PRESSURIZATION CONTROL IN CRITICAL SPACES

ANTEC controls

Room pressurization can be achieved using two different control strategies: Volumetric Offset Control and Direct Pressure Control. These control methods can effectively pressurize many spaces but should be selected properly when designing spaces where containment is crucial.

Room Pressurization

Room pressurization is essential in critical spaces to ensure contaminants do not migrate. For example, a positive pressure relationship between the room and adjacent spaces is required in operating rooms as it will contribute to protecting the patient from external contaminants[1]. In contrast, a laboratory might include a negatively pressurized room to mitigate the likelihood of airborne hazards from spreading to adjacent spaces[2].

To effectively pressurize a room, devices such as fans, dampers, and airflow control valves can be employed. The methods governing the reactions of these devices can vary, but the most common are **Volumetric Offset Control** and **Direct Pressure Control**[1].

General room pressurization is a result of the combined total supply (Q_S) and total return or exhaust (Q_E) airflows in and out of a space respectively, which yields a pressure difference between the pressurized room (P_R) and adjacent areas (P_A). The pressure difference dictates the infiltration airflow (Q_I) across the room envelope (including known and unknown openings), and can be generalized for rooms requiring positive or negative pressures with:

$$Q_I = CA\left(\frac{2}{\rho}\left|P_R - P_A\right|\right)^{0.5} \qquad \textbf{Eq.1}$$

$$P_R < P_A \text{ requires: } Q_E > (Q_s + Q_I)$$

$$P_R > P_A \text{ requires: } Q_s > (Q_E + Q_I)$$

Where C is the flow coefficient, A is the leakage area, ρ is the density of the infiltration air[2], and Q_I is in the opposite direction as the pressure gradient across the room envelope, as illustrated in Figure 1.

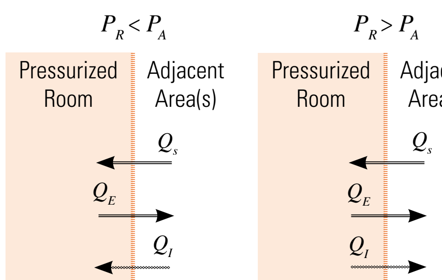

Figure 1 – Illustration of the airflow across the room envelope (orange rectangle) for negative and positive room pressurization respectively.

The difference between the total supply and exhaust airflows, referred to as the airflow offset, must be selected such that it compensates for the infiltration airflow without over- or under-pressurizing the space. For example, laboratories are commonly designed to operate at pressure differences equal or greater than 0.05 in.w.c., but less than 0.3 in.w.c. which could make opening doors difficult[2].

Monitoring of the differential pressure or offset airflow may be desirable depending on the application, design standards (like ANSI/ASHRAE Standard 170[1] and ASHRAE Laboratory Design Guide[2]), best practices, or in accordance with jurisdictional safety guidelines and standards (such as the OSHA Laboratory Safety Guide[3] and Canadian Biosafety Standard[4]). Furthermore, to permit faster re-pressurization after upsets and reduce the occurrences of nuisance alarms, additional sensors can be added to the system, such as sensors to detect doors opening or closing.

Volumetric Offset Control

The Volumetric Offset Control method regulates the supply and/or exhaust airflows to maintain a fixed offset airflow, which in-turn pressurizes the space. The generated pressure difference yields an infiltration airflow (following Eq.1), which the offset airflow must overcome. The offset flow rate is validated during system calibration to ensure it meets the requirements of the space. Once calibrated, the offset airflow is maintained without requiring direct measurement of the pressure difference between the room and surrounding spaces, which yields a fast responses to changes in airflow demand, such as during the opening/closing of exhaust hoods or snorkels, commonplace in laboratories.

Direct Pressure Control

Direct pressure control actively maintains a constant pressure difference between the space and adjacent areas by controlling the supply and exhaust airflows in and out of the space respectively. A system employing this method can provide a stable steady state room pressure with moderate pressure deadbands but must be designed to sufficiently respond to pressure upsets, such as sudden changes to infiltration rates (doors opening) and unexpected changes in the pressure referenced from adjacent areas. Pressurization control using this method may be suitable for stand-alone pressurized rooms, such as airborne infection isolation (AII) or protective environment (PE) rooms.

Summary

When designing HVAC systems for critical spaces, room pressurization can successfully be achieved using either volumetric offset control or direct pressure control. An understanding of the advantages and obstacles of each, as well as an understanding of the basic operating principles will help when selecting of the pressurization control method for an application.

Volumetric Offset Control		Direct Pressure Control
• Supply/Exhaust Airflow Difference	**Basis of Control**	• Room Pressure
• Stability • Speed	**Advantages**	• Accuracy
• Pressure Monitoring	**Risk Mitigation**	• Door Sensor • Control Deadbands

1 ANSI/ASHRAE/ASHE, Standard 170, Ventilation of Health Care Facilities, 2017.
2 ASHRAE, ASHRAE Laboratory Design Guide, 2 ed., Atlanta, 2015.
3 OSHA, Laboratory Safety Guidance, U.S. Department of Labor, 2011.
4 Government of Canada, Canadian Biosafety Standard (CBS), 2 ed., Ottawa, 2015.

ORANGE PAPERS Issue 01

February, 2022