ASHE/ASHRAE

Current/Updated Health Care Facilities Ventilation Controls and Guidelines for Management of Patients with Suspected or Confirmed SARS-CoV-2 (COVID-19)

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Executive Summary

In December 2019, the World Health Organization (WHO) received reports of a pathogenic HCoV, 2019 novel coronavirus (2019-nCoV) in Wuhan, China.[1] Reports of persistent concern and the need to develop public health strategies and countermeasures were reported in late January and early February 2020.[2] In late February 2020, health care facilities began to plan for the intake of infectious patients with the novel coronavirus SARS-CoV-2 (COVID-19).

The purpose of this document is to review recommended controls for treatment and isolation areas in health care facilities and provide updated information. Apart from previous ASHRAE Epidemic Task Force [March 2020],[3] and American Society for Health Care Engineering (ASHE) COVID-19 resources there are no defined and definitive recommendations for environmental controls when handling COVID-19 patients in health care facilities.

This guideline provides a current literature review of the aforementioned recommended practices, a review of ANSI/ASHRAE/ASHE Standard 170-2017, Ventilation of Health Care Facilities recommendations, and U.S. Centers for Disease Control and Prevention (CDC) controls pertaining to heating, ventilation and air-conditioning (HVAC) systems in health care facilities. Additionally, it addresses design and implementation of controls to limit potential exposure to staff and others through HVAC systems.

Introduction

On March 11, 2020, The World Health Organization (WHO) declared the novel coronavirus (COVID-19) outbreak a global pandemic. At that time, several organizations and associations began to formulate reference guidelines to assist hospitals and health care facilities with handling patient influx and care. Health care organizations began to examine their facilities' capabilities and procedures for high-consequence infectious disease surge.

Part of the response was to develop methods for handling patients with virtually unknown exposure and to compare care procedures to U.S. Centers for Disease Control and Prevention (CDC) transmission-based isolation guidelines. One of the first guidelines came from the CDC on March 31, 2020.[4] Some of the same recommendations listed in this first document hold true today and provide protection to health care staff.

Past and Current Guidance

Centers for Disease Control and Prevention (CDC)

Starting March 31, 2020, the CDC began publishing interim guidance for health care facilities to follow in response to the COVID-19 pandemic. In November 2020, the CDC published updated interim recommendations for health care facilities[5] including updated guidelines for ventilation and controls. This update also includes resources for using engineering controls to

reduce potential COVID-19 exposures, for example optimizing air-handling systems, to ensure proper air filtration in facilities and the use of physical barriers to guide walkways.

Additional guidance includes the use of airborne infection isolation rooms (AIIRs) for symptomatic patients and those undergoing aerosol-generating procedures (AGPs). Patients suspected of COVID-19 infection that are admitted to the facility should be placed in a single-occupancy patient room with the door closed.

Commonly performed medical procedures that are often considered AGPs or that create uncontrolled respiratory secretions[6,7] include:

- Open suctioning of airways
- Sputum induction
- Cardiopulmonary resuscitation
- Endotracheal intubation and extubation
- Placement of laryngeal mask airway (LMA)
- Noninvasive ventilation (e.g., BiPAP, CPAP)
- Bronchoscopy
- Manual ventilation
- High-frequency oscillatory ventilation
- Tracheostomy
- Chest physiotherapy
- Nebulizer treatment
- Nasopharyngeal swabbing

In December 2020, the CDC published practical ventilation guidance[8] directed at offices, schools and other public buildings. Practical recommendations include, but are not limited to, the following:

1. Ensuring the HVAC system is working to design.
2. Increasing outdoor air ventilation.
3. Adjusting the HVAC system to increase room air changes as much as the design will allow.
4. Opening outdoor dampers past their minimum settings to help reduce air recirculation.
5. Turning off any demand-controlled ventilation (DVC) during occupied hours.
6. Increase central air filtration to as high as possible without significantly reducing design airflow. Consider using high-efficiency particulate air (HEPA) filtration systems to help clean indoor air.
7. Maintaining mechanical systems and ensuring they are functioning properly.

U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)

OSHA published health care worker and employee guidance to protect health care facility employees as much as possible from the spread of COVID-19. Their recommended engineering controls include using physical barriers to triage, curtains when available, and airborne infection isolation rooms (AIIRs). AIIRs must be under negative pressure and meet either 6 or 12 air changes depending on building design/criteria.

If AIIRs are available, they should be used for suspected COVID-19 patients and any aerosol-generating procedures on patients that are suspect or known COVID-19 cases. Ensure that the room air exhausts directly to unoccupied areas outside of the building or passes through a HEPA filter if recirculated.

If AIIRs are not available, isolate the patient in a private room under negative pressure if possible. Keep the room door closed. If rooms are not available, isolation tents or other containment areas may be used as an alternative patient placement area. Ensure that the room air exhausts directly to unoccupied areas outside of the building or passes through a HEPA filter, if recirculated.

ASHRAE and The American Society for Health Care Engineering (ASHE)

COVID-19 guidance for health care facilities professionals was published with input from ASHRAE, the ASHRAE/ASHE Standard 170 Committee and ASHE in late March 2020. The purpose of the guidance was to assist facilities in developing action plans and temporary measures to meet ventilation needs for patient care unit, complete patient room conversions and plan for surge capacity. Based on review and input, the following key goals were established:

1. Ensure proper functionality of all existing airborne infection isolation rooms (AIIRs).
2. Reserve AIIRs for patients who will be undergoing aerosol-generating procedures.
3. Develop plans and design for creating temporary AIIRs.
4. Develop plans and design for creating temporary patient care units.
5. Develop plans and design for creating individual care rooms or spaces that are negatively pressurized.

Based on these past guidelines, a review and updated clarification of recommendations are listed in the following section, "Recommended facilities ventilation design," which also provides examples of temporary design considerations.

Recommended Facilities Ventilation Design

Ventilation design following ASHRAE/ASHE Standard 170-2017 and ASHRAE Standard 62.1 guidelines appears adequate for the control of airborne spread of SAR-CoV-2 (COVID-19) in hospitals and other work areas during non-aerosol-generating activities or procedures.

There has been no documentation of transmission and airborne spread of SARS-CoV-2 (COVID-19) by HVAC systems during non-aerosol-generating activities or procedures. Additional practices for masking, hand hygiene and social distancing have reduced the risk of exposure.

Additional considerations beyond use of ASHRAE/ASHE Standard 170-2017 and ASHRAE Standard 62.1 guidelines are recommended and include:

1. Increasing outside air intake to maximum allowable level to enhance mixing and elimination of recirculating air.
2. Improving filtration efficiencies, if practical.
3. Providing negative pressure to patient rooms.
4. Running systems continuously and eliminating economized function.
5. Disabling demand-controlled ventilation (DCV) provisions.

Environmental conditions and ventilation of spaces with suspect COVID-19 patients

Screening stations

In screening station health care environments, the implementation of CDC guidelines (e.g., use of PPE, use of masking, and social distancing while indoors) for prevention of contact and emission of airborne SARS-CoV-2 (COVID-19) is sufficient as long as HVAC systems meet ASHRAE/ASHE Standard 170-2017 and ASHRAE Standard 62.1 guidelines. No additional measures for ventilation control are recommended.

When screening stations are outdoors, natural ventilation appears to provide protection against airborne SARS-CoV-2. Nasopharyngeal swabbing of symptomatic patients is considered an aerosol-generating procedure even if done outdoors, thus proper wearing of full PPE is required. Some facilities will swab all patients who are ambulatory outside, triage them, and then place them in a negative pressure room when one is available in the emergency department (ED). No patient who has been swabbed in the outdoor tent or is suspected of having COVID-19 should be permitted to wait in the ED waiting room with other patients.

Emergency departments and acute care areas

Patients presenting to ED must be placed in the following controlled areas for treatment:

1. Known positive for COVID-19, no symptoms: Negative pressurization room that meets ASHRAE/ASHE Standard 170-2017 guidelines for the area of treatment. If room is not available, then a room with the door closed and dedicated bathroom.

2. Known positive for COVID-19, with active symptoms or requiring aerosol-generating treatment or procedure: airborne infection isolation room (AIIR) meeting ASHRAE/ASHE Standard 170-2017 and CDC guidelines (see AII rooms or AIIR).

3. Rule-out COVID-19, with symptoms or requiring aerosol-generating treatment or procedure (or if cardiopulmonary resuscitation or trauma in progress where the patient is too ill to stop at the COVID screening): AIIRs meeting ASHRAE/ASHE Standard 170-2017 and CDC guidelines (see AII rooms or AIIR).

4. Rule-out COVID-19, no symptoms:
   Negative pressurization room that meets ASHRAE/ASHE Standard 170-2017 guidelines for the area of treatment. If room is not available, then a room with the door closed and dedicated bathroom.

Requirements for management of COVID-19 positive patients

Patient care spaces require careful consideration to ensure staff and patient safety. Space within a health care facility is designed to allow for routine situations and mitigate the spread of infection through engineering controls that address a number of different patient needs. The built environment is not designed to accommodate many patients with comparable needs, as is necessary with this pandemic. It is important to examine these changing facility needs with the assistance of qualified facilities and clinical professionals that can assess the facility's engineering controls and patient flow and help verify that the considered response will properly protect patients. To develop responses it is strongly recommended to use a multidisciplinary approach, with professionals including but not limited to:

- Facility manager
- Architect
- Professional engineer
- Infection preventionist
- Clinical staff

For patients with COVID-19 or other respiratory infections, evaluate need for hospitalization. If hospitalization is not medically necessary, home care is preferred.

Hospitalization

If hospitalization is necessary and ample AIIRs are available:

- CDC doesn't require placement in AIIRs, but consider using if resources allow.
- Limit transport and movement of the patient outside of the room to medically essential purposes.
- Patients should be housed in the same room for the duration of their stay.
- Whenever possible, perform procedures/tests in the patient's room.
- Aerosol-generating procedures (AGPs) should be done in an AIIR.

If hospitalization is necessary and AIIRs are limited, the CDC suggests placement in a single-person room with the door closed:

- Ensure room has a dedicated bathroom.
- Limit patient transport and patient transfers.
- Consider providing a negative pressure relationship to the patient corridor. Recirculation of air back to the HVAC system, unless high-efficiency particulate air (HEPA) filtered, should be avoided.
- AIIRs should be reserved for patients who will be undergoing AGPs.

To limit staff exposure and conserve PPE consider dedicated COVID-19 patient wards:

- Consider designating entire units for COVID-19 patients separate from units designated for persons under investigation.
- The ward or unit that is used to house COVID-19 patients (rule-out or confirmed) should be designed to provide neutral-negative pressurization to the entire area to meet appropriate ASHRAE/ASHE Standard 170-2017 guidelines for the unit/area except for those spaces which require positive pressure relationship per ASHRAE/ASHE Standard 170-2017. HEPA filtration is recommended for the space, however if not practical, the use of employee respiratory protection must be required while in the work areas.
- Dedicated staff should be assigned to care for these patients.
- If multipatient rooms are to be used, all patients should be confirmed with the respiratory pathogen.
- Limit transport and movement of patients outside of room and unit to medically essential purposes.
- Patients should be housed in the same room for the duration of their stay.
    - Patients with positive COVID-19 infection and no active symptoms should be placed in a room with negative pressurization that meets ASHRAE/ASHE Standard 170-2017 guidelines for the area of treatment or occupancy.
    - Patients with positive COVID-19 infection and active symptoms should be placed in a room designed for negative pressurization that meets ASHRAE/ASHE Standard 170-2017 guidelines for the area of treatment or occupancy.
- Whenever possible, perform procedures/tests in the patient's room.
    - AIIRs should be reserved for patients who will be undergoing AGPs.
- Terminal cleaning should occur after sufficient time has elapsed for enough air changes to remove potentially infectious particles. (See additional information under "Space Clearance and Ventilation After Patient Occupancy.")

Operating and Procedure Rooms

Implementation of practice guidelines during procedures (e.g., defined minimum wait time after intubation, extubation of patient or placement of LMA) along with maintaining ventilation requirements, potentially reduces risk of transmission outside of the operative suite.

There have been no documented outbreaks or spread of COVID-19 due to operating or procedure rooms.

With implementation of infection control and approved practice guidelines (e.g., allowing for a number of air changes after intubation and extubation), the risk for exposure to staff in adjacent areas outside the operating room is unfounded at this time.

COVID-19 positive patients undergoing AGPs increase the risk of transmission of the SARS-CoV-2 virus. The CDC recommendation, in an ideal situation, is to perform all AGPs in airborne infection isolation rooms (AIIRs) which are negative pressure rooms. This recommendation may lead individuals to consider performing surgeries and other procedures normally performed in positive pressure rooms in negative pressure rooms due to the possibility of aspiration generation. However, it is recommended that operating and procedure rooms remain positively pressurized in order to minimize surgical site infection risk. Ventilation design following ASHRAE/ASHE Standard 170-2017 guidelines appear adequate for the control of airborne spread of SARS-CoV-2 (COVID-19) in operating rooms, procedure rooms and adjacent areas.

Additional considerations for operating and procedure rooms for COVID-19 positive patients are:

- Only medically necessary surgeries or procedures should be scheduled and performed after scheduled operating room hours or when there are no COVID-19 negative patients within the suite.
- Develop a dedicated COVID-19 operating room and procedure room.
- Limit the amount of equipment and supplies in the dedicated COVID-19 patient room.
- Minimize staff within the operating or procedure room, and all staff involved should wear N95 respirators. The facility should use enhanced droplet PPE protection for all AGPs.
- All doors to the operating or procedure room should be kept closed as much as possible. Consider assigning a runner outside of the room who will retrieve medications, instrumentation and other supplies to minimize opening of doors.
- Control practices should be implemented after intubation and extubation occurs. These practices include, but are not limited to, the following:
    - Limiting entrance into the room for a set period of time after intubation.
    - Pausing for a number of room air exchanges after extubation.
    - Only essential staff should be in the operating room during procedures.
    - Airway procedures should be performed in accordance with Anesthesia Patient Safety Foundation (APSF) guidelines.(9)
- Use negative pressure anterooms, when feasible or available, with positive pressure operative room in order to reduce surgical site infection risk.

- Develop policy and procedures indicating these practices. Educate staff on practices and processes.
- Terminal cleaning should be performed only after the necessary number of air changes has occurred to remove potentially infections particles. (See additional information under "Space Clearance and Ventilation After Patient Occupancy.")

Airborne infection isolation rooms (AIIRs)

AIIRs are designed to prevent the spread of droplet nuclei expelled by a patient with disease. AIIRs must be designed to have the following characteristics:

- Negative pressure relative to the adjacent area and other parts of the facility. Negative pressurization must be at least -0.01 in. of water (-2.5 Pa) for newly constructed rooms, or -0.001 in. of water (-0.25 Pa) for rooms constructed before 2005.[6]
- Air cannot escape to other parts of the facility when the door is closed and the ventilation system is operating properly.
- Air from AIIR should be exhausted directly to the outdoors, where the droplet nuclei will be diluted in the outdoor air, or passed through a special high efficiency air (HEPA) filter that removes most (99.97%) of the droplet nuclei before it is returned to the general circulation.
- AIIRs must have 12 air changes per hour (ACH) for newly constructed rooms, or 6 ACH for rooms constructed before 2005.

Temporary airborne infection isolation room (AIIR) options

Setup of temporary rooms to meet airborne infection isolation criteria can be challenging. In order to be able to designate and use a room as an AIIR, the room will need to meet all of the requirements listed in ASHRAE/ASHE Standard 170-2017. Additional considerations should include the following:

- Creating a method to document air changes per hour once space setup is completed.
- Documenting the ventilation changes on a floor plan and revisiting the facility changes on a recurring basis with hospital leadership.
- Performing and documenting daily inspections of the rooms with a measuring device such as a vinometer.
- Establishing a preventive maintenance procedure for filter inspection and replacement.

Facilities management must be mindful that any building management programming changes need to be validated under commercial and generator power sources to ensure they do not revert to original set points.

Temporary negative pressure patient room options

An approach that can be effective in creating this type of space is to adjust the air volume ratio to a patient room and have the return air volume exceed the supply air volume. While this adjustment will cause the room to have a negative pressure in relationship to the corridor, it is imperative to ensure that the room ventilation still meets the designed ventilation requirements, such as air changes per hour, humidity and temperature, etc. If this is done for several rooms, or the entirety of rooms in a ward, it can make the ward itself negative to its adjacent spaces.

Per the recommendation found in the March 22, 2020 ASHRAE/ASHE Epidemic Task Force guidance document "Small Surge Option 8" (see Figure 1), installing a HEPA filter on the return air grille will help prevent contaminants from entering the ventilation system. It should be noted that adding filtration to the return air grille will increase the static pressure within the return air system and could impact the amount of air returned and thus the pressure relationship to the corridor. The HEPA filter can be affixed to the grille using fire rated tape to aid in forming a tight seal and ensure it remains in place (see Photo 2 in "Photos").

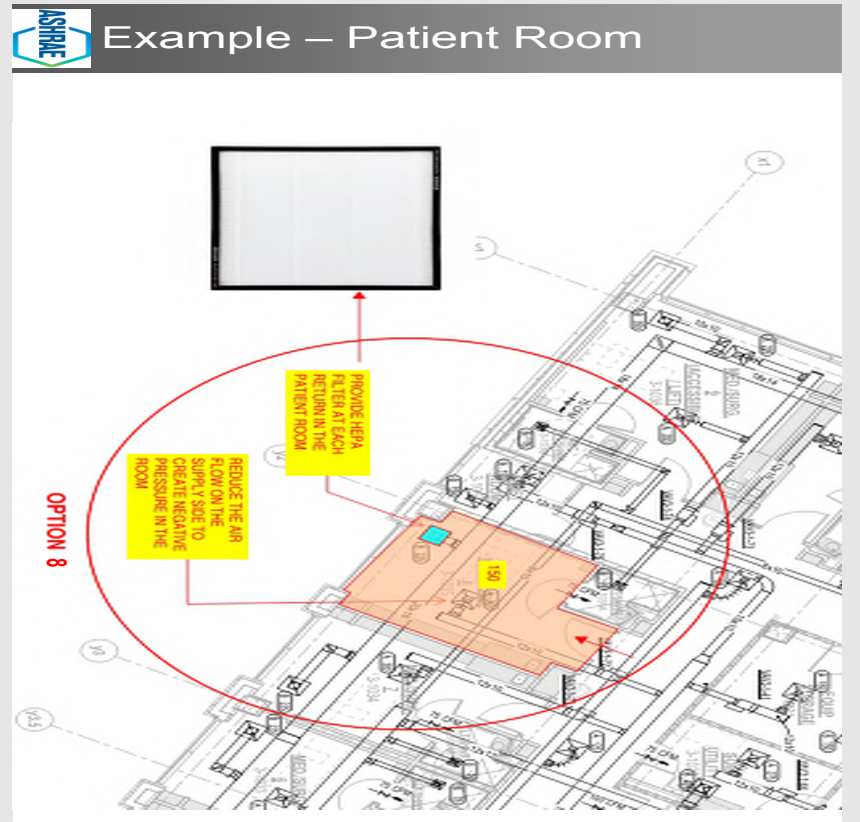


Figure 1. ASHRAE/ASHE Option 8. Image courtesy of TLC Engineering Solutions.

Another consideration when creating negative pressure patient rooms is to install exhaust air systems at the window (see Photo 1 in "Photos").

The following are acceptable sample configurations for temporary negative air rooms setup:

Example 1: HEPA Filtered to Outside

In a single patient room with dedicated bathroom:

- Seal off return air grill in patient room.
- Place HEPA filtered negative air machine either outside of or within the patient room and duct through exterior to outside.
- Remove window and enclose opening.
- Keep door to patient room closed.
- Verify negative pressure prior to placing room in service and monitor negative pressure while in service.
- Limit patient transport and patient transfers in and out of the room.
- Terminal cleaning should occur after sufficient time has elapsed for enough air changes to remove potentially infectious particles. (See additional information under "Space Clearance and Ventilation After Patient Occupancy.")

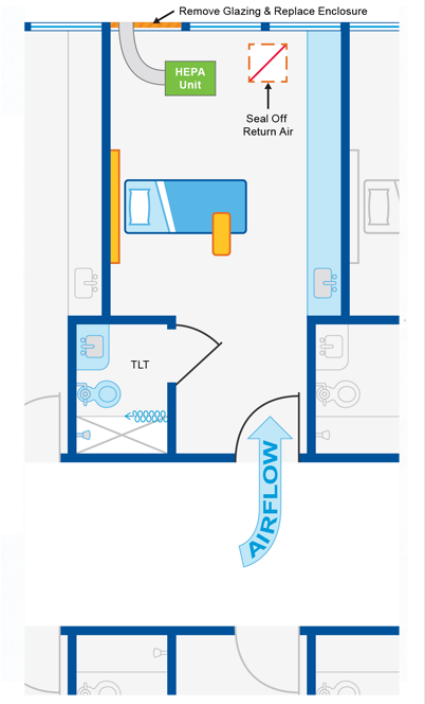


Figure 2. HEPA filtered to outside.

Example 2: HEPA to Corridor

In a single patient room with dedicated bathroom:

- Create "sealed" vestibule to patient room.
  - Vestibule should be a minimum 3'-0" x 6'-0" (1 m x 2 m).
  - Need minimum 5'-0" (1.5 m) egress clearance in the corridor.
- Seal off return air grill in patient room.
- Place HEPA filtered negative air machine in vestibule.
- Duct through the vestibule to corridor.
- Keep door to vestibule closed but door to patient room open.
  - Verify that patient room door is not a rated fire door! Any door over 20 minute rating may be a necessary fire door. These doors should be kept closed or on magnetic hold open.
- Verify negative pressure prior to placing room in service and monitor negative pressure while in service.
- Limit patient transport and patient transfers in and out of the room.
- Terminal cleaning should occur after sufficient time has elapsed for enough air changes to remove potentially infectious particles. (See additional information under "Space Clearance and Ventilation After Patient Occupancy.")

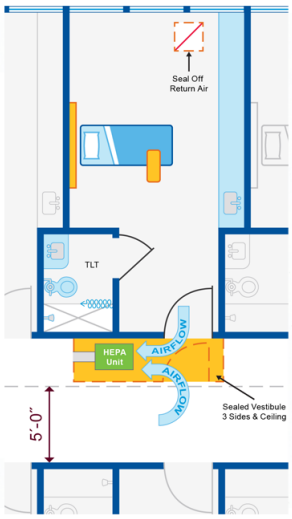


Figure 3. HEPA to corridor.

Example 3: HEPA Filtered to Return Air

In a single patient room with dedicated bathroom:

- Place HEPA filtered negative air machine in patient room.

- Duct to return air grill.
- Seal off remaining part of return air grill.
- Verify impact that this will have to the overall air-handling system (negative pressure in other patient rooms).
- Choosing rooms closest to the air handler may reduce impact.
- Keep door to patient room closed.
- Verify negative pressure prior to placing room in service and monitor negative pressure while in service.
- Limit patient transport and patient transfers in and out of the room.
- Terminal cleaning should occur after sufficient time has elapsed for enough air changes to remove potentially infectious particles. (See additional information under "Space Clearance and Ventilation After Patient Occupancy.")

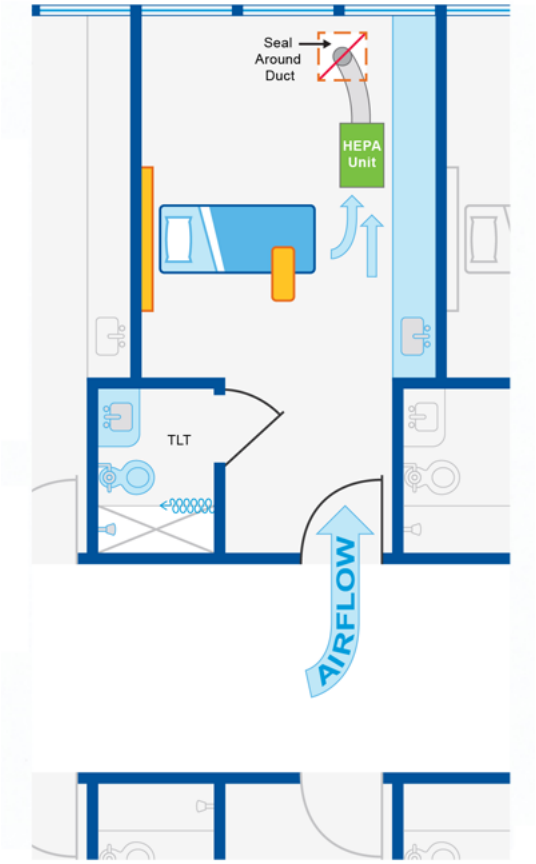


Figure 4. HEPA filtered to return air.

Temporary air-handling unit conversion options

To create a negative pressure environment within a patient unit, the following must be considered:

- Air handler should only serve area being dedicated to COVID-19 patients.
- If possible, replace filters on unit with HEPA filters it should be noted that this will increase the pressure drop to the air handler so testing and balancing (T&B) should be considered throughout the patient unit.
- Verify impact of negative pressure to all rooms.
- Patient rooms should be made more negative than rest of unit.
- Rooms with required positive relationship should remain positive:
    - Protective environment (PE) rooms, clean linen.
    - Clean workroom/holding.
- Limit access to the unit to only essential personnel.
- Create a control vestibule with a negative air machine at entrance.
- Verify negative pressure prior to placing unit in service and monitor negative pressure while in service.
- It is important that these types of spaces have negative pressure rooms.
- It is important to consult the facilities manager and maybe a professional mechanical engineer before these systems are altered.
- To make large scale unit conversions you may need to modify the air-handling unit as demonstrated in Figures 5 and 6:

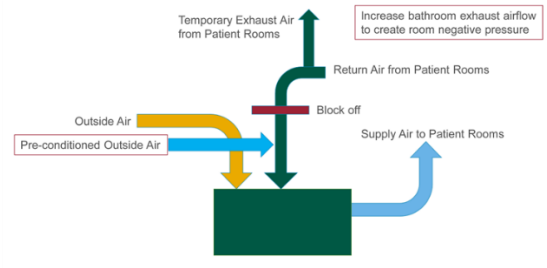


Figure 5. Example without Airside Economizer

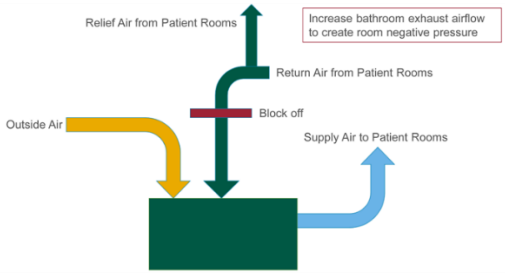


Figure 6. Example with Airside Economizer

HVAC Systems, Demand Control and Multiple Zone Variable Air Volume (VAV)

HVAC system design must meet current ventilation rates and parameters for ASHRAE/ASHE Standard 170-2017 in health care facilities and ASHRAE Standard 62.1 requirements in non-health-care areas.

The demand mode and use of zone VAV controls should be disabled in order to allow for constant flow and air exchange. Verify that systems are providing maximum air intake from outdoor source and exchange based on design.

Filtration and Exhaust Requirements
Maintain appropriate HVAC systems used for control and ventilation of COVID-19 care areas. If possible, increase filtration efficiency for HVAC systems. See examples 1-3 for room exhaust options under "Temporary negative pressure patient room options."

COVID-19 dedicated wards/units
High-efficiency particulate air (HEPA) filtration is recommended for recirculating air in dedicated COVID-19 patient care units. The entire unit must remain negatively pressurized in relationship to adjacent non-COVID-19 patient care areas.

HEPA filtered air appears adequate to maintain conditions when recirculating air from patient rooms used to maintain neutral-negative pressurization

Single patient rooms
Air exhausted directly outdoors from single patient rooms designed to maintain neutral-negative pressurization should be HEPA filtered, if possible. If not, the exhaust should be located at least 10 feet (3 m) off rooftop level and must be 25 feet (8 m) from outside air intakes in order to meet ASHRAE/ASHE Standard 170-2017 requirements. Hospitals constructing exhaust air not meeting the 10 foot (3 m) rooftop level discharge requirement must ensure that exhaust is not adjacent to windows, doors or other sources of entry.

Airborne infection isolation rooms (AIIRs)
Air from AIIRs must be exhausted directly outdoors. The exhaust should be located at least 10 feet (3 m) off rooftop level and must be 25 feet (8 m) from outside air intakes in order to meet ASHRAE/ASHE Standard 170-2017 requirements. Hospitals constructing exhaust air not meeting the 10 foot (3 m) rooftop level discharge requirement must ensure that exhaust is not adjacent to windows, doors or other sources of entry.

Space Clearance and Ventilation After Patient Occupancy

Once patients with active COVID-19 infection have been discharged from care and treatment, the room must be ventilated for removal of potential airborne aerosol following CDC guidelines. The ventilation air change rate in the room must be verified and used to determine the time required for airborne-contaminant removal prior to entering the room without PPE after patient discharge. The chart below should be used to determine time for airborne-contaminate removal by 99% efficiency.

Airborne Contaminant Removal

The number of air changes per hour (ACH) and time and efficiency.		
ACH §	**Time (mins.) required for removal 99% efficiency**	**Time (mins.) required for removal 99.9% efficiency**
2	138	207

The number of air changes per hour (ACH) and time and efficiency.		
ACH §	**Time (mins.) required for removal 99% efficiency**	**Time (mins.) required for removal 99.9% efficiency**
4	69	104
6+	46	69
8	35	52
10+	28	41
12+	23	35
15+	18	28
20	14	21
50	6	8

Table 1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency. From CDC Guidelines for Environmental Infection Control in Health-Care Facilities, Appendix B, Table B.1.[10]

+ Denotes frequently cited ACH for patient-care areas.
§ Values were derived from the formula:
t2 – t1 = – [ln (C2 / C1) / (Q / V)] X 60, with t1 = 0
where

t1 = initial timepoint in minutes
t2 = final timepoint in minutes
C1 = initial concentration of contaminant
C2 = final concentration of contaminant
C2 / C1 = 1 – (removal efficiency / 100)
Q = air flow rate in cubic feet/hour
V = room volume in cubic feet
Q / V = ACH

Example[7]: A standard patient room measuring 12 feet x 10 feet with a ceiling height of 9 feet is served with a 20% outdoor air ventilation system that delivers 65 cubic feet per minute (cfm) of supply air (Q_s = 65 cfm) and exhausts 72 cfm of air from the room (Q_e = 72 cfm). The room has good air mixing, assign k = 3. How much time is required to reduce the airborne particle concentration by 99%?

Since Q_e is larger than Q_s by 7 cfm, the heating, ventilation and air-conditioning (HVAC) system is pulling 7 cfm of air into the room from adjacent areas (i.e., the room is under negative pressure). For this example, the 7 cfm of transfer air is assumed to be free of infectious airborne particles. The clean volumetric airflow rate (Q) is the larger value between Q_s and Q_e, so Q = 72 cfm. Now, calculate the air changes per hour (ACH):

ACH = [Q x 60] / (room volume) = (72 cfm x 60) / (12’ x 10’ x 9’) = 4320/1080 = 4.0 ACH

Using Table 1 (CDC Table B.1), the perfect mixing wait time based on 4 ACH and a 99% reduction of airborne particles is 69 minutes.

Additional considerations for mixing factors: Using the mixing factor of 3, the estimated wait time for 99% reduction of airborne contaminants in the room is 3 x 69 = 207 minutes or 3 hours and 45 minutes.

Other HVAC Considerations

Ultraviolet germicidal irradiation (UVGI)
The use of UVGI light sources in HVAC systems and occupied spaces to disinfect surfaces or provide additional benefits to limit transmission of SARS-CoV-2 is not directly supported. Some facilities utilize UVGI light in air-handler systems for coil maintenance and have seen benefits. Several resources and studies have found additional benefits in using UVGI light for post-patient care room sanitation. However, the choice to use these devices in rooms should be based on organization research and past experience. At this time, the addition of UVGI light sources in HVAC system is not recommended.

Seasonal variations: effects of temperature and relative humidity
The effects of seasonal changes, including temperature and relative humidity, are not well understood at this time. Organizations should expect indoor environmental parameter changes during the year and adjust accordingly to meet ASHRAE standards.

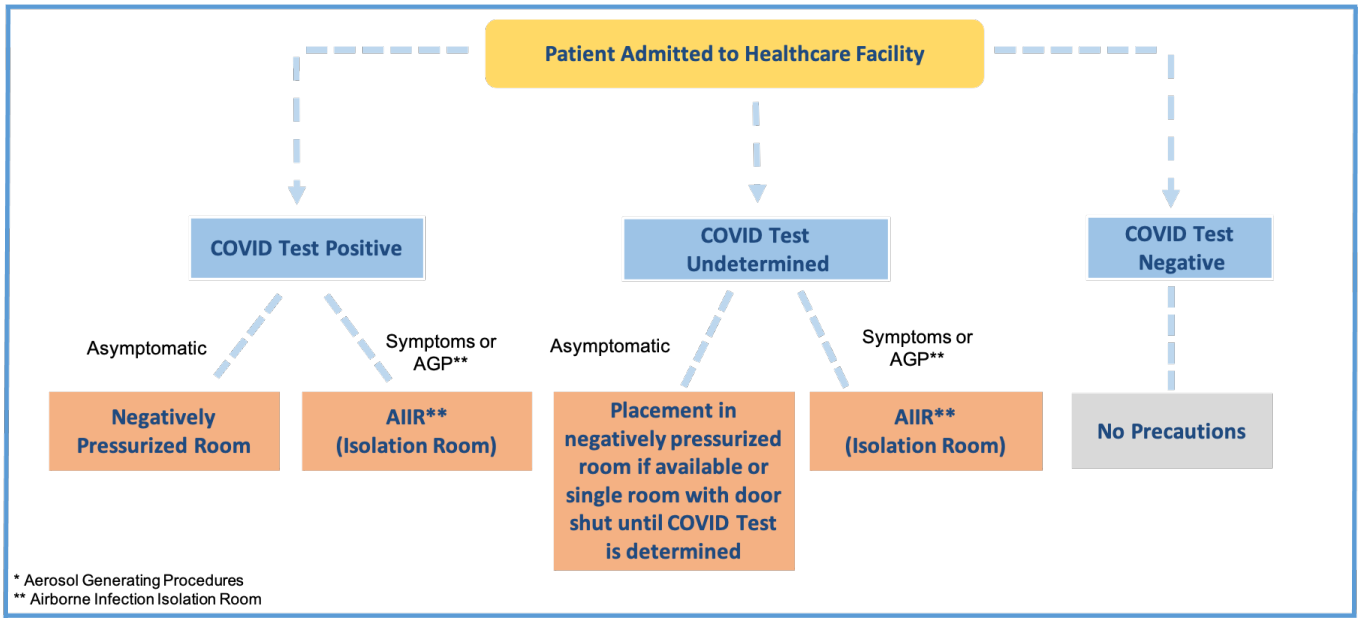
Room temperature and humidity
ASHRAE/ASHE Standing Standard Project Committee (SSPC) 170 reviewed 55 research papers in relation to the virucidal effects of temperature and relative humidity on pathogens. The review indicated a disparity in the research such that a general conclusion regarding temperature and relative humidity within health care spaces could not be reached.[11,12] One of the greatest concerns discovered in the research is that while higher temperature and relative humidity can reduce the airborne transmission of influenza and other viruses,[13,14] it also increases the fomite transmission of these same viruses.[15] This disparity is of significant concern since within a health care setting fomite and airborne transmissions of any pathogen must be adequately addressed. For these reasons, SSPC 170 recommends that temperature and relative humidity requirements within the 2017 edition of ASHRAE/ASHE Standard 170-2017 be followed.

Use of in-room air scrubber and movers
The use of separate air mover devices in spaces has not shown additional benefit when the HVAC system design meets appropriate guidelines. The use of ventilation designed for spaces following ASHRAE/ASHE Standard 170-2017 guidelines appears adequate. However, the choice to use these devices in rooms should be based on organization research and past experience.

Decision Flowchart

Determining patient flow during the pandemic is a vital process to ensure patient and staff safety. Taking the appropriate measures to achieve proper patient placement will significantly reduce the risk of exposure. The following flowchart provides a decision tree to support proper placement of patients.

Figure 7. Patient admittance decision flowchart.



Examples

Define the ventilation requirements (normal, negative, negative-AIIR). Answers are below.

1. Patient is positive for COVID-19, no symptoms, located on labor and delivery in single room.
2. Patient is positive for COVID-19, no symptoms, in ED or lab.
3. Patient is positive for COVID-19, with SYMPTOMS, no aerosol procedures performed at this time.
4. Patient is positive for COVID-19, no symptoms, having aerosol generating procedure.
5. Group of patients on a ward, all COVID-19 positive, no symptoms.

Answers

1. Negatively pressurized room
2. Negatively pressurized room
3. AIIR
4. AIIR
5. Negatively pressurized room for each unit must meet requirements for dedicated unit.

Staff protection and work practices

Clinical staff must follow current OSHA and CDC guidelines for personal protection while working in the health care environment with suspect or confirmed COVID-19 patients. Currently, the following guidelines for protection include, but are not limited to, the following:

1. Ensure that masking practices and face covering practices are followed at all times in the health care environment.
2. Use of N95 or higher respiratory protection for worker activities in rooms caring for positive COVID-19 patients.
3. Use N95, or preferred higher (HEPA) respiratory protection for worker activities in rooms caring for positive COVID-19 during aerosol-generating procedures.

Additional precautions may require use of face shields or face cover to prevent touching of mucus membranes. Isolation procedures such as those used for droplet precautions and special respiratory isolation must follow CDC guidelines.[16] Employees and individuals working in the health care facility must follow the infection control and safety guidelines set forth by the organization.

Individuals working on dedicated COVID-19 units that recirculate non-HEPA filtered air and/or no neutral-negative COVID-19 patient care rooms should consider wearing N95 or higher (HEPA) respiratory protection while in the space.

Maintenance and Contract Worker Activities

Workers in areas within 25 feet (7.62 m) of hazardous exhaust vents (not-HEPA filtered)

Employee protection must be developed for working near hazardous exhaust. Workers entering and working on the roof in the area of isolation room exhaust discharge must wear the following:

- N95 or higher respiratory protection when on the roof and when within 25 feet (7.62 m) of exhaust ventilation systems.
- Eye protection, such as goggles or face shield, to prevent touching of mucus membranes.

Facilities workers maintaining HVAC systems and changing filter material

Employee protection must be defined for workers servicing and maintaining HVAC systems associated with COVID-19 care areas. Work including air-handler unit maintenance and filter changes must have defined protection, such as, but not limited to:

- Use of personal protective clothing or disposable coveralls.
- Use of HEPA respiratory protection.
- Eye protection, such as goggles or face shield to prevent touching of mucus membranes.

Employees and individuals working in the health care facility must follow the infection control and safety guidelines set forth by the organization.

Recovery: Immediate and Short-Term Considerations

The COVID-19 pandemic is impacting the health care physical environment in ways never imagined. Facilities have been reimagined, renovated, expanded, enlarged and underutilized simultaneously. The pandemic's significant impact on the physical environment has offered challenges and learning experiences. Recovering from the impacts of this pandemic and documenting lessons learned are vital and will require significant planning and action. Not only will it require facilities to reimagine their responsibilities to their service population, but it will also require them to coordinate reopening with their coalition and state.

Specific Facility Ventilation Issues

Since this information is focused on recovering the health care physical environment, it is important to begin with the specific issues unique to the physical environment. There are many other recovery aspects that will need to be addressed in conjunction with those listed here, but ASHE strongly encourages identifying individuals to focus on recovering these specific issues to prevent potential and significant harm.

Altered ventilation systems

Facilities managers should assess what ventilation systems were altered during the response phase. A thorough assessment of these waivers will be required to ascertain that any regulatory compliance issues that were altered or deferred during the event are properly accounted for. As COVID care spaces are demobilized, consider the following recommended steps to return the space to Non-COVID care (NCC) patient care areas:

- Verify that all airflow relationships are correct and brought back minimally to the original design flow. If large areas are to be rebalanced, consider applying the appropriate ASHRAE/ASHE 170 standards. Ensure you have the appropriate engineering assistance to achieve this redesign.
- Verify that all pressure relationships for pressure related rooms are appropriate (e.g., soiled utility rooms are negative and clean supply rooms positive).
- Examine filtration media in air handler units to verify that mitigation efforts did not cause negative impacts and change as necessary.
- Verify that CDC recommended guidelines (see CDC Table B.1) for air changes and time required for contaminate removal based on air changes is followed.
- Verify that terminal cleaning is complete in clinical spaces and patient rooms following hospital or facility policies.

Damage to built environment

Damage to the built environment and the workload required to make repairs will also need evaluation. Consider damage from the creation of negative pressure rooms, the relocation of patient care equipment outside of patient rooms, and wear and tear on the facility due to the surge, as well as damage to ductwork or HVAC changes/modifications.

Sustainability measures

Determine the pandemic's impact on sustainability measures implemented within the organization. Areas that might have been impacted include: energy management systems that may have been overridden, set back or turned off to meet surge demands on the facility or other modifications due to the surge such as schedules or ventilation measures that have been modified, water or waste conservation measures that have been modified and any changes within the fleet management strategy for the organization.

Additional information

As mentioned earlier, the pandemic is impacting the health care physical environment in ways never imagined. Recovery from this extended public health emergency will require significant effort. For additional recovery efforts within the physical environment see the ASHE COVID-19 Recovery resources available at ashe.org/covid-19-recovery.

Photos

Photo 1: Temporary AIIR negative isolation room. Air is exhausted

by HEPA filtered air outside.
Photo Courtesy of University of Maryland Medical Center, Baltimore, Maryland.

Photo 2: Installation of HEPA filter on return air diffuser in order to create temporary neutral/negative pressure for single patient room.
Photo Courtesy of Naval Hospital Camp Pendleton, Camp Pendleton, California

Photo 3: Single patient room negative air configuration through exterior windows. Air is exhausted by HEPA filtered air at roof level.
Photo Courtesy of Orlando Health, Southlake Hospital, Orlando, Florida

Photo 4: Temporary single negative patient rooms in ED.
Photo Courtesy of Naval Hospital Camp Pendleton, Camp Pendleton, California

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