Return Ductwork Requirement for Airborne Pathogens Through the Airstream

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Focus:

There is no single guaranteed action that can be taken against COVID-19. Recommended actions at the Engineering Controls[1] level is a combination of several approaches, including ventilation, filtration, and disinfection, that have been proven to reduce pathogen transmission. Mechanical designs should consider inclusion of these features, with safety and the reduction of pathogen transmission being a fundamental basis of design. Energy optimization is important and should be considered in all mechanical designs. However, in cases where occupant safety and energy efficiency cannot be aligned, they should be aligned as closely as possible with the safety of the building occupants being the driving factor.

A building engineers' ability to reduce pathogen transmission in existing buildings are limited by the original design of the mechanical systems, the original installation achieving design intent, and proper maintenance by a skilled, trained, and certified technician. Two of the approaches that a building engineer has at their disposal to reduce pathogen transmission are pressure barriers and airflow distribution.

Per the International Mechanical Code (IMC)[2] and the Uniform Mechanical Code (UMC)[3], commercial buildings can use the cavity above the finished ceiling as a return plenum. Open ceiling plenum returns limit a building engineers' capabilities to reduce pathogen transmission by removing fundamental aspects of pressure barrier and airflow distribution strategies. In addition, ceiling plenum returns add additional safety concerns to daily maintenance tasks,

[1] Hierarchy of Controls. (2015, January 13). Retrieved July 04, 2020, from https://www.cdc.gov/niosh/topics/hierarchy/default.html
[2] *2018 IMC: International Mechanical Code*. (2018). Country Club Hills, IL: International Code Council.
[3] IAPMO, & Pipefitters, United Association of Plumbers and. (2019). *2018 Uniform Mechanical Code*. Ontario: IAPMO.

infiltration, source control, introduction of additional airborne particulates that may compromise indoor air quality, and reduced ability to disinfect. A common industry term for these return air systems is “wild” since they are so difficult to control.

- Return Ductwork allows for room pressure differentials to be accurately adjusted to maintain a consistent setpoint. With a ducted return system, a Testing, Adjusting, and Balancing (TAB) Technician has the capability to adjust room pressures during a pandemic given the attributes of the pathogen of concern. These capabilities include the ability adjust a room between positive, neutral, or negative pressures.
  The importance of this capability has become evident as building owners and users attempt to convert medical office buildings, wellness centers, and school nurse stations into alternate care sites for COVID-19 patients.
- Ducted inlets allow airflow patterns to be accurately adjusted and maintained without fluctuation. Ducted return systems provide additional capabilities for a TAB Technician to adjust airflow patterns during a pandemic.
- Return Ductwork containing pathogens within the ductwork still allows for safe maintenance within the ceiling plenum. Without this safety net, facilities personnel will be exposed to biologically active pathogens within the airstream and on the surfaces around them.
- If determined necessary, return ductwork can be cleaned and disinfected utilizing the following criteria.
  - ACR NADCA Standard for Assessment, Cleaning and Restoration of HVAC Systems.[4]
  - 4335 (RP-759) -- Methods and Criteria for Cleaning Contaminated Ducts and Air-Handling Equipment[5]

[4] *ACR, The NADCA Standard for Assessment, Cleaning & Restoration of HVAC Systems.* National Air Duct Cleaners Association, 2013.

[5] Brosseau, Lisa M, et al. *Methods and Criteria for Cleaning Contaminated Ducts and Air-Handling Equipment - ASHRAE RP-759*. ASHRAE, 2000.

Recommendation:

Given the health and safety benefits of return ductwork, ASHRAE Technical Committee (TC) 5.2 Duct Design recommends ducted return systems in all buildings as prioritized by occupancy classification and use.

- **Priority 1:** Medical Facilities – Institutional (Group I), Medical Office Buildings, buildings used for medical purposes, or any building has high chance to be commandeered during a pandemic to act as a medical facility.
- **Priority 2:** Educational Facilities (Group E)
- **Priority 3:** Assembly Areas (Group A), Business (Group B), Factory (Group F), Mercantile (Group M), Residential (Group R)

This recommendation would include new construction and shell and core renovations and additions. Return duct retrofits should be considered for priority 1 buildings.

Return Ductwork insulation would only be required for unconditioned locations or as determined necessary by the mechanical engineer to prevent condensation or improve energy efficiency.

A review of this recommendation includes a subjective assessment of current standard requirements, safety concerns of ceiling plenum returns, and the benefits of ceiling plenum returns. Concerns and benefits have been evaluated for both cost, energy, and safety concerns.

Current Requirements

Per the current versions of the IMC, International Energy Conservation Code (IECC), UMC, and California Mechanical Code (CMC), ceiling plenums returns can be used instead of ducted returns.

2018 IECC[6]

- C403.11.1 **Duct and plenum insulation and sealing (Mandatory).** Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than R-8 insulation in *Climate Zones* 1 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8. Where located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-8 insulation in *Climate Zones* 1 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8.

  Exceptions:

  1. Where located within equipment.

[6] *2018 International Energy Conservation Code*. International Code Council, Inc., 2017.

2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the *International Mechanical Code*.

2018 IMC[7]

- 602.1 **General. Supply, return, exhaust, relief and ventilation air plenums shall be limited to uninhabited crawl spaces, areas above a ceiling or below the floor**, attic spaces, mechanical equipment rooms and the framing cavities addressed in section 602.3. **Plenums shall be limited to one fire area**. Air systems shall be ducted from the boundary of the fire area served directly to the air-handling equipment. Fuel-fired appliances shall not be installed within a plenum.
    - 602.2.1 Materials within plenums. Except as required by Sections 602.2.1.1 through 602.2.1.8, **materials within plenums shall be noncombustible** or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723.

2021 UMC[8]

- 602.1 General. Materials used for duct systems shall comply with Sections 602.2 through Section 602.6 as applicable.
  Concealed building spaces[9] or independent construction within buildings shall be permitted to be used as ducts or plenums. Gypsum board shall not be used for positive pressure ducts.
  Exception: In healthcare facilities, concealed spaces shall not be permitted to be used as ducts or plenums.

2019 CMC[10]

Note: CMC is provided as an example given their medical facility exemptions.

- 602.1 General. Materials used for duct systems shall comply with Sections 602.2 through Section 602.6 as applicable.
  Exception: [OSHPD 1, 1R, 2, 3, 4 & 5][11] See section 407.4.1.3

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[7] *2018 IMC: International Mechanical Code*. (2018). Country Club Hills, IL: International Code Council.

[8] IAPMO, & Pipefitters, United Association of Plumbers and. (2019). *2018 Uniform Mechanical Code*. Ontario: IAPMO.

[9] Per UMC 2021 – Concealed Spaces. That portion(s) of a building behind walls, over suspended ceilings, in pipe chases, attics, and elsewhere whose size might normally range from 1 ¾ inch (44mm) stud spaces to 8 foot (2438 mm) interstitial truss spaces and that might contain combustible materials such as building structural members, thermal, electrical insulation, or both, and ducting. Such spaces have sometimes been used as HVAC plenum chambers.

[10] IAPMO, & Pipefitters, United Association of Plumbers and. (2019). *2019 California Mechanical Code*. Ontario: IAPMO.

[11] OSHPD 1 = General Acute-Care Hospitals including those that provide Rehabilitation Services; OSHPD 1R = Non-conforming Hospital Building removed from General Acute-Care Services; OSHPD 2 = Skilled Nursing Facilities and Intermediate Care Facilities; OSHPD 3 = Clinics, including those under H&S Code Section 1200 and Hospital

[Not permitted for OSHPD 1, 1R, 2, 3, 4 & 5][11] **Concealed building spaces**[12] **or independent construction within buildings shall be permitted to be used as ducts or plenums.** Gypsum board shall not be used for positive pressure ducts.
Exception: In healthcare facilities, concealed spaces shall not be permitted to be used as ducts or plenums.

- 407 Ventilation System Details. [OSHPD 1,1R,2,3,4]
    - 407.4.1.4 No space above a ceiling may be utilized as an outdoor-air, relief-air, supply-air, exhaust-air, or return-air plenum.

Concern of Ceiling Plenums

Reduced Exposure Control

- **Ceiling Plenums become a health concern for anyone working within the ceiling plenum by exposing them to an airstream of respirable particles prior to filtration and surfaces contaminated with a virus.**
- ASHRAE's Executive Committee and Epidemic Task Force approved the following Statement: *Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures*.[13]
- An April 2020 paper by ASHRAE found that viruses such as COVID-19 can spread through the air in two ways. Larger droplets travel between 6 and 7 feet before dropping to the ground, but smaller droplets can mix with room air, remaining airborne for extended periods.[14]

Outpatient Clinical Services provided in a freestanding buildings un H&S Code Section 1250; OSHPD 4 = Correctional Treatment Centers; OSHPD 5 = Acute Psychiatric Hospitals.

[12] Per UMC 2021 – Concealed Spaces. That portion(s) of a building behind walls, over suspended ceilings, in pipe chases, attics, and elsewhere whose size might normally range from 1 ¾ inch (44mm) stud spaces to 8 foot (2438 mm) interstitial truss spaces and that might contain combustible materials such as building structural members, thermal, electrical insulation, or both, and ducting. Such spaces have sometimes been used as HVAC plenum chambers.

[13] ASHRAE's statement on airborne transmission of SARS-CoV-2/COVID-19. (2020, April 20). Retrieved July 04, 2020, from https://www.ashrae.org/about/news/2020/ashrae-issues-statements-on-relationship-between-covid-19-and-hvac-in-buildings

[14] ASHRAE, ASHRAE Position Document on Infectious Aerosols. ASHRAE (April 2020), (https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf); see also Neeltje van Doremalen, et al, Aerosol and surface stability of HCoV-19 (SARS-CoV-2) compared to SARS-CoV-1, medRxiv preprint doi (March 13, 2020) (finding that viable COVID-19 viruses could be detected in aerosols up to 3 hours post aerosolization) (https://www.medrxiv.org/content/10.1101/2020.03.09.20033217v2).

- Depending on the pathogen, the safety concern may not be addressed by simply removing a fan from operation during maintenance. Per the CDC, "*SARS-CoV-2 may remain viable for hours to days on surfaces made from a variety of surfaces*."[15]
  Ceiling Plenums limit the ability to create pressurized rooms during a pandemic.
- A ducted return, exhaust, and supply is required to create, maintain, and accurately adjust room pressure. Open ceiling return systems allow a TAB technician to control supply air but inhibit their ability to adjust return air, and pressurized zones/areas.
- Ducted supply and return allow for air distribution and airflow patterns to be controlled. Without a ducted return, a TAB technician has limited ability to control airflow patterns as other inlets (open doors and door thresholds) may provide a higher draw.

Infiltration (Energy Concern)

- As a whole, a building should have positive pressure in comparison to the outside, which will limit infiltration through doors and windows. However, negative sections of the building may still result in infiltration.
- Depending on the pressure gradient, negative pressurized architectural plenums can draw in untreated and humid outside air, through building skin or roof, or unconditioned air from untreated spaces.[16]

Reduced Source Control

- Particles and contaminants within ceiling plenums can be added to the airstream. Plenum returns increase the likelihood of particulates and pathogens being introduced into the recirculated air stream, resulting in reduced air quality for building occupants. For buildings constructed before 1980, asbestos, polychlorinated biphenyls (PCBs) and heavy metal dust and particulates may be among the hazardous materials that may be introduced in ceiling plenums.
- Ceiling plenums can add micro-organisms to the return airstream following moisture being inadvertently added to ceiling plenum materials (i.e., leaks and condensation from uninsulated ductwork or piping) resulting in microbiological amplification[17]
- Maintenance activities, even by a worker wearing protective gear, in the ceiling plenum can agitate particles and fungal spores which can enter the return air stream.[17]

Cleaning and Disinfecting

- If determined necessary by the Center for Disease Control (CDC) or the ASHRAE Epidemic Task Force, return ductwork can be cleaned and disinfected using established methods.

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[15] Interim Recommendations for US Community Facilities with Suspected/Confirmed Coronavirus Disease 2019. (2020, May 27). Retrieved July 06, 2020, from https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/cleaning-disinfection.html

[16] Lstiburek, Joseph. (2009). 5 Fundamental changes in the last 50 years. Ashrae Journal. 51. 52-56.

[17] Pope, A. M., Patterson, R., & Burge, H. (1993). Chapter 7 - Engineering Control Strategies. In *Indoor allergens: Assessing and controlling adverse health effects*. Washington, DC: National Academy Press.

Benefits of Ceiling Plenum Return

The concerns and benefits of ceiling plenum return systems should be evaluated. Benefits of these systems include energy efficiency, reduced labor costs, and reduced material costs.

- Reduced total HVAC system costs due to lack of return ductwork (labor and materials) and hours of TAB (labor).
- Plenum returns can provide for additional installation space in plenums due to lack of ductwork. These openings can add labor efficiencies and additional options for other trades.
- Plenum returns can result in reduced fan energy as a result of lower plenum return resistance in comparison to ducted return.
- Use of passive relief or relief fans instead of return fans.
    - Relief fans use less energy than Return Fans[18]

[18] Kettler, J. 2004. "Return fans or relief fans." ASHRAE Journal. 28-33