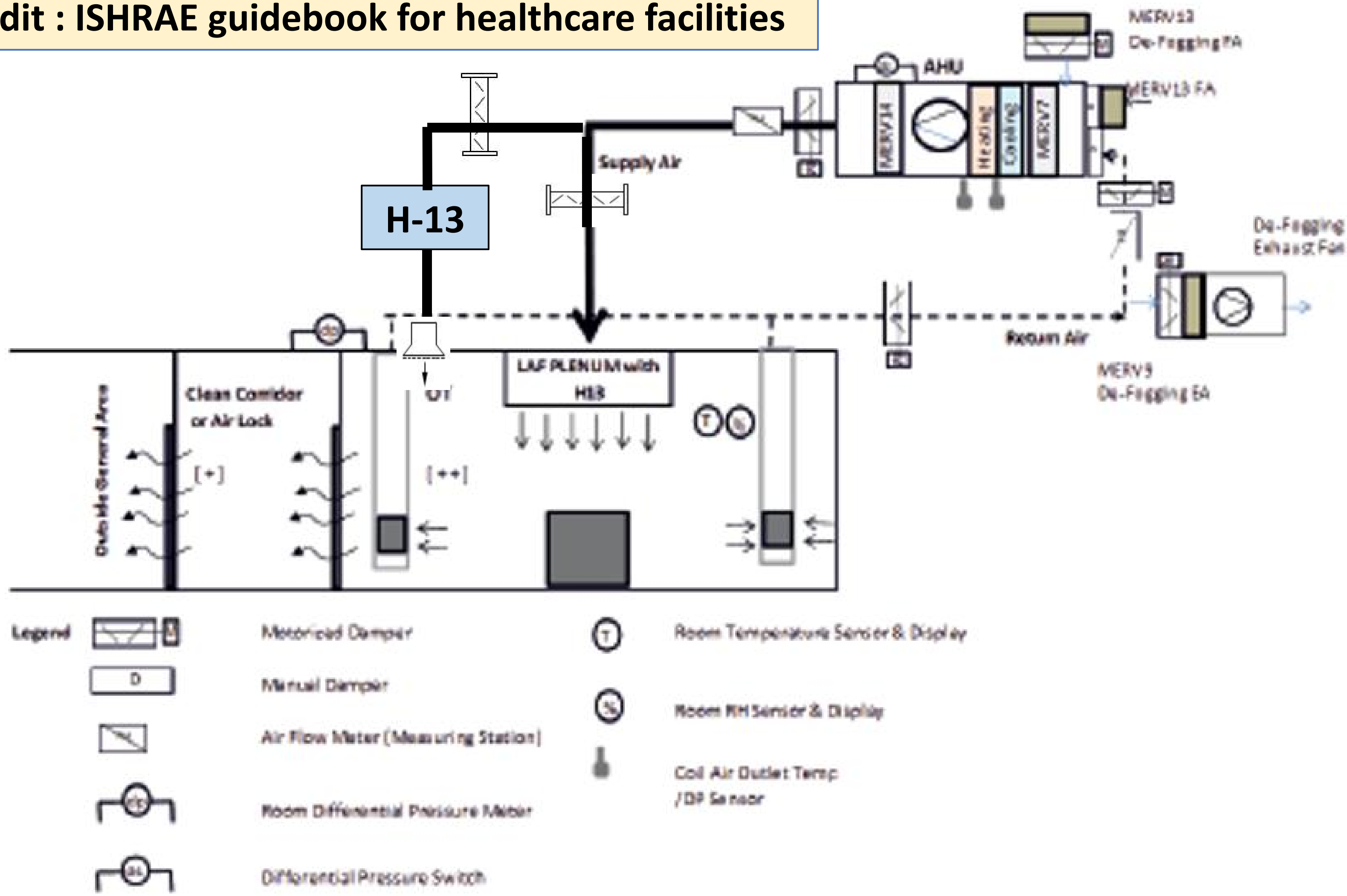
- **Why controls?**
  - **Equipment sizing.**
  - **Reliability.**
  - **Reduction of human dependency & errors.**
  - **Optimal energy usage.**
  - **Maintenance alerts.**
  - **Out if limit parameter alarm.**
  - **Operation safety.**
  - **Automatic scheduling & override.**
  - **Facility to monitor, record and trend.**

# Control Systems for OTs and Critical Areas

- HVAC system for OTs & critical areas
  - Air handling unit with
    - MERV-7 filters
    - Cooling coil (Either the chilled water coil or the Direct expansion refrigerant coil)
    - Heating coil or electric heaters for reheating as well as winter heating.
    - Fan
    - MERV-14 filters.
  - Return air duct with motorized damper
  - Supply air duct with air flow measuring device ( Nozzle on fan inlet cone for flow measurement acceptable) & LAF
  - Exhaust fan for defumigation or purge where required.

# Control Systems for OTs and Critical Areas

Credit : ISHRAE guidebook for healthcare facilities




Typical control schematic for operation theatre

# Control Systems for OTs and Critical Areas

- **Important parameters:**
  - **Room pressure (positive or negative as the case may be).**
  - **Room temperature.**
  - **Humidity.**
  - **Air flow rates.**

- **Important warnings & alarms:**
  - **Room pressure, upper & lower excursions**
  - **Room temperature, upper & lower excursion**
  - **Room humidity, upper & lower excursion.**
  - **Filter dirty status`**

# Control Systems for OTs and Critical Areas

- **Instrumentation & Field devices required:**
  - **Temperature sensor with room readout display.**
  - **Humidity sensor with room readout display.**
  - **Differential pressure across adjoining area.**
  - **Off coil temperature sensor post cooling coil.**
  - **Differential pressure switches across MERV-7 & MERV-14 filters.**
  - **Differential pressure transmitters across higher level filters.**
  - **Differential pressure transmitter for flow measurement.**
  - **Return air damper actuator.**
  - **Modulating control valves for chilled water. (In case of DX units staging of multiple units).**
  - **Modulating control valve for hot water (thyristor for electric heaters).**

# Control Systems for OTs and Critical Areas

- **Modes of operation:**
  - **Occupied mode : In this mode the system is operated at design air quantity, design temperature and humidity and with design differential pressure.**
  - **Unoccupied mode: In this mode air flow may be reduced to 50% of the day mode. The temperature may be reset to higher set point. However humidity and pressure differential will be continued to be maintained.**
  - **Fumigation mode or Purge mode (Where applicable): In this mode the system is switched off for predefined duration.**
  - **Defumigation mode: After fumigation cycle the system switches the mode such that it evacuates the fumes from the room.**

# Control Systems for OTs and Critical Areas

- Before the control system is activated, air side balancing needs to be performed. The process is as under:

  - Open all supply air and fresh air dampers fully.
  - Keep return air damper partially closed.
  - Defumigation fresh air and exhaust air dampers are fully closed with defumigation exhaust unit kept off.
  - Run the supply fan and ramp up the VFD slowly till approximately 110% of design flow is achieved.
  - Measure supply air quantities through LAF and grilles/diffusers.
  - Calculate percentage flow through each one with respect to design flow.

# Control Systems for OTs and Critical Areas

- Keeping the damper of lowest percentage device fully open, throttle other dampers so that the percentages through each device is approximately equal.
- At this stage, the AHU supply air control loop is activated with set point slightly higher than the designed flow.
- Measure the room differential pressure.
- If the pressure is lower, throttle the return air damper further to achieve the desired room pressure. If the room pressure is higher, open the return air damper to achieve the desired room pressure.
- Lock the return air damper at slightly higher open position.
- At this stage rest of the control loops can be activated.

# Control Systems for OTs and Critical Areas

- **Suggested control logic:**
- **Supply air flow control loop measures the air flow using the differential pressure sensor either across the fan inlet cone or across the air flow measuring station in the main supply air duct using the following formula.**
  - **Flow in CMH = *k* x Sqrt(ΔP) with ΔP in pascals for fan inlet cone measurement**
  - **Flow in CMH = 1.3 x Sqrt(ΔP) with ΔP in pascals for air flow measuring station.**

  **(Some AFMS manufacturers have contoured pitot static devises where published *k* factor should be used in place of 1.3)**
- **The set point for this loop is usually set at 2~5% higher than the design supply air flow.**
- **When the system is in unoccupied mode, the set point is reduced to 50%.**

# Control Systems for OTs and Critical Areas

- Room pressure control logic :
  - Room pressure control loop measures the room differential pressure.
  - Room differential pressure is achieved by controlling the return air damper.
  - For this purpose, a modulating damper actuator is installed on the return air damper.
  - The room pressure setpoint is set at the design room pressure (Usually between 8 to 12.5 Pa).
  - If room differential pressure increases the return air damper is modulated to open and if the room pressure decreases, the return air damper is modulated to close.
  - To avoid system hunting, it is advisable to freeze the loop when any of the OT doors are open. This signal can be achieved through the use of inexpensive proximity switches.
  - This loop remains active in unoccupied mode as well.

# Control Systems for OTs and Critical Areas

- **Room dry bulb and humidity control logic:**
- **Room dry bulb temperature and humidity is controlled thru**
  - **Modulating the chilled water control valve in case the cooling medium is chilled water or brine**

**OR**

  - **Staging the multiple condensing units to switch on when refrigerant DX systems are used.**

  - **Modulating the hot water valve when heating medium is hot water.**

**OR**

  - **Modulating the thyristor firing in case heating is achieved through electrical heating.**

# Control Systems for OTs and Critical Areas

- The room dry bulb temperature sensor is primarily used to control either the flow of hot water through heating coil or the current flowing through the heaters. When the temperature rises as compared to set point, the flow is reduced in modulating manner and when the temperature reduces as compared to setpoint, the flow is increased in modulating manner.
- The set point used for this heating loop is the design room dry bulb temperature.

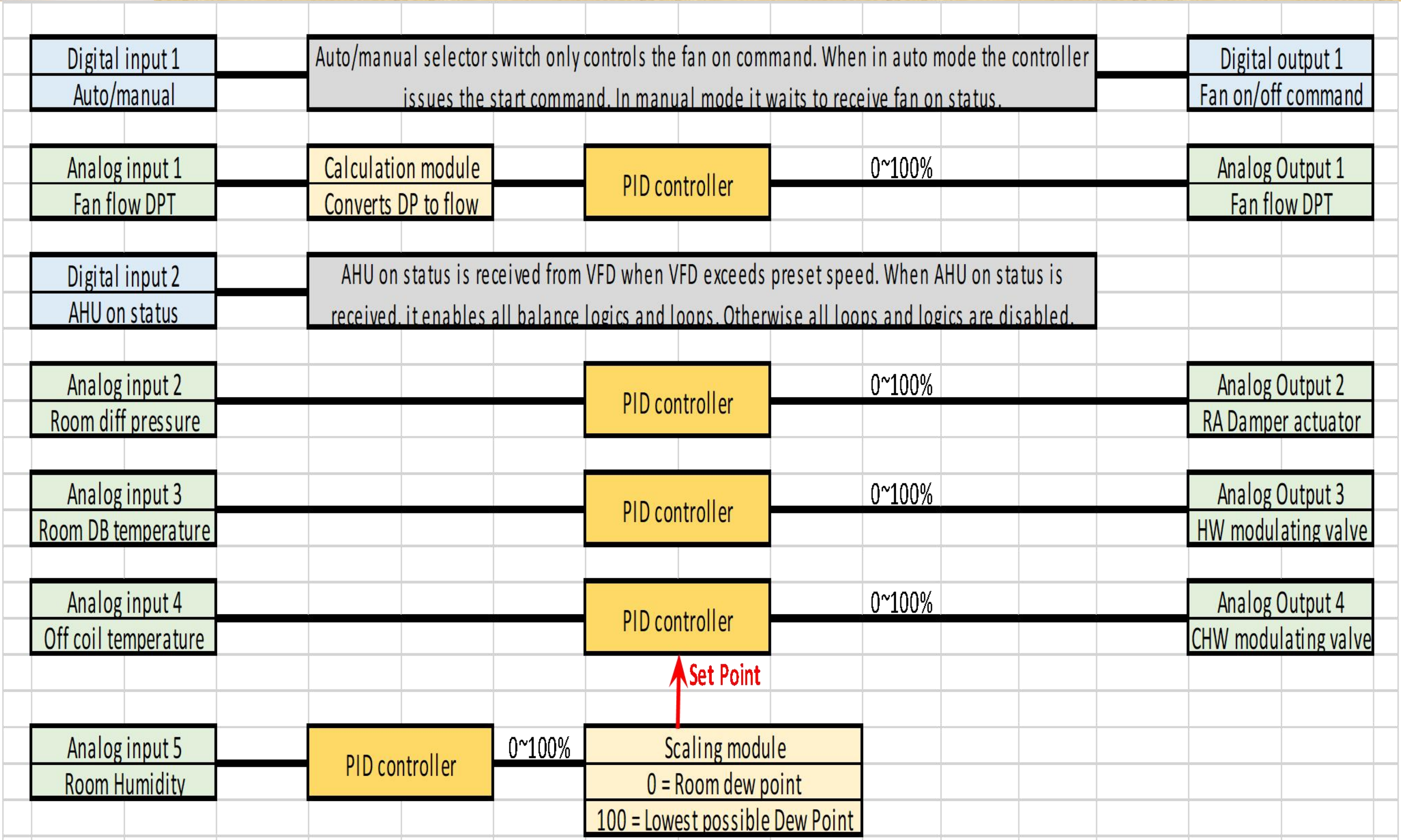
# Control Systems for OTs and Critical Areas

- **The chilled water valve or staging of direct expansion refrigeration units are controlled using the off coil temperature sensor. This temperature sensor is located immediately after the cooling coil but before the heating coil of electric heaters.**
- **In case heating coil is placed reasonably close to the cooling coil (which is normally the case), it is advisable to install a radiation shield for this temperature sensor.**
- **If the off coil temperature increases as compared to its set point, the chilled water flow is increased or additional DX unit is switched on and vice versa.**

# Control Systems for OTs and Critical Areas

- The room humidity sensor is used to decide the set point for the chilled water control loop.
- If the room humidity increases as compared to its set point, this resetting loop lowers the set point of chilled water flow control loop and if the room humidity reduces as compared to the set point the resetting loop increases the set point of chilled water flow control loop.
- The resetting of the set point of chilled water loop is either done in a modulating manner or in steps of $0.10^0$ centigrade.
- The resetting is limited between the room dew point and lowest achievable off coil temperature as provided in the coil selection. Where coil selection is not available, this data can be taken as $2^0$ C higher than chilled water inlet temperature.

# Control Systems for OTs and Critical Areas




**Control schematic - Graphical**

# Control Systems for OTs and Critical Areas

- **Defumigation mode:**
  - **In this mode the return air damper is fully closed.**
  - **The defumigation exhaust damper and defumigation fresh air damper is fully open.**
  - **Once the dampers are open, the controller starts the supply fan.**
  - **When the preset supply air fan speed is reached, the controller starts the exhaust fan.**
  - **The exhaust fan VFD modulates the exhaust fan speed so that required room differential pressure is maintained.**
  - **During this cycle, chilled water valve is opened fully.**
  - **The defumigation cycle runs for predetermined time which is decided through field trials during commissioning.**
  - **Post the completion of this cycle, the controller resumes either the occupied or unoccupied mode as the case may be.**

# Control Systems for OTs and Critical Areas

- **Alarms:**
  - Smoke detector on
  - Room high temperature
  - Room high humidity
  - Fan failure
  - Low room pressure

- **Warnings:**
  - MERV-7 filter dirty
  - MERV-13 filter dirty
  - LAF H-13 high pressure drop
  - Low room temperature
  - Low room humidity
  - High room pressure

# Control Systems for OTs and Critical Areas

- **All other critical areas too work on the similar logics with minor variations.**
- **ICU (Non infectious)**
  - **This area works only in two modes, either the occupied mode or in the purge mode.**
  - **The defumigation fan is replaced with the purge fan.**
  - **The purge cycle is manually activated when there is either the fowl smell or release of any unwanted gases.**
  - **The cycle is deactivated either manually or is based on the timer.**
  - **The room differential pressure remains positive during both the cycles.**

# Control Systems for OTs and Critical Areas

- **ICU (Infectious):**
  - **This area controls perform exactly as per the non infectious ICU except for the room differential pressure which is kept negative with respect to surrounding areas.**

Credit : ISHRAE guidebook for healthcare facilities

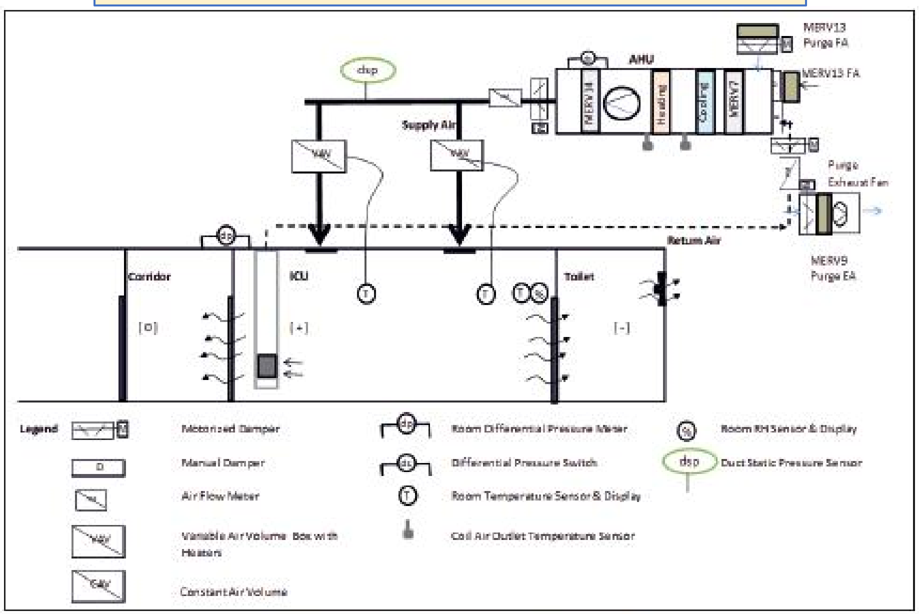



*Figure 2.3 Control Schematic for a Typical ICU (Non-Infectious) Air Flow*

Credit : ISHRAE guidebook for healthcare facilities

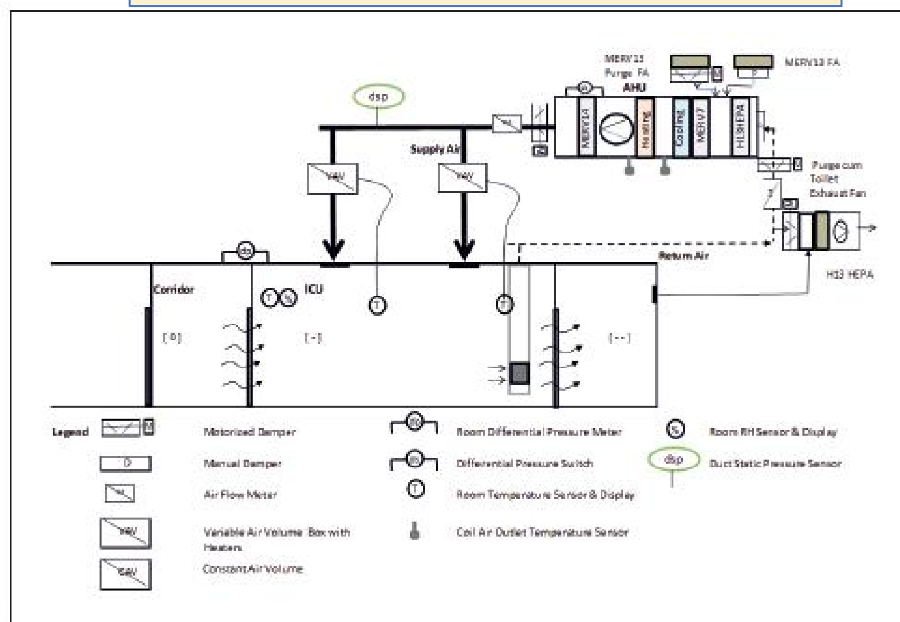
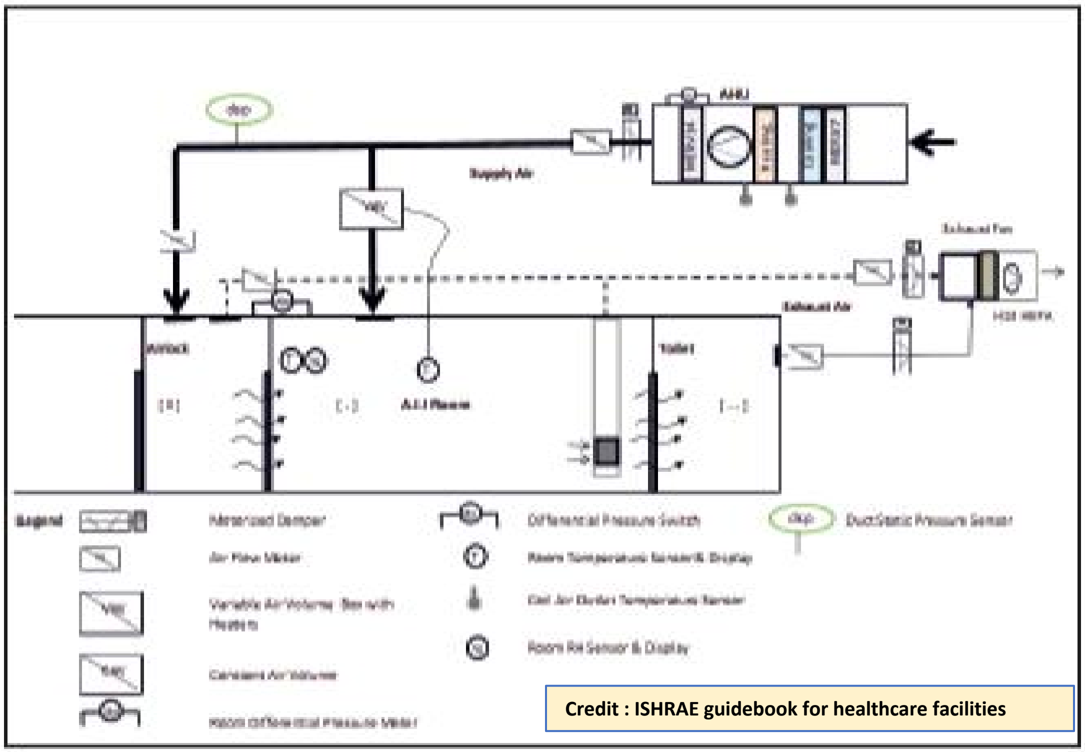



*Figure 2.4 Control Schematic for a Typical ICU (Infectious) Air Flow*

# Control Systems for OTs and Critical Areas

- **Airborne Isolation room:**
  - **This area preferably uses 100% fresh air with room air being exhausted.**
  - **The area has an airlock with VAV and the area too with a VAV is maintained negative with respect to air lock.**




Credit : ISHRAE guidebook for healthcare facilities

# Control Systems for OTs and Critical Areas

- **Protective Area (PE area)**
  - **Works only in one mode, that is occupied mode.**
  - **The area is maintained positive with respect to surrounding area.**

**Credit : ISHRAE guidebook for healthcare facilities**

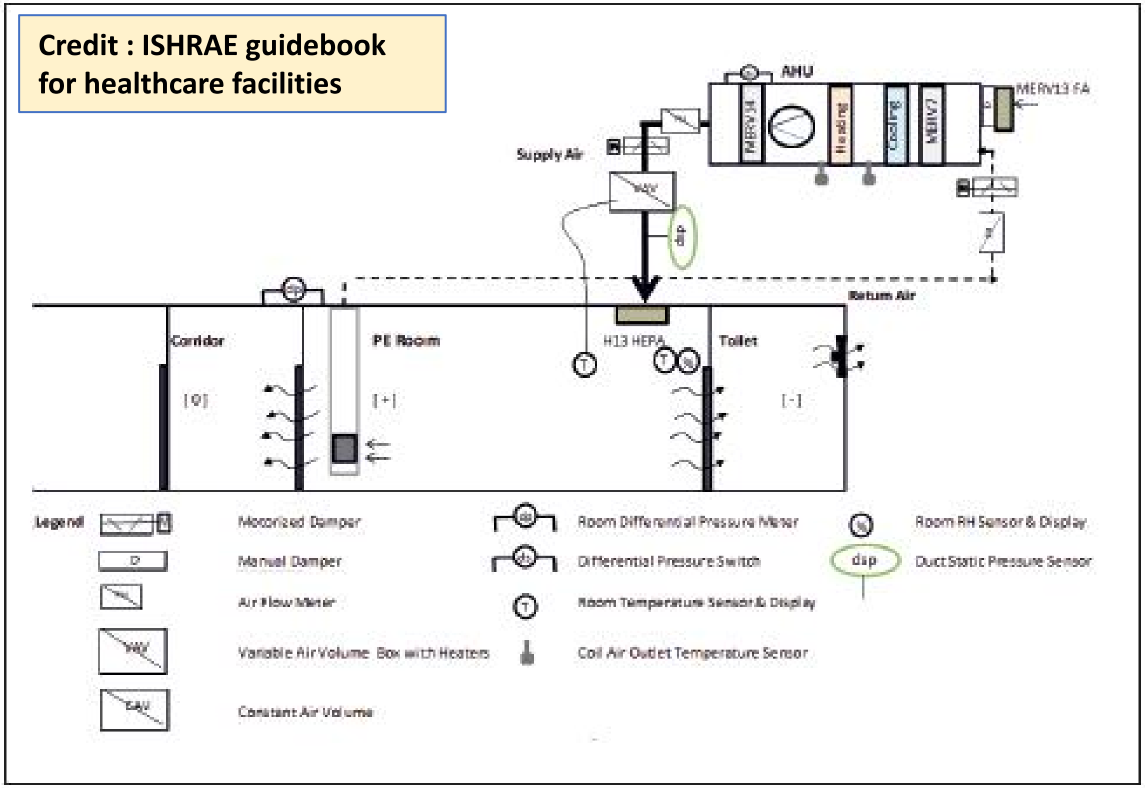
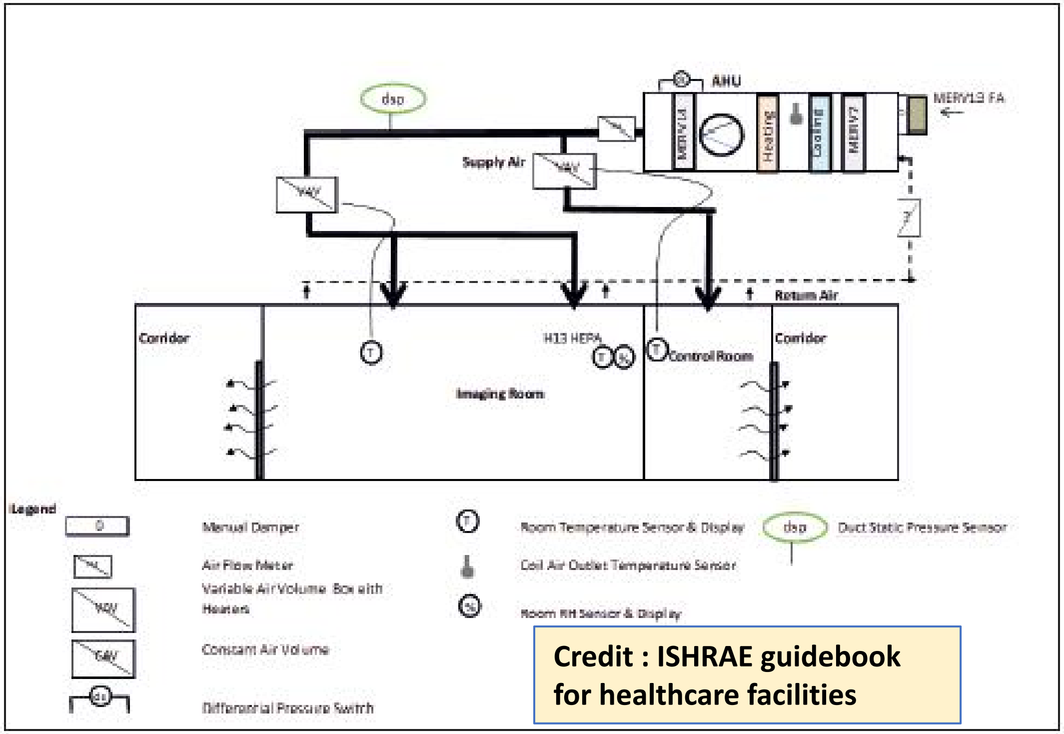



*Figure 2.6 Control Schematic for a Typical Protective Environment Air Flow*

# Control Systems for OTs and Critical Areas

- **Imaging room :**
  - **Imaging rooms are suite of 2 rooms, imaging room and control room. Each room preferable have a VAV unit.**
  - **The system works only in one mode that is occupied mode with temperature & humidity maintained round the clock.**




Credit : ISHRAE guidebook for healthcare facilities

*Figure 2.7 Control Schematic for a Typical Imaging and Control Room Air Flow*

The other areas of the healthcare facilities too need controls, but that det her