COVID-19 ENGINEERING CONTROLS AND VERIFICATION FOR MEDICAL TREATMENT FACILITIES

TIP NO. 98-108-0420

INTRODUCTION

This document provides guidance on the ventilation requirements that exist for areas of medical treatment facilities (MTFs) where COVID-19 patients or specimens may be located. It includes engineering controls to reduce the spread of COVID-19 as well as tools for the staff to verify that an area is meeting the necessary ventilation requirements for containment.

TRIAGE OF PATIENTS

- Provide separated, well-ventilated triage areas at an appropriate facility entrance with barriers, such as glass, plastic, or patient curtains to limit contact between personnel and patients.
- Patients with symptoms of COVID-19 or respiratory infections should be examined in a room that is separated from other patients and well-ventilated; waiting patients should be separated by 6 feet or more. The Centers for Disease Control (CDC) advises placing admitted patients with suspected or confirmed COVID-19 in private rooms with the door closed and a private bathroom (as possible)[1]. It is best to follow CDC's airborne precautions as closely as possible[1].

AIIR

- CDC recommends that AIIR be reserved for patients undergoing aerosol-generating procedures (AGP) or for diagnoses such as active tuberculosis (TB).
- Minimum of 12 air changes per hour (ACH) with 2 ACH of outside air per CDC and Unified Facilities Criteria (UFC) 4-510-01[2]. Older facilities (before approximately 1994) may have <12 ACH and should supplement with additional high-efficiency particulate air (HEPA®) filtration and ultraviolet germicidal irradiation (UVGI) to try to achieve 12 ACH.
- Differential pressure ≥0.02 inches water gauge (wg)[2] (Older facilities may have ≥0.01 inches wg).
- 20% more exhaust than supply air[2], ≥125 cubic feet per minute[3] (cfm) difference (older facilities may have ≥10% more exhaust than supply air (≥50 cfm difference)).
- Room sealed to ensure less leakage (approximately 0.5 square feet (ft^2) of leakage).
- Exhaust direct to outside[2] (exhaust from the AIIR, bathroom and anteroom not connected to any other spaces) and no recirculation. The current UFC 4-510-01[2] design guidance is for HEPA filtration of the exhaust discharge unless a re-entrainment analysis has been performed. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE®) 170[4] requires only that exhaust discharge for these areas is at least 25 feet from any building air intakes or occupied areas.

- Anterooms (where provided) are recommended to be under a negative pressure relative to the corridor and positively pressurized relative to the bedroom[2].
- Ventilation and pressurization control equipment serving AIIR bedrooms must be connected to the essential electrical system (EES)[2,4] .True AIIR rooms must have pressure-monitoring alarms and gauges mounted on the outside corridor wall and must be connected to the central Direct Digital Control (DDC) operator's station[2].
- VERIFICATION: Verify air exchange and differential pressure prior to use (note that measuring exhaust and supply air differential does not guarantee the necessary negative pressure, and this must be verified separately). Monitor air pressure daily with visual indicators while occupied (monthly when not occupied). Note and address any discrepancies between room air pressure monitors and visual indicators (e.g., monitor shows negative pressure, but visual indicator shows positive pressure). Conduct air balancing when the pressurization parameters are not met.

PATIENT ROOMS OR WARDS WITH HVAC SYSTEM ADJUSTMENT TO CREATE TEMPORARY NEGATIVE PRESSURE ISOLATION AREAS:

See U.S. Army Public Health Center (APHC) TIP No. 98-109-0420, Improvising Negative Pressure Isolation Rooms[5] document for improvised rooms that do not employ HVAC system adjustment. Note that true AIIR rooms have ventilation and pressurization systems connected to the EES to ensure continued operation in the event of power loss. Rooms that are under negative pressure but do not meet the requirements of an AIIR are considered negative pressure rooms and not AIIR.

- To convert patient rooms or wards to temporary negative pressure isolation rooms using the HVAC system requires careful coordination with facilities management. Ideally the system should be capable of providing up to 100% outdoor air with dedicated exhaust to the outside (e.g., switch to economizer mode at 100% outdoor air when outdoor air conditions permit), maintaining negative pressure for the room or area involved, and maintaining temperature and humidity requirements. Where patient room areas or wards are to be converted to negative pressure, it is recommended that the area is served by a single dedicated air-handling unit that can meet these requirements and that an anteroom or vestibule be provided at the entrance to the area that can assist with maintaining pressurization in the space when doors are opened or closed.[6,7] Consideration must be given to stairwell pressurization where a stairwell is adjacent to the area. The stairwell pressurization should be positive to the temporary negative pressure area to prevent contaminants from entering and traveling through the stairwell.[8]
- Substituting HEPA or Ultra-Low Particulate Air (ULPA) filtration into a recirculating air handling unit in place of the existing filter to increase effectiveness is an option; this option must be carefully considered prior to use as these filters carry substantial pressure drops that must be accommodated by the existing fan. They also require fit into the system with correct housing, effective gasketing and sealing, appropriate prefilters, and may also require testing in-situ prior to use (e.g., Dispersed Oil Particulate (DOP) or Polyalphaolefin (PAO)) to ensure there is no leakage[9].

- Consider location of the outdoor air intake in relation to the exhaust discharges from potentially infectious areas to avoid re-entrainment. Notify maintenance personnel and provide signage for previously nonbiohazard exhaust that is changed to a biohazard.
- Note that ASHRAE 170 and UFC 4-510-01 require HEPA filtration only in certain areas, so it is important to verify with facilities management what type of filtration is present for each system. Additional information on HEPA filtration can be found at the ASHRAE COVID-19 Resources Website: https://www.ashrae.org/technical-resources/resources.
- Current design requirements for relative humidity (RH) are in the range of 30-60 percent, depending on the specific patient care area[2]. Some studies suggest RH in the range of 40–60% RH to reduce viability of viruses[10,11], however, there is no definitive guidance in this regard. Depending on the system's humidification capabilities, it may be possible to increase humidification of HVAC systems to maintain at least 40% RH minimum if desired.
- VERIFICATION: Ensure negative pressure (preferably at least -0.01 inches wg) between these rooms or wards and adjacent areas, by using a manometer and visual verification (e.g., smoke test, flutter strip, and so forth). Check pressure prior to use and periodically when in use (preferably daily). Verify any changes made to the ventilation system to reduce virus spread, including the type of filtration used. Ensure that HEPA filtration, when used in ventilation systems, is appropriately tested.

In general, an ASHRAE journal[12] article advises the following for currently operational public buildings in conjunction with an evaluation of each building's individual HVAC system:

- Increase outdoor air ventilation (use caution in highly polluted areas); a lower population in the building also increases the effective dilution ventilation per person.
- Disable demand-controlled ventilation (DCV).
- Further open minimum outdoor air dampers, as high as 100%, thus eliminating recirculation (in the mild weather season; this need not affect thermal comfort or humidity but clearly becomes more difficult in extreme weather).
- Improve central air filtration to the Minimum Efficiency Reporting Value (MERV)-13 or the highest compatible with the filter rack, and seal edges of the filter to limit bypass.
- Keep systems running longer hours, if possible 24/7, to enhance the two actions above.
- Consider portable room air cleaners with HEPA filters (see Appendix A).
- Consider UVGI, protecting occupants from radiation, particularly in high-risk spaces such as waiting rooms, prisons, and shelters (see Appendix B).

PATIENT ROOMS REQUIRING PASSIVE ISOLATION (NO AIIR OR NEGATIVE PRESSURE ROOMS AVAILABLE)

Suggested methods for changing patient rooms to temporary negative pressure isolation rooms are provided in APHC TIP No. 98-109-0420, Improvising Negative Pressure Isolation Rooms[5].

- If insufficient AIIR or those rooms are reserved for AGP and insufficient temporary negative pressure rooms are provided, patients should be placed in adequately ventilated single rooms where possible with the door closed and a private bathroom with appropriate CDC protocols in place. Providing a negative pressure room and following CDC's airborne precautions[1] is always preferred. Patients undergoing AGP should be placed in an AIIR.
- Recirculating HEPA filtration units placed in the room (discharge back into room) will not create a negative pressure, nor will they provide outdoor air, but will increase air filtration if sized correctly based upon the room volume and properly placed (see Appendix A). Closing off the return air grille will prevent recirculation of air from the patient room[6] (closing off returns will affect system balance and must be discussed with Facilities Management). The supply air may require adjustment to keep the room from being under a positive pressure, which may distribute contaminants outside of the room. Bathroom exhaust may be useful in creating negative pressure for the room, but the discharge of the exhaust system should be considered and its proximity to building air intakes and occupied areas. This must be done in coordination with facilities management personnel as this will affect air balance, temperature, and humidity control. Notify maintenance personnel and provide signage for previously nonbiohazard exhaust that is changed to a biohazard. The portable HEPA filtration unit should be chosen to provide 12 ACH (see Appendix A).
- Current ventilation design per UFC 4-510-01 for patient bedrooms (non-AIIR) is 4 ACH with 2 ACH outdoor air, neutral pressure, with MERV 14 intermediate supply air filtration and bathrooms with direct exhaust to the outside and 10 ACH. The air from these rooms is recirculated to other areas of the facility.
- For general ward rooms with natural ventilation, adequate ventilation is considered to be 127 cfm (60 liters per second (L/s)) per patient[13].
- VERIFICATION: Ensure negative pressure (preferably at least -0.01 inches wg) for these rooms by using a manometer and visual verification (e.g., smoke test, flutter strip, and so forth). Verify prior to patient use and periodically (preferably daily) during use. Ensure that HEPA filtration units are correctly sized for the space (see Appendix A).

OPERATING ROOMS USED FOR COVID-19 PATIENTS

- The American Society for Health Care Engineering (ASHE) recommends following the same guidelines for Operating Room (OR) use for COVID-19 patients as is used for TB patient care: https://www.ashe.org/ashe-issues-recommendation-or-use-during-covid-19. The CDC and American Society of Anesthesiologists (ASA) state that when possible, procedures, including cough-inducing procedures, should be performed in an AIIR rather than in an operating room[14].
- OR design, per the UFC 4-510-01[2], is 20 ACH with 4 ACH outdoor air, MERV 17 filtration above the OR, and positive pressure (+0.02 inches wg, 20% more supply than return/exhaust).
- ASHRAE 170[4] does not require HEPA filtration of the supply air for the OR, but it is good practice.

- OR ventilation and pressurization control equipment serving ORs must be connected to the EES[2,4.]
- Negative pressure between the OR and adjacent corridor may be achieved by using an anteroom or vestibule (purchased or temporarily constructed and with portable HEPA filtration) placed outside the OR entrance door[6]. Sub-sterile rooms may also be altered for this purpose[15].
- Using additional air-cleaning technologies (e.g., portable HEPA or UVGI) may be considered to increase the equivalent ACH in ORs and Recovery Areas with consultation from infection control personnel (see Appendices A and B).
- Due to the risks and variables associated with surgical procedures on COVID-19 patients, a risk assessment involving appropriate personnel should decide on the course of action for COVID-19 patients requiring surgical procedures.
- VERIFICATION: Ensure anterooms are monitored for negative pressure differential prior to use and periodically (preferably daily) with a manometer to ensure at least -0.01 inches wg, preferably -0.02 inches wg, between the anteroom and adjacent areas and verify with visual means (e.g., smoke, flutter strip, and so forth). Verify that adjacent rooms, including adjacent ORs, maintain the desired pressurization (e.g., positive pressure of +0.02 inches wg for operating rooms) and are not adversely affected by any changes. Ensure that HEPA filtration units are correctly sized for the space (see Appendix A).

AUTOPSY ROOMS FOR COVID-19 PATIENTS

- CDC suggests that autopsies on known or suspected COVID-19 cases should be conducted in AIIRs (see verification for **AIIRs** section), or lacking availability of AIIR, a negative pressure room with no recirculation of air to adjacent areas[16].
- Doors to the room should be kept closed except during entry and egress[16].
- A portable HEPA recirculation unit may be used in the room to reduce contaminants from aerosol-generating procedures (see Appendix A)[16].
- Local airflow control (i.e., laminar flow systems) can be used to direct aerosols away from personnel.[16]
- Dedicated exhaust is required and should be directed away from building air intakes (including open windows) or occupied areas[16] or must have HEPA filtration.
- Autopsies on COVID-19 patients that must be performed in the mortuary suite should be performed with as much separation as possible from other areas of the suite and with adequate ventilation. Downdraft tables may be provided at the workstations. Equipment should have a local exhaust ventilation (LEV) system where possible (e.g., for saws). Local exhaust or fume hoods should be provided as necessary.[17]
- The UFC 4-510-01 design guidance for autopsy rooms is 20% more exhaust than supply air, -0.02 inches wg, 12 ACH with 3 ACH of outdoor air, and dedicated exhaust to the outside with a minimum of one low-level exhaust register, sized to remove a minimum of 20% of the total room exhaust volume.
- Air-cleaning technologies (e.g., HEPA filtration or UVGI) may be used to increase the number of equivalent ACH (CDC TB) with consultation from infection control personnel (see Appendix A and B).

- VERIFICATION: Verify that the autopsy room is under negative pressure by using manometer and visual means (e.g., smoke test or flutter strip, and so forth). Ensure that local exhaust ventilation is functional and meets guidelines. Ventilation of downdraft tables may be compared to VS-99-07 of the American Conference of Governmental Industrial Hygienists (ACGIH®), Industrial Ventilation A Manual of Recommended Practice for Design, 30th edition. Ventilation of anatomy dissection tables may be compared to VS-99-09a and b. Low-volume, high-velocity exhaust systems are discussed in Section 13.40. Ensure fume hoods are checked annually per American National Standards Institute (ANSI) Z9.5 Laboratory Ventilation.

INTENSIVE CARE UNIT (ICU) FOR PATIENTS WITH COVID-19

- See the above section on **AIIRs** for information on these spaces within the ICU.
- ICUs are designed, per the UFC 4-510-01[2], under a 10% positive pressure.
- Air-handling systems may be converted to single-pass systems and set up for increased outdoor air and negative pressure or may use increased filtration. See the **Patient Rooms or wards with HVAC system adjustment to create temporary negative pressure isolation areas** section for information on air-handling system modification.
- See the APHC TIP No. 98-109-0420[5] for information on conversion of patient spaces to negative pressure rooms.
- Air-cleaning technologies (e.g., HEPA filtration and UVGI) may be used to increase equivalent ACH in ICU waiting areas where appropriate, with consultation from infection control personnel (CDC TB Guidelines) (see Appendix A and B).
- VERIFICATION: Verify negative pressure in these areas or see the appropriate verification section for **AIIRs** and **Patient Rooms or wards with HVAC system adjustment to create temporary negative pressure isolation areas** for verification of ICU areas.

EMERGENCY DEPARTMENT FOR PATIENTS WITH COVID-19

- See the above section on **AIIRs** for information on these spaces within the emergency department.
- Air-handling systems may be converted to single-pass systems and set up for increased outdoor air and negative pressure or may use increased filtration. See the **Patient Rooms or wards with HVAC system adjustment to create temporary negative pressure isolation areas** section for information on air-handling system modification.
- Emergency room exam or treatment rooms or open bay areas may need conversion to negative pressure rooms with portable HEPA filtration. Conversion of areas in the emergency department to negative pressure areas should follow APHC TIP 98-109-0420[5].

- **EMERGENCY DEPARTMENT (ED) OR RADIOLOGY (CHEST X-RAY ONLY) WAITING AREAS.** Waiting areas in the emergency department or radiology (chest x-ray only) should follow CDC guidance. The UFC 4-510-01 design guidance for ED

(including pediatric) waiting rooms is 12 ACH with 2 ACH outdoor air and 20% more exhaust than supply air (-0.02 inches wg). The ASHRAE 170[4] requires radiology waiting for chest x-ray to have the same ventilation requirements. Exhaust must be directed to the outside (exhaust not connected to any other spaces per UFC 4-510-01[2]) and no recirculation. The current UFC 4-510-01 design guidance is for HEPA filtration of the exhaust discharge unless a re-entrainment analysis has been performed. ASHRAE 170[4] requires only that exhaust discharge for these areas are at least 25 ft from any building air intakes or occupied areas. Air-cleaning technologies (e.g., HEPA filtration and UVGI) may be used to increase equivalent ACH in ED waiting areas (TB guidelines) with consultation from infection control personnel (see Appendix A and B). LEV for contagious patients (e.g., pods) may also be used.

- VERIFICATION: See section on **AIIR** verification for those areas in the ED. Check ED spaces for negative pressure prior to use and periodically with a manometer and visual observation (e.g., smoke test, flutter strip, and so forth). Ensure ED and chest x-ray waiting areas are separated from other spaces or local exhaust ventilation is provided for contagious patients where necessary (check with manufacturer of LEV devices to determine negative pressure effectiveness). Ensure that HEPA filtration units, when used, are correctly sized and located for the space (see Appendix A).

LABORATORY SPACES USED FOR SPECIMENS FROM COVID-19 PATIENTS

- Per CDC's guidance, a Biosafety Laboratory (BSL)-2 is required for routine diagnostic testing. For diagnostic testing outside of a BSL-2, consult CDC guidance. AGPs should be performed in a Class 2 BSC or with precautions as outlined by the CDC[18].
- Per CDC guidance virus, concentration procedures require a BSL-2 with unidirectional airflow and BSL-3 precautions[18].
- Per CDC guidance, virus isolation in cell culture and initial characterization of viral agents recovered in cultures of Severe Acute Respiratory Syndrome Coronavirus [SARS-CoV-2] specimens should only be conducted in a BSL-3 laboratory using BSL-3 practices[18].
- BSCs require annual certification by qualified (certified) personnel. BSCs should be placed away from sources of airflow disturbance (doorways, supply air diffusers, and so forth).
- VERIFICATION: Verify annual certification of BSCs and proper placement within the laboratory space.
- BSL-2 Laboratories:
  - Mechanical ventilation systems should provide an inward flow of air without recirculation to spaces outside of the laboratory.
  - Self-closing doors.
  - The UFC 4-510-01 requires almost all laboratories have 10% negative pressure (10% more exhaust than supply), and 6 ACH with 2 ACH of outdoor air. Dedicated exhaust is specified for most laboratories.
  - A BSL-2 with unidirectional airflow has airflow into the laboratory from clean to dirty areas

  - VERIFICATION: Verify that air flows into the laboratory using a manometer with verification by a visual means (e.g., smoke test, flutter strip, and so forth). Verify self-closing doors. Verify annual certification of BSCs and proper placement within the laboratory space.
- BSL-3 Laboratories:
  - Entrance through two self-closing doors, potentially with an anteroom in between.
  - Separated from unrestricted areas.
  - Sustainable airflow from clean to dirty areas without reversal of airflow (from dirty to clean) during any condition including power loss.
  - Dedicated exhaust with no recirculation to other areas, HEPA-filtered exhaust to the exterior or discharge at least 25 ft away from any air intakes or occupied areas. Annual certification of HEPA filters and housing is required.
  - Annual recertification of BSL-3 laboratory facilities (design, operation, and procedures) is required.
  - VERIFICATION: Verify inward directional airflow at entrance(s) to laboratory. Verify that there are functional alarms in the event of airflow disruption. Verify annual certification of HEPA filters and housing. Verify annual recertification of the BSL-3 laboratory (this would include failure mode testing to ensure no reversal of flow during failure conditions).

OBSTETRICS PATIENTS WITH COVID-19

- CDC states that healthcare facilities should ensure recommended infection control practices for hospitalized pregnant patients who have confirmed COVID-19 or are Patients Under Investigation (PUIs)[19]. Practices should be consistent with the CDC's Interim Infection Prevention and Control Recommendations for Patients with Confirmed Coronavirus Disease 2019 (COVID-19) or PUIs for COVID-19 in Healthcare Settings[1]. The Society for Obstetric Anesthesia and Perinatology (SOAP) and the Anesthesia Patient Safety Foundation (APSF) recommend patients testing positive or PUIs should be admitted to an isolation or negative pressure room.[20]
- Labor, Delivery, Recovery, Post-Partem (LDRP) AIIR's and Isolation Nurseries, where present, have the same requirements as discussed in the **AIIR** section above. Nursery Isolation Room relative pressurization requirements may vary among individual facilities, depending upon functional requirements, so it should be verified that the isolation nursery is an infectious isolation room (negative pressure) and not protective isolation (positive pressure).
- When necessary for cesarean births, the patient should be moved into the OR and the **Operating Rooms used for COVID-19 patients** section followed. LDRP C-Section Rooms are designed for 20 ACH with 4 ACH outdoor air, and positive pressure (+0.02 inches w.g., 20% more supply than return/exhaust per the UFC 4-510-01[2]) and MERV 14 filtration. The UFC 4-510-01[2], as well as ASHRAE 170[4], do not specify MERV 17 filtration above the Labor & Delivery (L&D) C-Section Room, although it is recommended.
- VERIFICATION: See verification for **AIIRs** and **Operating Rooms used for COVID-19 patients** sections above. Confirm the filtration on the L&D C-Section Room to ensure HEPA filtration is provided.

APPENDIX A

CONSIDERATIONS FOR THE USE OF PORTABLE HEPA FILTRATION UNITS

- Ensure a sufficient supply of the correct filters needed for change-out of both the pre-filter and HEPA filter.

- Clean and disinfect any portable HEPA units that have been used previously; follow manufacturer's instructions and guidance for installation of new pre-filters and, if necessary, HEPA filters. Portable HEPA filtration units should be performance-tested before use. (See Appendix G of Airborne Infectious Disease Management Methods for Temporary Negative Pressure Isolation[21] https://www.health.state.mn.us/communities/ep/surge/infectious/airbornenegative.pdf

- Portable HEPA filtration units should be capable of recirculating all air in the room. Select the correct size portable HEPA filtration unit by calculating the desired air exchange rate for the individual room or area. For example, if 12 ACH is desired and the room size is 20 ft x15 ft x10 ft or 3000 ft^3, the airflow volume should be calculated as follows: 12 ACH ÷ 60 min x 3000 ft^3 or 600 cfm.

- Consider existing room ventilation when ducting the portable HEPA unit to a return air duct. For example, ducting a 600 cfm portable HEPA filtration unit to a return that normally returns 300 cfm of air will over-pressurize the duct and affect the airflow and pressurization of adjacent rooms.

- Portable HEPA filtration units must be located to avoid blocking egress per the Life Safety Code and local requirements.

- Other considerations to effectiveness of the units, according to CDC, are: Room configuration, furniture and people in the room, placement of units relative to room layout, and location of supply and exhaust grilles[3]. The unit should be as close as possible to the source (patient) and should not pull contaminated air past the healthcare workers. Avoid directing clean airflow onto patients or staff to avoid discomfort[3].

- Consider electrical requirements for the filtration unit, and consult safety personnel for the use of extension cords. Also, consider if the unit is required to connect to the EES system.

- Ensure preventive maintenance for the units and appropriate PPE for workers performing maintenance on the units.

- Obtain from the portable HEPA unit manufacturer the correct filter change requirements (both for the pre-filter and the HEPA filter). Ensure staff are aware of these requirements. Pressure drop should be verified periodically to ensure compliance with manufacturer's instruction on filter changes and to ensure the unit is not leaking[21].

APPENDIX B

CONSIDERATIONS FOR THE USE OF UVGI

- UVGI may be used as a supplemental engineering control and should not replace sufficient ventilation or filtration. The CDC states in their Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health-Care Settings[22], "UVGI is an air-cleaning technology that can be used in a room or corridor to irradiate the air in the upper portion of the room (upper-air irradiation) and is installed in a duct to irradiate air passing through the duct (duct irradiation) or incorporated into room air-recirculation units. UVGI can be used in ducts that recirculate air back into the same room or in ducts that exhaust air directly to the outside. However, UVGI should not be used in place of HEPA filters when discharging air from isolation booths or enclosures directly into the surrounding room or area or when discharging air from an Airborne Infectious Isolation Room into the general ventilation system."

- The UV systems installed in air-handling units are generally provided to control microbial growth on the coils and condensate pans and may not be suitable for air disinfection[23].

- These systems depend on factors such as good air mixing, room air ventilation rates, relative humidity, good design, installation, and maintenance, as well as the contaminant for which the system is used. Equipment selection should be carefully considered[24,25,26].

- Because upper-air UVGI systems are intended for use in occupied rooms, proper installation of the UVGI lamps is critical to ensure worker and patient safety. A risk assessment[27] is recommended to ensure that the UV emissions in the work area (i.e., lower room) are within applicable limits before allowing workers or patients to resume normal activity.

See the following APHC Fact and TIP Sheets for additional information:

- APHC Fact Sheet No. 24-016-0316, Hazard Alert for Upper Room Ultraviolet Germicidal Lamps. https://phc.amedd.army.mil/topics/workplacehealth/lor/Pages/Fact-Sheets.aspx

- APHC Fact Sheet No. 24-013-0316, Hazard Alert for Ultraviolet Germicidal Lamps Used In Air Handling Units. https://phc.amedd.army.mil/topics/workplacehealth/lor/Pages/Fact-Sheets.aspx

- APHC Technical Information Paper No. 24-103-0320, Effectiveness and Safety Of Ultraviolet Germicidal Irradiation Lamps Used for Air and Surface Disinfection. https://phc.amedd.army.mil/PHC%20Resource%20Library/TIP241030320EffectivenessSafetyUVLight.pdf#search=technical%20information%20paper%20UV

APPENDIX C

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