Phoenix Controls

laboratory sourcebook
5th edition

ensuring environmental integrity

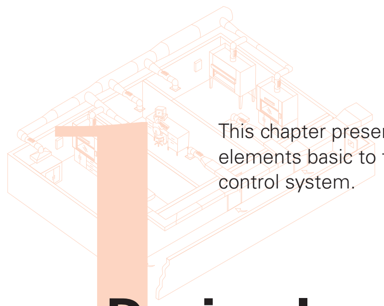
A Thorough Understanding of Laboratory Environments

As the setting for experimentation, testing or analysis, a laboratory is a specialized environment. Whether the laboratory is at a university, pharmaceutical or chemical facility, or in a medical or private research setting, its operation must be reliable. In every case, the laboratory airflow control system is vital to researchers' safety. It exhausts noxious fumes from the fume hoods, maintains correct room pressurization and creates a comfortable working environment.

Phoenix Controls has built its reputation on providing quality airflow controls for critical room environments. We are recognized as an innovative leader in laboratory airflow controls. Since the company's founding in 1985, we have grown our installed base to more than one half million valves shipped, nearly 100,000 fumehoods under control on more than 22,500 projects in 42 different countries.

This sourcebook explores airflow system design issues that affect laboratories, reviews commonly used control applications and describes our airflow control system components.

Phoenix Controls Laboratory Sourcebook



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This chapter presents an overview of the key elements basic to the design of a laboratory airflow control system.

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Design Issues for Laboratory Airflow

Primary Objectives of Laboratory Airflow Systems

With any control approach for laboratories, the ultimate objectives are:

- **Operator safety**–Capturing and containing fumes
- **Room pressurization**–Maintaining correct airflow direction
- **Ventilation**–Providing proper air changes
- **Comfort**–Providing proper temperature control

Historically, the standard method of controlling laboratory airflow was the constant volume (CV) approach. Next, two-state controls were used to gain efficiency by reducing laboratory airflow under specific conditions, such as night setback. A more comprehensive method of laboratory airflow control is the variable air volume approach (VAV), in which sash positioning helps determine airflow rate. A fourth approach is Usage Based Controls® (UBC). With UBC, the airflow rate is maintained at safe minimum levels and increased only when needed by the presence of a user at a hood. When either the VAV or UBC options are used, safety and energy savings are optimized. Finally, providing accurate information about the space's operation improves overall facility operation. Integration through the Phoenix Controls BACnet® portal provides efficient and seamless method of data exchange.

Applications for each of these control methods are reviewed in Chapter 3.

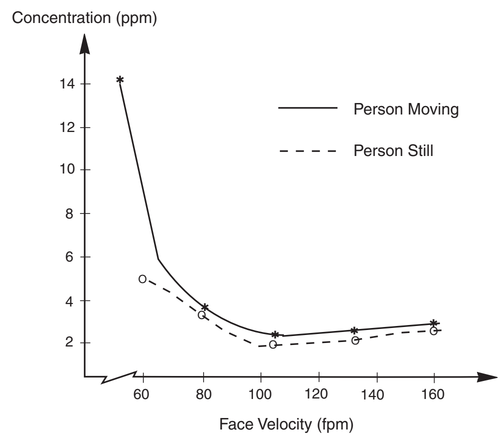
Determining Safe and Efficient Face Velocity Levels

Fume containment is critical to the safety of laboratory workers. Several factors are involved with the proper containment of fumes, including face velocity, cross-drafts, and work practices. Research and field experience offer insight into effective face velocity settings for fume hoods. Common industry guidelines range from 60-120 fpm (0.3-0.6 m/s). In many modern facilities, 100 fpm (0.5 m/s) is accepted as the standard for safe operation. The following research indicates that, in part, the presence and movement of an operator create the requirement for a 100 fpm face velocity.

- The ASHRAE Symposium CH-99-09 on Laboratory Verification and Testing offered the paper, "Containment Testing for Occupied and Unoccupied Control of Fume Hoods." This research offers significant findings that unoccupied hoods—those with no people present—contain fumes while operating at the reduced face velocity of 60 fpm (0.3 m/s). Occupied hoods, those with people present, required higher velocities to achieve proper containment. See Chapter 3 for details on Usage Based Controls (or hood occupancy control).

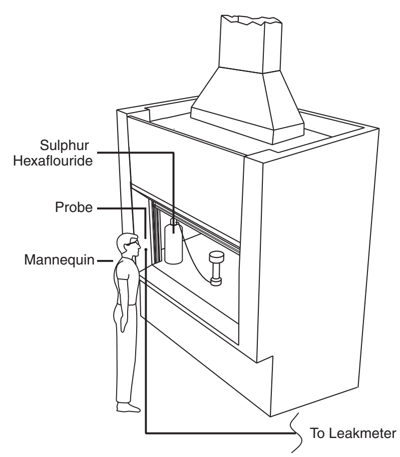
- Research by Bengt Ljungvist from the University of Stockholm at the *International Ventilation '91* conference has shown that the dynamic movement of an operator in front of a fume hood significantly affects containment when compared to a still person or mannequin (see Figure 1-1).

Figure 1-1. Effects of operator movement on fume hood containment. *The graph shows that the movement of an operator has little effect on containment at 80-100 fpm, but movement has a disturbing effect at flows below 80 fpm. However, with no operator movement, general containment down to 60 fpm is realized. (Ljungvist, 1991)[1].*



There is some interest in operating hoods below the 60 fpm (0.3 m/s) level. Hoods with sash opening limits and deeper hoods have been tested for this concept. Often the ASHRAE 110-95 test is used to test hoods for containment. This is a static test where tracer gas is released in the fume hood and a non-moving mannequin is used to test the breathing zone. The amount of tracer gas sensed at the mannequin determines the hood's containment level. If the level remains below the maximum threshold (e.g., 0.1 ppm), the hood may be deemed compliant.

Figure 1-2. Tracer gas test setup. *Both ASHRAE 110-95 and the DIN 12924 (a European standard) offer similar tracer gas test apparatus. Neither test is designed to account for active personnel movements.*



[1]Ljungvist, Bengt, "Some Observations on Aerodynamic Types of Fume Hoods," *Ventilation '91*, pp. 569-572.

This type of test does not assure containment under actual operating conditions. The static nature of the test does not take into account the dynamic conditions in a working laboratory. The movement of people, high-supply air cross-drafts, and operator work habits are examples of everyday events that affect proper containment.

Although the ASHRAE and DIN test use a mannequin, containment under dynamic conditions is currently difficult to quantify. However, visual smoke tests under dynamic conditions do show cause for concern at low-face velocities. For example, walk-by and hand movement tests show improved containment at 100 fpm vs. 60 fpm.

This all leads to a design dilemma for many projects. On one side is the need for containment, thus sizing systems to meet the 100 fpm need. On the other side is the desire to reduce system capacity—often to meet budget constraints. However, it is possible to get both the safety from containment and the reduction in HVAC system capacity by taking diversity—that is, designing a system for less capacity than the sum of the peak demands. Sizing systems with diversity may be risky, however. Understanding diversity in laboratories becomes critical for safe designs that optimize savings (see discussion on Diversity on page 29).

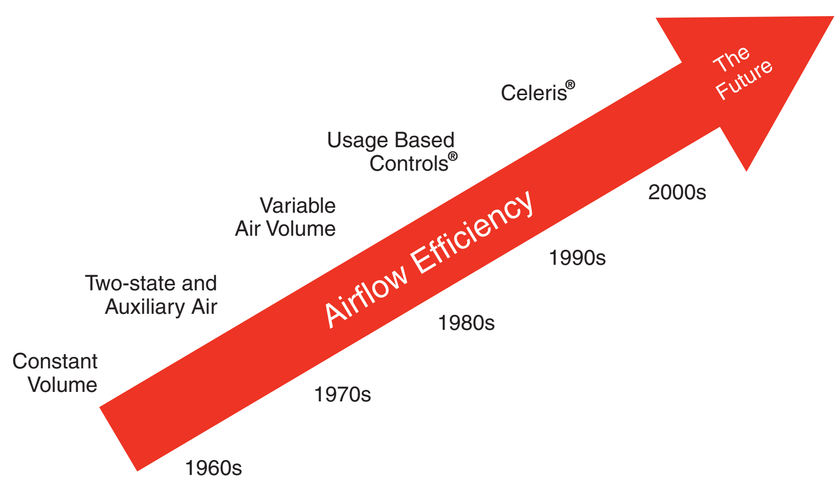


Figure 1-3. Airflow efficiency by control method.

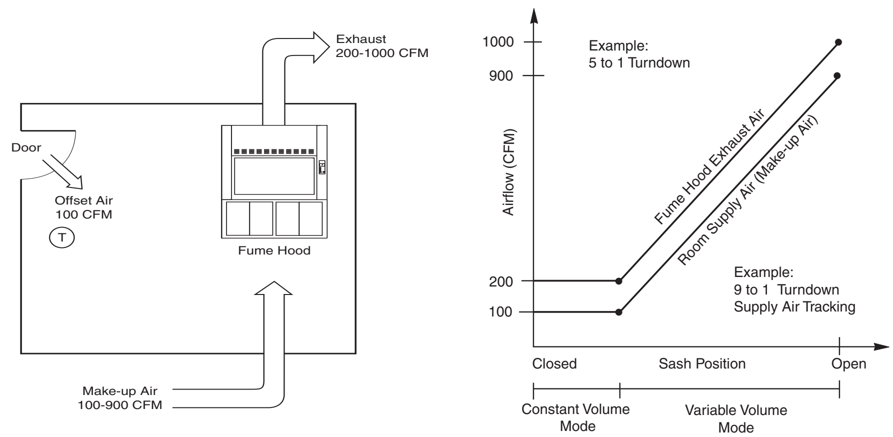
Other factors that impact fume hood operator safety include speed of response of the airflow control system as well as accuracy and stability of control. These factors are explored in greater detail in Chapter 3, but are summarized below:

- **Speed of response** —the airflow control system must respond to changes in airflow command rapidly to ensure proper face velocity control. A system that can respond to changes in flow commands in less than 1 second assures that the operators safety is never compromised due to changes in sash position of fume hood occupancy.
- **Accuracy** —the airflow control system must have the precision of control to maintain proper face velocity regardless of sash position. Errors in airflow control can compromise operator safety. Airflow devices whose accuracy is expressed as a percent of range, introduce the possibility of significantly high errors in face velocity.
- **Stability** —the airflow control system must provide consistent flow regardless of changes in duct static pressure and must respond precisely to changes in airflow command with little or no overshoot or undershoot

Room Pressurization: Net Negative Airflow

Another objective if a VAV laboratory control system is to provide net negative room pressurization. This is typically done by controlling the supply or make-up air into the room to match the total exhaust airflow minus some offset. This is shown in Figure 1-4 by the line marked "Room Supply Air." The exhaust to supply air offset is the airflow that comes into the room from the corridor door, transfer grills, other spaces, etc.

Figure 1-4. Volumetric tracking of VAV fume hood airflow to sash position. *The hood exhaust air maintains a constant face velocity through the sash travel while the make-up air tracks the total exhaust—maintaining room pressurization and proper ventilation.*



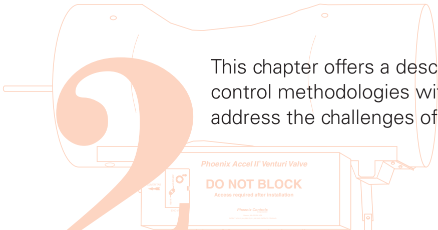
Ventilation and Comfort

The total airflow rate for a laboratory is dictated by the highest of the:

- Total amount of exhaust from the hoods
- Minimum ventilation rates
- Cooling required for heat loads

The minimum ventilation rate of Air Changes per Hour (ACH) is established to provide dilution and evacuation of any vapors or fumes that might escape from the fume hoods. Typical air changes rates are 6 to 12 ACH but could go as high as 20 ACH.

At times, the amount of airflow commanded by the hoods is below the amount needed to cool or ventilate the room (e.g., when the hood sash is closed and room thermal load is high). In these instances, the room's supply air volume must be increased to provide the proper amount of air. The lab control system must also act to maintain the proper lab pressurization by exhausting this "excess" supply air. This is achieved by adding a general exhaust valve to the room. This valve is controlled by the laboratory VAV system to maintain the proper balance between the total supply and total exhaust of the room.



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This chapter offers a description of the Accel II Air Valves airflow control methodologies with a focus on how the Accel II Air Valves address the challenges of controlling these dynamic environments.

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Airflow Control

The accuracy and stability of the airflow control device plays a critical role in maintaining the proper face velocity on fume hoods for operator safety, as well as 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 laboratory.

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 labs and set a new performance standard. This chapter compares different flow control techniques and how the Phoenix Controls Accel II valve may be configured for different applications.

VAV Box versus Accel II Air Valve

Traditional VAV controls and even industrial quality controls cannot handle many of the control requirements unique to laboratories for a number of reasons. A few of these reasons are detailed below.

VAV Boxes with Velocity Pressure Sensors

This approach fails to meet most of the important requirements unique to laboratories. This technology along with other approaches that put sensors into the airstream is susceptible to fouling by tissues, contaminants, etc. Additionally, these devices have an accurate control range of only 3 or perhaps 4 to 1, even with very accurate transducers. This is because the velocity pressure varies as the square of flow.

The table below illustrates how velocity pressure measuring systems get into trouble even with very accurate ± 1% full-scale transducers.

Flow	Velocity Pressure (VP)	VP Error	%VP Error	% Flow Error
100%	1.00"	0.01"	1%	0.5%
20%	0.04"	0.01"	25%	13%
10%	0.01"	0.01"	100%	100%

For simplicity, a 1" velocity pressure was assumed for full 100% flow. Furthermore, a 1" ±1% full-scale (±0.01") transducer was used for the best case or optimum match of the transducer to the required signal span. Usually the transducer has a larger span or full-scale range versus the signal range creating an even larger error than shown.

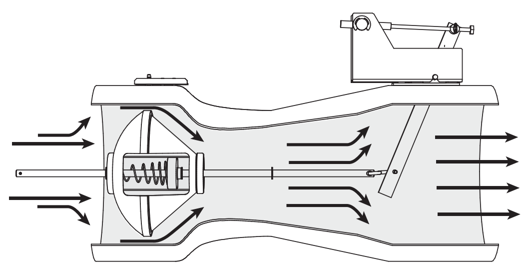
Other Flow Measuring Technologies

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 set point. Each time the static pressure, measured flow, or flow command changes this cycle repeats itself.

A Unique Solution—The Phoenix Accel® II Venturi Valve

The Phoenix Controls 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 and two-state applications.

Figure 2-1. 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 set point. 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 2-state valves, the air station delivers the desired minimum and maximum flows and the actuator is mechanically clamped at the flow set points.

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 set point is maintained continuously and instantaneously.

Pressure independent over a 0.6"-3.0" WC (150-750 Pa) drop across valve (medium pressure). Low Pressure valves are independent over a 0.3"-3.0" WC (75-750 Pa) drop across valve.

This specialized characterization process and the precision mechanical components allow the Accel II valve to deliver unparalleled accuracy of +/- 5% of reading over the entire operating range.

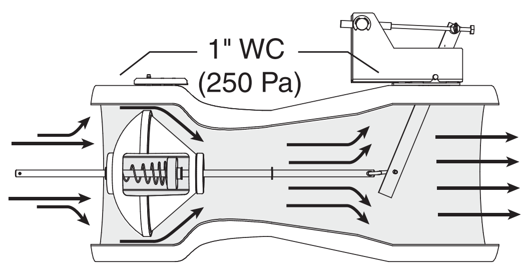


Figure 2-2. The effects of low static pressure on a venturi valve cone. *When there is low static pressure, less force is applied to the cone, which allows the spring within the cone to expand and push the cone away from the venturi. The combination of low pressure and a large open area provides the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

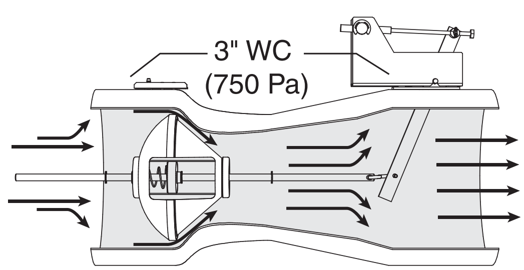


Figure 2-3. The effects of high static pressure on a venturi valve cone. *As static pressure increases force on the cone, the spring compresses and the cone moves into the venturi, reducing the open area. Higher pressure and the smaller opening combine to maintain flow set point.*

Speed of Response

The Accel II valve is available with three actuation options: pneumatic; high-speed electric and normal-speed electric.

The high speed pneumatic and electric options will reposition the pivot arm to within 90% of the commanded position within one second.

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).

Accel II Valve Configurations

Applications require that each valve be built to withstand unique environments. The Accel II valves are available in three construction types and three valve designs.

Construction

- 16 ga. spun aluminum valve body with continuous welded seam
- Composite Teflon® shaft bearings
- Spring grade stainless steel spring and polyester or PPS slider assembly
- Supply valves* insulated with 3/8" (9.5 mm) flexible closed-cell polyethylene.

Operating Range

- 32-122 °F (0-50 °C) ambient 10-90% non-condensing RH

Valve Construction

- **Class A:** Body and cone-uncoated aluminum; Shaft-uncoated 316 stainless steel
- **Class B:** Body and cone with phenolic coating; PFA coated stainless steel shaft (for standard fume hood applications)
- **Class C:** Body, cone and hardware with phenolic coating. PFA coated stainless steel shaft (for highly corrosive fume hood applications)

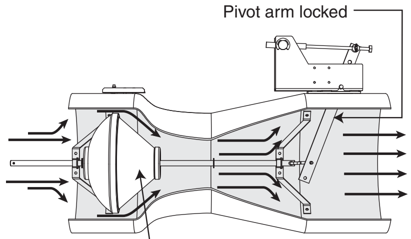
Valve Designs

- **A** - Conical Shape Diffuser (Standard Accel II Valve)
- **S** - Standard Shut-off Valve
- **L** - Low Leakage Shut-off Valve

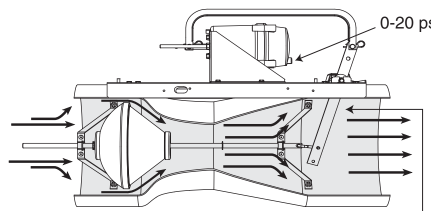
Valve Types

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:

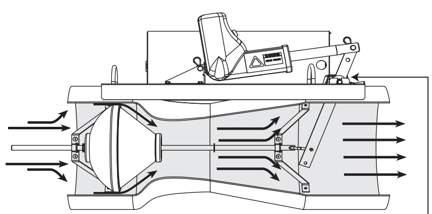
- **Constant Volume:** The valve's shaft is adjusted and then locked into a specific position, which provides the scheduled airflow via factory calibration.



- **Two-state:** The valve's actuator positions the shaft to two distinct airflows. Mechanical clamps assure precise minimum and maximum airflows via a factory preset.

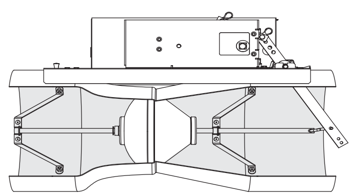


- **VAV:** Closed loop control of airflow via flow feedback to command. The shaft is positioned using direct potentiometer measurement to produce a linearized factory characterized feedback.



- **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	Two-position	Upgradable	Variable Air Valve Analog		Variable Air Volume Celeris			Traccel
Control type	C Fixed Flow	P Two-state (0/20 psi)	B Base Upgradable	A Analog (0-10 V)	E Analog (0-10V)	L Digital	N* Digital	M Digital	L Digital
Actuator Type	None	Pneumatic	Pneumatic	Pneumatic	High-speed electric	Low-speed electric	Pneumatic	High-speed electric	Low-speed electric
Fail safe	Fixed	NO/NC	NO/NC	NO/NC	NO/NC or last position	Last position	NO/NC	NO/NC, last position	Last position
Flow feedback signal	—	—	Option	✓	✓	✓	✓	✓	✓
Flow alarm via feedback circuit	—	—	—	✓	✓	✓	✓	✓	✓
Flow alarm via pressure switch	Option	Option	Option	Option	Option	Option	Option	Option	Option
Field-adjustable flow	✓	✓	✓	✓	✓	✓	✓	✓	✓
Factory-insulated valve body (supply)	Option	✓	✓	✓	✓	✓	✓	✓	✓
Low-noise diffuser construction†	✓	✓	✓	✓	✓	✓	✓	✓	✓
Single 14-inch	✓	Without Flow Feedback	Without Flow Feedback	N/A	N/A	✓	✓	✓	✓
Dual 14-inch	✓	N/A	N/A	N/A	N/A	✓	✓	✓	✓
Standard Shut-off	N/A	N/A	N/A	N/A	N/A	✓	✓	✓	✓
Low-Leakage Shut-off*	N/A	N/A	N/A	N/A	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**	✓	N/A	N/A	✓	✓	N/A	N/A	N/A	N/A
Quad valve body**	✓	N/A	N/A	✓	✓	N/A	N/A	N/A	N/A

* Not available in the 14-inch valve size.

** 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).

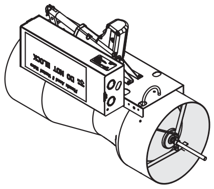
Accel II valves are designed to reduce sound over all frequencies, but significantly target the lower bands (125-500 Hz) to help eliminate the need for silencers.

Valve Sizes, and Operating Ranges

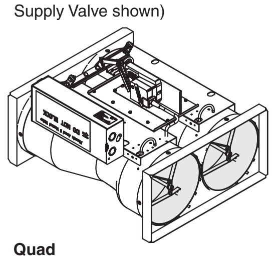
Accel II valves are available in four specific model sizes: 8, 10, 12 and 14" (for actual flow, refer to the chart below). In order to increase flow capacity, multiple valves may be assembled to operate as a unit.

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

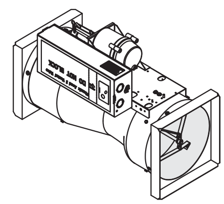
Single (Exhaust Valve shown)



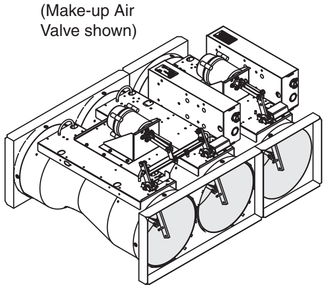
Dual (Pneumatic Supply Valve shown)



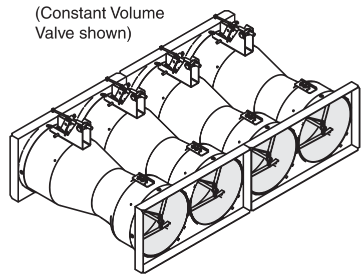
Single with Flange (Exhaust Valve shown)



Triple (Make-up Air Valve shown)



Quad (Constant Volume Valve shown)



		Standard Valves Celeris/Traccel/Analog Flow and Operating Range CFM (m3/h)				**Shut-off Valves - For both Standard "S" and Low-Leakage "L" Celeris/Traccel only Flow and Operating Range CFM (m3/h)**			
Designation	**Size**	**Single**	**Dual**	**Triple*** **	**Quad*** **	**Single**	**Dual**	**Triple**	**Quad**
Medium Pressure 0.6-3" WC (150-750 Pa)	08"	35-700 (60-1185)	—	—	—	35-600 (60-1015)	—	—	—
	10"	50-1000 (85-1695)	100-2000 (170-3390)	—	—	50-850 (85-1440)	100-1700 (170-2880)	—	—
	12"	90-1500 (155-2545)	180-3000 (310-5090)	270-4500** (465-7635)	360-6000** (620-10,180)	90-1300 (155-2205)	180-2600 (310-4410)	—	—
	**14"	200-2500 (340-4245)	400-5000 (680-8490)	—	—	200-1600 (340-2715)	400-3200 (680-5430)	—	—
Low Pressure 0.3-3" WC (75-750 Pa)	08"	35-500 (60-845)	—	—	—	35-400 (60-675)	—	—	—
	10"	50-550 (85-930)	100-1100 (170-1860)	—	—	50-450 (85-760)	100-900 (170-1520)	—	—
	12"	90-1050 (155-1780)	180-2100 (310-3560)	270-3150** (465-5340)	360-4200** (620-7120)	90-900 (155-1525)	180-1800 (310-3055)	—	—
	**14"	200-1400 (340-2375)	400-2800 (680-4750)	—	—	200-1000 (340-1695)	400-2000 (680-3390)	—	—

*CVVR - Flow Range: 35 cfm to 210 cfm (55m^3/hr to 355 m^3/hr) medium pressure only.

**Constant Volume, Celeris and Traccel only.

*** Analog controlled 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 a modern research facility. In shut-off mode, the valve 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.

Standard Shut-off Valve

The Standard Shut-off Valve is appropriate for applications where shut-off is for energy savings (GEX Shut-off), Fume Hood decommissioning and lab decommissioning (see Chapter 4 for more energy savings capabilities).

Low-leakage Shut-off Valve

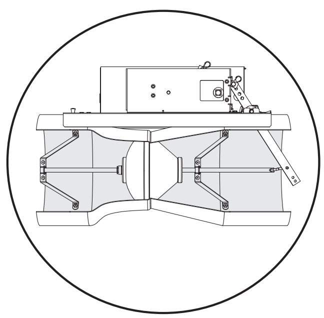


Figure 2-4. Valve in shut-off position.

The Low-leakage Shut-off Valve accommodates applications requiring a near bubble-tight ventilation system for critical environments needing emergency isolation or gaseous biodecontamination.

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,[1] 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.

[1] 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

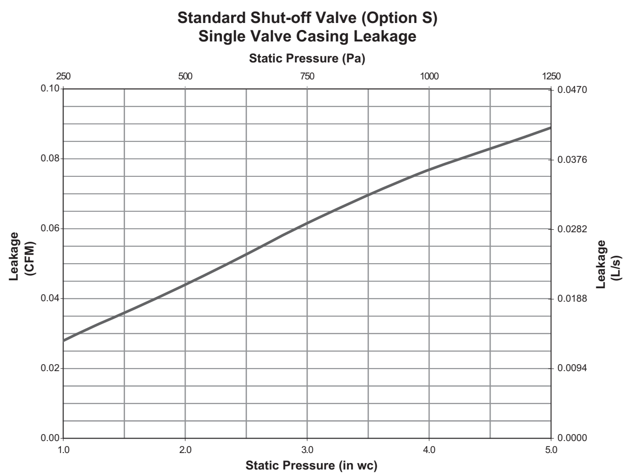


Figure 2-5. Standard Valve (A) and Standard Shut-off Valve (Option S) for 8, 10, 12 and 14-inch single body valves.

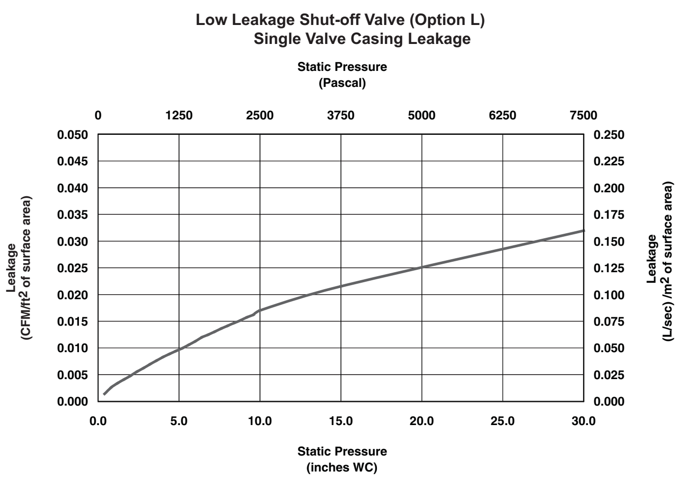


Figure 2-6. Low Leakage Shut-off Valve (Option L) — Shut-off leakage for 8, 10, 12 and 14-inch body valves.

Calculating Valve Areas		
Valve Size	**Area (ft²)**	**Area (m²)**
8"	3.60	0.33
10"	4.26	0.40
12"	6.28	0.58
14"	8.52	0.79

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 2-7. Standard Shut-off Valve (Option S) — Shut-off leakage for 8, 10, 12 and 14-inch single body valves.

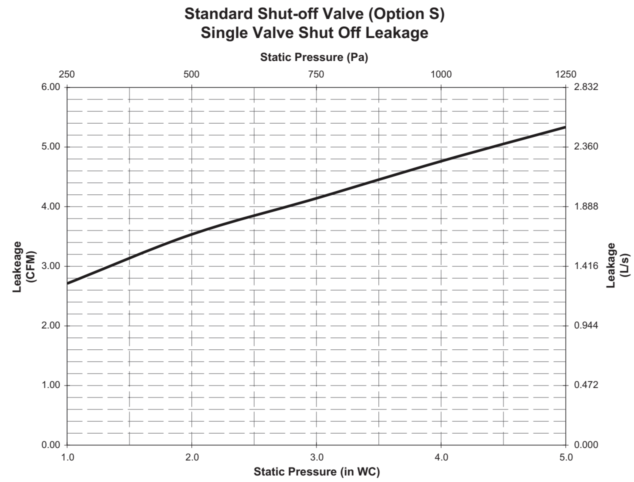
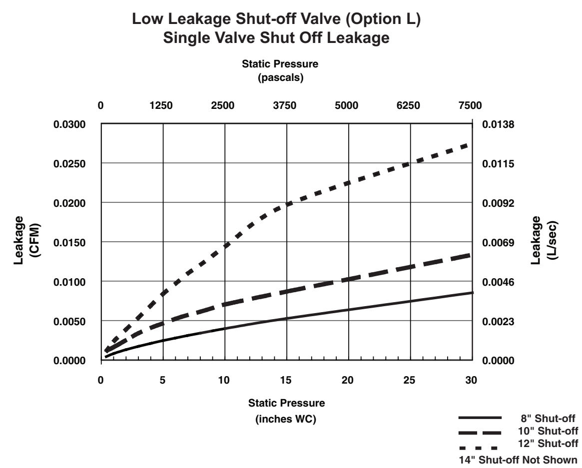


Figure 2-8. Low-Leakage Shut-off Valve (Option L).



Recommended Valve Class for Decontamination Agents	
Gaseous Decontamination Agent	**Recommended Valve Class***
Hydrogen peroxide vapor	Class A
Ethylene oxide	Class B
Ammonium chloride	Class A
Chlorine dioxide	Class A**
Parafirmaldehyde	Class A

*Chemical resistance data acquired from Compass Corrosion Guide.

**For concentrations up to 80 ppm. To achieve higher concentrations during decontamination, use Class B valves.

This chapter reviews each control approach, along with the advantages, disadvantages and benefits of each.

Table of Contents

3 Fume Hood Control Solutions

The four basic fume hood control approaches are: Constant Volume, Two-State, Variable Air Volume (VAV) and Usage-Based Controls (UBC).

- **Constant volume (CV) fume hoods** are designed to operate at a fixed airflow all the time (24/7). Whether these hoods are occupied or unoccupied, or have open or closed sashes, the fume hood flow remains the same. This type of fume hood tends to be the least energy efficient and is prone to having higher face velocity that when the sashes are lowered and lower face velocity when sashes are all the way open which can cause some safety concerns.
- **Two-state systems** are designed to switch between a minimum and maximum flow and differ significantly in flow design and switching mechanisms. Systems that interlock flow with light switches or room occupancy sensors will reduce flow at night but not during the day. Systems with sash switches allow each hood to control flow based on sash position. Unfortunately, sashes must be closed to realize the benefits.
- **Variable air volume (VAV) fume hoods** are designed to vary the flow through the sash openings as the sash(es) open or close to maintain a constant face velocity regardless of sash position. Designs of these types of fume hoods vary significantly from attempting control of the measured face velocity to measuring the sash opening and controlling the flow through the opening to maintain a constant face velocity regardless of sash position. The VAV fume hood offers the opportunity for significant energy reduction and savings through equipment downsizing, depending on whether users lower the sashes when the fume hood is not in use. See Diversity on page 29.
- **Usage Based Controls (UBC)** from Phoenix Controls has been designed to sense the actual presence of an operator at the fume hood and switch the flow between occupied and unoccupied face velocity setpoints. Many studies have shown that when there is no operator in front of an open fume hood "challenging" air flow used for containment, face velocities may be safely reduced by 20-40% which represents significant energy savings if the fume hood is unoccupied and the sash is left open for large portions of a 24-hour period. A UBC equipped fume hood will automatically "set back" to an unoccupied face velocity setpoint of 80 or even 60 fpm when the fume hood is not occupied. As soon as an operator steps in front of the fume hood, the face velocity will immediately switch back to 100 fpm and the desired face velocity will be achieved in less than 1 second. A fume hood with UBC us effectively a two-state hood, however it may be combined with a VAV control system with good sash management to realize up to 80% energy savings over CV fume hoods without compromising operator safety.

Face Velocity Controls Techniques

In order to maintain a constant face velocity with variable sash openings, there are two generally accepted methods of control.

1. Velocity sensing—the volume of air through the hood is controlled based in the measured speed of the air passing through the sash opening.
2. Sash sensing—the volume of air passing through the fume hood is calculated based on the measured sash opening using simple mathematics.

Velocity Sensing Systems

This system senses air velocity passing through a hole in the sidewall of the hood as an interpretation of average face velocity.

A slow speed of response is required to ensure stability (between 15 and 60 seconds). This is due to the large amount of turbulence in the sensed velocity signal of 100 fpm (about one mph). A single movement of an operator’s hands can further contribute to large changes in this sensed signal. The result is a loss of fumes when the sash is raised and dangerously high velocities when the sash is lowered.

Single point sensing does not sense the true average face velocity. Wide variations in the face velocity can occur over the entire sash area. Industrial hygienists have to take 9 to 12 readings to accurately measure the average face velocity. The relationship between the sidewall velocity and the average face velocity will also vary due to a variation in hood sash position, lab apparatus, people walking past the hood, door opening/closing, room air temperatures, heat sources within the hood, etc. The result is a constantly changing average face velocity and resultant lack of adequate face velocity control.

Hot Wire/Thermistor type velocity sensors are often used as side wall (through-the-wall) face velocity sensors. However, since fume hoods often contain explosive vapors, logic would preclude that the use of these devices, unless designed for Intrinsic Safety, could potentially cause an explosion. The UL 913 Standard sets the guidelines for Intrinsic Safety to limit the temperature and currents required to prevent ignition of the vapors during an equipment malfunction. Temperature and current limits required to prevent ignition or flashover can be exceeded during an equipment malfunction or in some cases even during normal operation.

When a user stands close to the front of the hood his body reduces the face velocities in front of him and increases the velocities in the rest of the hood opening by 10 to 30%. The sidewall sensor system responds by lowering the average face velocity. This reduces the velocity in front of the user from a low level to an even lower, potentially hazardous level. This is exactly the opposite response from what is needed for safe operation.

Sash Position Sensing Systems

This system senses sash position (open sash area) and commands exhaust volume linearly to maintain the average face velocity constant:

Average Hood Face Velocity = Exhaust Volume ÷ Open Sash Area

Fast response times of less than one second are possible since the required exhaust volume is determined immediately through the instantaneous measurement of sash position. To actually achieve fast response times with less than 5% overshoot, proper selection of the control system and measurement metering hardware must be selected as described later.

This control system is unaffected by lab room transients, apparatus in the hood or the position of hood operator. The system controls the hood’s true average face velocity.

Sash sensing technology from Phoenix Controls provides a unique methodology of measuring sash opening – so distinctive it has been covered under one or more patents. The Phoenix Controls approach is to use one or more vertical sash sensors to precisely measure the vertical sash opening and one or more horizontal sash sensors to measure horizontal sash opening and these values are summed to determine the total open area of the fume hood sash. The fume hood controller uses this value to calculate the volume of air required to achieve the desired face velocity through the sash opening. The fume hood monitor provides a command signal to the fume hood airflow valve which responds very rapidly to a change in the measured sash opening.

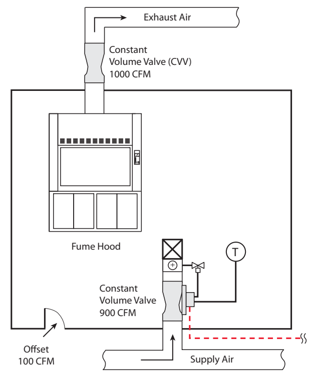
Multiple vertical sash sensors may be used to detect the position of multiple vertically moving sash panes. A combination of sensor bars, magnets, and blocking bars may be arranged in virtually any length or arrangement to measure the cumulative horizontal sash opening. Combination vertical and horizontal sash sensors terminate at a Horizontal/Vertical (H/V) interface PC board where the values are summed to create an total open sash area value for the fume hood monitor. So whether it is a single sided hood or four sided hood with movable upper and lower sashes, where each sash has any number of horizontal sash panes, Phoenix Controls has a sash sensing solution.

Not only is it the sash sensing techniques that make Phoenix Controls the market leader in fume hood control, the speed of response also sets us apart. From the moment a fume hood sash is moved, to the time the fume hood valve reaches 90% of its commanded value will be less then 1 second with little or no overshoot. Coupled with the accuracy, stability, turn-down, and pressure independence of the Accel II venturi valve Phoenix Controls the safest solution available on the market. Read on to learn about the savings delivered through Variable Air Volume control, Usage Based Control, diversity and maintenance free controls and you will understand why more Engineers specify Phoenix Controls and why more Owners, Health and Safety and Facilities personnel insist on Phoenix Controls for their laboratory control solution.

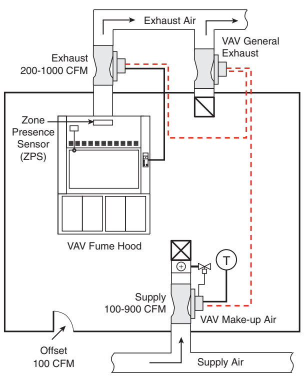
Phoenix Controls offers a wide variety of vertical and horizontal sash sensors. All styles of hood sashes (vertical, horizontal, combination and walk-in sashes) can be accommodated through the proper selection of the sash sensor type.

Comparing Control Approaches

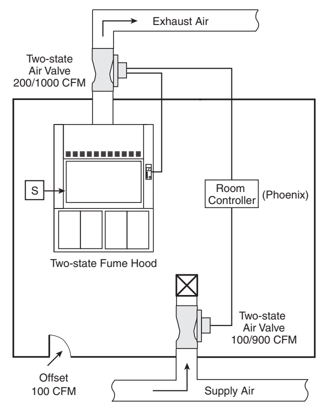
Deciding how to best control a laboratory depends on many factors. Safety, fume hood density, energy use, installation costs, and flexibility are a few of the issues that must be considered. This section explores the strengths and weaknesses of control applications in a generic form and offers insight into the benefits of the Phoenix Controls approach for each.



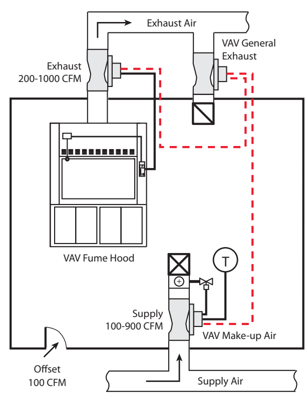
Constant Volume (CV)



Usage Based Controls (UBC)



Two-state (Traccel)



Variable Air Volume (VAV)

NOTES:

UBC and VAV are available in analog and digital platforms.

Constant Volume Laboratories

Generic Approach

In a generic constant volume (CV) system, a fixed blade damper is adjusted manually to set the fume hood exhaust rate—delivering the desired face velocity when the sash is at a specific opening. The room's make-up air rate is set by a fixed blade damper at a slightly lower rate to provide a net negative pressure in the lab and sufficient air change rates. Airflow through the space is usually sufficient for ventilation rates but additional air can be designed into the room, if required. Temperature control is normally provided by reheating the conditioned air or by supplemental baseboard or fan coil units.

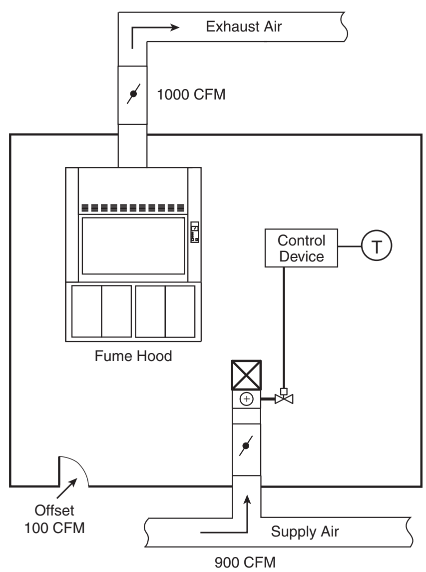


Figure 3-1. Generic constant volume laboratory.

Advantages

- Straightforward, simple design
- Low cost of controls

Disadvantages

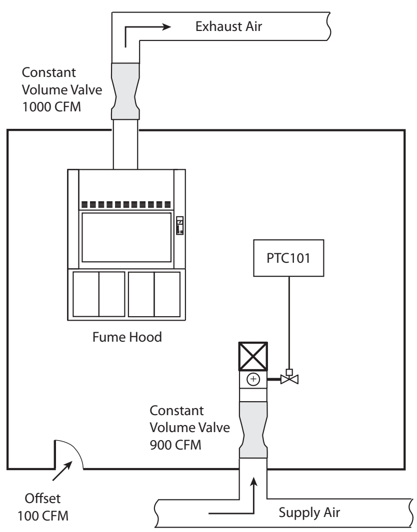
- Safety may be compromised. CV fume hoods do not control face velocity since different sash positions provide different face velocities. Bypass hoods are limited in their ability to prevent excessive face velocity.
- The system is pressure dependent. Changes and fluctuations create improper flow rates.
- Rebalancing is required at every damper location when changes are made or fan system performance degrades.
- High capital and life-cycle costs. Capital costs are high due to full load sizing of equipment; energy use is high due to continuous full-flow operation.
- Low flexibility. Future expansion may be limited due to equipment capacity limitations.
- Noise. Excess noise due to high airflow at all times.
- No inherent monitoring or alarming.

The Phoenix Constant Volume Approach

Option A: Constant Volume Application using Traccel

Phoenix Controls offers products to maximize performance in constant volume laboratories. Figure 3-2 shows typical CV laboratory devices with Phoenix Controls components.

Figure 3-2. Constant volume laboratory with Phoenix Controls. *Pressure-independent air valves (constant volume) maintain a constant volume at each location as system flow rates change. An optional monitor is available for continuous flow monitoring.*



Benefits

- Provides accurate, stable flow control.
- The system is pressure independent and maintains steady flow through system changes, filter loading and HVAC degradation.
- Flexible monitoring–Use either a Phoenix fume hood monitor (FHM) or the hood manufacturer's model.
- No wiring or tubing required for control.
- Ability to monitor and control temperature through the Phoenix Controls network.
- Ability to adjust offset via the network.

Figure 3-4 shows several constant volume laboratory exhaust devices controlled by pressure-independent constant volume changes.

Option B: Constant Volume Application using Phoenix Controls PTC Thermostat

Add the temperature control and monitoring capabilities of the Traccel system. Figure 3-3 shows typical CV laboratory devices with Phoenix Controls Traccel room controller.

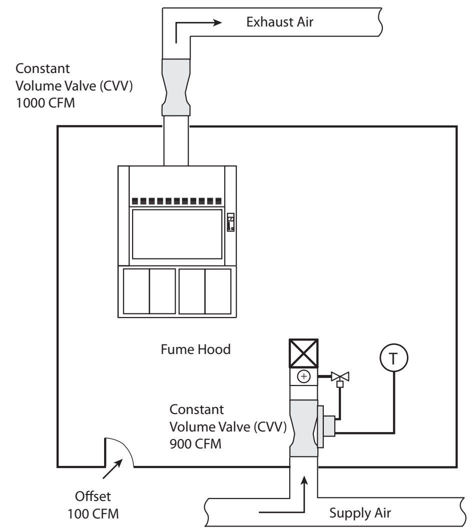
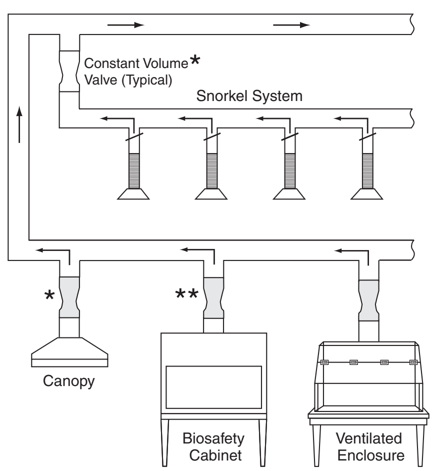


Figure 3-3. Constant volume laboratory with Phoenix Controls Traccel room controller. *All the benefits of the Accel II valve with the advantage of space comfort control through valve mounted controller. May operate standalone or as an integrated control system for remote monitoring.*



NOTES:
* Air valves used in this application can be two-position devices to conserve energy when these are not in use.
** Air valves for this application can be operated in two positions, shut-off and normal flow, to conserve energy when the cabinet is not in use.

Figure 3-4. Additional constant volume control needs. *The constant volume valves maintain precise flow and eliminate the need for future rebalancing at each lab device.*

Benefits

Add the option to integrate control and monitoring functions via:

- Direct LON integration to BMS.
- BACnet MS/TP integration to BMS Global controller.
- Integration through one of Phoenix Controls data servers BACnet IP.

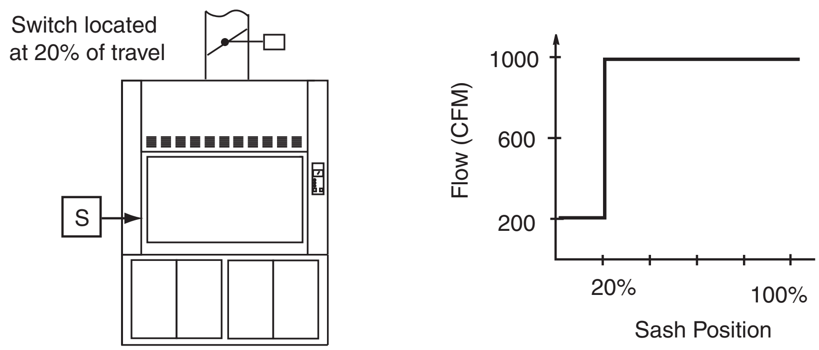
These devices may be hard balanced or add Traccel or Celeris controllers with low-speed actuators to gain both local and network control capabilities. With the networked solution as airflow requirements change, the system can be rebalanced via the network.

Two-state Laboratories

Generic Approach

This generic control approach uses two distinct levels of airflow through the fume hood to gain efficiency over CV systems. The set point is changed by a switching mechanism (typically a sash switch or light switch) to increase flow through the hoods when the switch is engaged. The flow is reduced when the switch is disengaged.

Figure 3-5. Generic two-state control with sash switch. *The graph shows the flow profile of a hood with the switch located at the 20% open position. With the sash below the switch point, the flow through the hood is reduced to a minimum value. Above the switch point, the flow increases to the maximum value.*



Advantages

- Saves energy–By switching fume hoods and room make-up air to lower flow rates, significant energy savings may be realized.
- Has fewer controls than a VAV system.

Disadvantages

- Common methods of switching may compromise safety.
  - "High-low" (also called "max-min") switches the airflow between two predetermined values. Manual switches allow for operator error. Sash switches eliminate operator error, but create switch points that cause either high- or low-face velocity. In addition, these do not reduce flow if the sash is left open (see Figure 3-5).
  - "Occupied-unoccupied" control via light switch interlock or room motion detectors may be used for night setback control, but offers little energy savings during daytime hours. HVAC equipment must be full-sized due to all hoods operating at full-flow during the day. Also, safety may be compromised when sashes have been left open and the hood is switched to low flow.
- Inability to confidently downsize a building's mechanical equipment.
- The need for variable air volume (VAV) supply controls on air handlers and fan systems serving areas with multiple hoods.
- The need for thermal demand override control may create system complexities.
- Hoods may not have monitoring or alarming.
- High maintenance on sash switches (poor quality).

Phoenix Two-state Approaches

Option A: Simple Two-state Application using Celeris or Traccel

Phoenix Controls offers simple pressure-independent air valves for use in two-state applications. Figure 3-6 shows a sash switch control option for a two-state laboratory. This example shows Phoenix Controls Traccel room-level controller for maintaining volumetric and space comfort control.

Phoenix valves that are used in two-state systems controlled by sash or light switches provide the advantages listed below.

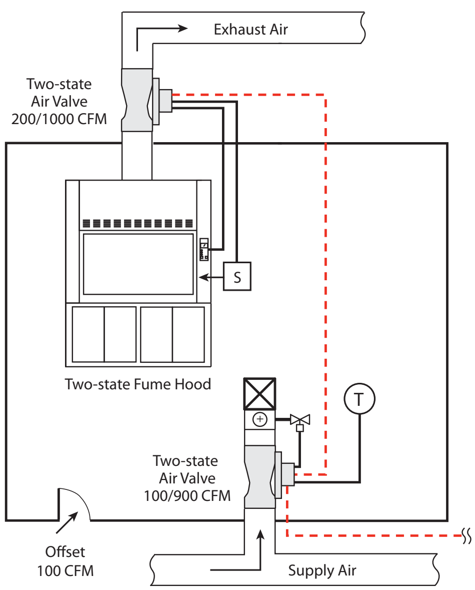


Figure 3-6. Two-state application with sash switch. *Pressure independent air valves maintain proper flow at each of two flow rates. The sash switch (by others) changes hood flow between low-high flows. A two-state supply valve tracks flow changes of the hood.*

Advantages

- Provides superior flow control with fast, stable adjustments.
- Control costs are low, compared to VAV.
- The pressure-independent system maintains steady flow through system changes, filter loading, and HVAC degradation.
- Flexible monitoring–Use either a Phoenix fume hood monitor (FHM) or the hood manufacturer's model.

Disadvantages

However, the disadvantages of controlling flow with these switching mechanisms still remain (see page 24).

Option B: Usage Based Controls (UBC) with Celeris

To address these concerns, Phoenix Controls offers a unique approach to two-state laboratory airflow control–Usage Based Controls (UBC). Refer to the section, “Usage Based Control Laboratories,” on page 28 for details. User occupancy of the fume hood determines normal or setback flow with 1 second speed of response.

Option C: Airflow Control in Classrooms with Traccel

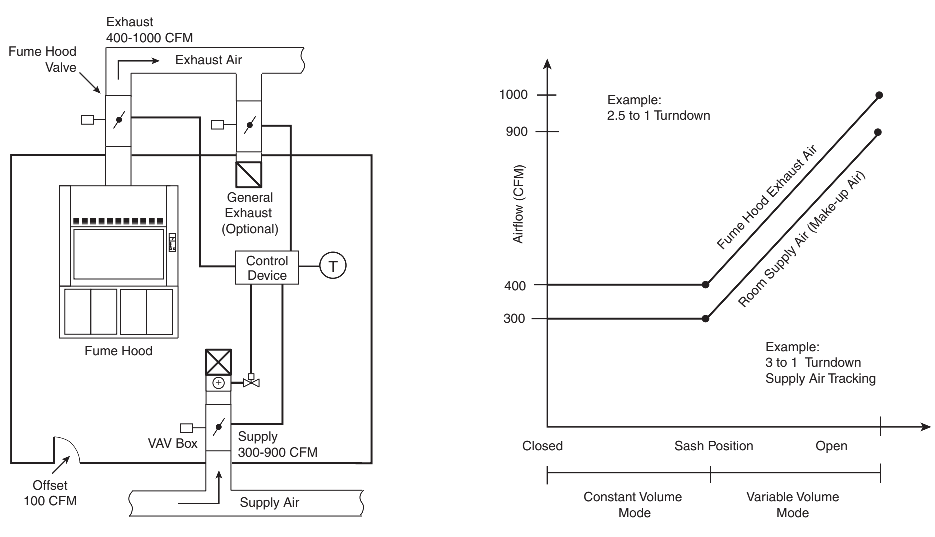
Airflow control in teaching classrooms may be implemented by switching the fume hoods and room airflows from lower to higher rates when the room is in use. The design can incorporate a local switch that allows the teacher to control the occupancy setting for the classroom. Additional safety factors may be included, such as sash switches or sash height alarms so that if any fume hood sash is open, the fume hood and room go into high flow mode. This application saves energy while giving users the schedule flexibility they need. Hood usage determines the normal or setback flow in which case 1 second speed of response is not required.

Variable Air Volume Laboratories

Generic Approach

A generic variable air volume (VAV) fume hood control system is designed to vary the hoods’ exhaust rate to maintain a constant average face velocity throughout the sash travel (e.g., 100 fpm), providing containment and significant energy savings. Room pressurization is maintained by adjusting the make-up air at a slightly lower rate than the exhaust. Minimum ventilation and proper temperature control may require the use of a general exhaust—where the exhaust air rate is increased to overcome the added supply requirements.

Figure 3-7. Variable air volume laboratory.



Advantages

- Significant energy savings will result when sashes are closed.
- Safety increases as a result of maintaining proper face velocity throughout the majority of sash travel.
- Inherent alarming and monitoring are typically part of a VAV system.
- Lab flexibility may be increased by the VAV controls' ability to accommodate system changes easily.
- Sound levels will be lower as flows are reduced.

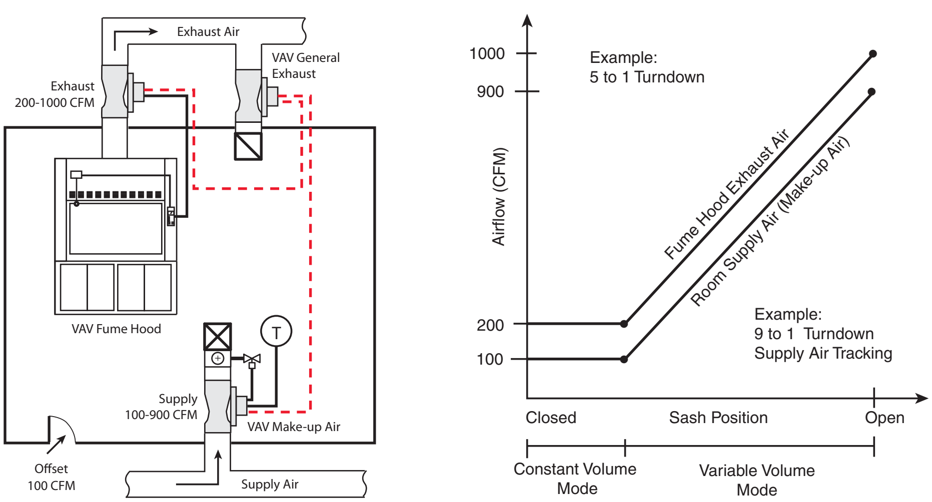
Disadvantages

- High airflows and operating costs if sashes remain open.
- Limited turndown capabilities. If the supply terminal box is limited to a 3:1 turndown ratio, the fume hood box must be limited to 2.5:1 which severely limits the ability to achieve substantial energy savings or diversity.
- The cost of controls may create payback issues. Since sash position typically determines airflow, proper sash management affects payback, acoustics, and diversity levels.
- The quality of the controllers will dramatically affect the performance of the HVAC system. Slow, inaccurate and high maintenance controllers are examples of features that are undesirable in VAV lab systems (see example in Figure 3-9).
- Not all VAV systems offer the same performance. Speed of control, turndown range, integrated comfort control, stability and maintenance requirements differ significantly among control systems.

Phoenix Variable Air Volume Approaches (using Celeris)

Variable Air Volume Laboratory with Fume Hoods

Phoenix Controls offers sash sensing, pressure-independent venturi air valves, and volumetric room flow controls for VAV applications. Figure 3-8 shows a VAV lab with Phoenix Controls components.



NOTE: Room controllers are required for analog systems.

Figure 3-8. Variable air volume application with Phoenix Controls. *Pressure-independent air valves maintain proper flows over the entire range of command. The sash opening determines flow requirements through the hood while the room make-up air adjusts to maintain pressurization. If additional air is needed due to thermal or ventilation requirements, the general exhaust and make-up air valves adjust accordingly. The fume hood monitor provides continuous monitoring, meeting regulatory requirements.*

Benefits

- Superior flow control with fast (< 1 second), stable adjustments over large flow changes (10, 15 or 20 to 1)
- Extremely low maintenance devices
- The pressure-independent system maintains steady flow through system changes, filter loading, and HVAC degradation.
- Low sound power levels
- Ability to pass all room-level and fume hood data to the BMS using a Phoenix Controls data server.
- Take advantage of any number of Phoenix Controls control functions designed specifically for laboratory airflow and temperature control.
- Ability to reset offset and ACH of labs remotely via the network

Phoenix valves provide the benefits listed above when used in variable volume systems. However, the disadvantages of not closing sashes still remain. To address these concerns, Phoenix Controls offers a unique approach to variable volume laboratory airflow control—Usage Based Controls (UBC). Refer to the Usage Based Control Laboratories section below for details.

A B

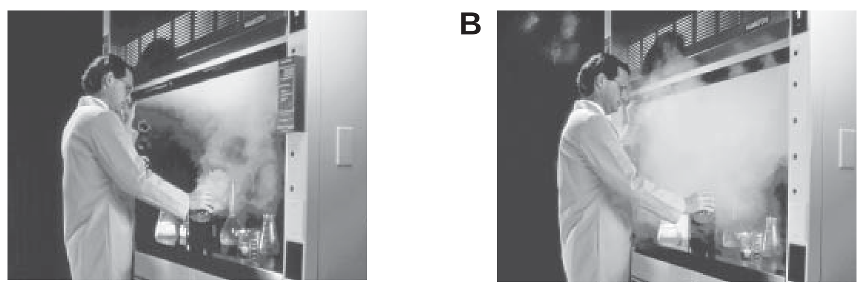


Figure 3-9. Fume hood controls that provide containment—and controls that do not. *Some variable air volume controls do not meet the objectives of airflow controls. These pictures show one fast, stable system that contains fumes (A) and one system that reacts slowly, allowing fumes to escape (B).*

Usage-based Solutions for Laboratory Airflow Control Design

Historically, fume hoods and the laboratory rooms containing fume hoods were operated at a constant volume independent of fume hood sash position, thermal loads, or lab usage. From an operating view, these systems increased life cycle costs due to peak-load equipment sizing and high energy use. This changed dramatically in the 1980s with the introduction of variable air volume (VAV) laboratory airflow control. The result was a reduction in the fume hood and lab airflow volumes from peak constant volume levels based on both fume hood sash position and lab room thermal requirements. Safe operation of the lab is thereby provided with potential reduction in equipment sizing and energy costs compared to constant volume (CV) operation (energy savings do not occur when sashes are left open). This section addresses the need for appropriate airflow rates to meet containment needs while *assuring* the reduction in airflow for savings.

Optimizing HVAC Design: Understanding Diversity

In its simplest definition, diversity is designing a system for less capacity than sum of the peak demands. Examples of systems designed with diversity include plumbing and telephone systems, in which piping and equipment is sized for predicted use, not total possible use. With laboratories, understanding the factors that affect diversity can help designers size HVAC systems properly and give them confidence to size them for predicted use, not total possible use.

Factors that Affect Fume Hood Diversity

- ***Presence of an operator***–Fume hood user presence is an important factor in determining diversity levels. Several independent studies (including "Measuring Fume Hood Diversity in an Industrial Laboratory," by John O. Varley–*ASHRAE Transactions 1993*, volume 99, part 2) have shown that the amount of time that the fume hoods are occupied during the day tends to be very short—often less than one hour per day. Figure 3-10 illustrates a typical example of the use of a fume hood.

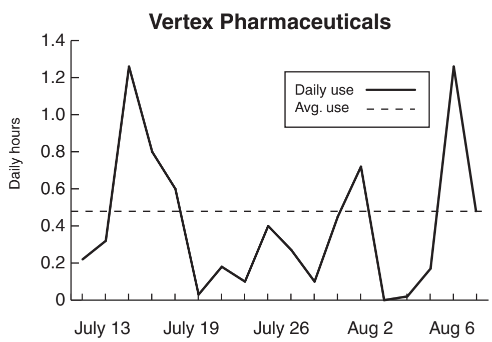


Figure 3-10. Operator usage of a fume hood. *The graph shows the total daily usage of a typical laboratory fume hood and the overall average daily use of less than one hour per day. This partial day use concept is backed further by the table below, which shows the fume hood user's presence for several categories of laboratories.*

Amount of Time that Operators are Present at Fume Hoods[2]

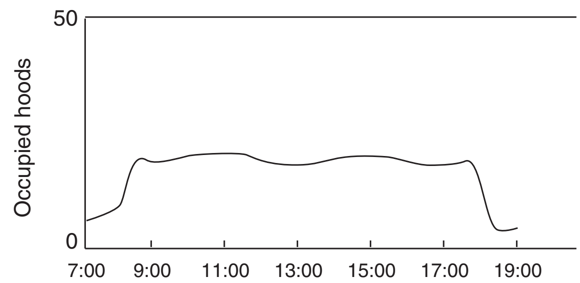
Facility Type	Number of Hoods	Hours of Hood Presence	Total Time Period	Presence as a % of Total Time	Max. Hours per Day	Min. Hours per Day	Average Hours per Day	Median Hours per Day	Standard Deviation
Chemistry/Biology	68	502.33	22,322.47	2.25	2.97	0.01	0.78	0.50	0.70
Pharmaceutical	31	281.71	5,521.70	5.10	4.08	0.03	1.40	0.83	1.25
Water Testing	9	86.52	1,046.17	8.27	5.50	0.42	2.13	1.51	1.53
Miscellaneous	6	100.21	1,940.25	5.16	5.50	0.01	1.05	0.67	1.05
All Facilities	114	970.77	30,830.59	3.15	5.50	0.01	1.17	0.74	1.11

- ***Sash management***–Another factor that affects fume hood diversity is how users treat the sashes. When users are in front of hoods, they typically have the sash open. When they leave the hood, they may or may not close the sash. The level of sash closure determines the sash management level (from poor to excellent) of a facility. Sash management is difficult to predict, so many designers assume the worst case and design for full capacity.

- ***Random use of fume hoods***–Research conducted at over 35 sites[2] helped determine that fume hood use is very random throughout the day. This is important because it means that there is no time throughout the day where most or all hoods will be occupied.

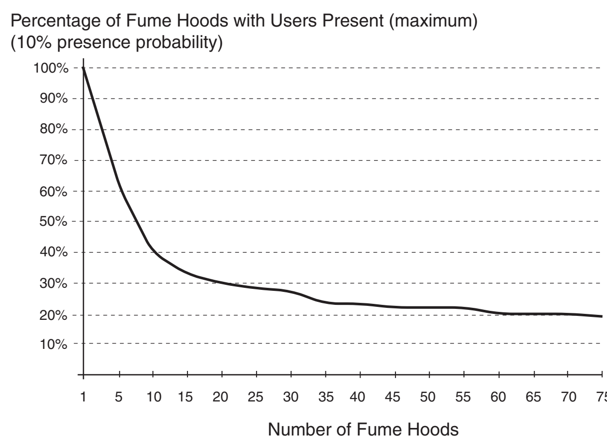
[2] Phoenix Controls, Field study of 114 hoods at 35 different sites, October 1993-July 1994.

Figure 3-11. Fume hood occupancy is a random function. *The graph shows the operator use trends of a fume hood. Research has shown that hoods have no peak time of use and are used randomly throughout the day (see the above table, "Amount of Time that Operators are Present at Fume Hoods").*



- ***Quantity of fume hoods***–By combining knowledge about the presence of an operator, the random use of hoods and the quantity of fume hoods on the system, a statistical tool, such as the Probability Distribution Function, can be used. This helps determine the quantity of operators that will be in front of a given number of fume hoods at any time (see Figure 3-12). By addressing issues, such as sash management, building operating hours, and number of hoods per manifold, system diversity can be calculated (see diversity example on page 29.

Figure 3-12. Diversity Potential. *The graph shows statistically the quantity of operators at a given number of hoods based on a 10-hour day and 1-hour/day use by an operator (a 10% user probability). Example: on a 10-hood project, 4 operators would be using their hoods at any given time (6 hoods would be vacant). Notice that once 45 fume hoods are connected to a manifold, the percentage of fume hoods with operators present approaches a constant 20%. This graph will change as the user presence probability changes.*



Diversity in New or Existing Laboratories

Existing laboratory facilities and new construction can benefit from applying diversity to the HVAC design. Diversity allows existing facilities to add fume hood capacity using current HVAC systems. Diversity design in new construction allows the facility to reduce capital equipment expenditures by downsizing the mechanical systems up front.

For either type of facility, designers must develop a solution that best fits the customers' needs. However, some designers are hesitant to take diversity since the savings are only realized when the fume hood sashes are closed. Often, this has led to systems with methods of "forced" diversity that have proven problematic:

- **Mechanical sash stops**–This "prevents" a user from opening a sash beyond a predetermined maximum setting. Unfortunately, users often override these mechanical stops for everyday activity and for setting up experiments. This can create a dangerously low face velocity profile if the controller is not sized for full sash opening.

- **Sizing flow control based on low face velocity settings**–By lowering flows, containment may be compromised.

Understanding the Control System Options

With the knowledge of diversity established, the types of control approaches can be better understood for their roles in optimizing HVAC systems.

Applying Diversity with Usage Based Controls

To illustrate the method for calculating HVAC system diversity in laboratories, several scenarios will be created. Assumptions:

Facility Type	Chemistry research facility
Number of fume hoods	50 (all on one exhaust manifold)
5' fume hood	100 CFM fully open 600 CFM at sash stops 200 CFM sash closed
Building occupied hours	10 (8 a.m. to 6 p.m.)
Fume hood sash position (user present)	100% (fully open)*
Fume hood sash position (no user present)	50% open*

* Sash position is very unpredictable. However, for this example, it will be assumed that when users are at their fume hoods, they have their sashes open fully (or 100% open). It will also be assumed that when they leave their fume hoods, only 50% of users will close their sashes.

From the graph in Figure 3-12, there will be 10 or fewer fume hoods with users present (50 hoods x 20% = 10 hoods). That leaves 40 hoods unoccupied. Given this information, design flows can be determined as illustrated in the following design scenarios:

1. Constant volume hoods operating at 1000 CFM
2. Constant volume hoods operating at 600 CFM (e.g., high-efficiency hoods)
3. Two-position hoods changed by a light switch
4. A VAV system
5. A Usage Based Controls system operating at 60 fpm when hoods are unoccupied, but changing to 100 fpm when occupied

Scenario #1: **CV operating at 1000 CFM**

This CV system will have all 50 hoods operating at full airflow throughout the day:

50 hoods @ 1000 CFM = 50,000 CFM

Unfortunately, hoods operating at this level of airflow present no diversity potential.

Scenario #2: **CV with sash stops operating at 600 CFM**

This CV system will have all 50 hoods operating at 600 CFM at all times:

50 hoods @ 600 CFM = 30,000 CFM

Although this reduces airflow by 40%, the fundamental requirement of fume containment may be compromised in real-world conditions. Also, this approach leaves no safe expansion capabilities.

Scenario #3: **Two-position hoods via light switch**

This approach will have all 50 hoods operating at 1000 CFM during occupancy, with reductions to 60 CFM during unoccupied times:

Day:	50 hoods	@	1000 CFM	=	50,000 CFM
Night:	50 hoods	@	600 CFM	=	30,000 CFM

Although this approach saves energy at night, it offers no design diversity. Also, safety may be compromised in the event that someone operates the hood with the room's lights off.

Scenario #4: **VAV hoods**

From our design assumptions, 50% of the unoccupied hoods have sashes open (1000 CFM) and 50% have the sashes closed (200 CFM). The flow calculation for this approach is:

10 occupied hoods	@	1000 CFM	=	10,000 CFM
20 unoccupied hoods	@	1000 CFM	=	20,000 CFM
20 unoccupied hoods	@	200 CFM	=	4,000 CFM
		Total	=	34,000 CFM

Although this VAV approach provides adequate face velocity for operator safety, saves energy, and offers opportunity for diversity flow reduction, it *requires* good sash management.

Scenario #5: **Usage Based Controls**

As in example #4, 50% of the unoccupied hoods have sashes open, but the flow through these hoods is reduced by 40% (600 CFM) because of UBC. The remaining unoccupied hoods have closed sashes (200 CFM). The flow calculation for this approach is:

10 occupied hoods	@	1000 CFM	=	10,000 CFM
20 unoccupied hoods	@	600 CFM	=	12,000 CFM
20 unoccupied hoods	@	200 CFM	=	4,000 CFM
		Total	=	26,000 CFM

With Usage Based Controls, airflow is kept at safe operating levels for the users while reducing airflow to levels below all other systems.

Rating Summary

Each scenario can be graded on various criteria. This table helps to summarize each approach.

	Safety	Diversity	Energy	Flexibility
	• • •	•	•	•
Scenario #2	• •	• • •	• •	•
Scenario #3	• •	•	• •	•
Scenario #4	• • •	• •	• • •†	• •
Scenario #5	• • • •	• • • •	• • • •	• • • •

EXCELLENT • • • • **GOOD** • • • **FAIR** • • **POOR** •

†Sash management dependent.

This means that higher flows are used only at the hoods that are occupied—for only the time someone is present. When the operator leaves, the flows are reduced, assuring lower airflow rates. UBC can be applied to enhance VAV and two-state systems.

Energy Consumption Comparison

The two tables below are examples of total flows a owner might expect in a day when comparing a high-efficiency hood with a VAV and VAV-UBC.

In both of these tables, a good and poor sash management scenario is used to point out the energy savings need that created the high-efficiency hood. Hood usage for both tables is based on field data explained in the "Factors that Affect Fume Hood Diversity" section on page 28.

In the VAV table, the owner can realize greater energy savings than a high-efficiency hood with a 40 fpm face velocity by requiring his operators to use good sash management with a standard VAV hood. This would allow the owner to also retain the safety level of 100 fpm recognized by all industry and government codes.

In the UBC table, the owner can experience even greater energy savings than high-efficiency hood by either adding or using VAV- UBC to their hood. In this example the VAV-UBC hood at 100 fpm provides savings that would force the high-efficiency hood to go far below 40 fpm to match. Phoenix Controls has provided this type of safe high-efficiency hood control for years.

Variable Air Volume Approach				
	Face Velocity	**Flow**	**Hours/Day**	**Total Flow**
Conventional Hood	100 fpm	1,000	24	24,000
High-efficiency Hood	60 fpm 40 fpm	600 400	24 24	14,400 9,600
VAV Poor Sash Management	100 fpm 100 fpm 100 fpm	1,000 600 200	1 16 7	1,000 9,600 1,400
	Total		**24**	**12,000**
VAV Good Sash Management	100 fpm 100 fpm 100 fpm	1,000 600 200	1 7 16	1,000 4,200 3,200
	Total		**24**	**8,400**

Usage Based Controls Approach				
	Face Velocity	**Flow**	**Hours/Day**	**Total Flow**
Conventional Hood	No opportunities for savings			
High-efficiency Hood	No opportunities for savings			
VAV Poor Sash Management	100 fpm 60 fpm 100 fpm	1,000 360 200	1 16 7	1,000 5,760 1,400
	Total		**24**	**8,160**
VAV Good Sash Management	100 fpm 60 fpm 100 fpm	1,000 360 200	1 7 16	1,000 2,520 3,200
	Total		**24**	**6,720**

This example shows that with VAV poor sash management, there is potential savings of 3840 cfm per day using Usage Based Controls!

With VAV good sash management the savings are less, however it still represents a 20% reduction in flow.

With this knowledge of diversity, an enhanced control system has been designed to sense the actual usage of the fume hood by an operator versus just sash position. This allows a designer to predict fume hood use and to assure a safe level of diversity.

4

This chapter compares differential pressure versus volumetric offset as a means of controlling fume hood labs. It also explores the many ways the Celeris and Traccel room control functions may be configured for various room control strategies. Finally, a number of built-in energy saving control schemes are presented.

Table of Contents

Room-Level Control Solutions

Unique Requirements of Laboratory Airflow Control

This section reviews control issues that are critical to creating safe and reliable laboratory buildings. The majority of these issues focus on VAV controls, but many of the criteria are also required for constant volume and two-state laboratories. To achieve the objectives, several important issues must be addressed:

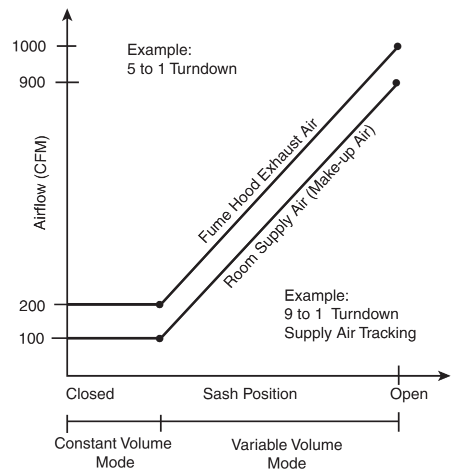
- Accuracy of the turndown ratio (control range)
- System response time
- Pressure independence response time
- Stability of the control system
- Insensitivity to inlet and exit conditions
- Equipment simplicity and reliability

Accurate Turndown Ratio (Control Range) of Approximately 10 to 1

The fume hood face velocity needs to be maintained accurately over a wide range for safety and energy-saving reasons. This requirement is evident from Figure 4-1. In this example, hood exhaust flow has a 5-to-1 turndown (1000 CFM to 200 CFM). Since the supply air is offset by a constant 100 CFM, the room supply air then requires a 9-to-1 turndown (900 CFM to 100 CFM).

Precise flow control over the entire turndown range is needed. An accuracy of ±5% of the desired airflow is important to maintain the correct face velocity and proper room pressurization. Concerning the latter, Figure 4-1 also shows how with the typically desired 10% room offset volume, if the supply flow is 900 +5% (945) and the exhaust is 1000 - 5% (950), then the room is at the worst case limit of still providing a net negative offset. Any worse accuracy would make the room go positive or require a larger than desired room offset.

Figure 4-1. Volumetric tracking of VAV fume hood and make-up air.



Speed of Response Time Less than One Second

In addition to the need for a fast responding hood exhaust control system, the supply and general exhaust control system must also respond rapidly to continuously maintain proper pressurization control. Figure 4-1 shows how the room pressure can go positive due to a slow supply flow response time. Furthermore, without supply and general exhaust controls that also respond in less than a second, the response time and containment performance of the fume hood system could be adversely affected.

Pressure Independence Response Time: Less than One Second

In a manifolded exhaust and/or supply system with more than one VAV control device, rapid changes in volume due to fume hood sash movements will typically cause changes in duct static pressure. Figure 4-2 illustrates how the variation in the response of individual VAV devices to a change in static pressure (pressure independence) might create oscillation in the total system.

This fast pressure independence guarantees a stable solution since all the VAV devices react almost instantaneously to changes in duct static pressure and volume. Other techniques, such as enlarging the duct work to reduce static losses, can also help reduce these oscillation problems. However, not only can these changes be expensive and hard to implement and evaluate, but these are also completely unnecessary when the <1 second system response requirement is met.

Stable Control System: Less than 5% Overshoot

The control system should exhibit less than a 5% overshoot or undershoot when attempting to reach a desired control value. Pulsations of face velocity caused by these oscillations could affect the hood's containment. Figure 4-2 indicates the type of serious oscillations that may occur if stability is compromised for speed of response. Control approaches that measure volumetric airflow are especially prone to this effect.

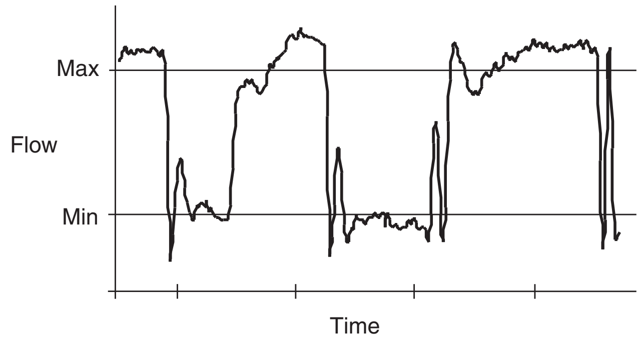


Figure 4-2. Laboratory VAV control system—typical system oscillations. *Many systems are not able to provide both speed and stability. This graph represents the instability that often occurs with typical controllers when sashes are opened and then closed.*

Insensitivity to Inlet and Exit Conditions

Laboratories typically have large volumes of exhaust and supply airflow, which results in congested, tight ceiling areas for the corresponding duct work. This duct work can be quite convoluted, leaving little room for the long straight duct runs necessary for the typical airflow measuring devices to meet stated accuracies. As shown in Figure 4-3, traditional flow measurement devices, such as pitot tubes, orifice rings, thermal or other point specific sensors, become poor candidates for lab applications. In addition, the extra duct work associated with these devices can significantly increase the installed cost of the system and increase static pressure.

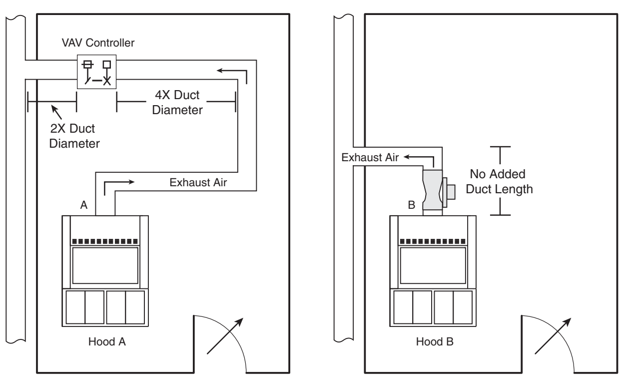


Figure 4-3. Installation requirements. *Traditional flow measurement devices (A) require laminar flow–adding several diameters of straight duct lengths for installation. Devices that do not have such limitations (B) are desirable for tight laboratory installations.*

Equipment must be Simple and Highly Reliable

Since life safety issues are involved, the quality and reliability of the system must be high. Fail-safe and redundant features should be installed wherever possible. Control system concepts and equipment must be simple and easily understood by the average maintenance person. Troubleshooting should also be quick and easy so that the owner's in-house service and maintenance people can keep the system in proper operation. The alternative is a system that has been disabled or bypassed, potentially creating a dangerous hazard to the lab users.

Two Approaches to Laboratory Pressurization Control

Constant Differential Pressure Control

A pressure or air velocity sensor is mounted in the lab/corridor wall to measure and control pressure difference per a setpoint between .005" to .05" WC.

Most sensors are unidirectional, potentially resulting in the wrong polarity of lab pressurization due to a disturbance such as a swing of a door in the corridor or a room pressurization change.

Very slow response times and time delays (over one minute) are required to ensure stability. This results in wide fluctuations in room pressurization when the hood sash is raised or lowered, thereby, changing hood face velocities.

The control of room pressure disappears when doors to corridors or other rooms are left open, windows are opened, ceiling tiles loosen, etc. The system will shut the supply air damper when a door is left open. This in turn requires all of the hood's make-up requirements to be pulled from the corridor. The result is a very negative corridor which also disturbs the room pressure controllers in other rooms connected to this corridor and effects the overall building pressure as well.

This approach may often require expensive "sealing" of the lab rooms, particularly in larger rooms. The normal porosity of most rooms reduces the room pressure offset to uncontrollable levels requiring such measures to tighten the room.

Since the volume offset between the lab room and the corridor is not held constant, the corridor and also the gross building pressure can vary uncontrollably. This persistent variation in building pressure can make balancing of the building and its subsystems difficult, if not virtually impossible.

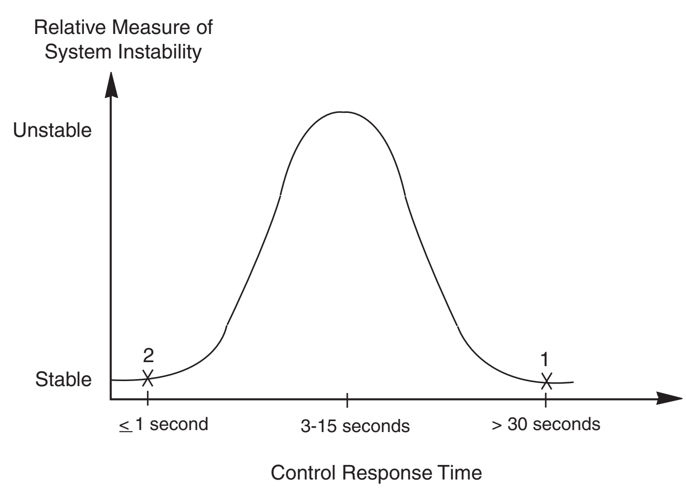


Figure 4-4. Representative curve of system instability vs. VAV device response times. *Traditional VAV supply systems for office buildings, etc., solve the oscillation problem by slowing down the response times and operating at a point on the curve, such as "1." This, however, is not acceptable in a laboratory since it would violate the speed of response requirement. The only solution is to operate at point "2," where the time delay has been effectively eliminated by reducing it to less than 1 second.*

Constant Volume Offset Control

The supply volume is controlled to maintain a fixed volume offset from the total exhaust volume. The objective is to maintain a net negative or positive pressurization versus trying to maintain an exact value of pressurization. For laboratory environments, this is all that is required by codes and standard laboratory safety practices.

This approach is unaffected by open doors, loose ceiling tiles, etc.

Net pressurization is maintained by using fast, supply and exhaust airflow control devices. (All exhaust and supply sources should be monitored). Building balance is straightforward to set up and maintain due to constant, set volumes being drawn from the corridor.

This simple proven approach has been used for many years in constant volume and VAV lab spaces. The accuracy, stability and lack of calibration shift over years of service make the Phoenix Controls Accel II valves ideal for this application.

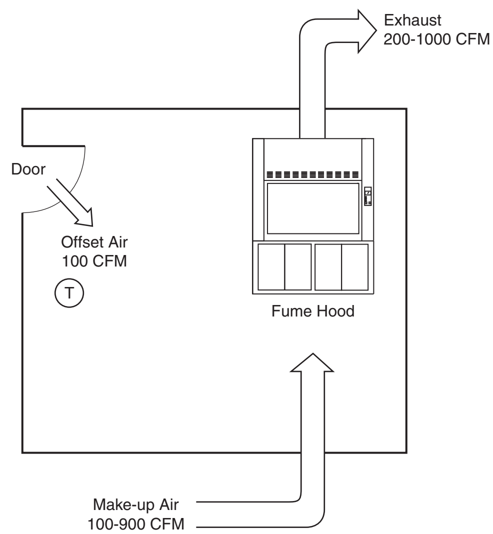


Figure 4-5. Volumetric Tracking of VAV fume hood airflow to sash position.

Environmental Control Solutions

In wet chemistry laboratory applications, changes in ventilation rates are driven primarily by fume hood demand. For operator safety and proper fume hood containment, it is important that the fume hood valve be able to track changes in sash position in order to maintain a constant face velocity. To do this, the air flow control device must be able to be repositioned to a new flow command within one second with little or no overshoot.

For proper laboratory pressurization, it is important that the make-up air (supply) and general exhaust have the same speed of response. The controllers responsible for ventilation pressurization and fume hood make-up air control must be able to sense the change in fume hood flow and issue new flow commands to the make-up air and general exhaust valves in order to allow them to track the fume hood flow (<1 second).

The focus for laboratory design today is on energy efficiency and flexible research space. Control strategies embedded in the valve mounted controller offer many conventional methods of achieving energy savings as well as control schemes just beginning to gain acceptance. The flexibility of the Celeris and Traccel control systems and the accuracy, stability and high turndown ratio of the Accel® II venturi valve, allow the system to easily be reconfigured for changing research requirements through a few network commands or configuration alterations for:

- Air change rates
- Polarity (negative or positive)– Based on the research conducted
- Temperature control strategies and set points

How flexible is the Phoenix Controls Environmental Control System?

The Celeris Environmental Control System is very flexible. Here are some examples of its scalability.

From	To
Adding a single Traccel valve controller to a space designed as constant volume for implementing specific control strategies or integrating lab data	Dozens of Celeris valve controllers functioning interactively to satisfy complex control strategies
Standalone, non-integrated systems	• Individual labs or groups of labs, seamlessly integrated to the BMS • Entire buildings with hundreds of valves and thousands of points seamlessly integrated to the BMS

As more extensive renovations or realignment of space occur, hoods may be added or deleted as research requirements change. The turndown of the Phoenix Controls Accel® II venturi valve used for air comfort and general exhaust can accommodate varying hood densities.

As airflow or pressurization requirements change, there may be an impact on adjacent spaces that contribute directly to the balance of all adjoining spaces. The common corridor must adapt to the changes in airflow. The airflow devices in the corridor must be sized to handle not only their own ventilation and cooling requirements, but also to supply offset air and absorb all offset air depending on control scheme.

Celeris® and Traccel® Environmental Control System

Phoenix Controls offers a variety of products and systems that control airflow precisely and save energy in laboratories. These products and systems are also designed to ensure all occupants are comfortable and safe.

- Celeris® Environmental Control System
- Traccel® family of Room Controllers

Benefits of the Phoenix Controls Environmental Control System and Venturi Valve

Both the Celeris Valve Controller and the Traccel Room Controller provide precision airflow control of the Phoenix Controls Accel II venturi valve using normal speed (60 seconds) electric actuation. The Celeris system adds high-speed (<1 second) pneumatic and electric actuation.

- A high turndown ratio allows the lab to remain in control over the range
- Precision flow metering allows the labs to respond accurately to a 200 CFM change in offset on a gross flow of 2500 to 3000 CFM total flow
- The pressure-independent Accel II valve maintains consistent flow with potential large changes in the suite's supply and exhaust demand, as well as any other changes on the common ventilation system
- The Celeris system monitors flow from adjoining spaces and adapts corridor flow automatically
- Shut-off valves and embedded control sequences

Other products are also available. Refer to Chapter 6 for details.

The Celeris Control System implements a wide variety of room-level control schemes through downloadable firmware. It accomplishes many sophisticated control sequences simply by connecting sensors and actuators to any available input or output on any available valve controller and configuring the modular control functions. Valves are available with high-speed electric and pneumatic actuations as well as with a normal-speed (<60 seconds) actuator. The valves are also available in both standard and shut-off configurations. The valve controllers use the room-level network to share I/O and control data to execute the desired control sequences.

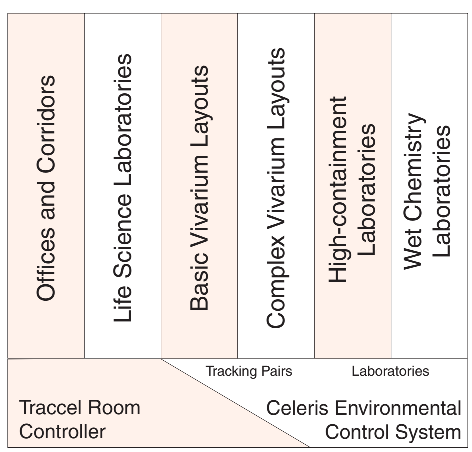
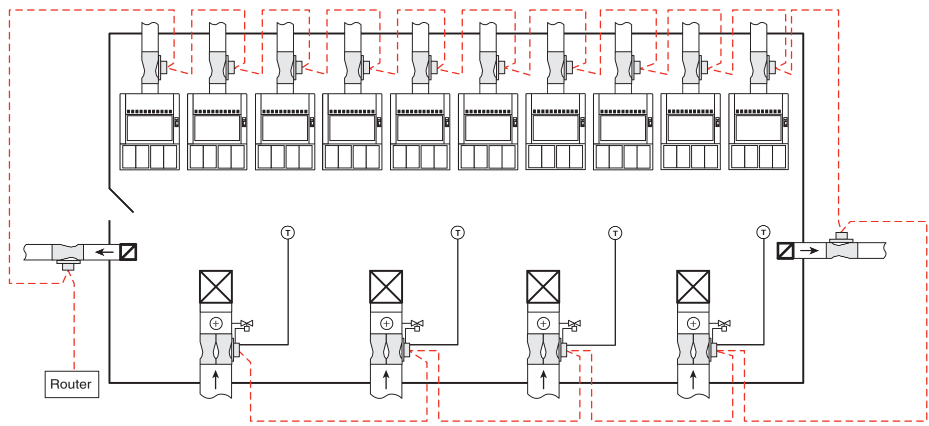


Figure 4-6. The Traccel Room Controller and Celeris Environmental Control are ideal in a variety of spaces and layouts.

The Celeris laboratory control system is designed specifically to provide high-performance air flow control. Each Celeris pressurization control zone supports:

- Up to 10 fume hood valves, each of which can have up to 2 boosters
- Up to 4 Makeup Air Valves, each of which may have up to 2 boosters
- Up to 2 office or support spaces within the lab space
- One General Exhaust, which may have up to 8 boosters

Figure 4-7. A lab system with 10 fume hoods and 4 temperature zones in one pressurization zone.



Where high-speed flow control is not required, Celeris tracking pairs are used for more complex room-level control where changes in airflow are driven by temperature or occupancy control as seen in

- Biology labs
- Animal holding spaces
- Procedure rooms
- Constant volume spaces requiring precise temperature and humidity control

Where VAV fume hood control is not required and the normal-speed (<60 second) electric provides the same precision control at a more economical price.

Each controller is assigned specific room-level control functions. Each valve controller is defined as either a supply or exhaust valve and then assigned some combination of room-level control functions, such as zone balance, temperature, occupancy, emergency mode, humidity or fume hood control. Sensors and actuators are connected, control functions are configured, network connections are defined and the system is then ready for use.

The system uses the LonWorks communication protocol to develop distributed control or peer-to-peer control architecture to implement the desired room-level control strategy.

Celeris Valve Controller

The Celeris Valve Controller controls valve position by monitoring the flow feedback signal and using one of several different style actuators and by for precision flow control. The room-level control scheme dictates the type of actuator required–high speed or normal speed.

- High-speed actuation is required in spaces where the system performs make-up airflow control of two-state or VAV fume hoods. Changes in sash position require one-second speed of response from the make-up air or general exhaust valves to maintain proper space pressurization. High-speed electric or pneumatic actuation with configurable fail-safe operation is available on the Celeris Valve Controller.
- Normal-speed actuation provides a more economical solution in non-fume hood spaces, where changes in airflow are dictated by temperature and occupancy control. The Celeris Valve Controller and Traccel Room Controller support the 60-second electric actuator. Because make-up air control for high-speed fume hood is not required in these applications, a fail-to-last position fail-safe is appropriate.

The desired actuation must be specified at the time of the order. The electric actuators obtain power from the valve controller. The pneumatically operated valve requires a 20 psi pneumatic source.

Traccel Room Controller

The Traccel Room Controller offers an even more economical solution for constant volume, certain 2-state hood applications as well as a wide variety of Life Science labs and any space in or adjacent to the laboratory spaces. The Traccel valve mounted controller has built-in flexible input output (I/O) and all control functions carried out by the single controller. The Traccel controller provides a scalable architecture with all the ventilation, pressurization and comfort control required for constant volume fume hood and non-fume hood applications where directional airflow is important.

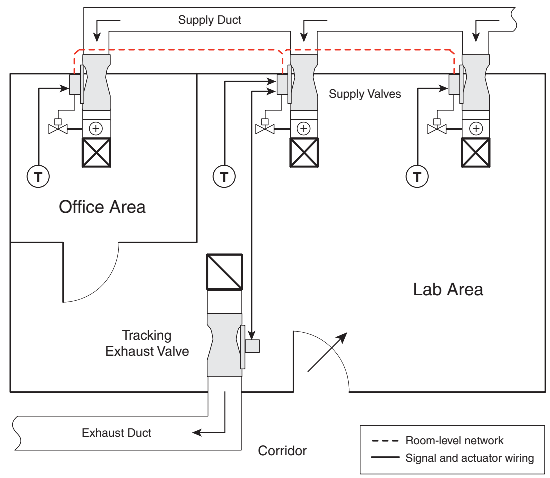
The Traccel Control System offers three levels of control for normal-speed applications:

- **Traccel Tracking Pairs (TP)**–An economical solution for tracking pair applications requiring precise ventilation, pressurization and basic temperature control
- **Traccel Enhanced (TX)**–Same as the Traccel tracking pairs with the addition of extra inputs and outputs (I/Os) to control humidity and pressure monitoring, plus an optional shut-off capability
- **Traccel Supply-only (SO)**–an economical solution for when a supply-only valve is required for a constant volume fume hood lab, an alcove or independent space. It maintains temperature and ventilation control and supports a reheat valve, if needed.

The Traccel room controller is designed to control two valve bodies, typically supply and exhaust. For volumetric offset tracking applications, the Traccel controller controls two normal speed (<60 seconds) actuators.

The Celeris and Traccel systems meet any requirement for controlling critical spaces in today's laboratories, life science facilities, biocontainment spaces, vivariums and cleanrooms.

Figure 4-8. In this application, the Traccel Room Controller is controlling temperature gradients in a large Life Sciences lab as well as an adjacent office space. *The Traccel Controllers work together to sum the total supply volume for three temperature zones and modulate one exhaust valve to maintain correct directional airflow*



This system provides a safe, comfortable working environment for research in a single standalone lab or an entire research complex. The flexibility, airflow turndown, and configurability make it the perfect solution for modular, mixed-use facilities.

The Celeris Valve Controller and Traccel Room Controller perform the valve flow position control and includes configurable I/O for connecting local control elements, such as sensors and actuators, for control and monitoring. The primary function of the controller is to perform precision flow control; however, at the time of commissioning, it is assigned specific room-level control functions. See table that follows.

Room-level Applications

	Celeris	Traccel TP	Traccel TX	Traccel SO
Zone Balance Control				
• Ventilation demand (ACH)	✔	✔	✔	✔
• Volumetric offset control	✔	✔	✔	
• Control airflow distribution across multiple supply valves (up to four supply systems)	✔			
• Differential pressure control	✔			
• Fume hood and Makeup air control for fume hoods (up to 10)	✔			
• Monitor non-networked device airflow; incorporate in zone balance function	✔	✔	✔	✔
• Shut-off of General Exhaust if not required for ventilation or temperature control	✔			
Temperature Control				
• Control reheat actuator	✔	✔	✔	✔
• Control ventilation rate for cooling or heating control	✔	✔	✔	✔
• Dual duct control (hot duct/cold duct)	✔			
• Thermal anticipatory control	✔			
• BTU compensation	✔			
• Auxiliary temperature control loops (cooling or heating, standalone or staged)	✔	✔	✔	✔
• Multiple temperature zones per lab (quantity)	✔ (4)	✔ (3)*	✔ (3)*	✔
Humidity Control				
• 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	✔	✔	✔	✔
HVAC Control Modes				
• Predefined purge, decontamination and shut-off modes	✔		✔	
• User configurable modes for hibernation, supply fan or exhaust fan failure, etc. (9)	✔	✔	✔	✔
Valve Mounted Controller I/O				
• Universal Inputs (thermistor, voltages current or resistance)	3	3	5	3
• Digital Inputs (logic level voltage or dry contact)	1	1	1	1
• Analog Inputs (0-10Vdc or 4-20 mA)	2	2	2	2
• Digital Outputs (1A, 24V, SPDT Relay)	1	1	1	1
• Floating Point Control Outputs (powered dual triacs)	N/A	1	1	1
*Temperature zones share common exhausts				

Adjacent Spaces

Life Science Laboratories and Generic Vivarium Spaces

When the Celeris and Traccel systems are used in the constant volume, two-state and variable air volume (VAV) room control applications described earlier in this chapter, you can accomplish varying levels of sophistication in the control sequences.

- Implement local temperature control
- Implement various occupancy and alternate emergency mode control strategies
- Remotely change ventilation rates or temperature set points based on changing research requirements
- Collect supply and exhaust flow variables from non-networked flow devices and factor these flows into the ventilation and room balance control
- Use the Celeris or Traccel network to integrate this information to the BMS

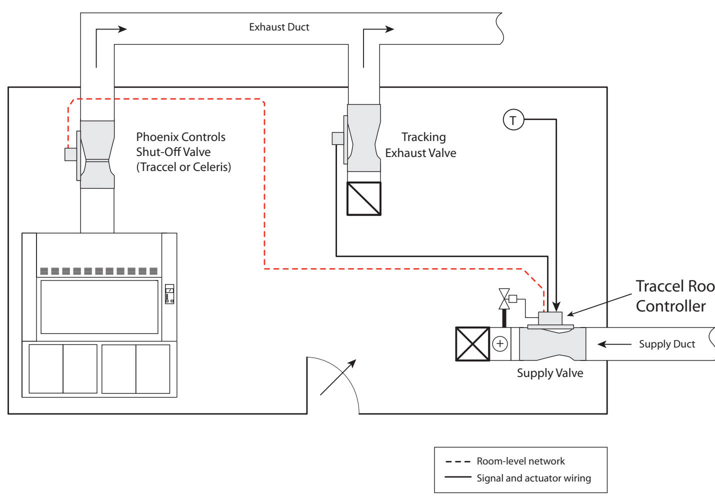


Figure 4-9. A life sciences application using the Traccel Room Controller and a Phoenix Controls Shut-off Valve. The Shut-off Valve on the biosafety cabinet (BSC) communicates over the room-level network with the Traccel Room Controller, which compensates for the change in flow to maintain room airflow balance and ensures correct directional airflow into or out of the room..

Control Functions

The Celeris and Traccel systems may be used as a standalone or fully integrated environmental control system. Each offers highly configurable control functions to satisfy a wide variety of applications. The Traccel system offers a full compliment of ventilation, pressurization and comfort control functions while the Celeris offers additional features specific to fume hood labs.

- Valve control
- Zone balance control
- Active pressure control
- Temperature control
- Humidity control
- Occupancy control
- Emergency mode control
- Monitoring and controlling non-networked devices
- Displaying data and editing set points locally
- Creating custom control sequences
- Integrating the Celeris system to the building management system (BMS)

Valve Control

- Accepts a flow command, positions the valve through a variety of electric and pneumatic actuators and provides a flow feedback value

Zone balance control

- Sums all supply and exhaust valve flows to maintain the minimum ventilation requirements (air changes per hour), make-up air control for fume hood demand (Celeris only) and volumetric offset
- Includes pressurization zones for up to 10 fume hoods, three non-networked flow devices, constant volume supply and exhaust valves and four temperature zones (Celeris only)

Active Pressure Control (Celeris only)

- Modulates either the supply or exhaust valves to maintain a positive or negative set point based on the output of a differential pressure sensor
- Configurable freeze modes or alternate offset modes ensure directional flow when doors between adjoining spaces are open

Temperature control

- Primary cooling–Provides volumetric override for cooling demand or controlling cooling coils
- Primary heating–Controls reheat coil actuators to satisfy heating demand
- Auxiliary control–May be used for either heating or cooling; operates as a standalone, tracking or staged control loop
- Discharge air control–Modulates heating and cooling control loops to maintain a consistent discharge air temperature, which may be reset (or cascaded) by a room-mounted sensor (Celeris only)
- BTU compensation or thermal anticipatory control (TAC)–Modulates the reheat output based on changes in airflow demand, or changes in discharge, room or general exhaust air temperature (Celeris only)

- Up to four temperature zones (Celeris) or three temperature zones (Traccel) per pressurization zone
- Average up to five (Celeris) or three (Traccel) temperature sensors

Humidity Control

- Modulates a stream humidifier or re-cool coil actuators to add or subtract moisture from the room under control
- Controls from either a room-mounted or duct-mounted humidity sensor based on a set point that may either be fixed, under BMS control or local control

Occupancy Control

- Varies the minimum ventilation rates (air changes) and temperature set points based on use or occupancy status
- Sets occupancy state through the BMS or local occupancy sensors, yet allows users to override through a local pushbutton

Emergency Mode Control

Through either a local input or BMS command, overrides any valve to maintain its present position or move to a predetermined flow set point to accommodate unusual circumstances (supply or exhaust fan failure, fire, smoke, chemical spill, etc.)

Monitoring and Controlling Non-networked Devices

Input/output (I/O) on each valve mounted controller is available for room-level sensing and control devices used in conjunction with the room-level control functions.

In addition, inputs from non-networked devices may be connected to any available input for control and/or monitoring purposes.

Example #1:	Non-networked flow devices may be connected to any available input and the flow term may be factored into the zone balance equation.
Example #2	Room-level devices or alarm contacts may be connected to the input of any valve mounted controller, and the analog value or alarm state will be passed across the network to the BMS.
Example #3:	The BMS can control room-level devices by connecting the local device to any available output on a valve mounted controller and passing command values or states across the network.

Displaying Data and Editing Set Points Locally

- Add a Local Display Unit (LDU200) (see Section 6) to a room-level network to display data from any valve controller on the room-level network on a 2.1-inch square LCD display
- Up to 250 parameters may be mapped to a LDU; each display shows a description and present value for up to five parameters
- Passcode protected to prevent unauthorized set point changes

Creating Custom Control Sequences

- Add a Programmable Control Module (PCM) (see Section 6) to a room-level network to implement complex, non-standard control sequences using a BASIC-like programming language
- Provides assorted inputs and outputs (quantity varies by model number)
- Provides local trending and scheduling functions

Integrating the Celeris System to the Building Management System (BMS)

- Add routers and repeaters, as required, to create a floor-level or building-level communications network to link together all of the room-level control networks
- Add one or more LonTalk to BACnet data server to connect up to thousands of devices to the BMS through one BACnet over IP portal

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.

- The shut-off sequence can be initiated either locally through a universal input or remotely via the network—either from the building management system (BMS) or Local Display Unit (LDU).
- The valve can function as a standalone device or as part of a fully integrated system.
- Precise airflow control—The factory-calibrated flow rate controller performs accurately throughout its operating range.
- Self-balancing pressure-independent operation—The valve maintains the airflow set point by automatically compensating for static pressure fluctuations in the system.

The standard shut-off Valve provides critical airflow control in normal mode. In shut-off mode, the valve flow is reduces to a minimum flow of approximately 5 cfm which is appropriate for fume hood hibernation, lab decommissioning and GEX shut-off applications.

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. See Chapter 2 for details.

Flexibility

The Celeris and Traccel systems are designed to be extremely flexible to accommodate a wide variety of control sequences. For example, the temperature control function may be configured for approximately 100 different temperature control schemes. There are literally thousands of possible control sequence configurations.

Energy Savings Opportunities for Laboratories

With energy costs staying at high levels, the cost to heat, cool, condition, and move one CFM of air each year remains in the $5-8 range. Every CFM of supply air that can be saved safely in laboratories provides instant savings.

The Phoenix Fume Hood Monitor, FHM631 and Zone Presence Sensors coupled with Celeris room-level control applications, reduce airflow and reduce energy consumption significantly. These include energy waste alert and fume hood hibernation, lab decommissioning, GEX shutoff and IAQ demand-based ventilation.

Usage Based Control

Only Phoenix Controls offers a unique approach to laboratory airflow control. This approach, known as Usage Based Controls (UBC), modulates hood flows based on the presence or absence of a hood user. UBC can be used in two-state and variable volume laboratories.

Two-state Usage Based Controls

UBC provides an intelligent form of two-state control for fume hoods that eliminates the disadvantages seen with traditional switching mechanisms (see page 28). For increased safety, UBC switches to high flow whenever an operator is in front of the fume hood. The system then switches to low flow when the operator is absent for greater energy savings and design diversity.

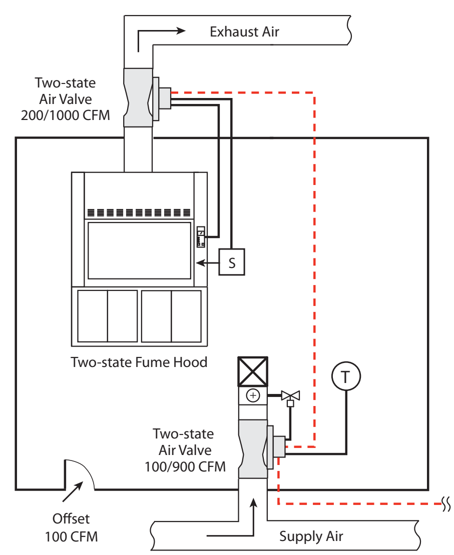


Figure 4-10. A two-state application with Usage Based Controls. *Pressure-independent air valves maintain proper flow at each of two flow rates. The rates are switched based on operator presence at the hood as sensed by a Zone Presence Sensor. This provides for proper containment because safe face velocities are maintained at all times. The fume hood monitor provides continuous monitoring, meeting regulatory requirements.*

Safety and Savings: Diversity for HVAC in Laboratories

Diversity can be defined as designing a system based on its practical use, not its total possible use. Plumbing and telephone system designs commonly include diversity.

Existing laboratory facilities and new construction can benefit from applying diversity to the HVAC design. Diversity allows existing facilities to add fume hood capacity using the current HVAC systems. Diversity design in new construction allows the facility to reduce capital equipment expenditures by downsizing the mechanical systems up front.

For either type of facility, designers must develop a solution that best fits the customers' needs. However, some designers are hesitant to take diversity since the savings are only realized when the sashes are lowered. Often, this has led to systems with methods of "forced" diversity that have proven problematic:

- Mechanical sash stops–This "prevents" a user from opening a sash beyond a predetermined maximum setting. Unfortunately, users often override these mechanical stops for everyday activities and setting up experiments. This can create a dangerously low face velocity profile if the controller is not sized for full sash opening.
- Sizing flow control based on low face velocity settings–By designing systems that provide full-time low flows, containment and future flexibility may be compromised.

Usage Based Controls (UBC) changes the hood flows based the presence or absence of a hood user. Flows are reduced when the hood is unoccupied and increased for safety only when the hood is occupied. This maintains safe flow levels under all conditions and allows for downsizing the HVAC systems, even without closing all sashes.

With UBC, airflow is kept at safe operating levels for the users while reducing airflow to levels below all other systems.

Benefits

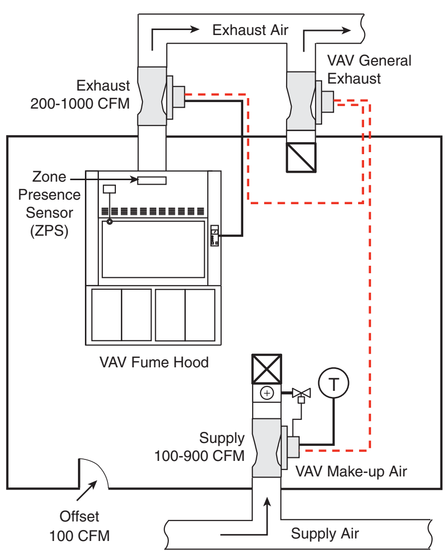
- Provides superior flow control with fast stable adjustments.
- The pressure-independent system maintains steady flow through system changes, filter loading, and HVAC degradation.
- Increases safety–Face velocity is maintained at a safe level at all times.
- Sizing HVAC system with diversity becomes predictable.

For more information about UBC, see page 28.

Variable Volume Usage Based Controls (Using Celeris)

The Phoenix UBC system provides an intelligent form of variable volume control for fume hoods. UBCs eliminate the disadvantage of not closing sashes (see page 28), yet maintain safe face velocity levels while minimizing the HVAC burden. The concept is quite simple: use a higher face velocity (e.g., 100 fpm) when an operator is in front of the hood creating turbulence, but reduce the flow to a safe level (e.g., 60 fpm) when no operator is present.

Figure 4-11 represents a typical UBC system. Room pressurization is maintained by adjusting the make-up air at a slightly lower rate than the exhaust. Minimum ventilation and proper temperature control may require the use of a general exhaust—where the exhaust air rate is increased to overcome the added supply requirements. All valves use high-speed electric or pneumatic actuation to ensure proper fume hood containment and room balance. High-speed hood valves should never be used with slow acting makeup air or general exhaust airflow devices otherwise space pressurization not only in the lab, but also the corridor may be compromised.



NOTE: Room controllers are required for analog systems.

Figure 4-11. Variable volume application with Usage Based Controls. *The hood is operated as a standard variable air volume application. The hood operates at the lowest flow possible to maintain safe face velocities. When an operator approaches the hood, the Zone Presence Sensor increases the flow to provide proper containment. As the operator leaves the hood, the flow resets itself to the lower, yet safe, flow. The fume hood monitor provides continuous monitoring, thereby meeting regulatory requirements.*

Benefits

- Diversity—The sizing of mechanical equipment based on partial load—becomes more predictable.
- Reduces HVAC capital costs by assuring reductions in airflow, even when sashes are left open.
- Energy costs are lower and more predictable.
- Increases lab safety due to the reduction in supply air currents that often affect fume hood containment.

For more information about UBC, see page 28.

Energy Waste Alert

The FHM631 fume hood monitor provides users both audible and visual feedback if the fume hood sash has been left open when the lights are off and the lab presumably unoccupied. If the sash is open such that the flow is greater then the hood minimum flow and the room is dark, the audible alarm will beep rapidly and the display will show "ENRG". This feature is intended to serve as a reminder to users to close their fume hood sash when the hood or the lab is not in use. The audible alarm also allows facilities personnel to locate open hoods after normal business hours.

This feature is standard with the FHM631 fume hood monitors and may be enabled or disabled in the monitor setup menu.

Fume Hood Hibernation

Existing codes require that a fume hood maintain a minimum exhaust flow based in chemicals used in the hood. However, these codes also allow this minimum exhaust flow to be reduced below this value when the hood is not in use (i.e., no chemicals present within the hood). Here are the excerpts from two standards and guidelines that address this topic.

- ANSI/AIHA Z9.5-2003, Section 3.3.1 (to be updated by ANSI/AIHA in 2012)—"The mechanism that controls the exhaust fan speed or damper position to regulate the hood exhaust volume shall be designed to ensure a minimum exhaust volume in constant volume systems equal to the larger of 50 CFM/ft. of hood width, or 25 CFM/sq. ft. of hood work surface area, except where a written hazard characterization indicates otherwise, or if the hood is not in use."
- NFPA 45-2004, Section 8.2.2—"Laboratory units and laboratory hoods in which chemicals are present shall be continuously ventilated under normal operating conditions."

Phoenix has added a means to hibernate fume hoods through the hood control system when there are no chemicals present in the hood and the sashes are fully closed. The exhaust flow from the hood will be reduced below the hood minimum and the zone balance function will actively adjust the supply and general exhaust accordingly to maintain offset, temperature control and ACH automatically.

The fume hood hibernation mode on the FHM631 will command the exhaust valve to its specified minimum position.

- For shut-off valves, this will be the shut-off position.
- For regular valves, this will be the specified minimum position (e.g., 90 CFM for a 12-inch valve).

This function may be activated locally from the FHM631, from a local momentary contact input or through a network command issued by the BMS. The hibernation mode will terminate immediately upon the fume hood sash being opened.

This function works only with a Celeris valve controller and is selectable during commissioning; it may be enabled or disabled. Additional wiring is required for this feature; refer to the product datasheet for details.

During the hibernation mode, the monitor display will show "OFF" and the standard operation LED will not be lit. All monitor alarms will continue to function (emergency exhaust, jam, etc.). In addition, there is a reportable point available on Celeris for integration to the BMS.

Demand-based Ventilation (IAQ control)

The Celeris and Traccel systems feature an Indoor Air Quality (IAQ) control function whereas the ventilation rate may be varied based on the quality of the air in the lab. This feature offers tremendous opportunity for savings if the occupied and unoccupied minimum air change rates can be reduced from 10 or 12 ACH to 4 or 6 and only over ridden if the indoor air quality suffers. The change in ACH is expressed in flow and there is a proportional relationship established between the output of the IAQ sensor and the change in ACH. Using an appropriate IAQ sensor, the minimum air changes per hour (ACH) can be reduced when air quality is acceptable and increased if air quality deteriorates.

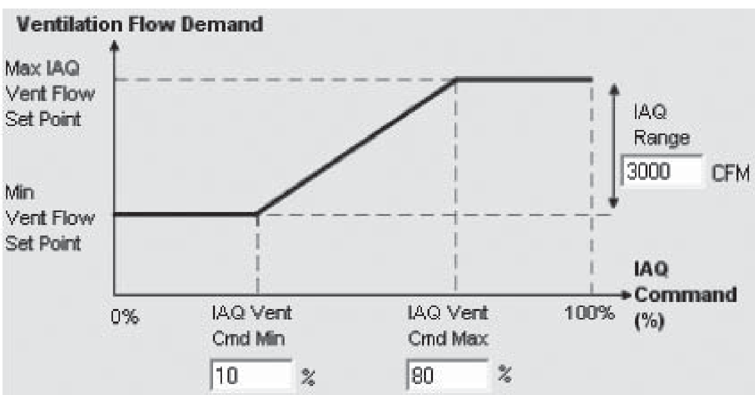


Figure 4-12. Minimum ACH is reduced when air quality is acceptable and increases when air quality deteriorates.

Room-Level Control Solutions

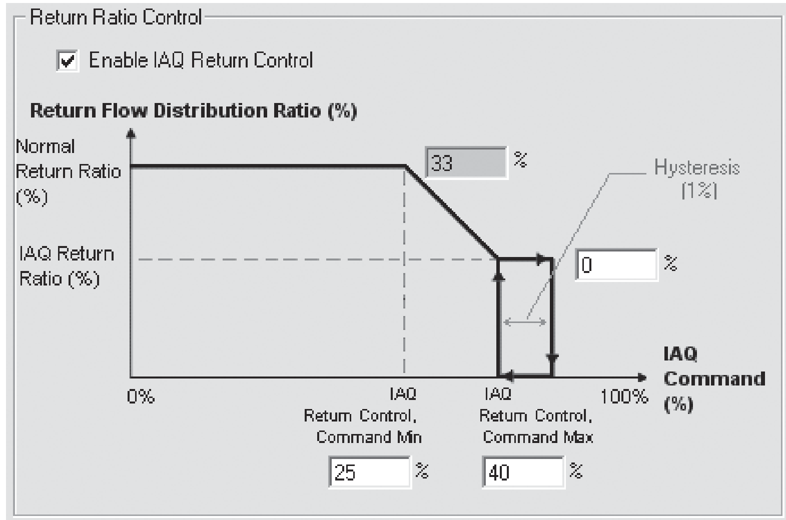
The room airflow control function will high-select against:

- Minimum Ventilation Rate
- Fume hood demand
- Thermal Demand
- IAQ Control

} = Effective ventilation rate

In addition, for a lab using an IAQ sensor and a return air system, the Celeris system offers the ability to perform ratiometric control of general exhaust and return air flow so that if air quality is acceptable, air may be recirculated. If air quality begins to degrade, the return air valve will modulate closed and the general exhaust valve would modulate open to purge undesirable vapors from the space. The total exhaust will remain the same to satisfy ventilation, fume hood and thermal flow demand.

Figure 4-13. Return air flow distribution ratio.



The Celeris system includes the ability to perform return air control which provides the opportunity for tremendous energy savings in laboratory spaces where return air control would be deemed acceptable.

5 Integration

The chapter explores some of the benefits of integrating the laboratory airflow control system with the building management system. It also describes Phoenix Controls' system components for its Celeris®, Traccel® and analog product lines.

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Benefits of Integration

One of the most important features of the Celeris© and Traccel© systems is their ability to seamlessly integrate thousands of points from hundreds of lab spaces through a single connection to the BMS (building management system). Fume hood data, flow data, and comfort control data, along with miscellaneous points picked up through hardwired connections in the lab are made available to the BMS system for trending, scheduling, alarming and display on operator workstations.

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

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

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

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

Phoenix Controls offers integration through a variety of product lines:

- Celeris Environmental Control System (digital)
- Traccel family of valve controllers
- Analog devices

Collecting and exchanging data between devices that make up the building controls system are the key elements in turning front-end systems into BMS or building automation systems (BAS). Controls 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.

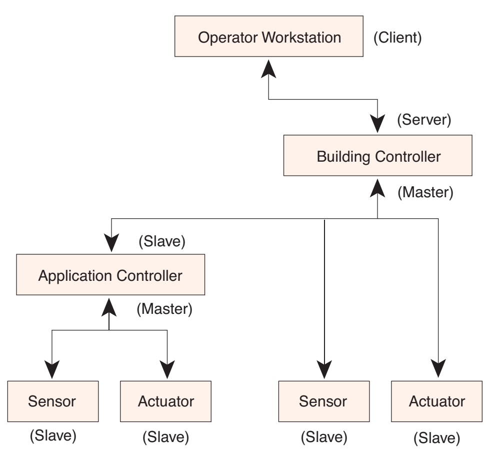


Figure 5-1. BACnet architecture.

BACnet is based on a model where devices and their associated *points* are represented as *object*. 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 master/slave relationship between devices. Clients (masters) make requests of servers (slave) devices, and the server (slave) devices respond. There are defined methodologies for how a client device can query a server device to determine which objects and services the server device supports in order to establish communications with that device.

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 programmatically

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 master slave/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.

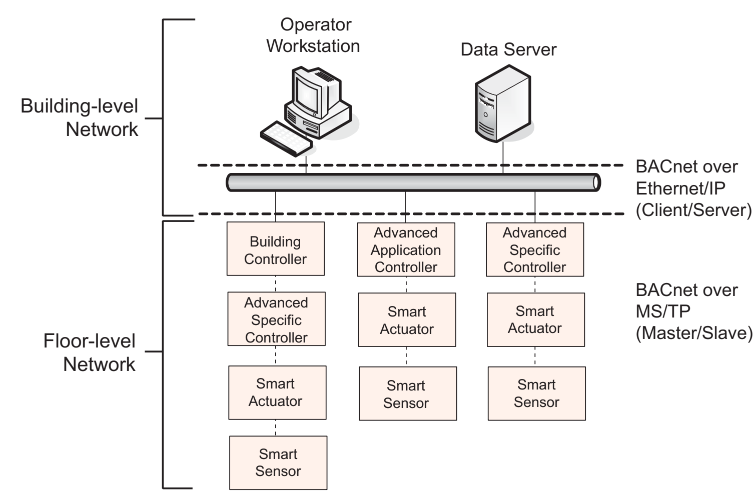


Figure 5-2. Layers of a BACnet network.

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 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.

Integration

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 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 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.

Interoperability

Many BAS 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.

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:

- Celeris Environmental Control System–Uses the LonWorks room-level network to implement a peer-to-peer control architecture, connected to a LonTalk to BACnet data server which is used to integrate the Celeris system with BACnet capable BASs. The Celeris system offers the utmost in flexibility, scalability, and sophistication to implement complex control sequences.
- Traccel Room Controller–Uses LonWorks technology incorporated into a valve mounted room controller to integrate flow and temperature data directly onto the BAS vendors LonWorks bus. The Traccel room controller is LonMark certified as a Space Comfort Controller, Variable Air Volume (SCCVAV Object type 8502). The Traccel system provides ventilation, pressurization and comfort control for non-fume hood lab spaces. Traccel controllers may also be integrated through the use of one of the Celeris LonTalk to BACnet data servers.

The MicroServer and MacroServer provides seamless integration to BACnet compatible BMS systems utilizing the enterprise Ethernet or IP network.

Phoenix Solutions for Integration

The Celeris Environmental Control System is designed around the concept that each pressurized space operates as an independent, local control network. These local control networks may be connected to create a floor-level or building-level communications network, which ultimately connects to the enterprise-wide network and the BMS using either the MicroServer or MacroServer LonTalk to BACnet data servers.

The Traccel Room Controller 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 variable air volume flow control valves, to control the ventilation rate, volumetric off set and space comfort of a typical biology lab, animal holding room, procedure room, airlock or corridor. It offers a more cost-effective solution for environmental control for the basic room-level control functions than the Celeris product line.

The Traccel Room Controller may be used in conjunction with the Celeris system and integrated with a MicroServer or MacroServer.

- The MacroServer is intended for large scale integration supporting up to 6,000 BACnet objects, or approximately 1200 devices.
- The MicroServer is intended for small to medium scale integration supporting up to 350 BACnet objects, or 35 devices.

There may be multiple MacroServers or MicroServers on the BACnet network and they be mixed, as required, to integrate the systems.

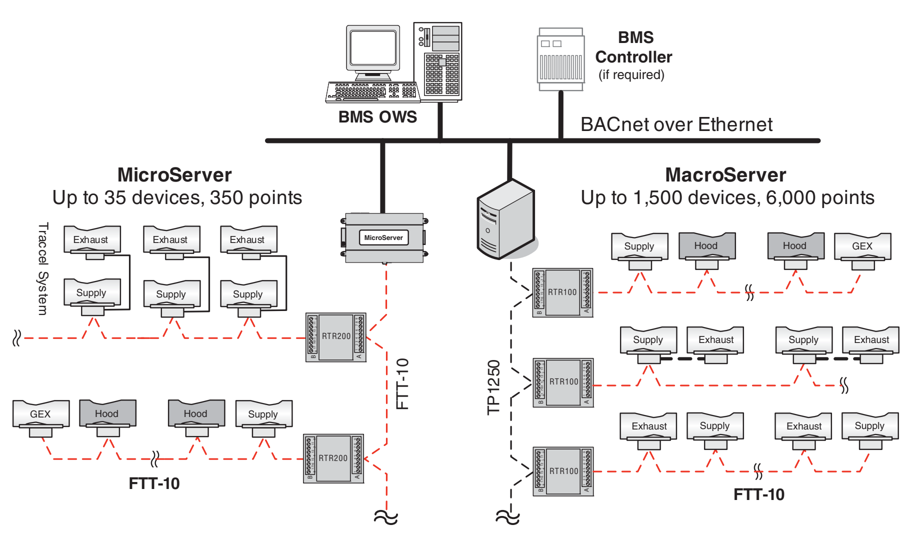


Figure 5-3. MacroServer and MicroServers on a BACnet network. *MacroServers are intended for medium to large scale integrated projects. The MicroServer is intended of small to medium integrated projects. The Microserver is an excellent way to integrate isolated lab spaces or when retrofitting spaces. Multiple MacroServers and MicroServers may use one campus LAN to integrate several research areas.*

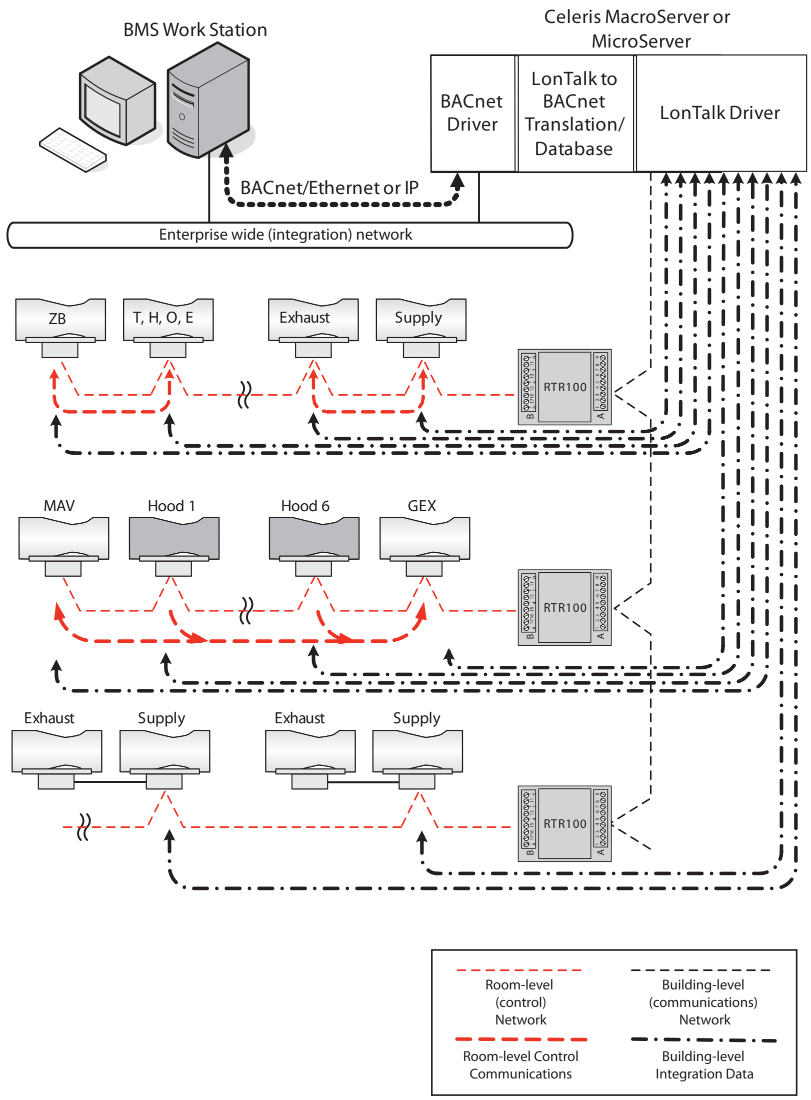
The MacroServer and the MicroServer include utilities to discover devices on the Celeris network and to map the desired points to BACnet objects. Each device on the Celeris network uses a combination of a Change of Value and a heartbeat scheme to "push" the present value for each network variable to the data server. This allows the most efficient use of network bandwidth and ensures the present value in the data server accurately reflects data in the field device. The data servers convert the LON data to BACnet objects and makes the data available to the BAS through its BACnet data sharing and alarm and event management services.

The MacroServer and the MicroServer support the full complement of BACnet services that allow the BAS to automatically discover the devices and the objects and services supported.

At the room level, the Celeris Valve Controllers pass data back and forth among each other to implement room-level control schemes. Control data is restricted to the room-level network by a LonWorks router. Each valve controller is also responsible for passing data to one of the Celeris data servers. The Celeris communications follows all the LonMark guidelines but is highly optimized to ensure that is sufficient network bandwidth for both control and communication and allows the Celeris Environmental Control System to extend well beyond the typical size and density of a typical LonWorks network.

The data servers collect data from the floor- or building -level networks, and convert the LonWorks data into BACnet objects. The servers create a seamless virtual network of BACnet devices and objects, and make the data available to the BAS through a variety of BACnet data sharing and alarm event notification services.

Figure 5-4. An enterprise integration network. *Each valve mounted controller manages communications with other devices on the room-level network to implement the desired control strategy. In addition, each controller reports all the data about itself and the control functions it is responsible for to the MicroServer or MacroServer for seamless integration.*



Routers isolate groups of devices into channels or subnets to implement the desired control strategies. In the Celeris Environment Control System, there are three network levels:

- Control network–This is the room-level network where all the devices reside and device-to-device communications is used to implement the desired room-level control strategy. The network uses the LonWorks 78 kbps FTT-10 communication scheme and is generally a single channel with a router at the top end of the network to connect it to the communications network.
- Communications network–This is the floor- or building-level network where all the network interface devices reside. The purpose of the communications network is to connect all the room-level networks together via routers to establish a data path from nodes on the room-level network to the MicroServer or MacroServer for integration to the BMS. The communications network may either be a floor- or building-level network.
  - Floor-level network–This communications network uses the same 78 kbps FTT-10 communications scheme as the room-level control network. This style network is used with the MicroServer and RTR200 series routers. The floor-level network has a maximum distance of 4,500’ (1,400 m), which is more than adequate for the number of devices supported by a single MicroServer. Repeaters are generally not required and are not supported.
  - Building level network–This is a high-speed network (1.25 mbps) using the LonWorks TP-1250 communications schemes. The style network is used with the Phoenix Controls MacroServer and RTR104 and RTR100 series routers. The TP-1250 network has a maximum distance of 425’ (130 m); however, it may be extended by adding a repeater (RPT100).
- Integration network–This is the network used by the Phoenix Controls MicroServer or MacroServer to interface with the Building Management System (BMS). It is typically the campus or corporate intranet, however it could also be a dedicate network for the building controls system. The MicroServer or MacroServer use the BACnet protocol over either Ethernet or IP to exchange data between the Celeris system and the BMS controllers and operator workstations.

Grouping devices into logical subnets ensures that there is sufficient network bandwidth to carry out room-level control strategies. The type of control application desired determines the number of nodes that may make up a subnet.

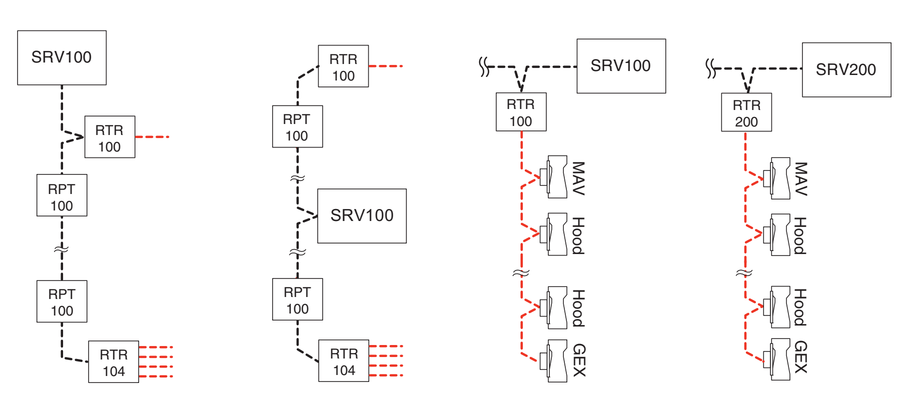


Figure 5-5. Routers for the MacroServer and MicroServer. *Routers isolate room-level networks to preserve network bandwidth for control purposes. Repeaters allow you to extend the building level network and tie all the room-level networks together for integration.*

For laboratory spaces where make-up air control for hoods and one-second speed of response is required, there are:

- One router per pressurization zone
- A maximum of 20 nodes for each zone.

For tracking pair applications where speed of response is not critical, there may be:

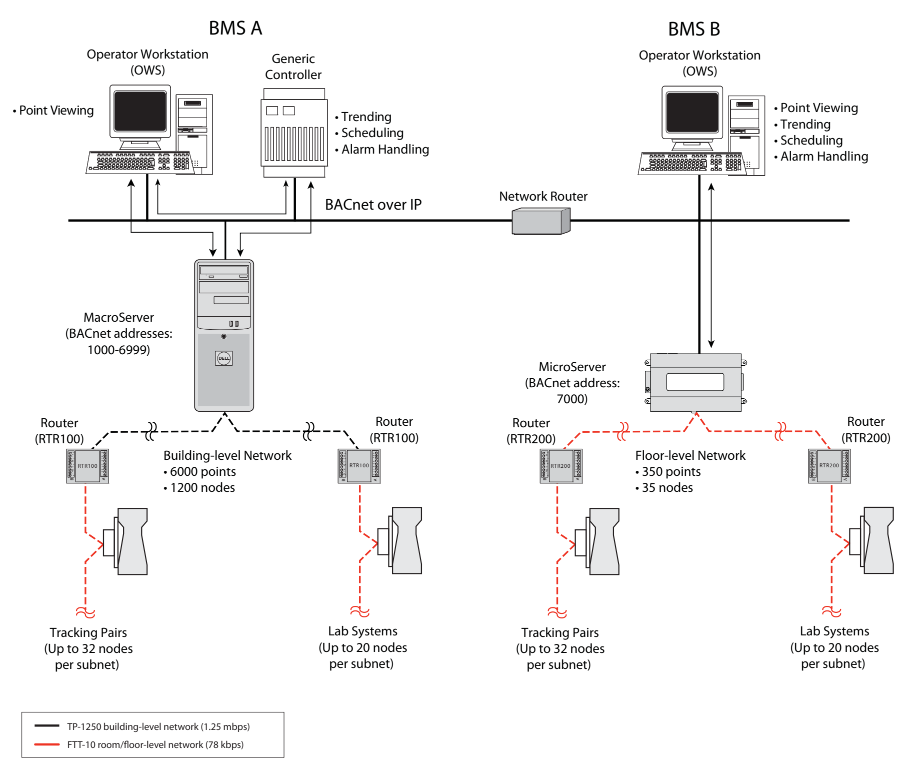
- Up to 32 nodes per router
- Multiple pressurization zones for each router

Network Layouts

- Each room-level control network is wired in a bus topology and requires two FTT-10 end-of-line terminators, which are included with routers purchased from Phoenix Controls.
- The floor-level communications network is wired in a bus topology and requires two FTT-10 end-of-line terminators, which are included with each MicroServer purchased from Phoenix Controls.
- Each segment of the building-level communications network is wired in a bus topology and requires two TP-1250 end-of-line terminators, which are included with each repeater and MacroServer purchased from Phoenix Controls.
- The enterprise integration network follows the architecture laid out by the information technology (IT) professionals involved with the project. All that is required for Phoenix Controls to connect the MicroServer or MacroServer to this network is a 10 base T, 100 base Tx or 1000 base Tx connection.

Because the Celeris MacroServer and MicroServer function as a BACnet server and support BACnet over IP, Celeris systems in multiple buildings and on multiple campuses can be integrated on one wide area network (WAN). Because the BAS is simply a BACnet client requesting data or subscribing to the data services of the Celeris system, multiple clients from multiple BAS vendors can retrieve data seamlessly.

Figure 5-6. Network integration with two building management systems (BMSs).



Points Available for Integration in the Celeris/Traccel Environment Control System

Individual Valve Points	Celeris	Traccel
• Valve flow feedback (read only)	✔	✔
• Valve flow set point (read only)	✔	✔
• Jam alarm (read only)	✔	✔
• Flow alarm (read only)	✔	✔
Zone Balance Control	**Celeris**	**Traccel**
• Total supply flow (read only)	✔	✔
• Total exhaust flow (read only)	✔	✔
• Zone offset (read only)	✔	✔
• Zone offset set point (read-write)	✔	✔
• Diversity alarm (read only)	✔	
Temperature Control	**Celeris**	**Traccel**
• Average space temperature (read only)	✔	✔
• Occupied heating set point (read-write)	✔	✔
• Occupied cooling set point (read-write)	✔	✔
• Unoccupied heating set point (read-write)	✔	✔
• Unoccupied cooling set point (read-write)	✔	✔
• Standby heating set point (read-write)	✔	✔
• Standby cooling set point (read-write)	✔	✔
• Effective temperature set point (read only)	✔	✔
• Auxiliary temperature set point (read-write)	✔	✔
Thermal Anticipatory Control	**Celeris**	**Traccel**
• Discharge air temperature (read only)	✔	
• Discharge temperature set point (read only)	✔	
• BTU delivered to the space (read only)	✔	

Humidity Control	Celeris	Traccel
• Space humidity (read only)	✔	✔
• Humidity set point (read-write)	✔	✔
Occupancy Control	**Celeris**	**Traccel**
• Occupancy Mode (read only)	✔	✔
• Occupancy override (read-write)	✔	✔
• Bypass time set point (read-write)	✔	✔
• Bypass time remaining (read only)	✔	✔
Emergency Mode Control	**Celeris**	**Traccel**
• Emergency mode (read only)	✔	✔
• Emergency override (read-write)	✔	✔
Fume Hood Control	**Celeris**	**Traccel**
• Face velocity (read only)	✔	
• Face velocity set point (read only)	✔	
• User status (read only)	✔	
• Sash position (read only)	✔	
• Sash height alarm (read only)	✔	
• Broken sash alarm (read only)	✔	
• Emergency override (read only)	✔	
Progressive Offset Control	**Celeris**	**Traccel**
• Space differential pressure (DP): Zone absolute pressure and reference absolute pressure (all read only)	✔	
• DP set point (read-write)	✔	
• DP warning set point (read-write)	✔	
• DP alarm set point (read-write)	✔	
• Freeze mode duration (read-write)	✔	
• Freeze mode time remaining (read only)	✔	
• Freeze mode alternate offset set point (read-write)	✔	
• Freeze mode override (read-write)	✔	

Integration Partners

Celeris BACnet integration was first developed in 1998 and continues to be the primary method to integrate with various BMS vendors. We have over 300 facilities worldwide integrated with multiple generations of systems from the following companies. Interoperability is an ongoing process and we continuously qualify and refine interfaces with a large number of integration partners including:

• Alerton	• Honeywell
• American Automatrix	• Intellution iFix
• Andover Controls	• Invensys
• Automated Logic	• Johnson Controls
• Carrier	• Reliable Controls
• Cimetrics BACnet/OPC	• Siemens
• Delta	• Tridium
• Field Server	• Trane

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 the Celeris Environmental Control System 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 setpoints may be written by an operator from the BMS workstation.

Integration with the Analog Product Line

Phoenix Controls can integrate its analog product line with all BMSs that are capable of monitoring a 0-20 Vdc signal.

Typical points include:

- Fume hood sash position
- Fume hood flow command
- Fume hood flow feedback
- Fume hood alarm
- Fume hood user status
- Fume hood emergency override
- Fume hood face velocity (flow feedback and sash position)
- Room supply flow
- Room offset
- General exhaust flow

In addition, our controllers can accept a thermal override signal in one of two forms:

1. Electronic signals (0-10 Vdc), which could come directly from an electronic thermostat or an DDC analog output.
2. Pneumatic signals (0-20 psi), usually directly from a pneumatic thermostat.

Two methods of integration with Phoenix Controls' analog product line are supported:

1. Point-to-point integration is accomplished by sampling one or many of the analog signals available at a make-up air controller (MAC series). One analog input point is needed for each point of BMS monitoring. This form of integration is available to all BMS vendors.
2. Component integration is a richer level if information exchange. The Phoenix component becomes a part of the DCC panel. All signals are integrated cleanly in the BMS via 40-pin ribbon cable terminators that are preconfigured.

Figure 5-7. Point-to-point integration. *Each point is wired between the MAC panel and the building management system.*

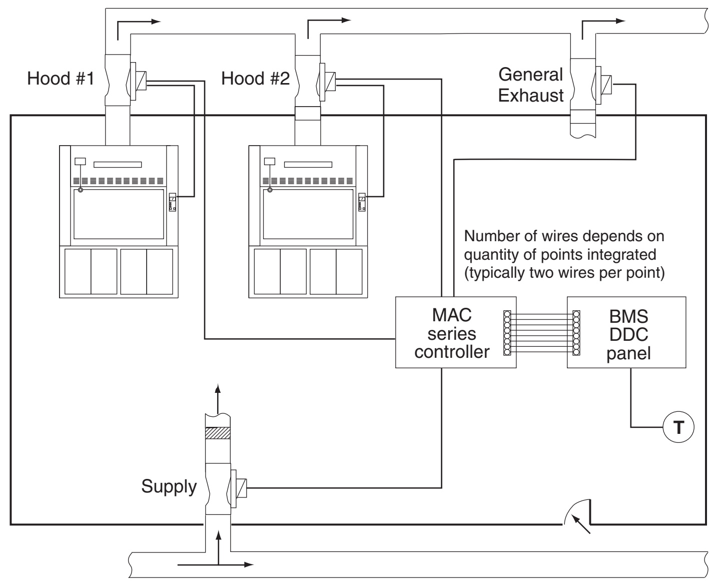
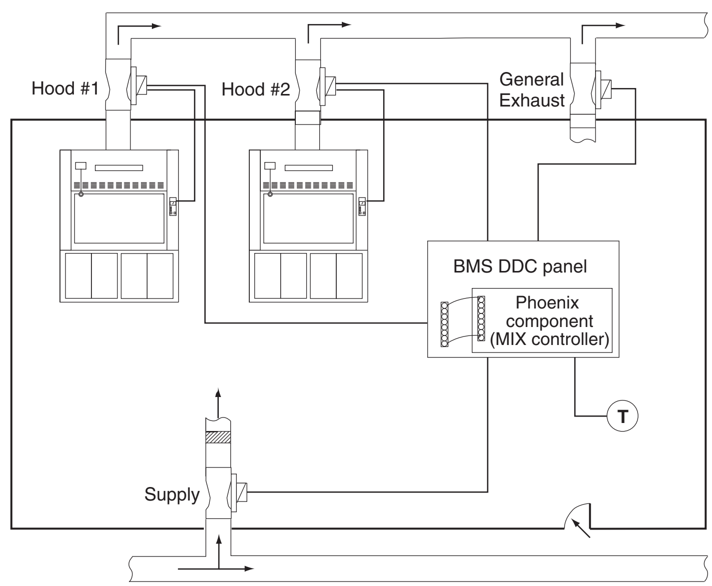


Figure 5-8. Component integration. *Phoenix components are integrated with the building management system vendor's preconfigured DDC controller.*



6 System Components

The chapter offers a description of the Phoenix Controls laboratory product line. The components are engineered to deliver reliable, effective control.

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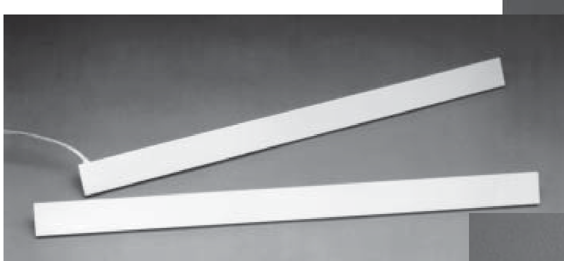

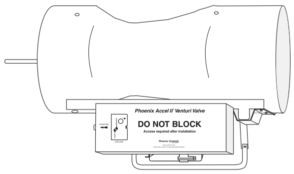

Celeris® Valves (digital)

The Phoenix Controls Celeris Venturi Valves combine a mechanical, pressure-independent regulator with a high-speed position/airflow controller with a highly configurable control platform to meet the unique requirements of airflow control. These valves can be used in constant volume, two-position, or VAV applications—all designed to maximize flow performance while reducing related noise. Valves for VAV applications may be either electrically or pneumatically actuated.

- Pressure-independent operation: All valve types include an immediate response mechanical assembly to maintain airflow set point as duct static pressure varies.
- Airflow control: By positioning the flow rate controller assembly, the airflow can be adjusted.
- Medium (range) pressure and low pressure (range) flow ranges
- Normal, standard shut-off and low-leakage shut-off

Celeris valves are available in:

- VAV (EXV/MAV series) with VAV closed-loop feedback control pneumatic low-speed or high-speed electric with pneumatic for fume hood applications or low-speed electric.
- When networked with a twisted pair cable, Celeris valves form a room-level control system, providing ventilation, volumetric offset, temperature, humidity, occupancy and emergency control.

Control Functions

- Valve Control
- Active pressure control
- Humidity control
- Emergency mode control
- Displaying data and editing set points locally
- Integrating the Celeris system to the building management system (BMS)
- Zone balance control
- Temperature control
- Occupancy control
- Monitoring and controlling non-networked devices
- Creating custom control sequences

Valve Sizes and Operating Ranges

Accel II digital valves are available in four specific model sizes: 8, 10, 12, and 14-inch. In order to increase flow capacity, multiple valves may be assembled to operate as a unit.

For complete information on valve dimensions, weights and operating ranges, see Product Data Sheet.

Specifications

Power	24 Vac (±15%) @ 50/60 Hz	
Power Consumption		
Control Type	***Single***	***Dual***
L (low-speed electric)	13 VA	17 VA
M (high-speed electric)	70 VA	96 VA
N (pneumatic)	11 VA	11 VA
Pneumatic Actuation	EXV/MAV-N (pneumatic control type) 20 psi (-0/+2 psi) with a 20 micron filter main air required	
I/O available for connecting field devices	3 universal inputs.	From voltage, current or resistance sensing devices - 0 to 10 Vdc - 4 to 20 mA - 0 to 65,000 ohms - Type 2 or 3, 10K ohm thermistor temperature sensor
	1 digital input	From two-state input or alarm devices, such as occupancy sensors or override buttons, key switches or alarm circuits - Dry contacts - Logic level voltage input
	2 analog outputs.	Drives voltage or current-driven actuator devices or provides a physical signal representing flow feedback or setpoint values - 0 to 10 Vdc - 4 to 20 mA
	1 digital output (Type C, 1 amp @ 24 Vac/Vdc)	Used for two-state control functions, local alarm annunciation or offset status - Single-pole, double throw (Form C) relay rated 1A up to 30 Vac/Vdc - Configurable for direct or reverse acting
Agency Compliance	CE, CSA (C US), FC	
Room-level communications	FTT-10, 78 KB, bus topology, LonTalk™ network	
Building-level communications	TP-1250, 1.2 MB, bus topology, LonTalk™ network	
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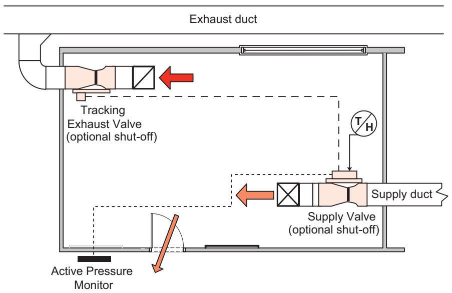

The Traccel-TX valve can maintain positive, negative or neutral directional airflow with variable air volume (VAV) temperature and humidity control.

Traccel® Family of Valves (digital)

The Phoenix Controls Traccel® Family of Valves is designed specifically for the ventilation requirements of demanding spaces in life science lab facilities, where ventilation zone control, energy savings and reducing maintenance costs are an important part of business operations.

System Benefits

- Factory characterization reduces system commissioning time
- Pressure-independent valves avoid rebalancing costs
- Medium (range) pressure and low pressure (range) flow ranges
- Normal, standard shut-off and low-leakage shut-off
- No flow sensors to maintain
- High turndown ratios contribute to reducing energy costs
- Flexibility to handle space configuration changes

Product Designs and Models

Product	Description
Traccel-TP (Tracking Pair VAV)	To meet the need of directional airflow, Traccel-TP features tracking valve pairs that maintain a prescribed CFM offset to enable accurate space pressurization and complete room climate control.
Traccel-TX (Enhanced Tracking Pair VAV)	For tracking pair applications in demanding spaces, Traccel-TX provides extra I/O to meet the needs of humidity control and pressure monitoring, plus optional shut-off capability for decontamination procedures.
Traccel-SO (Supply-only VAV)	In VAV applications where ducted exhaust is sufficient to meet local codes and engineering guidelines, Traccel-SO provides a cost-effective supply valve when no tracking exhaust valve is required.

Control Functions

- Valve Control
- Active pressure control
- Humidity control
- Emergency mode control
- Displaying data and editing set points locally
- Integrating the Celeris system to the building management system (BMS)
- Zone balance control
- Temperature control
- Occupancy control
- Monitoring and controlling non-networked devices
- Creating custom control sequences

Specifications

Power Consumption (using proportional reheat control)	***Single 8, 10 and 12-inch***	***Single 14-inch***	***Dual 10, 12, 14-inch***
	13 VA	20 VA	20 VA
Power Consumption (using floating point reheat control)	20 VA	26 VA	26 VA
Input accuracy	Voltage, current, resistance ±1% full scale		
Output accuracy	0 to 10 Vdc: ±1% full scale into 10K minimum 4 to 20 mA: ±1% full scale into 500 +0/-50		
I/O available for connecting field devices	3 universal inputs.	From voltage, current or resistance sensing devices - 0 to 10 Vdc - 4 to 20 mA - 0 to 65,000 ohms - Type 2 or 3, 10K ohm thermistor temperature sensor	
	1 digital input	From two-state input or alarm devices, such as occupancy sensors or override buttons, key switches or alarm circuits - Dry contacts - Logic level voltage input	
	2 analog outputs	Drives voltage or current-driven actuator devices or provides a physical signal representing flow feedback or setpoint values - 0 to 10 Vdc - 4 to 20 mA	
	1 digital output (Type C, 1 amp @ 24 Vac/Vdc)	Used for two-state control functions, local alarm annunciation or offset status - Single-pole, double throw (Form C) relay rated 1A up to 30 Vac/Vdc - Configurable for direct or reverse acting	
Agency Compliance			
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		
Room-level communications	FTT-10, 78 K, LonTalk™ network		

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Temperature and Humidity Sensors

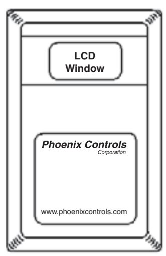
Phoenix Controls temperature, humidity and air quality sensors provide a stable, secure environment for those facilities that need it the most, such as hospitals, clean rooms, and laboratory animal facilities. Available in a variety of configurations in both wall mount and duct mount. These sensors also simplify room balancing by eliminating the need for a certified person to accompany the balancer during the commissioning process with a built-in test and balance switch. A three-position test and balance (T&B) switch allows for overrides into full heating or cooling modes, as well as for normal operation.

Available in:

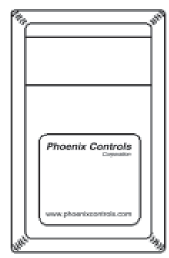
- Two wall mount styles
- Temperature
- Humidity
- Combination temperature/humidity

Wall mount sensors offered with a variety of features:

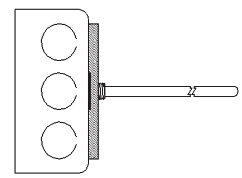
- Optional local setpoint slider adjustments
- Optional occupancy override pushbutton
- Optional LCD display



Temperature sensor



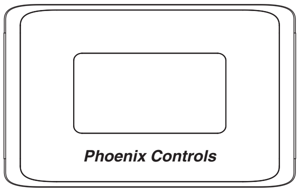
Humidity sensor



Duct sensor

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	—
• Duct mount sensor options: • Sensor lengths of 4, 8, 12 or 18-inch		• Lead lengths of 18, 60, 120 or 180-inch • Optional weatherproof enclosure with optional test and balance switch			
Agency Compliance	CE				



Advanced Pressure Monitor II (APM2)

Advanced Pressure Monitor

The Advanced Pressure Monitor II (APM2) accurately measures pressure differentials with a highly accurate pressure sensor, and presents room status and measured values on a large LCD touch-screen display.

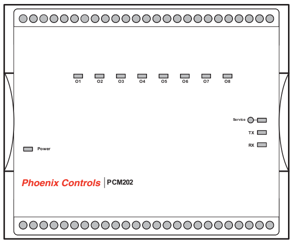
The APM2 provides a bright, easy-to-read display that combines a message to staff on the left one-third of the screen, together with dynamic room operating parameters on the right two-thirds of the screen. It can meet the stringent requirements of pressure sensing for laboratory animal facilities, critical healthcare spaces, cleanrooms, and any application where very low room pressure sensing is required.

Features

- 4.5" Color touch-screen display
- Password protected
- Option to monitor two spaces
- Audible local or remote alarming
- Valve pressure switch alarming, adjustable alarm duration and delay
- Door status indicator
- Mounts in standard electrical box
- Near flush-mount display
- IP-54 wipedown resistant
- Resistant to decontamination chemicals
- Positive, negative, or neutral setup with switchable alarm setpoints
- USB port allows configuration settings to be copied from one device to another using a USB flash drive

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 Code E ±0.25% ±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



Programmable Control Module (PCM)

Programmable Control Module

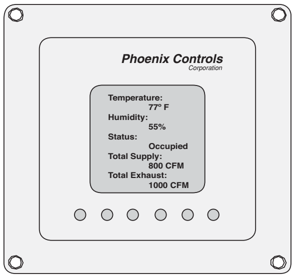
The Phoenix Controls Programmable Control Module (PCM) series provides a means of connecting additional inputs and outputs to the Celeris®, Theris® and Traccel® room-level network and developing custom control sequences to enhance the control functions already provided. The PCM offers varying numbers 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
- 4, 6, 10, and 12 universal inputs
- 6, 8 and 12 universal/digital outputs
- 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—5.7" x 4.7" x 2.0" (144.8 x 119.4 x 50.8 mm) PCM202—5.7" x 4.7" x 2.0" (144.8 x 119.4 x 50.8 mm) PCM203—7.7" x 4.7" x 2.0" (195.6 x 119.4 x 50.8 mm)
Environmental	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
Power Inputs	Voltage 24 Vac; ±15%, 50/60 Hz (PCM200 only) Voltage 24 Vac/Vdc; ±15%, 50/60 Hz (PCM201, PCM202, PCM203)
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)
General Specifications	Processor: Neuron® 3150®; 8 bits; 10 MHz Communication: LonTalk® protocol Channel: TP/FT-10; 78 Kbps Transceiver: TP/FT-10; 78 Kbps Clock: Real-time clock chip[1] Battery (for clock only): CR2032 Lithium (for clock)[1] Status indicator: - Green LEDs: power status and LON TX[2] - Orange LEDs: service and LON RX[2] 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
Agency Compliance	CE FC cULus



Local Display Unit (LDU)

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.

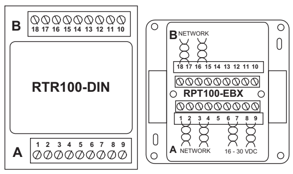
The LDU connects to the Celeris or Traccel room-level network and may be used to display flow, temperature, humidity, control or set point variables available on the Celeris network.

Features

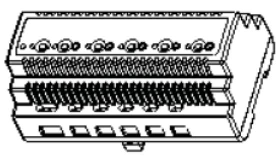
- 128x128 pixel, backlit LCD display measures 2.1" (5.5 cm) square
- Available in flush mount or surface mount
- Connects to either Celeris or Traccel room-level network
- 50 display windows of up to 5 values
  - 10 line display
  - 5 values
  - 5 descriptions (up to 16 characters)

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)



RTR100 and RPT100 modules



RTR104 module (multi-port router)

Router and Repeater Modules

The Phoenix Controls laboratory 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.

Features

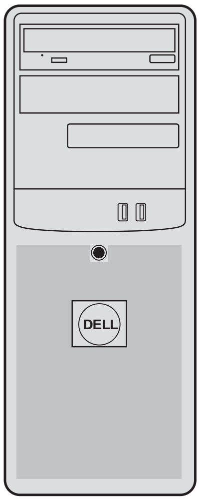
- Versatile mounting:
  - 4" sq. electrical junction box
  - DIN rail mount
- Polarity insensitive communications wiring
- Individual power and network status indicators
- Routers isolate room-level network to ensure reliable communications up to 8500 feet (2700 meters)
  - Lab spaces–20 nodes
  - Tracking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



MacroServer™

Integration Servers: MacroServer™ and MicroServer™

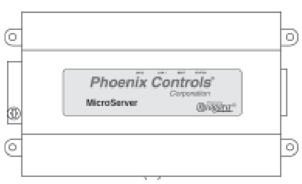
The Phoenix Controls Celeris® MacroServer™ and MicroServer™ function as data servers interfacing with the Celeris LonWorks®-based environmental control system and BACnet® capable Building Management System (BMS).

The 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.

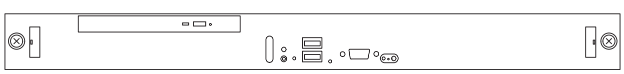
Integration flexibility with most BMS vendors offering BACnet.



MicroServer™

Features

MicroServer	MacroServer
• 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.	• 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



MacroServer™—Rack Mount

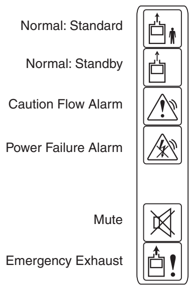
Specifications

MicroServer	MacroServer
Enclosure Plastic, DIN rail or screw-mount chassis, plastic cover Cooling–Internal air convection	**Enclosure** Tower server enclosure 19" Rack mount option
Operating Temperature Range 32-122 °F (0-50 °C) **Operating Humidity Range** 5-95%, non-condensing	**Operating Temperature Range** 50-95 °F (10-35 °C) ambient **Operating Humidity Range** 8-85%, non-condensing

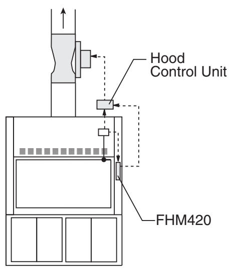
MicroServer	MacroServer
Power Requirements Choose from these power supply configurations: *PWR–DIN rail mounted* 24 Vac/DC power supply module (8.5 VA AC/8.5W DC) *Wall mount power modules* Universal input–90-264 Vac @ 0.5A, 50/60 Hz, 15Vdc @ 1 A, Power cord is 70" (1.8 m) long	**Power Requirements** 305-watt switchable power supply, 115 Vac (9 A) or 230 Vac (4.5 A) 50/60 Hz
Operating System QNX RTOS IBM J9 JVM Java Virtual Machine NiagaraAX	**Operating System** Windows XP Professional

Communication Protocols

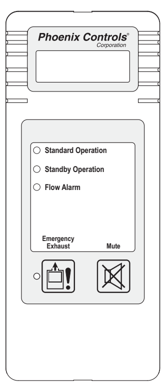
	MicroServer	MacroServer
BMS Network Protocol		
BMS Protocol	BACnet over Ethernet BACnet over IP 10/100 BaseT, RJ45	BACnet over Ethernet BACnet over IP 10/100/1000 BaseT, RJ45
Implementation	BIBBS—BBC (BACnet Building Controller)	BIBBS—ASC (Application Specific Controller)
Data transfer rates (points per second)	Read requests/second: 50 sustained 100 peak Write commands/second: 30 maximum	Read requests/second: 100 sustained 300 peak Write commands/second: 30 maximum
Room-level Network Protocol		
Building network	ANSI 709.1–LonTalk protocol FTT-10 transceiver	ANSI 709.1–LonTalk protocol TP1250 transceiver
Celeris network connection	22 AWG, Level IV, twisted-pair cable	22 AWG, Level IV, twisted-pair cable



Slim-Line Fume Hood Monitor (FHM420)



FHM420 as a part of a fume hood system



X30 Series Fume Hood Monitor

FHM 420 Slim-Line and X30 Series Fume Hood Monitors

Phoenix Controls FHM420 Fume Hood Monitor is sized to fit any fume hood and includes icons for simple and universal operation. The FHM420 works in conjunction with a separate hood interface unit (mounted on top of the fume hood) to provide flow control logic and alarming functions.

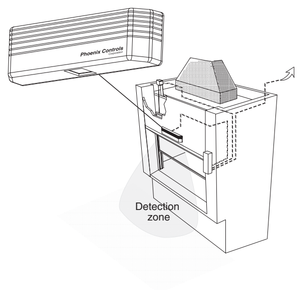
Phoenix Controls X30 Series Fume Hood Monitors (FHMs) are used on fume hoods with Phoenix Controls valves for airflow control. Airflow control on these fume hoods is achieved with the use of constant volume valves (CVV), two-position valves (PEV or BEV) or variable air volume valves (VAV). Each FHM provides two primary functions: indication of hood exhaust operating condition and alarming. In VAV systems, each FHM also provides face velocity control.

Specifications

	X30	FHM420
Enclosure: ABS plastic: IP44 compliant (display unit only)	✔	✔
FHM Color: Light gray (standard) or white	✔	✔
Indicates unique customer conditions	✔ (Yellow LED)	✔
Wired directly from customer's device to dedicated conductors within 9-wire signal cable		✔
Wired directly from customer's device to dedicated conductors within 8-wire signal cable	✔	
Limited to < 5 Vdc with maximum current draw of 0.010 amps		✔
Limited to < 12 Vdc with maximum current draw of 0.012 amps. Customer must install 1K ohm resistor in series with input signal.	✔	
Visual indication only, no audible	✔	✔
Power Loss Alarm Option **(±15 Vdc powered monitor only)**	• Indicates loss of power to the fume hood system. • During power failure, a red LED flashes once every 4 sec • Accompanied by short audible alarm "chirp" • Alarm continues for at least 64 hours or until power is restored	
Agency Compliance		

Features and Options	Constant Volume FHM530	Two-position FHM530	Variable Air Volume FHM430	Variable Air Volume FHM631	Hood Interface Unit (HIU)
Faceplate*					
Face velocity display				✓	
Operating mode LED	✓	✓	✓	✓	
Emergency exhaust LED	**	✓	✓	✓	
Caution flow alarm	✓	✓	✓	✓	
Spare or diversity LED	✓†	✓†	✓†	✓†	
Emergency exhaust button LED	✓	✓	✓	✓	
Setback LED	✓	✓	✓	✓	
Power loss LED	✓†	✓†	✓†	✓†	
Emergency exhaust override button		✓	✓	✓	
Mute button	✓	✓	✓	✓	
Control					
Energy waste alert				✓	
Decommission mode				✓	
Normally open (NO) microswitch input	✓	✓			
Sash position input	✓	✓	✓	✓	✓
Sash opening alarm setting	✓	✓	✓	✓	
Two-position switch point setting		✓			
Standby mode input [e.g., Zone Presence Sensor (ZPS)]		✓	✓	✓	✓
Emergency exhaust (locally or remotely)		✓	✓	✓	✓
VAV hood exhaust command output			✓	✓	✓
24 Vdc relay output two-position mode		✓			
Primary-secondary option (e.g., teaching hood)			✓†		
Standby velocity setting		✓	✓	✓	✓
Auto alarm mute	✓	✓	✓	✓	
Mute duration setting	✓	✓	✓	✓	
Sound volume setting	✓	✓	✓	✓	
Power loss alarm	✓†	✓†	✓†	✓†	
Spare LED control	✓†	✓†	✓†	✓†	
Broken sash alarm	✓	✓	✓	✓	
±15 Vdc or 24 Vac power	✓	✓	✓	✓	
Monitoring					
Hood exhaust command/emergency exhaust			✓	✓	✓
Hood exhaust feedback			✓	✓	✓
Alarm signal			✓	✓	✓
Normally open (NO) alarm relay	✓	✓			
Sash position	✓	✓	✓	✓	✓
User status		✓	✓	✓	✓
Diversity Alarm				✓	

* Faceplates available in English, Danish, French Canadian, French, German, Norwegian and Swedish.
** Does not modulate exhaust CV valve, but allows the operator to test the alarm circuit.
† Options



VAV system using a Zone Presence Sensor (ZPS)

Zone Presence Sensor®

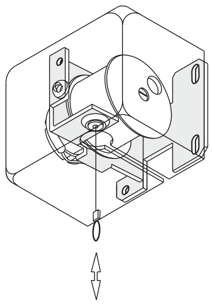
Phoenix Controls Zone Presence Sensor® (ZPS®) detects the presence of personnel in front of a fume hood. When an operator is present, the ZPS signals the fume hood system into the standard, higher flow, mode. When operators are absent, the ZPS signals the fume hood system into the standby, lower flow, mode, thereby maximizing energy savings and system diversity.

Features

- Used in variable air volume and two-position applications
- Interfaces to Phoenix Controls fume hood monitor to initiate standard and standby operation
- ZPS and Phoenix Controls airflow control valves provide less than one-second response time for full-range flow change
- System fail-safe configured for highest flow set point
- Optical sensing for presence detection (object or operator)
- Motion detection sensing for operator movement
- Mounting height field adjustment from 6-12' (1.8-3.7 m) above the floor surface [factory default mounting height setting of 7' (2.1 m) for a six-foot wide hood]
- One ZPS for fume hoods up to 8' or 2.4 m width. Consult factory for larger fume hoods.
- Detection zone extends approximately 20" (50 cm) from front of fume hood (adjustable)
- Orientation adaptable to non-level and non-plumb monitoring spaces

Specifications

Enclosure	• Dustpro of (NEMA 1, IP21) • Color—White
Power Requirements	
Indicates unique customer conditions	• 24 Vac, ±15%, 50-60 Hz, 3 VA • ±15 Vdc, ±15%, 50-60 Hz,120mA
Light Requirements	50-100 foot candles
Agency Compliance	



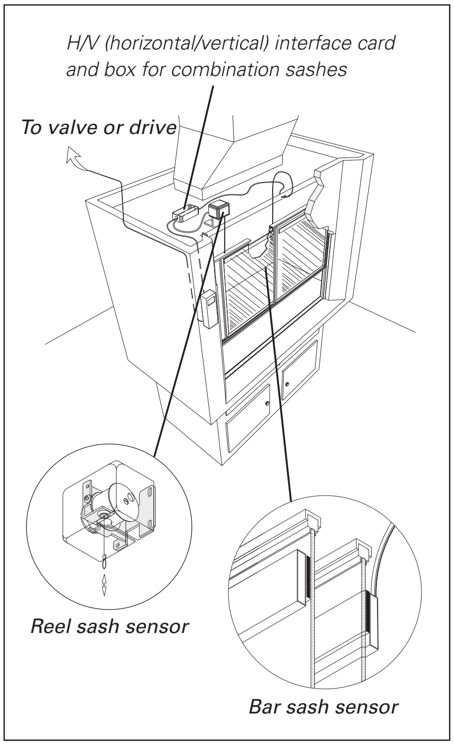
Sash sensor

Sash Sensors

Phoenix Controls Sash Sensors detect a fume hood's sash position. Sensors can be configured to operate with the sash configurations found on most VAV fume hoods. The sash sensors are used together with a Phoenix Controls fume hood monitor and Accel II valve to maintain a constant average face velocity at the sash opening.

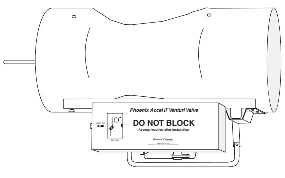
Features

- Vertical sash sensors are used to measure vertical sash movement
- Horizontal sash sensors consist of a combination of sensor bars and magnets and are used to measure horizontal sash pane movement
- Combination sash sensors allow you to use a wide variety of vertical and horizontal sash sensors in varying quantities to measure total open sash are on almost any combination of sash arrangements.



Specifications

VSS
Direct reel sash sensing technology
Stainless steel, nylon-jacketed cable coupled to a 10-turn precision potentiometer. Maximum retraction of 41" (1041 mm)
0-10,000 ohm output proportionate to sash position
1, 2, 3, or 4 vertical sensors available for side-by-side configurations
Tested for 475,000 life cycles
22 AWG two-wire, PVC-jacketed signal cable factory wired (12', 3.6 meters)
Surface or bracket mount (bracket not included) on top of hood
Dimensions: 2.05" H, 2.00" W, 2.50" L (52 x 51 x 64 mm)
0-50 °C (32-122 °F) ambient
Color: Light gray
HSS
A sensor bar/magnet combination measures overlap between sashes
Sensor/magnet bars are 0.3" (8 mm) thick with tape and 1" (25 mm) wide
Standard and thin magnet bars must be mounted within 0.75 in. (19 mm) of the sensor bar
22 AWG two-wire, FEP-jacketed rigid plenum-rated cable factory wired (15', 4.5 meters)
Maximum sensor bar length of 75" (1905 mm) cumulative for HSS1xx and 120 in. (3048 mm) for HSS3xx
Bar lengths made to order
Color: Light gray
CSS
Utilizes both reel and bar sensors
Interface card and box mounted on top of hood
Requires a three-conductor cable from interface card to monitor SSS—Requires factory consultation
Agency Compliance
CE c CSA us



Accel II Valve (analog)

Accel® II Valve (analog)

The Phoenix Controls Accel II Venturi Valves combine a mechanical, pressure-independent regulator with a high-speed position/airflow controller to meet the unique requirements of airflow control. These valves can be used in constant volume, two-position, or VAV applications—all designed to maximize flow performance while reducing related noise. Valves for VAV applications may be either electrically or pneumatically actuated.

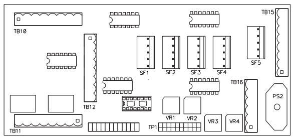
- Pressure-independent operation: All valve types include an immediate response mechanical assembly to maintain airflow set point as duct static pressure varies.
- Airflow control: By positioning the flow rate controller assembly, the airflow can be adjusted.

Accel II valves are available in:

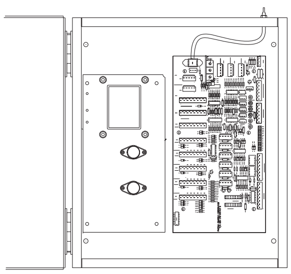
- Constant volume (CVV series) for maintaining an airflow set point under variable static pressure conditions
- Two-position (PEV/PSV series) for high/low flow control (pneumatic only)*
- Base upgradable (BEV/BSV series) for pneumatic flow control with feedback option and upgradability to VAV (pneumatic only)*
- VAV (EXV/MAV series) with VAV closed-loop feedback control (pneumatic or electric)** (not available in 14" size)

Specifications

Construction	• 16 ga. spun aluminum valve body with continuous welded seam • Valve bodies available as uncoated aluminum or with corrosion-resistant baked phenolic coatings • Composite Teflon® shaft bearings • Spring grade stainless steel spring, and polyester or PPS slider assembly • Supply valves* insulated with 3/8" (9.5 mm) flexible closed-cell polyethylene. Flame/smoke rating 25/50. Density is 2.0 lb/ft³ (32.0 kg/m³).
Operating Range	• 32-122 °F (0-50 °C) ambient • 10-90% non-condensing RH
Sound	Designed for low sound power levels to meet or exceed ASHRAE noise guidelines.
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 • No additional straight duct runs needed before or after valve • Available in flows from 35-10,000 (60-16,990 m³/hr) • Response time to change in command signal: < 1 second • Response time to change in duct static pressure: < 1 second
VAV Controller	Pneumatic Actuation: • ±15 Vdc, ±5% @ 0.145 amp (pneumatic only) • Only applicable to PEV, PSV, BEV/BSV and EXV/MAV-N (pneumatic control type) • 20 psi (-0/+2 psi) with a 20 micron filter main air required (except for CVV) Electric Actuation: • 24 Vac (±15%) @ 60 Hz • single and dual valves: 96 VA • triple and quad valves: 192 VA
Agency Compliance	



MAC300V



MAC500P (cover open)
MAS212/MIX400/500 not shown

Make-up Air Controller

Phoenix Controls Make-up Air Controllers (MACs), used together with Phoenix Controls analog valves, are designed to maintain proper pressurization of a particular space.

- Summing the total exhaust flow from all exhaust sources
- Controlling a make-up air valve using volumetric tracking of the exhaust (make-up air = exhaust – offset)
- Temperature override control for cooling
- Minimum ventilation control

Four types of make-up air controllers are available:

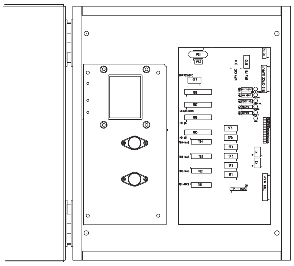
1. MAC300V: Valve-mounted unit for labs with two hoods maximum
2. MAC500P: Panel-mounted unit for labs with six hoods maximum
3. MIX400†: integrated unit for labs with two hoods maximum
4. MIX500†: integrated unit for labs with six hoods maximum

Specifications

Operating Range	32-122 °F (0-50 °C) ambient
Analog Signals	0-10 Vdc scaled @ 200/500/1250 CFM/volt (340/850/2125 m³/hr/volt)
Available Signals	• Fume hood exhaust flow • Fume hood sash position • Fume hood user status • Fume hood flow alarm • Fume hood emergency exhaust alarm • Make-up airflow • Make-up airflow alarm • General exhaust flow • General exhaust flow alarm
Panel (MAC500P)	• 16 gauge NEMA-1 (UL listed) • Light gray baked enamel finish • 0.875/1.125" (22/29 mm) diameter knockouts • 1/8" bulkhead fitting for pneumatic thermostat option • Power input: 100-120 Vac, 47-63 Hz or 215/230-240 Vac, 47-63 Hz (field-configurable) • Power output: +15 Vdc, -15 Vdc, ±5% @ 1.5 amp for up to 3 hood inputs; 3.0 amp for 4, 5 and 6 hood inputs • Weight: 19 lbs (8.3 kg)
Agency Compliance	CE CSA C US

Features/Options	MAC300V Series	MAC500P Series	MIX400 Series†	MIX500 Series†
Maximum hood inputs	2	6	2	6
Make-up air output	1	1	1	1
General exhaust output	1	1	1	1
General exhaust or supply input	1	1		1
Dedicated constant volume input		1		1
Dedicated office supply input		1		1
Dedicated snorkel/canopy exhaust input		1		1
Adjustable room offset	✓	✓	✓	✓
Emergency exhaust override	✓	✓	✓	✓
Pneumatic and electronic thermal override control signals	✓	✓	✓	✓
Minimum ventilation control	✓	✓	✓	✓
Unoccupied ventilation control		✓	✓	✓
Exhaust fan control	✓	✓	✓	✓
Common alarm contact	✓	✓		
Factory-mounted power supply		✓		
Interfaces with all DDC systems via individual hardwired signals	✓	✓		
Interfaces with specific DDC systems† via 40-pin ribbon cable			✓	✓
Installation location	Analog valve	Panel	BMS panel	BMS panel
Pluggable terminal block wiring	✓	✓	✓	✓
Unity gain: Supply and exhaust at same factor scales	✓	✓		✓
Fume hood exhaust flow	2	6	2	6
Fume hood sash position	2	6	2	6
Fume hood user status	2	6	2	6

†Contact Phoenix Controls for DDC partner list.



MAS212 panel (cover open)

MAS212 Master Summing Panel

The Phoenix Controls Master Summing Panel (MAS) is used with our Accel® II analog valve to total airflows from multiple sources and generate an output for analog valves.

Features

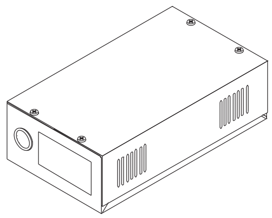
- Inputs–Up to 12 flow inputs, of which six can be non-Phoenix products scaled to a CFM/ volt signal.
- Outputs–Three flow signals: one to control a Phoenix Controls airflow control valve and two that can be scaled to control a variable speed drive or as a signal to a building management system (BMS).

Specifications

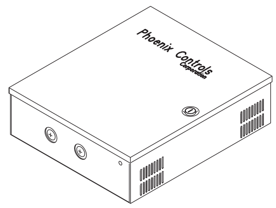
Operating Range	32-122 °F (0-50 °C) ambient
Power	• Input: 100-120 Vac, 47-63 Hz or 215/230-240 Vac, 47-63 Hz (field configurable) • Output: +15 Vdc, -15 Vdc, ±5% @ 0.8 amp • Optional 1.5 amp and 3.0 amp available
Flow Signals	14 inputs, 0-10 Vdc: • 6 from Phoenix Controls valves at input scale factor • 6 can be field scaled at input scale factor • 1 from Phoenix Controls valve at output scale factor • 1 from Phoenix Controls valve at inverted output scale (e.g., 13 exhaust, 1 supply) • 3 outputs, 0-10 Vdc: • 1 to control Phoenix valve • 2 field scaled to control drive or non-Phoenix Controls device
Panel	• 16 gauge NEMA-1 (UL listed) • Light gray baked enamel finish • 0.875/1.125" (22/29 mm) diameter knockouts
Agency Compliance	

Power Supplies

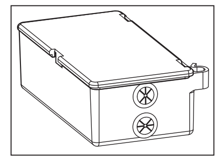
Used to provide a clean, stable ±15 Vdc power source for analog valve controllers and certain fume hood components.



WPS108/208



WPS115/WPS130



WPS4XX

Specifications

	WPS108	WPS208	WPS115	WPS130	WPS405	WPS410	WPS420	WPS440
Input Power	100/200 Vac, 47-63 Hz	215/230-240 Vac 47-63 Hz	100/120/215/230-240 Vac (+10%, -13%) 47-63 Hz		24 Vac ±10% or 15 Vdc, ±10%			
Output Voltage	±15 Vdc	±15 Vdc	±15.1 Vdc	±15.1 Vdc	±15 Vdc	±15 Vdc	±15 Vdc	±15 Vdc
Output Current	±5% @ 0.8 A 60 Hz	±5% @ 0.72 A 60 Hz	±5% @ 1.5 A 60 Hz	±5% @ 3.0 A 60 Hz, 2.7 A 50 Hz	±5% @ 0.5 A	±5% @ 0.100 A	±5% @ 0.200 A	±5% @ 0.400 A
Terminal Block Connections	✓	✓	✓	✓	✓	✓	✓	✓
Enclosure	**Metal**				**Polycarbonate**			
Conduit Knockouts	✓	✓	✓	✓				
Power Supplies Feature	• 32-122 °F (0-50 °C) ambient operating temperature • Automatic current limiting • ±0.5% line load regulation							
Location	The maximum length of cable from the power supply to the system it is powering is 200 ft (61 m) at 22 AWG							
Conditions	The disconnect device, overcurrent protection, and connection to the primary power must be provided by others							
Agency Compliance	CE CSA							

NOTES

NOTES

Phoenix Controls products are covered by one or more of the following U.S. patents:
5,251,665 5,304,093 5,385,505 D642894 5,545,086
and other patents pending.

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MKT-0156 MPC-1677