

**NUCLEAR MEDICAL RADIOSOTOPE
HOOD (JACC)
DESIGN ANALYSIS
October 3, 2012**

**VA Gulf Coast Veterans Health Care System
Joint Ambulatory Care Center (JACC)
790 Veterans Way
Pensacola, FL 39507**

100% Submittal

By
JMZ Group
With:
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Joint Ambulatory Care Center Nuclear Medical Radioisotope Hood Architectural & Electrical Design Analysis

ARCHITECTURAL & Electrical

The architectural component of this project is primarily concerned with button up surfaces and finishes around the work to be performed by the mechanical and electrical subcontractors.

Removing the existing exhaust hood and installing the new radioisotope hood in its place will require the removal of quite a bit of suspended ceiling, both to gain access to the duct work and also provide room for workmen to do their job. Additionally a section of flexible duct currently located in the existing system will have to be replaced with a length of seamless stainless duct. This location will also require the removal of ceiling.

Once this work is completed the affected ceiling areas will require reframing with new grid and replacement of ceiling tile to match the existing texture and pattern.

The room containing the radioisotope hood also contains both existing overhead and base cabinets which are in excellent condition. Notes have been added to the drawings warning the General Contractor to protect all finishes and surfaces during construction and that if any damage is sustained, these components will have to be replaced.

In the interstitial space above the floor containing the hood, a fire rated fan room exists that contains the existing fan for the hood to be replaced. The new fan for the new hood will be spark proof and explosion proof.

Based on our code analysis, with the installation of an explosion/spark proof motor, it has been deterred that the room containing the fan does not need to be designated as a Class 1 Division 1 Area. For this reason the existing J-boxes, devices and other equipment in the room may remain as is. The codes having jurisdiction over these issues are the NEC and the VA HVAC and Electrical Guide.

Joint Ambulatory Care Center Nuclear Medical Radioisotope Hood Mechanical Design Analysis

General

The general scope of this project is to replace an existing bio-safety cabinet in Hot Lab 2C106 with a new radioisotope hood.

Applicable Codes and Standards:

- International Building Code – 2009
- International Mechanical Code – 2009
- International Plumbing Code – 2009
- HVAC Design Manual for New, Replacement, Addition, and Renovation of Existing VA Facilities – March 2011

HVAC

The heating and cooling loads for Hot Lab 2C106 are not affected by this project, thus no load calculations have been completed. Section 3.8 of the HVAC Design Manual lists 15 specific requirements for fume hoods. There are several requirements in the list that do not apply to this project because the primary hood exhaust system is existing and a complete redesign of the system is not within the scope of this project. In an effort to be thorough, a complete list of the requirements is below whether the requirement applies to this project or not. A statement regarding compliance with each requirement is also included.

1. Requirement: Provide emergency power for the exhaust system and associated controls for hood exhaust systems.

Compliance: The building owner has indicated that the exhaust fan is already on emergency power. The new lab hood controller will also be on emergency power.

2. Requirement: Do not connect any exhaust from sources other than identical hoods to the fume hood exhaust system.

Compliance: The new radioisotope hood is the only hood connected to this exhaust system.

3. Requirement: Radioisotope hoods can be grouped together to form a combined exhaust system. General Purpose or Chemical Hoods can be grouped together to form a combined exhaust system. Perchloric Acid hoods cannot be grouped together. Each Perchloric Acid Hood must have its own dedicated exhaust system.

Compliance: The new radioisotope hood is the only hood connected to this exhaust system so this requirement does not apply.

4. Requirement: Provide spark-proof construction fans and explosion-proof motors.

Compliance: The existing fan carries a Type C spark rating. The existing motor is being replaced with an explosion-proof motor.

5. Requirement: Provide an airflow control valve with readout capability or a DDC CV/VAV terminal unit in each branch exhaust duct.

Compliance: A new DDC controls system is being installed in this room that includes a lab hood exhaust terminal and motorized dampers. The system will continuously monitor the hood sash position, and lab hood face velocity. It will also monitor the total supply air and exhaust air in the room to make sure the room stays negative with respect to the adjacent corridor.

6. Requirement: Provide local and remote alarm capability at the ECC for each fume hood in the event of a system failure or the face velocity readout outside the high or low setpoints.

Compliance: The new lab hood control system has the required alarms. A local room pressure monitor has also been added to visual proof that the room is under negative pressure.

7. Requirement: Provide round, stainless-steel welded ductwork for hood exhaust. Provide a stainless steel transition piece between the hood discharge connection and the exhaust duct.

Compliance: All existing exhaust duct is welded stainless steel. Any new ductwork required to connect to the new hood will also be welded stainless steel.

8. Requirement: Keep entire exhaust ductwork under negative air balance.

Compliance: The existing exhaust system consists of ductwork under negative pressure between the Hot Lab and the mechanical mezzanine where the fan is located. The positive pressure exhaust duct extends from the fan up through the roof. No changes to the duct system will be made.

9. Requirement: Discharge exhaust air from the highest level of the building. Provide a discharge stack at least 10 feet tall. Increase the stack height as required to meet the dispersion analysis recommendations. The discharge velocity at the nozzle shall be 3,500 FPM.

Compliance: The exhaust stack and accelerator cone are existing and no changes will be made. The existing stack extends 14 feet above the roof and the discharge velocity is 3,100 FPM.

10. Requirement: Include the discharge air velocity pressure and the static pressure drop through the hood in the fan static pressure calculations.

Compliance: The fan is existing and the total exhaust air flow is not being modified. No static pressure calculations are required.

11. Requirement: Include recommended acoustic analysis measures to contain the fan noise traveling back to the exhaust fan in the system design.

Compliance: The fan and exhaust system is existing. No acoustical analysis is required or provided.

12. Requirement: Do not attempt heat recovery from exhaust ducts of fume hoods.

Compliance: There is no heat recovery on the existing exhaust system.

13. Requirement: Do not install fume hood exhaust ducts in the same shafts that environmental ducts are housed. See NFPA 90A for additional information.

Compliance: The existing exhaust duct is not in a shaft that houses environmental ducts. No action is required.

14. Requirement: Do not install fire dampers in fume hood exhaust ducts.

Compliance: There are not fire dampers in the existing fume hood exhaust duct.

15. Requirement: The designer shall verify the project-specific filtration requirements for the Radioisotope hood exhaust air system in consultation with the end-users and the Radiation Safety Officer. The filtration requirements depend on the use/quantity and type of isotopes used and may require MERV 17 (HEPA) filter, or a combination of MERV 17 (HEPA) and a charcoal filter, or no filters at all.

Compliance: The Radiation Safety Officer has determined that no filtration is required.

Plumbing

No plumbing work is required in the scope of this project.

Fire Protection

No fire protection work is required in the scope of this project.

Room Pressure Monitor

Description

The Room Pressure Monitor (RPM) is designed for critical low differential pressure applications that require stringent pressure monitoring and alarming. The unit can be configured to monitor positive or negative pressure in protected environments and hospital isolation rooms per CDC guidelines.

Features

- Touch screen display
- Password enabled
- Local audible alarm
- Visual red and green room status displays
- SPST alarm relay
- Door status monitor
- Variable alarm delay
- Positive and negative pressure monitoring
- Bar graph display
- CE and RoHS compliant
- Easy to install, set-up and calibrate
- Fingertip operation
- Password security
- Local display of room

Applications

- Hospital patient isolation wards
- Pharmaceutical manufacturing
- Semiconductor fabs
- Cleanrooms
- Research laboratories



Specifications

Performance Data

	547-xxxB	547-xxxA
Accuracy RSS * (at constant temp)	± 0.25%	± 0.5%
Non-linearity (BFSL based)	± 0.24%	± 0.49%
Hysteresis	± 0.05%	± 0.05%
Non-repeatability	± 0.05%	± 0.05%
Zero setting tolerance	± 0.5% FS	± 0.5% FS
Span setting tolerance	± 0.5% FS	± 0.5% FS
Thermal Effects **		
Compensated range °F (°C)	± 0.03%FS (± 0.05% FS)	
Overpressure	± 1 PSI	
	± 15"W.C. for ± 0.1 and ± 0.05 in W.C.	

* RSS of Non-linearity, non-repeatability, and hysteresis

** Units calibrated at nominal 70°F (21°C). Maximum thermal error computed from this datum.

Environmental Data

Temperature	
Operating *	32°F (0°C) to 120°F (50°C)
Storage	-20°F (-30°C) to 160°F (70°C)
Operating humidity	5% to 95% rh (non-condensing)

* Operating temperature limits of electronics only.

Physical Description

Case	Fire retardant plastic (NEMA 1, IP20 rated for indoor applications)
Dimensions	8" H × 5.1" W × 1.8" D (203 mm H × 130 mm W × 46 mm D)
Electrical connection	Removable terminal block
Pressure fittings	Barbed fittings for 1/4" OD tubing

Specifications, Continued

Weight (approx.) 1.5 lbs (680 g)
 Mounting 4 × 4 plaster ring
 (mounts to double gang electrical box)

Communications Option

BACnet® MS/TP ASC
 P1 FLN trunk

Display

LCD 128 × 128 RGB backlit
 Status indicators Green LED – Normal
 Red LED – Alarm
 Backlit LCD

Electrical Data (Voltage)

Circuit 3-wire (Exc, Out, Com)
 Output* 0 to 5 Vdc
 0 to 10 Vdc
 Excitation 18 to 32 Vac, 50 to 60 Hz
 Power consumption 5 W
 Alarm output SPDT relay
 1A @ 24 Vdc

* Calibrated into a 50K ohm load, operable into a 5000 ohm load or greater.

Electrical Data (Current)

Circuit 2-wire
 Output 4 to 20 mA
 External load 0 to 510 ohms
 Excitation 18 to 32 Vac, 50 to 60 Hz

Pressure Media

Air or non-conductive, non-explosive gases.

Certifications

CSA Standard C22.2 No. 0-M91 General Requirements
 Canadian Electrical, Part 1
 CAN/CSA C22.2 N9. 0.4-04 Bonding of Electrical Equipment
 CAN/CSA-C22.2 No. 61010-1-04 Safety Requirements
 for Electrical Equipment for Measurement,
 Control and Laboratory Use
 Part 1: General Requirements
 ANSI/UL61010-1 (2nd Edition) Safety Requirements for
 Electrical Equipment for Measurement,
 Control

Accessories



547-100 Pressure Tap Plate

Ordering Information

Product Number	WC	Protocol	FS
547-101A	+/- 0.05" wc (12.5 Pa)	P1	0.5%
547-102A	+/- 0.1" wc (25 Pa)	P1	0.5%
547-103A	+/- 0.25" wc (62.5 Pa)	P1	0.5%
547-104A	+/- 0.50" wc (12.5 Pa)	P1	0.5%
547-105A	+/- 1.0" wc (250 Pa)	P1	0.5%
547-106A	+/- 2.55" wc (625 Pa)	P1	0.5%
547-107A	+/- 5.0" wc (1250 Pa)	P1	0.5%
547-101B	+/- 0.05" wc (12.5 Pa)	P1	0.25%
547-102B	+/- 0.1" wc (25 Pa)	P1	0.25%
547-103B	+/- 0.25" wc (62.5 Pa)	P1	0.25%
547-104B	+/- 0.50" wc (12.5 Pa)	P1	0.25%
547-105B	+/- 1.0" wc (250 Pa)	P1	0.25%
547-106B	+/- 2.55" wc (625 Pa)	P1	0.25%
547-107B	+/- 5.0" wc (1250 Pa)	P1	0.25%
547-201A	+/- 0.05" wc (12.5 Pa)	BACnet	0.5%
547-202A	+/- 0.1" wc (25 Pa)	BACnet	0.5%
547-203A	+/- 0.25" wc (62.5 Pa)	BACnet	0.5%
547-204A	+/- 0.50" wc (12.5 Pa)	BACnet	0.5%
547-205A	+/- 1.0" wc (250 Pa)	BACnet	0.5%
547-206A	+/- 2.55" wc (625 Pa)	BACnet	0.5%
547-207A	+/- 5.0" wc (1250 Pa)	BACnet	0.5%
547-201B	+/- 0.05" wc (12.5 Pa)	BACnet	0.25%
547-202B	+/- 0.1" wc (25 Pa)	BACnet	0.25%
547-203B	+/- 0.25" wc (62.5 Pa)	BACnet	0.25%
547-204B	+/- 0.50" wc (12.5 Pa)	BACnet	0.25%
547-205B	+/- 1.0" wc (250 Pa)	BACnet	0.25%
547-206B	+/- 2.55" wc (625 Pa)	BACnet	0.25%
547-207B	+/- 5.0" wc (1250 Pa)	BACnet	0.25%

Dimensions

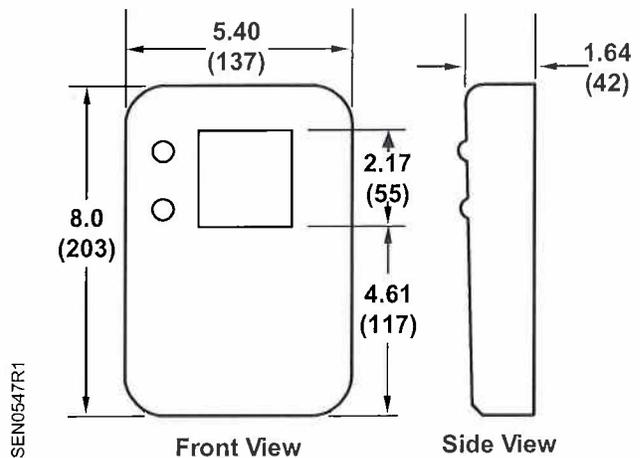
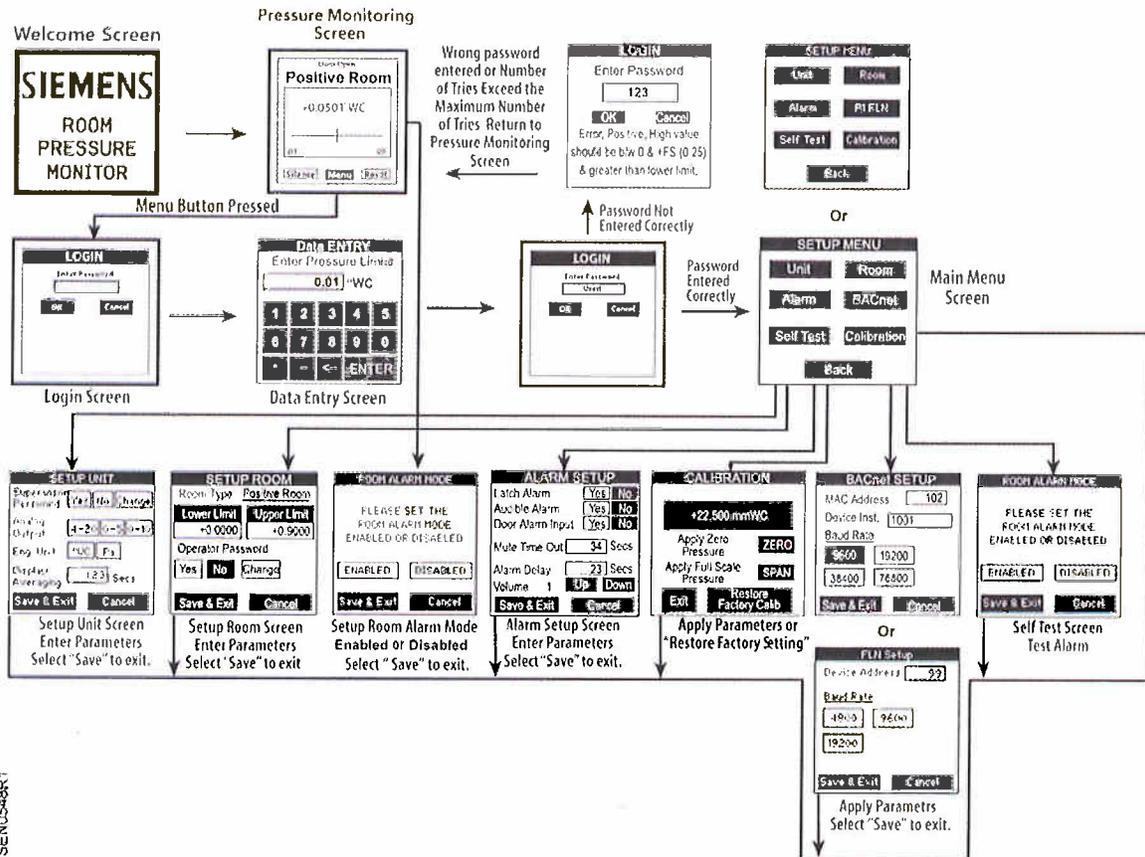
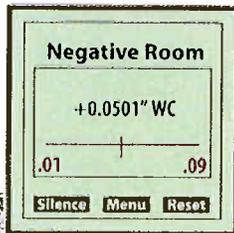


Figure 1. Dimensions in Inches (Millimeters).

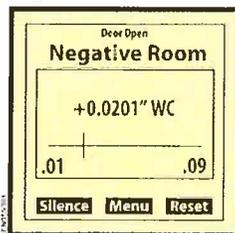
RPM Menu Tree



SENC5-6801



If pressure is normal, the screen is green



If pressure is normal and door is open, the screen is yellow



If pressure falls outside of preset limits (Alarmed State), the screen is red

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Lab and Pressurized Room Controllers with Off-board Air Modules



Figure 1. Lab Controller Module.



Figure 2. Off-board Air Module 550-818B.

Description

The APOGEE[®] Automation System Laboratory Room Controllers and Room Pressurization Controllers are available on a new hardware platform. The Lab Controller Module (LCM) uses the Off-board Air Module (OAM) to measure airflow for standard and custom pressurized room control applications.

Lab Controller Module

The LCM (Figure 1) operates as an independent, stand-alone DDC controller and can be connected on the Floor Level Network (FLN) with the APOGEE[®] Automation System. The LCM includes the largest physical point count of any APOGEE FLN device. Not all physical points are used in all applications.

Off-board Air Module

The OAM (Figure 2) contains the air velocity sensor (a specialized differential pressure transducer), V/F conversion circuitry and solenoid for auto-zero function. Advanced digital signal processing produces a highly accurate reading of even the noisiest flow signals.

The auto-zero solenoid connects to the air velocity pressure transducer's inlet ports to enable automatic periodic re-calibration. This re-calibration ensures accurate, drift-free airflow measurement. Automatic re-calibration of the differential pressure transducers occurs upon system power-up and when airflows are stable with frequency selectable from 1 to 6 times a day.

Features

- LCM can be factory mounted on terminal units or venturi air valves, or field mounted in panels located for easier access.
- OAM factory mounted on terminal units or venturi air valves eliminates field installation of airflow signal tubing.
- Control applications available for a variety of airflow control devices, including dampers, terminal units, fans with VFDs and venturi air valves.
- Control applications using a variety of actuation types including high-speed electronic, low-speed electronic and pneumatic (with transducers).
- Control applications that do not use a general exhaust, do not require a second OAM.
- Airflow sensor is read five times per second, independent of the output device loop time, giving the most accurate reading at all times.
- Airflow sensor is automatically recalibrated periodically to maintain highest accuracy.
- BTU Compensation temperature control application allows tighter control without over-cooling or over-heating during transients (requires discharge temperature sensor).
- Supports the use of wall switch input to change from occupied to unoccupied state.
- Optional room pressurization alarm output to notify laboratory occupants.
- Reports airflow directly in actual cfm (lps).
- Electrically Erasable Programmable Read Only Memory (EEPROM) used for storing control parameters—no battery backup or re-entry of data required.
- Quick return from power failure without operator intervention that maintains room pressure relationship.
- Maintains room pressurization during transient conditions.
- Secure Mode prevents unauthorized users from making changes to the TEC through the MMI port or room sensor, supporting FDA 21 CFR Part 11 compliance guidelines for protection of electronic records (see *Application Information*).
- User-adjustable offset for the calibration of room temperature reading when required for validation purposes (see *Application Information*).

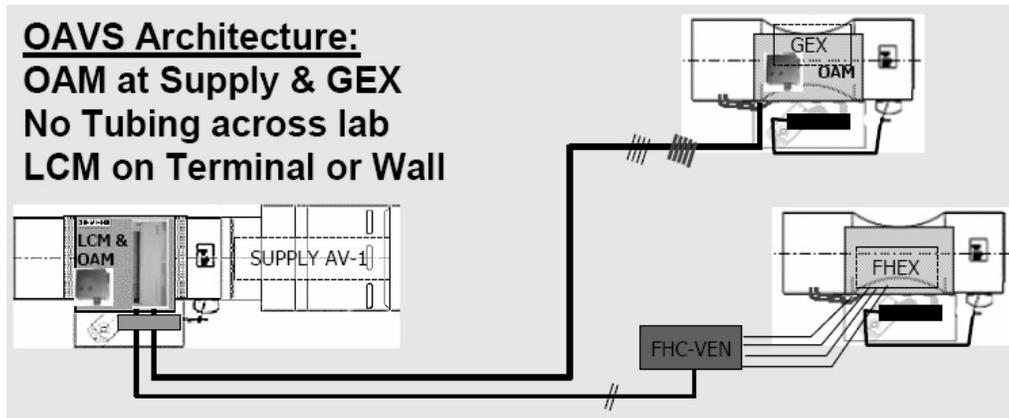
Specifications

Power Requirements	
Operating Range	19.2 to 27.6 Vac 50 or 60 Hz
Power Consumption	3.8 VA (Nominal) to 5.3 VA (Peak) @ 24 Vac (plus 12 VA per DO)
Inputs	
Analog	1 room temperature sensor (10K thermistor) 1 setpoint (optional at RTS) 1 auxiliary temperature sensor (100k thermistor) 2 selectable 0-10 Vdc/4-20mA
Digital	2 air velocity sensor inputs (Only for OAM inputs) 2 dry contacts
Outputs	
Analog	3 0-10 Vdc
Digital	8 DO 24 Vac optically isolated solid state switches @ 0.5 amp 1 DO dedicated to AZ function
Airflow Sensing	
Measurement Range	0 to 5600 fpm (0 to 26 m/s)
Accuracy	3.5% maximum error from velocity pressure of 0.023"wc (5 Pa)
Controlled Temperature	
Accuracy	±1.5°F (0.9°C)
Dimensions	
	4-1/8" W × 11-1/4" L × 1-1/2" H (105 mm × 197 mm × 38 mm)
Weight	
	Approximately 1.65 lb (750g)
Communications	
Remote	4800 bps FLN Trunk
Local	Portable Operator's Terminal
Ambient Conditions	
Storage Temperature	-40°F to 167°F (-40°C to 75°C)
Operating Temperature	32°F to 122°F (0°C to 50°C)
Humidity Range	0% to 95% (non-condensing)
Agency Listings	
UL Listing	UL 916, PAZX,
cUL Listed	Canadian Standards C22.2 No. 205-M1983, PAZX7
Compliance	
	FCC 47 CFR Part 15 European EMC Directive (CE) Australian EMC Frame (C-Tick)

Application Information

LCM P/N	Application	Airflow Control		Temperature Control		Application Notes
		Device	Output Type	Application	Output	
550-767C	2620	Venturi	High-speed Modulating	Room Temp Sensor	0-10V	Flow-Tracking, compatible with VAV fume hood control. OCC and UOC states have separate, selectable: >Differential Flow Setpoint >VAV or CAV Temp Control Mode Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
	BTU Comp [Discharge Temp Req'd]					
550-767D	2622	Venturi	Low-speed Modulating	Room Temp Sensor	0-10V	Flow-Tracking, compatible with CV2 fume hood control. OCC and UOC states have separate, selectable: >Differential Flow Setpoint >VAV or CAV Temp Control Mode Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
	BTU Comp [Discharge Temp Req'd]					
550-767E	2621	Damper	High-speed 3-state	Room Temp Sensor	0-10V	Flow-Tracking, compatible with VAV fume hood control. OCC and UOC states have separate, selectable: >Differential Flow Setpoint >VAV or CAV Temp Control Mode Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
	BTU Comp [Discharge Temp Req'd]					
550-767F	2623	Damper	Low-speed 3-state	Room Temp Sensor	0-10V	Flow-Tracking, compatible with CV2 fume hood control. OCC and UOC states have separate, selectable: >Differential Flow Setpoint >VAV or CAV Temp Control Mode Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
	BTU Comp [Discharge Temp Req'd]					
550-767G	2624	Damper supply Venturi exhaust	Low-speed Modulating / Low-speed 3-state	Room Temp Sensor	0-10V	Flow-Tracking, compatible with CV2 fume hood control. OCC and UOC states have separate, selectable: >Differential Flow Setpoint >VAV or CAV Temp Control Mode Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
	BTU Comp [Discharge Temp Req'd]					

NOTE: Setpoint hardware adapter is required when using 10K duct sensor in place of room temperature sensor.

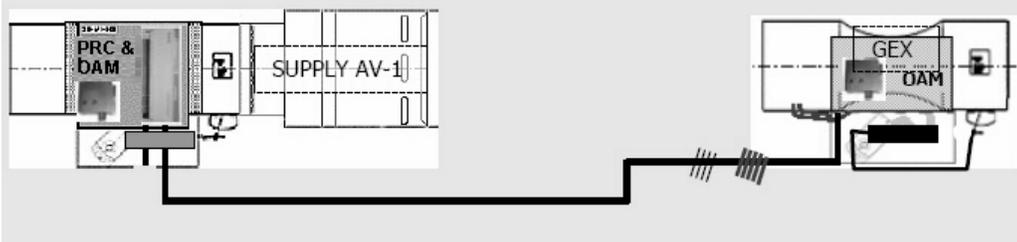


Application Information

LCM P/N	Application	Airflow Control		Temperature Control		Application Notes
		Device	Output Type	Application	Output	
550-767N	2463	Damper	Low-speed 3-state	Room Temp or Discharge Temp Sequenced with Radiation	REHEAT 3pos /0-10V optional RADIATION 0-10V	Flow-Tracking, NO FH FLOW INPUT. Separate Heating & Cooling Set Points Two pressurization states. Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.
550-767H	2631	Various	Low-speed 3-state OR Modulating	Discharge Temp	REHEAT 0-10V	“Cacade” Control of Room Pressure by Resetting Flow-Tracking Differential Room Temperature Offset for single-point calibration and SECURE MODE for Part 11 compliance solution.

PRC-OAVS ARCHITECTURE

No Fume Hood, just tracking pair.



Ordering Information

Description	Part Number
Lab Controller Module	550-767_ (various)
Off-board Air Module	550-818B
Single Duct Supply Terminal	LGSn....n
Dual Duct Supply Terminal	LGDn....n
Exhaust Terminal	LGEN....n
Airflow Measurement Station	LGFn....n
Venturi Air Valve	
– Constant Volume	AVCn....n
– Variable Volume	AVVn....n
– Zero Leakage Shut-Off	AVZn....n
Venturi Air Valve Accessories	AVAn....n
Laboratory Electronic Actuator	GNP191.1P
TEC Duct Sensor Set Point Adapter Kit	540-656

Technical Specification Sheets	Part Number
FHC-VAV	149-245
FHC-CV2	149-947
Venturi Air Valves	149-425
Venturi Air Valve Accessories	149-495
Laboratory Room Single Duct Supply Air Terminal	149-319
Laboratory Exhaust Air Terminal	149-320
Laboratory Room Dual Duct Supply Air Terminal	149-338
Laboratory Airflow Station	149-317
Laboratory Electronic Actuator	155-771
Submittal Sheet	

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UniTrak Fume Hood Sash Sensors



Specifications

Sensing Range	0" to 85" (0 cm to 218cm)
Resistance	96K Ω /ft
Expected Life	>1,000,000 cycles
Ambient Conditions	
Storage Temperature	-40°F to 167°F (-40°C to 75°C)
Operating Temperature	0°F to 120°F (-20°C to 50°C)
Operating Humidity	20% to 80% rh non-condensing

Table 1. Materials of Construction.

Bill of Materials	Construction
Linkage	Stainless Steel, Type 316
Actuator Block Assembly	Stainless Steel, Type 440, 304, 302, and 18-8, PVC
Adhesive	Acrylic
Sensor Connector	Plastic, Nylon 6/6
Connector	Plastic, Nylon 6/6
Cable	Teflon Coated
Sensor Strip	Polyester Film
Sensor Track	Rigid PVC Type II
Sensor Shield	Rigid PVC Type II

Ordering Information

Vertical Sensor Kits *

Description	Installed	Product Part Number
30 (762)	33.3 (846)	546-00490
32 (813)	35.3 (897)	546-00489
35 (889)	39.3 (998)	546-00488
40 (1016)	40.3 (1024)	546-00487
44 (1118)	48.3 (1227)	546-00486
53 (1346)	57.3 (1455)	546-00485
71 (1803)	75.3 (1913)	546-00484
85 (2159)	89.8 (2281)	546-00443

*Vertical Kits include 1 UniTrak with sensor, 1 sash actuator car, 2 straight linkages, and 1 sash sensor shield.

Horizontal Sensor Kits**

Description	Installed	Product Part Number
34 (863.6)	39.3 (998)	546-00495
43 (1092)	48.3 (1227)	546-00493
52 (1321)	57.3 (1455)	546-00492
70 (1778)	75.3 (1913)	546-00491
84 (2134)	89.8 (2280)	546-00442

**Horizontal kits include 2 UniTraks with 2 sensors, 4 sash actuator cars, 5 straight linkages, and 2 sash sensor shields. Do not cut or trim horizontal sash tracks. Functionality of one of the sash actuator cars will be lost.

Tools and Replacement Parts

Description	Product Part Number
Spare Linkage Kit: Vertical	546-00215
Spare Linkage Kit: Horizontal	546-00494
Sensor Trim Toolkit	546-00041
Linkage Forming Tool	546-00558
Sash Sensor Cable	546-00175
Sash Sensor Actuator Kit	537-829

Sash Sensor Shields (included in kits or available as spares)

Description	Product Part Number
37.3 (947)	546-00565
46.3 (1176)	546-00566
55.3 (1405)	546-00567
73.3 (1862)	546-00568
87.8 (2230)	546-00569

Document

Description	Document Number
VAV FHC Specification Sheet	149-245P25
Unitrak Sensor Kit Installation Instructions	546-00449

Table 2. Fume Hood Sash Applications.

Sash Type	Sash Kit Requirements
Vertical/Multi-Vertical Sash	1 Vertical Kit per Vertical Sash
Horizontal Sash	1 Horizontal Kit per 4 Horizontal Sashes
Combination Sash	1 Vertical Kit per Vertical Sash, 1 Horizontal Kit per 4 Horizontal Sashes

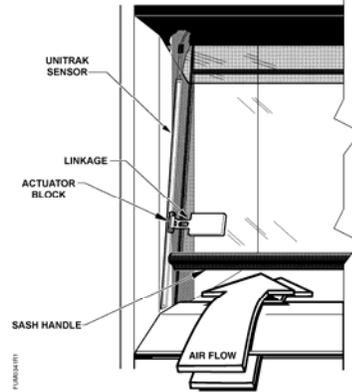


Figure 3. Outside Installation.

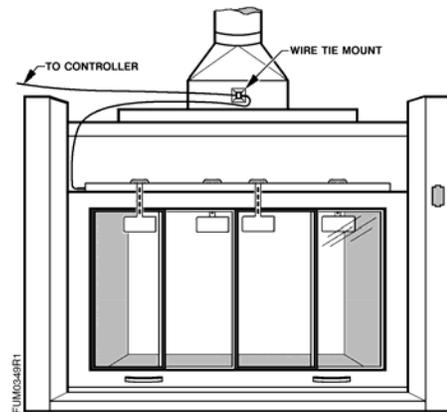


Figure 4. Cable Placement.

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Fume Hood Controller Variable Air Volume (VAV)

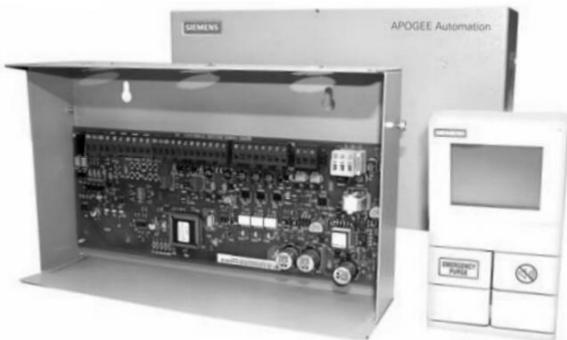


Figure 1. Fume Hood Controller (SMT board), Enclosure and Operator Display Panel

The Fume Hood Controller is an integral part of the APOGEE™ Automation System. The controller is a proven, patented stand-alone Direct Digital Control (DDC) system for Variable Air Volume (VAV) control of laboratory fume hoods. The controller maintains constant face velocity as the fume hood sash is raised and lowered. An Operator Display Panel provides the fume hood user with the face velocity readout, operating status of the hood, alarm horn, and an emergency purge function. The Fume Hood Controller operates independently and extends the benefits of DDC to an entire facility's HVAC equipment.

Features

Controller

- Constant face velocity fume hood operation.
- Maintains programmed minimum exhaust flow.
- Fully integrates with the APOGEE Automation System controllers and software.
- True exhaust flow measurement used to position the flow control device.
- Modular components, easy to install and service.

- Program and calibration parameters are user defined or modified via the Laptop Terminal
- PID closed loop control for all control devices
- Electrically Erasable Programmable Read Only Memory (EEPROM) memory for setpoint and control parameters—no battery needed
- Supports multiple hood and sash configurations
- Supports damper, VFD and Venturi Air Valve airflow control devices
- Surface Mount Technology for low electrical noise

Operator Display Panel

- Continuous display of hood operating parameters using a large alpha-numeric display,
- Colored hood status lights for normal (green), marginal (yellow), and alarm (red) conditions,
- Purge push-button for activation of emergency operation mode,
- Alarm horn for high and low face velocity and emergency purge indication
- Easy to install and connect to the controller via a single cable and telephone type connectors.

Applications

Operating independently, or integrated with the APOGEE Automation System, the Fume Hood Controller may be configured for the following types of laboratory fume hood applications:

- Single/Multi-Vertical Sash, Horizontal Sash and Combination Sash Bench top and Distillation type Fume Hoods,
- Vertical and Horizontal Sash Walk-in Hoods,
- Damper or Venturi Air Valve control for manifold exhaust systems or VFD for single hood fans
- Electronic or pneumatic damper actuators

Description

The VAV Fume Hood Controller consists of the following components, which are required for each fume hood:

- Fume Hood Controller
- Operator Display Panel and Cable
- Sash Sensor Kits (Vertical/Horizontal)
- Airflow Measurement and Control Options

For Pneumatic Damper applications you will need the Pneumatic Fume Hood Exhaust Terminal, which includes:

- #3 Pneumatic Actuator
- LAB AO-P Module.
- Velocity Pressure Transmitter
- Orifice Plate Airflow Sensor
- Single Blade Damper

For Electronic Actuation applications you will need the Electronic Fume Hood Exhaust Terminal which includes:

- Lab Electronic Damper Actuator Assembly
- Velocity Pressure Transmitter
- Orifice Plate Airflow Sensor
- Single Blade Damper or Venturi Air Valve Controller

The Fume Hood Controller consists of a control circuit board and metal enclosure. The enclosure may be mounted directly on the exterior of the fume hood or remotely on the laboratory wall or ceiling. The controller circuit board is snap mounted inside the enclosure and provides all wiring terminations for input and output points, 24 Vac power, FLN trunk, and the Operator Display Panel. A spare digital input and output are provided for user applications such as auxiliary sensors and alarms.

The control algorithms are pre-programmed. The Fume Hood Controller is ready to begin operation after selecting the proper application number defining the network address, and appropriate setpoint and control parameters using the laptop terminal. User definable parameters include:

- Face Velocity Setpoint
- Alarm and Warning Limits
- Minimum Exhaust Flow
- Maximum Exhaust Flow
- Hood Sash Dimensions
- Control PID Gains
- Display Resolution
- Alarm Delay
- Emergency Setpoint
- Sash Open Area "Alert" for both Attended and Unattended conditions

The controller uses the measured sash position and the exhaust airflow to calculate the fume hood face velocity using the equation:

$$\text{Face Velocity} = \frac{\text{Exhaust CFM}}{\text{Hood Open Area}^*}$$

*Includes the sash opening, air foil and bypass area

The face velocity is compared to the face velocity setpoint to calculate the required exhaust flow. The controller modulates the damper using a floating output to maintain the required exhaust airflow. VFD and Venturi Air Valve applications include use of calibration table and an analog output to take advantage of the special flow control characteristics of these devices. The fume hood controller performs this control algorithm up to 10 times per second to ensure maximum speed of response to changes in hood sash upsets. Concurrently, the controller continually monitors and updates all fume hood points including:

- Face Velocity
- High/Low Alarms
- Exhaust Airflow
- Sash Position

Controller Specifications

Power Requirements	
Operating Range	18-30 Vac, 50/60 Hz
Power Consumption	4.0 VA (nominal) @ 24 Vac plus actuator loads
Inputs	
Analog	1 Velocity Pressure Sensor (4-20 mA) 1 Spare (0-10 Vdc)
Digital	5 Sash position sensors 1 dry contact
Outputs	
Analog (0-10 Vdc)	1 Exhaust Airflow Signal 1 Modulating for use with Venturi or VFD, or Spare
Digital (24 Vac optically isolated solid state switches @ 0.5A)	1 Damper Actuator (2 DOs) 1 Spare
Package	
Dimensions	6.5" H x 10.5" W x 3.0" D (165 mm x 267 mm x 67 mm)
Weight	Approx. 3 lb. (1.35 kg)
Environmental	
Storage Temperature	-40°F to 167°F (-40°F to 75°C)
Operating Temperature	32°F to 122°F (0°C to 50°C)
Operating Humidity	20% to 80% RH non-condensing
Agency Listings	UL 916, PAZX & CSA Certified FCC, Class B, Subpart J

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	CE, C-tick
Communications	
Local Area Network (FLN trunk)	RS-485 4800 baud
Portable Operator's Terminal	RS-232 1200 baud
Control Performance	
Speed of Response	<1 second to flow change
Airflow Measurement	
Range	
Accuracy*	0 – 2.5" wc ±3.0%

*Accuracy is shown in percent of Actual Airflow and includes differential pressure transmitter accuracy.

Operator Display Panel

The Fume Hood Controller Operator Display Panel (ODP) includes a custom designed package for visual and audible indication of fume hood operating conditions and push-buttons for emergency mode operation, alarm silence and user defined auxiliary functions. The panel is mounted on the fume hood in an easy to access location and will fit over an unused hood electrical box or over pre-drilled holes. RJ-11 type connectors provide termination to the Fume Hood Controller and for the Portable Operator's Terminal. One Operator Display Panel is supported per Fume Hood Controller.

The Operator Display Panel supports the following functions:

- Digital display of face velocity in FPM (MPS),
- Green, yellow and red status lights,
- Emergency purge push button,
- Alarm horn with silence push button, and
- Two auxiliary push buttons.

The face velocity display also indicates high and low alarm conditions, emergency purge activation, and diagnostic failure mode conditions when the controller is in the minimum flow mode. Face velocity FPM (MPS) display may be blanked as an option for applications where the user does not desire the face velocity reading.

Operator Display Panel Specifications

Face Velocity Display Range	0 fpm to 255 fpm (0.0 MPS to 1.3 MPS)
Display Resolution	1 fpm adjustable up to 255 fpm
Push-Buttons Switch inputs	1 Emergency Purge 1 Horn Silence 2 Momentary Auxiliary
Alarm Horn	85 dB @ 4" (10 cm)
Dimensions	5.5" H x 3.125" W x 1.5" D (140 mm x 80 mm x 39 mm)
Weight	8 oz. (0.2 kg)

Fume Hood Controller Communication

Compatible with the Modular Building Controller (MBC), Mechanical Equipment Controller (MEC) and FLN Controller, up to 32 Fume Hood Controllers can be connected to each one of a field panel's three FLN Trunks, for a total of 96 per field panel.

Operators can communicate with the Fume Hood Controller from any field panel on the system network. The APOGEE Automation System network does not require additional hardware to connect controllers. When Fume Hood Controllers are networked to an MBC, MEC or FLN Controller, all the APOGEE Automation System features available can utilize the Fume Hood Controller.

Portable Operator's Terminal

The laptop computer serving as the Portable Operator's Terminal can communicate with the Fume Hood Controller. The terminal connects to the controller via a plug-in jack on the ODP. The terminal can be used to remotely adjust setpoints, to troubleshoot and start up the system. The terminal uses full English language prompting for all functions, eliminating the need to remember coded commands.

Ordering Information

Description	Part Number	
Fume Hood Controller – Universal Configuration, Different Horizontal Sash Widths	546-00705	(Board Only)
<ul style="list-style-type: none"> • Application 941 for use with Damper • Application 942 for use with Venturi Air Valve or VFD 	546-00705E	(With enclosure)
Fume Hood Controller – For use with Damper (only)		
<ul style="list-style-type: none"> • Application 903 Vertical Only, Single, dual side-by-side, dual top/bottom, or four top/bottom side-by-side • Application 905 Horizontal Only, 2-4 sashes in 2 tracks • Application 907 Combination Vertical with 2-4 Horizontal in 2 tracks 	546-00701	(Board Only)
	546-00701E	(With enclosure)
4:8 Sash Sensor MUX Board	537-460	
Operator Display Panel (consisting of two parts)		
Operator Display Panel, Panel	537-720A	
Operator Display Panel, Mounting Kit	537-720B	
Operator Display Cable 15'	537-772	
Operator Display Cable 25'	537-773	
Operator Display Cable 50'	537-774	
Lab Electronic Actuator Assembly	546-00438	
Lab Electronic Actuator, Only (LEA)	546-00437B	
LEA 90 Deg Rotation Mounting Kit	546-00581	
LEA 45/60 Deg Rotation Mounting Kit	546-00582	
LEA Interface Board	546-00450	
Lab Pneumatic Actuator	546-00020	
Lab AO-P Module (for pneumatic actuation)	546-00090	
UNITRAK™ Sash Sensor Technical Specification Sheet	149-269P25	
Venturi Air Valve Technical Specification Sheet	149-425P25	
Laboratory Exhaust Terminal Technical Specification Sheet	149-320P25	

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Laboratory Room Exhaust Air Terminal



Figure 1. Laboratory Room Exhaust Air Terminal.

The APOGEE® Automation Laboratory Room Exhaust Air Terminal is an industrial grade, easy-to-install, pre-packaged airflow measurement and control terminal unit. When used with the Laboratory Room Controller, it provides fast-acting, stable and precise laboratory general exhaust airflow control over the entire range of room airflow requirements.

Measurement of airflow is accomplished by unique orifice plate or four quadrant sensing technology that minimizes pressure loss and duct obstruction while maintaining measurement accuracy at 2% of actual flow (sensor only). Airflow control uses a round single blade damper. The terminal is comprised of 22 gauge-galvanized steel including the damper and orifice plate components. For corrosive environments, 316L stainless steel or Teflon® is available as an option. Slip or flange end fitting connections may be selected to match the ductwork construction. Flanges comply with the SMACNA Round Industrial Duct Construction Standard (RIDCS).

Features

- Orifice plate airflow measurement or four quadrant airflow sensor with multipoint, center averaging and signal amplification.
- Solid stainless steel damper shaft on Teflon bushings for fast acting control and maintenance free operation.
- Option of three different materials for construction, 1) Galvanized steel for non-corrosive, general applications. 2) 316L stainless steel for potentially corrosive applications. 3) Teflon for highly corrosive applications.
- Low non-recoverable static pressure loss.
- Eleven standard sizes with airflow capacities from 36 to 5591 CFM – additional sizes are available.
- Only two pivoting mechanical points, the damper shaft ends in Teflon bushings are exposed to the airstreams.
- Field commissionable and adjustable—not dependent upon factory calibration.
- Factory-mounted measurement and control devices to simplify installation (optional).
- Electronic or pneumatic damper control.

Description

The Lab Room Exhaust Air Terminal consists of the following components:

- Round duct casing, damper blade, and airflow sensor in sizes from 4 inches to 18 inches diameter.
- Material offerings: Galvanized steel, 316L stainless steel, Teflon-coated cold-rolled steel.
- Galvanized steel equipment enclosure with exterior supply connection (optional).
- Factory-mounted controls (optional)

Specifications

Materials (within air stream) – Standard

Construction A	22-gauge Galvanized steel casing, orifice & blade. Shaft is zinc-plated steel. Type A or B sensors available.
Construction B	20-gauge 316L stainless steel casing, orifice & blade. Shaft is solid stainless steel. Type A sensors only.
Construction C	Teflon-coated 18 ga. Cold-rolled Carbon Steel casing, orifice, blade, shaft, nuts, bolts. Type A sensors only.
Damper Shaft	Teflon shaft bushings. 1/2-inch (1.27 cm) diameter, End marked with blade position
Flanges	Comply with SMACNA RIDCS. Seam welded BEFORE coating for A or C code.

Materials (outside air stream) – Standard

Control Enclosure	18 gauge galvanized steel
Pneumatic Tubing	UL rated 94 V-2 fire retardant
Pneumatic Fittings with enclosure only	Brass, dual barbed

Airflow Measurement

Sensor Type A	Square edge orifice plate Two sets of averaging pressure taps Same material as duct casing
Sensor Type B	Four quadrant, with 12 sensing points, center averaging and signal amplification

Accuracy

Flow Measurement	±2% of actual flow @ listed ranges <i>(Sensor only. Does not include accuracy of controller or transmitter.)</i>
Installation Requirements	Rigid duct of the same diameter 1 x duct diameters upstream from the sensor, or taper angle less than 30 deg, is required.

Airflow Control

Damper Blade	Round, non-sealing single blade with 90 degree control
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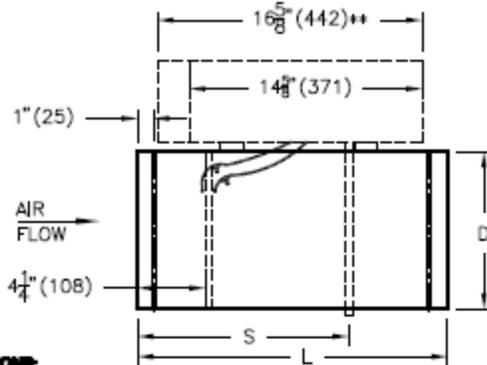
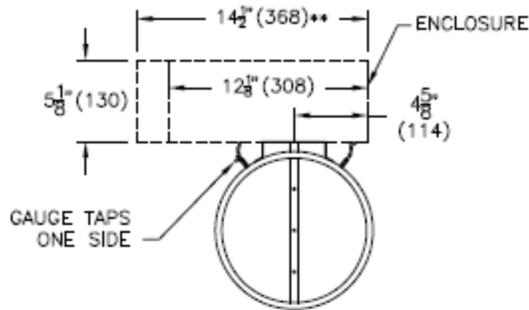
Environmental

Operating Temperature/% RH	40 to 120°F (4 to 50°C) 0 to 95% non-condensing
Storage Temperature/% RH	-10 to 150°F (-23 to 65°C) 0 to 95% non-condensing

Dimensions

Sizes	See <i>Figure 2</i> and <i>Figure 3</i>
Weight	20 to 32 lbs. (9.1 to 14.5 kg)

Dimensions



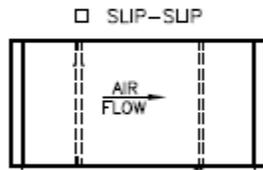
NOTES: (AA TYPE)

- 22 GA. GALVANIZED STEEL
- RIVETED DUCT CONSTRUCTION, SEALED WITH SILICONE.
- TEFLON DAMPER BEARINGS
- ZINC PLATED CONTINUOUS SHAFT WITH POSITION INDICATOR
- ORIFICE RING FLOW SENSOR
- NO DAMPER GASKET

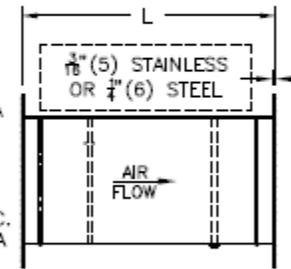
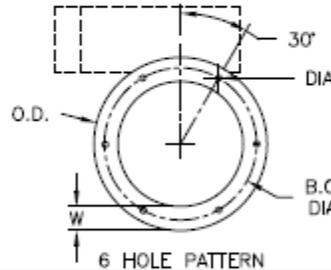
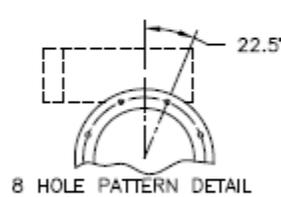
OPTIONS:

- (BA TYPE) 20 GA. 316L STAINLESS STEEL CONTINUOUSLY WELDED CONSTRUCTION C/W STAINLESS SHAFT.
- (CA TYPE) 18 GA. COLD ROLLED STEEL c/w TEFLON COATING INSIDE. PAINTED OUTSIDE. c/w CONTINUOUS STAINLESS STEEL DAMPER SHAFT.
- CONTROLS ENCLOSURE, 18GA, ZINC COATED
- CONTROLS FACTORY MOUNTED

OPTIONAL END CONFIGURATIONS



FLANGE-FLANGE (PER SMACNA STANDARD)

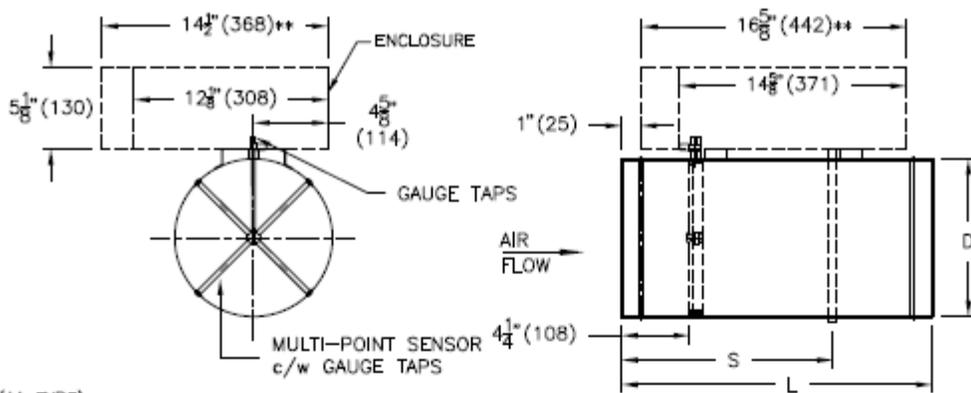


IMPERIAL/(METRIC)

NOM SIZE	D (mm)	L (mm)	S (mm)	# OF HOLES	FLANGE W (mm)		HOLE DIA (mm)		B.C. DIA (mm)	O.D. (mm)	
					BA	CA, AA	BA	CA, AA		BA	CA, AA
4	3 7/8 (99)	16 (406)	12 (305)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	5 1/4 (133)	6 (152)	6 (152)
6	5 7/8 (149)	16 (406)	12 (305)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	7 1/4 (184)	8 (203)	8 (203)
7	6 7/8 (175)	16 (406)	12 (305)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	8 1/4 (210)	9 (229)	9 (229)
8	7 7/8 (200)	16 (406)	12 (305)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	9 1/4 (239)	10 (254)	10 (254)
9	8 7/8 (311)	19 1/2 (495)	13 1/4 (337)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	10 3/4 (260)	11 (279)	11 (279)
10	9 7/8 (251)	19 1/2 (495)	13 1/4 (337)	6	1 (25)	1 (25)	7/16 (11)	7/16 (11)	11 1/4 (286)	12 (305)	12 (305)
11*	11 7/8 (302)	20 1/2 (521)	13 1/4 (337)	6	1 (25)	1 1/2 (38)	7/16 (11)	7/16 (11)	13 1/4 (337)	14 (356)	15 (381)
12	11 7/8 (302)	20 1/2 (521)	13 1/4 (337)	6	1 (25)	1 1/2 (38)	7/16 (11)	7/16 (11)	13 1/4 (337)	14 (356)	15 (381)
14	13 7/8 (353)	23 (584)	14 1/2 (368)	8	1 1/2 (38)	1 1/2 (38)	7/16 (11)	7/16 (11)	15 3/4 (400)	17 (432)	17 (432)
16	15 7/8 (403)	25 (635)	15 1/2 (394)	8	1 1/2 (38)	1 1/2 (38)	7/16 (11)	1/2 (13)	17 3/4 (451)	19 (483)	19 (483)
18	17 7/8 (454)	25 (635)	15 1/2 (394)	8	1 1/2 (38)	1 1/2 (38)	7/16 (11)	1/2 (13)	19 3/4 (502)	21 (533)	21 (533)

NOTES: * SIZE 11" IS 12" CASING WITH SMALLER ORIFICE.
 ** LARGER ENCLOSURE REQ'D FOR Q575 CONTROLS PACKAGE.
 ALL METRIC DIMENSIONS () ARE SOFT CONVERTED. IMPERIAL DIMENSIONS ARE CONVERTED TO METRIC AND ROUNDED TO THE NEAREST MILLIMETER.

Figure 2. Laboratory Room Exhaust Air Terminal with Orifice Flow Sensor.



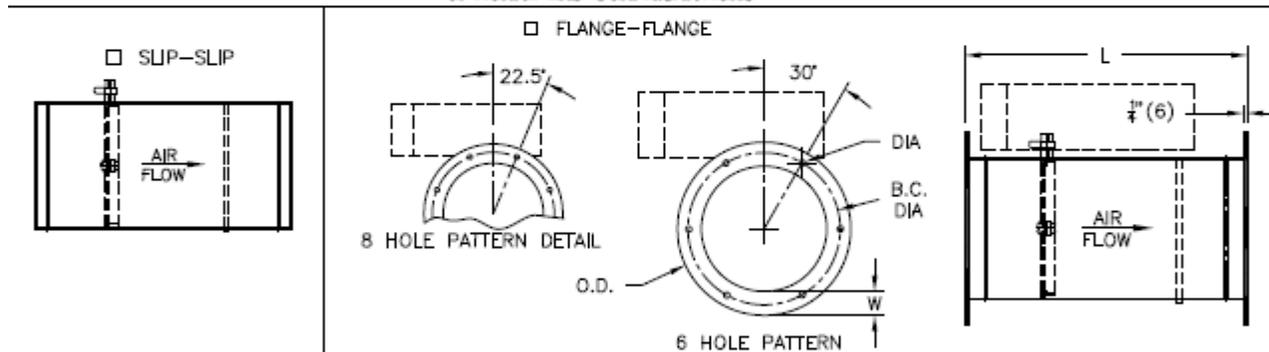
NOTE: (AA TYPE)

- 22 GA. GALVANIZED STEEL
- RIVETED DUCT CONSTRUCTION, SEALED WITH SILICONE.
- TEFLON DAMPER BEARINGS
- ZINC PLATED CONTINUOUS SHAFT WITH POSITION INDICATOR
- MULTI-POINT AIR FLOW SENSOR
- NO DAMPER GASKET

OPTION:

- CONTROLS ENCLOSURE, 18GA, ZINC COATED
 - CONTROLS FACTORY MOUNTED
- END CONFIGURATIONS AS SHOWN BELOW:
- SLIP - SLIP
 - FLANGE - FLANGE

OPTIONAL END CONFIGURATIONS



IMPERIAL/(METRIC)

NOM SIZE	D (mm)	L (mm)	S (mm)	# OF HOLES	FLANGE W (mm)	HOLE DIA (mm)	B.C. DIA (mm)	O.D. (mm)
6	5 7/8 (149)	16 (406)	12 (305)	6	1" (25)	7/16" (11)	7 1/4" (184)	8" (203)
7	6 7/8 (175)	16 (406)	12 (305)	6	1" (25)	7/16" (11)	8 1/4" (210)	9" (229)
8	7 7/8 (200)	16 (406)	12 (305)	6	1" (25)	7/16" (11)	9 1/4" (239)	10" (254)
9	8 7/8 (311)	19 1/2 (495)	13 1/4 (337)	6	1" (25)	7/16" (11)	10 1/4" (260)	11" (279)
10	9 7/8 (251)	19 1/2 (495)	13 1/4 (337)	6	1" (25)	7/16" (11)	11 1/4" (286)	12" (305)
12	11 7/8 (302)	20 1/2 (521)	13 1/4 (337)	6	1 1/2" (38)	7/16" (11)	13 1/4" (337)	15" (381)
14	13 7/8 (353)	23 (584)	14 1/2 (368)	8	1 1/2" (38)	7/16" (11)	15 3/4" (400)	17" (432)
16	15 7/8 (403)	25 (635)	15 1/2 (394)	8	1 1/2" (38)	1/2" (13)	17 3/4" (451)	19" (483)

NOTE: ** LARGER ENCLOSURE REQ'D FOR Q575 CONTROLS PACKAGE.

ALL METRIC DIMENSIONS () ARE SOFT CONVERTED. IMPERIAL DIMENSIONS ARE CONVERTED TO METRIC AND ROUNDED TO THE NEAREST MILLIMETER.

Figure 3. Laboratory Exhaust Air Terminal with Multi-Point Flow Sensor.

Table 1. Minimum Pressure Drop at Listed Airflow.

Unit Size	Flow		Minimum Operating Pressure Drop		Unit Size	Flow		Minimum Operating Pressure Drop	
	CFM	Lps	IN WG	Pa		CFM	Lps	IN WG	Pa
4	36	17	0.01	2.5	10	238	112	0.01	2.5
	44	21	0.01	2.5		273	129	0.01	2.5
	87	41	0.05	12.5		545	257	0.03	7.5
	175	83	0.20	50.0		1091	515	0.14	35.0
	252	119	0.42	105		1686	796	0.37	92.5
6	89	42	0.02	5.0	12	339	160	0.00	0.0
	98	46	0.03	7.5		393	185	0.00	0.0
	196	92	0.12	30.0		785	370	0.02	5.0
	393	185	0.51	128		1571	741	0.06	15.0
	627	296	1.32	330		2394	1130	0.12	30.0
7	121	57	0.02	5.0	14	460	217	0.00	0.0
	134	63	0.02	5.0		535	252	0.00	0.0
	267	126	0.09	22.5		1069	504	0.01	2.5
	535	252	0.36	90.0		2138	1009	0.07	17.5
	855	403	0.93	233		3254	1536	0.19	47.5
8	148	70	0.01	2.5	16	626	295	0.00	0.0
	175	83	0.02	5.0		698	329	0.00	0.0
	349	165	0.06	15.0		1396	659	0.01	2.5
	698	329	0.22	55.0		2793	1318	0.04	10.0
	1049	495	0.48	120		4429	2090	0.12	30.00
9	196	92	0.01	2.5	18	791	373	0.00	0.0
	221	104	0.01	2.5		884	417	0.00	0.0
	442	209	0.05	12.5		1767	834	0.01	2.5
	884	417	0.18	45.0		3534	1668	0.04	10.0
	1389	655	0.44	110		5591	2638	0.11	27.5

Table 2. Exhaust Terminal Casing Leakage in CFM.

LGE Casing Leakage (Per ASHRAE 130-1996)							
Imperial Units (CFM, Inches Water)							
Unit Size	1" WC	3.0"WC	6.0"WC	Unit Size	1.0" WC	3.0" WC	6.0"WC
4	0	1	3	10	1	3	4
6	0	1	3	11 / 12	1	2	3
7	1	2	4	14	1	3	5
8	1	2	4	16	1	3	5
9	1	2	4	18	1	3	5
Metric Units (Lps, Pascals)							
Unit Size	250 Pa	750 Pa	1500 Pa	Unit Size	250 Pa	750 Pa	1500 Pa
4	0.0	0.5	1.4	10	0.5	1.4	1.9
6	0.0	0.5	1.4	11 / 12	0.5	0.9	1.4
7	0.5	0.9	1.9	14	0.5	1.4	2.4
8	0.5	0.9	1.9	16	0.5	1.4	2.4
9	0.5	0.9	1.9	18	0.5	1.4	2.4

Table 3. Exhaust Terminal Damper Leakage in CFM.

LGE Closed Blade Leakage, No Seals (Per ASHRAE 130-1996)							
Imperial Units (CFM, Inches Water)							
Unit Size	1.0" WC	3.0"WC	6.0"WC	Unit Size	1.0" WC	3.0" WC	6.0"WC
4	13	20	25	10	67	110	135
6	31	50	63	11/12	72	144	168
7	39	58	77	14	98	195	228
8	42	73	94	16	133	266	310
9	56	94	111	18	112	280	335
Metric Units (Lps, Pascals)							
Unit Size	250 Pa	750 Pa	1500 Pa	Unit Size	250 Pa	750 Pa	1500 Pa
4	6	9	12	10	32	52	64
6	15	24	30	11 / 12	34	68	79
7	18	27	36	14	46	92	108
8	20	34	44	16	63	126	146
9	26	44	52	18	53	132	158
LGE Blade Seal Leakage (VOLARA; Per ASHRAE 130-1996)							
Imperial Units (CFM, Inches Water)							
Unit Size	1" WC	3.0"WC	6.0"WC	Unit Size	1.0" WC	3.0" WC	6.0"WC
4	0	1	3	10	1	3	4
6	0	1	3	11/12	1	2	4
7	1	2	3	14	1	3	5
8	1	2	3	16	1	3	5
9	1	2	4	18	1	3	5
Metric Units (Lps, Pascals)							
Unit Size	250 Pa	750 Pa	1500 Pa	Unit Size	250 Pa	750 Pa	1500 Pa
4	0.0	0.5	1.4	10	0.5	1.4	1.9
6	0.0	0.5	1.4	11 / 12	0.5	0.9	1.9
7	0.5	0.9	1.9	14	0.5	1.4	2.4
8	0.5	0.9	1.9	16	0.5	1.4	2.4
9	0.5	0.9	1.9	18	0.5	1.4	2.4

Table 4. Flow Range for Orifice Air Flow Sensor.

Flow Range for Sensor "A"							
Inlet Size	Maximum Flow @ 1.0" dp		Minimum Flow @ 0.02" dp		Flow Sensor Inlet Area		Flow Coefficient
	CFM.	Lps	CFM	Lps	SQ.FT	M ²	
4	252	119	36	17	0.087	0.008	0.721
6	627	296	89	42	0.196	0.018	0.797
7	857	404	121	57	0.267	0.025	0.801
8	1049	495	148	70	0.349	0.032	0.750
9	1389	656	196	93	0.442	0.041	0.785
10	1686	796	238	112	0.545	0.051	0.772
11	2054	969	290	137	0.785	0.073	0.653
12	2394	1130	339	160	0.785	0.073	0.761
14	3254	1536	460	217	1.069	0.099	0.760
16	4429	2090	626	295	1.396	0.130	0.792
18	5591	2639	791	373	1.767	0.164	0.790

Table 5. Flow Range for Sensor – Center-Averaging Multi-Port.

Note: The multi-point flow sensor option is not available for unit sizes 4, 11, and 18.

Flow Range for Sensor "B"							
Inlet Size	Maximum Flow @ 1.0" dp		Minimum Flow @ 0.02" dp		Flow Sensor Inlet Area		Flow Coefficient
	CFM.	Lps	CFM	Lps	SQ.FT	M ²	
6	468	221	66	31	0.196	0.018	0.596
7	673	318	95	45	0.267	0.025	0.629
8	923	436	126	59	0.349	0.032	0.660
9	1155	545	163	77	0.442	0.041	0.652
10	1487	702	210	99	0.545	0.051	0.681
12	2141	1010	303	143	0.785	0.073	0.681
14	3045	1437	431	203	1.069	0.099	0.711
16	4074	1923	576	272	1.396	0.130	0.729

Table 6. Radiated Sound Data for Exhaust Terminal. Sound Power Levels, Lw dB, re 10⁻¹² Watts.

Unit Size	Pressure Drop Airflow		125 Pa (0.5" W.G.)							250 Pa (1.0" W.G.)							500 Pa (2.0" W.G.)							750 Pa (3.0" W.G.)						
			Octave Band							Octave Band							Octave Band							Octave Band						
	Lps	cfm	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7				
4	35	75	51	29	27	22	19	17	51	32	30	27	24	24	52	36	33	31	29	31	52	38	35	34	32	35				
	71	150	52	34	36	31	27	23	52	38	40	35	32	30	53	41	43	40	37	36	53	43	45	42	40	41				
	106	225	52	38	42	36	31	26	53	41	45	41	36	33	53	45	49	45	41	40	53	47	51	48	44	44				
	132	279	53	39	45	39	33	28	53	43	48	43	39	35	53	46	52	48	44	42	54	48	54	50	47	46				
6	59	125	41	27	23	21	20	20	44	31	27	26	26	26	46	35	32	31	32	33	48	38	34	34	35	37				
	118	250	44	33	30	29	26	25	46	37	35	34	31	31	49	41	39	39	37	38	50	43	42	41	40	42				
	177	375	45	36	35	33	29	28	48	40	39	38	35	34	50	44	44	43	40	41	52	46	46	46	44	44				
	236	500	46	38	38	36	31	30	49	42	42	41	37	36	51	46	47	46	43	43	53	49	50	49	46	47				
296	628	47	40	40	39	33	32	50	44	45	44	39	38	52	48	49	49	44	44	54	50	52	51	48	48					
7	71	150	43	28	22	21	22	19	45	31	26	25	26	24	46	34	30	29	31	29	47	36	33	31	34	33				
	142	300	46	33	29	29	27	24	47	36	33	33	32	29	49	39	37	36	37	35	50	41	40	39	40	38				
	212	450	47	36	33	33	30	27	49	39	37	37	35	32	50	42	42	41	40	38	51	43	44	43	43	41				
	284	601	48	38	36	37	33	29	50	41	40	40	37	34	51	44	45	44	42	40	52	46	47	46	45	43				

Unit Size	Pressure Drop		125 Pa (0.5" W.G.)							250 Pa (1.0" W.G.)							500 Pa (2.0" W.G.)							750 Pa (3.0" W.G.)						
	Airflow		Octave Band							Octave Band							Octave Band							Octave Band						
	Lps	cfm	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7				
8	83	175	42	30	25	22	23	23	44	33	29	26	28	28	47	37	33	30	32	34	48	38	35	32	35	37				
	177	375	45	34	32	30	29	28	47	37	36	34	34	33	50	41	40	38	38	39	51	42	42	40	41	42				
	271	575	47	36	36	35	33	31	49	40	40	38	37	36	52	43	44	42	42	42	53	45	46	44	45	45				
	366	775	48	38	39	38	35	33	50	41	43	42	40	38	53	44	47	45	44	44	54	46	49	47	47	47				
	527	1117	49	40	42	42	38	35	52	43	46	45	43	41	54	46	50	49	47	46	56	48	53	51	50	49				
9	118	250	38	30	27	25	25	24	41	34	31	29	31	30	45	39	35	33	36	36	47	42	38	36	39	40				
	236	500	42	34	33	32	29	27	46	38	38	36	35	34	49	43	42	40	40	40	51	46	45	42	43	44				
	354	750	45	36	37	35	32	29	48	41	42	39	37	36	52	45	46	43	43	42	54	48	48	46	46	46				
	469	994	47	37	40	38	34	31	50	42	44	42	39	37	53	47	49	46	44	43	55	50	51	48	48	47				
10	118	250	43	28	23	24	25	24	46	32	28	29	30	30	49	36	32	34	34	35	51	39	34	36	37	39				
	260	550	45	33	32	30	30	29	48	37	37	35	35	34	51	41	41	40	40	40	53	44	43	43	43	43				
	401	850	46	36	37	34	33	31	49	40	41	39	38	37	52	44	46	44	43	42	54	47	48	47	46	45				
	543	1150	47	38	41	37	35	33	50	42	45	41	40	38	53	46	49	46	45	44	55	49	52	49	48	47				
	684	1450	47	40	43	39	37	34	50	44	48	43	42	40	53	48	52	48	46	45	55	50	54	51	49	48				
	824	1745	48	41	45	40	38	35	51	45	50	45	43	41	54	49	54	50	48	46	56	52	56	53	50	49				
11	165	350	38	28	26	23	24	24	42	31	29	27	29	30	45	35	33	30	33	37	47	37	35	32	36	41				
	307	650	43	34	33	30	30	28	46	37	36	34	35	35	49	41	40	37	40	41	51	43	42	40	42	45				
	448	950	46	37	37	34	33	31	49	41	41	38	38	37	52	45	44	42	43	44	54	47	46	44	46	48				
	590	1250	48	40	41	38	36	33	51	43	44	41	41	39	54	47	48	45	46	46	56	49	50	47	49	50				
	701	1485	49	41	43	40	38	34	52	45	46	43	43	40	55	49	50	47	48	47	57	51	52	49	51	51				
12	165	350	37	29	27	25	27	26	40	33	32	29	33	33	43	38	36	34	38	40	45	40	38	36	41	44				
	401	850	44	36	36	33	33	31	47	40	40	37	38	38	50	44	44	42	44	44	52	47	47	44	47	48				
	637	1350	47	39	40	37	36	33	50	44	44	41	41	40	53	48	49	46	47	47	55	50	51	48	50	50				
	873	1850	49	42	43	40	38	35	53	46	47	44	43	41	56	50	52	49	48	48	57	53	54	51	52	52				
	1109	2350	51	43	45	42	39	36	54	48	50	47	45	43	57	52	54	51	50	49	59	55	56	53	53	53				
	1186	2513	52	44	46	43	40	36	55	48	50	47	45	43	58	53	54	51	50	50	60	55	57	54	54	54				
14	236	500	42	29	30	27	28	26	45	35	35	32	34	33	48	40	40	38	40	39	50	43	44	41	43	43				
	590	1250	47	38	39	36	35	32	50	43	44	41	41	39	53	48	50	47	46	45	55	51	53	50	50	49				
	944	2000	50	42	44	41	38	36	53	47	49	46	44	42	56	52	54	51	50	48	58	55	58	54	53	52				
	1298	2750	52	44	47	44	41	38	55	50	52	49	47	44	58	55	58	54	52	50	60	58	61	57	56	54				
	1615	3421	54	46	49	46	42	39	57	51	54	51	48	45	60	57	60	56	54	52	61	59	63	60	57	55				
16	283	600	45	34	35	33	35	28	47	37	39	38	40	34	49	41	42	42	45	40	50	44	44	45	48	44				
	661	1400	50	40	42	39	39	34	52	44	46	44	45	40	54	48	49	48	50	46	55	51	51	51	53	49				
	1038	2200	53	44	46	42	42	36	55	48	49	47	47	43	57	52	53	51	52	49	58	54	55	54	55	52				
	1416	3000	55	47	49	44	44	39	57	51	52	49	49	45	59	55	55	54	54	51	60	57	57	56	57	54				
	1793	3800	56	49	51	46	45	40	58	53	54	51	50	46	60	56	57	55	55	52	61	59	59	58	58	56				
	2110	4470	57	50	52	47	46	41	59	54	55	52	51	47	61	58	59	56	56	53	62	60	60	59	59	57				
18	358	760	45	34	35	33	35	28	47	37	39	38	40	34	49	41	42	42	45	40	50	44	44	45	48	44				
	835	1770	50	40	42	39	39	34	52	44	46	44	45	40	54	48	49	48	50	46	55	51	51	51	53	49				
	1311	2780	53	44	46	42	42	36	55	48	49	47	47	43	57	52	53	51	52	49	58	54	55	54	55	52				
	1792	3800	55	47	49	44	44	39	57	51	52	49	49	45	59	55	55	54	54	51	60	57	57	56	57	54				
	2264	4800	56	49	51	46	45	40	58	53	54	51	50	46	60	56	57	55	55	52	61	59	59	58	58	56				
2665	5650	57	50	52	47	46	41	59	54	55	52	51	47	61	58	59	56	56	53	62	60	60	59	59	57					

Performance Notes:

1. Tested in accordance with ASHRAE Standard 130-1996: "Methods of Testing for Rating Ducted Air Terminal Units."
2. Airflow given in liters/seconds (L/s); and in cubic feet per minute (cfm).
3. Pressure given in Pascals (Pa) and inches of water gauge (in W.G.).

Table 7. Discharge Sound Data for Exhaust Terminal. Sound Power Levels, Lw dB, re 10⁻¹² Watts.

Unit Size	Airflow Lps cfm		125 Pa (0.5" W.G.)							250 Pa (1.0" W.G.)							500 Pa (2.0" W.G.)							750 Pa (3.0" W.G.)						
			Octave Band							Octave Band							Octave Band							Octave Band						
			2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7				
4	35	75	46	43	45	43	43	38	51	49	50	49	49	45	56	54	55	54	55	53	58	58	58	58	58	57				
	71	150	52	50	52	50	49	43	56	56	57	56	55	50	61	61	62	61	61	58	64	65	65	64	65	62				
	106	225	55	54	56	54	53	46	60	60	61	60	59	54	65	65	67	65	65	61	67	69	70	68	68	65				
	132	279	57	56	59	56	54	48	62	62	64	62	60	55	66	67	69	67	66	63	69	71	72	71	70	67				
6	59	125	47	40	43	45	43	39	51	45	48	50	49	45	56	50	52	54	55	52	59	53	55	57	59	56				
	118	250	54	48	50	51	48	44	58	53	55	55	54	50	63	58	60	60	60	57	66	61	62	63	63	61				
	177	375	58	53	54	54	50	47	62	58	59	59	56	53	67	63	64	64	63	60	70	66	67	67	66	64				
	236	500	61	56	57	56	52	49	65	61	62	61	58	55	70	66	67	66	64	62	73	69	70	69	68	66				
	296	628	63	58	59	58	54	50	68	64	64	63	60	57	72	69	69	68	66	64	75	72	72	71	70	68				
7	71	150	43	38	41	40	39	36	48	42	45	45	45	43	53	47	50	50	51	50	55	50	53	52	54	54				
	142	300	51	46	48	48	45	42	56	51	53	52	51	49	61	56	58	57	57	55	64	58	60	60	60	59				
	212	450	55	51	53	52	49	45	60	56	57	57	55	52	65	61	62	61	61	59	68	63	65	64	64	63				
	284	601	59	55	56	55	52	48	64	59	61	60	58	54	69	64	65	64	63	61	72	67	68	67	67	65				
8	83	175	43	38	40	43	45	38	48	43	45	47	51	45	53	48	50	52	57	53	56	50	53	55	60	58				
	177	375	52	47	49	50	50	44	57	52	53	54	56	52	62	57	58	59	62	59	64	59	61	62	65	64				
	271	575	57	53	53	54	53	47	61	57	58	58	59	55	66	62	63	63	64	63	69	64	66	66	68	67				
	366	775	60	56	57	57	55	49	65	61	61	61	61	57	70	65	66	66	66	65	73	68	69	69	70	70				
	527	1117	64	61	61	60	57	52	69	65	66	65	63	60	74	70	70	69	69	68	77	72	73	72	72	73				
9	118	250	46	41	42	43	42	34	51	46	47	48	48	41	56	51	51	53	54	48	59	54	54	56	57	52				
	236	500	53	48	50	50	48	41	58	53	55	55	53	48	63	58	59	59	59	55	66	61	62	62	63	59				
	354	750	58	53	55	54	51	45	63	58	59	58	57	52	68	63	64	63	62	59	71	66	66	66	66	63				
	469	994	60	56	58	56	53	47	66	61	62	61	59	54	71	66	67	66	65	61	74	69	69	69	68	66				
10	118	250	45	41	42	41	41	40	50	46	47	47	47	47	54	51	51	52	52	54	57	54	54	55	56	58				
	260	550	54	50	51	48	47	45	59	55	55	53	53	52	63	59	60	59	59	59	66	62	62	62	63	63				
	401	850	59	54	55	52	51	48	64	59	60	57	57	55	68	64	65	62	63	62	71	67	67	66	66	65				
	543	1150	63	58	59	54	54	50	67	62	63	60	60	57	71	67	68	65	66	64	74	70	71	68	69	67				
	684	1450	65	60	61	56	56	52	70	65	66	62	62	58	74	70	70	67	68	65	77	72	73	70	71	69				
	824	1745	67	62	63	58	57	53	72	67	68	63	63	60	76	72	73	69	69	66	79	74	75	72	73	70				
11	165	350	49	42	42	42	37	53	47	47	47	48	44	57	53	51	52	54	51	60	56	54	55	57	55					
	307	650	55	48	48	47	41	59	54	53	52	53	48	64	59	58	57	59	55	66	62	61	60	62	60					
	448	950	59	52	52	51	50	44	63	57	57	56	55	51	67	63	62	60	61	58	70	66	65	63	65	62				
	590	1250	62	55	55	53	52	46	66	60	60	58	57	53	70	66	65	63	63	60	73	69	68	66	67	64				
	701	1485	64	57	57	54	53	47	68	62	62	59	59	54	72	67	67	64	65	62	75	70	70	67	68	66				
12	165	350	46	41	41	41	42	36	50	46	46	46	48	43	55	51	50	51	54	50	57	54	53	54	57	54				
	401	850	56	51	51	49	48	43	60	56	56	54	54	50	64	61	60	59	60	57	67	63	63	62	64	61				
	637	1350	61	55	56	53	52	46	65	60	61	58	58	53	70	65	65	63	64	61	72	68	68	66	67	65				
	873	1850	65	59	59	56	54	49	69	64	64	61	60	56	73	69	69	66	66	63	76	72	71	69	70	67				
	1109	2350	67	61	62	58	56	51	72	66	67	63	62	58	76	71	71	68	68	65	78	74	74	71	71	69				
	1186	2513	68	62	63	59	57	51	72	67	67	64	62	58	77	72	72	69	68	66	79	75	75	72	72	70				
14	236	500	47	41	42	43	45	40	51	47	47	47	50	46	55	52	51	52	56	53	58	55	53	54	59	56				
	590	1250	57	51	53	52	51	47	62	57	57	56	57	53	66	62	61	60	62	59	68	65	64	63	65	63				
	944	2000	63	56	58	56	55	50	67	62	62	61	60	56	71	67	67	65	65	62	74	70	69	67	68	66				
	1298	2750	66	60	62	59	57	52	71	65	66	64	62	58	75	70	70	68	68	65	78	74	73	71	71	68				
	1615	3421	69	62	64	61	59	54	73	67	68	66	64	60	77	73	73	70	69	66	80	76	75	73	72	70				
16	283	600	47	42	43	44	46	39	51	47	47	49	52	46	56	52	51	54	58	53	58	55	54	57	61	57				
	661	1400	56	51	52	51	51	44	60	56	56	56	56	51	65	61	60	61	62	58	67	64	63	63	66	62				
	1038	2200	61	56	57	55	53	47	65	61	61	60	59	54	69	66	65	64	65	61	72	69	68	67	68	65				
	1416	3000	64	59	60	57	55	49	68	64	64	62	61	56	73	69	68	67	66	63	75	72	71	69	70	67				
	1793	3800	67	61	62	59	56	50	71	66	67	64	62	57	75	71	71	69	68	64	78	74	73	71	71	68				
	2110	4470	68	63	64	60	57	51	73	68	68	65	63	58	77	73	72	70	68	65	79	76	75	73	72	69				

Unit Size	Airflow Lps cfm		125 Pa (0.5" W.G.)							250 Pa (1.0" W.G.)							500 Pa (2.0" W.G.)							750 Pa (3.0" W.G.)						
			Octave Band							Octave Band							Octave Band							Octave Band						
			2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7				
18	358	760	47	42	43	44	46	39	51	47	47	49	52	46	56	52	51	54	58	53	58	55	54	57	61	57				
	835	1770	56	51	52	51	51	44	60	56	56	56	56	51	65	61	60	61	62	58	67	64	63	63	66	62				
	1311	2780	61	56	57	55	53	47	65	61	61	60	59	54	69	66	65	64	65	61	72	69	68	67	68	65				
	1792	3800	64	59	60	57	55	49	68	64	64	62	61	56	73	69	68	67	66	63	75	72	71	69	70	67				
	2264	4800	67	61	62	59	56	50	71	66	67	64	62	57	75	71	71	69	68	64	78	74	73	71	71	68				
	2665	5650	68	63	64	60	57	51	73	68	68	65	63	58	77	73	72	70	68	65	79	76	75	73	72	69				

Performance Notes:

1. Tested in accordance with ASHRAE Standard 130-1996: "Methods of Testing for Rating Ducted Air Terminal Units."
2. Airflow given in liters/seconds (Lps); and in cubic feet per minute (cfm).
3. Pressure given in Pascals (Pa) and inches of water gauge (in W.G.).

Ordering Information

Part numbers are created based on the selections you choose. There are no spaces or dashes in the SAP part number.

NOTE: Not all combinations or configurations will yield a valid part number in SAP.

Sample Part Number: LGEG815R14BAS

Model Number	Control Package Number	Mounting Side	Inlet (Duct) Size	Casing Material and Sensor Type	End Fitting	Custom Options
LGE	G815	R	14	BA	S	S or T
Laboratory Exhaust Air Terminal	Enclosure with a #3 actuator, a transducer, and a Flow Transmitter.	Available in R only.	The inlet (or duct) size is 14 inches.	Stainless steel casing and Orifice sensor.	Slip fitting	Including this letter at the end of your part number creates a number that is non-orderable in SAP. Please contact your Siemens Representative for this Custom solution.

To create an orderable part number that can be entered in SAP, complete the following steps:

1. Begin with the Model Number, **LGE**.
2. Select a Control Package number, and append it to the Model Number:

Control Package	...includes the following Control Components:			
	Actuator Part Number	Transducer Part Number	Flow Transmitter Part Number	Controller Part Number
E000	—	—	—	—
E800	546-00020	—	—	—
G000	—	—	—	—
G504	GDE131.1P	—	550-818A	—
G506	GMA131.1P	—	550-818A	—
G565	546-00437B	546-00450	550-818A	—
G800	546-00020	—	—	—
G803	546-00020	545-113	590-780	—
G815	546-00020	—	590-780	—
G862	546-00437B	546-00450	590-780	—
G865	546-00437B	546-00450	—	—
G904	GDE131.1P	—	—	—
G905	GDE161.1P	—	590-780	—
G906	GMA131.1P	—	—	—
G907	GMA161.1P	—	590-780	—
R904	GDE131.1P	—	—	540-104
R906	GMA131.1P	—	—	540-104
U945	GMA131.1P	—	590-780	546-00750A
U862	546-00437B	546-00450	590-780	546-00750A
V862	546-00437B	546-00450	590-780	546-00705

Control Components Legend			
Part Number	Description	Part Number	Description
540-104	Constant Volume TEC with Auto-Zero Module	546-00750A	Constant volume Fume Hood Controller
545-113	AOP 0-10V - Voltage to Pneumatic Transducer, 0-10 Vdc input	550-818A	OAM - Offboard Air Module
546-00020	No. 3 Pneumatic Actuator	590-780	Differential Pressure Transmitter, 1" WC, 4-20 mA, 0.4% accuracy
546-00090	High-Speed Pulsed Pneumatic Transducer	GDE131.1P	Fail-in-Last Position, Floating, 44 in-lb electric actuator
546-00437B	L.E.A - Lab Electronic Actuator	GDE161.1P	Fail-in-Last Position, Modulation, 44 in-lb electric actuator
546-00450	Interface Board for L.E.A. "AN"= 10 Vdc, "FP"= Floating	GMA131.1P	Fail-safe Spring Return Floating, 62 in-lb electric actuator
546-00705	Variable Volume Fume Hood Controller	GMA161.1P	Fail-safe Spring Return Modulating 62 in-lb electric actuator

- Choose **R** for the Mounting Side, and append the letter to the part number. (The **R** is required.)
- Choose the Inlet size (the size of the duct), and append the 2-digit number to the part number.

Inlet Size (in inches)	2-digit Number	Inlet Size (in inches)	2-digit number
4	04	11	11 (12" casing with special orifice)
6	06	12	12
7	07	14	14
8	08	16	16
9	09	18	18
10	10	—	—

- Choose the Casing Material and the Sensor, and append the letters to the part number:

Casing Material and Sensor Type	
AA	Galvanized steel casing with orifice sensor.
AB	Galvanized steel casing with multi-point sensor. (Does not apply to inlet sizes 4, 11, or 18.)
BA	Stainless steel casing with orifice sensor.
CA	Teflon®-coated steel casing with orifice sensor.

- Select the End fitting, and append that letter to the part number:

S = Slip

F = Flange

- (Custom Options) This selection is for **custom orders** only, and will not be accepted in SAP. Please see your Siemens representative if you want to choose one or both of these options:

T = Transformer (120/24 CL.2) and Disconnect Switch

S = Volara Blade Seals

After completing your selections, you should have an SAP orderable part number that looks similar to the example given here:

SAMPLE Part Number: LGEG815R14BAS

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SPECIFICATION SECTIONS TO BE INCLUDED IN FINAL SUBMITTAL

Joint Ambulatory Care Center Nuclear Medical Radioisotope Hood Outline Specification

Division 09

- 09 51 00 – Acoustical Ceilings
- 09 29 00 – Gypsum Board
- 09 91 00 – Painting

Division 23

- 23 05 11 – Common Work Results for HVAC
- 23 05 12 – General Motor Requirements for HVAC and Steam Generation Equipment
- 23 05 93 – Testing, Adjusting, and Balancing for HVAC
- 23 09 23 – Direct-Digital Control System for HVAC
- 23 31 00 – HVAC Ducts and Casings

Division 26

- 26 05 11 – Requirement for Electrical Installations
- 26 05 21 – Low-Voltage Electrical Power Conductors and Cables (600 Volts & Below)
- 26 05 26 – Grounding and Bonding for Electrical Systems
- 26 05 33 – Raceway and Boxes for Electrical Systems