Phoenix Controls

healthcare sourcebook, 5th edition

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Phoenix Controls Healthcare Sourcebook

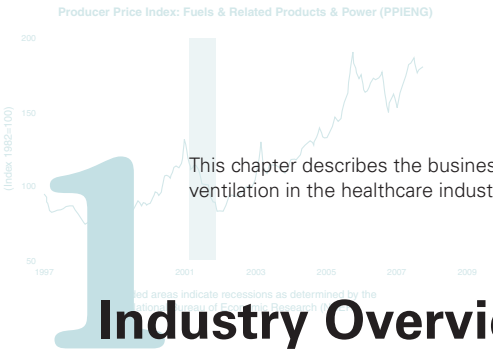
Airflow Design for Healthcare Facilities

This guide describes best practices in airflow control and ventilation design for healthcare facilities. It is intended to aid the engineer and designer in specifying airflow products and control methodology that meet or exceed currently published and accepted industry guidelines. Furthermore, this guide will educate the reader about emerging and forward-looking airflow trends in healthcare, so that the designer can offer additional value to the customer for patient safety, energy conservation, pandemic preparation, and other benefits that can be sustained after construction or renovation.

- Chapter 1, **Industry Overview**, presents a brief overview of what the business drivers are in healthcare that motivates an investment in airflow control.
- Chapter 2, **Ventilation Requirements**, describes the specific airflow needs of each type of discrete space within a healthcare facility, including the reasoning behind the design principle.
- Chapter 3, **Airflow Control Applications**, outlines how to apply control solutions for each room application. A new product family from Phoenix Controls which is dedicated to the healthcare industry, Theris™, is introduced in this chapter.
- Chapter 4, **Integration**, details how valves and controllers integrate with Building Management Systems (BMSs) that use open protocols such as Lon® and BACnet™.
- Chapter 5, **System Components**, provides complete technical specifications of each valve and controller, including dimensions, valve sizes, flow ranges, performance data, electrical and communications requirements, and options for control.
- Chapter 6, **Standards & Guidelines**, covers leading organizations that have researched, tested and published ventilation guidelines in the industry. In the United States and Canada, the standards referenced are followed most by states, provinces, local authorities and industry regulators.

As one observes year-to-year revisions in established published guidelines, it is clear that there is an ever-increasing need for directional airflow and pressurized spaces in the healthcare environment. There is no question now that proper airflow can protect the health of workers and patients, and contribute significantly to lower operational costs. With each application of pressurized space, the need for overall airflow balance throughout the facility becomes even more important.

Following the design principles in this document will prepare the reader to offer a high value airflow control solution to engineers, architects, and the healthcare community to meet the needs of ventilation requirements today, and into the future.



1 Industry Overview

This chapter describes the business motivators for addressing ventilation in the healthcare industry.

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Airflow Design for Healthcare Facilities

In a global economy where air travel and commerce extends around the world, human disease can be easily transmitted through airborne delivery, contact with infected people and contaminated surfaces, and via clothing and household articles that come from other nations. Evidence of the spread of highly infectious disease occasionally appear in the news media, usually resulting in some alarm for the general public and the healthcare industry. Recent cases include Severe Acute Respiratory Syndrome (SARS), Tuberculosis (TB), Bovine Spongiform Encephalopathy (BSE), and others.

The healthcare industry, particularly local hospitals, is the first line of defense in identifying and treating patients. It is the responsibility of these caregivers to not only diagnose the disease, but also contain serious strains of bacterial and viral pathogens from spreading to others within the hospital, and the public at large. Proper facility and ventilation design is a key factor in addressing this problem. Applying the principles of directional airflow, combined with filtration and sanitation techniques, is an effective way to reduce the spread of airborne infectious agents.

Healthcare ventilation has always contained regulatory design criteria to ensure health and safety, as well as to reduce risk of infection control. Along with the cost associated with meeting statutes, regulations, standards and codes; healthcare facilities face additional financial challenges from other areas. Corporate budget constraints, liability costs, insurance costs, employee turnover and increased operational costs to name a few. During times of construction the budget may be challenged by delays, changes in regulatory criteria, increases in material costs, and design changes.

In addition to ensuring that components and systems meet regulatory requirements, healthcare facility ventilation design requires additional attention and detail to planning of space layout, air-balance, temperature control, humidity control, space pressurization, communication technology, forecasting maintenance costs, and assessment of energy demand in order to achieve maximum design benefit with effective cost.

When considering these factors, designing healthcare ventilation to just "meet" standards becomes an obsolete and risky approach. Meeting regulatory compliance is simply not enough in today's market. New approaches to facility ventilation design are necessary to achieve owner satisfaction and several owner motivators should be considered when designing effective and efficient healthcare ventilation.

Snapshot of the Healthcare Industry

The business motivators for ventilation in healthcare are infection control, energy savings, maintenance-free operation, pandemic readiness, and the flexibility to control ventilation throughout the facility for varying uses over the lifetime of the building. These subjects can be grouped into four main topics important to running a hospital:

- Patient healing
- Liability and risk
- Operational cost reduction
- Construction and renovation risk

Patient Healing Motivators

Evidenced-Based Design

Evidenced-Based Design (EBD) is a growing trend in the design of healthcare facilities, where the approach has found support among many healthcare administrators. The ideas behind EBD are not new, but there is no question that over the last few years, there has been a dramatic trend toward incorporating EBD in renovation, retrofits and new construction of healthcare facilities.

Although there are currently no promulgated standards for EBD, many of the important discoveries will eventually find their way into such standards as the FGI Guidelines for Design and Construction of Hospitals and Healthcare Facilities, as well as ASHRAE's Ventilation of Health Care Facilities. Evidence-Based Design represents an approach to design that requires professionals to research findings and incorporates their results into the design of the facility.

Liability and Risk Motivators

Infection Control

Healthcare facilities comprise many types of buildings, with varied uses for the care of patients. The facilities covered in this document include general hospitals, urgent care facilities, ambulatory care facilities, outpatient clinics, medical office buildings, and other facilities where the general public may seek medical attention for the treatment of diseases. Such facilities, by their nature, are highly susceptible to the spread of bacterial and viral infection. Thousands of deaths each year are directly linked to this problem. The healthcare community is keenly aware of this fact. Hence, the control of facility-borne infectious disease (known as Healthcare-Associated Infection or HAI) is a driving principle in the design of healthcare facility ventilation systems.

> "There are approximately 2.1 million hospital-associated infections, 90,000 deaths, and $4.5 billion in associated costs to the healthcare industry each year."
>
> *– Centers for Disease Control and Prevention (CDC)*

The design of airflow control to abate HAI is an extensively researched science, and several organizations have published guidelines for the construction community. These organizations include the United States Center for Disease Control and Prevention (CDC), the Facilities Guideline Institute (FGI), the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), and the American Society of Healthcare Engineers (ASHE). In Canada, the Canadian Standards Association (CSA) issues the HVAC Standard CSA.Z317.2-10. Many of these guidelines are used by state and provincial authorities having jurisdiction for licensure and registration of healthcare organizations. Yet, these published documents often represent only the minimum requirements for airflow control and ventilation design, and not the clear benefits that can be obtained by engineering best practices into a project.

> "Ventilation air dilutes viral and bacterial contamination within a hospital. If ventilation systems are properly designed, constructed, and maintained to preserve correct pressure relations between functional areas, they remove airborne infectious agents from the hospital environment."
>
> *– 2009 ASHRAE Handbook–HVAC Applications*

Pathogens

Infectious airborne pathogens include viruses, bacteria and fungi. Viruses and bacteria are most commonly introduced into the hospital by incoming patients, while fungi can enter the environment due to incomplete filtration and poor direction airflow. Aspergillus is another dangerous fungi in the healthcare environment; since it is common throughout the northern hemisphere; its spores can be found in air and contaminate anything in contact with air.[1] The average hospital will acquire in excess of 400 nosocomial infections during a year, with the average cost per infection costing the facility approximately $14,000, according to the Joint Commission on Accreditation of Healthcare Organizations (known as the Joint Commission).

Below is a list of commonly found airborne pathogens that hospitals need to be concerned with according to the CDC. For more details, see *Table 4, Microorganisms associated with airborne transmission, Guidelines for Environmental Infection Control in Health-Care Facilities, in Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC)*.

Microorganisms Associated with Airborne Transmission[1]

	Fungi	Bacteria	Viruses
Numerous reports in healthcare facilities	Aspergillus spp.[2] Mucorales (Rhizopus spp.)	Mycobacterium tuberculosis [2]	Measles (rubeola) virus, Varicella-zoster virus
Atypical, occasional reports	Acremonium spp. Fusarium spp. Pseudollescheria boydii Scedosporium spp. Sporothrix cyanescens[5]	Acinetobacter spp. Bacillus spp.[5] Brucella spp.[3] Staphylococcus aureus Group A Streptococcus	Smallpox virus (variola)[4] Influenza viruses Respiratory syncytial virus Adenoviruses Norwalk-like virus
Airborne in nature; airborne transmission in healthcare settings not described	Coccidioides immitis Cryptococcus spp. Histoplasma capsulatum	Coxiella burnetii (Q fever)	Hantaviruses Lassa virus Marbur virus Ebola virus Crimean-Congo virus
Under investigation	Pneumocystis carinii	—	—

[1] This list excludes microorganisms transmitted from aerosols derived from water.
[2] Refer to text for references for these disease agents.
[3] Airborne transmission documented in the laboratory but not in patient-care areas.
[4] Airborne transmission of smallpox is infrequent. Potential for airborne transmission increases with patients who are effective disseminators presented in facilities with low relative humidity in the air and faulty ventilation.
[5] Documentation of pseudoepidemic during construction.

[1] VandenBergh, MF et al. "Epidemiology of nosocomial fungal infections: invasive apergillosis and the environment," ***Diagnostic Microbiology and Infectious Disease.*** 1999 Jul;34(3):221-7.

Healthcare-Associated Infection

Poor air quality, lack of directional airflow, and high humidity allows the transmission of bacteria, which places patients and staff members at risk of contracting an HAI (also known as a "nosocomial" infection). Both the frequency and severity of this type of illness have risen by 35% in the US during the past 20 years.[2] Additionally, many patients are immunocompromised due to advanced medical treatments, and are especially prone to contracting infections in the healthcare setting.[3]

Respiratory infections are one of the most dangerous forms of HAI, underscoring the importance of appropriate HVAC controls for containing the transmission of infectious agents. There are approximately 300,000 cases of nosocomial respiratory infections each year in the US, and mortality can exceed 30%.[4]

Pandemic Readiness

Since hospitals and clinics are often the first place people go when they are sick, it is important to design facilities that can sustain an influx of patients in the event of a pandemic influenza outbreak, bioterrorism, or other incident affecting large numbers of people. Known in the industry as *surge*, facilities often have documented procedures and trained staff to handle these situations.

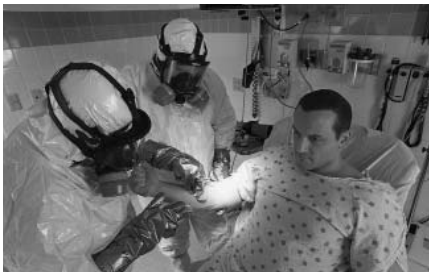


Figure 1-1. Medical personnel in biocontainment suits attend to an infected patient.

During a pandemic incident, many patients with potentially highly communicable diseases may be placed in close proximity within an emergency department or other containment area of a hospital. Few hospitals have sufficient numbers of Airborne Infection Isolation (AII) rooms running negative pressure to the corridor to accommodate a surge. Therefore, proper HVAC design that includes negative pressure floors, wings, and general patient rooms enables a hospital to contain further spread of airborne pathogens to staff and non-affected patients.

Federal and state grant money is sometimes available to retrofit building systems for pandemic readiness.

Critical Airflow Control

A healthcare facility's HVAC system is its first line of defense against airborne pathogens. The ability to precisely control the direction of airflow, air pressure, air changes per hour, and humidity can limit the spread of internally generated airborne pathogens throughout the facility, improve patient safety, increase care delivery effectiveness, and enhance the overall quality of care. These are achievable when the environment is designed to be therapeutic for patients, efficient for staff and restorative for all involved.

Operational Cost Motivators

Energy Conservation

Infection control is not the only HVAC concern in the healthcare community. Healthcare facility managers today face energy costs that continue to rise, creating very difficult challenges when managing the operating budget. Hospitals, especially, are one of the most demanding energy consumers in the nation due to 24x7 operations and relatively intensive power requirements

[2]Steed CJ. "Common infections acquired in the hospital: the nurse's role in prevention," ***Nursing Clinics of North America.*** 1999; 34:443.

[3]Liu, H. "Nosocomial Infections A Multidisciplinary Approach to Management," ***Purdue pharma.*** 6/2003.

[4]Cross JT Jr, Campbell GD Jr. "Drug-resistant pathogens in community- and hospital-acquired pneumonia," ***Clinics in Chest Medicine.*** 1999:20:49.

of medical diagnostic equipment. Hence, it is important for acute care facilities to implement new and creative energy conservation measures, balanced against the need to support comfortable patient care, and ensure surgical procedures are carried out under the correct climate conditions.

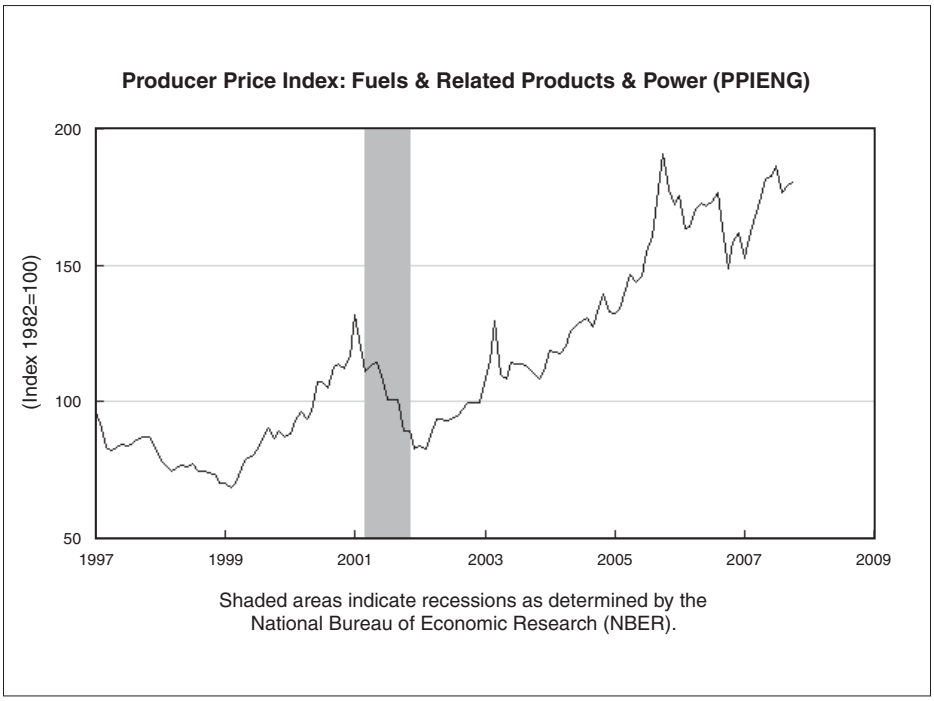


Figure 1-2. Producer Price Index for Fuels & Related Products & Power, a 10-year trend of rising energy prices, according to the U.S. Department of Labor: Bureau of Labor Statistics.

Some HVAC factors that drive high energy use at healthcare facilities include:

- High Efficiency Particulate Air (HEPA) filtration, which is required to prevent nosocomial infections in the ventilation system. HEPA filters that achieve 99.7% efficiency[5] place greater electric demand on fans for proper air circulation.
- Stringent indoor air quality (IAQ) levels must be maintained, especially in operating rooms (OR), emergency rooms (ER), intensive care units (ICU), and laboratories. These rooms require 20 to 30 air changes per hour (ACH).
- Airborne Infectious Isolation (AII) rooms and Protective Environment (PE) rooms require special pressurization for directional airflow. Healthcare facilities frequently drive higher supply or exhaust airflow to guarantee pressurization.
- In many areas of the facility, IAQ must be strictly regulated for temperature, humidity, and air quality. This increases the need for proper heating, cooling, and fresh air intake.
- Procedure rooms sometimes require climate control set at 60°F to accommodate the adhesive cement used for orthopedics, which tend to set too quickly in warmer temperatures.

As energy prices continue to rise and pressures to reduce consumption grows greater, there is greater interest in implementing energy conservation measures (ECM). Many hospitals do not implement effective ECMs because of the overwhelming concern for directional airflow

[5]ASHRAE recommends 90% HEPA filtration at a minimum, but this is often over-specified at 99.7% as a further precaution.

in operating rooms, procedure rooms, and isolation rooms. But a properly designed airflow control system can enable high turndown of heating or cooling needs based on occupancy, while still maintaining proper directional airflow in or out of the space. This turndown will result in significant operating cost savings.

HVAC Maintenance

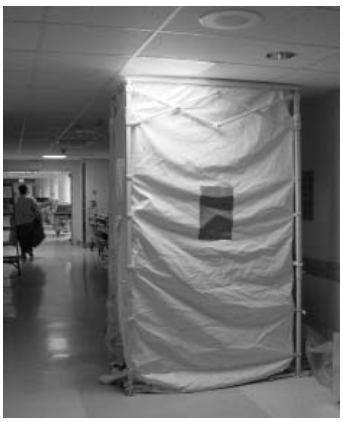


Figure 1-3. A work screen is required for HVAC services, increasing maintenance time and expense.

Servicing mechanical equipment in a hospital is expensive. Any equipment that requires access above the ceiling must have a work screen erected prior to removing ceiling tiles. Sometimes sections of the facility must be taped off to prevent dust or debris from entering a clean or sterile area. Work must be scheduled to avoid interrupting urgent surgical needs or other services that generate revenue for the hospital.

It is important, then, that equipment require as little maintenance as possible and be of the highest reliability to ensure minimal downtime and avoid disruption to hospital activities.

To meet the needs of modern new construction and retrofit in healthcare, designers must address the key aspects of business motivators for facility owners; reducing liability, increasing patient healing and associated revenue, and reducing costs.

Mechanical elements can deteriorate over time due to build up of dust and lint, and personnel may inadvertently change control parameters, rendering controls ineffective. Periodic inspection and verification of components and systems is necessary to ensure proper operation to design. Essential equipment includes systems that require little to no maintenance for reduced replacement cost and performance disruption. Products that have built-in safety or monitoring features, regulatory certification and warranties help decrease hospital downtime and reduce ongoing service costs.

> "Decreased performance of healthcare facility HVAC systems, filter inefficiencies, improper installation, and poor maintenance can contribute to the spread of health-care-associated airborne infections."
>
> *– CDC–Guidelines for Environmental Infection Control in HealthCare Facilities*

Design Efficiences

Achieving operational efficiency starts at the early stages of the project. No matter what size or scope of the project, healthcare facilities designers are challenged to develop the most efficient mechanical systems in order to provide the best solution for facility managers and owners. It is required and day after day conditions are more demanding due to higher standards and regulations. Not doing it will lose competitiveness with other alternatives available in the market. Having this in mind, tools for modeling and analysis has become more and more important to support healthcare projects. Thus, Phoenix Controls is developing new solutions and alternatives to help architects and engineers with innovative solutions that will help to select best alternatives for airflow control, monitoring and servicing. It is imperative to be able

to compare technologies or identify ROI well in advance. PC Optimizer, among others , can bring such analysis in addition to other features that makes this software unique in the marketplace.

PC Optimizer

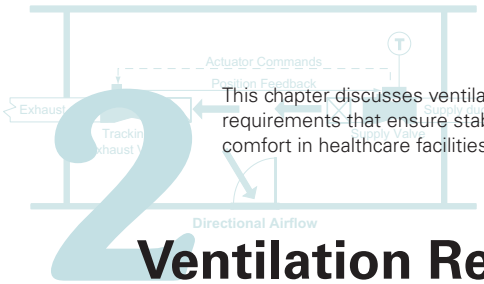
PC Optimizer is our industry changing airflow energy and life cycle cost analysis calculator. Unlike other HVAC modeling programs, within minutes a very accurate representation if a building's HVAC operational cost can be obtained and easily identify ROI for the project. This software contains the followign features:

- Wizard style user interface
- Better reporting
- More accurate VAV modeling
- Simple or detailed analysis
- What-if analysis

Note: A copy of the PC Optimizer can be obtained for free by visiting our web site at: https://www.phoenixcontrols.com/resource-pc-optimizer.htm.

APM2 Central Display

The Central Display is a remote touch-screen display that monitors the status of several Advanced Pressure Monitor II (APM2) BACnet® units installed on a floor. Using the Central Display, users are able to immediately see if rooms are safe and operating properly without walking to the APM2 mounted outside a room. Up to eight (8) APM2s can be monitored using one Central Display, providing easy access to view room conditions and to hear alarms remotely.



This chapter discusses ventilation design requirements that ensure stability, safety and comfort in healthcare facilities.

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2 Ventilation Requirements

There is a great diversity of use types in the spaces of a healthcare facility. Today many rooms are not considered critical in terms of airflow requirements; however, as designers respond to Evidence Based Design the flexibility to use spaces for purposes other than originally intended is becoming attractive to owners who wish to have the option to convert spaces for revenue generating procedures. These spaces must then be pressure controlled, and designed as such from the outset of a project.

Depending on a patient's illness or prescribed treatment, space requirements can vary dramatically. A hot, dry environment of 90 °F (32 °C) dry bulb (db) and 35% relative humidity (RH) is common for treating patients with rheumatoid arthritis. Clinical areas devoted to upper respiratory disease should be maintained at 30-60% RH. Bone setting and cast applications require a cool 60 °F (16 °C) db environment so casting materials do not harden prematurely. Patients needing oxygen therapy and those with tracheotomies need warm, humid air. Burn patients require room temperatures up to 90 °F (32 °C) db and 95% RH. Operating room temperatures can range from 60-72 °F (16-22 °C) depending on the procedure and the preference of the surgical staff. Fluoroscopic, radiographic, and deep therapy rooms must be maintained at 78-80 °F (26-27 °C) db and 40-50% RH. As conditions vary based on occupancy of the space, airflow turndown and pressurization continue to be important for energy savings and infection control respectively.[6]

Directional airflow can be even more critical for immunocompromised patients and patients undergoing surgical procedures that are highly susceptible to infection. These include cancer treatment, organ transplant, bone marrow transplant, and prosthesis.

Hospital Ventilation—Best Practices

The requirements below represent best practices in airflow for the purpose of optimizing infection control measures, energy savings, and reducing maintenance of HVAC equipment. While lawful compliance with ASHRAE codes and FGI guidelines is important, it does not always meet the long-term goals of a building's lifecycle in terms of operating efficiency and flexibility. The requirements below represent extensive research with hospital facility owners and healthcare engineers, and practical HVAC engineering demanded by today's leading healthcare facility managers.

Not every space in a hospital requires directional airflow and proper pressurization. However, as noted in Table 7-1—ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities on page 68, many spaces do require pressurization. If venturi valves and terminal boxes are mixed in this environment, directional airflow can be compromised by improperly balanced VAV systems and poorly maintained flow sensors, impacting primary infection control procedures and energy consumption alike.

[6] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2007 ASHRAE Handbook: HVAC Applications.

From a best practices approach, the critical spaces in a hospital are:

- Isolation rooms—airborne infectious isolation (AII) of contagious disease or protective environment (PE) for immunocompromised care
- Operating rooms—surgical procedures
- Specialty spaces—pharmacies, autopsy, morgue or gas storage
- Patient rooms—general patient care

It is notable that patient rooms qualify today as critical spaces. The treatment of HVAC in patient rooms is an important trend in today's healthcare business.

Airborne Infection Isolation (AII) and Protection Environment (PE) Rooms

AII/PE rooms are single bed patient rooms designed to protect either the patient or staff and public from infectious disease. AII/PE rooms can vary a great deal in design, depending on ward configuration, patient needs, and design principle. All isolation rooms require directional airflow either inward or outward from the room, plus some type of pressure monitor to verify proper operation.

The two types of rooms are described below:

- Airborne Infectious Isolation (AII)—negative pressure rooms with directional airflow inward. AIIs are used to protect staff and hospital occupants from patients that have contagious diseases such as tuberculosis or smallpox. Negative pressure rooms are required to prevent airborne pathogens from contaminating adjacent hallways and other rooms.
- Protective Environment (PE)—positive pressure rooms with directional airflow outward. PEs are used to protect the patient from contagious disease that may be carried by staff or hospital occupants. Patients confined to PE isolation are generally immunocompromised due to HIV, cancer treatment, organ transplant, or other reasons that make a person hypersensitive to infection.

There are two basic designs of AII/PE rooms; with and without an anteroom. An anteroom is a small intermediate space between the patient room and the hallway. When an immunocompromised patient also requires airborne infection isolation, then an anteroom is required. The anteroom provides additional protection against escaping pathogens when the doors are opened and closed. In each situation, directional airflow is achieved between the room and the corridor and/or anteroom.

There are generally three ways to treat airflow in isolation rooms:

- Tracking Pair VAV
- Enhanced Tracking Pair VAV
- Constant Volume

Each of these will be discussed later in the chapter.

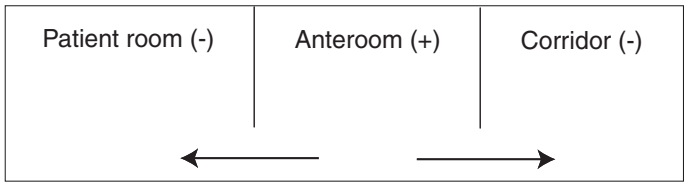
Anteroom Pressurization

There are three common approaches to anteroom relative pressurization according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) with the preference for having the anteroom positive to the room and its surrounding space for protective environments.[7] FGI states that "there is no prescribed method for anteroom ventilation" but the advantage of a clean anteroom is that health care workers need not mask before entering the anteroom. Both seem to favor option 1, with the anteroom positively pressurized and air

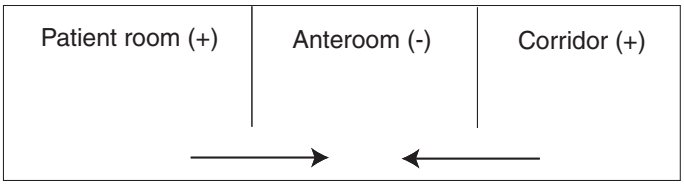
[7] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 2003 ASHRAE Handbook: HVAC Applications, p. 7.3.

moving from it to the patient room and corridor. Refer to NFPA fire codes for more information about ventilation in anterooms.

1. The anteroom is positive to the patient room and corridor. (This approach corresponds to the "Protective Environment with Airborne Infectious Isolation" application on page 42.)

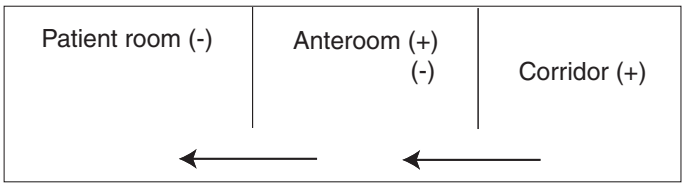


2. The anteroom is negative to the surrounding space. (This approach corresponds to the "Protective Environment with Airborne Infectious Isolation" application on pages 43-45.)



3. The anteroom is positive to the room and negative to the corridor. (This approach corresponds to the "Airborne Infectious Isolation with an Anteroom Negative to the Corridor" application on page 44)

All with Anteroom



Pressurization Control Approach

The magnitude of the pressure differential recommended by the CDC for infectious isolation and protective environments is 0.01 inch water gauge (2.5 Pa) in relation to the adjacent space. While it is agreed that it is the difference in air pressure between two adjacent rooms that causes air to flow from inside or outside of a room, how that differential is controlled may be approached two different ways. One method, called volumetric offset, relies on the basic principle of exhausting a volume of air greater (or lesser) than supply volume, thereby creating an "offset." The second method, known as differential pressure sensing, employs a mechanical sensing device to measure the pressure within the two spaces and based on that, controls the amount of supply and exhaust air delivered to the space.

Both approaches create a pressure differential; however, based on years of controlling pressurization in critical laboratory environments, Phoenix Controls has found volumetric offset to be a very stable, reliable method of control. Differential pressure sensing has historically been+more difficult, less stable and dependent on sensor accuracy and maintenance. In the Z9.5-2009 standard, the American National Standards Institute (ANSI) and the American Industrial

Hygiene Association (AIHA) support the use of volumetric offset over differential pressure for laboratory environments: "...specifying quantitative pressure differential is a poor basis for design…What really is desired is an offset air volume. Attempts to design using direct pressure differential measurement and control vs. controlling the offset volume may result in either short or extended periods of the loss of pressure when the doors are open or excessive pressure differentials when the doors are closed, sufficient to affect the performance of the low pressure fans."[8]

Ventilation Rates

For new construction, a minimum of 12 air changes per hour (ACH) for infectious and protective isolation rooms is recommended. Anterooms and toilet rooms may be slightly less at 10 ACH. Many existing facilities may have lower ACH because prior to 2001, the minimum was 6 ACH. For more information, see Table 7-1—ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities on page 68.

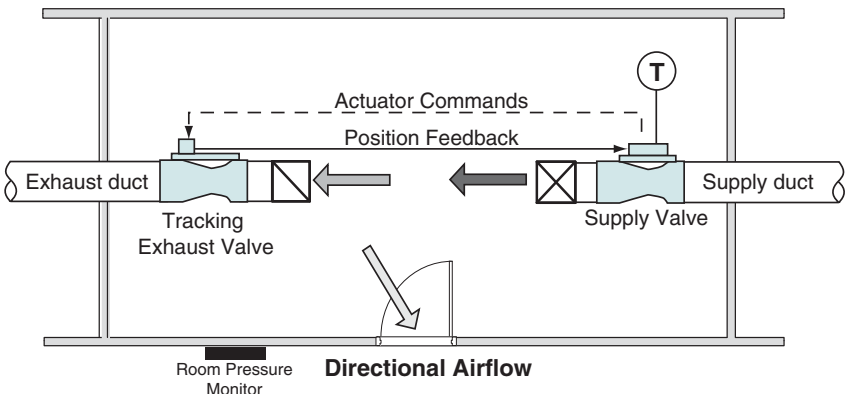
Room Pressurization Monitoring

A permanently installed, pressure-monitoring device with visual and audible alarms is recommended to ensure that the patient room is pressurized as specified. Remote monitoring and documentation of pressure status is also recommended by integrating operating information with the building management system. Monitoring of valve flow feedback may be advantageous to verify the stability of the room pressurization versus the volumetric offset. This signal may also be integrated to the building management system. Refer to the APM2 on page 93.

Tracking Pair VAV and Design Flexibility

A tracking pair VAV application is a supply and exhaust valve that work together to maintain a prescribed CFM offset (positive, negative or neutral to the corridor) regardless of airflow rate and independent of duct variations in static pressure. The valves support changes in airflow for occupied/unoccupied states, but maintain the directional airflow required for AII or PE rooms. Tracking valve pairs include all the benefits of CVV pairs, but in a VAV application and control of directional airflow. In addition, as of 2010 the FGI guidelines allow for the turndown of airflow for the use of AII/PE rooms as patient rooms as long as proper pressurization is maintained. Tracking pairs allow a facility to take advantage of the energy savings benefit while maintaining pressurization.

Figure 2-1. An example of a Tracking Pair VAV application for an isolation room (AII or PE).



[8]American Industrial Hygiene Association (AIHA). American National Standard for Laboratory Ventilation (ANSI/AIHA Z9.5-2003), pp. 28-29.

Enhanced Tracking Pair VAV

Additional requirements for the design of AII/PE rooms include maximizing the room's flexibility for multiple purposes:

- General patient room—higher turndown ratio for energy efficiency
- Pressure monitoring—included with valve controls, required for isolation rooms
- Humidity control—for special environment requirements of burn, respiratory, tracheotomy, or tissue-sensitive patients
- Shut-off control—for room-level decontamination following AII use

Enhanced tracking pair VAV meets the needs of designers who are engineering the most flexible use of space in a hospital. This is important for owners who want a facility that can respond to changing requirements, generate new revenue, and meet the future needs of unforeseen events.

Constant Volume

Constant Volume Valves (CVV) are set for fixed flow operation and stable airflow throughout an AII/PE room. Valves can be installed in pairs and configured at the factory for different cubic feet per minute (CFM) flow rates.

CVVs carry no electronics, but are designed to regulate proper CFM regardless of changes in duct static pressure. Like all Phoenix Controls valves, CVVs require no maintenance, and provide reliable directional or neutral airflow indefinitely.

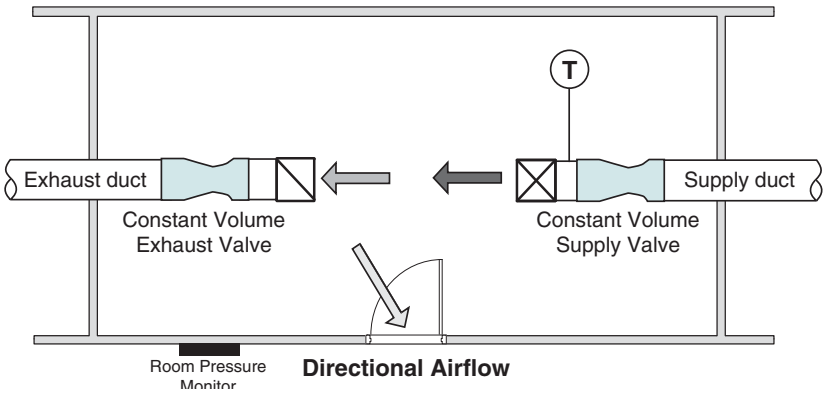


Figure 2-2. An example of Constant Volume Valves application for an isolation room— Protective Environment (PE).

Operating Rooms

Nowhere is infection control more critical than in operating rooms (ORs), where the surgical theatre exposes sensitive internal tissue to skin squames and airborne pathogens. From a ventilation standpoint, many types of rooms are treated as operating rooms, all of which receive positive pressure relationship to adjacent spaces. Rarely, highly infectious patients undergoing a surgical procedure will require a negative pressure OR.

Rooms treated like an OR include:

- Surgical operating
- Surgical cystoscopic
- Delivery
- Critical or intensive care (burn or intermediate)
- Newborn intensive care
- Nursery suite
- Trauma
- Minor procedure

In addition to ventilation and proper directional airflow, temperature and humidity play an important role in successful surgical procedures and patient treatment. Conditions affected include rheumatoid arthritis, upper respiratory disease, chronic pulmonary disease, burn victims, and those requiring oxygen therapy. Hence, there are clear benefits to coordinated ventilation, pressurization, and temperature and humidity control from a single system such as Phoenix Controls.

Outside Air

ASHRAE 170 recommend 20 ACH for ORs with a minimum of 4 outdoor ACH or 20%[9] outside air. Outside air dilutes any viral or bacterial contamination when mixed with recirculated air, even through HEPA filters. If ventilation systems are properly designed, constructed, and maintained to preserve correct pressure relations between functional areas, they remove airborne infectious agents from the hospital environment.

Air Movement and Circulation

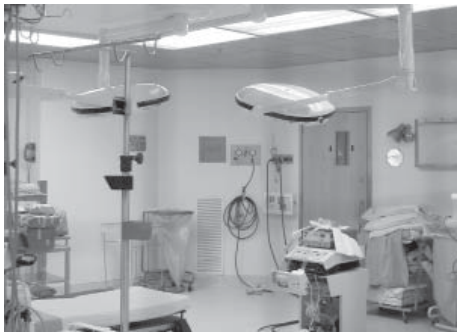


Figure 2-3. At floor level on the far wall is the return air duct in an OR. *Airflow from top-center to bottom-perimeter is an effective guard against airborne pathogens or skin squames.*

Supply diffusers delivering air to ultra clean areas such as ORs should be located at or near the ceiling, with return air duct at the perimeter and near the floor (laminar airflow). This arrangement provides downward movement of clean air through the breathing and working zones to the floor area exhaust. VAV systems must ensure that during minimum ventilation rates (Table 7-1—ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities on page 68) pressure relationships between the OR and adjacent spaces is maintained positive at all times. With VAV systems, a method such as air volume tracking between supply, return, and exhaust could be used to control pressure relationships (Lewis 1988).[10]

Usually, air is delivered from the ceiling, with a downward movement toward several exhaust or return ducts near floor level. Completely perforated ceilings, or those partially perforated, and those with laminar diffusers are effective in moving air from clean to unclean areas in an OR. Common air exchange rates are 20 ACH or greater, with no recirculation within the room, or recirculation with HEPA filtration. A minimum of 4 ACH outside air is required.

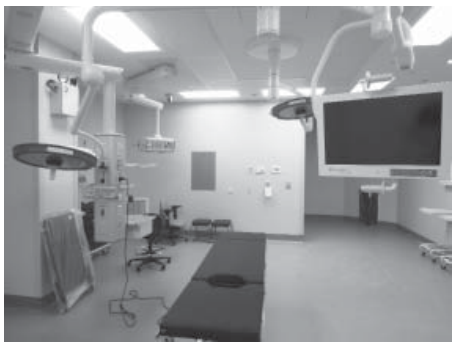


Figure 2-4. Laminar airflow diffusers above an operating room ensure directional airflow from clean to unclean areas.

Temperature and Humidity

Temperature and relative humidity set points should be designed so that the surgical staff can make changes as required for the procedure and comfort of the surgical team. Temperature in ORs can range from 60°F to 80°F. Relative humidity can range from 20% to 60% typically. More information for specific types of procedures can be found in Table 7-1—ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities on page 68.

Pressure Monitoring

A pressure monitoring device should be installed to allow air pressure reading in the room relative to the adjacent space. Differential pressure between the space and corridor should be a minimum of 0.01"WC. Refer to specific codes and standards for required pressure relationships for various room types. Any alarm function should be designed to be muted if necessary.

Specialty Spaces

Additional critical spaces that require room pressurization include in-hospital pharmacies, and morgue and autopsy rooms. Hospital pharmacy applications are covered in Chapter 3. General guidelines for morgue and autopsy, and other spaces requiring pressurization are noted in Table 7-1—ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities on page 78.

Patient Rooms

FGI 2010 guidelines require new construction patient rooms be designed as single beds. The primary reason for this change was the potential for infection to spread from one patient to another in a multi-occupant room. It is known that coughed saliva can travel up to two meters as aerosolized matter, and have a mass up to 6.7 mg.[11] Hence, the risk of contaminating the air of a neighboring bed is significant. This new regulation acknowledges as fact that guarding against the transmission of airborne infections applies to more than just isolation rooms and operating rooms in a hospital.

Another trend regarding general patient rooms involves the need for a hospital to be prepared for an outbreak of pandemic influenza. As hospitals prepare procedures to respond to a pandemic outbreak, most agree that there would be insufficient AII rooms to accommodate an influx of patients (known as a ***surge***). The ability to use pressurized general patient rooms as AII rooms in an emergency can reduce the spread of disease within the hospital and safeguard other patients and staff.

Finally, Evidence-Based Design has an influential role regarding general patient rooms. Evidence-Based Design findings have shown that airflow is one of the key factors that contribute to patient healing. More information about EBD will be outlined later in this chapter.

[11] Shengwei Zhu, PhD. and Shensuke Kato, PhD., "Investigating How Viruses are Transmitted by Coughing," American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *IAQ Application, Vol. 7, No 2, Spring 2006.*

There are four ways Phoenix Controls valves can meet current guidelines and the emerging trends that apply to patient rooms. Each has benefits and cost-efficiency to improve upon infection control and energy savings:

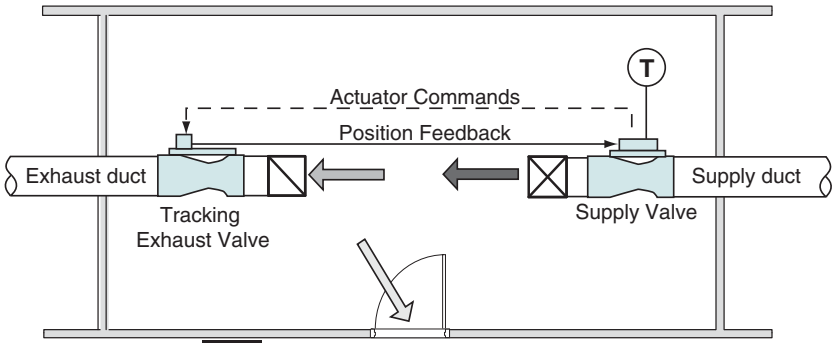
- Tracking Pair VAV
- Enhanced Tracking Pair VAV
- Supply-only VAV
- Constant Volume

More specifics on how to apply each of these four approaches is covered in Chapter 3.

Tracking Pair VAV

A tracking pair VAV application is a supply and exhaust valve that work together to maintain a prescribed CFM offset (positive, negative, or neutral to the corridor) regardless of airflow rate and independent of duct variations in static pressure. The room can be switched between positive, negative, or neutral depending on the requirement and overall facility balance. Tracking pair VAV is important as a design consideration for pandemic readiness, because general patient rooms can be converted to pandemic AII rooms on-demand in an emergency. Tracking valve pairs include all the benefits of Supply-only and CVV pairs, plus provide the ability to adjust the supply and exhaust airflows automatically based on user requirements.

Figure 2-5. An example of a Tracking Pair VAV application for a patient room.



Enhanced Tracking Pair VAV

Additional requirements for the design of general patient rooms include maximizing the room's flexibility to be used for multiple purposes.

- Pressure monitoring—should the need arise to add additional AII or PE rooms
- Humidity control—for special environment requirements of burn, respiratory, tracheotomy, or tissue-sensitive patients
- Shut-off control—for room-level decontamination following AII use

Enhanced tracking pair VAV meets the needs of designers who are engineering the most flexible use of space in a hospital. This is important for owners who want a facility that can respond to changing requirements, generate new revenue, and meet the future needs of unforeseen events.

Patient rooms are not required to be pressurized spaces, and can be engineered neutral to the corridor. This is the minimum design standard according to FGI 2010 guidelines. A terminal box with reheat coil and ducted exhaust is adequate to meet most state codes; however,

this design does not take into consideration the long-term use of the facility. Several factors important to facility operation become overlooked.

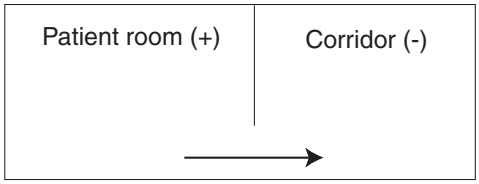
Energy Consumption and Maintenance

Terminal boxes require flow sensors to measure airflow into the space. The flow sensor sends a CFM reading via the controller to the damper actuator to control airflow and climate conditions in the room. If the sensor is clogged, the CFM reading is lower than the actual airflow. A lower CFM reading tells the damper to open more to increase the airflow. This is unnecessary, and wastes energy. Flow sensors require cleaning several times a year to prevent this energy waste. This service increases HVAC maintenance expenses and can potentially cause lost revenue in areas of the hospital that generate income with medical procedures or diagnostic testing.

Infection Control

With each revision of the FGI guidelines, more and more emphasis is placed on air quality and proper ventilation for infection control to reduce HAI-related deaths. There are also ancillary benefits affecting patient recovery in a single bed configuration that indirectly relate to airflow, such as sunlight, personal comfort, lower noise levels, and other EBD elements.

A general patient room that is positive to the corridor helps assure the occupant can recover from the illness originally presented with a reduced chance that a nosocomial infection will be transmitted into the space from people passing by in the hallway.



Surge from Pandemic Outbreak

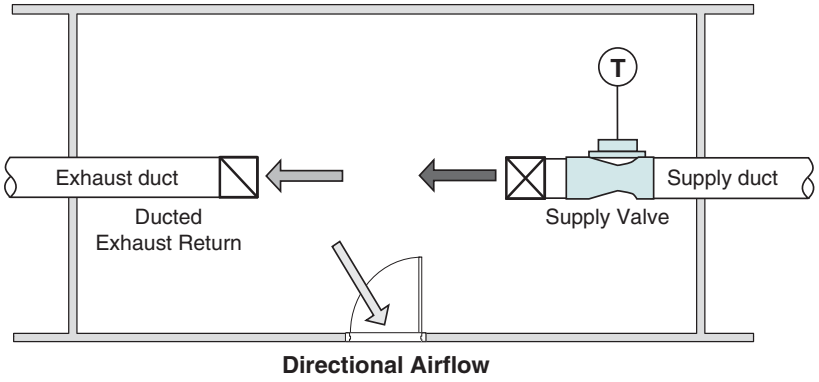
Ventilation controls for directional airflow and room pressurization can provide effective protection for patients, staff, and visitors against the risk of infection from airborne pathogens. However, it is worth noting that engineering controls are but one of three types of controls for an effective infection control program, the other two being administrative and personal respiratory protection.

While concerns surrounding the spread of tuberculosis (TB) in healthcare settings have existed for a number of years, recent outbreaks of Severe Acute Respiratory Syndrome (SARS) in several countries and preparedness in response to potential bioterrorism attacks have heightened interest in infection control.

Supply-only VAV

FGI 2010 guidelines require single patient rooms in new construction. The minimum requirement for ventilation specifies ducted exhaust, and does not specify the type of supply needed. Supply-only VAV from Phoenix Controls will not produce a pressurized space with ducted exhaust, but can achieve other benefits such as temperature control, higher turndown ratios and reduced maintenance.

Figure 2-6. An example of a Supply-only VAV application for a patient room.

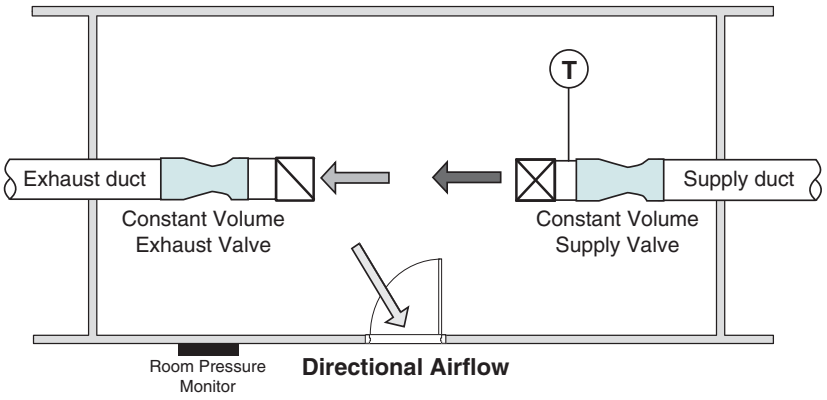


Constant Volume

An improvement over ducted exhaust design in patient rooms can be designed with a pair of constant volume valves (CVV). CVVs are set for fixed flow operation and stable airflow throughout the room. Valves can be installed in pairs and configured at the factory for different cubic feet per minute (CFM) flow rates, depending on whether directional airflow in or out of the room is required. If slightly negative to the corridor is desired, CVV provides an effective barrier to the spread of airborne pathogens from patient to corridor, or vice versa for protective environment.

CVVs carry no electronics, but are designed to regulate proper CFM regardless of changes in duct static pressure. Like all Phoenix Controls valves, CVVs require no maintenance, and provide reliable directional or neutral airflow indefinitely.

Figure 2-7. An example of a Constant Volume Valves application for a patient room.



Airflow Control Considerations

The accuracy and stability of the airflow control device plays a critical role in maintaining the proper space pressurization for containment and ventilation as well as comfort control. Not only must these devices provide precision air flow control, they must function with other devices as part of a system to maintain the safety and integrity of the entire healthcare facility.

Phoenix Controls introduced the venturi valve as an airflow control device in the early 1980s. With over half a million valves installed, the Accel® II venturi valve has changed the way people control their critical spaces and continues to set the highest performance standards in the industry

This section will review traditional airflow control methods and the associated issues critical to creating safe, stable and reliable healthcare facilities. Historically, healthcare facility spaces have run at constant volume and required excessive service in order to maintain suitable control. Cleaning, balancing and rebalancing have often been an ongoing and costly task. To overcome these problems and better achieve the operational objectives, several important control issues must be addressed.

A better understanding of different flow control techniques can help show the many benefits that the Phoenix Controls Theris line of venturi valves provides over traditional Variable Air Volume (VAV) terminal Boxes and airflow measurement.

VAV Terminal Box

Traditional VAV controls and even industrial quality controls cannot handle many of the requirements set forth in the various standards and guidelines that oversee healthcare facilities. The need to control airborne infection and run a highly efficient facility are at the forefront of these standards. It is extremely difficult to optimally achieve both requirements because of the use of airflow measurement devices. Airflow measurement devices provide an obstacle to flow control for the following reasons.

Maintenance

Architects and engineers that design hospital HVAC systems know that bed linens create significant airborne fibers that clog VAV terminal box flow probes. It is acknowledged that these facilities demand reliable airflow control components that are different than those used for commercial office buildings. Controlling flows accurately for temperature and pressurization is critical. Evidence-Based Design has shown that proper airflow and climate control in the healing environment contributes significantly to patient recovery and fewer days in the hospital. With a clogged sensor the ability to properly measure flow becomes an impossibility and in a sense renders the device useful to maintain directional airflow in a critical space. In addition, energy benchmarking, Evidence Based Design, and other goals are no longer attainable.

Accuracy

Flow measurement devices by their very design include inaccuracies. These inaccuracies need to be accounted for in critical spaces where directional airflow is essential to maintaining sterile environments. Inaccuracies result from the inability to control at lower velocity pressure and the natural drift that occurs over time. Different devices have different levels of inaccuracies, but as would be suspected, the better the controllability of the measurement device the more expensive the system will be.

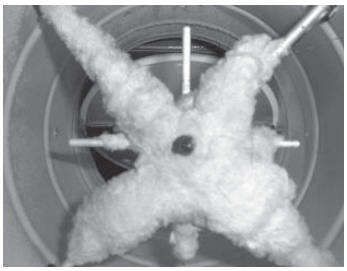


Figure 2-8. Materials used in healthcare facilities such as clothing, towels, and linens can give off significant particles which become airborne and cling to surfaces such as grilles and airflow probes. *Dirty airflow probes adversely affect room air change rates, room pressurization, energy use, and temperature control throughout the facility*

Turndown

With the need to reduce energy consumption in healthcare facilities, there can be great savings achieved by embracing a true Variable Air Volume control method and reducing airflow according to the standards when spaces are unoccupied. Air Terminal boxes with typically sized airflow measurement devices for the healthcare setting can only accurately control ranges of 2 or perhaps 3 to 1 (assuming the device is properly sized, cleaned, calibrated and installed properly with straight duct runs).

The table below illustrates how velocity pressure measuring systems get into trouble even with ± 1% full-scale transducer (10" duct example).

CFM	FPM	Actual Velocity Pressure, "WC	XDCR Error, "WC	Measured Velocity Pressure, "WC	Measured CFM	Measured FPM	Flow Error
1000	1833	0.2095	0.015	0.2245	1035	1898	4%
500	917	0.0524	0.015	0.0674	567	1040	13%
200	367	0.0084	0.015	0.0234	334	612	67%

1.5" ±1% full-scale (±0.015") transducer was used for a typical scenario.

Recalibration

In addition to accuracy issues at lower airflows, measurement devices drift over time. Yearly maintenance is needed to prevent this from happening; otherwise it becomes harder and harder to control the pressurization of a space. –The table below shows the effect of drift coupled with natural accuracy issues can have on the ability to manage a healthcare facility's airflow needs. The loss of control not only poses an issue for maintaining proper pressurization, but it also provides difficulty in achieving the parameters (setpoints, energy savings, etc.) that were set forth in the initial commissioning of a facility. As a result, recalibration cost considerations should be taken into account for the life cycle cost of a building when using this type of technology.

Standard Healthcare Sized Transducer		
Inputs	Transducer Range	1.5" WC
	Transducer Drift per year	1 % Full Scale
	Transducer Accuracy	1 % Full Scale
	Airflow Turndown	4:1
	Duct diameter	10"
	Occupied Airflow	1000 CFM
	Room Volumetric Offset	-75 CFM
Outputs	Maximum Flow Capacity	1833 FPM
	Maximum Flow Vp	0.2096" WC
	Unoccupied Airflow	250 CFM
	Minimum Flow Velocity	458 FPM
	Minimum Flow Vp	0.0131" WC

Year	Cumulative Transducer Drift, " WC	Direction of Error Stacking	Occupied vs. Unoccupied CFM	Measured Velocity Pressure, " WC	Calculated Velocity, FPM	Calculated Flow, FPM	Flow Error, CFM	Flow Error
1	0.015	Positive	1000	0.2396	1960	1069	69	6.9%
			250	0.0431	831	453	203	81.4%
2	0.03	Positive	1000	0.2546	2021	1102	102	10.2%
			250	0.0581	965	527	277	110.6%
3	0.045	Positive	1000	0.2696	2079	1134	134	13.4%
			250	0.0731	1083	591	341	136.2%
4	0.06	Positive	1000	0.2846	2136	1165	165	16.5%
			250	0.0881	1189	648	398	159.3%
5	0.075	Positive	1000	0.2996	2192	1196	196	19.6%
			250	0.1031	1286	701	451	180.6%

For simplicity, this chart only show a uni-directional drift. In actuality there would be a flow error in both the positive and negative direction.

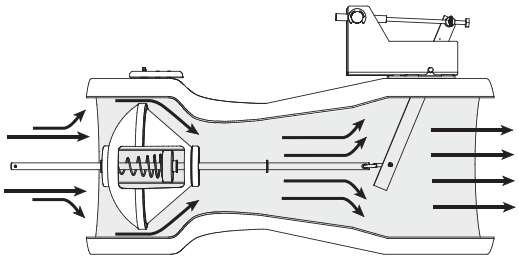
Other Flow Measuring Technologies

Orifice plates and flow cross measuring techniques rely on much the same principles–measuring low-level differential pressure values and calculating an inferred flow rate. Errors and delays may occur as the flow controller runs through a process of; measure, control and adjust. Because of the inherent delays in this process it may require several cycles which could result in over and under shoots as the flow controller hones in on the flow setpoint. Each time the static pressure, measured flow, or flow command changes this cycle repeats itself.

A Unique Solution—Theris Venturi Valve

The Phoenix Controls Theris brand of Accel II venturi valves combine a mechanical pressure independent regulator with a high-speed position/airflow controller to meet the unique requirements of laboratory airflow. These valves can be used in VAV, as well as constant volume.

Figure 2-9. Cutaway view of a venturi valve.



Flow Control

Variable flow control is accomplished by using a pivot arm to repositioning the shaft and cone assembly to achieve the desired flow setpoint. Each and every valve that ships from the Phoenix Controls manufacturing facility is characterized on a sophisticated NIST traceable air station where shaft position is correlated to actual valve flow.

For constant volume valves, the air station delivers the desired air flow and the pivot arm locked in place at the fixed set point.

For VAV valves, a precision potentiometer is attached to the pivot arm and each valve is ramped through its entire flow range at a fixed static pressure and a characterization curve of resistance versus flow is captured and downloaded to the valve mounted controller. The valve mounted controller precisely measures and controls the shaft position through a variety of actuation options and develops a precise flow feedback value. The known relationship of pivot arm position to flow allows the controller to rapidly drive the cone and shaft a specific orifice opening with little or no overshoot.

Performance

Accuracy

All Phoenix Controls valves maintain a fixed flow of air by adjusting to changes in static pressure. Each valve has a cone assembly with an internal stainless steel spring. The custom engineered springs were selected based on passing one million cycles of full-deflection testing. The cone assembly adjusts the open area of the venturi to system pressure as described below so that the flow setpoint is maintained continuously and instantaneously.

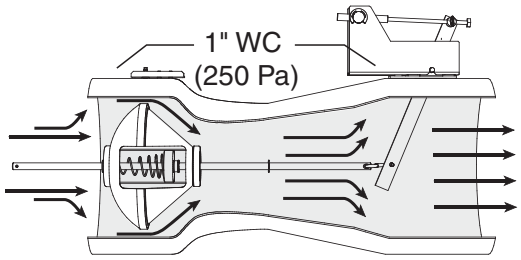


Figure 2-10. The effects of low static pressure on a venturi valve cone. *When there is low static pressure, less force is applied to the cone, which allows the spring within the cone to expand and push the cone away from the venturi. The combination of low pressure and a large open area provides the desired flow.*

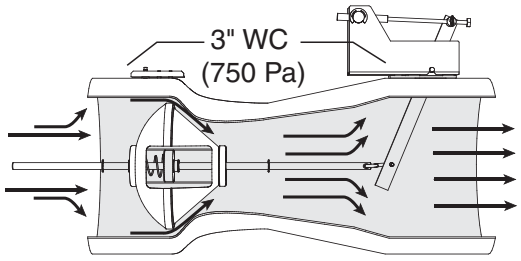


Figure 2-11. The effects of high static pressure on a venturi valve cone. *As static pressure increases force on the cone, the spring compresses and the cone moves into the venturi, reducing the open area. Higher pressure and the smaller opening combine to maintain flow set point.*

Speed of Response

The Theris line incorporates normal-speed electric actuation.

The normal-speed electric actuator has the ability to drive the pivot arm over the entire operating range in less then 60 seconds. Subtle flow command changes are obviously accomplished in significantly less time.

The valve works on the simple principle of metering airflow versus an air velocity measurement and control approach. Because pressure independence is de-coupled from the flow control with the Accel II valve, the two functions do not compete with one another as with flow sensing techniques. Flow sensing attempts to compensate for variations in measured flow due to both changes in flow command and static pressure which suggests the system is frequently repositioning.

The Accel II valves require no additional straight duct runs before or after valve for accurate control. They are available in flows from 35-5,000 CFM (60-8,480 m^3/hr).

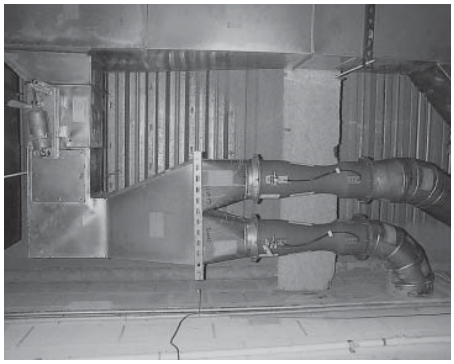
Other Airflow Control Considerations

Installation in Congested Spaces

Since healthcare rooms must be free from mechanical equipment to the greatest extent possible, most environmental control devices are located above the ceiling or in interstitial spaces. Building components commonly found in this space include:

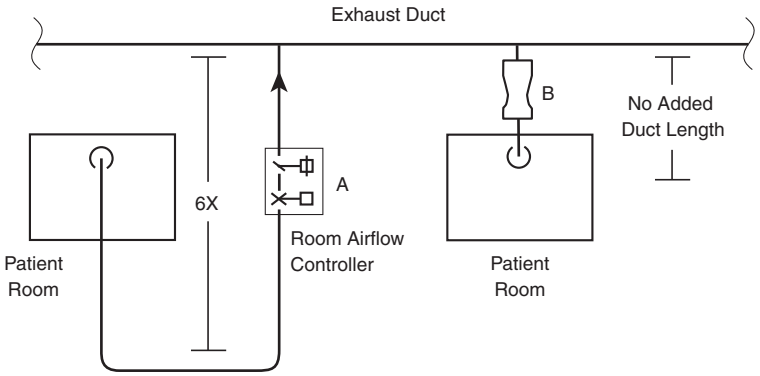
All of these devices, ducts, pipes and wires crowd ceiling spaces, making it difficult or impossible to provide the required straight runs of duct upstream and downstream of terminal boxes that are critical for them to operate according to the manufacturer's catalog data. This is another reason why the typical airflow measurement devices, such as pitot tube, orifice rings, thermal or other point specific sensors, are poor candidates for these applications. For example:

Figure 2-12. Installation in congested spaces.



- Mechanical system ductwork
- Electrical wiring and conduit
- Lighting fixtures
- Mechanical system piping
- Plumbing piping
- Sprinkler piping
- Communications equipment and wiring
- Building structural members
- Suspended ceiling support members
- Miscellaneous devices not listed above

Figure 2-13. Installation requirements. *The traditional flow measurement device (A) requires laminar flow—adding several diameters of straight duct lengths upstream and downstream of the device. Airflow control devices (B) that do not have such limitations are desirable for tight installations.*



Notes:

Terminal box with needed duct diameter.

Phoenix valve with no additional requirements

Redundancy and Emergency Power Operation

All hospital spaces must be maintained at a constant stable condition around the clock, even if electrical power is interrupted or if maintenance is required. This requires the use of redundancy of the critical components of the HVAC system. The system must be capable of maintaining the temperature, relative humidity and other parameters that affect the stability of the patient's environment. Exhaust fans, supply air handling units, boilers, pumps, and controls are among the system components that require redundancy and must also have emergency power during a utility power failure, especially exhaust fans for isolation rooms.

With the use of flow measurement devices, redundancy power will be required to ensure that sensors are still able to measure airflow in order to maintain the pressurization of critical spaces. The Theris venturi valves can fail in place or to a reduced airflow as determined by a facilities emergency management protocol. Because of mechanical pressure independence, the venturi valve is able to maintain proper directional airflow even with changes in duct static pressure.

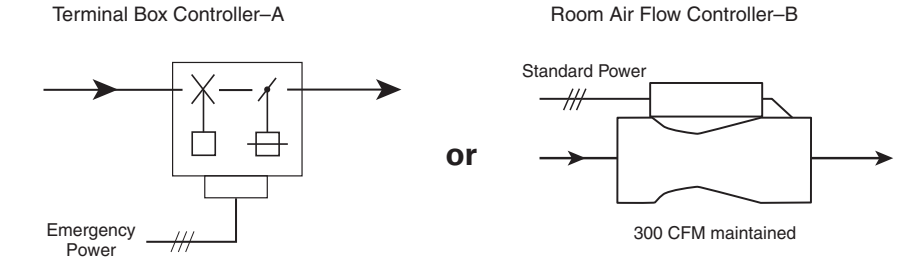


Figure 2-14. Fail-safe operation. *Room air flow controls must be on emergency power for operation during power failure (A) or fail-safe to a fixed flow (B).*

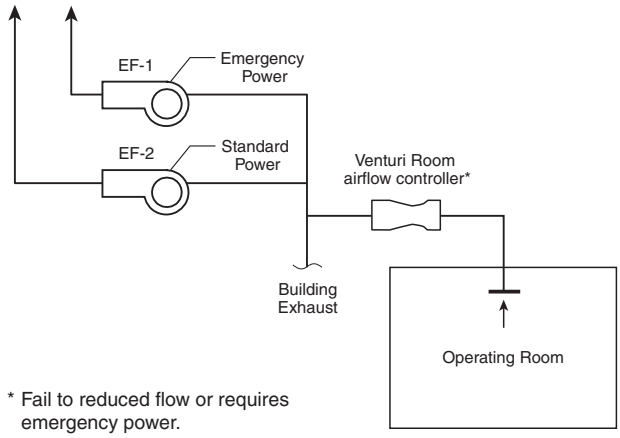


Figure 2-15. Emergency operation. *Systems must be designed to operate at reduced levels under emergency operation. Redundant fans with partial emergency power is typical. Controls must either fail to a reduced flow level or receive emergency power. Supply side systems must be similar.*

Flow Control Summary

The use of traditional blade dampers and terminal boxes in healthcare facilities has proven to be less than ideal because these devices:

- Lack accuracy and repeatability required for tightly controlled rooms
- Require periodic recalibration
- Require periodic cleaning of airflow probes
- Require a longer straight duct than is typically available
- May require periodic auto-zeroing (causes room to go out of control temporarily)

FGI Guidelines referenced in Chapter 6, "Standards and Guidelines," require ventilation systems to operate at a reduced flow during power loss. Reduced flows ideally are allocated such that non-essential areas (storage and some procedure rooms) would receive little or no flow so that essential areas are not affected. The Phoenix Controls valve is ideal for this application since it does not require power or pneumatic air to maintain the correct preset reduced flow.

Fail-safe Requirements	VAV Terminal Boxes	Phoenix Controls Valves
• Auto fails to predetermined flow on power loss	No	Yes
• Extra wiring required	Yes	No
• Extra tubing required	Yes	No

Phoenix airflow control valves are self-balancing and auto fail-safe, which eliminates the need for emergency power for all room airflow control devices.

HVAC Redundancy

Hospital facilities are considered critical to the health of the general public. As such, designers often take into consideration operations under emergency power. From an airflow design, the supply and exhaust systems would require emergency power for operation during power outages. Since total redundancy is seldom practical, a common approach to system design is multiple fans, each sized at partial load. In the event of power loss or service, one fan for the supply and exhaust systems is enabled by emergency power—allowing for partial air flow (e.g., 66%).

The room level controls must also be considered for emergency power conditions. The room air flow terminal devices must maintain flow control and pressure-independence with emergency power or must mechanically fail to a reduced setpoint.

Benefits of Turndown and Reduced Maintenance

Airflow turndown can have significant benefits. Although a hospital is in operation 24/7, a very large majority of the critical spaces requiring proper pressurization are only occupied 40 to 50% of the time. ASHRAE's *Design Manual for Hospitals and Clinics* includes Table 16 (below) which gives a list of common spaces and their average occupancy. If we use these numbers as a guideline, it becomes very apparent that running a constant volume facility is unnecessarily costly. Often facilities will have no choice but to run at constant volume do to the inaccuracies shown above from measurement devices they use.

Space	Typical Occupied Hours/Week
Patient Rooms	80% of rooms normally occupied 24 hours, 7 days/ week
ICU Rooms	75% of rooms normally occupied 24 hours, 7 days/ week
Nurses Stations	24 hours, 7 days/week
Emergency Room Areas/Exam Rooms	24 hours, 7 days/week
Lab Areas (normally 50% of total areas)	24 hours, 7 days/week
Emergency Radiology Areas (normally 10-20% of total area)	24 hours, 7 days/week
Autopsy	24 hours, 7 days/week
Central Sterile Supply	24 hours, 7 days/week
Nursery	24 hours, 7 days/week
Corridors/Waiting Areas	24 hours, 7 days/week
Medical Records	24 hours, 7 days/week
Receiving	60 hours/week
Clean Linen Storage	50 hours/week
Purchasing	50 hours/week
Maintenance Office	50 hours/week
Ultrasound Areas - General	50 hours/week
Mammography Areas - General	50 hours/week
Nuclear Medicine Areas - General	50 hours/week
Fluoroscopy Areas - General	60 hours/week
Endoscopy Areas - General	60 hours/week
X-Ray Areas - General	60 hours/week
Surgery Prep Areas - General	65 hours/week
Operating Rooms - General	65 hours/week
Outpatient Operating Rooms - General	50 hours/week
C-Section Operating Rooms	40 hours/week
Administrative Offices/Conference Rooms	50 hours/week
Recovery - General	55 hours/week
Physical/Occupational Therapy	60 hours/week
Outpatient Exam/Office Areas	65 hours/week
Cardiac Catherization Labs	55 hours/week
Dietary	98 hours/week
Dining Areas	98 hours/week
Laundry	60 hours/week

The following are two examples of spaces that according to ASHRAE are required to be pressurized and regularly have low occupancy rates. In these examples, you will see a comparison between Theris, a terminal box and a constant volume system. All examples include energy savings from a relaxed temperature setpoint during unoccupied hours, but they differ in their reduced controllable airflow rates. Notice the difference in dollar savings and actual energy conservation between the three scenarios. Next, look at the payback periods. In these particular spaces, higher airflow is required for infection control and because of that, incorporating setback technologies can quickly pay for itself. The biggest difference between the three scenarios lies in their present values. The life cycle cost of a Theris system is much lower then that of any terminal box and an owner will see a higher return on their investment. A terminal box is unable to achieve the same present value as a Theris venturi valve because of its inability to achieve the same yearly energy savings, but more so due to the inclusion of scheduled yearly maintenance to clean and recalibrate transducers that is necessary to ensure they work properly. If a facility were to overlook the maintenance issues, then the present value would still be low, if not lower, because the ability to achieve optimal energy savings would no longer be attainable.

Operating Room

	Theris	**Terminal Box**	
Actual Turndown (% of Max.)	25%	50%	Constant Volume
Yearly Energy Savings[1]	$4,089.84	$3,152.45	$1277[2]
Yearly kWh Conservation	34,413.81	26,868.73	11,778.56
Yearly Therm Conservation	720.51	517.31	110.91
PV of Investment	$57,424.50	$38,571.44	$10,679.54
Payback Period (years)	0.70	0.90	2.26

Assumptions

Positive Pressurized Spaces 20 ACH
4 Total Outdoor ACH
500 sq. ft.
Occupied 40% of the week[2]

[1] Typical occupancy based on ASHRAE Design Manual for Hospitals and Clinics Table 16

[2] Savings from CV achieved from relaxed temperatures during unoccupied states.

X-Ray

	Theris	**Terminal Box**	
Actual Turndown (% of Max.)	25%	50%	Constant Volume
Yearly Energy Savings[1]	$1,721.49	$1,369.97	$666.92[2]
Yearly kWh Conservation	12,905.18	10,075.77	4,416.96
Yearly Therm Conservation	478.85	402.65	250.26
PV of Investment (ROI)	$22,839.43	$12,502.58	$2,043.12
Payback Period (years)	1.20	1.75	3.69

Assumptions

Positive Pressurized Spaces15 ACH
3 Total Outdoor ACH
250 sq. ft.
Occupied 40% of the week[2]

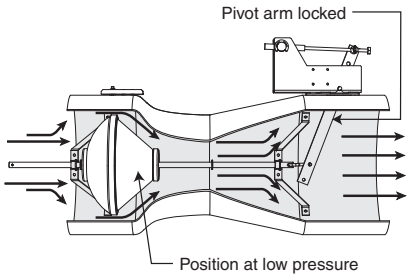
[1] Typical occupancy based on ASHRAE Design Manual for Hospitals and Clinics Table 16

[2] Savings from CV achieved from relaxed temperatures during unoccupied states.

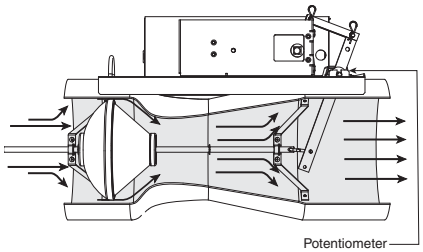
Valve Types

With the internal pressure independent cone assembly in operation, airflow can be regulated by positioning the shaft/cone assembly. The following types of Accel II valves are available

- **Constant Volume:** The valve's shaft is adjusted and then locked into a specific position, which provides the scheduled airflow via factory calibration.

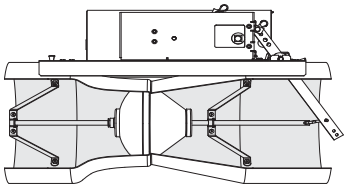


- **VAV:** Closed loop control of airflow via flow feedback to command. The shaft is positioned using direct potentiometer measurement to produce a linearized factory characterized feedback.



- **Shut-off:** There are two configurations of shut-off valve, standard and low-leakage. The standard shut-off provides a metal-on-metal seal between the valve body and cone assembly which allows on the order of 5 cfm (8 l/s) at 4" of static pressure. The low-leakage shut-off valve adds a gasket to the cone assembly which reduces the leakage rate past the cone to less then 0.010 cfm (0.005 l/s) at 4" of static pressure.

  The shut-off valves provide 2-state or VAV control under normal conditions and may be commanded to shut-off via a local input or network command.



Feature/Option	Constant Volume	Theris
Control type	C Fixed Flow	L Digital
Actuator Type	None	Low-speed electric
Fail safe	Fixed	Last position
Flow feedback signal	—	✓
Flow alarm via feedback circuit	—	✓
Flow alarm via pressure switch	Option	Option
Field-adjustable flow	✓	N/A
Factory-insulated valve body (supply)	Option	✓
Low-noise diffuser construction	✓	✓
Single 14-inch	✓	✓
Dual 14-inch	✓	✓
Standard Shut-off	N/A	✓
Low-Leakage Shut-off[1]	N/A	✓
Medium Pressure .6 to 3" WC (150 to 750 Pa)	✓	✓
Low Pressure .3 to 3" WC (75 to 750 Pa)	✓	✓
Single valve body	✓	✓
Dual valve body	✓	✓
Triple valve body[2]	✓	N/A
Quad valve body[2]	✓	N/A

[1] Not available in the 14-inch valve size.

[2] 12-inch valve only.

Notes:

All valves include pressure-independent, factory-calibrated position controllers, and are available in flows from 35-10,000 CFM (60-16,900 m^3/hr).

Accel II valves are designed to reduce sound over all frequencies, but significantly target the lower bands (125-500 Hz) to help eliminate the need for silencers.

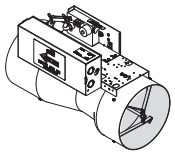
Neutralizers are available for all valve sizes to lower mid to high frequencies and lower overall power level. A complete review and sound analysis should be conducted by a qualified acoustician to ensure target sound levels will be met for any specific project and for various room type criteria.

Valve Sizes, and Operating Ranges

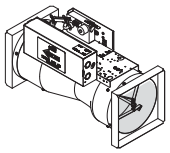
Accel II valves are available in four specific model sizes: 8, 10, 12 and 14" (for actual flow, refer to the chart below). In order to increase flow capacity, multiple valves may be assembled to operate as a unit.

For complete information on valve dimensions and weights, see various valve Product Data Sheets.

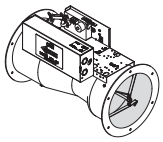
Single



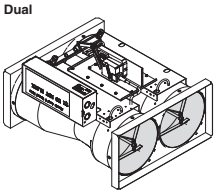
Single with Square Flange



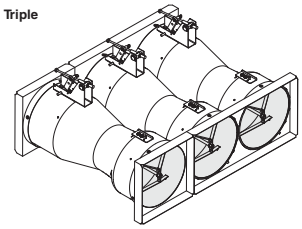
Single with Round Flange



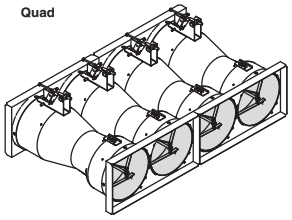
Dual



Triple



Quad



		Standard Valves Celeris/Traccel/Analog Flow and Operating Range CFM (m³/h) [l/s]				Shut-off Valves - For both Standard "S" and Low-Leakage "L" Flow and Operating Range CFM (m³/h) [l/s]			
Designation	**Size**	**Single**	**Dual**	**Triple**	**Quad**	**Single**	**Dual**	**Triple**	**Quad**
Medium Pressure 0.6-3" WC (150-750 Pa)	08"*	35-700 (60-1185) [17-330]	—	—	—	35-600 (60-1015) [17-283]	—	—	—
	10"	50-1000 (85-1695) [24-472]	100-2000 (170-3390) [47-944]	—	—	50-850 (85-1440) [24-401]	100-1700 (170-2880) [47-802]	—	—
	12"	90-1500 (155-2545) [42-708]	180-3000 (310-5090) [85-1416]	—	—	90-1300 (155-2205) [42-614]	180-2600 (310-4410) [85-1227]	—	—
	14"	200-2500 (340-4245) [94-1180]	400-5000 (680-8490) [189-2360]	—	—	200-1600 (340-2715) [94-755]	400-3200 (680-5430) [189-1510]	—	—
Low Pressure 0.3-3" WC (75-750 Pa)	08"	35-500 (60-845) [17-236]	—	—	—	35-400 (60-675) [17-189]	—	—	—
	10"	50-550 (85-930) [24-260]	100-1100 (170-1860) [47-519]	—	—	50-450 (85-760) [24-212]	100-900 (170-1520) [47-425]	—	—
	12"	90-1050 (155-1780) [42-496]	180-2100 (310-3560) [85-991]	—	—	90-900 (155-1525) [42-425]	180-1800 (310-3055) [85-850]	—	—
	14"	200-1400 (340-2375) [94-661]	400-2800 (680-4750) [189-1321]	—	—	200-1000 (340-1695) [94-472]	400-2000 (680-3390) [189-944]	—	—

*CVVR - Flow Range: 35 cfm to 210 cfm (55m³/hr to 355 m³/hr) medium pressure only.

Shut-off Valves

Phoenix Controls Shut-off Valves are available in two valve designs-Standard (Option S) and Low-leakage (Option L). Both designs are intended for use in critical airflow applications, where isolating the HVAC system from the room is necessary. Both versions of the shut-off valve provide the same precision and pressure independence of the standard Accel II valve with the addition of the ability to effectively shut-off the airflow as part of an automated or manually initiated control sequence. Normal control is maintained by way of network or local commands.

Shut-off sequences may be initiated through pre-programmed control sequences or over the network as BMS commands.

The Shut-off Valve provides critical airflow control demanded by modern facilities. In shut-off mode, the valve provides low-leakage isolation of the HVAC system from the room. An example of a typical application is an operating room or an isolation room requiring decontamination for sterile prep or cleaning.

Standard Shut-off Valve

The Standard Shut-off Valve is appropriate for applications where shut-off is beneficial, but bubble tight is not a requirement.

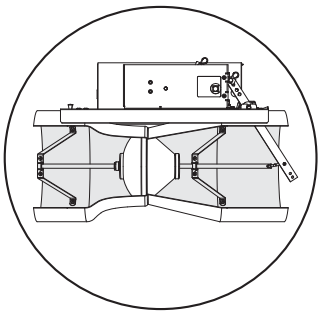


Figure 2-16. Valve in shut-off position.

Low-leakage Shut-off Valve

The Low-leakage Shut-off Valve accommodates applications requiring a near bubble-tight ventilation system for critical environments needing emergency isolation or gaseous biodecontamination. The Low-leakgage shut-off valve is ideal for pandemic sequence provided at the room level for surge capacity.

Many project standards for applications, such as BSL-3 spaces, may require a higher standard of isolation than what the Standard Shut-off Valve provides. With the Low-leakage Shut-off Valve, leakage rates achieved are insignificant to the overall duct volume.

In many projects, the duct volume entering and exiting critical spaces must be leak tested to ensure they are truly isolated. Most governing standards accept leakage rate from 0.1–0.2% of volume per minute of the duct volume at a given pressure. The Low-leakage Shut-off Valve contributes minimally to the overall volume tested. This insignificant leakage volume, combined with the valve's ability to control airflow precisely and compensate instantly to changes in pressure, makes the Low-leakage Shut-off Valve the ideal choice for these critical applications.

The Low-leakage Shut-off Valve, which has been tested with the ASME N510 Pressure Decay method,[12] has the lowest total casing leakage compared to our current valve portfolio. The casing leakage for this valve is 0.01 CFM per square foot for each area.

[12] American Society of Mechanical Engineers (ASME), ASME N510, Testing of Nuclear Air Treatment Systems, 1985 (reaffirmed 1995).

Shut-off Leakage Performance

In these graphs, the term, shut-off leakage, refers to the expected airflow through the valve in the shut-off position. The term, casing leakage, refers to the expected airflow through the penetrations of the valve body.

Casing Leakage

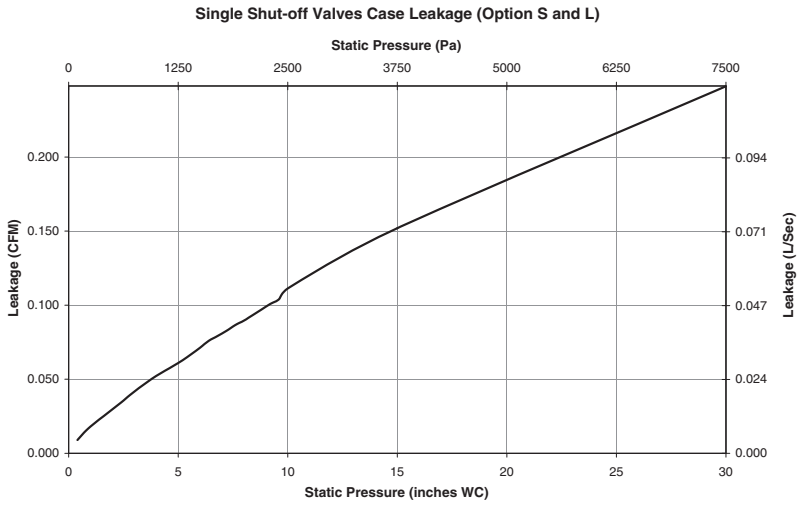


Figure 2-17. Single Shut-off Valve Case Leakage (Option S and L) for 8, 10, 12 and 14-inch single body valves.

Notes:

- Leakage rates shown in this graph are for all four valve sizes: 8-, 10-, 12-, and 14-inch. A 14-inch low leakage valve is not available at this time.
- Exceeds Eurovent Class A, B, C and D specifications (Eurovent Committee of Air Handling and Equipment Manufacturers) when valve duct surface areas noted in Table 4 (this page) are taken into account.
- Option S leakage rates are for all four valve sizes (8", 10", 12", 14").
- Option L leakage rates are for 8-, 10-, and 12-inch valves only. A 14-inch low-leakage valve is not available at this time.

To calculate leakage areas that take into account valve and duct area, use the Casing Leakage graph above and this table. Select the valve leakage at the appropriate design pressure and the related valve area from the table. For example:

Leakage Specification = Leakage/Valve Area = 0.150 CFM/3.60 ft^2 = 0.42 CFM per ft^2

Calculating Valve Areas		
Valve Size	**Area (ft^2)**	**Area (m^2)**
8"	3.60	0.33
10"	4.26	0.40
12"	6.28	0.58

For 8, 10 and 12-inch valves (14-inch low-leakage is not available at this time) exceeds Eurovent Class A, B, C and D specifications (Eurovent Committee of Air Handling and Equipment Manufacturers).

Figure 2-18. Standard Shut-off Valve (Option S) — Shut-off leakage for 8, 10, 12 and 14-inch single body valves.

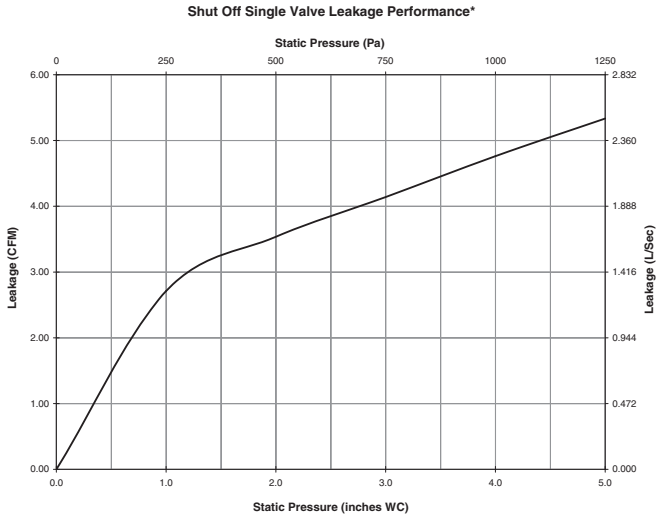
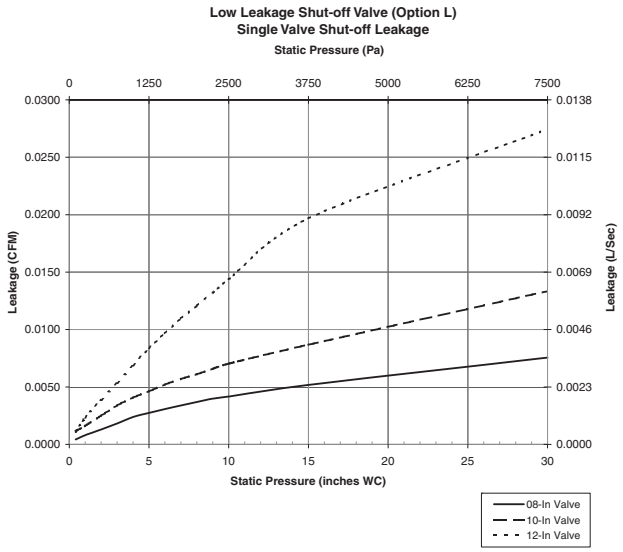


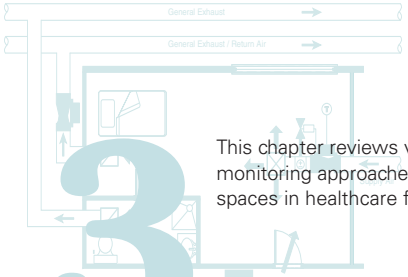
Figure 2-19. Low-Leakage Shut-off Valve (Option L).



Recommended Valve Construction for Decontamination	
Gaseous Decontamination Agent	**Recommended Valve Construction***
Hydrogen peroxide vapor	A
Ethylene oxide	B
Ammonium chloride	A
Chlorine dioxide	A**
Paraformaldehyde	A

*Chemical resistance data acquired from Compass Corrosion Guide.

**For concentrations up to 800 ppm. To achieve higher concentrations during decontamination, use construction B valves.



This chapter reviews various control and monitoring approaches for ventilating critical spaces in healthcare facilities.

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3 Airflow Control Applications

Hospitals, by nature, attract airborne infectious agents carried in by patients, visitors and staff. With each revision of the FGI Guidelines and ASHRAE 170, airflow requirements become more stringent. Committees and standards setting bodies within the FGI, ASHRAE, CDC, and U.S. Pharmacopeia all recognize the affect proper pressurization and airflow balance can have in abating the spread of infectious agents.

This chapter describes the specific applications of the Phoenix Controls venturi valve in various room type. It is important to note that the general benefits of these valves apply throughout the hospital for the best infection control, energy savings, reduced maintenance, and flexibility to use spaces for future needs. Information is included about the product, ordering proper equipment, sequences, and points lists.

Phoenix Controls' Theris® Family of valves are designed specifically for the ventilation requirements of critical spaces in healthcare facilities. Theris provides constant volume (CV) and variable air volume (VAV) solutions for directional airflow, climate control, and overall ventilation balance. There are six control options.

Theris-TX (Enhanced Tracking Pair VAV) (LON/BACnet)

For tracking pair applications in demanding spaces that require some additional features like humidity control and shut-off capabilities. TX also provides additional multi-use inputs to support a pressure sensor and valve alarming.

Theris-TX-RTN (Enhanced Tracking Pair VAV) (BACnet)

Similar feature set to the TX-EXH. The TX-RTN provides the ability to add an optional return valve (Ratio metric) without an additional controller (3 Valves - 1 controller). This is an ideal solution for common areas near a lab or for use in a lab being monitored by IAQ with pandemic switch.

Theris-TP (Tracking Pair VAV) (LON/BACnet)

To meet the need of directional airflow, Theris-TP features tracking valve pairs that maintain a prescribed CFM offset enabling accurate space pressurization and complete room climate control.

Theris-SO (Supply-only VAV) (LON/BACnet)

In VAV applications where ducted exhaust is sufficient to meet local codes and engineering guidelines, Theris SO provides a cost effective main valve when no tracking valve is required.

Theris-EO (Exhaust Only) (BACnet)

Theris EO provides an additional exhaust valve with controller to allow 2 state LED control from a switch (Min or Max flow limits), shut-off and alarming for a 2 state hood, snorkel or Bio Safety Cabinet. This functionality also lends itself to green-Ready/red-Unoccupied indicator lights outside an OR.

Theris TX-EXH (BACnet)

Along with many of the standard TX tracking pair features, TX-EXH provides the ability to locally control an additional exhaust valve without an additional controller (3 valves - 1 controller). This is an ideal solution for spaces that have an additional BSC or 2-state hood.

Theris-CV (Constant Volume)

For fixed-flow operation and stable airflow throughout the facility, Theris-CV provides a solution for constant volume supply and exhaust applications.

The following are recommendations for achieving the best results using Phoenix Controls venturi valves in healthcare applications.

- Use medium pressure ductwork
- Eliminate any uncontrolled branches
- Decouple supply and exhaust fans for independent control
- Ensure supply fan capacity is 110% of total CFM requirement for the space
- Provide a minimum of a .3 inch WC pressure drop for the valve furthest from the fan for low pressure valves and a minimum of .6 inch WC pressure drop for medium pressure valves
- Design room offset value to 10% of the total exhaust down to a minimum of 75 CFM
- Utilize Fan Static Reset to operate at a minimum required static pressure drops to ensure the valves furthest away from the air handler functions properly and the system is operating at its lowest energy cost.

Note: Low-leakage is not available in low pressure valves.

Theris Valve Control Matrix

	LonMark®			BACnet®					
	TP	TX	SO	TP	TX	TX-RTN	TX-EXH	SO	EO
Zone Balance Control									
Ventilation Demand (ACH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Volumetric Control Offset	✓	✓		✓	✓	✓	✓		
Control Airflow Distribution across Multiple Exhaust/Return Valves						1 Exh 1 Return	2 Exh (1 Local CMD EXH)		
Active Pressure Monitoring		✓		✓	✓	✓	✓		✓
Booster Valve Options	No Boosters			No Boosters					
Monitor Device Airflow; Incorporate in Zone Balance Function	✓ 2 Network Inputs			4	4	2	2	1	1
IAQ Control									
Dynamic ACH from IAQ System Input	✓	✓	✓	✓	✓		✓	✓	
Temperature Control									
Control Reheat Actuator P=Proportional F=Floating Point	✓ P or F			✓ P or F					
Control Ventilation Rate for Cooling or Heating Control	✓	✓	✓	✓	✓	✓	✓	✓	
Temperature Sensor Discharge/Room/Exhaust	Discharge/Room			Discharge/Room					
Auxiliary Control Loops (Cooling or Heating, Standalone or Staged)	✓	✓	✓	✓	✓	✓	✓	✓	
Multiple Temperature Zones per Lab (Quantity)	3	3	3	1	1	1	1	1	
Cooling Override L=Local, N=Network	L or N	L or N	L or N	L	L	L	L	L	
Humidity Control									
Humidity Monitoring		✓		✓	✓	✓	✓		✓
Humidification Actuator Control		✓			✓	✓	✓		
Dehumidification Actuator Control		✓			✓	✓	✓		
Occupancy Control									
Reset Minimum Ventilation for Occupied and Unoccupied Periods	✓	✓	✓	✓	✓	✓	✓	✓	
Reset Temperature Control Setpoints for Occupied and Unoccupied Periods	✓	✓	✓	✓	✓	✓	✓	✓	
Inputs and Outputs (per Controller)	Typically 1 controller per room or zone			Typically 1 controller per room or zone					
Universal Inputs	3	5	3						
Multi-Use Inputs (Analog Selectable) 0-5V, 0-10V, 4-20mA or Dry Contact				4	4	2	2	3	5
Factory Fixed Configured				4/5	4/5	6/7	4/7	3/3	2/3
Digital Inputs	1	1	1						
Analog Outputs	2	2	2	4	6	7	7	2	1
Local Digital Outputs	1	1	1						

	LonMark®			BACnet®					
	TP	TX	SO	TP	TX	TX-RTN	TX-EXH	SO	EO
Network Binary Outputs				4	4	2	2	3	3
Additional Flow Outputs (Feedback)				2	2	3	3	1	1
Floating Point TRIAC	1	1	1	1		1	1	1	
HVAC Control Modes									
Standard and Low-Leakage Shut-off Capabilities		✓			✓	✓	✓		✓
Pandemic Mode (Control sequence for airborne infectious isolation)		✓	✓			✓			
User Configurable Modes for Purge, DeCon, Decommission, Supply Fan or Exhaust Fan Failure, etc.	✓	✓	✓	✓	✓	✓	✓	✓	✓
LED 3-State Switch Capable									✓
Local Alarm Outputs	1	1	1	1	2				1
Actuation Options									
Normal Speed Actuation Failsafe (Last Position)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Integration									
Open LonMark Certified	✓	✓	✓						
Native BACnet MS/TP (BTL Certified)				✓	✓	✓	✓	✓	✓
Interface with BACnet/IP:BACnet/ Ethernet with Phoenix Server (BTL Certified)	✓	✓	✓						

General Note: The various control schemes shown on this matrix are achievable provided the application has the physical I/O available.

Airborne Infection Isolation (AII) and Protective Environment (PE) Rooms

AII/PE rooms require higher levels of infection control than most spaces in a hospital, necessitating continuous control of directional airflow. In the past, most AII/PE rooms were designed to be constant volume. Theris-CV, Constant volume valves, provide the most basic and affordable method for achieving fixed flow pressurization in isolation rooms. Under the new FGI 2010 guidelines, isolation rooms can now turndown when unoccupied and be converted to standard patient room, with reduced ACH, as long as the respective pressurization is maintained at all times. The Theris-TP product is now the ideal solution for most isolation rooms to allow for flexibility and to take advantage of energy savings (refer to Figure 3-1). The Theris-TX lines offer additional functionality that may be required to satisfy additional needs such as humidity control, pressure monitoring and valve shut-off capability for decontamination.

A broad array of control sequences may be used to meet the specialized airflow requirements of isolation rooms. Five of these are presented in this section:

- Protective environment (PE) with airborne infectious isolation (the anteroom is negative to the patient room and the corridor)
- Airborne infectious isolation (AII) environment without an anteroom
- Protective environment (PE) without an anteroom
- Airborne infectious isolation (AII) environment with an anteroom negative to the corridor
- Protective environment (PE) with airborne infectious isolation (the anteroom is positive to the patient room and the corridor)

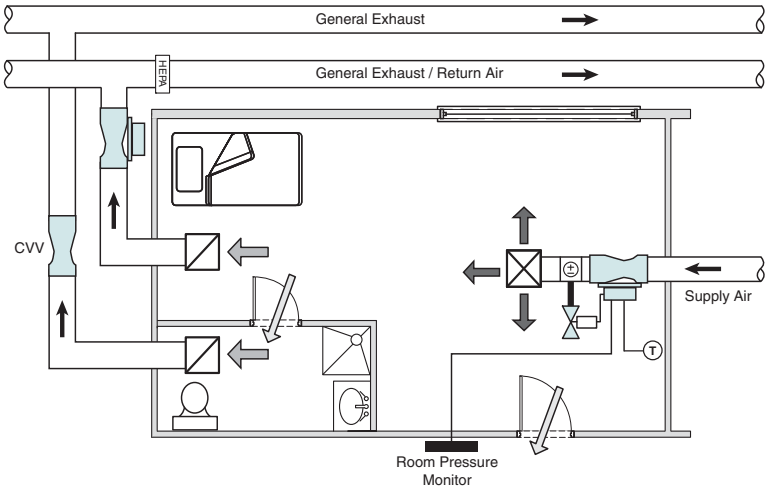


Figure 3-1. An example of an isolation room using Theris-TP.

Protective Environment or Airborne Infectious Isolation using Theris-TP or Theris-TX

The following AII/PE room has a Phoenix Controls Theris Tracking Pair valve on the supply and exhaust sides. The Theris supply valve can have an associated temperature sensor and can control a hot water valve, as well as a second stage of heating, if needed. An optional duct temperature sensor can be used to control room temperature when a duct-mounted sensor in the exhaust duct replaces a standard room temperature sensor mounted on the wall. A duct temperature sensor can also monitor discharge air temperature when a duct-mounted sensor in the supply duct is used.

Phoenix Controls Hardware Options

- One Theris-TP tracking pair (shut-off/decontamination capability available with Theris-TX)
- One or more temperature sensors
- One 24 Vac transformer (26 VA minimum required)
- Advanced Pressure Monitor II (to display actual room pressure)
- One duct temperature sensor

Equipment List Example

Theris-TP—Isolation Room without Humidity or Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TP 10" Supply Valve	1.1.1	1.1.1	200	800	100
Theris-TP 10" Exhaust Valve	1.1.1	1.1.1	100	700	—
Room Temp Sensor	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—

Theris-TP—Isolation Room with Humidity or Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	200	800	100
Theris-TP 10" Exhaust Shut-off Valve	1.1.1	1.1.1	100	700	—
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—	—
Voltage Converter	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—	—

Sequence of Operation

The following describes the sequence of operation using a variable volume terminal air valve with tracking return and heating.

1. Pressure independent control provides for both supply and exhaust valves while maintaining their flow setpoints to within ±5% accuracy.
2. The supply air valve modulates from maximum to minimum settings to maintain space cooling. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.
3. The return air valve modulates with the supply air valve to maintain the differential preset supply and return airflow rates (offset).
4. The control system monitors duct discharge temperature, zone temperature, hot water control valve and airflow.
5. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.
6. Included alarm and monitor sequences shown below.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Airborne Infectious Isolation (AII) Environment without an Anteroom using Theris-TP (Recommended)

The AII room airflow is supplied and exhausted with a venturi variable air volume valve to meet ventilation, pressurization and thermal requirements. The room's prescribed pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. The airflow volume for the required air changes per hour shall be as listed on the engineer's schedules. A local pressure monitor provides visual confirmation of pressurization status and will initiate audible and visual alarms if the room pressure is not within acceptable limits.

Sequence of Operation

Tracking pair valves (supply and exhaust) maintain the supply airflow into the room and the exhaust airflow out of the room. A fixed constant volume offset is maintained by setting the exhaust air volume greater than the supply volume. The offset produces negative pressure in the isolation room relative to the corridor. Flows may be varied depending on room conditions either to reduce it and obtain energy savings if the room is unoccupied for a period of time

or higher due to thermal load and the requirement to cool the room above the nominal air changes per hour requirements. Both scenarios maintain the same airflow offset values and the pressurization integrity of the room.

Alarm and Monitor Sequence

A room pressure monitor is installed next to the door entering the room. A room pressure pickup port and reference pressure pickup port in the adjoining spaces provide direct measurement of pressure. The word "NORMAL" highlighted in green will display on the monitor when the room is pressurized correctly and within the alarm limits. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm may sound after a time delay and if there is a loss of pressurization outside the alarm limits. A mute button on the touch screen will appear upon sensing an alarm which upon touching will silence the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered. An adjustable alarm time delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition for Loss of Room-level Network Communication

In the event of a loss of room-level network communication, the supply and the exhaust valves will maintain the last setpoint determined by the temperature sensor. This zone fails in place with no change in offset.

Fail-safe Condition for Loss of Building-level Network Communication

In the event of a loss of building-level network communication, the supply and the exhaust valves will maintain the setpoint determined by the temperature sensor. There is no change in offset.

Fail-safe Condition for Loss of Power

In the event of a loss of power the supply and exhaust valve airflow setpoints will fail in place. Static pressure compensation shall be effective during a power failure. A power failure will result in no change in offset.

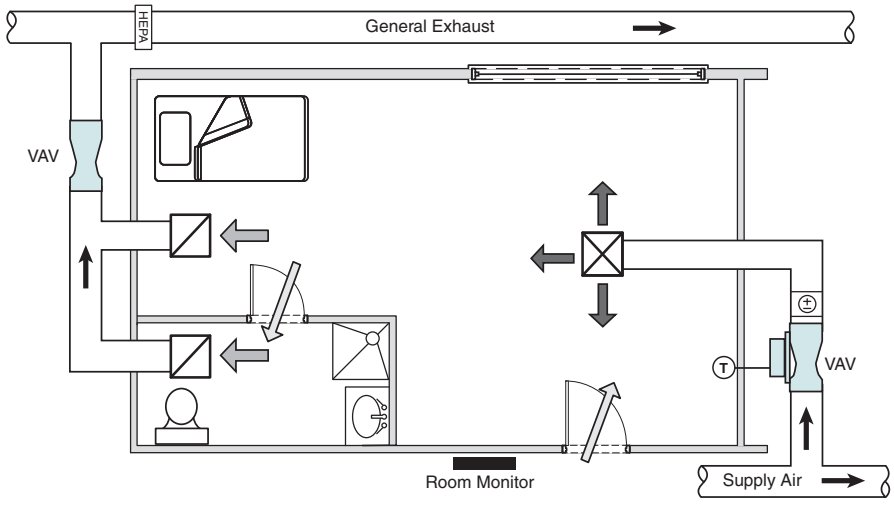
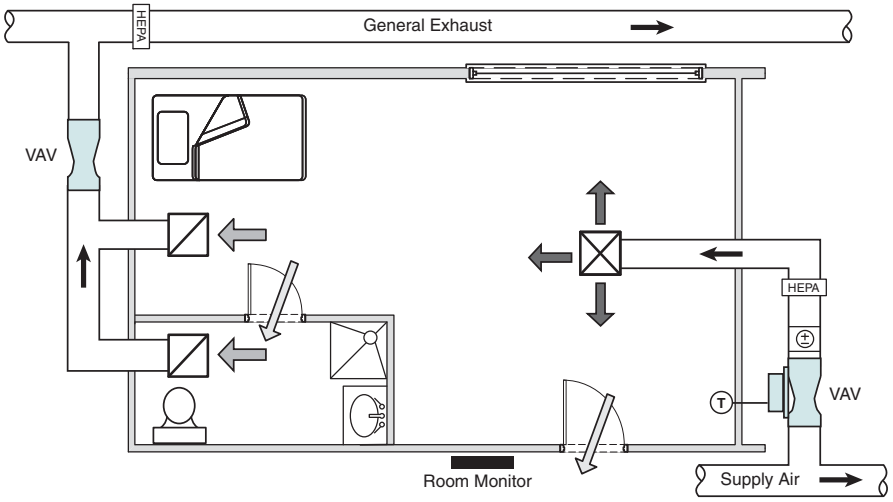


Figure 3-2. An example of an airborn infectious isolation room without an anteroom.

Protective Environment without an Anteroom using Theris-TP (Recommended)

The PE room airflow is supplied and exhausted with a venturi variable air volume valve to meet ventilation, pressurization and thermal requirements. The room's prescribed pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. The airflow volume for the required air changes per hour shall be as listed on the engineer's schedules. A local pressure monitor provides visual confirmation of pressurization status and will initiate audible and visual alarms if the room pressure is not within acceptable limits.

Figure 3-3. An example of a protective environment without an anteroom.



Sequence of Operation

Tracking pair valves (supply and exhaust) maintain the supply airflow into the room and the exhaust airflow out of the room. A fixed constant volume offset is maintained by setting the supply air volume greater than the exhaust volume. The offset produces positive pressure in the isolation room relative to the corridor. Flows may be varied depending on room conditions either to reduce it and obtain energy savings if the room is unoccupied for a period of time or higher due to thermal load and the requirement to cool the room above the nominal air changes per hour requirements. Both scenarios maintain the same airflow offset values and the pressurization integrity of the room.

Alarm and Monitor Sequence

A room pressure monitor is installed next to the door entering the room. A room pressure pickup port and reference pressure pickup port in the adjoining spaces provide direct measurement of pressure. The word "NORMAL" highlighted in green will display on the monitor when the room is pressurized correctly and within the alarm limits. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm may sound upon after a time delay and if there is a loss of pressurization outside the alarm limits. A mute button on the touch screen will appear upon sensing an alarm which upon touching will silence the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered. An adjustable alarm time delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition for Loss of Room-level Network communication

In the event of a loss of room-level network communication, the supply and the exhaust valves will maintain the last setpoint determined by the temperature sensor. This zone fails in place with no change in offset.

Fail-safe Condition for Loss of Building-level Network communication

In the event of a loss of building-level network communication, the supply and the exhaust valves will maintain the setpoint determined by the temperature sensor. There is no change in offset

Fail-safe Condition for Loss of Power

In the event of a loss of power the supply and exhaust valve airflow setpoints will fail in place. Static pressure compensation shall be effective during a power failure. A power failure will result in no change in offset

Infectious Isolation Environment with an Anteroom using Theris-TP / SO (Recommended)

Anteroom Negative to Corridor, Positive to Patient Room

The patient room and anteroom (also known collectively as the airborne infectious isolation room) are supplied and exhausted with a supply and exhaust variable air volume valve to meet ventilation, pressurization and thermal requirements. The room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of patient room pressurization status and will initiate audible and visual alarms if the room pressure is not within acceptable limits.

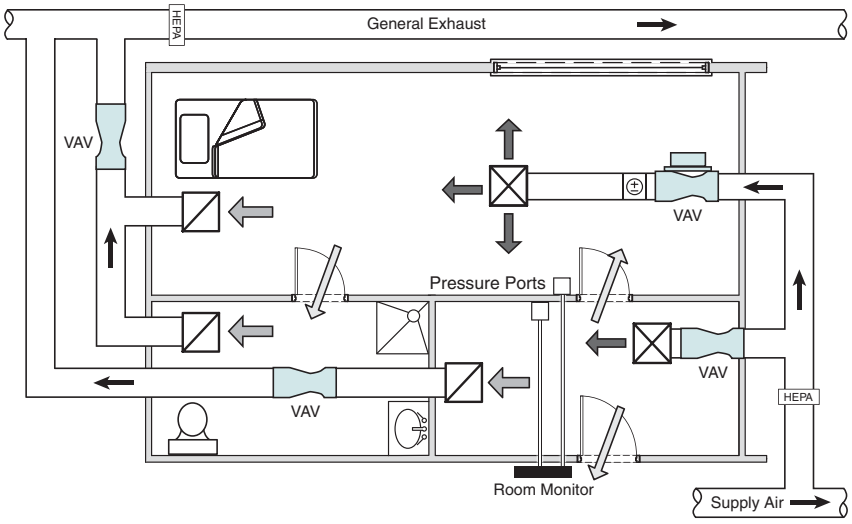


Figure 3-4. An example of an airborn infectious isolation room with an anteroom negative to the corridor.

Sequence of Operation

Theris supply tracking pair and supply only variable air volume valves maintain the supply airflow into the patient room and the anteroom respectively. Theris exhaust tracking pair variable air volume valves maintain the exhaust airflow out of the patient room.

A fixed constant volume offset in the patient room is maintained by setting the exhaust air volume greater than the supply air volume. The offset produces a negative pressure in the patient room relative to the anteroom.

A fixed constant volume offset in the anteroom is maintained by setting the the supply air volume. The offset makes the anteroom negative to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room pressure pickup port and reference pressure pickup port in the adjoining space provide direct measurement of pressure. With the addition of an optional second pressure port the monitor will be able to sense the pressurization between room, anteroom, and corridor. The word "NORMAL" will be highlighted in green indicating that the respective space is properly pressurized. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button on the touch screen will appear upon sensing an alarm which upon touching will silence the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered.. An adjustable alarm time delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition for Loss of Room-level Network communication

In the event of a loss of room-level network communication, the supply and the exhaust valves will maintain the last setpoint determined by the temperature sensor. This zone fails in place with no change in offset.

Fail-safe Condition for Loss of Building-level Network communication

In the event of a loss of building-level network communication, the supply and the exhaust valves will maintain the setpoint determined by the temperature sensor. There is no change in offset.

Fail-safe Condition for Loss of Power

In the event of a loss of power the supply and exhaust valve airflow setpoints will fail in place. Static pressure compenstation shall be effective during a power failure. A power failure will result in no change in offset.

Protective Environment with Airborne Infectious Isolation using Theris-TP (Recommended)

Anteroom is Positive to Patient Room and Corridor

The patient room and anterooms are supplied and exhausted with Theris tracking pair variable air volume valves to meet the ventilation, pressurization and thermal requirements. Each room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of patient room pressurization status and audible and visual alarms will initiate if the room pressure is not within acceptable limits.

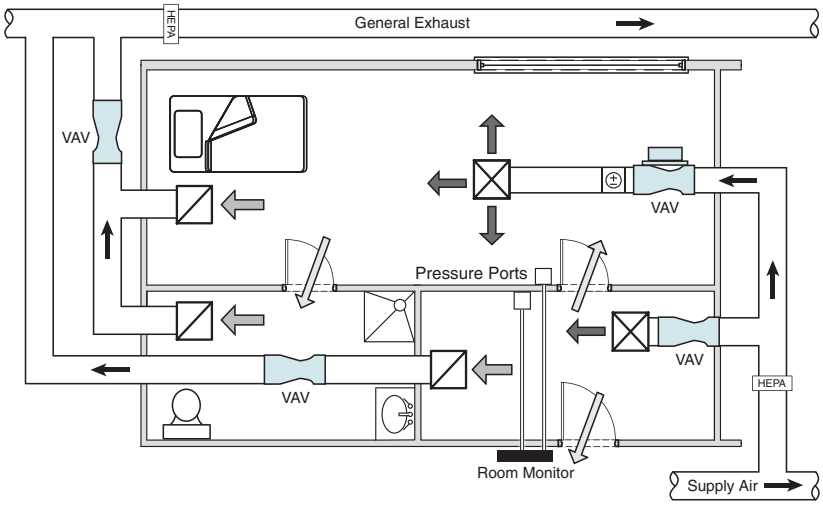


Figure 3-5. An example of a protective environment with airborne infectious isolation, in which the pressure of the anteroom is positive to the patient room and the corridor.

Sequence of Operation

Theris supply tracking pair and supply only variable air volume valves maintain the supply airflow into the patient room and the anteroom respectively. Theris exhaust tracking pair variable air volume valves maintain the exhaust airflow out of the patient room.

A fixed constant volume offset in the patient room is maintained by setting the supply air volume greater than the exhaust air volume. The offset produces a positive pressure in the patient room relative to the anteroom.

A fixed constant volume offset in the anteroom is maintained by setting the supply air volume greater than the exhaust air volume. The offset makes the anteroom positive to the patient room and positive to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room pressure pick up port and reference pressure pick up port in the adjoining space provide direct measurement of pressure. With the addition of an optional second pressure port, the monitor will be able to sense the pressurization between room, anteroom, and corridor. The word "NORMAL" will be highlighted in green indicating that the respective space is properly pressurized. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button on the touch screen will appear upon sensing an alarm which upon touching will silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been

triggered. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition for Loss of Room-level Network communication

In the event of a loss of room-level network communication, the supply and the exhaust valves will maintain the last setpoint determined by the temperature sensor. This zone fails in place with no change in offset.

Fail-safe Condition for Loss of Building-level Network communication

In the event of a loss of building-level network communication, the supply and the exhaust valves will maintain the setpoint determined by the temperature sensor. There is no change in offset.

Fail-safe Condition for Loss of Power

In the event of a loss of power the supply and exhaust valve airflow setpoints will fail in place. Static pressure compensation shall be effective during a power failure. A power failure will result in no change in offset.

Protective Environment with Airborne Infectious Isolation using Theris-TP (Recommended)

Anteroom is Negative to Patient Room and Corridor

The isolation room is supplied and exhausted with Theris tracking pair variable air volume valves to meet the ventilation, pressurization and thermal requirements. The room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of status and audible and visual alarms will initiate if the room pressure is not within acceptable limits.

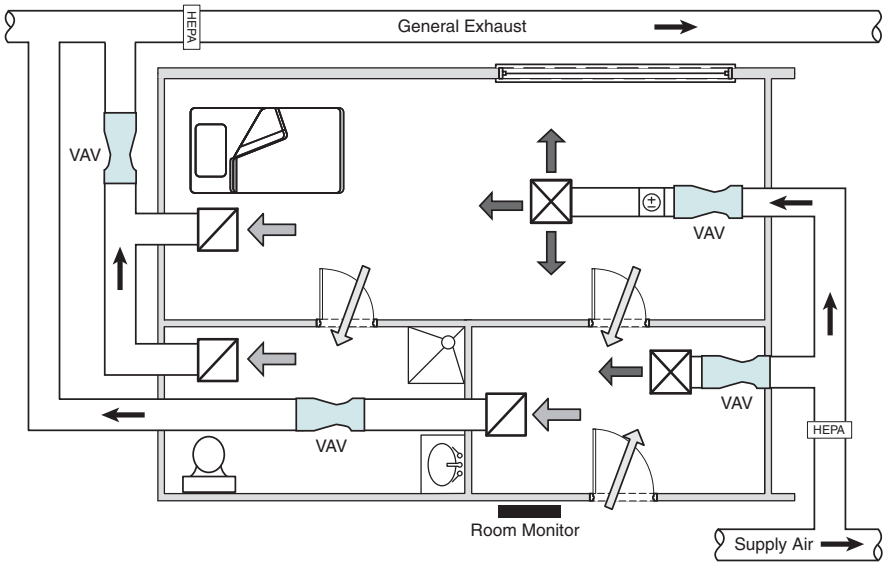


Figure 3-6. An example of a protective environment with airborne infectious isolation, in which the pressure of the anteroom is negative to the patient room and the corridor.

Sequence of Operation

Theris tracking pair variable air volume valves maintain the supply airflow into the room and the exhaust airflow out of the room. A fixed constant volume offset is maintained by setting the supply air volume greater than the exhaust air volume. The offset produces a positive pressure in the isolation room relative to the anteroom.

A fixed constant volume offset in the anteroom is maintained by setting the exhaust air volume equal to the supply air volume, plus the offset air volume from the patient room and the corridor. The offset makes the anteroom negative to the patient room and negative to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room pressure pick up port and reference pressure pick up in the adjoining space provide direct measurement of pressure. With the addition of an optional second pressure port the monitor will be able to sense the pressurization between room, anteroom, and corridor. The word "NORMAL" will be highlighted in green indicating that the respective space is properly pressurized. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button on the touch screen will appear upon sensing an alarm which upon touching will silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered.. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa)..

Fail-safe Condition for Loss of Room-level Network communication

In the event of a loss of room-level network communication, the supply and the exhaust valves will maintain the last setpoint determined by the temperature sensor. This zone fails in place with no change in offset.

Fail-safe Condition for Loss of Building-level Network communication

In the event of a loss of building-level network communication, the supply and the exhaust valves will maintain the setpoint determined by the temperature sensor. There is no change in offset.

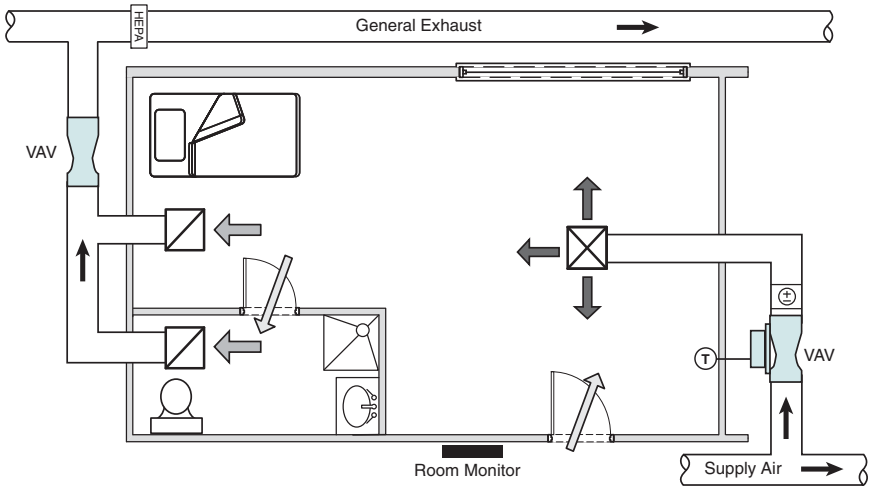
Fail-safe Condition for Loss of Power

In the event of a loss of power the supply and exhaust valve airflow setpoints will fail in place. Static pressure compensation shall be effective during a power failure. A power failure will result in no change in offset.

Airborne Infectious Isolation (AII) Environment without an Anteroom using Theris-CV

The AIF room is supplied and exhausted with a constant volume of air to meet ventilation, pressurization and thermal requirements. The room's prescribed airflow is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of status and audible and visual alarms if the room pressure is not within acceptable limits.

Figure 3-7. An example of a airborne infectious isolation room without an anteroom.



Sequence of Operation

Individual constant volume air valves maintain the supply airflow into the room and the exhaust airflow out of the room. A fixed constant volume offset is maintained by setting the exhaust air volume greater than the supply volume. The offset produces negative pressure in the isolation room relative to the corridor.

Alarm and Monitor Sequence

A room pressure monitor is installed next to the door entering the room. A room sensor and reference sensor in the adjoining spaces provide direct measurement of pressure. The word "NORMAL" highlighted in green will display on the monitor when the room is pressurized as it should be. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition

Since constant volume valves require neither pneumatic air nor power, a fail-safe condition does not apply to this application. *This room is always in an infectious containment mode (provided supply and exhaust fans are operational).*

Protective Environment without an Anteroom using Theris-CV

The PE room is supplied and exhausted with a constant volume of air to meet ventilation, pressurization and thermal requirements. The room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of status and audible and visual alarms if the room pressure is not as desired.

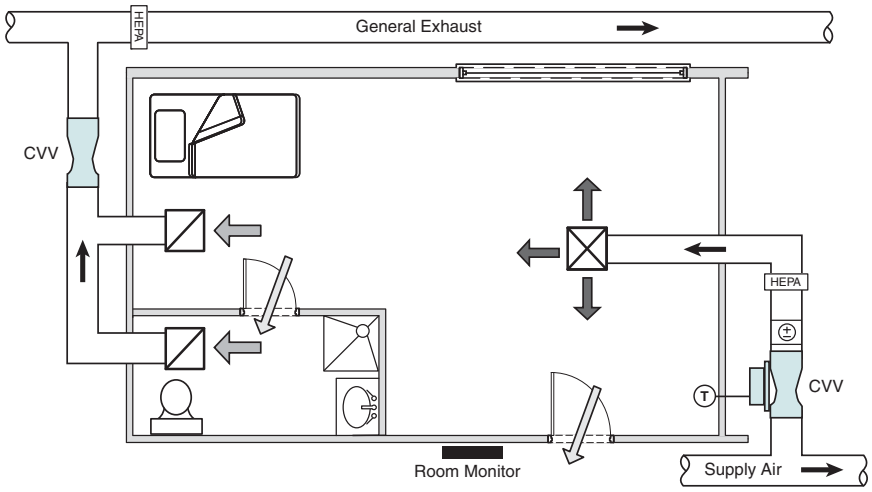


Figure 3-8. An example of a protective environmrent without an anteroom.

Sequence of Operation

Individual constant volume air valves maintains the supply airflow into the room and the exhaust airflow out of the room. A fixed constant volume offset is maintained by setting the supply air volume greater than the exhaust air volume. The offset produces a positive pressure in the isolation room relative to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room sensor and reference sensor in the adjoining spaces provide direct measurement of pressure. The word "NORMAL" highlighted in green will display on the monitor when the room is pressurized as it should be. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition

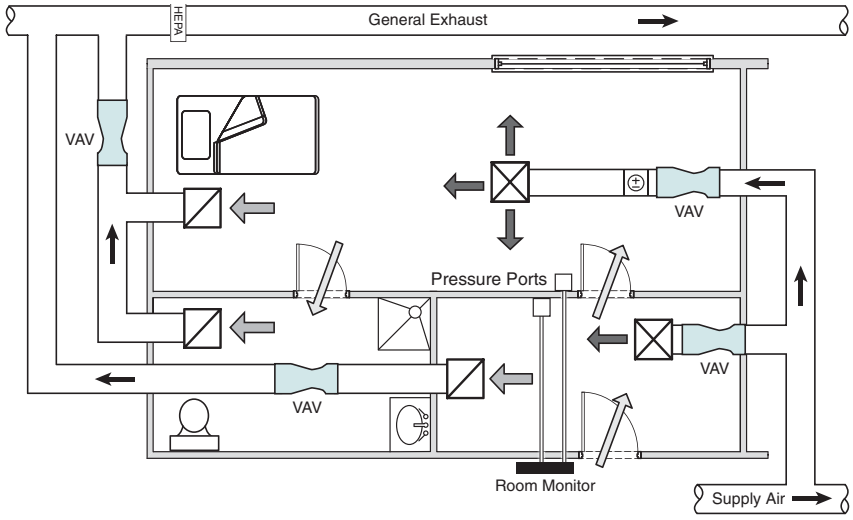
Since constant volume valves require neither pneumatic air nor power, a fail-safe condition does not apply to this application. This room is always in a protective containment mode.

Infectious Isolation Environment with an Anteroom using Theris-CV

Anteroom Negative to Corridor, Positive to Patient Room

The patient room and anteroom (also known collectively as the airborne infectious isolation room) are supplied and exhausted with a constant volume of air to meet ventilation, pressurization and thermal requirements. The room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of patient room status and audible and visual alarms if the room pressure is not as desired.

Figure 3-9. An example of an airborne infectious isolation room with an anteroom negative to the corridor.



Sequence of Operation

Individual constant volume air valves maintain the supply airflow into the patient room and the anteroom. Individual constant volume air valves maintain the exhaust airflow out of the patient room and anteroom.

A fixed constant volume offset in the patient room is maintained by setting the exhaust air volume greater than the supply air volume. The offset produces a negative pressure in the patient room relative to the anteroom.

A fixed constant volume offset in the anteroom is maintained by setting the exhaust air volume equal to the supply air volume. The offset makes the anteroom positive to the patient room and negative to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room sensor and reference sensor in the adjoining space provide direct measurement of pressure. With the addition of an optional second pressure port the monitor will be able to sense the pressurization between room, anteroom, and corridor. The word "NORMAL" will be highlighted in green indicating that the respective space is properly pressurized. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered.. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition

Since constant volume valves require neither pneumatic air nor power, a fail-safe condition does not apply to this application. *This room is always in a protective containment mode (provided supply and exhaust fans are operational).*

Protective Environment with Anteroom using Theris-CV

Anteroom is Positive to Patient Room and Corridor

The patient room and anterooms are supplied and exhausted with a constant volume of air to meet the ventilation, pressurization and thermal requirements. Each room's pressurization is maintained by a fixed volumetric offset between the supply and exhaust air volumes. A local pressure monitor provides visual confirmation of patient room status and audible and visual alarms if the room pressure is not as desired.

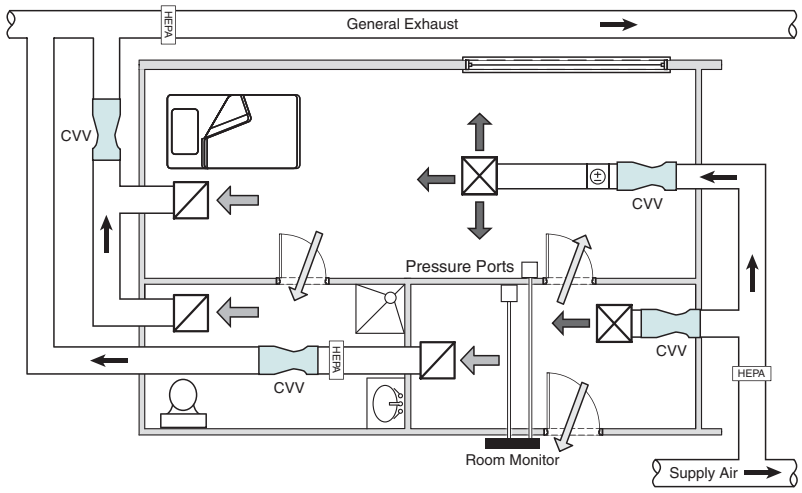


Figure 3-10. An example of a protective environment with airborne infectious isolation, in which the pressure of the anteroom is positive to the patient room and the corridor.

Sequence of Operation

Individual constant volume air valves maintain the supply airflow into the patient room and the anteroom. Individual constant volume air valves maintain the exhaust airflow out of the patient room and anteroom.

A fixed constant volume offset in the patient room is maintained by setting the exhaust air volume greater than the supply air volume. The offset produces a negative pressure in the patient room relative to the anteroom.

A fixed constant volume offset in the anteroom is maintained by setting the supply air volume greater than the exhaust air volume. The offset makes the anteroom positive to the patient room and positive to the corridor.

A room pressure monitor is installed next to the door entering the isolation room. A room sensor and reference sensor in the adjoining space provide direct measurement of pressure. With the addition of an optional second pressure port, the monitor will be able to sense the pressurization between room, anteroom, and corridor. The word "NORMAL" will be highlighted in green indicating that the respective space is properly pressurized. The word "ALARM" highlighted in red will flash on the screen and a user defined audible alarm can sound upon an unspecified loss of pressurization. A mute button silences the audible portion of the alarm. As an additional optional feature, the monitor can alarm indicating that the pressure drop across the valve is not being maintained or an added door switch has been triggered. An adjustable alarm delay prevents nuisance alarms caused by opening the door. The monitor displays the room pressurization to 0.0001 inches of water gauge (0.0249 Pa).

Fail-safe Condition

Since constant volume valves require neither pneumatic air nor power, a fail-safe condition does not apply to this application. *The patient room is always in protective containment mode with the anteroom positive to the corridor (provided supply and exhaust fans are operational)*

Additional Considerations for AII/PE Rooms

Differential pressure control schemes require significantly more effort to commission and maintain than straight volumetric offset. Some considerations:

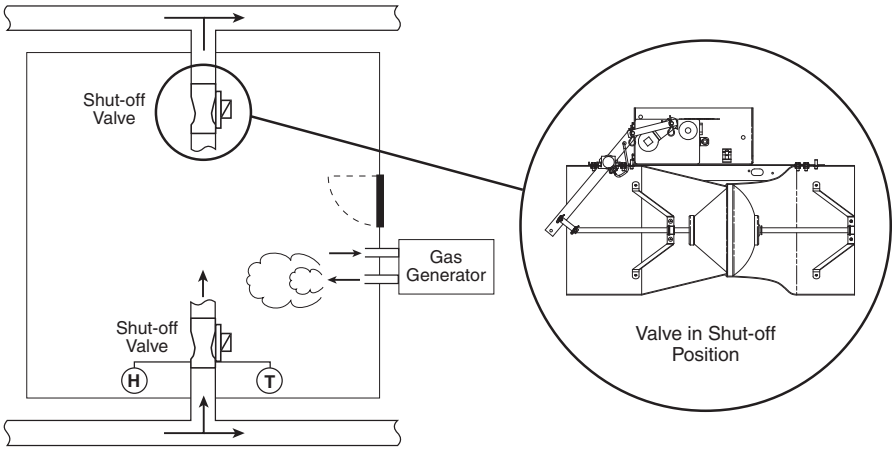
- In airlocks and anterooms, segregate pressurized spaces from non-pressurized spaces.
- Openings or passageways between pressurized spaces should be only one step above or below the adjacent space.
- Map out personnel and material flow carefully to prevent cross-contamination.
- Place pressure sensor ports where they will not be influenced by stray air currents.
- It is sometimes best to connect the reference port to a large bore (one-half to one-inch) pipe or tube to serve as a dampener for fluctuations on the reference port.

Shut-off Valves for Decontamination or HVAC Isolation

Phoenix Controls' Shut-off Valves are intended for use in critical airflow applications, where isolating the HVAC system from the room is necessary. Under normal operation, these valves provide the critical airflow control performance demanded by a modern hospitals. In the shut-off mode, the valves provide low leakage isolation of the HVAC system from the room.

- The shut-off sequence can be initiated either locally through a universal input or remotely–either from the building management system (BMS) or Local Display Unit (LDU).
- Shut-off confirmation is available through a local digital output (DO) or an integrated point.
- These valves can operate as standalone devices or in a fully integrated system.

Figure 3-11. The typical room setup for decontamination.



During the decontamination cycle:

- The space is taken from a normal control mode to a depressurize mode where the airflow is reduced to minimum flow while remaining slightly negative. Equipment that will not be decontaminated is moved out, then the decontamination equipment is set up.
- The space is switched to a shut-off mode where the supply and exhaust ducts are effectively closed off (see leakage table below) and the door is sealed.
- The decontamination process commences and runs for the prescribed duration.
- The space is set back to the depressurize mode (slightly negative) and the door is unsealed.
- The space is set to a purge mode where the valves open to their maximum set value while maintaining a negative pressurization until the decontamination agent has been purged from the space.
- The room is returned to normal operational control.

Shut-off During the Exhaust Fan Failure

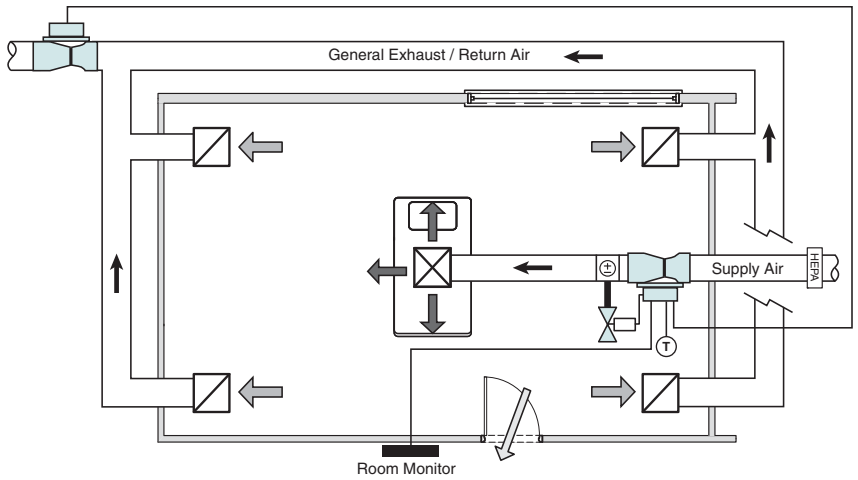
Designs that require a room to remain negatively pressurized at all times may want to consider using shut-off valves on the supply air. In the event of an exhaust fan failure, if the supply air is not shut down, the room will become positively pressurized by the fact that air is being introduced to the room from the makeup air handling system and the air will exit via the door to adjacent anterooms and corridors. Utilizing a shut-off valve for these applications will allow the supply air flow to be interlocked with exhaust systems and shut down when the exhaust fails. This will allow the room to remain neutral during the failure. Upon restoration of the exhaust system, the room can be returned to normal negative pressurization.

Operating Rooms

Operating Room using Theris-TX—VAV tracking pair with enhanced features

Applications for Theris-TX are more demanding than what is needed for a patient room. Theris-TX provides additional functionality that includes full temperature control, humidity control, pressure monitoring, and valve shut-off capability. Rooms that fall into this category are operating rooms, hazardous materials storage, pharmacies and isolation rooms.

Figure 3-12. An example of an operating room with a VAV tracking pair with enhanced features.



Phoenix Controls Hardware Options

- A Theris-TX tracking pair (shut-off/decontamination capability optional)
- One or more temperature sensors
- One humidity sensor (or combination temperature/humidity)
- One 24 Vac transformer (26 VA minimum required)
- Advanced Pressure Monitor II (to display actual room pressure)
- One duct temperature sensor

Equipment List Example

Theris-TP—Operating Room without Humidity or Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TP 14" Supply Valve	1.1.1	1.1.1	1200	2400	250
Theris-TP 14" Exhaust Valve	1.1.1	1.1.1	950	2150	—
Room Temp Sensor	1.1.1	1.1.1	—	—	—
Voltage Converter	1.1.1	1.1.1	—	—	—

Equipment List Example

Theris-TX—Operating Room with Humidity and Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TX 14" Supply Shut-off Valve	1.1.1	1.1.1	1200	2400	250
Theris-TX 14" Exhaust Shut-off Valve	1.1.1	1.1.1	950	2150	—
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—	—
Voltage Converter	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—	—

Sequence of Operation

The following describes the sequence of operation for an operating room with variable volume terminal venturi valves.

Flow Control

1. Pressure independent control provides supply and exhaust valves while maintaining their flow setpoints to ±5% accuracy.
2. A positive volumetric offset (room differential) is maintained between the operating room and adjoining spaces at all times.

Climate Control

1. The supply air valve modulates from maximum to minimum settings to maintain space temperature. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.
2. Humidity monitoring and control to desired percent RH for procedure.
3. The control system monitors duct discharge temperature, zone temperature, hot water control valve, airflow rates, occupied/unoccupied status, and relative humidity (RH only at locations indicated).
4. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.
5. Include alarm and monitoring sequences discussed on page 43.

Occupancy

The system operates the air valves and heating control valve in an occupied or unoccupied mode according to the user defined schedule through input at the control system, and includes an override at the zone thermostat or as described below.

- Occupied Mode—The supply and return air valves maintains the occupied air volume scheduled. Upon a call for heating, the hot water control valve modulates to maintain space setpoint.
- Unoccupied Mode—The system modulates the supply and return valves from maximum to minimum positions and the heating valve maintains the setback temperature.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Monitoring Operating Room Pressure

Monitoring Sensors/Devices

Temperature: Typically located in ducts and/or on the walls of rooms.

Humidity: Usually located in the room's general exhaust duct and/or in the room.

Airflow: Duct-mounted or flow feedback signal from a Phoenix Controls valve.

Pressure: The pressure monitoring device indicates alarms and/or actual pressure differential. Conditions indicated are GREEN for normal room conditions; RED for pressure, valve, or ACH alarms; YELLOW for door or other warning indications, and GRAY for Unoccupied or Standby modes

Integration of Monitoring and Control Systems

Data collection and reporting can be done in several ways:

1. These systems are in addition to BMS systems and offer hospital personnel their own monitoring system that reports data to their desktops, rather than through the BMS front end.
2. *Building Management Systems (BMS*) (examples: Andover Controls, Automated Logic, Honeywell, Johnson Controls, Siebe, Siemens).

Phoenix Controls has established partnerships with all of the above BMS contractors for digital integration for control and monitoring. Analog interface is available for integration with all of the companies listed above.

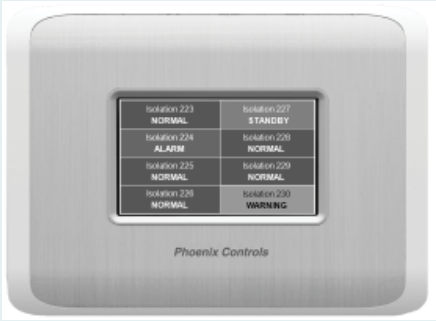
Example of an Advanced Pressure Monitor II used outside an operating room. Staff can observe and verify positive pressure. Optional integrated alarming with the BMS system..

Monitoring Critical Healthcare Spaces

Application

One APM2 Central Display is used to monitor the status of up to eight (8) pressure spaces (four ISO rooms if monitoring both patient and ante rooms). Conditions indicated are GREEN for normal room conditions; RED for pressure, valve, or ACH alarms; YELLOW for door or other warning indications, and GRAY for Unoccupied or Standby modes.

Using the Central Display, users are able to immediately see if rooms are safe and operating properly without walking to the APM2 mounted outside a room.



Integrating the Central Display via BACnet MS/TP

The Central Display has a bright, easy-to-read display and touch-screen that makes it easy to operate by just pressing areas of the screen to perform functions. From the home screen, touching any room status on the Central Display shows all of the screen information being displayed on the remote APM2, including room label, alarms, active or standby condition, occupied and unoccupied condition, pressure, temperature, humidity, door status, and air change rate. The Central Display also has a configurable audible alarm feature which will notify operators if an alarm condition is present on a remote APM2.

Example of an APM2 Central Display used at a Nurses Station. Staff can observe and verify room conditions and to hear alarms remotely.

Hospital Pharmacies

Hospital pharmacies source many types of medications and treatments for patients, including Compounded Sterile Preparations (CSPs) for cancer treatment. Patients can become harmed by non-sterile and inaccurately prepared CSPs if improper ventilation compromises the environment surrounding personnel that prepare these drugs for use. This environment is regulated by the United States Pharmacopeia (USP) Chapter <797>. USP <797> requires a comprehensive environmental sampling (ES) program to identify trends, or points of failure, before they become critical. Hence, ventilation is a key component in controlling the spread of airborne particulates.

USP <797> requires sterile mixing in a properly maintained laminar airflow hood that complies with ISO Class 5 environmental conditions. This is to be situated in an ISO Class 7 clean room with either an ISO Class 8 ante area or ISO Class 8 anteroom.

ISO Classification of Particulate Matter in Room Air[1] (limits are in particles of 0.5 µm and larger per cubic meter [current ISO] and cubic feet [former Federal Standard No. 209E, FS 209E])[2]

Class Name		Particle Count	
ISO Class.	**U.S. FS 209E**	**ISO, m^3**	**FS 209E, ft^3**
3	Class 1	35.2	1
4	Class 10	352	10
5	Class 100	3,520	100
6	Class 1,000	35,200	1,000
7	Class 10,000	352,000	10,000
8	Class 100,000	3,250,000	100,000

[1] Information courtesy USP<797>, pg 27

[2] Adapted from former Federal Standard No. 209E, General Services Administration, Washington, DC, 20407 (September 11, 1992 and ISO 14644-1 :1999, Cleanrooms and associated controlled environments - Part 1: Classification if air cleanliness. For example, 3,520 particles of 0.5 µm^3 or larger (ISO Class 5) is equivalent to 100 particles per ft^3 (Class 100) (1 m^3 = 35/2 ft^3).

Environmental Quality and Control

The most common sources of ISO Class 5 containment for CSPs are laminar airflow workbenches (LAFWs), compounding aseptic isolators (CAIs), compounding aseptic containment isolators (CACIs), and biological safety cabinets (BSCs). This equipment serves what is known as the Primary Engineering Control or PEC. Secondary engineering controls for buffer areas such as ante areas and anterooms generally serve as the core for the location of the PEC.

The buffer areas are either Class 7 or Class 8 environments supplied with HEPA-filtered air. HEPA filters need to be at least 99.97% efficient to yield Class 8 spaces for most applications, generally with a 25% efficient prefilter located somewhere upstream. Hence, filter loading and a drop in duct static pressure can be an issue unless pressure-independent devices such as Phoenix Controls valves are used.

General Guidelines for Hospital Pharmacies

- ISO Class 5 PEC
  - Compounding in LAFW, BSC, CAI, or CAC
- ISO Class 7 PEC environment
  - HEPA filters that are >99.97% efficient
  - Air change rates of 30 ACH
- ISO Class 8 anteroom
  - HEPA filters that are 99.97% efficient
  - Air change rates between 20-30 ACH
  - Pressurization +0.02 to +0.05 between PEC and anteroom
  - Pressurization at least +0.01 between anteroom and corridor
  - Continuous pressure monitoring between PEC and anteroom, and between anteroom and corridor
- ISO Class 8 ante areas
  - HEPA filters that are 99.97% efficient
  - Air change rates between 20-30 ACH
  - Pressurization +0.02 to +0.05 reference to corridor
  - Continuous pressure monitoring between ante area and corridor
  - Two examples of hospital pharmacy environmental areas that comply with USP <797> appear in Figure 3-13 and Figure 3-14

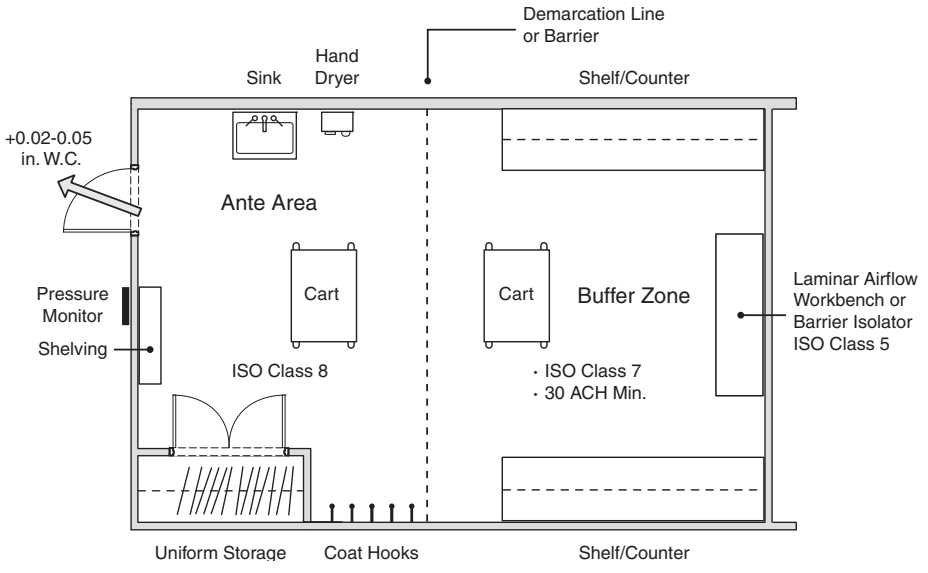
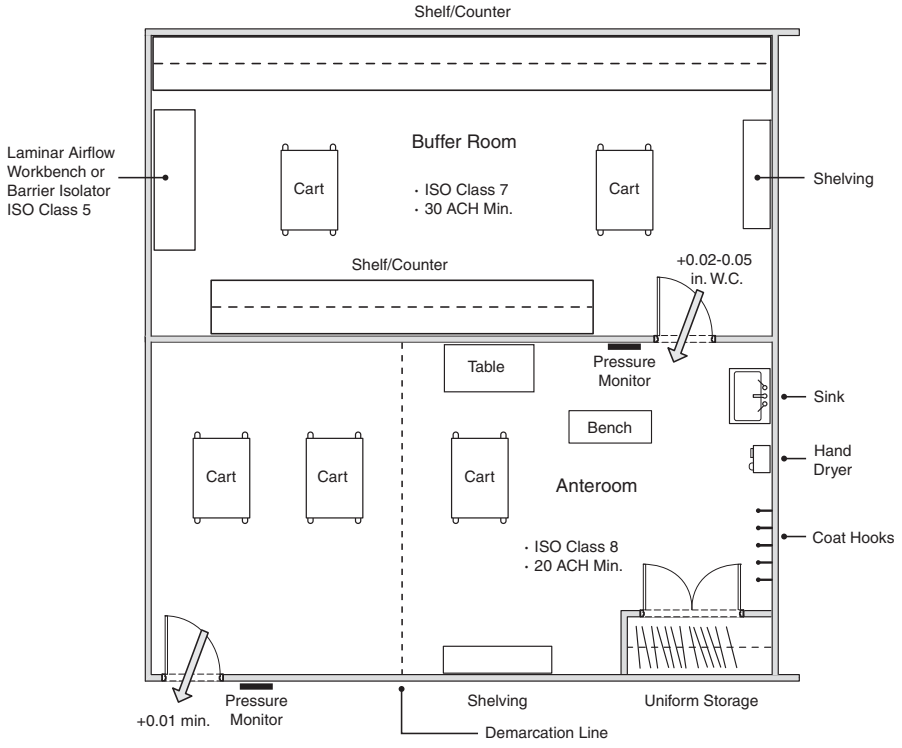


Figure 3-13. An example of a hospital pharmacy with ante area and buffer zone.

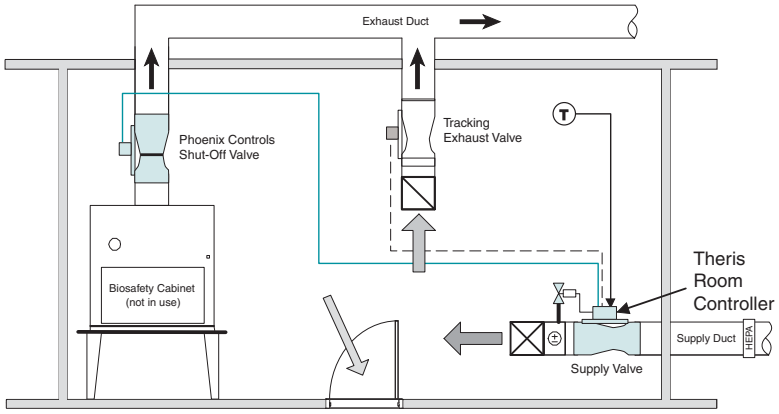
Figure 3-14. An example of a hospital pharmacy with separated anteroom and buffer room.



Pharmacy Applications using Theris-TP or Theris-TX

If no BSCs are present and simple temperature and pressurization control are the primary focus, then Theris-TP is the best solution. If humidity control and shut-off capability are needed, then Theris-TX is the best choice. The Celeris shut-off valve should be used when high speed actuation is needed. If a non-high speed coated valve is specified, then a Traccel valve will be required.

Figure 3-15. An example of a hospital pharmacy application using the Theris-TP Controller and a Phoenix Controls Shut-off Valve.



In the following example, a Phoenix Controls Shut-off Valve isolates the BSC exhaust flow when not in use, or shuts down in the event of a failure. The Shut-off Valve communicates over the room-level network with the Theris-TX Controller, which compensates for the change in flow to maintain room airflow balance and ensures correct directional airflow into or out of the room.

Phoenix Controls Hardware Options

- One Theris-TX tracking pair (shut-off/decontamination capability optional)
- One or more temperature sensors
- One humidity sensor (or combination temperature/humidity)
- One 24 Vac transformer (26 VA minimum required)
- Advanced Pressure Monitor II (to display actual room pressure)
- One duct temperature sensor

Equipment List Example

Theris-TX—Hospital Pharmacy with Humidity and Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	600	900	-100
Theris-TX 10" Exhaust Shut-off Valve	1.1.1	1.1.1	200	500	—
Traccel -TX 10" Phenolic Coated Shut-off Valve	1.1.1	1.1.1	500	500	—
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—	—
Voltage Converter	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—	—

Sequence of Operation

The following describes the sequence of operation for a pharmacy with variable air volume venturi valves.

Flow Control

1. Pressure independent control is provided for both supply and exhaust valves while maintaining their flow setpoints within ±5% accuracy.
2. A positive or negative volumetric offset (room differential) is maintained between the pharmacy and the adjoining spaces at all times.
3. The supply air valve will track the BSC exhaust valve to satisfy both BSC make-up air and room pressurization.

Climate Control

1. The supply air valve modulates from maximum to minimum settings to maintain space temperature. Upon a call for heating, the hot water control valve modulates to maintain space setpoint.
2. Humidity monitoring and control to desired percent RH as needed.

3. The control system monitors duct discharge temperature, zone temperature, hot water control valve, airflow rates, occupied/unoccupied status, and relative humidity (RH only at locations indicated).
4. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.

Occupancy

The system operates the air valves and heating control valve in an occupied or unoccupied mode per the user defined schedule through input at the control system, and includes an override at the zone thermostat or as listed.

- Occupied Mode—The supply and return air valves maintain the occupied air volume scheduled. Upon a call for heating, the hot water control valve modulate to maintain space setpoint.
- Unoccupied Mode—The system modulates the supply and return valves from maximum to minimum positions and the heating valve maintains the setback temperature.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Speciality Spaces

Autopsy Rooms and Specialty Spaces using Theris-TP or Theris-TX

Autopsy rooms are susceptible to heavy bacterial contamination and odor. For these reasons autopsy rooms require special attention. The design of these specialty rooms is similar to the design found in a laboratory. They should be negatively pressured relative to adjoining spaces to prevent the spread of contamination. ASHRAE requires a minimum of 12 ACH of one time pass through air, and extra design steps are taken regarding the exhaust side. Exhaust intakes should be located both at the ceiling and in the low sidewall. The exhaust system should discharge the air above the roof of the hospital, away from points of possible reentrainment. Where large quantities of formaldehyde are used, special exhaust systems can be used to control concentrations below legal exposure limits. In smaller hospitals, where these rooms are used less frequently, accurate control of the ventilation system along with an odor control system using either activated charcoal, or potassium permanganate-impregnated activated alumina may be more appropriate methods of odor control.

Phoenix Controls Hardware Options

- A Theris-TX tracking pair (shut-off/decontamination capability optional)
- One or more temperature sensors
- One humidity sensor (or combination temperature/humidity)
- One 24 Vac transformer (26 VA minimum required)
- Advanced Pressure Monitor II (to display actual room pressure)
- One duct temperature sensor

Equipment List Example

Theris-TX—Autopsy without Humidity or Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TP 12" Supply Shut-off Valve	1.1.1	1.1.1	650	1250	-150
Theris-TP 12" Exhaust Shut-off Valve	1.1.1	1.1.1	800	1400	—
Room Temp Sensor	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—

Theris-TX—Autopsy with Humidity and Shut-off					
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**	**Offset**
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	650	1250	-150
Theris-TX 10" Exhaust Shut-off Valve	1.1.1	1.1.1	800	1400	—
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—	—
Voltage Converter	1.1.1	1.1.1	—	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—	—

Sequence of Operation

The following describes the sequence of operation for a specialty room with Theris-TX.

Flow Control

1. Pressure independent control provides for both supply and exhaust valves while maintaining their flow setpoints to within ±5% accuracy.
2. A positive or negative volumetric offset (room differential) is maintained between the pharmacy and the adjoining spaces at all times.

Climate Control

1. The supply air valve modulates from maximum to minimum settings to maintain space temperature. Upon a call for heating, the hot water control valve modulates to maintain space setpoint.
2. Humidity monitoring and control to desired percent RH as needed.
3. The control system monitors duct discharge temperature, zone temperature, hot water control valve, airflow rates, occupied/unoccupied status, and relative humidity (RH only at locations indicated).
4. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.

Occupancy

The system operates the air valves and heating control valve in an occupied or unoccupied mode according to the user defined schedule through input at the control system, and includes an override at the zone thermostat or as described below.

- Occupied Mode—The supply and return air valves maintain the occupied air volume scheduled. Upon a call for heating, the hot water control valve modulates to maintain space setpoint.
- Unoccupied Mode—The system modulates the supply and return valves from maximum to minimum positions and the heating valve maintains the setback temperature.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points List

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Patient Rooms

Patient Room using Theris-TP—VAV Tracking Pair, Supply and Exhaust

This patient room has a Theris-TP valve on the supply and exhaust sides. Supply and exhaust valves track airflow rates to maintain room pressurization and offset. The Theris-TP supply valve can have an associated temperature sensor and control a hot water valve, as well as a second stage of heating, if needed. An optional duct temperature sensor can be located in the ductwork on either the supply or exhaust side to monitor or control temperature.

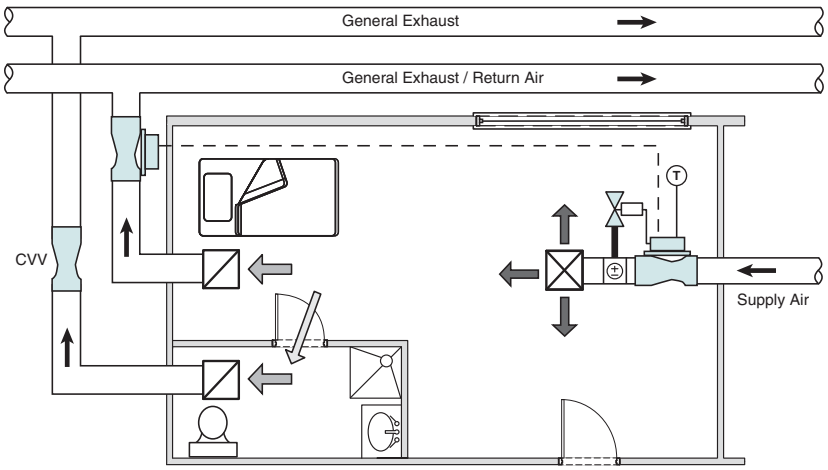


Figure 3-16. An example of a patient room with a Theris-TP valve on the supply and exhaust sides.

Hardware Requirements

- One standard Theris-TP tracking pair
- One temperature sensor
- One 24 Vac transformer (26 VA minimum required)

Theris-TP—Patient Room without Humidity or Shut-off				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-TP 10" Supply Valve	1.1.1	1.1.1	200	800
Theris-TP 10" Exhaust Valve	1.1.1	1.1.1	100	700
Theris-CV 8" Valve	1.1.1	1.1.1	100	100
Room Temp Sensor	1.1.1	1.1.1	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—

Sequence of Operation

The following describes the sequence of operation using variable volume terminal air valves with tracking return and heating.

1. Pressure independent control provides for both supply and exhaust valves while maintaining their flow setpoints to within ±5% accuracy.
2. The supply air valve modulates from maximum to minimum settings to maintain space cooling. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.
3. The return air valve modulates with the supply air valve to maintain the differential oreset supply and return airflow rates (offset).

   For patient rooms, the return airflow rates maintain the matching supply airflow rates less the room constant volume exhaust. The supply and return exhaust airflow rates will continue to maintain the exhaust differential (offset) throughout the modulation from maximum airflow to minimum airflow and vice versa.
4. The control system monitors duct discharge temperature, zone temperature, hot water control valve, and airflow.
5. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Patient Room using Theris-SO—Standalone Supply and Ducted Return

This patient room has a standalone Theris-SO valve on the supply side and a ducted return on the exhaust side. The Theris-SO valve can have an associated temperature sensor and can control a hot water valve. An optional temperature sensor can be located in the ductwork to monitor duct temperature either on the supply or exhaust side.

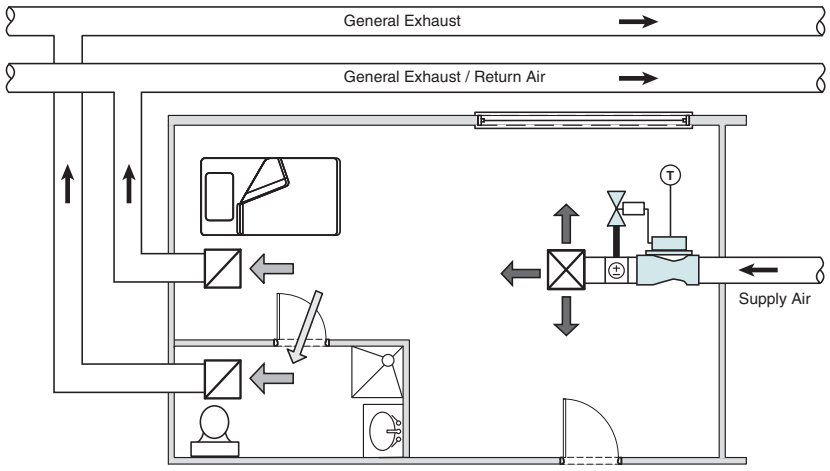


Figure 3-17. An example of a patient room with a standalone supply and ducted return on the exhaust side.

Phoenix Controls Hardware Requirements

- One Theris-SO standalone valve
- One wall-mounted temperature sensor
- One 24 Vac transformer (26 VA minimum required)

Optional Equipment

- One duct-mounted temperature sensor

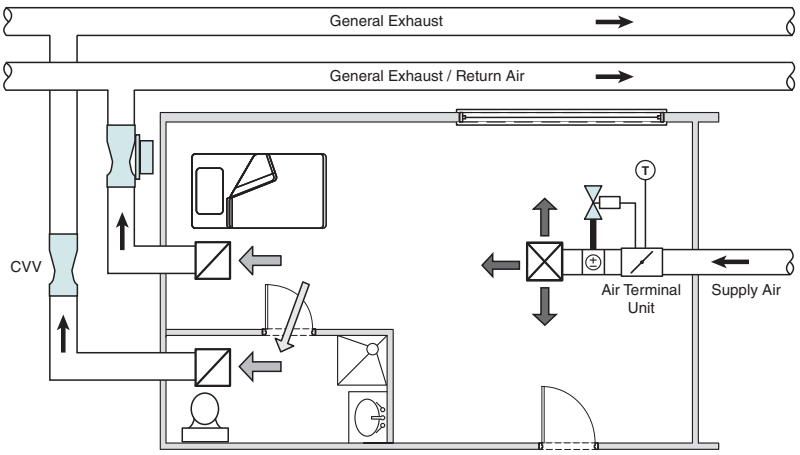
Equipment List Example

Theris-SO—Patient Room with Standalone and Ducted Return				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-SO 10" Supply Valve	1.1.1	1.1.1	200	800
Room Temp Sensor	1.1.1	1.1.1	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—

Patient Room using Theris-EO—Standalone Exhaust and Alternate Supply

This patient room uses an alternate supply device and a Theris-EO Valve on the exhaust. This room is designed to track airflow to maintain the neutral pressure relationship and the advantage of energy savings. Theris-EO provides the benefits of no scheduled maintenance on the exhaust as there is no longer a need for cross flow sensors.

Figure 3-18. An example of a patient room with standalone exhaust and alternate supply.



Phoenix Controls Hardware Requirements

- One Theris-EO standalone valve

Optional Equipment

- One duct-mounted temperature sensor

Equipment List Example

Theris-EO—Patient Room with Standalone Exhaust and Alternate Supply				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-EO 10" Exhaust Valve	1.1.1	1.1.1	200	800
Room Temp Sensor	1.1.1	1.1.1	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—

Sequence of Operation

The following describes the sequence of operation using variable volume terminal air valves with heating and ducted return.

1. Pressure independent control provides for supply air valve while maintaining its flow setpoint to within ±5% accuracy.
2. The supply air valve modulates from maximum to minimum settings to maintain space temperature. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Patient Room using Theris-CV—Constant Volume with Supply and Exhaust

This patient room has a Theris-CV (constant volume) valve on the supply and exhaust sides. Temperature can either be controlled at room-level with the PTC101 BACnet thermostat or by the BMS. No maintenance is required and valves will maintain these flow settings indefinitely.

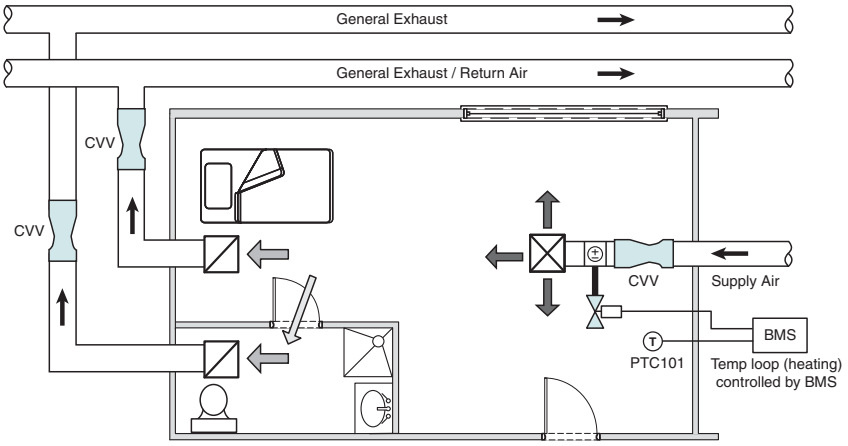


Figure 3-19. An example of a patient room with constant volume supply and exhaust.

Phoenix Controls Hardware Requirements

- Two Theris-CV constant volume valves
- PTC101 thermostat

Optional Equipment

- One 24 Vac transformer (26 VA minimum)

Equipment List Example

Theris-CV—Patient Room with Constant Volume Supply and Exhaust				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-CV 10" Supply Valve	1.1.1	1.1.1	500	500
Theris-CV 10" Exhaust Valve	1.1.1	1.1.1	400	400
PTC101	1.1.1	1.1.1	—	—

Sequence of Operation

The following describes the sequence of operation using constant volume supply and exhaust.

1. Pressure independent control provides for both supply and exhaust.
2. The supply air valve maintains a fixed flow regardless of room conditions. The pressure independent operation maintains the flow setpoint with ±5% accuracy. The exhaust valve also maintains a fixed flow with ±5% accuracy. A negative or positive offset (room differential) is achieved when the two valves are set at differing flows. Pandemic Applications for Patient Rooms

Pandemic Applications

Pandemic Mode Sequence using Theris-TX and Two Room Exhaust Valves

A single bed patient room can be converted to an isolation room on-demand in the event of a pandemic incident. On the exhaust side, this is done by designating one valve for return air and a second valve for exhaust to outdoor air. A supply valve serves the room and a constant volume exhaust valve is used in the bathroom.

- Supply valve – Theris-TX
- Return air valve – Tracking shut-off exhaust valve linked to Theris-TX supply valve
- Exhaust air valve – Theris-TX shutoff valve used as a stand-alone exhaust valve
- Bathroom valve – Theris-CV constant volume valve

Under normal patient use, the exhaust air valve is in shut-off position and the return air valve tracks the supply valve to maintain neutral offset condition to the corridor. In pandemic mode, a panic button on the floor or BMS command initiates an emergency mode sequence which drives the return air valve to shut-off position and opens the exhaust air valve to a flow that achieves negative room offset.

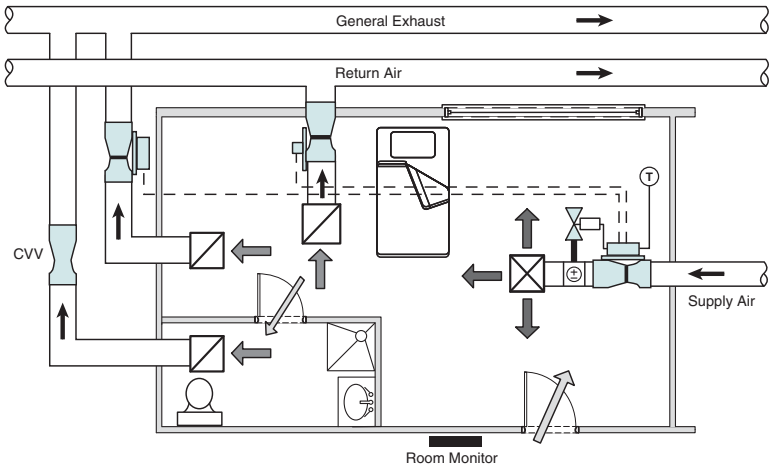


Figure 3-20. A patient room designed to respond to a pandemic incident. *Tracking exhaust valves change between recirculation and exhaust to outdoors.*

Hardware Requirements

- One Theris-TX tracking pair, with shut-off
- One Theris-TX supply valve with no insulation, to be used for exhaust
- One Theris-CV exhaust valve for bathroom
- One temperature sensor
- One 24 Vac transformer (26 VA minimum required)

Optional Equipment

- Advanced Pressure Monitor II (to display actual room differential pressure)

Equipment List Example

Theris-TX—Pandemic-Ready Patient Room with Humidity and Optional Shut-off				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	650	1250
Theris-TX 10" Exhaust Shut-off Valve	1.1.1	1.1.1	800	1400
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	50	1000
Theris-CV 8" Constant Volume Valve	1.1.1	1.1.1	100	100
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—
Voltage Converter	1.1.1	1.1.1	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—

Sequence of Operation

The following describes the sequence of operation using a variable volume terminal air valve with tracking return and heating.

1. Pressure independent control provides for both supply and exhaust valves while maintaining their flow setpoints to within ±5% accuracy.
2. The supply air valve modulates from maximum to minimum settings to maintain space cooling. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.
3. The return air valve modulates with the supply air valve to maintain the differential preset supply and return airflow rates (offset).

   For patient rooms the return airflow rates maintain the matching supply airflow rates less the room constant volume exhaust. The supply and return exhaust airflow rates will continue to maintain the exhaust differential (offset) throughout the modulation from maximum airflow to minimum airflow and vice versa.
4. The room exhaust valve is in shut-off position, and the return air valve is tracking to the Theris-TX supply valve. Room offset is neutral.
5. Pandemic mode is initiated from either a panic button dry contact or BMS control command. This initiates an Emergency Mode sequence on the Theris-TX supply valve.
6. The Emergency Mode sequence drives the return air valve to shut-off position, and commands the Theris-TX room exhaust valve to open and go to a flow position that causes the room to go to a negative offset.
7. The BMS monitors supply air at the central air handler and trims the recirculation air with outdoor air to maintain supply air to the floor
8. The control system monitors duct discharge temperature, zone temperature, hot water control valve and airflow.
9. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.
10. In pandemic mode, include alarm and monitoring sequences described on page 42,

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details..

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Pandemic Mode Sequence using Theris-TX and Exhaust through Bathroom

A single bed patient room can be converted to an isolation room on demand on the event of a pandemic incident. In this scenario, the bathroom exhaust valve is not constant volume, but rather variable air volume and is used to create negative offset in the room. The door to the bathroom is fitted with a grill to permit sufficient airflow when the door is closed.

One valve is used for return air and the bathroom valve is used to exhaust to outdoor air. A supply valve serves the room and a constant volume exhaust valve is used in the bathroom.

- Supply valve – Theris-TX
- Return air valve – Tracking shut-off exhaust valve linked to Theris-TX supply valve
- Exhaust air valve and bathroom valve – Combined. Theris-TX shutoff valve used as a stand-alone exhaust valve

Under normal patient use, the bathroom valve is balanced with the patient room to provide negative offset to the bathroom. The return air valve tracks the supply valve to maintain neutral offset condition to the corridor. In pandemic mode, a panic button on the floor or BMS command initiates an emergency mode sequence which drives the return air valve to shut-off position and opens the exhaust/bathroom air valve to a flow that achieves negative room offset.

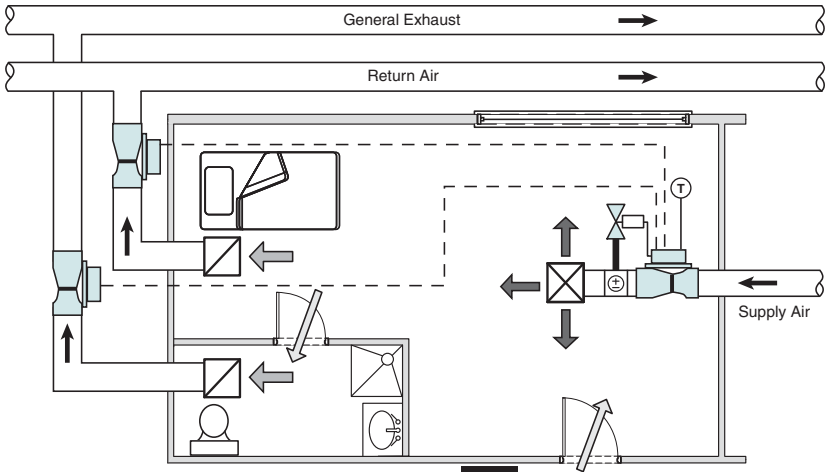


Figure 3-21. A patient room designed to respond to a pandemic incident. *In pandemic mode, bathroom exhaust is used to create negative offset.*

Hardware Requirements

- One Theris-TX tracking pair, with shut-off
- One Theris-TX supply valve with no insulation, to be used for exhaust/bathroon
- One temperature sensor
- One 24 Vac transformer (26 VA minimum required)

Optional Equipment

- Advanced Pressure Monitor II (to display actual room differential pressure)

Equipment List Example

Theris-TX—Pandemic-Ready Patient Room with Humidity and Optional Shut-off				
Phoenix Part Description	**Room No.**	**Tag No.**	**Min. Flow**	**Max. Flow**
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	650	1250
Theris-TX 10" Exhaust Shut-off Valve	1.1.1	1.1.1	800	1400
Theris-TX 10" Supply Shut-off Valve	1.1.1	1.1.1	50	1000
Combination Temp/Humidity Room Sensor	1.1.1	1.1.1	—	—
Voltage Converter	1.1.1	1.1.1	—	—
Duct Temp Sensor	1.1.1	1.1.1	—	—
Advanced Pressure Monitor II	1.1.1	1.1.1	—	—

Sequence of Operation

The following describes the sequence of operation using a variable volume terminal air valve with tracking return and heating.

1. Pressure independent control provides for both supply and exhaust valves while maintaining their flow setpoints to within ±5% accuracy.
2. The supply air valve modulates from maximum to minimum settings to maintain space cooling. Upon a call for heating with the air valve at minimum position, the hot water control valve modulates to maintain space setpoint.
3. The return air valve modulates with the supply air valve to maintain the differential preset supply and return airflow rates (offset).

   For patient rooms the return airflow rates maintain the matching supply airflow rates less the room constant volume exhaust. The supply and return exhaust airflow rates will continue to maintain the exhaust differential (offset) throughout the modulation from maximum airflow to minimum airflow and vice versa.
4. The bathroom valve is balanced with the patient room to provide negative offset to the bathroom. Theris-TX supply valve with no insulation. Room offset is neutral.
5. Pandemic mode is initiated from either a panic button dry contact or BMS control command. This initiates an Emergency Mode sequence on the Theris-TX supply valve.
6. The Emergency Mode sequence drives the return air valve to shut-off position and commands the Theris-TX exhaust/bathroom valve to open and go to a flow position that causes the room to go to a negative offset
7. The BMS monitors air supply at the central air handler and trims the recirculation air with outdoor air to maintain supply air to the floor.
8. The control system monitors duct discharge temperature, zone temperature, hot water control valve and airflow.
9. Zone setpoints are capable of local or remote adjustments with the capability to lockout local adjustment.
10. In pandemic mode, include alarm and monitoring sequences described on page 42,

Input/Output Terminations

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Points Lists

Refer to the appropriate *Theris Family of Valves Product Data Sheets* for complete details.

Pandemic Mode Sequence using Theris-SO

The combination of a Theris-SO standalone valve and the ducted return do not provide the tools to accomplish a pandemic mode sequence on their own. However, using dampers in the ductwork, the air handler can provide a standard return air system during normal operation, and when the pandemic mode sequence is initiated can quickly switch to 100% outside air.

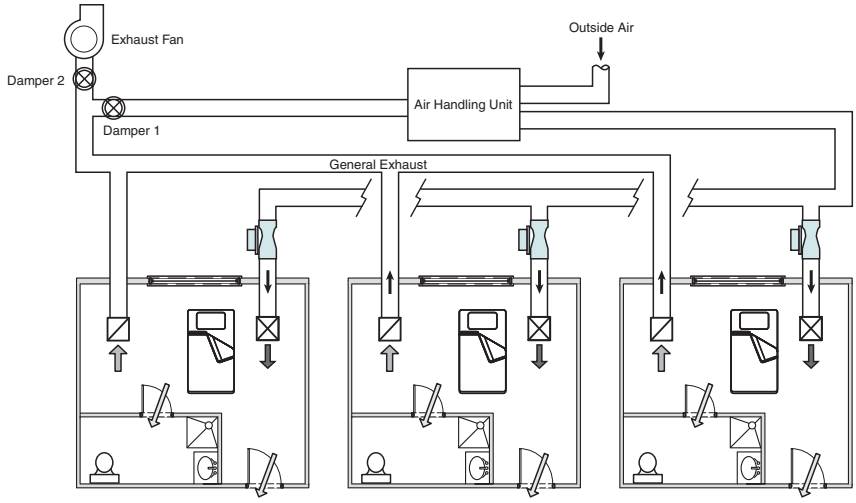


Figure 3-22. An example of a patient room in pandemic mode using Theris-SO.

Pandemic Mode Sequence using Theris-CV

The equipment listed in the Theris-CV application will function similar to the sequence using Theris-SO. Keep in mind, if a CV application is used for pandemic sequences, then the room must be designed to always run at the proper pressure relationship depending on if the room will be used as a Protective Environment or an Infectious Isolation room during pandemic modes. This also means that air change rates need to be maintained at higher flows than would normally be required by patient rooms .

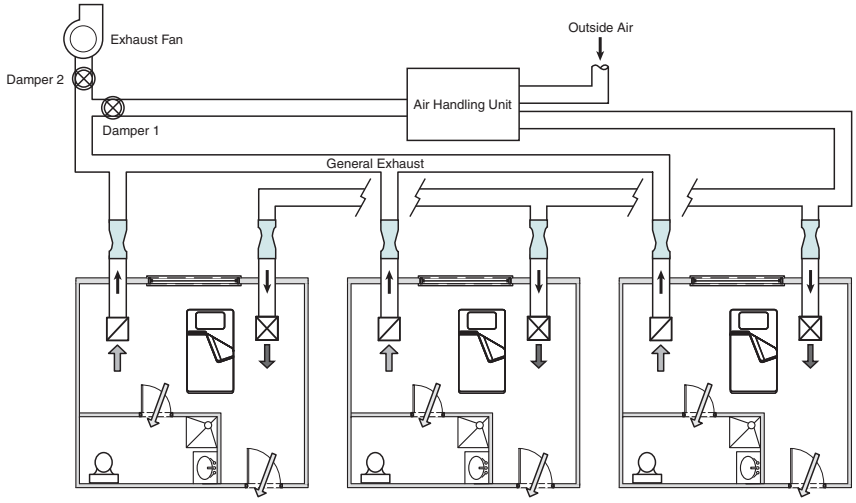


Figure 3-23. An example of a patient room in pandemic mode using Theris-CV.

ANSI/ASHRAE/ASHE Design Parameters and Recommended Theris Solutions

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities*; Table 7-1, pp. 7-10

Function of Space	Pressure relationship to adjacent areas[h]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[i]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Surgery and Critical Care										
Classes B and C Operating Rooms[m, n, o]	Positive	4	20	—	No	20-60	68-75 (20-24)	TP, TX	Phoenix Temp/ Humidity Control, APM2	Shut-off
Operating/Surgical Cystoscopic Rooms[m, n, o]	Positive	4	20	—	No	20-60	68-75 (20-24)	TP, TX	Phoenix Temp/ Humidity Control, APM2	Shut-off
Delivery Room (Caesarean)[m, n, o]	Positive	4	20	—	No	20-60	68-75 (20-24)	TP, TX	Phoenix Temp/ Humidity Control, APM2	Shut-off
Substerile Service Area	—	2	6	—	No	—	—	TP, SO, EO	—	—
Recovery Room	—	2	6	—	No	30-60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control	
Critical and Intensive Care	—	2	6	—	No	30-60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Intermediate Care[s]	—	2	6	—	—	max 60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Wound Intensive Care (Burn Unit)	—	2	6	—	No	40-60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Newborn Intensive Care	Positive	2	6	—	No	30-60	72-78 (22-26)	TP, TX, EO	Phoenix Temp Control, APM2	—
Treatment Room[p]	—	2	6	—	—	20-60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control,	—

Function of Space	Pressure relationship to adjacent areas[n]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[1]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Trauma Room (Crisis or Shock)[c]	Positive	3	15	—	No	30-60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Medical/Anesthesia Gas Storage[r]	Negative	—	8	Yes	—	—	—	TP, TX, EO	—	—
Laser Eye Room	Positive	3	15	—	No	20-60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
ER Waiting Rooms[q]	Negative	2	12	Yes	—	max 65	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control	—
Triage[q]	Negative	2	12	Yes	—	max 60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control	—
ER Decontamination	Negative	2	12	Yes	No	—	—	TP, TX, EO	Phoenix Temp Control, APM2	Shut-off
Radiology Waiting Rooms[q, w]	Negative	—2	12	Yes	—	max 60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control	—
Class A Operating/ Procedure Room[o,d]	Positive	3	15	—	No	20-60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Inpatient Nursing										
Patient Room(s)[s]	—	2	6	—	—	max 60	70-75 (21-24)	SO, TP, TX, EO, CV	Phoenix Temp Control	
Toilet Room	Negative	—	10	Yes	No	—	—	TP, CV	—	—
Newborn Nursery Suite	—	2	6	—	No	30-60	72-78 (22-26)	TP, SO, EO	Phoenix Temp Control	—
Protective Environment Room[t]	Positive	2	12	—	No	max 60	70-75 (21-24)	TP, TX, CV	Phoenix temp Control, APM2	Shut-off
All Room[u]	Negative	2	12	Yes	No	max 60	70-75 (21-24)	TP, CV, EO	Phoenix temp Control, APM2	Shut-off

Function of Space	Pressure relationship to adjacent areas[h]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[f]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Combination AII/PE Room	Positive	2	12	Yes	No	Max 60	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
PE Anteroom[t]	Note e	—	10	—	No	—	—	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Combination AII/PE Anteroom	Note e	—	10	Yes	No	—	—	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
All Anteroom[u]	Note e	—	10	Yes	No	—	—	TP, TX, CV	Phoenix temp Control, APM2	Shut-off
Labor/Delivery/ Recovery/Postpartum (LDRP)[s]	—	2	6	—	—	max 60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control	—
Labor/Delivery/ Recovery (LDR)[s]	—	2	6	—	—	max 60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control	—
Patient Corridor	—	—	2	—	—	—	—	SO, EO, CV	—	—
Skilled Nursing Facility										
Resident Room	—	2	2	—	—	—	70-75 (21-24)	SO, EO	Phoenix Temp Control	—
Resident Gathering/ Activity/Dining	—	4	4	—	—	—	70-75 (21-24)	SO, EO	—	—
Physical Therapy	Negative	2	6	—	—	—	70-75 (21-24)	TP, EO	—	—
Occupational Therapy	—	2	6	—	—	—	70-75 (21-24)	SO, EO	—	—
Bathing Room	Negative	—	10	Yes	—	—	70-75 (21-24)	TP, EO	—	—
Radiology[v]										
X-ray (Diagnostic and Treatment)	—	2	6	—	—	max 60	72-78 (22-26)	TP, SO, EO	Phoenix Temp Control	—
X-ray (Surgery/ Critical Care and Catherization)	Positive	3	15	—	No	max 60	70-75 (21-24)	TP, TX, EO	Phoenix Temp Control, APM2	—
Darkroom[g]	Negative	2	10	Yes	No	—	—	TP, TX, EO	APM2	—

Function of Space	Pressure relationship to adjacent areas[h]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[i]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Diagnostic and Treatment										
Bronchoscopy, Sputum Collection and Pentamidine Administration[n]	Negative	2	12	Yes	No	—	68-73 (20-23)	TP, TX, EO	Phoenix Temp Control, APM2	—
Laboratory, General[v]	Negative	2	6	—	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Bacteriology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Biochemistry[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Cytology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Glass Washing[v]	Negative	2	10	Yes	—	—	—	TP, TX, EO, Celeris	APM2	Shut-off
Laboratory, Histology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Nuclear Medicine[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Pathology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory Serology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Microbiology[v]	Negative	2	6	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Laboratory, Sterilizing[v]	Negative	2	10	Yes	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off

Function of Space	Pressure relationship to adjacent areas[n]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[f]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Laboratory, Media Transfer[v]	Positive	2	4	—	—	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Autopsy Room[n]	Negative	2	12	Yes	No	—	68-75 (20-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Non-refrigerated body-holding room[n]	Negative	—	10	Yes	No	—	70-75 (21-24)	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Pharmacy[b]	Positive	2	4	—	—	—	—	TP, TX, EO, Celeris	Phoenix Temp Control, APM2	Shut-off
Examination Room	—	2	6	—	—	max 60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control	—
Medication Room	Positive	2	4	—	—	max 60	70-75 (21-24)	TP, EO	—	—
Gastrointestinal Endoscopy Procedure Room	Positive	2	6	—	No	20-60	68-73 (20-23)	TP, TX, EO	Phoenix Temp Control, APM2	—
Endoscope Cleaning	Negative	2	10	Yes	No	—	—	TP, TX, EO	Phoenix Temp Control, APM2	—
Treatment Room	—	2	6	—	—	max 60	70-75 (21-24)	TP, SO, EO	Phoenix Temp Control	—
Hydrotherapy	Negative	2	6	—	—	—	72-80 (22-27)	TP, TX, EO	Phoenix Temp Control	—
Physical Therapy	Negative	2	6	—	—	max 65	72-80 (22-27)	TP, TX. EO	Phoenix Temp Control	—
Sterilizing										
Sterilizer Equipment Room	Negative	—	10	Yes	No	—	—	TP, TX, EO	Phoenix Temp Control	Shut-off
Central Medical and Surgical Supply										
Soiled or Decontamination Room	Negative	2	6	Yes	No	—	72-78 (22-26)	TP, TX, EO	—	Shut-off

Function of Space	Pressure relationship to adjacent areas[h]	Minimum air changes of outdoor air per hour	Minimum total air changes per hour[i]	All room air exhausted directly to outdoors[j]	Recirculated by means of room units[a]	Relative humidity[k] (%)	Design temperature[l] (degrees F/C)[l]	Recommended Theris Controller	Complimentary Components	Recommended Options
Clean Workroom	Positive	2	4	—	No	max 60	72-78 (22-26)	TP, TX, EO	—	Shut-off
Sterile Storage	Positive	2	4	—	—	max 60	72-78 (22-26)	TP, TX, EO	—	Shut-off
Service										
Food Preparation Center[i]	—	2	10	—	No	—	72-78 (22-26)	TP, SO, EO	—	—
Warewashing	Negative	—	10	Yes	No	—	—	TP, TX, EO	—	—
Dietary Storage	—	—	2	—	No	—	72-78 (22-26)	TP, SO, EO	—	—
Laundry, General	Negative	2	10	Yes	No	—	—	TP, TX, EO	—	—
Soiled Linen Sorting and Storage	Negative	—	10	Yes	No	—	—	TP, TX, EO	—	Shut-off
Clean Linen Storage	Positive	—	2	—	—	—	72-78 (22-26)	TP, TX, EO	—	—
Soiled Linen and Trash Chute Room	Negative	—	10	Yes	No	—	—	TP, TX, EO	—	—
Bedpan Room	Negative	—	10	Yes	No	—	—	TP, TX, EO	—	—
Bathroom	Negative	—	10	Yes	No	—	72-78 (22-26)	TP, TX, EO	—	—
Janitor's Closet (Housekeeping)	Negative	—	10	Yes	No	—	—	TP, TX, EO	—	—
Support Space										
Soiled Workroom or Soiled Holding	Negative	2	10	Yes	No	—	—	TP, TX, EO	—	Shut-off
Clean Workroom or Clean Holding	Positive	2	4	—	—	—	—	TP, TX, EO	—	—
Hazardous Material Storage	Negative	2	10	Yes	No	—	—	TP, TX, EO	—	Shut-off

TX—Theris Enhanced Tracking Pair (LONMark or BACnet)

TP—Theris Tracking Pair (LONMark or BACnet)

SO—Theris Supply Only (LONMark or BACnet)

EO—Theris Exhaust Only (BACnet)

CV—Theris Constant Volume

Notes:

a. Recirculating room HVAC units (with heating or cooling coils) are acceptable to achieve the required air change rates. Because of the cleaning difficulty and the potential for buildup of contamination, recirculating room units shall not be used

in areas marked "No." Isolation and intensive care unit rooms may be ventilated by reheat induction units in which only the primary air supplied from a central system passes through the reheat unit. Gravity-type heating or cooling units, such as radiators or convectors, shall not be used in operating rooms and other special care areas.

b. Pharmacy compounding areas may have additional air change and filtering requirements beyond the minimum of this table depending on the type of pharmacy, the regulatory requirements (which may include adoption of USP 797), the associated level of risk of the work (see USP 797), and the equipment utilized in the spaces.

c. The term trauma room as used herein is a first aid room and/or emergency room used for general initial treatment of accident victims. The operating room within the trauma center that is routinely used for emergency surgery is considered to be an operating room by this Standard.

d. Pressure relationships need not be maintained when the room is unoccupied.

e. See Section 7.2 and its subsections for pressure-relationship requirements.

f. This letter is not used in ths table.

g. Exception: All air need not be exhausted if darkroom equipment has a scavenging exhaust duct attached and meets ventilation standards regarding NIOSH, OSHA, and local employee exposure limits.[2,3]

h. A nonrefrigerated body-holding room is applicable only to facilities that do not perform autopsies on-site and use the space for short periods while waiting for the body to be transferred.

i. Minimum total air changes per hour (ACH) shall be that required to provide proper makeup air to kitchen exhaust systems as specified in ANSI/ASHRAE Standard 154[4]. In some cases, excess exfiltration or infiltration to or from exit corridors compromises the exit corridor restrictions of NFPA 90A[5], the pressure requirements of NFPA 96[6], or the maximum defined in the table. During operation, a reduction to the number of air changes to any extent required for odor control shall be permitted when the space is not in use. (See AiA [2006] in Informative Annex B: Bibliography.)

j. In some areas with potential contamination and/or odor problems, exhaust air shall be discharged directly to the outdoors and not recirculated to other areas. Individual circumstances may require special consideration for air exhausted to the outdoors, for example, intensive care units in which patients with pulmonary infection are treated and rooms for bum patients. To satisfy exhaust needs, constant replacement air from the outdoors is necessary when the system is in operation.

k. The RH ranges listed are the minimum and/or maximum limits allowable at any point within the design temperature range required for that space.

l. Systems shall be capable of maintaining the rooms within the range during normal operation. Lower or higher temperature shall be permitted when patients' comfort and/or medical conditions require those conditions.

m. National Institute for Occupational Safety and Health (NIOSH) criteria documents regarding occupational exposure to waste anesthetic gases and vapors, and control of occupational exposure to nitrous oxide[7] indicate a need for both local exhaust (scavenging) systems and general ventilation of the areas in which the respective gases are utilized. Refer to NFPA 99 for other requirements[8].

n. If pressure monitoring device alarms are installed, allowances shall be made to prevent nuisance alarms. Short term excursions from required pressure relationships shall be allowed while doors are moving or temporarily open. Simple visual methods such as smoke trail, ball-in-tube, or flutterstrip shall be permitted for verification of airflow direction. Recirculating devices with HEPA filters shall be permitted in existing facilities as interim, supplemental environmental controls to meet requirements for the control of airborne infectious agents. The design of either portable or fixed systems should prevent stagnation and short circuiting of airflow. The design of such systems shall also allow for easy access for scheduled preventative maintenance and cleaning.

o. Surgeons or surgical procedures may require room temperatures, ventilation rates, humidity ranges, and/or air distribution methods that exceed the minimum indicated ranges.

p. Treatment rooms used for bronchoscopy shall be treated as bronchoscopy rooms. Treatment rooms used for procedures with nitrous oxide shall contail provisions for exhausting anesthetic waste gases.

q. In a recirculating ventilation system, HEPA filters shall be permitted instead of exhausting the air from these spaces to the outdoors provided the return air passes through the HEPA filters before it is introduced into any other spaces.

r. See NFPA 99 for further requirements[8].

s. For patient rooms, intermediate care, labor/delivery/recovery rooms, and labor/delivery/recovery/postpartum rooms, four total ACH shall be permitted when supplemental heating and/or cooling systems (radiant heating and cooling, baseboard heating, etc.) are used.

t. The protective environment airflow design specifications protect the patient from common environmental airborne infectious microbes (i.e., Aspergillus spores). Recirculation HEPA filters shall be permitted to increase the equivalent room air exchanges; however, the outdoor air changes are still required. Constant volume airflow is required for consistent ventilation for the protected environment. The pressure relationship to adjacent areas shall remain unchanged if the PE Room is utilized as a normal patient room. Rooms with reversible airflow provisions for the purpose of switching between protective environment and All functions shall not be permitted.

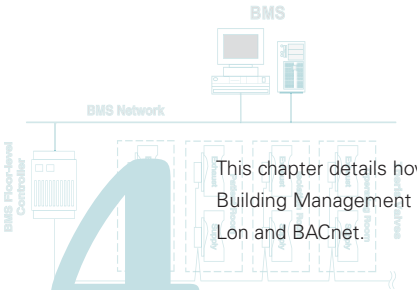
u. The All room described in this standard shall be used for isolating the airborne spread of infectious diseases, such as measles, varicella, or tuberculosis. Supplemental recirculating devices using HEPA filters shall be permitted in the All room to increase the equivalent room air exchanges; however, the minimum outdoor air changes of Table 7-1 are still required. All rooms that are retrofitted from standard patient rooms from which it is impractical to exhaust directly outside may be recirculated with air from the All room, provided that the air first passes through a HEPA filter. When the All room is not utilized for airborne infection isolation, the pressure relationship to adjacent areas, when measured with the door closed, shall remain unchanged and the minimum total air change rate shall be 6 ACH. Switching controls for reversible airflow provisions shall not be permitted.

v. When required, appropriate hoods and exhaust devices for the removal of noxious gases or chemical vapors shall be provided in accordance with NFPA 99[8].

w. This requirement applies only to radiology waiting rooms programmed to hold patients who are waiting for chest x-rays for diagnosis of respiratory disease.

* As referenced in the 2010 Facility Guidelines Institute's Guidelines for Design and Construction of Health Care Facilities.

[1] Total air changes indicated should be either supplied or, where required, exhausted. Number of air changes can be reduced when the room is unoccupied, if the pressure relationship is maintained and the number of air changes indicated is reestablished any time the space is used. Air changes shown are minimum values. Higher values should be used when required to maintain room temperature and humidity conditions based on the cooling load of the space (lights, equipment, people, exterior walls and windows, etc.).



4 Integration

This chapter details how valves and controllers integrate with Building Management Systems that use open protocols such as Lon and BACnet.

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Integrating Healthcare Applications with the BMS

An integrated airflow control system offers all of the benefits that our standalone system provides:

- Reduced first costs
- Decreased operating costs
- Reliability
- Flexibility

While these benefits continue to be the foundation of our offering, integrating healthcare controls with the BMS makes it easy to monitor the status of all critical rooms from a central location and archive operating data. System integration expands and improves upon the core benefits by providing:

- Comprehensive remote monitoring and diagnostics
- Energy use tracking
- Easy identification of potential operating problems
- Report generation through the BMS, such as alarm monitoring, safety analysis and energy use

Collecting and exchanging data between devices that make up the building controls system are the key elements in turning front-end systems into building management systems (BMSs). Control systems in today's buildings are becoming increasingly sophisticated, relying heavily on microprocessor-based controllers to implement the desired control strategies. With the advent of plant, floor and room controllers powered by high-end microprocessors, the question becomes, "How do you knit all of this into one homogeneous system?"

In the past, many BMSs relied primarily on proprietary protocols to establish communications between field devices and the front-end. This effectively locked competitors out of buildings or campuses because there was no practical way for control equipment from one vendor to communicate with the BMS of another vendor. Owners demanded interoperability, and the industry responded by defining and documenting open communication schemes like BACnet (Building Automation and Control network) and LonTalk (local operating network).

BACnet®

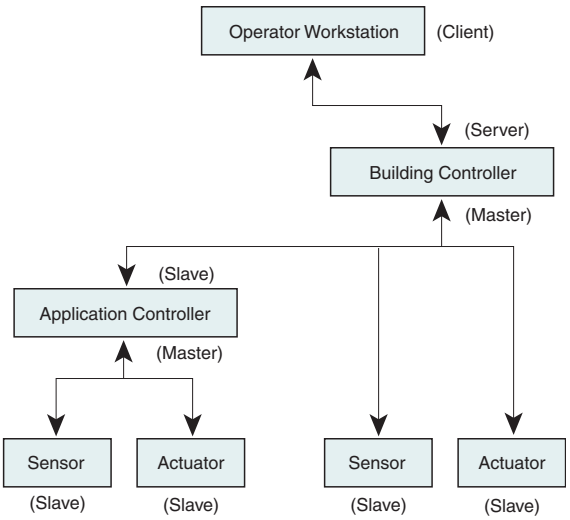
The BACnet Committee was formed in 1987 and began work on the BACnet standard. In June 1995, after years of industry input and reviews, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) adopted BACnet as a new standard for the industry. In 2003, the International Standards Organization (ISO) and European Committee for Standardization (CEN) adopted BACnet as a European standard (EN ISO 16484-5). BACnet has undergone several major revisions; the current version is Standard 135-2004. There are several BACnet Interest Groups (BIGs) that have formed around the world to promote the use of BACnet, as well as the BACnet Testing Laboratory (BTL), which tests products to certify

compliance with the BACnet standard. There are currently 75 known manufacturers of BACnet products.

BACnet is based on a model where devices and their associated *points* are represented as *objects*: device, analog input, analog output, binary input, binary output, and so on. These objects have a varying number of properties, such as present value, object name, object ID, description, status, etc. These object properties are passed from one device to another through *services*, such as read property, write property, change of value, and event notification, to name a few.

The BACnet architecture is based on an established hierarchy of a client/server or main/booster relationship between devices. Clients (mains) make requests of servers (booster) devices, and the server (booster) devices respond. There are defined methodologies for how a client (main) device can query a server (booster) device to determine which objects and services the server (booster) device supports in order to establish communications with that device. Data may be retrieved using various polling mechanisms (read property, read property multiple) or by the client subscribing to a server's data sharing service (change of value, etc.).

Figure 4-1. The basic components of BACnet architecture.



The BACnet standard defines these device types:

- Operator workstation–This is the human-to-machine interface device or terminal where data is captured and displayed. It may be used to configure devices and systems, but it is not intended to implement control strategies.
- Building controller–This is a general purpose, field programmable device that executes many of the control and automation routines as part of the overall building control strategy. A building controller is typically a floor-level or supervisory controller with a fairly high level of integration that can act as a router (or bridge) between the building-level and floor-level network segments.
- Advanced application controller–This class of controller fits between the higher-end building controller and less sophisticated application specific controller.
- Application specific controller–This class of devices has limited programmable control capabilities and resources relative to the advanced application controller. It is generally intended to perform specific types of control or automation functions.
- Smart actuator–This type of device is typically a simple control device with limited resources intended to perform a specific function.

- Smart sensor–This is a simple device with very limited resources intended for simple sensing and detection applications. It also defines the minimum subset of BACnet functionality or services each class of device must support. These services are known as *BACnet Interoperability Building Blocks (BIBBs)*, which are organized as follows:
  - Data sharing–These services define how messages are formatted and passed between devices using services, such as read property, read property multiple, write property, write property multiple and change of value.
  - Alarm and event management–These services define how alarm messages are structured, delivered and acknowledged.
  - Scheduling–These services define how events scheduled by dates and times are administered between devices on the network.
  - Trending–These services define how trend log files are structured, how devices on the network can initiate or end trend sessions manually and programmatically, and how the files are passed between devices.
  - Device and network management–These services define how one device on the network can initiate communications with one or more other devices, how it can programatically discover which functions the device(s) support, and which device and point objects are available. There are several network management functions, such as restarting or reinitializing a foreign device.

There are typically at least two layers for a BACnet network:

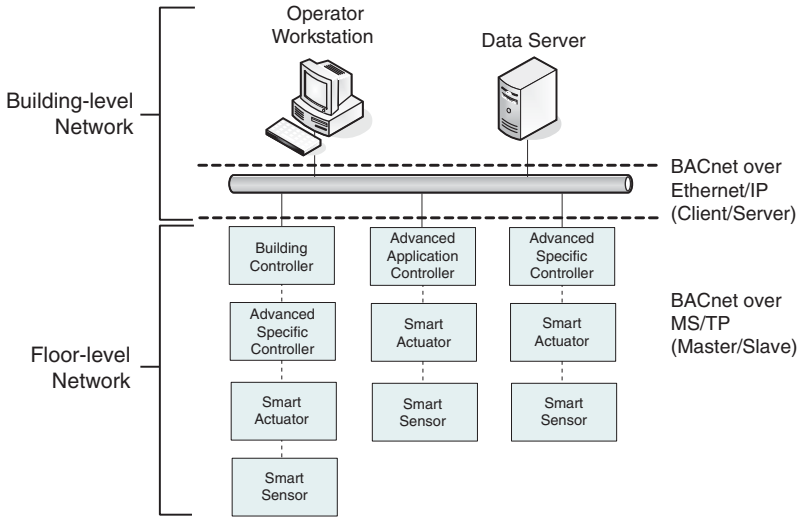
- Building-level network–This network generally consists of BACnet workstations and data servers communicating with various BACnet controllers. The communication method is typically through a client/server relationship using BACnet over Ethernet or Internet Protocol (IP), depending upon the facility's network architecture.
- Floor-level network–This network typically contains BACnet controllers communicating with lower-level controllers that communicate with smart sensors and actuators. The communication method often employed is a BACnet main booster/token passing (MS/TP) network using EIA-485 or point-to-point with RS-232.

BACnet uses sophisticated schemes for one device detecting other devices and reading which services are supported, which objects are available, and the properties of the device's input and output objects. These methods are defined for establishing communications between devices:

- Read/write property, a single read and write request sent from one device to another to update the value or status of a device or point object property. This mechanism relies on a poll/response communications scheme.
- Read Property Multiple/Write Property Multiple–A complex read and write request sent from one device to another to update the value or status of a multiple properties of a device or point object. This mechanism relies on a more sophisticated poll/response communications scheme.
- Subscription based services–These schemes rely on one device subscribing to a change of value or event notification service of another device. Using these schemes the subscriber requests data updates be pushed from the sender to the recipient based on an object property changing value or state. These schemes offer tremendous network efficiencies as only dynamic values are passed.

In general, the BACnet protocol is very feature rich in that there is a lot of information available from each device and for each point available from that device. BACnet is intended to be a hierarchal type of architecture and is very well suited for handling large volumes of data over large scale networks.

Figure 4-2. Layers of a BACnet network.



LonTalk®

The LonTalk protocol was developed by Echelon Corporation in the early 1990s. The protocol is incorporated in several standards ANSI/EIA709.1, SEMI E56.6, IEEE 1493-L, EN14908, and others. The Echelon transceiver technology has been approved under ANSI/EIA709.2 and 709.3 and is expected to be included in the EN14908 standard. There are numerous branches of LonMark International around the world. LonMark promotes the use of LonWorks technology and maintains the standard as well as certifies products meet the standard for interoperability. There are currently 228 members of LonMark International. There is also an organization called the Open Systems Alliance (OSA) which is a pool of systems integrators and companies that train them to design, install, and commission LonWorks systems. There are currently 187 member organizations.

LonTalk is a much more simplistic communications protocol than BACnet. The LonTalk protocol was designed around the principle of a peer-to-peer network where any device on the network can share data with any other device on the network. The functionality of the device is defined, the structure of the network variables, and the protocol is embedded in the application microprocessor. Interoperability on a LonWorks network is tied to two key elements established by LonMark International:

- Functional profiles–The concept of the functional profile is that most control devices will fit into some generic classification where the basic functionality and input and output points required for control and integration can be defined. There are currently 86 functional profiles defined by the LonMark organization which outline the general functionality of everything from a temperature sensor to a roof-top unit controller. This allows systems integrators to know what functionality they can expect from a device and what input and output network variables will be available to integrate with other devices or with the BMS.
- Data types–Points or network variables in the LonWorks world are defined as standard network variable types (SNVT). The LonMark organization has at present established 187 standard network variable types for everything from a simple voltage value to the operational status of a piece of HVAC equipment. Each SNVT is thoroughly defined in terms of range, resolution, polarity and for enumerations the function of each state is defined. This allows them to be passed across the network and shared with other devices through simple read and write commands. If device A is reading a temperature value from device B, the fact that it is a LonMark defined SNVT means that each device knows exactly what to expect in terms of range, resolution and format.

Therefore, a temperature sensor or space comfort controller from one vendor will have a minimum subset of input and output network variables identical to devices with the same profile from other vendors. Each device has an external interface file (XIF), which defines the functional profiles and resulting network variables supported by each product. Therefore, the systems integrators can anticipate what variables will be available from a device and what format they will be in.

Because devices on a LonWorks network are all peers, the network is essentially flat, even though there may be some hierarchal structure built in to the network topology in order to manage network traffic or wiring considerations. Because of the flat architecture, data may be passed easily from one device to another. As with BACnet, data can be passed either through a poll/response or broadcast scheme where one device will "push" its data to other devices by way of a change of value or heartbeat scheme. Because each interoperable device on the network understands the supported data types, the messages passed between devices tend to be small and extremely efficient. Most devices on a LonWorks network rely on a COV or heartbeat scheme, or binding, which allows device-to-device communications to be very efficient.

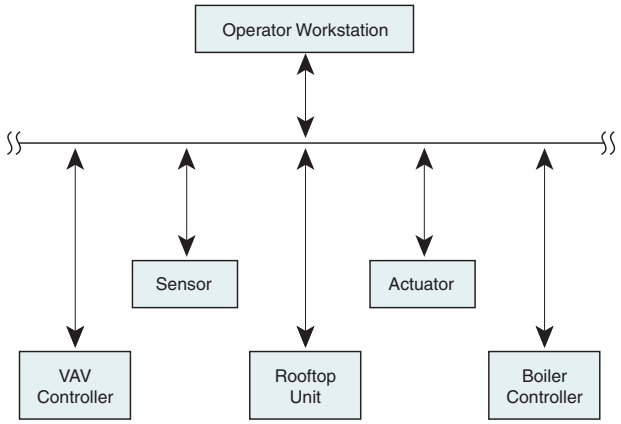


Figure 4-3. Peer devices on a LonWorks network.

Interoperability

Many BMS vendors have responded by supporting both the BACnet and LonTalk protocols, at the room-level, floor-level and enterprise-level. This opened the door for many smaller companies to develop sensors, actuators and controllers that are highly interoperable with the majority of building automation systems on the market.

BACnet and LonTalk have been implemented in every type of device from wall switches to Internet-based, multi-building, data management systems. To ensure interoperability, organizations, such as the BACnet Testing Laboratory and LonMark International, established guidelines and testing protocols to determine the interoperability of products. This gives owners and engineers many choices when selecting equipment to be used in their buildings – whether it is based on price, features, quality, or brand loyalty.

One of the most important features of the Theris system is its ability to seamlessly integrate thousands of points from hundreds of hospital rooms through a single connection to the BMS. Flow data and comfort control data, along with miscellaneous points picked up through hard-wired connections are made available to the BMS system for trending, scheduling, alarming and display on operator workstations.

While Phoenix Controls believes LonWorks is an excellent communications protocol for peer-to-peer control architecture, we also believe that BACnet is better suited to manage large numbers of devices and points in a consistent manner.

Phoenix Controls offers two networked-based control platforms: LonMark or BACnet.

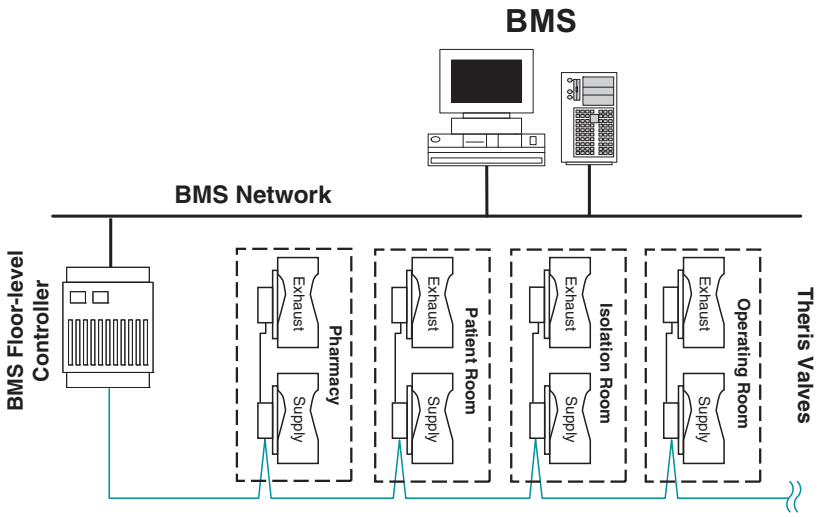
The Theris Family of Valves uses LonWorks technology incorporated into a valve mounted room controller to integrate flow and temperature data directly onto the BMS vendors LonWorks bus. Theris is LonMark certified as a Space Comfort Controller, Variable Air Volume (SCCVAV Object type 8502). The Theris system provides ventilation, pressurization and comfort control for healthcare spaces.

Theris valves can reside on a BACnet network as well with the same functionality. There are two options to integrate BACnet with the BMS network. The preferred method is to use the open protocol and have Theris controllers reside on the BMS vendors BACnet bus. The second option is to use of one of the Celeris LonTalk to BACnet data servers (known as MicroServer or MacroServer) and have a series of routers interact with the BMS network.

Integrating the Theris Family of Valves

Theris is a standalone, valve-mounted, room-level controller. It has sufficient physical inputs and outputs to connect all of the temperature sensing and control elements, as well as two (LonWorks) or three(BACnet)variable air volume flow control valves, to control the ventilation rate, volumetric off set and space comfort. It offers a more cost-effective solution for environmental control for the basic room-level control functions than the Celeris product line and allows for direct integration on the BMS vendor's LonWorks or BACnet communications network.

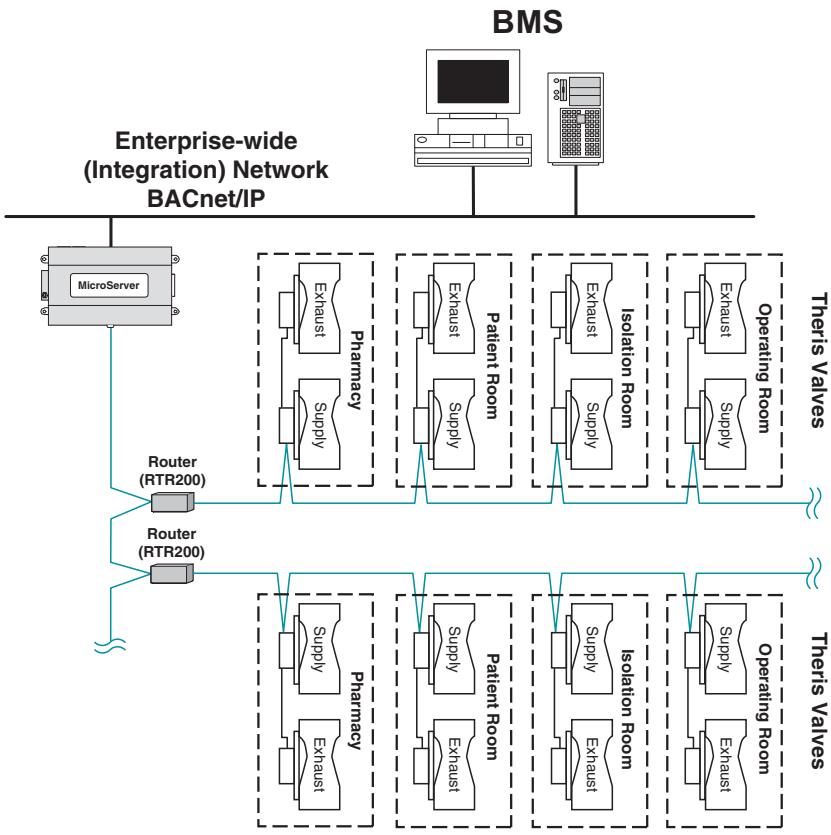
Figure 4-4. An integrated network with Theris Family of Valves.



As a standalone device, Theris implements the desired room-level control strategy, as well as passing desired data to the BMS system. Because Theris communicates on the 78 K FTT-10 communications channel, it will connect to the BMS through a floor- or room-level controller in most instances.

Theris can reside on the same network as other LonWorks or BACnet-based devices do. Standard guidelines for the number of devices and network topologies apply. Theris supports a large complement of network variables that support either binding or polling.

For larger installations, routers and repeaters may be used to extend the network. Theris can be connected to any Celeris network and integrated through either a MicroServer or MacroServer.



NOTE: A MacroServer may be used instead of a MicroServer.

Figure 4-5. An integrated Theris network extended with routers.

Points Available for Integration in the Theris Family of Valves

Zone Balance Control

- Auxiliary supply flow demand percent (read-write)
- BMS zone flow offset set point (read-write)
- Effective zone volumetric offset set point (read only)
- Zone volumetric offset feedback (read only)
- BMS minimum supply flow set point (read-write)
- Supply valve flow set point (read only)
- Supply valve flow feedback (read only)
- Exhaust valve flow feedback (read only)
- Zone total supply flow (read only)
- Zone total exhaust flow (read only)
- BMS HVAC flow override command (read-write)
- BMS HVAC emergency override (read-write)
- Unit status output (read only)
- Application mode input (read-write)
- Current alarm status of all alarm bits (read only)
- Summary of alarm activity (read only)
- Exhaust valve flow set points (read only)

Temperature Control

- Space temperature sensor input (read-write)
- Occupied temperature set point (read-write)
- Occupied temperature set point offset input (read-write)
- Effective primary temperature control loop set point (read only)
- Effective space temperature (read only)
- Auxiliary temperature set point input (read-write)
- Auxiliary temperature control loop command (read only)
- Unoccupied cooling set point (read-write)
- Unoccupied heating set point (read-write)
- Discharge air temperature (read only)
- Terminal load (read only)
- Local temperature set point lever enable/scaling input (read-write)

Occupancy Control

- Occupancy override input (read-write)
- Occupied sensor input (read-write)
- Occupancy mode status (read only)
- Bypass active remaining time output (read only)

Integration Partners

BACnet integration continues to be the primary method to integrate with various BMS vendors. Interoperability is an ongoing process and we continuously qualify and refine interfaces with a large number of integration partners.

Current integration partners include:

- Alerton
- American Automatrix
- Andover Controls
- Automated Logic
- Carrier
- Cimetrics BACnet/OPC
- Delta
- Eagle Technology
- Honeywell
- Intellution iFix
- Invensys
- Johnson Controls
- Reliable Controls
- SCADA Engine
- Siemens
- TAC
- Tridium
- Trane
- WonderWare

Note: Each BMS vendor will require unique hardware and software on their end to accomplish this integration. Phoenix Controls is committed to creating integration partners and will work with the BMS vendor of choice to create the necessary interface to accomplish the system integration for a building owner. Contact Phoenix Controls for the current status of BMS vendor integration solutions.

Although Theris is fully interoperable, the system can operate as an independent, standalone control solution. All control, fail-safe and alarm strategies are implemented at the room level. All control, system status, and alarm data are available to the BMS, and as a convenience, many set points may be written by an operator from the BMS workstation.

5 System Components

This chapter describes all of the components in the Phoenix Controls healthcare product line. These components are engineered to deliver reliable, effective control.

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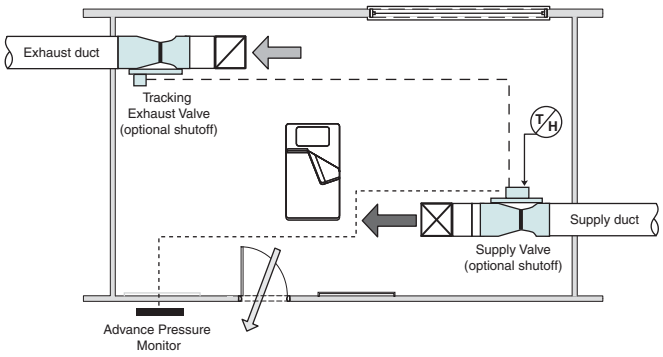
Theris® Family of Valves

Phoenix Controls Theris Family of Valves are designed specifically for the ventilation requirements of critical spaces in healthcare facilities, where infection control, energy savings and reducing maintenance costs are an important part of business operations. Theris provides constant volume (CV) and variable air volume (VAV) solutions for directional airflow, climate control, and overall ventilation balance.



System Benefits

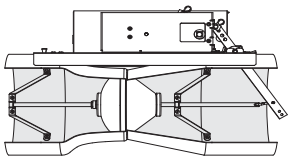
- Factory characterization reduces system commissioning time
- Pressure-independent valves avoid rebalancing costs
- No flow sensors to maintain
- High turndowns ratios contribute to reducing energy costs

Product	Description
Theris-TP (Tracking Pair VAV) LON/BACnet	To meet the need of directional airflow, Theris-TP features tracking valve pairs that maintain a prescribed CFM offset to enable accurate space pressurization and complete room climate control.
Theris-TX-RTN (Enhanced Tracking Pair VAV) BACnet	For tracking pair applications in isolation rooms, operating rooms, and other spaces, Theris-TX provides extra I/O to meet the needs of humidity control and pressure monitoring, plus optional return valve; all with shut-off capability for decontamination procedures or pandemic mode.
Theris-TX (Enhanced Tracking Pair VAV) LON	For tracking pair applications in isolation rooms, operating rooms, and other spaces, Theris-TX provides extra I/O to meet the needs of humidity control and pressure monitoring, plus optional shut-off capability for decontamination procedures.
Theris-SO/EO (Supply-only VAV or Exhaust) SO—LON/BACnet EO—BACnet	In VAV applications where ducted exhaust is sufficient to meet local codes and engineering guidelines, Theris-EO/SO provides a cost-effective main valve when no tracking exhaust valve is required.
Theris-CV (Constant Volume) LON/BACnet	For fixed-flow operation and stable airflow throughout the facility, Theris-CV provides a solution for constant volume supply and exhaust applications.
Theris-EXH (Tracking Pair) BACnet	Along with many of the standard TX tracking pair features, TX-EXH provides the ability to locally control an additional exhaust valve without an additional controller (3 valves - 1 controller).

Specifications

Performance	Pressure independent over a 0.3"-3.0" WC (74-747 Pa) drop across valve Volume control accurate to ±5% of airflow command signal No additional straight duct runs needed before or after valve Available in flows from 35-5000 CFM (59-8495 m^3/hr) Response time to change in command signal: <1 minute
Performance	Pressure independent over a 0.3"-3.0" WC (74-747 Pa) drop across valve Volume control accurate to ±5% of airflow command signal No additional straight duct runs needed before or after valve Available in flows from 35-5000 CFM (59-8495 m^3/hr) Response time to change in command signal: <1 minute
Power Requirement	24 Vac (±15%) @ 50/60 Hz
Power Consumption (using Proportional Reheat Control)	Single 8", 10", 12": 13 VA; Single 14": 20VA Dual 10", 12", 14": 20 VA
Power Consumption (using Floating Point Reheat Control)	Single 8", 10", 12": 20 VA; Single 14": 26VA Dual 10", 12", 14": 26 VA
Input Accuracy	Voltage, current, resistance: ±1% full scale
Output Accuracy	0 to 10 Vdc: ±1% full scale into 10 KΩ minimum 4 to 20 mA: ±1% full scale into 500 Ω +0/-50 Ω
Interoperability	Based on LONWORKS technology for peer-to-peer communication between room controllers LonMark certified according to the Interoperability Guidelines Version 3.4 LonMark functional profile SCC-VAV #8502
Agency Compliance	LONMARK 3.4 CE c SP US
Room-level Communications	FTT-10, 78 KB, LonTalk™ network

Shut-off Valve (Digital)



Shut-off Valve (shown in shut-off position)

Phoenix Controls Shut-off Valves are intended for use in critical airflow applications, where isolating the HVAC system from the room is necessary. Under normal operation, it provides the critical airflow control performance demanded by a modern research facility. In the shut-off mode, it provides low leakage isolation of the HVAC system from the room. An example of a typical application is a laboratory research building space using gaseous biodecontamination.

- The shut-off sequence can be initiated either locally through a universal input or remotely via the Celeris network—either from the building management system (BMS) or Local Display Unit (LDU).
- Shut-off confirmation is available through a local digital output (DO) or an integrated point.
- Can operate as a standalone device or in a fully integrated system.

Features

Feature/Option	Celeris EXV/MAV		Theris TSV/TEV
Control type	**L**	**M**	**TX**
Actuator type	Low-speed electric	High-speed electric	Normal
Response time	< 1 minute	< 1 second	< 1 minute
Control platform	Celeris	Celeris	Traccel
Failsafe	Fail to last position	NO/NC/Last Position	Fail to last position
Shut-off mode activation	Local UI or remote via Celeris network	Local UI or remote via Celeris network	Local UI or remote via Traccel network
Flow alarm via feedback circuit	Yes	Yes	Yes
Flow alarm via pressure switch	Option	Option	Option
Shut-off function	Yes	Yes	Yes
Factory-insulated valve body	Supply valve only	Supply Valve Only	Supply Valve Only

Specifications

Performance	Pressure independent over a 0.6"-3.0" WC (150-750 Pa) drop across valve Volume control accurate to ±5% of airflow command signal throughout normal operating range No additional straight duct runs needed before or after valve Available in flows from 50-2600 CFM (85-2888 m^3/hr)
Power Requirement	24 Vac (±15%) @ 50/60 Hz
Power Consumption (using Proportional Reheat Control)	Single 8", 10", 12": 13 VA; Single 14": 20VA Dual 10", 12", 14": 20 VA
Power Consumption (using Floating Point Reheat Control)	Single 8", 10", 12": 20 VA; Single 14": 26VA Dual 10", 12", 14": 26 VA
Input Accuracy	Voltage, current, resistance: ±1% full scale
Output Accuracy	0 to 10 Vdc: ±1% full scale into 10 KΩ minimum 4 to 20 mA: ±1% full scale into 500 Ω +0/-50 Ω
Interoperability	Based on LONWORKS technology for peer-to-peer communication between room controllers LonMark certified according to the Interoperability Guidelines Version 3.4 LonMark functional profile SCC-VAV #8502
Agency Compliance	LONMARK 3.4
Room-level Communications	FTT-10, 78 KB, bus topology, LonTalk™ network
Building-level Communications	TP-1250, 1.2 MB, bus topology, LonTalk™ network

Programmable Control Module (PCM)

Programmable Control Module

The Phoenix Controls Programmable Control Module (PCM) series provides a means of connecting additional inputs and outputs to the Celeris®, Theris® and Traccel® LonMark® and BACnet® room-level network and developing custom control sequences to enhance the control functions already provided. The PCM offers varying numbers of configurable input and output connections, a graphical programming interface for developing custom control applications. The PCM adds tremendous power and flexibility to the Phoenix Controls environmental control system. The graphical programming interface makes developing custom control sequences simple and efficient.

Features

- Interfaces with Celeris, Theris and Traccel room-level networks (BACnet and LonMark)
- 4, 6, 10, and 12 universal inputs (PCM200 Series); 6, 10, and 12 universal inputs (PCM500 Series)
- 6, 8 and 12 universal/digital outputs (PCM200 Series); 8 and 12 universal/digital outputs (PCM500 Series)
- Graphical block-oriented programming
- DIN rail or surface mounting (PCM200 is surface mount only)
- Separable housing allows removal of controller from wiring base

Specifications

Enclosure	ABS type PA-765-A tan enclosures with gray connectors
Dimensions	PCM200—4.8" x 5.9" x 2.5" (122.5 x 149.1 x 63.0 mm) PCM201,PCM202,PCM501,PCM502—5.7" x 4.7" x 2.0" (144.8 x 119.4 x 50.8 mm) PCM203, PCM503—7.7" x 4.7" x 2.0" (195.6 x 119.4 x 50.8 mm)
Environmental	**PCM200 Series** Operating temperature 32 °F to 158 °F (0 °C to 70 °C) Storage temperature -4 °F to 158 °F (-20 °C to 70 °C) Relative humidity 0 to 90% non-condensing **PCM500 Series** Operating temperature 32 °F to 122 °F (0 °C to 50 °C) Storage temperature -4 °F to 122 °F (-20 °C to 50 °C) Relative humidity 0 to 90% non-condensing
Power Inputs	Voltage 24 Vac; ±15%, 50/60 Hz (PCM200 only) Voltage 24 Vac/Vdc; ±15%, 50/60 Hz (PCM201, PCM202, PCM203, PCM501, PCM502, PCM503)
Power Consumption	PCM200—18 VA (typical) / - 85 VA (maximum), PCM201—18 VA (typical) / - 25 VA (maximum), PCM202—18 VA (typical) / - 33 VA (maximum), PCM203—18 VA (typical) / - 50 VA (maximum), PCM501—14 VA (typical) / - 23 VA (maximum), PCM502—16 VA (typical) / - 33 VA (maximum), PCM503—22 VA (typical) / - 60 VA (maximum)
General Specifications	Processor: Neuron® 3150®; 8 bits; 10 MHz (PCM200 Series) Communication: LonTalk® protocol Clock: Real-time clock chip[1, 3] Battery (for clock only): CR2032 Lithium (for clock)[1] Status indicator: - Green LEDs: power status and LON TX[2] (PCM200 Series), power status and LAN TX (PCM500 Series) - Orange LEDs: service and LON RX[2] (PCM200 Series), service and LAN RX (PCM500 Series) Communication Jack: LON® audio jack mono 1/8" (3.5 mm) Inputs/Outputs: Type and quantity of I/O are determined by model number [1] PCM200 and PCM201 do not have a clock function [2] All except PCM200 [3] Battery backup (PCM502 and PCM503 only)
Agency Compliance	CE FC c UL us LISTED

Advanced Pressure Monitor II (APM2)

Advanced Pressure Monitor II

The Advanced Pressure Monitor II (APM2) is a flexible, touch-screen local display unit that measures pressure, temperature, humidity, and air change rate for pressurized spaces for the purpose of ensuring integrity of ventilation and airflow. BACnet® communications enable a number of advanced features, and allows the APM2 to integrate seamlessly with Phoenix Controls Traccel® and Theris® family of BACnet valve controllers. One APM2 is also capable of supporting two rooms when used with optional accessories.

The APM2 provides a bright, easy-to-read display that combines a free-form message banner on the left one-third of the screen, together with dynamic room operating parameters on the right two-thirds of the screen. The touch-screen display makes the APM2 easy to operate by just pressing areas of the screen to perform functions. Nuisance alarms are virtually eliminated because of the high accuracy and reliability of the APM2, and through the use of eight types of alarm functions. If desired, the APM2 can be configured so it never needs to be touched by staff on the floor.

Features

- 4.3" Color touch-screen TFT display
- Option to monitor two spaces
- Message banner informs staff of room condition
- Two levels of password protection
- Visual/audible local or remote alarming
- Mounts in standard electrical box
- Occupancy control using the Message Banner
- On-screen temperature control via BACnet valve controller
- Resistant to spray washdown (IP-54)
- French language home screen and keyboard

Specifications

Choice of Full Scale Ranges **Bi-Directional**	±0.05" W.C. (±12.45 Pa) ±0.10" W.C. (±24.91 Pa) ±0.25" W.C. (±62.27 Pa) ±0.50" W.C. (±124.54 Pa) ±1.00" W.C. (±249.09 Pa)
OverPressure	±1 PSI (27 inches of water)
Performance Data	Accuracy RSS (at constant temp) Code V ±0.25% Code E ±0.5% Stability per year ±1.0% FS
Pressure Media	Air, or non-conductive non-explosive gases
Power	18-32 Vac, 50-60Hz, non-isolated, resettable fuse, 9.6 VA maximum
2 Analog Inputs	0-10V for optional external pressure transducer or to switch polarity of pressure alarm setpoints
1 Digital Input	For door switch, pressure switch or alarm contact input
1 Analog Output	0-10 Vdc or 4-20 mA filter output of primary pressure sensor
1 Digital Output	SPDT alarm output
Agency Compliance	CE

Accuracy

Using pressure transducer technology, the APM2 is capable of sensing at a 0.5% (±0.25%) full scale accuracy and with a display resolution up to 0.0001"WC.

Advanced Pressure Monitor II (APM2) Central Display

Advanced Pressure Monitor II Central Display

The Central Display is a remote touch-screen display that monitors the status of several Advanced Pressure Monitor II (APM2) BACnet® units installed on a floor. Using the Central Display, users are able to immediately see if rooms are safe and operating properly without walking to the APM2 mounted outside a room. Up to eight (8) APM2s can be monitored using one Central Display, providing easy access to view room conditions and to hear alarms remotely.

The Central Display has a bright, easy-to-read display and touch-screen that makes it easy to operate by just pressing areas of the screen to perform functions. From the home screen, touching any room status on the Central Display shows all of the screen information being displayed on the remote APM2, including room label, alarms, active or standby condition, occupied and unoccupied condition, pressure, temperature, humidity, door status, and air change rate. The Central Display also has a configurable audible alarm feature which will notify operators if an alarm condition is present on a remote APM2.

Features

- 4.3" Color touch-screen TFT display
- Audible alarming from remote APM2 units
- One-touch access to remote APM2 information
- Password protection
- Visual/audible local or remote alarming
- Mounts in standard electrical box
- Status of up to eight (8) rooms on a single display
- Auto-discovery of remote APM2 units
- Resistant to spray washdown (IP-54)
- Clone configuration feature / Software upgradeable

Specifications

Environmental Data	Operating °F (°C) - 32 to +120 (0 to +50) Storage °F (°C) - -20 to +160 (-30 to +70)
Operating Humidity	5 to 95% RH (non-condensing)
Power	18-32 Vac, 50-60Hz, non-isolated, resettable fuse, 9.6 VA maximum
Communications	3-conductor, twisted, shielded 22 AWG cable
Agency Compliance	CE

PC Optimizer

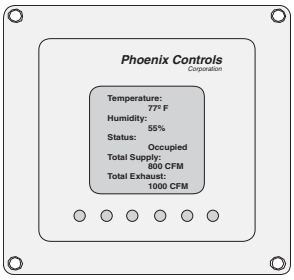
PC Optimizer™

The PC Optimizer™ is a cross-market analysis tool including healthcare and life sciences modeling. Inputting project-specific data used in standard engineering (ASHRAE) calculations will return energy consumption, savings, and cost comparisons between Phoenix Controls products and their alternatives. Essentially this is intended for go / no go analysis for product selection and not for the extensive energy analysis found in DOE-like programs. Unlike other HVAC modeling programs, within minutes a very accurate representation if a building's HVAC operational cost can be obtained and easily identify ROI for the project.

Features

- **Wizard style user interface** - PC Optimizer is designed for ease of use. The intuitive interface will guide you through the program to ensure all required fields are filled in to perform an analysis. In addition to the intuitive progression, there is quick help access to answer all of your questions.
- **Better reporting** - Sustainability measures are just as important as monetary ones. Reporting from PC Optimizer will demonstrate how Phoenix Controls can help achieve these goals by producing standard Department of Energy Metrics.
- **More accurate VAV modeling** - Flexibility is at the heart of this program. PC Optimizer provides the ability to model constant volume, two-state, and VAV systems for a 24x7 analysis or just a simple design day. In addition, PC Optimizer provides the best alternative to perform a true VAV analysis based on building envelope without having to incorporate the complications of a load modeling software.
- **Simple or detailed analysis** - You can be as precise or as simplistic as desired. PC Optimizer allows a user to model an in-depth or quick analysis to determine airflow paybacks and demands for a single room or an entire building.
- **What-if analysis** - A robust what-if analysis will show true value of Phoenix Controls over the competition and make sure building are being designed as efficiently as possible. See what happens if turndowns are increased by a percentage vs. adjusting static pressure. Or see how much energy can be saved by varying the deadband for all of your spaces.

Note: A copy of the PC Optimizer can be obtained for free by visiting our web site at: https://www.phoenixcontrols.com/resource-pc-optimizer.htm.



Local Display Unit

Local Display Unit

The Local Display Unit (LDU) is a networked-based user interface panel intended to display data and/or edit set point variables for vivariums, biocontainment or laboratory spaces maintained by the Celeris® or Traccel Environmental Control System. The LDU may be flush or surface mounted on a variety of electrical enclosures. It is intended to be installed in corridors outside of critical environments to provide users with information related to operating conditions inside the space. The LDU can display up to five parameters simultaneously. Each parameter includes a 16-character user defined description and the present value, including units of measure.

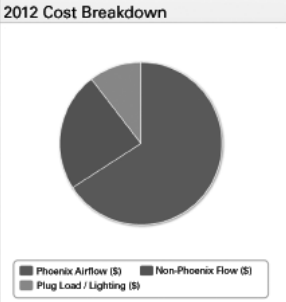
The LDU connects to the Celeris or Traccel room-level network and may be used to display flow, temperature, humidity, control or set point variables available on the Celeris network.

Features

- 128x128 pixel, backlit LCD display measures 2.1" (5.5 cm) square
- Available in flush mount or surface mount
- Connects to either Celeris or Traccel room-level network
- 50 display windows of up to 5 values
  - 10 line display
  - 5 values
  - 5 descriptions (up to 16 characters)

Specifications

Power Voltage	24 Vdc/Vac; ±15%, 50/60 Hz
Power Consumption	8 VA (13 VA maximum)
Communication	LonTalk® protocol
Transceiver	TP/FT-10, 78 kbps
Enclosure	Material: ABS resin Color: Off-white
Dimensions	Flush mount: 6" x 6" x 1.5" (151 x 151 x 38 mm) Surface mount: 4.5" x 4.5" x 1.5" (113 x 113 x 38 mm)



Supervisor Screen Image

Supervisor

Phoenix Controls Supervisor software is used to visualize data from critical environments using Phoenix Controls airflow control systems, sensors, and monitors. Real-time data is collected from Phoenix Controls MacroServers™ or MicroServers™. Data can also be pulled from any third party device on a facility's BACnet® network.

The information is graphically displayed as dashboard web pages on a standard HTML5 enabled web browser. Dashboard pages can include energy management, safety, compliance monitoring, and equipment maintenance and diagnostics. Functions such as centralized data logging, historical data trending, alarming, and optional archiving to enterprise class databases are included in this software.

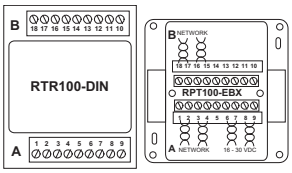
Dashboard displays can be used as is or customized to the facility, including creating views based on individual users. The dashboards supplement building automation system (BAS) information and provide more data than is typically integrated to the BAS.

Features

- Standard dashboard web pages for energy management, safety monitoring, and equipment maintenance
- HTML5 web-based graphical user interface
- Can display up to 1,000 dashboard points with options to provide additional points in increments of 500 up to 12000
- Individual users can customize dashboards to their own views
- Displays real-time as well as historical data
- Non-invasive, flexible installation with existing or new integrations
- Smart import for MicroServers and MacroServers for quick job startup
- Integrates with BACnet IP or BACnet Ethernet
- Supports visualization of third-party BACnet devices
- Native functions include centralized data logging, historical data trending and reporting package
- Enterprise-level information exchange using an SQL database and HTTP/HTML/XML text formats
- Security and password protection using standard Java authentication and encryption techniques
- Optional security via an external LDAP connection
- Exports archived trend and alarm data to SQL
- Supports standard Niagara objects and feature set components

Specifications

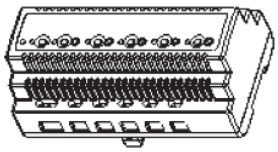
Processor	Intel Pentium™ IV, 2 Ghz or higher, Core 2 Duo also acceptable
Operating System	- Microsoft® Windows® XP Professional SP3 32-bit - Microsoft® Windows® 2008 Server (if Microsoft IIS is disabled) 64-bit - Microsoft® Windows® 7 Professional, 32- or 64-bit - Microsoft® Windows® 7 Enterprise, 32- or 64-bit
Web Browsers	- Microsoft® Internet Explorer® 9 or later - Google Chrome 24 or later - Mozilla Firefox® 18 or later - Apple Safari 5 or later
Memory	1 GB minimum, 2 GB or more recommended for large systems, 8 GB or more recommended for the Windows 64-bit version



RTR100 and RPT100 modules

Router and Repeater Modules

The Phoenix Controls control system relies on router (RTR) and repeater (RPT) modules to optimize communications for the LonTalk communications bus. Routers isolate groups of nodes into subnets, which represent groups of Celeris nodes performing specific control functions. The multi-port router (RTR104) connects four room-level networks to the building-level network through a signal connection. Repeater modules extend the building-level network when longer runs are required.



RTR104 module (multi-port router)

Features

- Versatile mounting:
  - 4" sq. electrical junction box
  - DIN rail mount
- Polarity insensitive communications wiring
- Individual power and network status indicators
- Routers isolate room-level network to ensure reliable communications up to 8500 feet (2700 meters)
  - Lab spaces–20 nodes
  - Tracking pairs–32 nodes
- Repeaters extend the building-level network beyond 425 feet.

Additional features of the multi-port router (RTR104)

- The multi-port router (RTR104) can connect up to:
  - Four FTT-10, 78 kbps room-level networks
  - One TP-1250, 1.25 mbps building-level network
- Built-in diagnostic function

Specifications

	RTR100 and 200, RPT100	RTR104
Power	16 to 30 volts AC or DC, 2 VA maximum Must be powered by Class 2 circuit	9-28 Vac (40-70 Hz) 9-35 Vdc 500 mA maximum current
Dimensions	- DIN—6.3" H x 3.9" W x 1.64" D (16 cm x 10 cm x 4.2 cm) - EBX—3.9" sq x 1.75" (10 cm sq x 4.4 cm)	35" H x 6.2" W x 2.6" D (8.9 cm x 15.8 cm x 6.6 cm)
Communication	RTR10x—78 kbps to 1.25 mbps RTR200—78 kbps to 78 kbps RPT—1.25 mbps to 1.25 mbps	RTR104-(4) 78 kbps to (1) 1.25 mbps
Agency Compliance	CE FC c UL us LISTED	

MacroServer™

Integration Servers: MacroServer™ and MicroServer™

The Phoenix Controls Celeris® MacroServer and MicroServer function as data servers interfacing with the Celeris LonWorks®-based environmental control system and BACnet® capable Building Management System (BMS). The MacroServer may be oriented horizontal or vertical and there is an optional rack-mount sliding shelf.

The servers perform bidirectional translations between LonTalk and BACnet to manage read requests and write commands between the BMS and the Celeris room-level devices, ensuring safe and reliable communications.

The servers concentrate data, collecting from hundreds or thousands of points from room-level devices and making this data available to the BMS via a single Ethernet or IP connection.

The MacroServer also hosts the Celeris LNS database, a Configuration plug-in, and several diagnostic utilities.

Integration flexibility with most BMS vendors offering BACnet.

MacroServer™—Rack-Mount

MicroServer™

Features

MacroServer	MicroServer
• Supports up to 1500 devices or 6000 points. • 56K modem for remote configuration and troubleshooting. • Self-ventilated enclosure. • Built on a server-class computer platform. • Primary/Secondary hard drives for backup and quick recovery. • Both tower and rack mount configurations are available	• Supports up to 35 devices or 350 points. • Small, compact enclosure. • All solid-state construction - no fans or hard drives. • Internal battery provides secure shutdown on power loss and stability over power fluctuations. • Flexible mounting options.

Specifications

MacroServer	MicroServer
Enclosure Tower server enclosure 19" Rack mount option	**Enclosure** Plastic, DIN rail or screw-mount chassis, plastic cover Cooling–Internal air convection
Operating Temperature Range 50-95 °F (10-35 °C) ambient **Operating Humidity Range** 20-80%, non-condensing	**Operating Temperature Range** 32-122 °F (0-50 °C) **Operating Humidity Range** 5-95%, non-condensing
Power Requirements 275-watt high efficiency auto-sensing power supply, 90 TO 264 Vac, 50/60 Hz	**Power Requirements** Choose from these power supply configurations: PWR—DIN rail mounted 24 Vac/DC power supply module (8.5 VA AC/8.5W DC) Wall mount power modules Universal input–90-264 Vac @ 0.5A, 50/60 Hz, 15Vdc @ 1 A, Power cord is 70" (1.8 m) long
Operating System Windows 7 Professional	**Operating System** QNX RTOS IBM J9 JVM Java Virtual Machine NiagaraAX
Data Ports - 4 USB ports in front and 6 USB ports in back - 1 internal 16x DVD-ROM drive - 2 internal SATA drives, 250 GB each (minimum)	**Data Ports** - 2 Ethernet ports, 10/100 mbps (RJ-45 connectors) - 1 RS 232 Port (9 pin D-shell connector) - 1 RS 485 non-isolated port (3-screw connector on base board) - 1-78 kbps FTT10 A LonTalk (pluggable TP connector 22 AWG)
Agency Compliance	

Communication Protocols

	MacroServer	MicroServer
BMS Network Protocol		
BMS Protocol	BACnet over Ethernet BACnet over IP RJ45	BACnet over Ethernet BACnet over IP 10/100 BaseT, RJ45
Implementation	BIBBS—ASC (Application Specific Controller)	BIBBS—BBC (BACnet Building Controller)
Data transfer rates (points per second)	Read requests/second: 100 sustained 300 peak Write commands/second: 30 maximum	Read requests/second: 50 sustained 100 peak Write commands/second: 30 maximum
Room-level Network Protocol		
Building network	ANSI 709.1–LonTalk protocol TP1250 transceiver	ANSI 709.1–LonTalk protocol FTT-10 transceiver
Celeris network connection	22 AWG, Level IV, twisted-pair cable	22 AWG, Level IV, twisted-pair cable

Fan Static Reset Kit

Fan Static Reset Kit

The Fan Static Reset Kit accurately measures the static pressure drop across a clean air valve and provides feedback to the Building Management System (BMS) to optimize fan control. The sensor is housed in a rugged polycarbonate enclosure, which mounts directly to the valve base channel and has a 3-wire connection to the valve mounted controller for power and signal. Two pressure pickups, two pressure dampers and two, six foot lengths of silicon tubing are included for mounting upstream and downstream of the valve to obtain optimized pressure readings. One device with a range of 0.0 to 5.0" W.C. covers both medium and low pressure valves and allows for dynamic fan control to reduce energy consumption under varying flow conditions.

Specifications

Pressure Transmitter	
Pressure Range	0 to 5" W.C. (0 to 1.245 Pa)
Output Voltage	0.25 to 4.0 Vdc
Zero Pressure Output	0.25 ±0.06 Vdc
Accuracy	1.5% of span (0.0 to 3.0" W.C. at 75° F) (0 to 747 Pa at 23.9° C) 2.0% of span (3.0 to 5.0" W.C at 75° F) (747 to 1245 Pa at 23.9° C)
Proof Pressure	1 PSI either Port (6.9K Pa) (performance will be affected)
Burst Pressure	1.5 PSI either Port (10.4K Pa)
Corrosion Resistance	Pressure sensor is suitable for clean, non-corrosive, non-condensing air only
Supply Voltage	7 to 32 Vac or 7 to 40 Vdc
Power Consumption	0.12 VA maximum
Storage Temperature	40 °F to 203° F (-40° C to 95° C)
Operating Temperature	32° F to 140° F (0° C to 60° C)
Temperature Error	±2% of Span (Over the Operating Temperature Range)

PTC Series Thermostats

PTC Series Thermostats

The Phoenix Controls PTC Series Thermostats are specifically designed for room applications where constant volume valves are used and there is a need for local hydronic reheat control.

The product features a backlit LCD display with dedicated function menu keys for simple operation. Accurate temperature control is achieved due with a Proportional Integral (PI) control algorithm, which virtually eliminates temperature drift associated with traditional, differential-based thermostats. Models are available for three point floating and analog 0 to 10 Vdc control. In addition remote room sensing is available.

All models contain a Single Pole, Single Throw (SPST) auxiliary switch that can be used to control lighting or auxiliary reheat. Three additional inputs are also provided for monitoring and/or various advanced functions.

All devices include a LonTalk® or BACnet MS/TP network adapter.

The thermostats are also compatible with a Passive Infrared (PIR) cover. Thermostats using the optional PIR cover provide advanced active occupancy logic, which will automatically switch occupancy levels from Occupied to Stand-By and Unoccupied as required by local activity being present or not. This advanced occupancy functionality provides advantageous energy savings during occupied hours without sacrificing occupant comfort.

Features

- Advanced occupancy functions
- Ready for PIR access cover
- Three configurable inputs
- Preconfigured sequences of operation
- Available for 24 Vac On/Off, Floating or Analog reheat control
- Lockable keypad
- Configuration setup utility
- Auxiliary output
- LonTalk or BACnet communications
- Preconfigured default values for standby setpoints and PIR timer settings

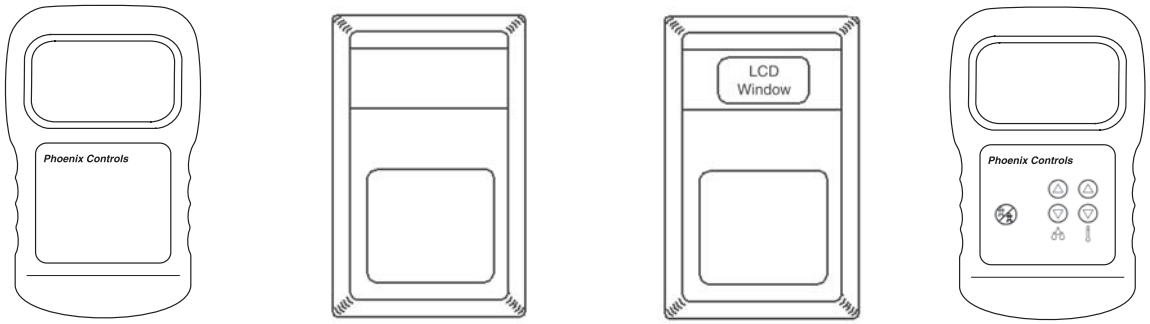
Specifications

Power	24 Vac (19-30 Vac range), 50/60 Hz, 2 VA Class 2
PIR Cover Power Requirement	5 Vdc current draw of 7 mA
Binary Inputs	Dry contact across terminal BI1, BI2 and UI3 to Scom
Contact Output Rating	Triac output: 30 Vac, 1 Amp. Maximum, 3 Amp in-rush Analog: 0 to 10 Vdc into 2k ohm resistance minimum
Temperature Sensor Resolution	±0.9 °F @ 70 °F (21 °C) typical calibrated
Temperature Control Accuracy	±0.9 °F @ 70 °F (21 °C) typical calibrated
Occ. Stand-by and Unocc Cooling Set Point Range	54-100 °F (12-37.5 °C)
Room and Ourdoor Temperature Display Range	-40-122 °F (-40-50 °C)
Proportional Band for Room Temperature Control	Cooling and Heating: 3.2 °F (1.8 °C)
Approvals (all models)	LONMARK 3.4

Temperature and Humidity Sensors

Phoenix Controls temperature, humidity and air quality sensors provide a stable, secure environment for those facilities that need it the most, such as hospitals, research facility laboratories and cleanrooms. These sensors also simplify room balancing by eliminating the need for a certified person to accompany the balancer during the commissioning process.

- Teflon-insulated wires ensure resistance to moisture, corrosive elements and abrasion.
- A three-position test and balance (T&B) switch allows for overrides into full heating or cooling modes, as well as for normal operation.



Sensors—Wall mount styles available with and without display

Specifications

	Temperature		Humidity and Combination		
	Room	**Duct**	**Room**	**Duct**	**Outside**
Signal	10K, Type 2 thermistor	10K, Type 2 thermistor	4 to 20 mA (output)	4 to 20 mA (output)	4 to 20 mA (output)
Supply Voltage	5 to 25 Vdc (LCD only)	—	15 to 24 Vdc (current or voltage output)	—	—
Power Consumption	< 0.2 VA	—	< 1.1 VA	—	—
Operating Temperature Range	-67 to 302 °F (-55 to 150 °C)	-67 to 302 °F (-55 to 150 °C)	32 to 158 °F (0 to 70 °C)	-10 to 160 °F (-23 to 71 °C)	-10 to 160 °F (-23 to 71 °C)
Environmental Temperature Range	32 to 122 °F (0 to 50 °C)	-40 to 212 °F (-40 to 100 °C)	32 to 122 °F (0 to 50 °C)	-22 to 150 °F (-30 to 70 °C)	-22 to 158 °F (-30 to 70 °C)
Environmental Humidity Range	0 to 95% RH (non-condensing)	0 to 100% RH (non-condensing)	0 to 95% RH (non-condensing)	0 to 100% RH	0 to 100% RH
Housing Material	ABS plastic	Steel	ABS plastic	Weatherproof cast aluminum	Weatherproof cast aluminum
Accuracy	±0.2 °C (0 to 70 °C)	±0.2 °C (0 to 70 °C)	±2% from 15 to 95% RH at 25 °C	±2% from 15 to 95% RH at 25 °C	±2% from 15 to 95% RH at 25 °C
Dissipation Constant	3 mW/C	3 mW/C	—	—	—
Stability	< 0.02 °C/year	< 0.02 °C/year	—	—	—
Reference Resistance	10 kW at 25 °C	10 kW at 25 °C	—	—	—
Sensing Element	Thermistor	Thermistor	Impedance type humidity sensor	—	—
Response Time	—	—	20 seconds for a 63% step	20 seconds for a 63% step	—
Agency Compliance	CE				

Table of Contents

Standards and Guidelines

This is a compilation of excerpts from many of the applicable healthcare standards and guidelines currently used within the industry. It provides owners, engineers, architects and healthcare facility users an overview of standards and guidelines that apply to the design and use of these facilities. Because design requirements vary geographically, it is important to consult all relevant local, state and federal building codes (also knows as the Authority Having Jurisdiction or AHJ) to determine which standards and guidelines from this document apply to a particular facility.

The healthcare standards and guidelines quoted in this publication are:

- Facilities Guidelines Institute (FGI), *2010 Guidelines for Design and Construction of Healthcare Facilities*—"These Guidelines are made available for a wide variety of public and private uses. These include reference in laws, codes, rules, and regulations, as well as use in private self-regulation and standardization of space and equipment requirements and the promotion of safe practices and methods in planning, design, and construction for various types of health care facilities (p. 3)."
- Centers for Disease Control (CDC), *Guidelines for Environmental Infection Control in Health Care Facilities*—"This report reviews previous guidelines and strategies for preventing environment-associated infections in health-care facilities and offers recommendations. These include 1) evidence-based recommendations supported by studies; 2) requirements of federal agencies (e.g., Food and Drug Administration, U.S. Environmental Protection Agency, U.S. Department of Labor, Occupational Safety and Health Administration, and U.S. Department of Justice); 3) guidelines and standards from building and equipment professional organizations (e.g., American Institute of Architects, Association for the Advancement of Medical Instrumentation, and American Society of Heating, Refrigeration, and Air-Conditioning Engineers); 4) recommendations derived from scientific theory or rationale; and 5) experienced opinions based upon infection-control and engineering practices. The report also suggests a series of performance measurements as a means to evaluate infection-control efforts (p. 1)."
- American National Standards Institute (ANSI), American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), and American Society of Healthcare Engineering (ASHE), Standard 170-2008, Ventilation of Health Care Facilities.- "[This standard] is one of a family of documents that offers guidance, regulation, and mandates to designers of healthcare facilities. It is first and foremost a mandatory minimum requirement and, as such, may not offer the state-of-the-art best practice of health care ventilation design. Other publications such as the ASHRAE HVAC Design Manual for Hospitals and Clinics, may provide more depth and detail for the designer. In addition, the health care designer must refer to any design requirements from the appropriate jurisdiction that has authority."
- United States Pharmacopeia (USP), General Chapter <797> Guidebook to Pharmaceutical Compounding – Sterile Preparations. – "The objective of this chapter is to describe conditions and practices to prevent harm, including death, to patients that could result from (1) microbial contamination (nonsterility), (2) excessive bacterial endotoxins, (3) variability in the intended strength of correct ingredients that exceeds either monograph limits for official articles or 10% for nonofficial articles, (4) unintended chemical and physical contaminants, and (5) ingredients of inappropriate quality in compounded sterile preparations (CSPs)."
- National Fire Protection Association (NFPA) 99, Standard for Health Care Facilities— This standard addresses "fire-related problems in and about health care facilities. These documents covered health care emergency preparedness, inhalation anesthetics, respiratory therapy, laboratories in health-related institutions, hyperbaric facilities, hypobaric facilities, inhalation anesthetics in ambulatory care facilities, home use of respiratory therapy, medical–surgical vacuum systems in hospitals, essential electrical systems for health care facilities, safe use of electricity in patient care areas of health care facilities, and safe use of high-frequency electricity in health care facilities."

Note:

Canadian Standards Association (CSA) Standard CSA-Z317.2-10 should be referenced for HVAC systems in Canada.

General Heating, Ventilation and Air-Conditioning (HVAC) Requirements

Ventilation Requirements

FGI Health Care Design and Construction Guidelines, p. 68, Section 2.1–8.2.4.3 "Exhaust Systems"

"(1) General

"(a) To enhance the efficiency of recovery devices required for energy conservation, combined exhaust systems shall be permitted."

"(b) Local exhaust systems shall be used whenever possible in place of dilution ventilation to reduce exposure to hazardous gases, vapors, fumes, or mists."

"(c) Fans serving exhaust systems shall be located at the discharge end and shall be readily serviceable."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; Space Ventilation: General Requirements, p.6

"(1) Spaces shall be ventilated according to Table 7-1"

"(a) Design of the ventilation system shall provide air movement which is generally from clean to less clean areas. If any form of variable air volume or load shedding system is used for energy conservation, it must not compromise the corridor-to-room pressure balancing relationships or the minimum air changes required by the table. See Table 7-1, note (t) for additional information."

"(b) The ventilation rates in this table cover ventilation for comfort, as well as for asepsis and odor control in areas of healthcare facilities that directly affect patient care. The air changes rates specified are for supply in positive pressure rooms and for exhaust in negative pressure rooms. Ventilation rates for many areas not specified here can be found in ANSI/ASHRAE standard 62.1 (see information annex B: Bibliography). Where areas with prescribed rates in both standard 62.1 -2007 and Table 7-1 if this standard exists,the higher of the two air change rates shall be used."

"(c) For design purposes, the minimum number of total air changes indicated shall be either supplied for positive pressure rooms or exhausted for negative pressure rooms. For spaces that require a positive or negative pressure relationship, the number of air changes can be reduced when the space is unoccupied, provided that the requires pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is reestablished anytime the space becomes occupied. Air change rates in excess of the minimum values are expected in some cases in order to maintain room temperature and humidity conditions based upon the space cooling or heating load."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities, p. 2

"Without high-quality ventilation in health care facilities, patients, health care workers, and visitors can become infected through normal respiration of particles in the air. Poorly ventilated health care facilities are places where the likelihood of pathogenic particles occurring in the air is quite high."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; Utilities: Ventilation Upon Loss of Electrical Power, p. 4

"The space ventilation and pressure relationship requirements of the design parameters shall be maintained for the following spaces, even in the event of loss of normal electrical power:

a. All rooms

b. PE rooms

c. Class B & C Operating Rooms, including Delivery Rooms (Caesarean)

For further information, see NFPA 99 (2005), in Informative Annex B: Bibliography."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; Space Ventilation: General Requirements, p. 6

"a. If any form of variable-air-volume or load-shredding system is used for energy conservation, it shall not compromise the pressure balancing relationships or the minimum air changes required by Table 7-1, Design Parameters."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; Space Ventilation: General Requirements, p. 6

"c. For spaces that require a positive or negative pressure relationship, the number of air changes can be reduced when the space is unoccupied, provided that the required pressure relationship to adjoining spaces is maintained while the space is unoccupied and that the minimum number of air changes indicated is reestablished anytime the space becomes occupied."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities, p. 7, Table 7-1, note j

"In some areas with potential contamination and/or odor problems, exhaust air shall be discharged directly to the outdoors and not recirculated to other areas. Individual circumstances may require special consideration for air exhaust to the outside, for example; an intensive care units in which patients with pulmonary infection are treated, and rooms for burn patients. To satisfy exhaust needs, consistent replacement air from the outdoors i snecessary when the system is in operation".

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities, p. 7, Table 7-1, note q

"In a recirculating ventilation system, HEPA filters shall be permitted instead of exhausting the air from these spaces to the outdoors provided the return air passes through the HEPA filter before it is introduced into any other spaces. This requirement applies onlt to waiting rooms programmed to hold patients awaiting chest x-rays for diagnosis of respiratory disease".

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities, p. 7, Table 7-1, note d

"Pressure relationships need not be maintained when the room is unoccupied."

CDC Health Care Facility Guidelines for Infection Control, p. 5, Section I.B (partial)

"Monitor ventilation systems in accordance with engineers' and manufacturers' recommendations to ensure preventive engineering, optimal performance for removal of particulates, and elimination of excess moisture."

"1. Ensure that heating, ventilation, air conditioning (HVAC) filters are properly installed and maintained to prevent air leakages and dust overloads..."

"3. Engineer humidity controls into the HVAC system and monitor the controls to ensure adequate moisture removal.
   "a. Locate duct humidifiers upstream from the final filters."
   "b. Incorporate a water-removal mechanism into the system."
   "c. Locate all duct takeoffs sufficiently downstream from the humidifier so that moisture is completely absorbed."

"4. Incorporate steam humidifiers, if possible, to reduce potential for microbial proliferation within the system, and avoid use of cool-mist humidifiers..."

"8. Remove bird roosts and nests near air intakes to prevent mites and fungal spores from entering the ventilation system."

"9. Prevent dust accumulation by cleaning air-duct grilles in accordance with facility-specific procedures and schedules and when rooms are not occupied by patients."

"10. Periodically measure output to monitor system function; clean ventilation ducts as part of routine HVAC maintenance to ensure optimum performance."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.G

"Seal windows in buildings with centralized HVAC systems, including PE areas."

CDC Health Care Facility Guidelines for Infection Control, pp. 6-7, Section I.I

"Develop a contingency plan for backup capacity in the event of a general power failure."

"1. Emphasize restoration of appropriate air quality and ventilation conditions in AII rooms, PE rooms, operating rooms, emergency departments, and intensive care units."

"2. Deploy infection-control procedures to protect occupants until power and systems functions are restored."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.L

"Whenever possible, avoid inactivating or shutting down the entire HVAC system, especially in acute-care facilities."

Design Requirements

FGI Health Care Design and Construction Guidelines, p. 64, Section 2.1–8.2.1.1

"(1) Efficiency. The mechanical system shall be designed for overall efficiency and appropriate life-cycle cost. Details for cost-effective implementation of design features are interrelated and too numerous (as well as too basic) to list individually."

"(a) Recognized engineering procedures shall be followed for the most economical and effective results. A well-designed system can generally achieve energy efficiency at minimal additional cost and simultaneously provide improved patient comfort. Different geographic areas may have climatic and use conditions that favor one system over another in terms of overall cost and efficiency."

"(b) In no case shall patient care or safety be sacrificed for conservation."

"(c) Use of recognized energy-saving mechanisms such as variable-air-volume (VAV) systems, load shedding, programmed controls for unoccupied periods (nights and weekends, etc.), and use of natural ventilation shall be considered, site and climatic conditions permitting."

"(d) Facility design considerations shall include site, building mass, orientation, configuration, fenestration, and other features relative to passive and active energy systems."

"(e) (Air-handling systems) shall be designed with an economizer cycle where appropriate to use outside air. (Use of mechanically circulated outside air does not reduce the need for filtration)."

"(f) VAV systems. The energy-saving potential of variable-air-volume systems is recognized, and the standards herein are intended to maximize appropriate use of those systems. Any system used for occupied areas shall include provisions to avoid air stagnation in interior spaces where thermostat demands are met by temperatures of surrounding areas."

"(2) Air-handling systems with unitary equipment that serves only one room. These units may be used as recirculating units only. All outdoor air requirements shall be met by a separate central air-handlingsystem with proper filtration, as noted in 2.1-8.2.5.1 (filter efficiencies)."

"(3) Vibration isolators. Mechanical equipment, ductwork, and piping shall be mounted on vibration isolators as required to prevent unacceptable structure-borne vibrations."

"(4) System valves. Supply and return mains and risers for cooling, heating and steam systems shall be equipped with valves to isolate the various sections of each system. Each piece of equipment shall have valves at the supply and return ends."

"(5) Renovations. If system modifications affect greater than 10 percent of the system capacity, designers shall utilize pre-renovation water/airflow rate measurements in the affected zones to verify that sufficient capacity is available and that renovations have not adversely affected flow rates in non-renovated areas."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; Space Ventilation: Air Distribution Systems, p. 5

"Maintain the pressure relationships required in Table 7-1 in all modes of HVAC system operation, except as noted in the table. Spaces listed in Table 7-1 that have required pressure relationships shall be served by fully ducted returns. The air-distribution design shall maintain the required space pressure relationships, taking into account recommended maximum filter loading, heating-season lowered airflow operation, and cooling-season higher airflow operations."

CDC Health Care Facility Guidelines for Infection Control, p. 5, Section I.A

"Use AIA guidelines as minimum standards where state or local regulations are not in place for design and construction of ventilation systems in new or renovated health-care facilities. Ensure that existing structures continue to meet the specifications in effect at the time of construction."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.B.5

"Ensure that air intakes and exhaust outlets are located properly in construction of new facilities and renovation of existing facilities."

"a. Locate exhaust outlets >25 ft from air-intake systems."

"b. Locate outdoor air intakes >6 ft above ground or >3 ft above roof level."

"c. Locate exhaust outlets from contaminated areas above roof level to minimize recirculation of exhausted air."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.E

"Conduct an infection-control risk assessment (ICRA) and provide an adequate number of AII and PE rooms (if required) or other areas to meet the needs of the patient population."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.G

"Seal windows in buildings with centralized HVAC systems, including PE areas."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.M

"Whenever feasible, design and install fixed backup ventiolation systems for new or renovated construction of PE rooms, AII rooms, operating rooms, and other critical-care areas identified by ICRA."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.K

"HVAC systems serving offices and administrative areas may be shut down for energy conservation purposes, but the shutdown must not adversely affect pressure differentials maintained in laboratories or critical-care areas with specific ventilation requirements (i.e., PE rooms, AII rooms, operating rooms)."

Insulation and Sound

FGI Health Care Design and Construction Guidelines, p. 62, Sections 2.1–8.2.3

"**8.2.3.1** General. Insulation shall be provided within the building to conserve energy, protect personnel, prevent vapor condensation, and reduce noise."

"(1) Vapor barrier. Insulation on cold surfaces shall include an exterior vapor barrier. (Material that will not absorb or transmit moisture will not require a separate vapor barrier.)"

"(2) Flame-spread rating. Insulation, including finishes and adhesives on the exterior surfaces of ducts, piping, and equipment, shall have a flame-spread rating of 25 or less and a smoke-developed rating of 50 or less as determined by an independent testing laboratory in accordance with NFPA 255."

"(3) Renovation. Existing accessible insulation within areas of facilities to be modernized shall be inspected, repaired, and/or replaced, as appropriate."

"**8.2.3.2 Duct linings"**

"(1) Duct linings exposed to air movement shall not be used in ducts serving operating rooms, delivery rooms, LDR rooms, nurseries, protective environment rooms, and critical care units. This requirement shall not apply to mixing boxes and sound attenuators that have special coverings over such lining."

"(2) Duct lining shall not be installed within 15 feet (4.57 meters) downstream of humidifiers."

"(3) Renovation. If existing lined ductwork is reworked in a renovation project, the liner seams and punctures shall be resealed."

Remediation

CDC Health Care Facility Guidelines for Infection Control, p. 16, Section III, I.5

"Contain dust and debris during remediation and repair as outlined in air recommendations."

General Patient Rooms

Ventilation Requirements

FGI Health Care Design and Construction Guidelines, p. 65, Section 2.1–8.2.1.2

"Ventilation and space requirements. All rooms and areas used for patient care shall have provisions for ventilation. See part 6 (ASHRAE 170) for further requirements."

"(1) Although natural ventilation for nonsensitive areas and patient rooms (via operable windows) shall be permitted, mechanical ventilation shall be considered for all rooms and areas in the facility in accordance with part 6, table 7-1."

CDC Health Care Facility Guidelines for Infection Control, p. 132, Table 2.1-2, note 10

"Total air changes per room for patient rooms, intermediate care, labor/delivery/recovery rooms, and labor/delivery/recovery/postpartum rooms may be reduced to 4 when supplemental heating and/or cooling systems (radiant heating and cooling, baseboard heating, etc.) are used."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.J

"Do not shut down HVAC systems in patient-care areas except for maintenance, repair, testing of emergency backup capacity, or new construction."

"1. Coordinate HVAC system maintenance with infection-control staff and relocate immunocompromised patients if necessary."

"2. Provide backup emergency power and air-handling and pressurization systems to maintain filtration, constant ACH, and pressure differentials in PE rooms, AII rooms, operating rooms, and other critical-care areas."

"3. For areas not served by installed emergency ventilation and backup systems, use portable units and monitor ventilation parameters and patients in those areas."

"4. Coordinate system startups with infection-control staff to protect patients in PE rooms from bursts of fungal spores."

"5. Allow sufficient time for ACH to clean the air once the system is operational (Table 1, see Appendix)."

Design Requirements

FGI Health Care Design and Construction Guidelines, p. 67, Section 2.1–8.2.4.1

"Return air systems. For patient care areas, return air shall be via ducted systems."

Airborne Infection Isolation (AII) Rooms

Ventilation Requirements

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note a

"Recirculating room HVAC units (with heating or cooling coils) are acceptable to achieve the required air change rates. Because of the cleaning difficulty and the potential for buildup or contamination, recirculating room units shall not be used in areas

marked "No." Isolation and intensive care rooms may be ventilated by reheat induction units which only the primary air supplied from a central system passes through the reheat unit. Gravity-type heating or cooling units, such as radiators or convectors, shall not be used in operating rooms and other special care rooms."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 6, Space Ventilation: Section 7.2.1

"a. AII rooms shall have a permanently installed device and/or mechanism to constantly monitor the differential air pressure between the room and adjacent spaces."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 6, Space Ventilation: Section 7.2.1

"b. All air from the AII room shall be exhausted directly to the outdoors. Exception: AII rooms that are retrofitted from standard patient rooms from which it is impractical to exhaust directly outdoors may be ventilated with recirculated air from the rooms' exhaust, provided that the air first pass through a HEPA (MERV 17) filter."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 6, Space Ventilation: Section 7.2.1

"c. All exhaust air from the AII rooms, associated anterooms, and associated toilet rooms shall be discharged directly to the outdoors without mixing with exhaust air from any other non-AII room or exhaust system."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 6, Space Ventilation: Section 7.2.1

"f. Differential pressure between AII rooms and adjacent spaces that have a different function shall be a minimum of -0.01 in. w.c. (-2.5 Pa)."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note n

"If monitoring device alarms are installed, allowances shall be made to prevent nuisance alarms. Short term excursions from required pressure relationships shall be allowed while doors are moving or temporarily open."

CDC Health Care Facility Guidelines for Infection Control, p. 5, Section I.B.2

"Monitor areas with special ventilation requirements (e.g., AII or PE) for ACH, filtration, and pressure differentials."

"a. Develop and implement a maintenance schedule for ACH, pressure differentials, and filtration efficiencies by using facility-specific data as part of the multidisciplinary risk assessment. Take into account the age and reliability of the system."

"b. Document these parameters, especially the pressure differentials."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.D.2

"Follow appropriate procedures for use of areas with through-the-wall ventilation units..."

"2. Do not use a room with a through-the-wall ventilation unit as an AII room unless it can be demonstrated that all required AII engineering controls are met."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.F

"When ultraviolet germicidal irradiation (UVGI) is used as a supplemental engineering control, install fixtures 1) on the wall near the ceiling or suspended from the ceiling as an upper air unit; 2) in the air-return duct of an AII area; or 3) in designated enclosed areas or booths for sputum induction."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.K

"HVAC systems serving offices and administrative areas may be shut down for energy conservation purposes, but the shutdown must not alter or adversely affect pressure differentials maintained in laboratories or critical-care areas with specific ventilation requirements (i.e., PE rooms, AII rooms, operating rooms)."

Design Requirements

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note u

"The AII room described in this standard shall be used for isolating the airborne spread of infectious diseases, such as measles, varicella, or tuberculosis. The design of AII rooms shall include the provision for normal patient care during periods not requiring isolation precautions. Supplemental recirculating devices using HEPA filters shall be permitted in the patient room to increase the equivalent room air changes; however, the outdoor air changes are still required. AII rooms that are retrofitted from the standard patient rooms from which it is impractical to exhaust directly outside may be recirculated with air from the AII room, provided that the air first passes through a HEPA filter. HEPA filtered exhaust air from AII rooms may mix with the exhaust air that serves non-AII spaces prior to being discharges directly outdoors. Rooms with reversible airflow provisions for the purpose of switching between protective environment and AII function shall not be permitted. See guidelines in informative AnnexB: Bibliography for more information."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.M

"Whenever feasible, design and install fixed backup ventilation systems for new or renovated construction of PE rooms, AII rooms, operating rooms, and other critical-care areas identified by ICRA."

Protective Environment (PE) Rooms

Ventilation Requirements

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 6, Section 7.2.2

"b. PE rooms shall have a permanently installed device and/or mechanism to constantly monitor the differential air pressure between the room and adjacent spaces."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note f

"Protective environment rooms are thise used for high-risk immunocompromised patients. Such rooms are positively pressurized relative to all adjoining spaces to protect the patient."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note n

"If monitoring device alarms are installed, allowances shall be made to prevent nuisance alarms. Short term excursions from required pressure relationships shall be allowed while the doors are moving or temporarily open."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 11, Section 7.2.2

"d. Differential pressure between any dissimilar adjacent spaces shall be a minimum of +0.01 w.c. (+2.5 Pa)."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 11, Section 7.2.2

"e. PE rooms retrofitted from standard patient rooms may be ventilated with recirculated air, provided that air first passes through a HEPA filter and the room complies with parts "a" through "d" of this section."

CDC Health Care Facility Guidelines for Infection Control, p. 5, Section I.B.2

"Monitor areas with special ventilation requirements (e.g., AII or PE) for ACH, filtration, and pressure differentials.

"a. Develop and implement a maintenance schedule for ACH, pressure differentials, and filtration efficiencies by using facility-specific data as part of the multidisciplinary risk assessment. Take into account the age and reliability of the system."

"b. Document these parameters, especially the pressure differentials."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Section I.D.1

"Follow appropriate procedures for use of areas with through-the-wall ventilation units."

"1. Do not use such areas as PE rooms."

CDC Health Care Facility Guidelines for Infection Control, p. 6, Sections I.G-H

"G. Seal windows in buildings with centralized HVAC systems, including PE areas."

"H. Keep emergency doors and exits from PE rooms closed except during an emergency; equip emergency doors and exits with alarms. "

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.K

"HVAC systems serving offices and administrative areas may be shut down for energy conservation purposes, but the shutdown must not alter or adversely affect pressure differentials maintained in laboratories or critical-care areas with specific ventilation requirements (i.e., PE rooms, AII rooms, operating rooms)."

Design Requirements

FGI Health Care Design and Construction Guidelines, p. 172, Section 2.2–8.2.2.2

"Protective environment rooms.The protective environment (PE) room is used to protect the profoundly immunosupressed patient with prolonged neutropenia (i.e., a patient undergoing an allogenic or autologous bone marrow/stem cell transplant) from common environmental airborne infectious microbes (i.e., Aspergillus spores)."

"(1) These special ventilation areas shall be designed to provide directed airflow from the cleanest patient care area to less clean areas."

"(2) Supply air to the PE rooms, and to anterooms if provided, shall pass through HEPA filters just before entering the room. For a suite of rooms, installation of the HEPA filters upstreamof the suite shall be permitted.

"(3) Each PE room shall have permanently installed visual mechanism to constantly monitor the pressure status of the room when occupied by a patient requiring a protective environment. The mechanism shall monitor the pressure differential between the PE room and the corridor or common space, whether or not there is an anteroom between the corridor or common space and the PE room."

"(4) When an anteroom is provided, airflow shall be from the patient room into the anteroom and from the anteroom into the corridor."

"(5) See part 6 for additional ventilation requirements."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note t

"Constant volume airflow is required for consistent ventilation for the protected environment. If the design criteria indicate that AII is necessary for protective environment patients, an anteroom should be provided."

CDC Health Care Facility Guidelines for Infection Control, p. 7, Section I.M

"Whenever feasible, design and install fixed backup ventilation systems for new or renovated construction of PE rooms, AII rooms, operating rooms, and other critical-care areas identified by ICRA."

Combination (AII/PE) Room

Design Requirements

FGI Health Care Design and Construction Guidelines, p.92, Section 2.2-2.2.4.5

"This type of room is for profoundly immunosupressed patient with prolonged neutropenia (i.e., a patient undergoing an allogeneic or autologous bone marrow/stem cell transplant) who require a protective environment and have an airborne infectious disease.

"(1) Number. Hospitals with PE rooms shall include at least one combination AII/PE room."

"(2) Each combination AII/PE room shall comply with the requirements in 2.2-2.2.4.4 (Protective Environment room) as well as the requirements in this section."

"(3) Anteroom. Combination AII/PE room shall be equipped with an anteroom that meets the following requirements:

- "(a) The anteroom shall provide space for persons to don personal protective equipment before entering the patient room."
- "(b) All doors to the anteroom shall have self-closing devices.

"(4) See 2.2-8.2.2.3 for HVAC requirements for combination AII/PE rooms."

Ventilation Requirements

FGI Health Care Design and Construction Guidelines, p. 172, Section 2.2-8.2.2.3

"(1) Supply air shall comply with the requirements of 2.2-8.2.2.2 (2) for PE rooms."

"(2) Exhaust air from the combination AII/PE room and anteroom shall comply with the requirements of AII rooms.

"(3) The airflow pattern of the anteroom shall be one of the following:

- "(c) Airflow for the anteroom to both the patient room and the corridor, or
- "(d) Airflow from both the patient room and the corridor into the anteroom."

"(4) Rooms with reversible airflow provisions for the purpose of switching between protective environments and airborne infection isolation functions shall not be permitted."

"(5) Each combination AII/PE room shall have two permanently installed visual mechanisms to constantly monitor the pressure status of the room when occupied by patients with an airborne infectious disease and/or requiring a protective environment. One mechanism shall monitor the pressure differential between the patient room and the anteroom. The second mechanism shall monitor the pressure between the anteroom and the corridor."

Operating Rooms

NFPA 99 2012 edition does not have language referring to smoke control or smoke management. Instead, the new code says ventilation throughout the healthcare facility shall be in accordance to ASHRAE Standard 170. ASHRAE 170 does not have specific references to smoke control or smoke management. For more details, refer to *NFPA 99 Standard for Health Care Facilities, p. 92, Section 9.3.1.1.*

Note:

Sections 6.4.1.2 and 6.4.1.3 were removed from NFPA 99 2012 edition.

Design Requirements

NFPA 99 Standard for Health Care Facilities, p. 75, Section 6.3.2.2.8.4

"Operating rooms shall be considered to be a wet procedure location, unless a risk assessment conducted by the healthcare governing body determines otherwise."

NFPA 99 Standard for Health Care Facilities, p. 85, Section 6.5.2.1.1.1

"Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.1 second."

NFPA 99 Standard for Health Care Facilities, p. 92, Section 9.3.1.1

"Heating, cooling, ventilating, and process systems serving spaces or providing healthcare functions covered by this code or listed within ASHRAE 170, *Ventilation of Health Care Facilities,* shall be provided in accordance with ASHRAE 170."

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities; p. 10, Table 7-1, note O

"Surgeons or surgical procedures may require roon temperatures, ventilation rates, humidity ranges, and/or air distribution methods that exceed the minimum indicated ranges."

Ventilation Requirements

FGI Health Care Design and Construction Guidelines, p. 65-66, Section 2.1-8.2.2.5

"Operating and Delivery Rooms"

"(1) Air supply."

"(a) In new construction and major renovation work, air supply cesarean delivery rooms shall be in accordance with section 7.4.1 (class B and C operating Rooms) of Part 6 (ASHRAE 170).":

"(b) In addition to the required low return (or exhaust) air grilles, such grilles placed high on the walls shall be permitted."

"(2) Ventilation rates

"(a) Operating and delivery room ventilation systems shall operate at all times, except during maintenance and conditions requiring shut-down by the building;s fire system."

"(b) During unocuppied hours, operating and delivery room air change rates may be reduced, provided the positive room pressure is maintained as required in Part 6."

"(3) Standards for special procedures. Where extraordinary procedures, such as organ transplants, justify special designs, installation shall properly meet performance needs as determined by applicable standards. These special designs should be reviewed on a case-by-case basis."

ASHRAE Standard 170, p. 4, Section 6.1.1

"Ventilation Upon Loss of Electrical Power. The space ventilation and pressure relationship requirements of Table 7-1 shall be maintained for the following spaces, even in the event of loss of normal electrical power: c. Class B & C Operating Rooms, including Delivery Rooms (Caesarean)."

ASHRAE Standard 170, p. 11, Section 7.4.1

"Operating rooms shall be maintained at a positive pressure with respect to all adjoining spaces at all times. A pressure differential shall be maintained at a value of at least +0.01 in. wc (2.5 Pa). Operating rooms shall be designed with primary supply diffusers that are designed as follows."

"(a) The airflow shall be unidirectional, downwards, and the average velocity of the diffusers shall be 25 to 35 CFM/ft^2 (127 L/s/m^2 to 178 L/s/m^2). The diffusers shall be concentrated to provide an airflow pattern over the patient and the surgical team. (See memarzadeh [2002] and memarzadeh [2004] in Informative Annex B: Bibliography)."

"(b) The area of primary supply diffuser array shall extend a minimum of 12 in. (305 mm) beyond the footprint of the surgical table on each side. No more than 30% of the primary supply diffuser array area shall be used for non-diffuser uses such as lights, gas columns, etc. Additional supply diffusers may be required to provide additional ventilation to the operating room to achieve the environmental requirements of Table 7-1 relating to temperature, humidity, etc."

"The room shall be provided with at least two low sidewall return or exhaust grilles spaced at opposite corners or as far apart as possible, with the bottom of these grilles installed approximately 8 in. (203 mm) above the floor."

Morgue and Autopsy Rooms–Ventilation Requirements

ANSI/ASHRAE/ASHE Standard 170-2008 Ventilation of Health Care Facilities, p. 10, Table 7.1, note n

"If monitoring device alarms are installed, allowances shall be made to prevent nuisance alarms. Short term excursions from required pressure relationships shall be allowed while doors are moving or temporarily open."

Other Considerations

Patient Safety Risk Assessment

FGI Health Care Design and Construction Guidelines, p. 20, Section A1.2.-4

"(a) Every new or renovated health care building should be designed to facilitate the safe delivery of care."

"(b) Definitions

Hazards: Anything that has the potential to burn

Risk: The likelihood that somebody or something will be harmed by a hazard, multiplied by the severity of the potential harm."

"(c) During the functional programming phase of a project, the owner should provide an assessment of the potential risks to patients inherent in each space and building component that is to be part of the project. For each space or component, this patient safety risk assessment (PSRA) should identify the specific hazards, the likelihood of their occurrence based on historical data, and the degree of potential harm to patients from the hazard."

"(d) The PSRA should be conducted by an interdisciplinary panel appointed by the owner that is made up of representatives from clinical departments that are part of the project or could be affected by the project, safety specialist(s), medical staff, infection preventionists, architects, engineers, and other appropriate individuals. The PSRA panel should produce a report that identifies the known hazards and specifies design features to be included in the project design that are intended to reduce or eliminate this risks.

Sustainable Design

FGI Health Care Design and Construction Guidelines, p. 28, Section 1.2-6.2.1.4

"Energy Efficiency"

"Efficient mechanical and electrical syatems shall be selected and sized to meet the loads efficiently utilize space, and consider climate characteristics, daylighting, and building orientation to significantly reduce overall energy demand and consumption."

"(1) Energy efficient goals shall be considered in all phases of facility development or renovation."

"(2) The quality of the health care facility environment shall be supportive of the occupants and functiion served. Therefore, design for energy efficiency shall enhance and not adversley affect patient health, safety, or accepted personal comfort levels."

FGI Health Care Design and Construction Guidelines, p. 29, Section 1.2-6.2.1.5

"Indoor Environmental Quality"

"(1) The impact of building design and construction on indoor environmental quality should be addressed."

"(2) Impact from both exterior and interior air-contamination sources shall be minimized."

CDC Airflow Requirements

CDC Health Care Facility Guidelines for Infection Control, p. 7

Table 1. Air changes/hour (ACH) and time required for airborne-contaminant removal efficiencies of 99% and 99.9%

ACH	Time (min) required for removal efficiency of 99%	Time (min) required for removal efficiency of 99.9%
2	138	207
4	69	104
6	**46**	**69**
8	35	52
10	28	41
12	23	35
15	**18**	**28**
20	14	21
50	6	8

Notes:

Bold entries denote frequently cited ACH for patient-care areas.

Values apply to an empty room with no aerosol-generating source. With a person present and generating aerosol, this table would not apply. Other equations are available that include a constant generating source. However, certain diseases (e.g., infectious tuberculosis) are not likely to be aerosolized at a constant rate. The times given assume perfect mixing of the air within the space (i.e., mixing factor = 1). However, perfect mixing usually does not occur. Removal times will be longer in rooms or areas with imperfect mixing or air stagnation. Caution should be exercised in using this table in such situations. For booths or other local ventilation enclosures, manufacturers' instructions should be consulted.

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A Thorough Understanding of Healthcare Environments

Healthcare facilities such as hospitals and outpatient clinics provide an important service to the public when illness strikes. Infection control, energy conservation, and patient healing are critical considerations when designing a ventilation system for this environment. With each revision of healthcare ventilation standards, regulatory organizations have consistently increased the requirement for directional airflow.

Phoenix Controls is widely recognized as the leader in precision ventilation systems for critical room environments, bringing innovative products to market year-after-year to meet the needs of many industries. The ventilation system must prevent the spread of airborne pathogens, create a safe and comfortable environment for healing, and at the same time conserve energy.

This sourcebook contains information specific to the unique requirements of the healthcare industry, including descriptions of airflow control approaches for isolation rooms, operating rooms, patient rooms, and other areas in these critical care facilities. Forward-looking design principles are also discussed so both engineer and owner can understand the most cost-effective methods for achieving optimal use of ventilation resources.