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COVID-19 PANDEMIC

AIRBORNE INFECTION ISOLATION OPTIONS

Technical Guidance Document
for
New York State Nurses Association
(NYSNA)

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Novel negative air controls to alleviate AIIR shortages

"During a large-scale airborne infectious disease outbreak, the number of patients needing hospital-based health care services may exceed available negative-pressure isolation room capacity."[3]

"Extraordinary incidents resulting in airborne infectious disease outbreaks could produce patient isolation requirements that exceed most hospitals' capacity. With careful implementation under emergency circumstances in which engineered isolation rooms are unavailable, expedient methods can provide affordable and effective patient isolation while reducing exposure risks and potential disease transmission to health care workers, other patients, and visitors."[2]

There are multiple options for implementing *temporary* patient isolation using novel negative air infection controls to relieve deficiencies in AIIR surge capacity.

Options for implementing additional ventilation interventions include creation of pressure differentials, use of portable HEPA-filtration units, use of local exhaust ventilation, use of curtains or other barriers to alter ventilation patterns, use of fire-rated spaces, and modifications to the existing mechanical ventilation system.

Note that during a shortage of negative-pressure rooms, as in the current COVID-19 pandemic, physical isolation of infectious patients should be implemented even in the absence of additional options for ventilation.

Methods that rely upon general/dilution ventilation include:

- Repurposing anterooms for negative pressure applications.
- Negative pressure for single-bed room, HEPA to outside.
- Negative pressure for single-bed room, HEPA to return.
- Negative pressure for single-bed room, zone-within-zone.
- Negative pressure for multiple-bed room, zone within zone.
- Negative pressure for infectious disease zone.
- Negative pressure from single air handling unit, multiple-bed room.

Methods that rely on local exhaust ventilation (LEV) include:

- NIOSH ventilated headboard, singe bed.
- NIOSH ventilated headboard, multiple beds.

Caveat: These measures are intended to reduce risk of infection in the context of an emergency need for access to critical care facilities during the COVID-19 pandemic. While these measures can be effective and even life-saving, some also introduce additional risks, including potential contamination of clean areas of the facility, potential re-entrainment of contaminated air discharged to the exterior, adverse impact on the mechanical ventilation system, and potential compromise of fire safety measures. Some of these novel solutions are unlikely to be fully compliant with applicable regulations and guidance. Some are unlikely to be as protective of patients or of HCWs as are permanent AIIRs designed and operated

to legal or consensus specifications. Implementation of some of these novel remedies may warrant consultation with facilities engineers or ventilation engineers as modification of mechanical ventilation operation may inadvertently impact ventilation elsewhere in the hospital. Similarly, it may be advisable to consult with local fire departments to ensure that temporary or permanent structural alterations do not create fire hazards or violate fire codes. These novel solutions for negative pressure infection control isolation under critical care surge conditions should be considered emergency solutions implemented on a temporary basis under crisis conditions. These temporary measures should be incorporated into the facility's infection control and emergency response plans.[4] *However, the appropriate solution to AIIR under-capacity is improved, proactive long-term planning for, and implementation of, increased permanent AIIR capacity and increased built-in options for local exhaust ventilation.*

1. Negative pressure general/dilution ventilation

Temporary Option: HEPA to Outside[1]

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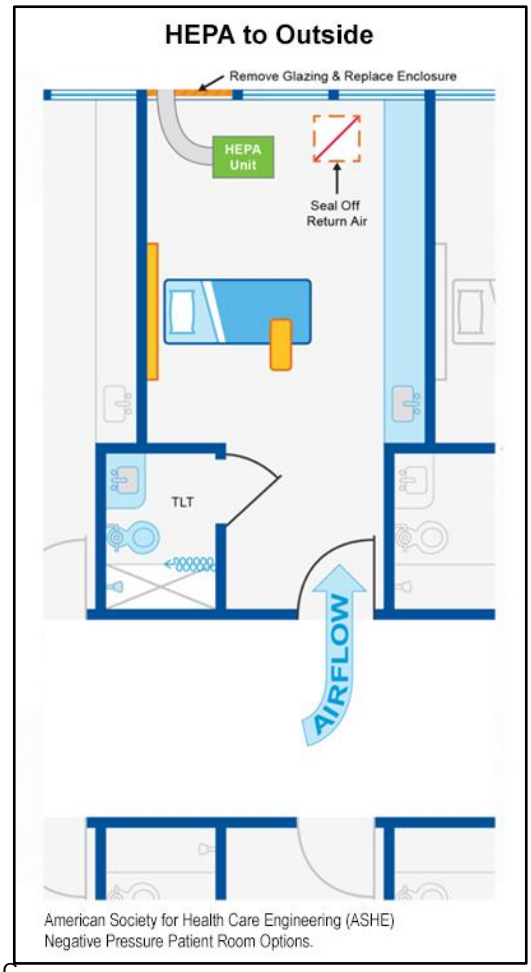
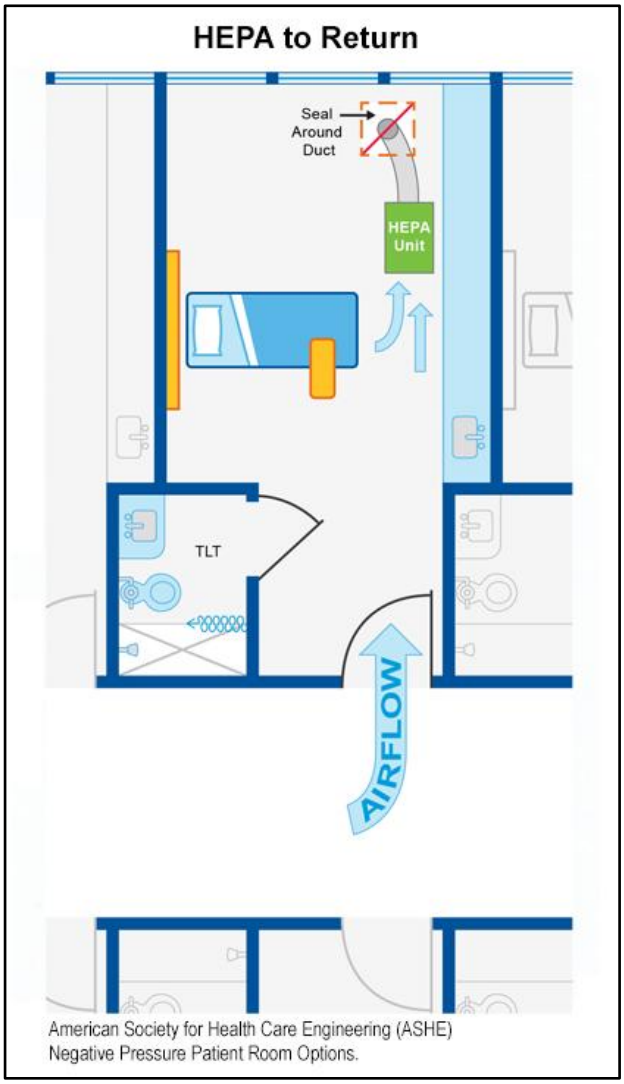
An existing standard single-patient routine care room with a dedicated bathroom is temporarily converted to an AIIR-like negative pressure room for airborne infection isolation. The return air register in the patient room is sealed off and a HEPA-filtered negative air machine is installed near the window. The window is removed and a plywood window adapter is constructed with a circular hole and installed in the window to provide an airtight fit. A sheet metal flange around the hole is used to attach the flexible duct from the HEPA-filtered negative air machine. When everything is in place and airtight, the machine is turned on and adjusted to



achieve a pressure differential of negative 2.5 Pa with the door closed. The patient room is now under negative pressure relative to the corridor. Pressure should be monitored daily.



Temporary Option: HEPA to Return[1]

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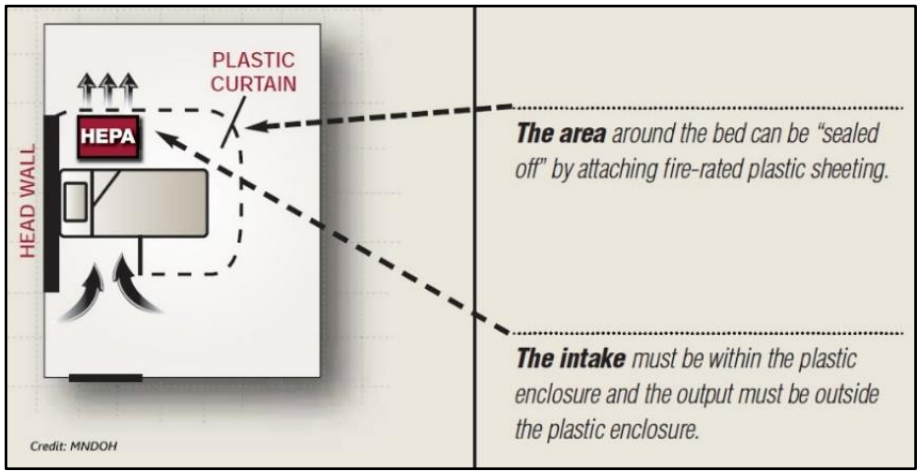
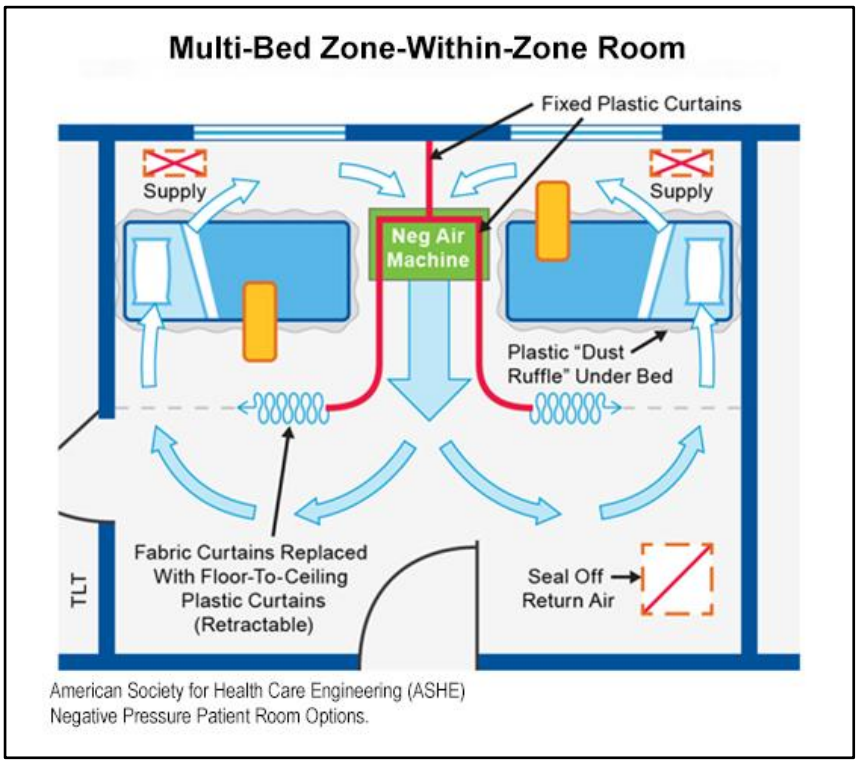
An existing windowless standard single-patient routine care room with a dedicated bathroom is temporarily converted to an AIIR-like negative pressure room for airborne infection isolation. A HEPA-filtered negative air machine is installed near the return air grill. The flexible duct adapter is attached to the return grill and the flexible duct from the HEPA-filtered negative air machine is attached to the adapter. The grill and all attachment points are tightly sealed to prevent leakage. When everything is in place and airtight, the machine should be turned on and adjusted to achieve a pressure differential of negative 2.5 Pa with the door closed. The patient room is now under negative pressure relative to the corridor. The pressure should be monitored daily. Confirm with the appropriate engineers that discharging air into the return air system is not adversely impacting pressure in other rooms.

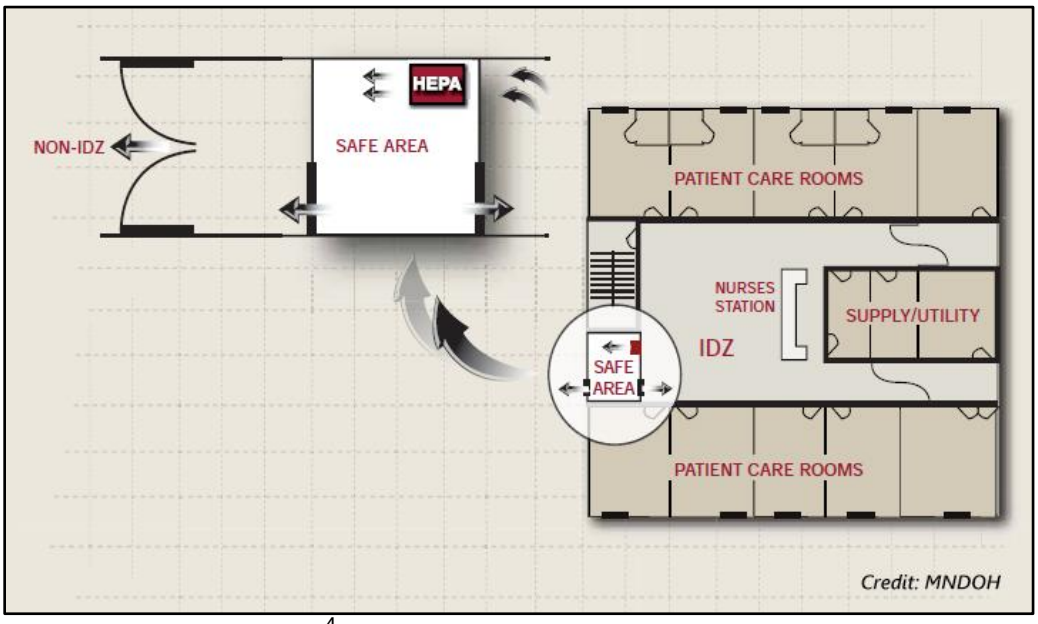
Single Bed Zone-Within-Zone Room



Zone within Zone Room[1,4] ▶

A negative pressure zone is temporarily created *within* a single or multi-bed routine patient care room. The area around the bed(s) is largely sealed off with fire-rated plastic sheeting. A HEPA-filtered negative air machine is strategically placed within the sealed off negative pressure zone. The intake of the negative air machine must be within the plastic enclosure and the output must be outside the plastic enclosure. An opening is provided for discharge of HEPA-filtered air from the negative pressure zone into general room air outside the enclosure. Dust ruffles or similar are provided under the bed(s) to minimize air movement below the bed(s). Exhaust air grills are sealed off. Supply air vents may be inside or outside the containment area with openings as appropriate in the plastic sheeting to permit re-entry of clean room air. The door to the patient room must be kept closed. Verify negative pressure prior to placing the room in service. Continuously monitor negative pressure while in service.





Negative Pressure for Infectious Disease Zone[4]

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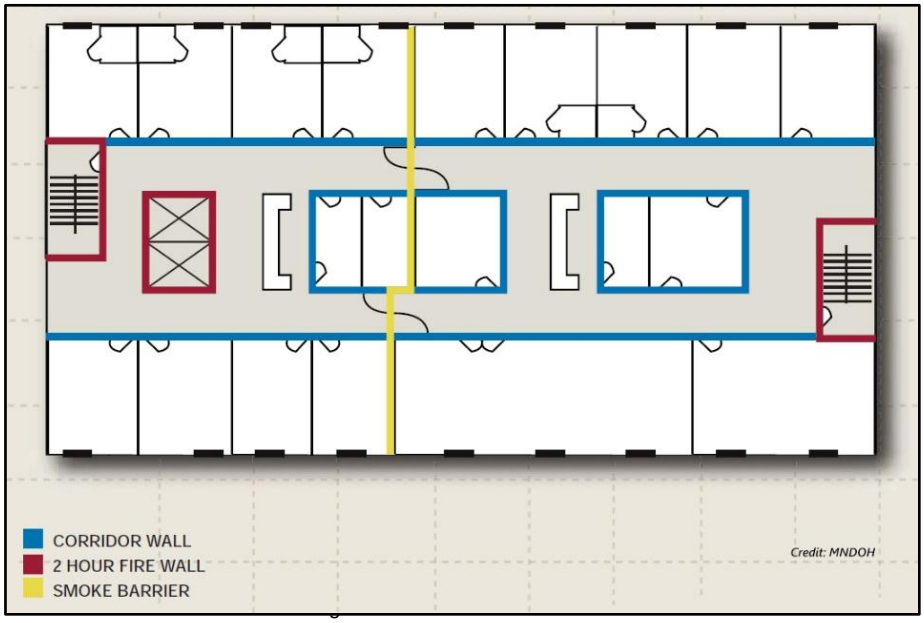
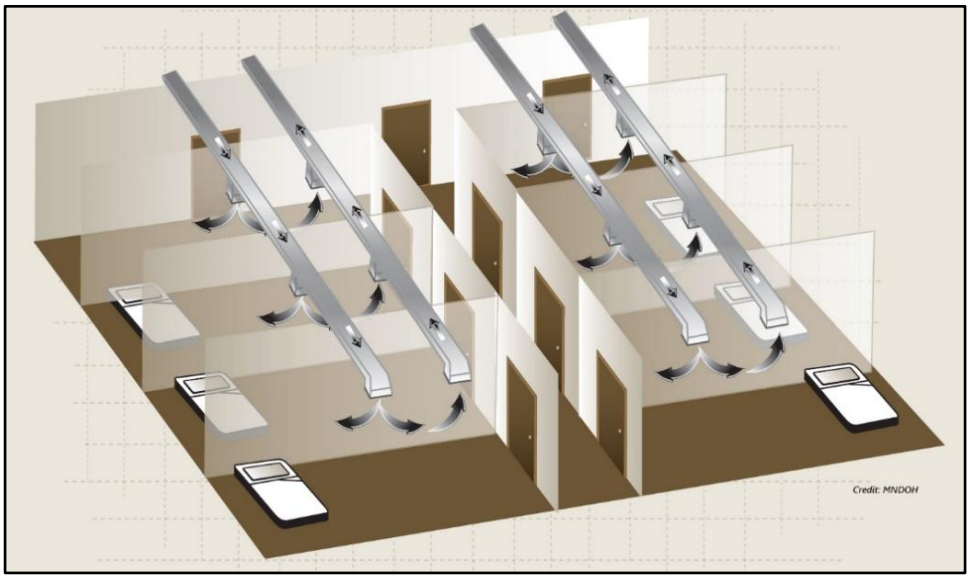
An *infectious disease isolation zone* is a multiroom area used to isolate a large number of infectious patients.[4] In the first illustration, a 10-room ward is temporarily placed under negative pressure relative to the outside corridor. An existing anteroom is used, or a new one is temporarily created, separating the ward from the corridor. The anteroom should be large enough to permit the passage of personnel, equipment, and supplies in and out of the ward, as well as facilitate donning and doffing of PPE, washing or sanitizing of hands, and disposal of waste. A HEPA-filtered negative air machine is positioned in the anteroom to place it under positive pressure relative to both the ward and to the outside corridor; i.e., the ward is under negative pressure relative to the anteroom. This is accomplished by drawing air directly into the HEPA-filtered negative air machine from the (contaminated) ward and discharging the filtered air into the interior of the anteroom, from which it flows both into the corridor and the ward. Airtight seals are required for all connections.



In the second example, a designated smoke zone is used to temporarily create an infectious disease isolation zone. Smoke zones are designed with smoke barriers and fire-rated doors to prevent smoke from migrating to other zones. This property can be utilized to isolate infectious patients. In addition, the area can potentially be placed under negative pressure by using a HEPA-filtered negative air machine to discharge filtered air to the exterior or to the return (exhaust) air system.



◄ Negative Pressure from Single Air Handling Unit[4]

An air handling unit (AHU) is a major component of a mechanical ventilation system, also known as the heating, ventilation, and air conditioning (HVAC) system. The AHU controls air movement, air cleanliness, temperature, and humidity for an entire building, a single floor, a group of rooms, or a single room. In a large facility such as a hospital, a suite or a wing may be served by a single AHU. In this case, a ventilation engineer may be able to modify the HVAC program or the physical HVAC settings for the suite or wing to provide 100% exhaust to the exterior, creating a temporary negatively pressurized infectious disease isolation zone. All doors to this zone must be kept closed except for entry and exit.

2. Negative pressure local exhaust ventilation

Local Exhaust Ventilation: NIOSH Ventilated Headboard, Single Bed[5,7,8]

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The NIOSH prototype ventilated headboard is a DIY (do-it-yourself) portable, retractable, 3-sided canopy hood that fits over the head of a supine patient, with the patient and the bed forming the fourth side of the enclosure. Used in conjunction with a HEPA negative air machine, it provides a high degree of source control. Performance tests indicate nil source migration from the inner isolation zone and up to 87% reduction in the concentration of airborne respirable particles measured at the HCW compared to concentrations measured at the source within the hood.[2] "In addition to the direct-capture capabilities of the ventilated headboard, the HEPA fan/filtration system provides continuous air cleaning of the surrounding room air."[7]

Local Exhaust Ventilation: NIOSH Ventilated Headboard, Multi-Beds[6]

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Multiple NIOSH ventilated headboards can be incorporated into a multi-bed system served by a single HEPA negative air machine as distinct from the use of multiple headboards, each of which is mated to its own HEPA fan unit. The number of individual headboards that can be incorporated into a single

system will depend upon the capacity of the available fan or HEPA fan/filter unit and the associated duct work. If the air is to be

exhausted outdoors and away from buildings and people, the system may not require HEPA filtration. However, removal of large amounts of tempered air may adversely impact general ventilation in other areas of the facility and may warrant adjustment of the HVAC system.

NIOSH offers this caveat regarding use of the ventilated headboard:

> In the absence of an emergency scenario, the investigated isolation approach should not be considered an acceptable replacement for engineered airborne infection isolation rooms. However, under extraordinary circumstances where the quantity of engineered airborne infection isolation rooms is insufficient to meet surge demand for patient isolation, hospital facilities could quickly deploy portable filtration equipment in combination with zone-within-zone patient isolation configurations.[2]

RESOURCES

1. American Society for Health Care Engineering (ASHE). Negative pressure patient room options. March 23, 2020. https://www.ashe.org/negative-pressure-rooms.

2. Mead KR. Johnson DL. An evaluation of portable high-efficiency particulate air filtration for expedient patient isolation in epidemic and emergency response. *Annals of Emergency Medicine.* 44(2004) 635-645.

3. Miller S. et. al. Implementing a negative-pressure isolation ward for a surge in airborne infectious patients. *American Journal of Infection Control.* 45 (2017) 652-9.

4. Minnesota Dept. of Health, Office of Emergency Preparedness (MNDOH). Airborne infectious disease management: Methods for temporary negative pressure isolation. 2020. http://www.health.state.mn.us/oep/training/bhpp/isolation.html.

5. National Institute for Occupational Safety and Health (NIOSH). Engineering controls to reduce airborne, droplet, and contact exposures during epidemic/pandemic response: ventilated headboard. April 27 2020. https://www.cdc.gov/niosh/topics/healthcare/engcontrolsolutions/ventilated-headboard.html.

6. NIOSH. Expedient airborne infection isolation – 5 bed demonstration kit. Undated. https://www.cdc.gov/niosh/topics/hcwcontrols/engcontrolsolutions/pdfs/ExpedientAirborneInfectionIsolation5bedDemoKitAssemblyInstructions.pdf.

7. NIOSH. Science blog: NIOSH ventilated headboard provides solution to patient isolation during an epidemic. April 14 2020. https://blogs.cdc.gov/niosh-science-blog/2020/04/14/ventilated-headboard/.

8. NIOSH. The ventilated headboard: A cost-effective intervention that protects healthcare workers and provides surge isolation capacity. (Video) April 24 2020. https://www.youtube.com/watch?time_continue=3&v=8H2kmZkbuR4&feature=emb_logo.