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Design Requirements Manual **News to Use**

February 2026
Vol. 03, No. 2

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_o)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \bar{U}_i}{\partial x_j}-\rho\overline{u_i u_j}\right)+g_i(\rho-\rho_o)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \bar{T}}{\partial x_i}-\rho\overline{u_i h}\right)$ *biomedical research facilities.*

Elevator Piston Effect – Designing and Commissioning Pressure-Resilient Suite Boundaries: Part I

Pressure-sensitive biomedical suites, high-containment laboratories (such as BSL-3/ABSL-3), aseptic processing facilities (APFs), airborne infection isolation (AII) suites, procedure rooms, and similar spaces are routinely designed around relatively small suite-boundary differential pressures (dP) and an assumption of stable corridor relationships. In operation, the most disruptive events at the boundary are often not slow drifts but rapid transient pressure changes that couple the building core to the corridor and suite door, such as those caused by the elevator piston effect. While HVAC controls can compensate (as explored in part-2 of this series), the most reliable way to reduce elevator-driven dP disturbances is through architectural design: avoid direct adjacency between elevator cores/lobbies and pressure-critical suite boundaries by providing buffered transition spaces and controlled interfaces early in design.

The Elevator Piston Effect

The elevator piston effect occurs when elevator car movement creates transient pressures and flows, exchanging air between the hoistway, elevator lobbies, and connected floor volumes. While the piston effect is often discussed in the context of smoke migration, the underlying airflow physics are the same in day-to-day operation: a moving car displaces air and pressure propagates through available leakage and openings.[1] Importantly, the piston effect is not exclusive to high-rise buildings; any elevator-served building can experience it. Taller buildings, express service elevators, higher car speeds, and greater trip density increase the frequency, magnitude, and complexity of pulses, but the fundamental mechanism is the same.

Pulse Polarity Matters at the Boundary

Elevator motion can create brief over-pressure and under-pressure events at the lobby/suite interface. Because either positive or negative pressure pulses can temporarily reduce the intended differential (and in some cases reverse flow), testing should include both elevator directions and representative car positions.

The Coupling Pathway: Elevator Car-Hoistway-Lobby-Corridor-Suite Boundary

For building teams, the most useful mental model is not "the elevator causes problems," but rather **"**where does the pulse go?" A simple path description is:

1. **Source – Hoistway dynamics:** Car motion displaces air in the hoistway. The hoistway becomes a transient pressure generator whose "output" is shaped by shaft leakage, shaft openings/vents, and the effective leakage area of landing doors and adjacent construction.
2. **First receiver – Elevator lobby:** The lobby is often where the piston effect becomes apparent as door movement, drafts, or pressure spikes. If the lobby is directly connected to corridors (via large openings, open return paths, leaky separations, etc.), it becomes a distribution manifold for pulses.
3. **Distribution – Corridor and ceiling plenum networks:** Corridors, return air plenums, and above-ceiling interstitial spaces can transfer substantial air volumes. Even when doors are closed, small leakage paths can carry pulses a considerable distance, especially when a corridor is long, contiguous, and contiguous above the ceiling.
4. **Endpoint – The pressure-critical door (suite boundary):** The suite boundary door (or vestibule/anteroom door that functions as the boundary) is where the consequence is realized: increased nuisance alarms, unpredictable door forces, and, most importantly, momentary uncertainty in airflow direction at the boundary.

Why Small Suites Can Feel Bigger Pulses

Many biomedical suites are compact relative to the adjacent core volumes. Smaller volumes and tighter cascades can be more dynamically sensitive as they have less "buffer distance/volume" between elevator lobby pulses and the boundary and therefore less time for pulses to dampen before they reach the suite door. This does not imply no gradient exists; it simply reveals that even meaningful dP targets can be challenged by rapid transients when the boundary is tightly coupled to the elevator core.[2]

Architecture: Reduce Coupling Before You "Tune" Anything

The architectural thesis here is simple: decoupling reduces pulse energy reaching the suite boundary. Elevator-driven pressure transients are often best addressed first through architectural design rather than relying solely on HVAC controls. When a pressure-critical suite boundary is directly adjacent to an elevator lobby/core, transient over-pressure/under-pressure events can couple directly to the suite interface and create operational instability even if steady-state differential pressure targets are met.

Architectural strategies include:

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- **Use the elevator lobby as a pressure break (or create one):** When the elevator lobby is enclosed and separated from pressure-critical corridors, it becomes the first buffer between hoistway dynamics and clinical flows. The same compartmentation logic used to interrupt vertical smoke/air transport pathways can reduce day-to-day coupling of elevator piston-effect pressure pulses into adjacent corridors.[3]
- **Add a second buffer when margins are thin:** If an enclosed lobby is the first break, a short vestibule/anteroom or buffered corridor segment can provide additional damping, often warranted near express stops, high trip-density floors, or highly sensitive suites. Compartmentation strategies used for smoke control can also reduce piston effects.
- **Keep the pressure-critical door out of the elevator lobby:** The shorter the path between lobby transients and the suite boundary, the less opportunity exists for damping—and the more likely the suite door becomes the unintended relief path.
- **Design leakage paths deliberately:** Elevator shafts are not airtight; some air movement is inevitable due to car motion and building stack effects. The design team should treat leakage as a controlled variable, prioritizing robust suite boundary continuity (door gasketing, frame tolerances, ceiling/partition continuity, penetration sealing) and locating pressure equalization in a lower-risk "mediator" zone rather than at the pressure-sensitive biomedical boundary.[4]

Early design choices that introduce a buffered transition (e.g., vestibule/anteroom/controlled corridor segment) and avoid direct adjacency provide the most reliable reduction in nuisance dP disturbances and reduce the likelihood of costly retrofits later.

Conclusion and Part I

Where Part I of this series has covered ways reducing coupling and "energy delivered" to the suite boundary, Part II will focus on receiver design and proof of how mechanical systems and controls define intentional transfer/relief pathways. Part II also explores how alarms avoid transient noise while still protecting safety intent and how commissioning tests realistic multi-car elevator behavior so that the boundary's performance is verified, not assumed. Both architectural and mechanical mitigations reduce the impact of elevator piston effects on the suite boundary differential pressure control.

References

1. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (2023). Fire and smoke control: Elevator piston effect. In *Handbook (HVAC Applications)*. ASHRAE. https://www.ashrae.org/technical-resources/ashrae-handbook
2. Stroup, D.W. (2003). *Literature review on enclosure of elevator lobbies* (NISTIR 6973). National Institute of Science and Technology. https://www.nist.gov/publications/literature-review-enclosure-elevator-lobbies
3. Klote, J.H., and Tamura, G. (1986). Elevator piston effect and the smoke problem. *Fire Safety Journal, 11*(3), 227-233. https://doi.org/10.1016/0379-7112(86)90065-2
4. Dooley, S. W., Jr, Castro, K. G., Hutton, M. D., Mullan, R. J., Polder, J. A., & Snider, D. E., Jr (1990). Guidelines for preventing the transmission of tuberculosis in health-care settings, with special focus on HIV-related issues. *MMWR. Recommendations and reports: Morbidity and mortality weekly report. Recommendations and reports*, *39*(RR-17), 1–29.