ISHRAE

IMA HBI- ISHRAE COVID-19 GUIDANCE DOCUMENT for AIR-CONDITIONING and VENTILATION in HEALTHCARE FACILITIES

"How to operate air conditioning and ventilation systems to control spread of coronavirus disease (COVID-19) in Healthcare Facilities."

Indian Society of Heating, Refrigerating & Air Conditioning Engineers

Indian Medical Association

Hospital Board of India

Preface

This Pandemic has led to a continuously increasing demand on Healthcare Services in existing Hospitals. This has also necessitated the building up of multitude, temporary care facilities to try and cater to the demand.

Apart from COVID care, there are variety of other care-giving facilities ranging from Nursing Homes to large Hospitals that render to all forms of Medical care and treatment of patients suffering from multiple ailments other than COVID 19. Some are already in operation and a large number of the Clinics and Nursing Homes shall soon be needed be reopened once lockdown restrictions are eased.

The spread of the COVID-19 and other Infectious diseases can occur by several different routes which includes, transmission through air. However, this spread can be effectively controlled and medical care spaces can be made safe for use with Air-conditioning & Ventilation. It all depends on how the HVAC equipment and systems are installed and operated in the given facility.

To provide Guidance, ISHRAE (Indian Society of Heating, Refrigerating & Air-conditioning Engineers) constituted a COVID-19 Task Force . After a detailed study and analysis of information and literature available till date, the Task Force released a comprehensive Guidance Document. This Guidance Document is available for free download from www.ishrae.in. The Document covers the Operation and Maintenance of Air conditioning Systems in Residential , Commercial and Industrial spaces during the Pandemic .

Addressing the need for a **Comprehensive Guidance Document for Healthcare Facilities,** the ISHRAE COVID–19 Task Force put together this **document, exclusively detailing the Operation of Air Conditioning Systems installed in Healthcare Facilities** during and after the Pandemic.

The Document covers the recommendations for use of all types of existing Air- conditioning Units, ranging from Window Room Air conditioners to split Air conditioners to Ducted air conditioners, Air Handling Units and Evaporative (Desert) Coolers installed as standalone systems or in Central Air-conditioning Plants. The suitability of each of these types of Air-conditioners and Systems is described as per their applications in various types of Medical facilities and Spaces. These include Surgical operations Rooms, Quarantine Rooms, Intensive Care Units, Patient Wards, Doctors' Chambers, Medical Office areas, Diagnostic Centre, Single or poly Clinics and General use areas in a Hospital.

The publication jointly released by ISHRAE and IMA shall serve to be a comprehensive guidance document for Medical Facility Owners and as well as for the Managers of Air-conditioning Systems.

In preparing this document, the COVID-19 Task Force has extracted, examined, analyzed and compiled information pertaining to the Climatic regions of the Indian Sub-continent. The Team has referred to publications in peer reviewed journals and reports from other relevant organizations from around the world in arriving at this conclusive guideline.

I acknowledge the efforts of the Task Force members and support from IMA. This document is ISHRAE's contribution to generate awareness among masses, keep building occupants and service providers safe and win over COVID-19.

Vishal Kapur
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Message from The President, IMA

I am delighted to know that ISHRAE has come out with the COVID-19 Guidance Document for Air conditioning and Ventilation. Spread of infection through air conditioning and ventilation is a subject of concern for all those who are using such a facility, more so in Healthcare Establishments due to obvious increase in the load of infective agents in their environment. ISHRAE's Technical Committee has put tremendous effort in bringing about this guidelines. This document will be of great help to hospitals, nursing homes and clinics in redesigning their conditioning and ventilatory requirements. Hope everyone will utilise the benefit of this publication. Congratulations for coming out with such an informative document.

Dr. Rajan Sharma

National President

About IMA

Indian Medical Association (IMA) is the largest representative organisation of doctors of modern system of medicine in India. It has a membership of 3.25 lakh doctors spread over in 28 State Branches, 5 Union territorial Branches and 1765 local branches in almost all the districts of India. IMA was founded on 28th December, 1928 and it was registered in the year 1930 under the Societies Registration Act, XXI of 1860. IMA has complimented many Government Programmes like Revised National Tuberculosis Control Programme. IMA is a founder member of WMA.

Objectives

- To promote and advance medical and allied sciences in all their different branches and to promote the improvement of public health and medical education in India
- To maintain the honour and dignity and to uphold the interest of the medical profession and to promote co-operation amongst the members thereof;
- To work for the abolition of compartmentalism in medical education, medical services and registration in the country and this to achieve equality among all members of the profession.

About IMA HBI

IMA HBI is a wing of IMA. It handles the interest of the medical profession in Hospital industry. The leadership in healthcare delivery has been slowly and steadily passing into the hands of entrepreneurs of all backgrounds. It is important to moor the industry strongly on the ethics and dynamics of the medical profession. To achieve the political objective of maintaining the benign influence of the medical profession on the healthcare industry, IMA has stepped in with the initiative of IMA Hospital Board of India.

Aims and objectives

- To assist and equip all healthcare institutions to provide quality healthcare to people by facilitating accreditation.
- To facilitate all healthcare institutions to play their effective role in public health.
- To represent and safeguard the interest of all health care institutions and their personnel irrespective of their affiliation.

Team IMA

Dr. Rajan Sharma, National President, IMA
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Team IMA HBI

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Introduction

The COVID-19 pandemic, commonly known as CORONA has engulfed the world and India is no exception. The COVID-19 virus belongs to the CORONA family to which SARS and MERS also belong. As the COVID-19 virus is still not fully understood, the behaviour of SARS and MERS is considered as a reference to the extent they do not contradict the present observations.

The size of a coronavirus particle is in the range of 80-160 nanometers. It is transferred via infected microscopic airborne particles and contaminated aerosol droplets. Droplets and small particles of a broad spectrum of diameters get generated during the course of coughing & sneezing and , to a lesser extent , even by talking and breathing.

Most large cough droplets fall on nearby surfaces and objects – such as desks and tables, where they remain active for hours and even 2-3 days. People can get infected by touching those contaminated surfaces or objects; and then touching their eyes, nose or mouth. If people are standing within 1-2 meter of an infected person, they can be infected by breathing-in droplets sneezed or coughed out or exhaled by them.

Small particles (less than 5 microns) released during cough stay airborne for hours and can be transported over long distances. Small droplet nuclei or residue are formed from droplets (usually within milliseconds) in the air which shrink in size due to the process of evaporation and desiccation in low humidity.

Apart from cough generated aerosols, the particulates suspended in the air also work as a substrate for viruses and consequently their transmission through this path [1]. In the indoor environment, one of the sources of dust is atmospheric dust coming in through fresh air intakes. The other prominent source is the dust generated by processes such as printing. Reduction of indoor dust levels is a step towards mitigation of this source of COVID-19 transmission.

Another path for transmission is when virus-laden aerosols are deposited on apparel and on the floor and then get re-suspended into the air due to the movement of people. That is why sanitizing the floors frequently and limiting the movement of people is helpful in curtailing this route of transmission. In healthcare facilities sanitization of apparel is recommended as per protocol [2].

Effect of Environmental Conditions

1. Relative Humidity

Relative humidity is found to affect the infectivity of virus through the respiratory route. When we breathe dry air the mucous membrane in the lungs become dry. The fluid over lining the cells becomes more viscous, and the little hairs called cilia, which protect our lungs from deep settling of viable & non-viable particles, cannot work and particles settle more deeply in the lungs.

Relative humidity of at least 40% is considered the threshold [3]. Studies indicate that survival tendency of COVID-19 virus above 80% relative humidity is very less. However, too much humidity leads to higher levels of dust mites and fungi, two of the worst culprits for indoor allergy sufferers. Mold and fungi are known to exacerbate respiratory conditions such as asthma.

All things considered, the relative humidity level of 40%~70% is considered to be the most suitable for humans & decreases problems from pathogens.

2. Temperature

Temperature tends to be a factor that directly affects the comfort of building or hospital occupants. **Comfort temperature is generally considered between 24 - 30 °C , after accounting for air velocity, relative humidity and clothing.** The study of the transmission of COVID-19 virus in 100 cities of China indicates that high temperature and high humidity significantly reduce the transmission of influenza [4].

Studies conducted at various RH levels have shown that using viral culture methods low temperatures (7–8 °C) were optimal for airborne influenza survival, with virus survival decreasing progressively at moderate Temperatures (20.5–24 °C) and further decreases at higher (greater than 30 °C) temperatures [5].

As per some recent studies, SARS-CoV-2 has been found highly stable on surfaces for 14 days at 4 °C; one day at 37 °C and 30 minutes at 56 °C were needed to inactivate the virus [6].

Though ISHRAE recommends temperature range of 24-30 °C for comfort conditioning, in case the job requires use of special clothing, for example PPE for healthcare staff, temperature lower than 24 °C may be kept to ensure sufficient dissipation of heat released from body through heavier clothing.

General Patient Areas

OPD area, doctor chambers, clinic waiting rooms, general IP wards, specimen collection areas, café, pharmacy, diagnostic center.

Maintaining the humidity, temperature and maximize ventilation is the best approach to limit the risk of COVID-19 infection. It is recommended to maintain temperature between 24-30°C and relative humidity between 40-70% to achieve thermal comfort while also reducing survival rate of virus and pathogens.

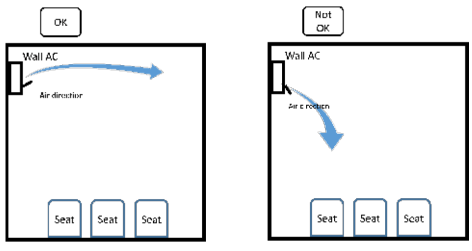
If the doctors or medical personnel have to wear PPE, low temperature may be required to provide thermal comfort to the medical personnel. Further, the lower temperature setpoint may also be required in the chamber if the regulations or guidelines prescribe specific environmental conditions for the medical activities.

The clinics which do not have air conditioning, should have provision for good ventilation by ensuring fresh air intake through windows or other openings. In addition, providing exhaust fans in room or adjoining toilet is also recommended. The location of intake air and exhaust should be such that the air passes through the room.

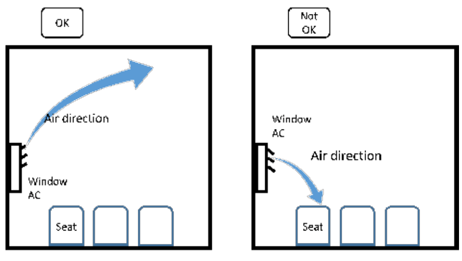
Window, Wall mounted, Cassette split air conditioners

In general these are installed in chambers, waiting rooms, diagnostics, back offices and at times in the wards also.

The room air conditioners can be operated to maintain thermal comfort with certain precautions. Recirculation of air through room air conditioners must be accompanied by outdoor air intake through mechanical fans or slightly open windows or doors and exhaust using a fan. The location of the exhaust fan and the intake of the air should be such that that the air passes thru the room before getting exhausted. For Cassette type AC units it is recommended to connect outdoor air to suction port of the machine to ensure adequate ventilation rates. Exhaust air could be routed through adjoining toilet exhaust fan or by installing an extra fan. Care to be taken to discharge exhaust into the open atmosphere and not to some other occupied area.



Typical elevation of waiting Room



Typical elevation of waiting Room

Usually, the waiting areas have higher occupancy and therefore, it is recommended to use higher rate of outdoor ventilation.

Considering that the virus spreads through coughing and sneezing by an infected patients, it is important to ensure that the draft of air from the AC unit is not directed to the occupants. It is recommended to direct the supply air into the occupied zone in such a way that a high velocity draft is avoided. Both Window and wall mount split AC have setting to direct the air flow. Figures as illustrated above for guidelines.

Fan Coil Units (FCUs):

In general, used in wards, chambers, office areas and diagnostic centers.

FCUs can be operated to maintain thermal comfort with certain precautions. It is recommended to supply Fresh air by an inlet duct and fan. Fresh air should be directly into the room through the supply grille or at the suction of the machines and accordingly suitable exhaust also to be provided. Exhaust air could be routed through adjoining toilet exhaust fan or by installing an extra fan. Care to be taken to discharge exhaust into the open atmosphere and not to some other occupied area.

Install UVGI (Ultraviolet Germicidal Irradiation) to keep Coils continuously clean and disinfected. When installing UVGI systems necessary safety precautions to be considered.

Ducted units / Air Handling Units (AHUs):

Typically installed in larger spaces, such as lobbies, waiting areas, corridors and at times for multiple wards also.

- Maximize supply of outside air within the limits of the system. Two air changes per hour are recommended
- For air handling unit it is advisable to provide a MERV 13 or higher filter fitted on the air handling unit. If a filter of higher filtering capability is retrofitted into an existing system, care shall be taken to ensure that the fan and motor capacities are adequate to handle the higher pressure drop. "If for some reasons your system cannot handle a MERV 13 even after some adjustments : it is recommended to ensure at least MERV 7 as Stage-1 filter and adding Stage-2 filtration levels up to MERV 10. Any increased filtration will be an improvement".
- Addition of a TFA (Treated Fresh Air) unit is recommended if increased outdoor air intake adversely impacts cooling performance.
- It is advisable to inspect the AHUs and ducts for air tightness and low leakage.
- The supply air grill angle should be such that draft of air is not directed on the occupants.
- In buildings without mechanical ventilation systems, it is recommended to actively use operable windows. Wherever necessary install exhaust fans.
- UVGI (Ultraviolet germicidal irradiation) can be installed for larger ducted units and AHUs to keep coils continuously clean and disinfected. When installing UVGI systems necessary safety precautions to be considered.

Evaporative (Desert) coolers:

Should draw air from outside to ensure good ventilation. It is advisable to discharge the air directly to an open area and not to any other occupied zone. If an exhaust fan is located at a nearby location then it must be kept running to exhaust air for better ventilation.

Intensive Care Units (ICUs)

The ASHRAE Standard 170-2017 [7] specifies the following parameters for the ICUs:

ASHRAE Standard 170-2017, for ICUs				
Temperature F [C]	Relative Humidity %	Room pressure w.r.t surroundings	Outside air	Recirculation air
70F~75F [21.1~23.9]	30%~60%	Positive,Negative or Neutral	Minimum 2ach	Minimum 6ach

ach = Air changes per hour

In case of ICUs for non-infectious patients, filtration recommended at AHU is MERV 7 for return air & MERV 14 or better, as the final filter for supply air. The area can be at positive pressure.

In addition, HEPA filters in supply air may be preferred in some ICUs for caring for large numbers of immuno-compromised patients.

Negative pressure of a minimum of minus 2.5 Pascals is required in ICU rooms for infectious patients. If the air is once through (as is recommended for COVID19), the AHU will need to have MERV 7 filter in fresh air inlet and MERV 14 or better as the final filter at supply air. The exhaust to atmosphere will have to be with H13 or equivalent grade HEPA filter or a plume exhaust into the atmosphere to a high level above the building.

In case of recirculation of air in the AHUs for infectious patients, the AHU will need to be additionally provided with H13 or equivalent grade HEPA in the return air at AHU. In this case too, the exhaust to atmosphere will have to be with H13 or equivalent grade HEPA filter or a plume exhaust into the atmosphere to a high level above the building.

The ducting should be used for supply air as well as return air, false ceiling return is not recommended.

Local air circulating type of air conditioners such as room air conditioners, Hi wall splits & cassettes are not recommended because of various reasons:

i. Maintenance of the units have to be done in the patient area

ii. Filtration is inadequate

iii. There is no provision of fresh air or exhaust.

However, the fact is that today many of the ICUs are based on local air circulating air conditioning units listed above. Till it is practical to go for an upgrade, following steps can be taken to alleviate the inside conditions:

1. Introduce an inline fan for inducting fresh air of minimum 2 air changes per hour. Use two stage filtration with minimum MERV 7 and MERV14 rated filters.
2. Since directly inducting fresh air into the room can lead to condensation in the room especially during monsoon, make sure that the fresh air is led to the return air grill portion of the air conditioning unit.

For ICU room having patients with infectious disease (excluding COVID), the room will need to be kept at a negative pressure of a minimum 2.5Pascals. When the area is under negative pressure, the adjoining room should be maintained at the same level of hygiene as the ICU as air from this area will infiltrate into the ICU. The exhaust to atmosphere will have to be with H13 or equivalent grade HEPA filter.

Converting General Patient Rooms or ICUs into COVID-19 Patient Areas –

Considerations pertaining to HVAC Systems

COVID-19 positive patients and patients with COVID-19 related symptoms are to be accommodated in designated "Airborne Infection Isolation Rooms" in hospitals to control spread of the disease. However due to the surge in the number of such patients, healthcare facilities may not have adequate number of "AII" rooms to accommodate all such patients. Hence, healthcare facilities would need to convert their existing patient rooms or ICUs into COVID-19 patient rooms or COVID-19 ICUs to handle the current pandemic. The most important factor in this scenario is to ensure that the virus laden airborne particles do not leak out of the rooms occupied by COVID-19 patients and also to maintain the concentration of virus laden particles inside the COVID-19 patient room at a minimum. This is required to control the spread of infections and also to protect the healthcare workers.

As it is in normal practice, most of these patient rooms would be served by a HVAC system that would be of a recirculatory type, wherein the air from the room is taken back to the AHU for thermal conditioning and brought back. The same HVAC system could also be connected to a few other areas of the hospital. In some cases, there might be no dedicated return air duct and it could be a ceiling return system. If a COVID-19 patient had to be admitted to such a room, it would present a significant risk of the virus laden particles spreading out from the designated COVID-19 patient rooms.

To convert an existing patient room or ICU into a COVID-19 patient area, it is first necessary to convert the room into a non-recirculatory system (100% once through system) [8, 9]. On an emergency basis, this can be achieved by blanking (blocking) off the return air vents in the COVID-19 patient room. It is important to make sure that the AHU will have provision to receive adequate outdoor air supply. The outdoor air source for the AHU shall not be from within the building and all care shall be taken to avoid intake of outdoor contaminants, to the best possible extent. Additionally, an independent exhaust blower shall be provided to extract the room air and exhaust out into the atmosphere, preferably, after suitable "exhaust air treatment". The exhaust air quantity shall be greater than the supply air quantity such that a negative pressure of minimum 2.5Pa (preferably >5 Pa) is achieved in the room [9]. It is advisable to install differential pressure meters to measure this metric. The supply air quantity shall be such that it will provide a minimum of 12 air changes per hour. The position of the extract air in the room shall be just above the head of the patient's bed [9].

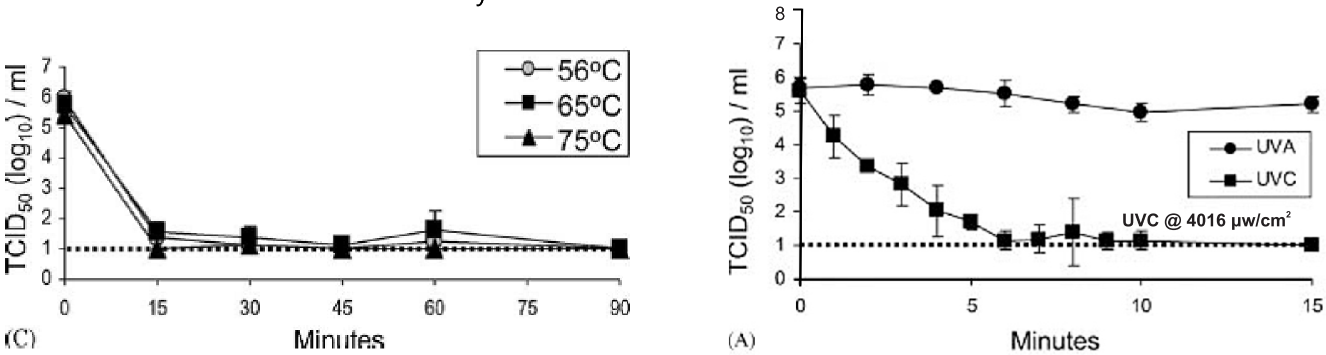
Treatment of Exhaust Air from COVID-19 Patient Areas

The exhaust air is most likely to contain particles carrying a viral load and hence a suitable technique should be deployed to prevent the spread of infections. Treatment of exhaust air can be done preferably by HEPA filtration [8]. (HEPA filters shall be tested and certified for performance in accordance to international standards like IEST, EN, ISO, IS etc.). These HEPA filters shall be a minimum of H13 (EN1822-1) filter class or equivalent. When not possible, treatment of exhaust air by Chemical disinfection is acceptable. When both the methods are not viable, the exhaust air shall be let off into the atmosphere through a high velocity upward plume at a height of 3 m above the tallest point of the building, thereby lowering the viral load concentrations to insignificant levels by dilution [9]. This exhaust discharge shall be well away from other air intake points and populated places.

When HEPA filters are used to treat the exhaust air, it is preferable to install them at the primary point of air extraction in the room and the exhaust blower shall be at the discharge end of the exhaust duct in order to maintain a negative pressure in the exhaust duct.

Chemical disinfection of the exhaust air from COVID-19 patient room can be done by bubbling the exhaust air through a "Diffused air aerator tank" (preferably of non-metallic material) holding a 1% sodium hypochlorite solution [10, 11, 12]. The concentration shall be checked on a regular basis and dosing undertaken based on need. The aeration tank shall be placed in an unpopulated outdoor area and not inside enclosed space. Suitable PPE shall be used while handling the hypochlorite solution and direct contact with skin and eyes shall be avoided. The above chemical inactivation procedure for treatment of exhaust air is suggested based on the available information at this time.

The other two options available for exhaust air treatment being UV irradiation and heating. MER Darnell et al. [13] observed that, an exposure time of 45min at a temperature of 75 °C resulted in complete inactivation of SARS-CoV. Similarly, an UVC (254 nm wavelength) irradiation with an exposure time of 15 minutes at irradiation intensity of 4016 μW/Cm2 resulted in complete inactivation of SARS-CoV. Figure below shows the effect of heat treatment and UV radiation on infectivity of SARS- CoV.



Effect of heat treatment and UV radiation on infectivity of SARS- CoV. [13]

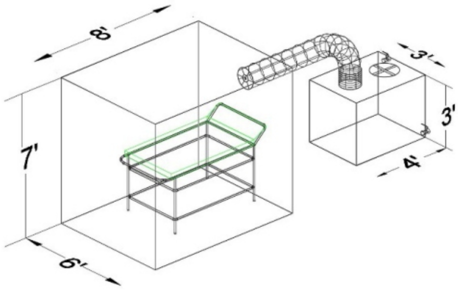
It is to be noted that the exhaust systems could have viral load deposits, some of which may be active. Therefore, suitable personal and environmental protection protocols shall be followed during any maintenance activity on the exhaust system, for personnel protection and to avoid environmental spill. It may be noted that the treatment of exhaust air by HEPA filtration is the preferred method and the other suggested methods may be adopted due to non-availability of HEPA systems.

Disinfection of the condensate water from the air conditioning system shall be done by using an inline UVGI treatment on the drain line or by 1% sodium hypochlorite dosing.

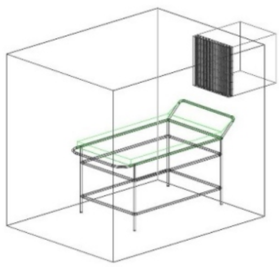
Wherever possible, it is advisable to introduce UVGI of adequate intensity to disinfect the cooling coil and drain pan of air conditioning equipment.

Setting Up Make-shift Isolation Enclosures

In resource constrained healthcare settings, several COVID-19 patients may be required to be admitted to a single large room. This presents a significant risk to the health care workers as well as a possibility for environmental spread of virus laden particles. For such instances, a make-shift patient isolation enclosure could provide the necessary protection. This could be a temporary makeshift cubicle or tent constructed out of a skeleton structure (of plastic or metal) and plastic sheet or canvas covering. The tent shall be covered on all sides excepting the front, where PVC strip curtains or a similar arrangement can be provided. Arrangements for light and a fan inside the tent can be provided for the comfort of the patient, as necessary. The tent shall be provided with an exhaust blower to extract the air inside the enclosure and exhaust out into the atmosphere after suitable treatment. Exhaust air treatment can be done as mentioned earlier. The exhaust blower shall be so sized that a negative pressure of >2.5Pa is maintained inside the enclosure [9].



Isolation enclosure with Chemical disinfection for exhaust air. *(Dimensions are only indicative)*



Isolation enclosure with HEPA filtration for exhaust air

In case of air-conditioned patient rooms served by unitary air conditioners, the Isolation enclosure can be installed inside the patient room with HEPA filtered exhaust air. The exhaust air, after HEPA filtration can be discharged inside the room. This provides a localized negative pressure zone inside the room and helps control infection spread and offers protection to the healthcare workers.

Quarantine Areas

Quarantine refers to separation of individuals who are not yet ill, but have been exposed to COVID-19 and therefore have a potential to become ill. Quarantine can happen at home or in quarantine centre, where several such individuals may be under quarantine. In a quarantine situation, it is the physical distancing and avoidance of contact (direct and indirect) transmission that is the key.

A quarantine centre shall be well ventilated and preferably be maintained at a negative or neutral differential pressure. When mechanical ventilation is resorted to, it shall be a once through system (non- recirculatory system) that provides a "clean to dirty" (towards the patient and away to the exhaust) air flow pattern. Care shall be taken to ensure that the exhaust air will be discharged into areas that have very less or no human traffic. Rooms with stand-alone air conditioning systems, that do not recirculate the air to the other parts of the building are preferred to be used as single patient quarantine rooms.

Emergency Waiting Rooms (ER)

The ASHRAE Standard 170-2017 [7] specifies the following parameters for the ER Waiting areas:

ASHRAE Standard 170-2017,ER Waiting Area				
Temperature F [C]	Relative Humidity %	Room pressure w.r.t surroundings	Outside air	Recirculation air
70F~75F [21.1~23.9]	Maximum 65%	Negative	2ach	Minimum 12ach

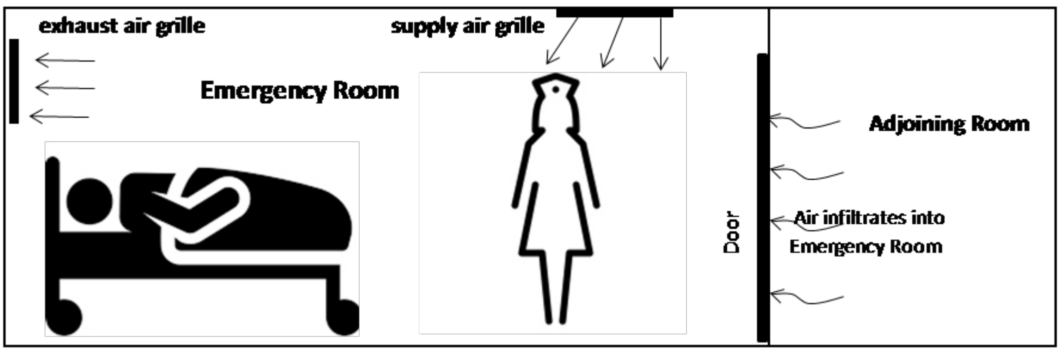
ach = Air changes per hour

The emergency department is point of entry to a hospital for undiagnosed patients, some of whom may be carriers of infectious diseases like tuberculosis or have other medical conditions like trauma, broken bones, lacerations etc.

Emergency rooms will need to have HVAC systems that require maintenance for 24x7usage.

Emergency room waiting areas must be 100% exhausted. If air conditioned with recirculation, H13 or equivalent grade HEPA filter in return is required to protect the patients & staff from infectious patients.

If it is not viable to use once through air conditioning system, the hospital may opt for a ventilation system with outside air supply and the used room air exhausted into the atmosphere. A minimum of 6 air changes per hour of supply air will have to be provided. The exhaust has to be more in order to achieve a minimum negative of 2.5 Pa in the ER. The filtration of the room supply air will have to be with a minimum MERV7 filters. The exhaust air will have to be led out into the atmosphere and it has to be ensured that the air is discharged where it will not infect any passers-by.



Emergency Room Air Pattern: Room under negative pressure. Air movement: Clean to dirty

Operating Rooms

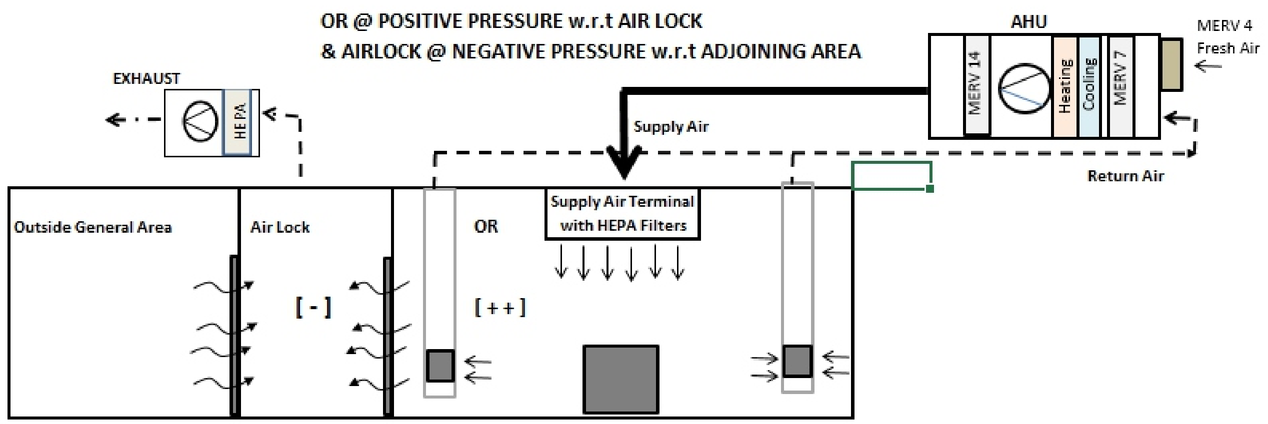
Operating rooms (ORs) have requirement of specific sets of temperature, humidity, differential pressure and air changes as indoor conditions.

Operating Rooms (ORs) shall have independent HVAC systems (Air side) and shall be provided with HEPA filters on the supply air, preferably at the point of discharge into the OR. Control of relative humidity and temperature is a critical requirement of the HVAC system deployed for an OR application.

According to National Accreditation Board for Hospitals [14], *the temperature inside an OR should be maintained 21 °C ± 3 °C (except for Joints replacement surgeries where it should be 18 °C ± 2 °C) with corresponding relative humidity between 20 to 60%, though the ideal RH is considered to be 55%. In order to dilute the internally generated contaminants and for maintaining a good Indoor Air Quality, the HVAC system should be able to provide a minimum of 20 "Total air changes per hour" including 4 "Fresh air changes per hour".*

Operating rooms (ORs) are always maintained at a positive pressure of more than 2.5 Pa with respect to their adjoining areas [14]. This positive pressure results in an air bleed from the OR to the outside, thereby preventing infiltration of contaminants into the OR. However, in the COVID scenario, it is important to prevent the spread of infectious agents from the OR to the other areas of the hospital, should the patient turn out to be COVID positive.

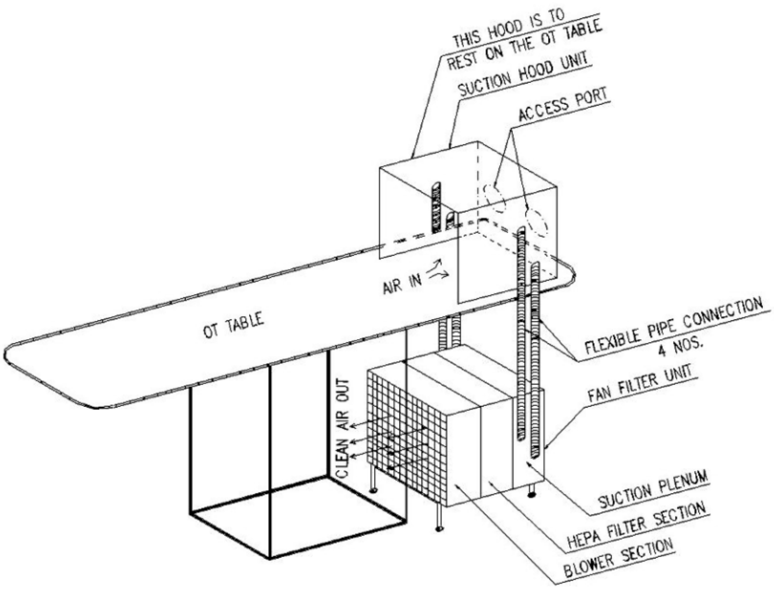
A positive pressure OR, in this scenario could aid spread of infectious agents to the other parts of the hospital. On the other hand, an OR with a negative pressure could bring in contaminants from outside and compromise the aseptic nature of the OR, thereby increasing the chances for infection to the patient. In this scenario, it is necessary to have an arrangement which will meet both the requirements: prevent the spread of infections to the other parts of the hospital, simultaneously preventing ingress of contaminants into the OR. Figure below shows such an arrangement.



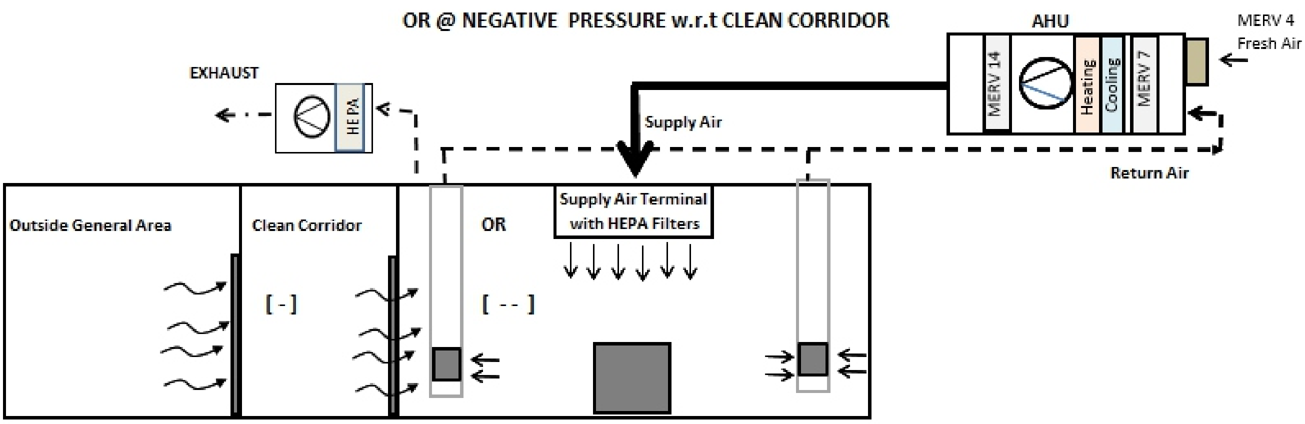
The "Air lock" room shown, serves as a "negative pressure sink" and thereby prevents spread of infectious agents from the OR to other areas of the hospital. Furthermore, the OR is maintained at a positive pressure with respect to the "Air lock", thereby preventing the ingress of contaminants into the OR. The total and the fresh air changes may be increased to the maximum extent allowed by the system design to enhance dilution of contaminants inside the OR.

The Pressure differentials suggested would apply irrespective of the type of HVAC system employed in the OR and the type of air flow in the OR.

Usage of a "Negative Pressure Hood" (NPH) covering the patient's head and neck as shown in the figure can be considered for implementation. The transparent NPH with access ports for the surgeon's hands provide a physical barrier and isolation between the patient and the surgical team. The air drawn by the "Fan & Filter Unit" (FFU) from the NPH would provide the necessary barrier for aerosol egress at the openings of the negative pressure hood. Thus the aerosols generated by the patient are prevented from mixing with the OR environment and are transported and captured by the HEPA filter in the FFU. The inflow air velocity at the open face of the NPH shall be minimum of 0.38 m/s [15] in order to provide aerosol egress protection. This provides a safe environment in the OR, protecting the surgical team from the risks of patient generated infectious agents, if any.



Another option (when controlling the spread of infectious agents from the OR to the other areas of the hospital is the only requirement), is to convert the OR into one that is at a negative pressure with respect to its adjoining areas. The negative pressure shall be at a minimum of 2.5 Pa. In this case, it is to be noted that due to the infiltration of outside air into the OR, the air quality inside the OR could be compromised. Figure below shows such an arrangement.



The above modifications are suggested to mitigate the risks, keeping in mind the challenges involved in using ORs during the COVID Pandemic.

Portable Room Air Cleaners

At the outset, it is important to note that a portable air cleaner will only clean the air that passes through the cleaner. The air cleaner will not be able to protect people from direct (droplets) and indirect (surface contamination) exposure, but can help reduce the indoor concentration of contaminants through the action of dilution. Thus, over a period of time, the air in a space can be cleansed with the right air cleaners.

a. Types

There are many technologies used in portable air cleaners. With regards to removing virus and bacteria, specifically, technologies vary from passive filtration (all kinds of media filters) to active filtration (UVGI, ESP, PCO, Ionization, Plasma, etc). With any active filtration technology, it is important to ensure the single pass efficiency and the possibility of any harmful by-products that may be released due to the active nature of the cleaning.

b. Selection basis

The various points to consider when selecting a portable room air cleaner are:

(i) Air Changes Per Hour (ACH)

ACH simply is the number of times an air purifier filters all of the air in a room in one hour. Ideally, one must use air cleaners with a minimum ACH of about 9-10. The higher the air changes, the better the efficiency of cleaning. The ACH can be easily calculated as follows:

$$\frac{\textbf{CFM of air delivered by machine x60}}{\textbf{Air volume of the room (Cubic feet)}} = \textbf{Air Changes Per Hour}$$

(ii) Noise levels (at the appropriate speed based on air changes)

The sound level of a cleaner depends on the fan type and speed. The amount of filtration and the level of noise a machine makes are inverse of each other. Hence, one must analyse the CFM of the unit at different speeds, and choose the machine with the right CFM (based on room size) and based on speed and noise to ensure proper filtration and comfort from a noise perspective.

(iii) Life of filters

Life of the filters is an important issue when choosing portable cleaners. Many claims about long life are based on initial performance. Understanding the true life-cycle cost of filter change will enable the correct decision.

(iv) Long Term Performance and Maintenance

The maintenance required to keep the machine operational in terms of filter cleaning and filter changes is an important criteria. The quality and size of the filters will determine the life of the same.

c. Technologies

(I) HEPA **:** HEPA filters are characterized by a particular particle size, called as the "Most Penetrating Particle Size" (MPPS), at which their filtration efficiency is lowest. The filtration efficiency will be higher for all other particle sizes, smaller or larger than the MPPS. The MPPS of HEPA filters typically falls between 0.15 to 0.25 microns. A H13 HEPA filter will offer a minimum filtration efficiency of 99.95% at MPPS [8].

This is one of the most critical aspects in an air cleaner. A certified H13 filter is critical as it will ensure that the filtration efficiency promised is actually achieved. A H13 (EN1822-1) or an equivalent HEPA filter will be capable of arresting sub-micronic particles effectively.
HEPA filters fitted in "Portable Room Air cleaners" that are used in Healthcare applications could have a bio load on them. The replacement of these filters should be done by trained personnel with the necessary PPE and disposal of these filters shall be done in accordance to "Bio medical waste" regulations.

(I) UVGI – UVGI has been shown to kill microorganisms at a wavelength of 253.7 nano meters, after a certain exposure time and light intensity. The exposure time required can vary depending on the light intensity of the UVGI. Human beings should not be exposed to UVGI. If the wavelength changes to a much higher or lower level than the optimal it may also produce ozone as a by product.

(ii) Ionization – Ionizers disperse negatively (and / or positively) charged ions into the air. These ions attach to particles in the air giving them a negative (or positive) charge so that the particles may attach to nearby surfaces such as walls or furniture or attach to one another and settle out of the air. The particles are not actually removed but adhere to surfaces. In general Ionizers produce harmful ozone as a by-product.

(iii) Electro Static Precipitators (ESP) – Electronic air cleaners remove small particles from the air, but because they use high voltage to generate ionized fields they can produce ozone either as a by product or by design. One must be aware that they need to be serviced regularly and typically the efficiency decreases upon use as the collection plates get saturated.

(iv) Photocatalytic Oxidation (PCO) – This new technology for filtration of gases is still in its infancy. PCO cleaners use UV lamps along with a substance called a catalyst that reacts with the light. They are designed to destroy gaseous pollutants by changing them into harmless products but they're not designed to remove particulates. Depending on the chemical reaction sometimes harmful by products may also be created in very small quantities.

For some of these options, the efficacy for Corona virus is not yet clearly proven and results from different sources may have contra-indications.

Commercial Facilities

Commercial Establishments have multiple occupancy as well as transient visitors. It is this aspect that necessitates precaution in operating their Air conditioning Systems. The best action to limit risk of COVID-19 infection by air is to ventilate indoor environments with outdoor air as much as possible. ***Mechanical ventilation systems and air conditioning systems, which provide ventilation, can perform this function more effectively than simply opening the windows, because they improve the quality of the outdoor air with filtration.***

For the purpose of Guidance for operation during a Pandemic like COVID-19 , Air Conditioning is **Categorized** based on the **types of Indoor Units installed :** (These indoor Units may be connected via refrigerant or chilled water pipes to DX Outdoor Units , VRF Outdoor Units or a Chiller)

CATEGORIES OF INDOOR UNITS :

i) **Multiple Cassette / Hi wall / Tower Units:** Ceiling mounted units that can each cool up to 50 sqm and can be controlled individually or as a group.

ii) **Fan Coil Units :** Installed in guest rooms, individual office spaces or patient wards.

iii) **Ducted Units :** A mini central Air conditioning system that is easy to operate.

iv) **Air Handling Units:** Can provide better ventilation, filtration and Coil disinfecting.

OPERATING GUIDELINES FOR ALL CATEGORIES

A) **Air Filters must be kept clean**

B) A minimum fresh air volume of 8.5 cum/hour per person and 1.1 cum per hour per sqm (5 cfm per person and 0.06 cfm per sq ft) must be provided . The recommendation is to maximize supply of outside air within the limits of the system."

C) **Inspect and clean the indoor unit Coils**

D) **Set Room Temperature between 24°C and 30°C.** Maintain relative humidity between 40% and 70%. (In humid Climates set temperature closer to 24°C for de-humidification and in dry climates closer to or at 30°C. Use fans to increase air movement)

E) Toilet and kitchen exhaust fans must be kept in operating mode. Add exhaust fans if need be for better ventilation.

RECOMMENDATIONS FOR CATEGORY i) & ii) INDOOR UNITS :

If outdoor air is not provided, it is advisable to introduce a duct attached to a central inline fan filter unit and distribute the outdoor air by grilles into the space or near machine suction. For Cassette Units the outdoor air duct may be connected to the available port of the Cassette Unit. In case outdoor air cannot be provided through a fan it is recommended to actively use operable windows.

A separate Treated Fresh Air Unit may be provided in the case of a multiple unit installation. This will help mitigate the impact of reduced cooling capacity due to supplying non treated outdoor air.

RECOMMENDATIONS FOR CATEGORY iii) & iv) INDOOR UNITS :

- Outdoor air must be provided by an inlet duct and fan. It is advisable to provide a MERV 13 or higher filter fitted on the Air Handling Unit. If a filter of higher filtering capability is retrofitted into an existing system, care shall be taken to ensure that the fan and motor capacities are adequate to handle the higher pressure drop. "If for some reasons your system cannot handle a MERV 13 even after some adjustments : it is recommended to ensure at least MERV 7 as Stage1 filter and adding Stage-2 filtration levels up to MERV 10. Any increased filtration will be an improvement".

In buildings without mechanical ventilation systems it is recommended to actively use operable windows. Add a TFA (treated fresh air) unit if recommended Fresh Air intake impacts cooling performance. It is advisable to inspect the AHUs and ducts for air tightness and low leakage.

Install UVGI (Ultraviolet Germicidal Irradiation) for ducted units and AHUs to keep coils continuously clean and disinfected.

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About ISHRAE

The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE), was founded in 1981 at New Delhi by a group of eminent HVAC&R professionals. ISHRAE today has over 30,000 HVAC & R professionals and Student -members. ISHRAE operates from 43 Chapters and sub Chapters spread across India with its Head Quarters in Delhi. ISHRAE is led by a team of elected officers, who are members of the Society, working on a voluntary basis, and collectively called the Board of Governors.

ISHRAE's Objectives :

- Advancement of the Arts and Sciences of Heating, Ventilation, Air Conditioning and Refrigeration Engineering and Related Services.
- Continuing education of Members and other interested persons in the said sciences through Lectures, Workshops, Product Presentations, Publications and Expositions.
- Rendition of career guidance and financial assistance to students of the said sciences.
- Encouragement of scientific research.

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