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The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \overline{U}_i \overline{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U}_i}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \overline{U}_i \overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ *biomedical research facilities.*

Managing Transfer Air Across Pressure-Critical Doors in Biomedical Facilities

In biomedical facilities, it is common to actively maintain a differential pressure (dP) between areas of differing risk and/or International Organization for Standardization (ISO) classification to minimize the migration of lower-quality air into spaces requiring higher-quality environments. dP recovery time from transient events, most commonly door opening/closing cycles, can destabilize dP and induce fluctuations and pressure reversals, with potential implications for containment/isolation performance. Implementing different transfer air methods can help minimize dP recovery time, depending on the facility and the transfer airflow required. This article examines the potential advantages of using ceiling-mounted transfer grilles on each side of a pressure critical door to improve dP stability, simplify cleaning and maintenance, and enhance recovery time under typical operating conditions.

Overview

Most laboratory HVAC systems establish room-to-room dP by maintaining a defined offset between supply and exhaust airflows. In a common control approach, supply flow remains constant while exhaust tracks supply volume to preserve the intended pressure gradient. The transfer-air pathway (either intentional, e.g., undercuts or transfer grilles, or incidental, e.g., leakage through wall penetrations/door seals) provides the final “trim” that stabilizes dP and improves recovery after short-term disturbances such as door openings or control fluctuations.

When transfer-air requirements are small, minor flow variability can often be absorbed by flow via the door undercuts and incidental leakage without compromising dP control. When transfer-air requirements are large, the undercut can become a limitation to transfer airflow: velocity increases, local turbulence at the threshold can rise, and dP recovery can slow or become less stable.

Transfer-airflow targets are typically fixed after balancing and validation. The most common way to set dP across a doorway is to adjust the effective area of the door undercut using a fixed-blade sweep. While automatic sweeps can modulate the opening dynamically, some organizations (including NIH) have moved away from them due to maintenance burden and reliability history. In lieu of mechanical sweeps, passive alternatives, such as static transfer grilles or “pressure stabilizers” (transfer grilles equipped with dampers and insect screens), can provide higher-capacity transfer paths with more predictable performance at higher flow rates.

The Case for Door Undercuts

Undercuts in lab spaces are typically set with the door sweep being cut to provide the required cross-sectional area to enable the desired rate of air transfer. Door undercuts represent the most straightforward method of transfer air control. They are passive, meaning there are no moving parts, sensors, or actuators involved. However, simplicity comes with limitations, such as the following:

1. The precise height of the sweep relative to the floor is difficult to set and maintain perfectly. Small shifts can drastically change the airflow over time as sweeps become misaligned, torn, or worn.
2. Door sweeps are difficult to finetune, requiring small, manual adjustments; this difficulty is compounded by challenges in validating airflow in the undercut.
3. Code limits the height of the door undercut which can limit transfer air flow, and as velocity of transfer air rises, it can begin to whistle.
4. Undercuts require ongoing inspection, monitoring, and maintenance and are more difficult to clean.

Despite these limitations, undercuts remain a practical solution in many standard laboratories because they:

1. Provide relatively fine-tuned pressure control, suitable for most applications.
2. Aid system balancing by providing an additional control over the differential pressure.
3. Help ensure airflow/cascade directionality for contaminant control.
4. Are appealing in facilities with many doors because of reduced complexity in installation and qualification, resulting in lower first costs.

The Case for Transfer Air Dampers and Grilles

By contrast, transfer air dampers provide a more controllable and adaptable solution. The damper itself can be fixed, manually adjusted, or tied to the building automation system (BAS) for active or remote control. Complexity comes at a cost, however:

1. More complex than undercut systems, resulting in higher first costs.
2. In aseptic processing facilities (APFs) and biosafety labs (BSLs), the space around the strike side of the door is typically congested with controls and displays, making

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ceiling-to-ceiling design the only reasonable location for the grilles.
3. Repair and replacement of components are significantly more expensive and require more complex planning with a greater risk of extended impact to facility operations.
4. Higher risk of impact from complications following power loss or BAS issues, which could result in unintended impacts to the dPs in the facility for BAS-integrated valves/dampers.
5. May lead to higher risk of contamination during pressure reversal events.

Despite these costs, transfer air dampers have many benefits, which include:

1. The ability to precisely control the transfer of larger volumes of air vs. undercuts, improving dP stability and recovery in higher flow situations.
2. Low variability and fewer inspections necessary between certifications.
3. Easy-to-measure airflow.
4. Ease of adjustment when balancing airflows; this process can be motorized and tied to the BAS to allow for remote adjustment.
5. Ease of cleaning a ceiling-mounted grille.

Conclusion

The control of transfer air across laboratory doors is a deceptively complex yet critical aspect of maintaining safe and functional laboratory environments. Door undercuts represent a low-cost, low-maintenance solution for managing transfer air/fine pressure control. The *Design Requirements Manual* Chapter 13: APFs recommends using a door undercut to achieve pressure differentials between adjoining rooms and states pressure stabilizers or relief vents are to be avoided due to contamination, maintenance, and cleaning concerns. Transfer air dampers, though more complex and costly, provide precision and adaptability, especially for higher air transfer rates, improving stability and recovery. Designers must weigh cost, performance, and safety to determine the most appropriate strategy. Ultimately, both methods remain valuable tools.

Further Reading

1. *DRM* Ch 13 and Ch 6
2. https://basc.pnnl.gov/resource-guides/undercut-doors#edit-group-scope
3. https://www.sciencedirect.com/science/article/pii/S0360132322000968

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