SMP
ARCHITECTS

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26 June 2024

Alex M. Smith
Director of the Philadelphia Art Commission
Philadelphia City Planning Commission
City of Philadelphia

RE: Parkway Central Library, 1901 Vine Street, Philadelphia, PA 19103
Request for Art Commission Administrative Approval

Dear Mr. Smith:

We respectfully request to be included on the Art Commission agenda Wednesday July 10, 2024, for Administrative Approval of renovations to the Main Branch of the Free Library of Philadelphia, third floor Rare Book Department, located at the address referenced above.

We understand that the construction budget for the project is approximately $5.7M. The Rare Books Department of the Free Library of Philadelphia Main Branch requires HVAC upgrades to provide a conservation quality interior environment to support the longevity of their collection materials housed on the third floor of the building. The design team is proposing to replace the existing HVAC system, currently located in the mechanical penthouse, with a new HVAC system relocated to the exterior west-side roof, parallel to N 20th Street at the intersection of Vine Street. The height of the equipment atop the new dunnage does not exceed the height of the existing west-side roof balustrade; therefore, from the sidewalk below, the sightlines of the two new Air Handling Units will be hidden from view. For context, please refer to the Roof Plan on sheet A3 noting locations and heights of the proposed new equipment and photographs on sheet A2 taken at the ground level from various vantage points around the site.

The Parkway Central Library, built in 1927 as part of the Free Library branch system, required Administrative Review from the Philadelphia Historical Commission and has received approval. The approval letter is enclosed for your reference.

The current drawings for this project are attached for your reference. Please let me know if you require any additional information for your consideration at this time.

Respectfully submitted,

SMP ARCHITECTS

Jennifer Gajewski Heon

FREE LIBRARY OF PHILADELPHIA MAIN BRANCH RARE BOOKS HVAC UPGRADE

CITY OF PHILADELPHIA

ART COMMISSION DOCUMENTATION

6.26.2024

SMP ARCHITECTS

PROJECT NUMBER: 780.02

A1 SITE PLAN

RARE BOOKS HVAC UPGRADE

6.26.2024

PROJECT NUMBER: 780.02

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500 FT FROM SITE, VIEW FROM SOUTH SIDE OF BENJAMIN FRANKLIN PARKWAY

250 FT FROM SITE, VIEW FROM SOUTH SIDE OF BENJAMIN FRANKLIN PARKWAY

300 FT FROM SITE, VIEW FROM WEST SIDE OF BUILDING

50 FT FROM BUILDING, VIEW FROM 20TH STREET

VIEW FROM SIDEWALK AT 20TH STREET

MEASUREMENT TAKEN AT WEST FACADE ROOF BALUSTRADE

A2 EXISTING CONDITIONS

RARE BOOKS HVAC UPGRADE

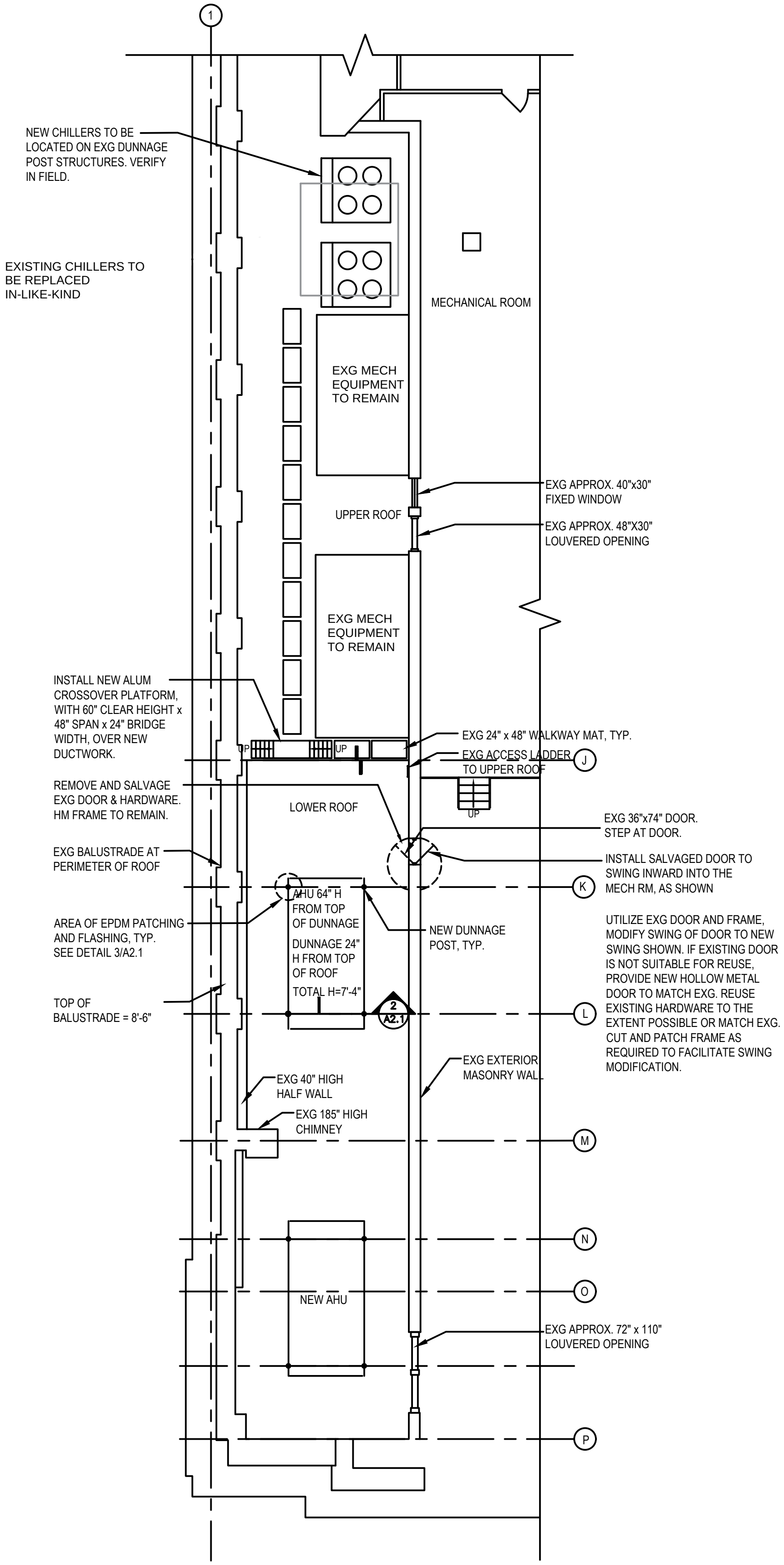
6.26.2024

PROJECT NUMBER: 780.02

SMP ARCHITECTS

VIEW FROM UPPER ROOF, FACING NORTH.

VIEW FROM UPPER ROOF, FACING SOUTH.
THERE IS NO EXISTING MECHANICAL EQUIPMENT.



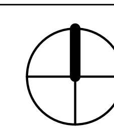
GENERAL NOTES

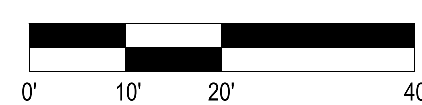
1. ALL EXISTING MECHANICAL EQUIPMENT IS APPROXIMATE AND SHOWN FOR REPRESENTATIONAL PURPOSE ONLY. REFER TO MEP AND SPECIFICATIONS FOR ADDITIONAL INFORMATION. ACTUAL SIZE, LOCATION, AND QUANTITY TO BE VERIFIED IN FIELD.
2. ALL ELEMENTS AND DIMENSIONS OF EXG BUILDING TO BE VERIFIED IN FIELD PRIOR TO WORK. IF DISCREPANCIES ARE FOUND, CONSULT ARCHITECT.

A3 ROOF PLAN

RARE BOOKS HVAC UPGRADE

6.26.2024





PROJECT NUMBER: 780.02

SMP ARCHITECTS

NEW ROOF EQUIPMENT DOES NOT EXCEED HEIGHT OF EXISTING BALUSTRADE. EQUIPMENT IS SPECIFIED TO BE THE COLOR BEIGE, TO MATCH THE BALUSTRADE SURFACE.

A4 EXTERIOR ELEVATION DIAGRAMS

RARE BOOKS HVAC UPGRADE

6.26.2024

PROJECT NUMBER: 780.02

SMP ARCHITECTS

turn to the experts℠

SUBMITTAL

Project

Central Library

Date

4/29/2024

Customer

Herman Goldner

Equipment

(2) Carrier Outdoor Air Handling Units

Carrier Contact

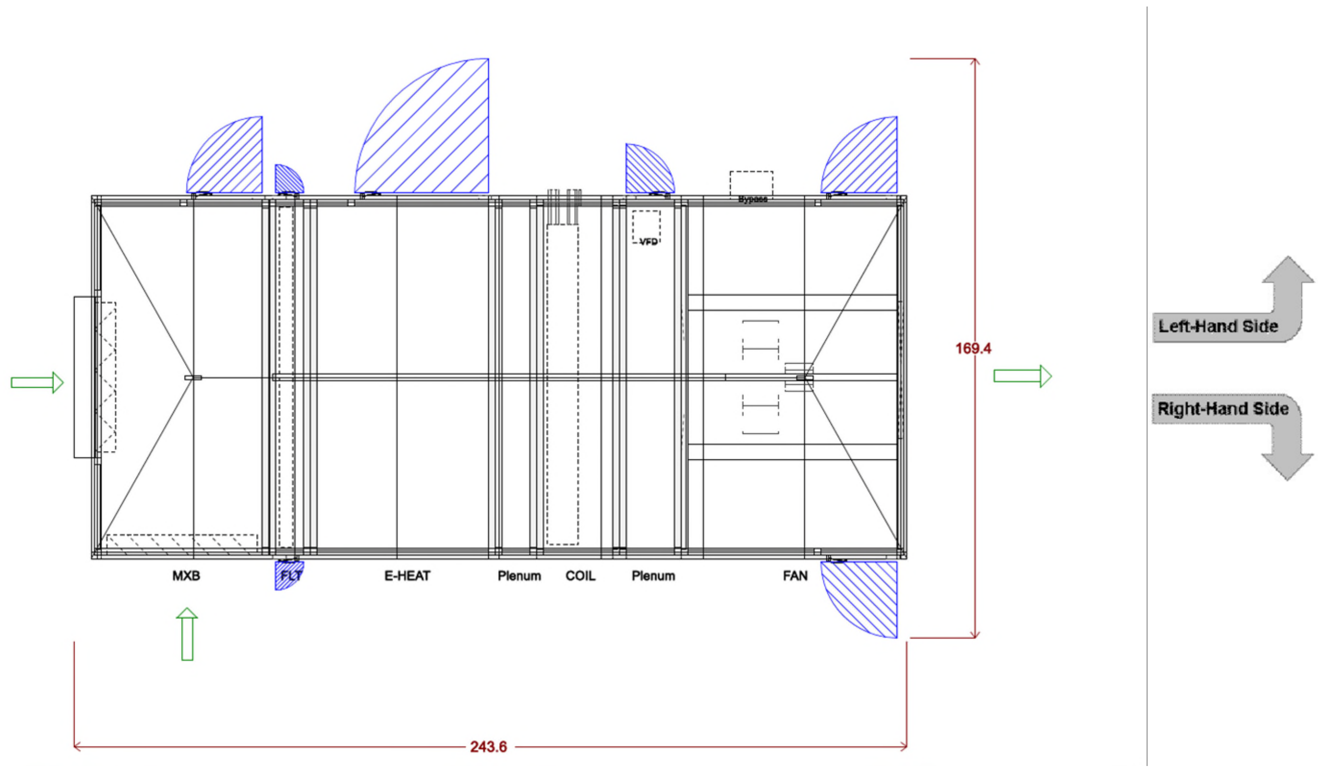
Andrew Bowden

Carrier Direct Sales
4110 Butler Pike
Plymouth Meeting, PA 19462
andrew.bowden@carrier.com / 215-581-1653

SCOPE
OF
WORK

AHU Handing and Inlet/Outlet Definition Verification

Please Verify AHU Handing and Air Inlet Locations per the diagram below.



Section	Description	Handing Definition (R/L/ETC)	Approval
Mixing Box	Side Return	RIGHT	
Mixing Box	Rear OA Return	REAR	
Filter	Filter module	RIGHT & LEFT	
Cooling Coil	Chilled water coil	LEFT	
Condensate Pan	CW condensate pan	LEFT	
VFD plenum	VFD plenum	LEFT	
Supply fan	VFD location / bypass	LEFT	
Supply fan doors	Supply fan doors	LEFT & RIGHT	

Carrier AERO Semi-Custom Air Handling Unit — Qty: (2)

Model:
39MW – outdoor - 15,000 cfm

Mark For:
AHU-1 & 2

The following items are included:

- Outdoor semi-custom air handling unit
- 460-3-60
- Unit to ship in a single piece
- Painted galvanized steel casing
- 2" thick double wall panel with R-13 foam insulation
- Post and panel construction with thermal break
- Casing deflection shall not exceed L/240 with an internal pressure of ± 8-in. wg
- **22 gauge interior, 22 gauge exterior panels**
- **NO CONTROLS PROVIDED**
- Unit Configuration:
- Mixing box:
  - Right side return air damper, premium
  - Rear outside air damper, premium
  - Rear damper has rear louver with debris screen **(no OA hood)**
- Filter section (**2 sets of filters provided**)
  - Premium dampers
  - 2" MERV 8 Flat filter
  - 2" MERV 13 Flat filter
  - Access door on left side
- Electric Heating Coil
  - 149 kW 480V electric heating coil
  - Vernier control
  - VAV electric heat
- Cooling Coil
  - 30% PG
  - Stainless steel drain pan
- Supply Fan
  - Direct drive plenum fan **with factory-mounted ABB VFD with bypass**
  - VFD housed inside AHU cabinet for weather protection
  - ODP, premium efficiency motors
  - 2" spring isolators
  - Access door on left

Please note the following clarifications and/or exclusions:

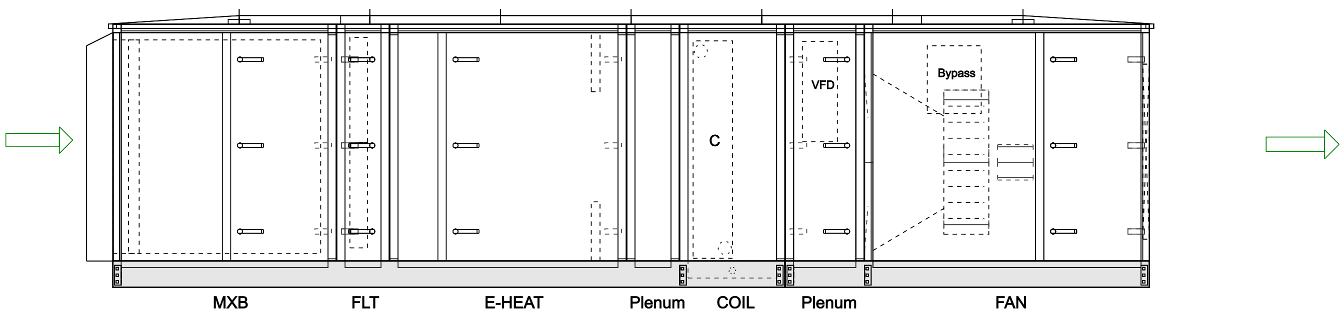
- Refrigerant, piping, and/or piping specialties are not included unless explicitly stated above
- Refrigerant piping sizing and/or design are not included unless explicitly stated above
- Start-up beyond days allotted above or on non-straight time hours
- Warranty coverage beyond that indicated above is not included
- Maintenance during warranty period is not included unless explicitly stated above
- Single point power is not included unless explicitly stated above
- Panel piping penetrations for DX coils are not included
- Installation of shipped loose UVC lights is not included
- Installation of shipped loose intake or exhaust hoods is not included
- Installation of any shipped loose items is not included
- Commissioning and/or commissioning assistance are not included
- External vibration isolation is not included unless explicitly stated above
- Installation is not included
- Spare filters are not included unless explicitly stated above
- Any ATC is not included unless explicitly stated above
- Any electrical and/or plumbing work are not included unless explicitly stated above
- Rigging, carting, and/or storage are not included unless explicitly stated above
- **Controls, smoke dampers, valves**
- **Spare filters**
- **Rear OA hood**
- **Epoxy coated cooling coil – would require to increase cabinet dimensions which would differ than what is on drawings**
- **Cooney coil**
- **18 gauge panels**
- **Startup**
- **Extended labor or parts warranty**

https://www.carrier.com/commercial/en/us/products/airside/air-handlers/39m/

PERFORMANCE DATA

Unit Report AHU-1 and AHU-2

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2



Unit Parameters

Aero Outdoor Air Handler
39MW Size 30W
Insulation: R-13 Double Wall Sealed Panel
Exterior Finish: Painted Exterior Panels
Interior Finish: Galvanized Interior Panels
Level II Thermal Break
6 inch tall Base Rail
Pad Mounted

Mixing Box

Oversize Acceptable Selected
Louver with Debris Screen Rear
Damper: Rear Premium Opposed
Damper: Right Side Premium Parallel
Door Left Side

Flat Filter

2In. Flat Filter
2" Pleated MERV 8 Filter
Qty (10) 20in. x 24in.
Pre Filter : 2In. Flat Filter
2" Pleated MERV 13 Filter
Qty (10) 20in. x 24in.
Door Right Side
Door Left Side

2 electrical circuits required on unit. One for electric heat section and other for supply fan VFD.

Electric Heat Section

Factory Wired Panel Left Side
149KW 480 Volts 3 Phase Unsheathed Element
Vernier Control
VAV Electric Heat

Plenum

Length 12 inches

Chilled Water Coil

304 Stainless Steel Drain Pan Left Side
Chilled Water 30.35 sq.ft 8 Row 14 FPI Double Circuit
Coil Connection Left Side

1/2 in. Tube Diameter
AL fins 304 Stainless Steel Casing
Non-Ferrous Header
No Coating

VFD Plenum

Length 18 inches
VFD Located in Plenum
Door Left Side

Draw-Thru Supply Fan

Perforated panels
Rear Inlet
Fan Sled
- Plenum Fan B PDLA01330
- Direct Drive Fan
- 1300 fanRPM Class II
- User Specified Custom Discharge(s)
- Inlet Screen
- Spring Fan Isolation

Motor
- 25 HP Premium Efficiency ODP 208-230/460 3Ph 60Hz 1200 RPM
  - Manufacturer - Generic
  - Frame Size - 324T
  - Motor Shaft Diameter (in.) - 2.125
  - Voltage Selected - 460/3/60
  - Full Load Amps - 37.4
  - Efficiency - 93.0%

Variable Frequency Drive
- 460 Volts 3 Phase 60Hz
- Factory Mounted With Bypass

Door Right Side
Door Left Side

Weights and Dimensions

(LxWxH in ft in) 20' 4" x 8' 10" x 5' 2" **
Operating 7207 LB **

Configuration Notes

Maximum Discharge Temperature 140F

Preheat coil configurations can cause freezstat to trip if the downstream cooling coil isn't drained in heating season and/or PID valve control loop is too slow to react.

Overdimensional units require special shipping permits and have additional transportation restrictions which may result in transportation delays and increases to delivery estimates.

VAV Electric heaters must have 11in. clearance upstream and downstream from field installed components.

An Outdoor Plenum fan may not discharge through the roof of the unit.

If a bottom connection is required, use a Discharge Plenum Section.

Discharge duct(s) must be gasketed and screwed directly to the discharge panel of the unit.

Careful consideration must be made for mixing outside and return air streams in VAV applications due to reduced velocity in heating mode. Consider the use of a blow-thru plenum fan as a mixing device.

** Weights and Dimensions are approximate. Weights include base unit weight, coils (wet & dry), fans and fan motors, and other components, but does not include filters, drives and skids. Approximate dimensions are provided primarily for shipping purposes, for exact dimensions, refer to submittal drawings. Shipping skids are not included.

All filter media efficiency ratings are for the filter media only.

Chilled Water Coil Performance Summary

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Cooling Application's Balance Criteria: Fluid Temp Diff.

Coil Model	**NC-28MC**	
Number of Coils	**1**	
Row / FPI / Circ	**8 / 14 / DB**	
Fin Thickness	**.0042**	in
Fin Type	**Sine Wave**	
Face Area Type	**Large**	
Coil Face Area	**30.35**	sqft
Face Velocity	**494.2**	fpm
Fin-Casing Material	**Al-St. Stl.**	
Tube Diameter	**0.5**	in
Tube spacing: Stf x Str	**1.25 x 0.781**	in
Tube Wall Thickness	**0.016**	in
Actual Airflow	**15000**	CFM
Site Altitude	**0**	ft
Standard Airflow (adj. to std. dry atmosphere)	**14464**	SCFM
Total Cooling Capacity	**564.28**	MBH
Sensible Cooling Capacity	**408.97**	MBH
Fluid Flow Rate	**119.2**	gpm
Fluid Pressure Drop	**6.2**	ft wg
Fluid Velocity	**2.7**	ft/s
Entering Fluid Temperature	**44.00**	F
Leaving Fluid Temperature	**54.00**	F
Fluid Temperature Rise	**10.0**	F
Entering Air Dry Bulb	**80.00**	F
Entering Air Wet Bulb	**67.00**	F
Entering Air Enthalpy	**31.50**	BTU/lb
Leaving Air Dry Bulb	**54.29**	F
Leaving Air Wet Bulb	**54.28**	F
Leaving Air Enthalpy	**22.8**	BTU/lb
Air Friction	**1.13**	in wg
Brine	**PG**	
Brine Concentration	**30**	%
Fouling Factor	**0.0**	(hr-sqft-F)/BTU

NOTE: Coil is NOT certified by AHRI. Coil is within the scope of the AHRI Forced-Circulation Air-Cooling and Air-Heating Coils Certification Program.

LEGEND:
- Stf -- Tube spacing across coil face
- Str -- Tube spacing in direction of airflow

Electric Heater Performance Summary

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Unit Size	**30W**	
Coil Face Area	**14.52**	sqft
Face Velocity	**1033.1**	fpm
Actual Airflow	**15000**	CFM
Minimum Airflow	**5082**	CFM
Altitude	**0**	ft
Heating Capacity	**508.54**	MBH
kW	**149**	kW
Voltage, 3 phase	**480**	
FLA	**179**	
MCA	**224**	
MOCP	**225**	
Subcircuits	**4**	
Number of Stages	**Vernier**	
Ent. Air Temperature	**55.00**	F
Lvg. Air Temperature	**85.82**	F
Air Friction	**0.05**	in wg

Note: Electric heat performance is not within the scope of AHRI Standard 410 Certification

Unit Acoustics Summary

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Unit Acoustics Sound Power Level:

	Discharge	Inlet	Casing
63 Hz	**93**	**85**	**84**
125 Hz	**93**	**88**	**87**
250 Hz	**93**	**92**	**90**
500 Hz	**87**	**83**	**80**
1000 Hz	**85**	**75**	**73**
2000 Hz	**83**	**76**	**73**
4000 Hz	**81**	**73**	**70**
8000 Hz	**78**	**69**	**66**

Sound power levels for 39M units are rated in accordance with AHRI Standard 260.

Unit Acoustics A-weighted Sound Power Level:

	Discharge	Inlet	Casing
63 Hz	**66**	**59**	**58**
125 Hz	**77**	**72**	**71**
250 Hz	**84**	**83**	**81**
500 Hz	**83**	**79**	**77**
1000 Hz	**85**	**75**	**73**
2000 Hz	**84**	**77**	**74**
4000 Hz	**82**	**74**	**71**
8000 Hz	**77**	**68**	**65**

Sound power levels for 39M units are rated in accordance with AHRI Standard 260.

Sound contributed by Supply Fan

Supply Fan Performance Summary

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

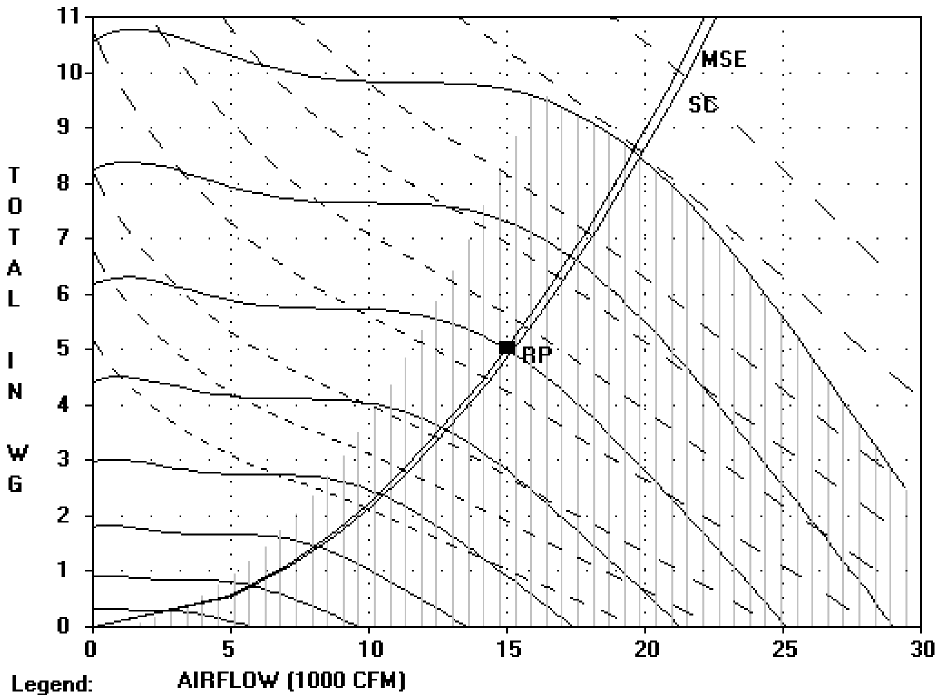
Fan Model	**39M3001HPDL-D**
Unit Size	**30W**
Fan Type	**DIRECT DRIVE PLENUM**
Fan Wheel Diameter	**33**
Fan Class	**II**
Fan Application	**Draw Thru**
Orientation	**Horizontal**
Actual Airflow, CFM	**15000**
Site Altitude, ft	**0**
Upstream Ext. Static, in wg	**0.00**
Downstream Ext. Static, in wg	**2.00**
Cooling Coil Static, in wg	**1.13**
Heating Coil Static, in wg	**0.00**
Total Accessory Static, in wg	**1.91**
Total Static Pressure, in wg	**5.04**
Calculated Fan RPM / Motor RPM	**1300 / 1200**
Class II Max. RPM	**1620**
Static Efficiency (%)	**67**
Number of Fans	**1**
Fan BHP	**17.8**
VFD Setting, Hz	**66**
Fan Electrical Power, kW	**14.7**

AHRI CERTIFIED® www.ahridirectory.org
Central Station Air-Handling Unit Supply Fans
AHRI Standard 430/431

Accessories:
(1) Flat pleated (2") MERV 8, Dirty [0.58]
(1) Flat Synthetic (2") MERV 13,Dirty [0.89]
(1) Side Intake Louver [0.10]
(1) Side Mixing or Exhaust Box [0.11]
(1) Debris Screen [0.17]
(1) MFA Electric Heat [0.05]

Current fan curve ran with 50% dirty filters. 25HP motor required if "full" dirty performance is ran.

NOTE: Certified in accordance with the AHRI Central Station Air-Handling Unit Certification Program, which is based on AHRI Standards 430/431. Certified units may be found in the AHRI Directory at www.ahridirectory.org



Legend:
\ - RPM \ - BHP MSE - Max. Static Eff. SC - System Curve RP - Rated Point

RPM = 1300 BHP = 17.8 CLASS II MAX. RPM = 1620

RPM's (x 100, L to R): 3. 5. 7. 9. 11. 13. 15. 17.

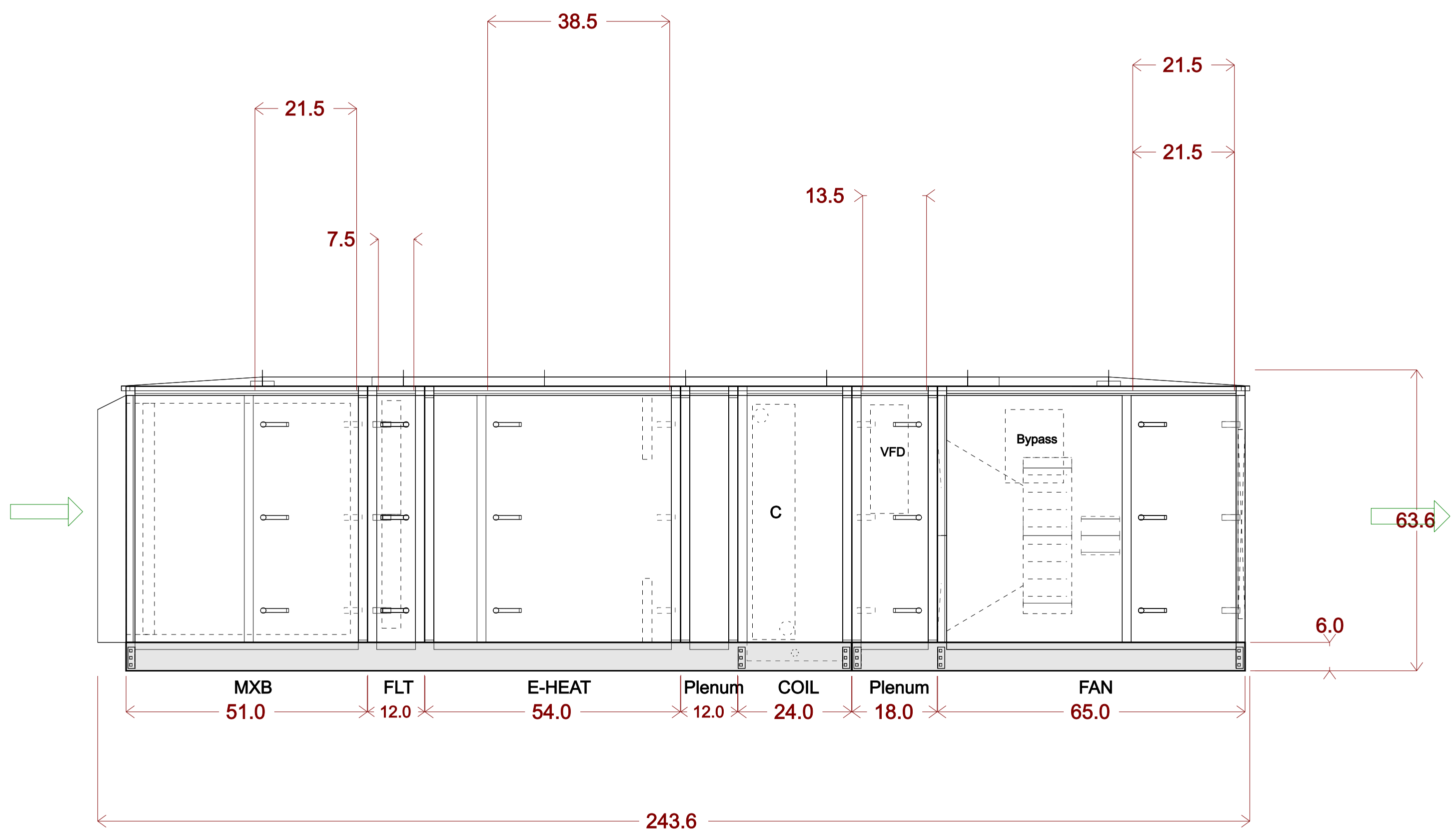
BHP's (L to R): 5 7.5 10 15 20 25 30 40 50

DRAWINGS
& CUT SHEETS

Unit width: 106.0 (plus lifting lugs)
2In. Flat Filter
Qty (10) 20in. x 24in.
Pre Filter : 2In. Flat Filter
Qty (10) 20in. x 24in.
Chilled Water 8 Row 14 FPI Double Circuit (qty. 1)

Draw-Thru Supply Fan
25 HP Premium Efficiency ODP 208-230/460 3Ph 60Hz 1200 RPM
Operating weight: 7207.0 lbs.
Upstream Corner Weight (each): 1695.0 lbs.
Downstream Corner Weight (each): 1909.0 lbs.

Split	Airway Length	Weight (lbs.)
(Split 1)	236.6	7207



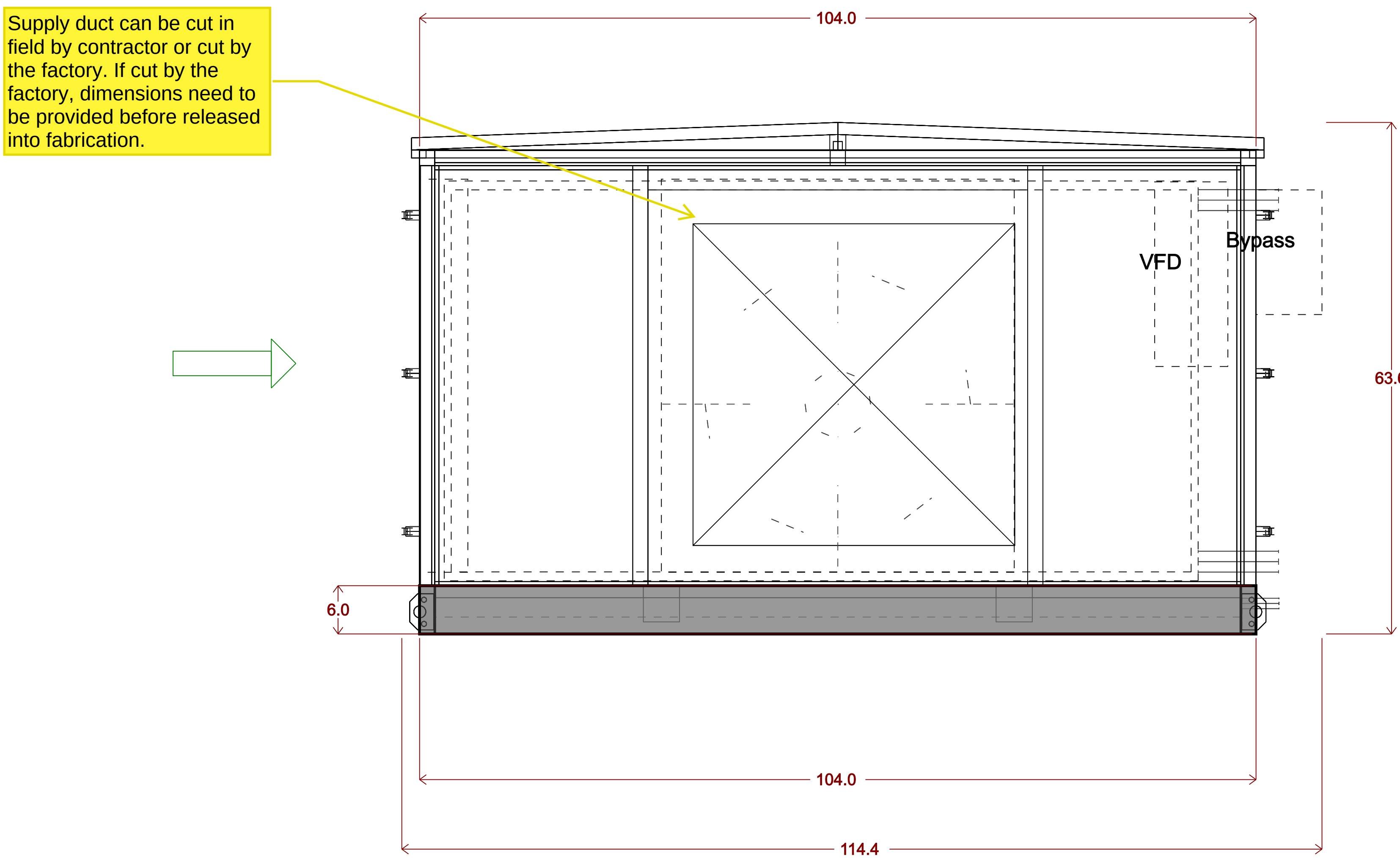
DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Assembly Drawing	Side View

Carrier

39MW

Unit viewed from right side of side elevation view.
Unit length: 243.6
2In. Flat Filter
Qty (10) 20in. x 24in.
Pre Filter : 2In. Flat Filter
Qty (10) 20in. x 24in.
Chilled Water 8 Row 14 FPI Double Circuit (qty. 1)

Draw-Thru Supply Fan
25 HP Premium Efficiency ODP 208-230/460 3Ph 60Hz 1200 RPM
Operating weight: 7207.0 lbs.
Upstream Corner Weight (each): 1695.0 lbs.
Downstream Corner Weight (each): 1909.0 lbs.

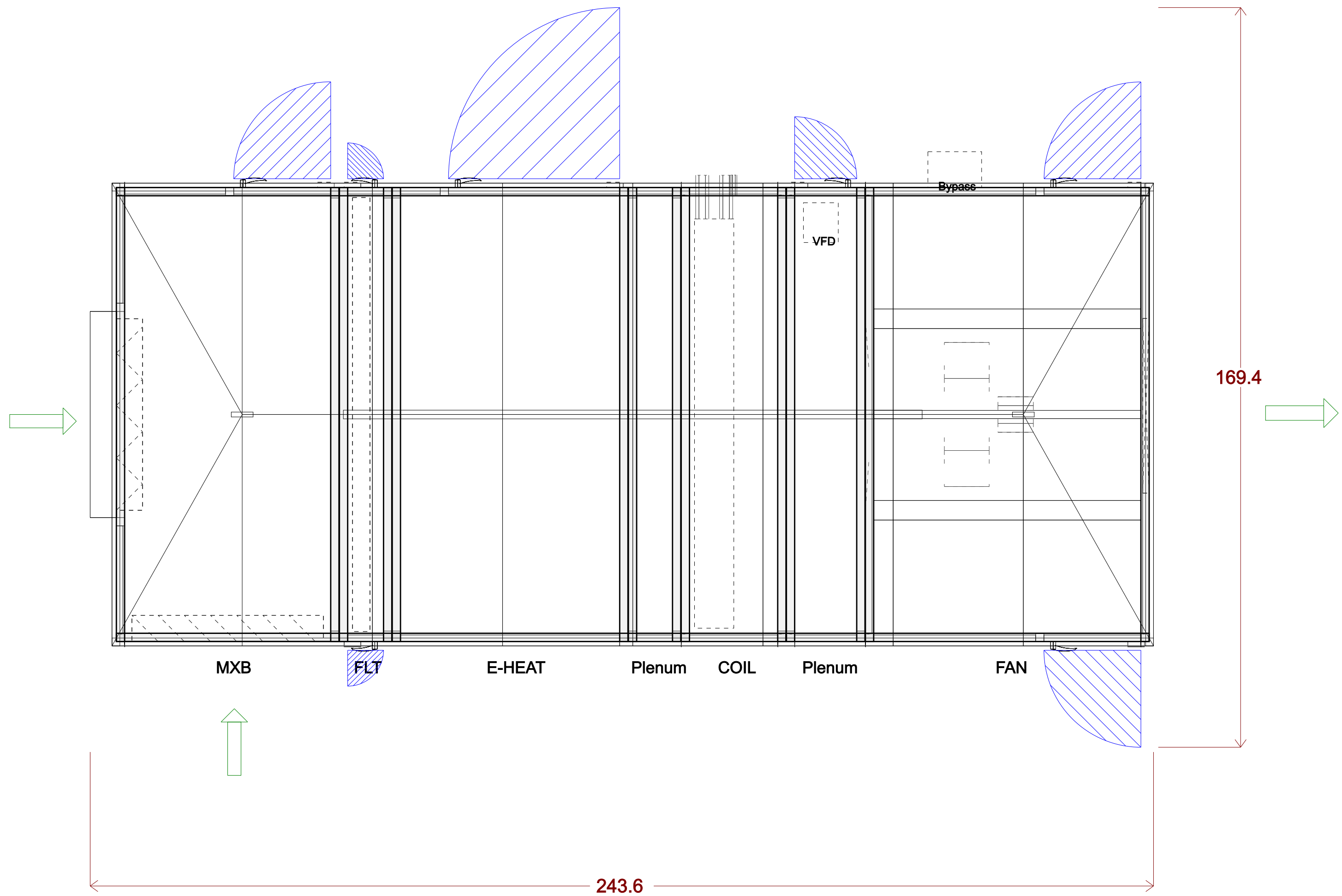


DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Assembly Drawing	End View

39MW

Unit height: 62.1
2In. Flat Filter
Qty (10) 20in. x 24in.
Pre Filter : 2In. Flat Filter
Qty (10) 20in. x 24in.
Chilled Water 8 Row 14 FPI Double Circuit (qty. 1)

Draw-Thru Supply Fan
25 HP Premium Efficiency ODP 208-230/460 3Ph 60Hz 1200 RPM
Operating weight: 7207.0 lbs.
Upstream Corner Weight (each): 1695.0 lbs.
Downstream Corner Weight (each): 1909.0 lbs.

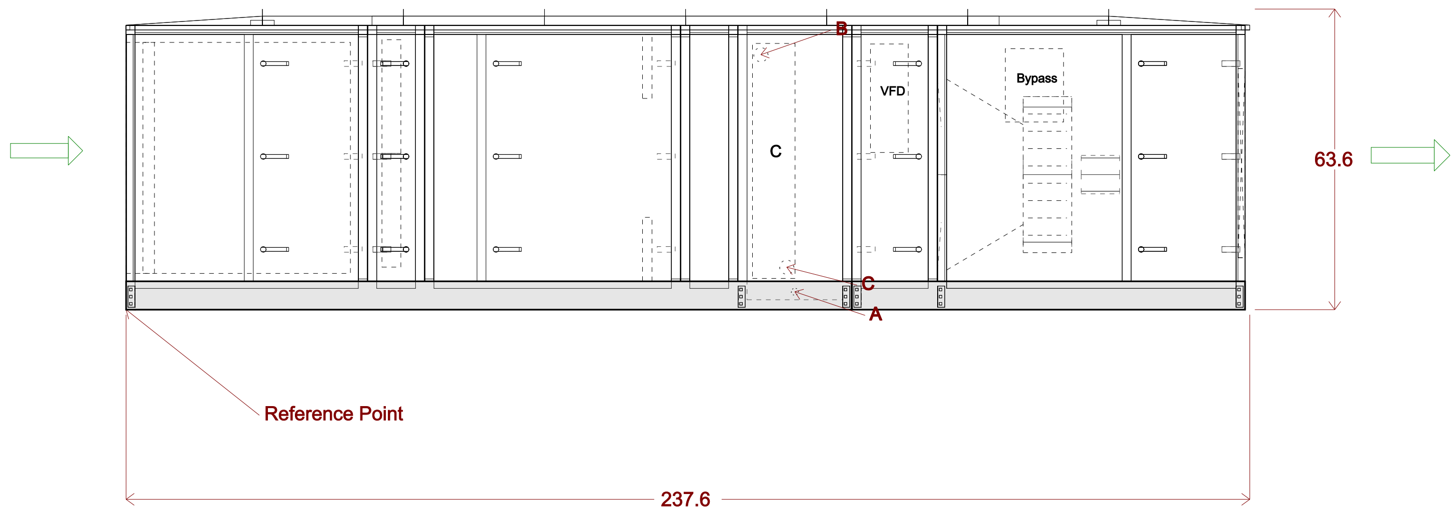


DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Assembly Drawing	Top View

39MW

Chilled Water 8 Row 14 FPI Double Circuit (qty. 1)

Pipe	x	y	diameter	Usage
A	141.4	3.79	1.5	DrainPan
B	134.2	53.95	3.0	CW Outlet
C	139.7	8.99	3.0	CW Inlet

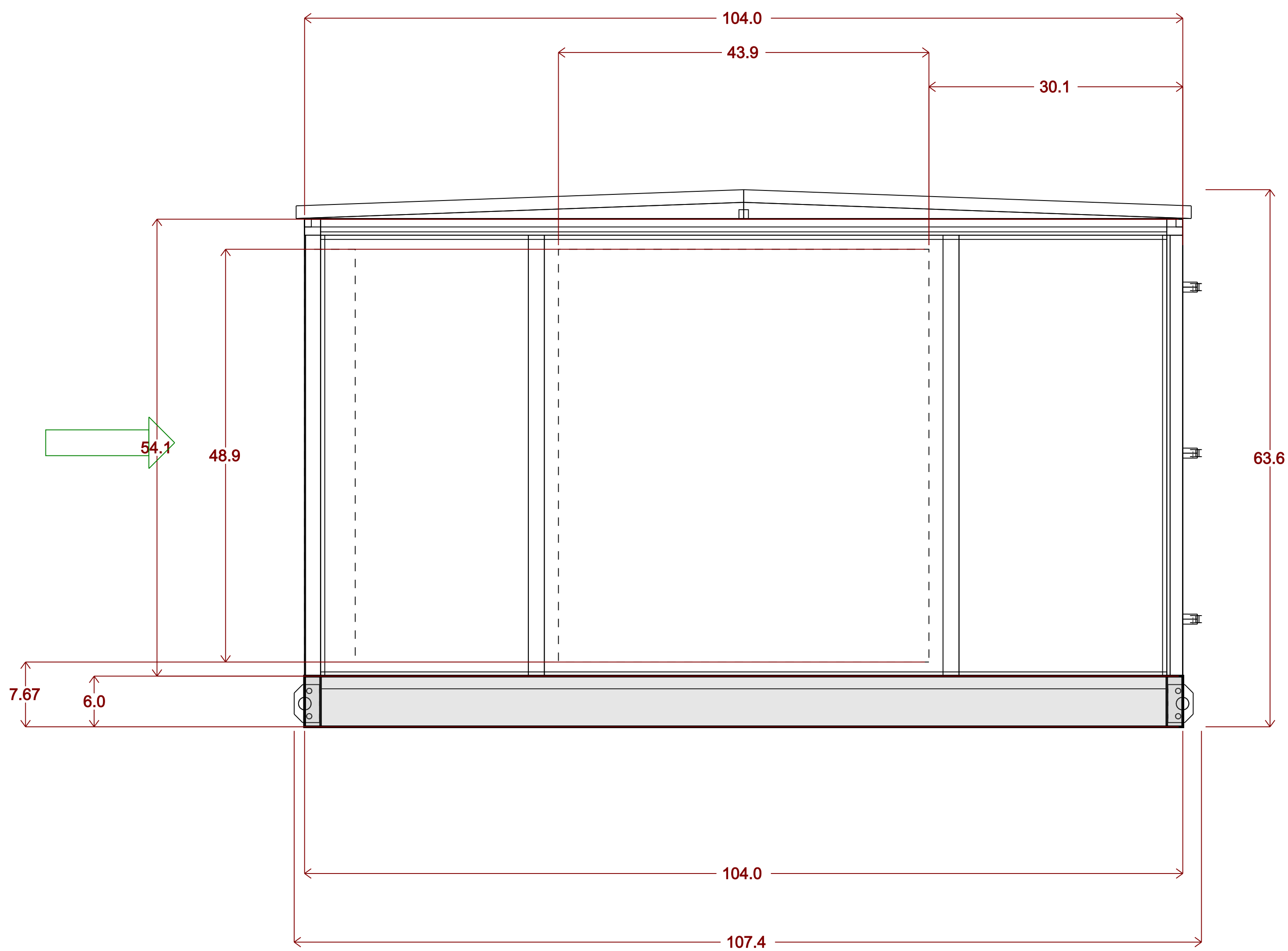


DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Assembly Drawing	Side View

Carrier

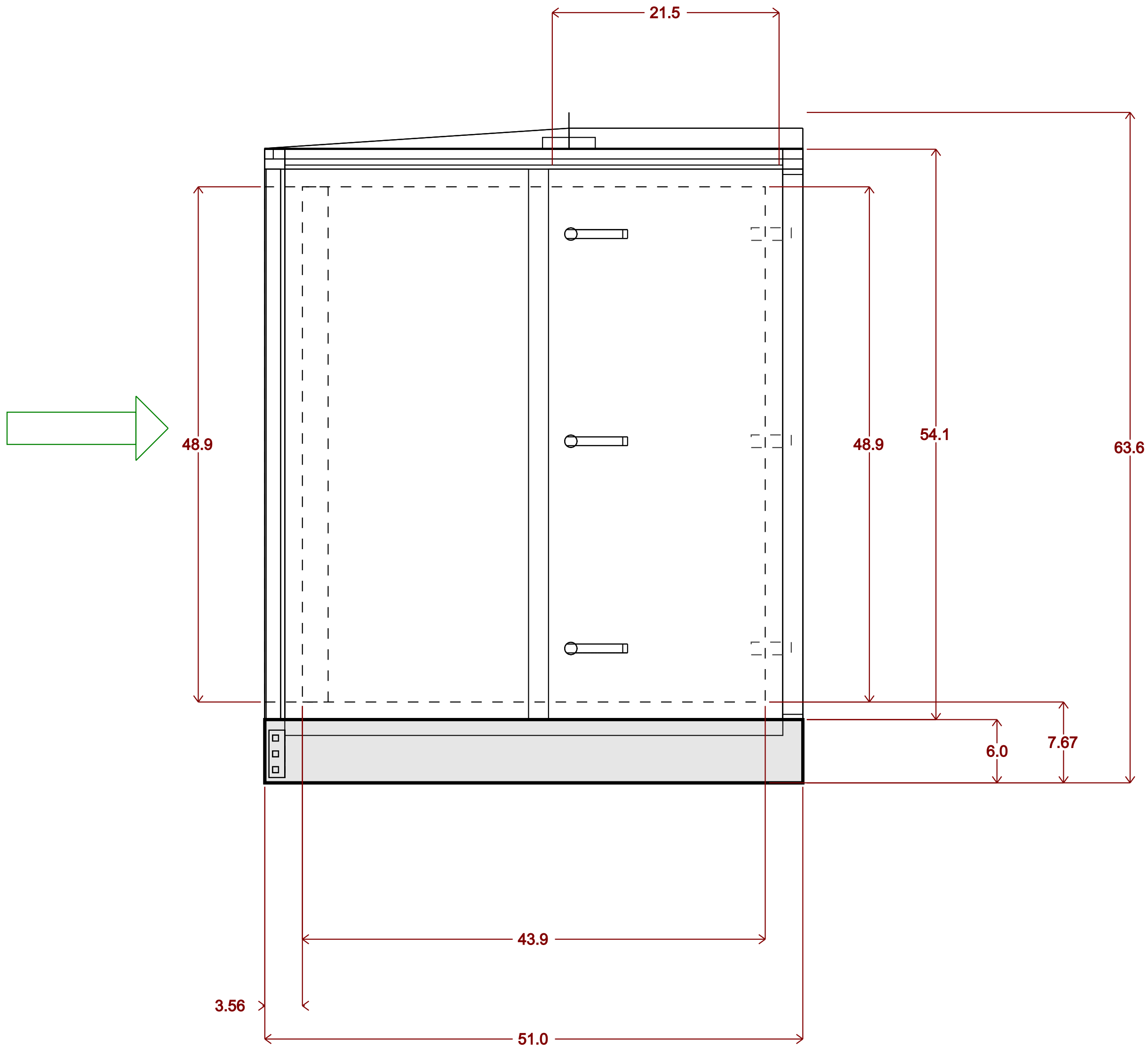
39MW

Unit viewed from right side of side elevation view.



DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2	
		Mixing Box	End View

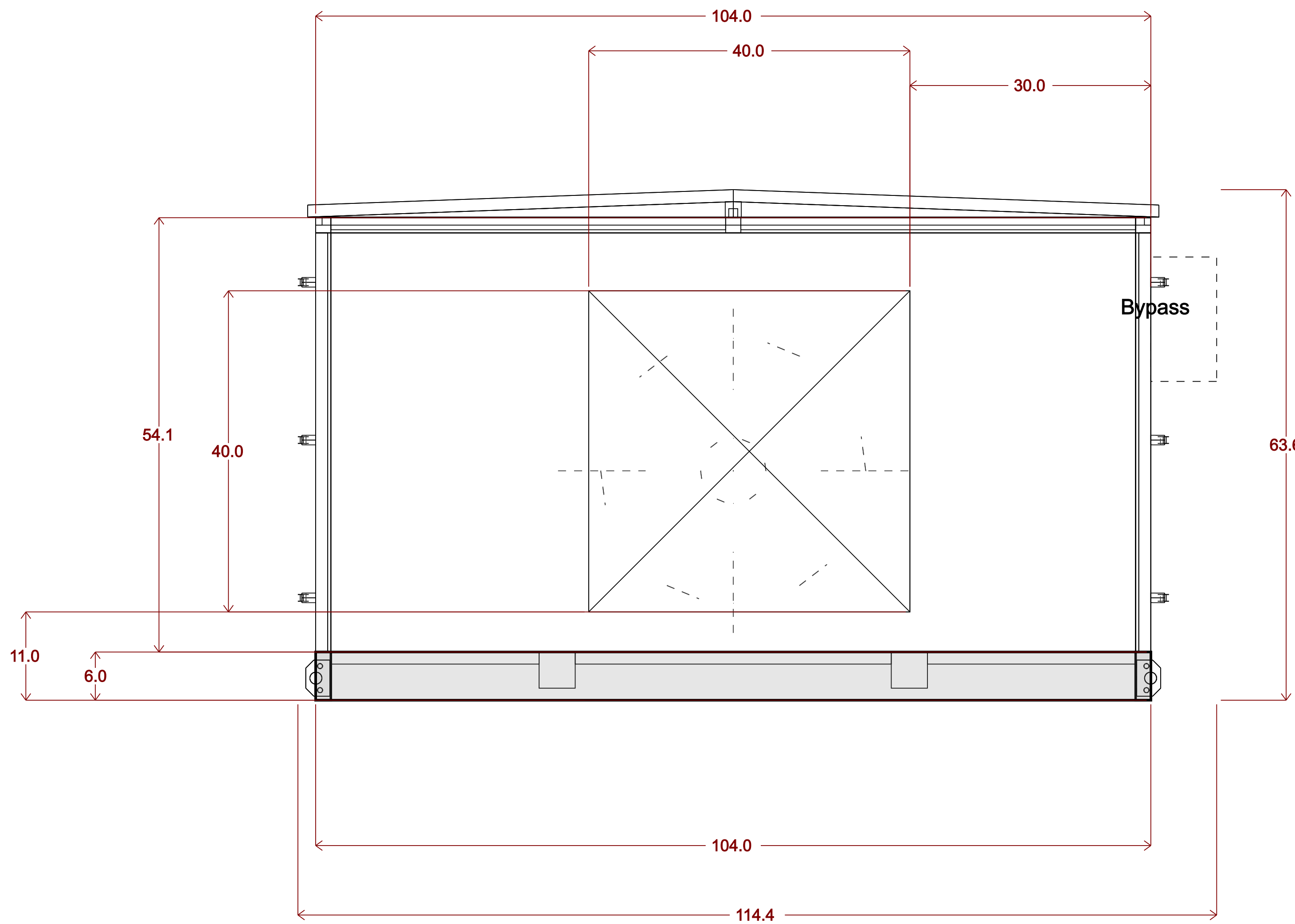
39MW



DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2	
		Mixing Box	Side View

39MW

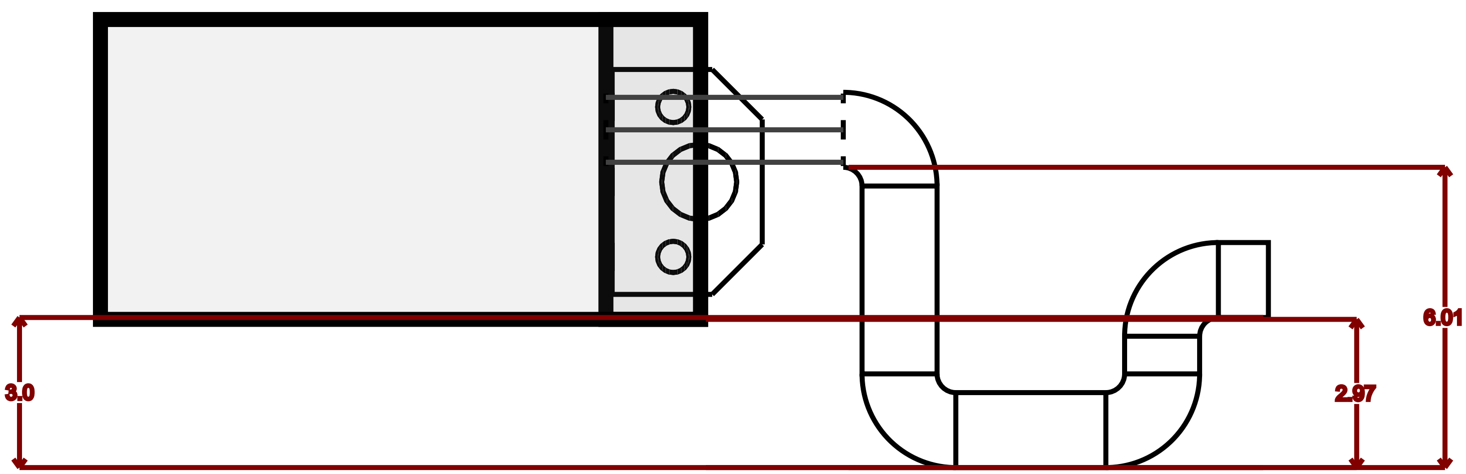
Unit viewed from right side of side elevation view.
Draw-Thru Supply Fan
25 HP Premium Efficiency ODP 208-230/460 3Ph 60Hz 1200 RPM



DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Draw-Thru Supply Fan	End View

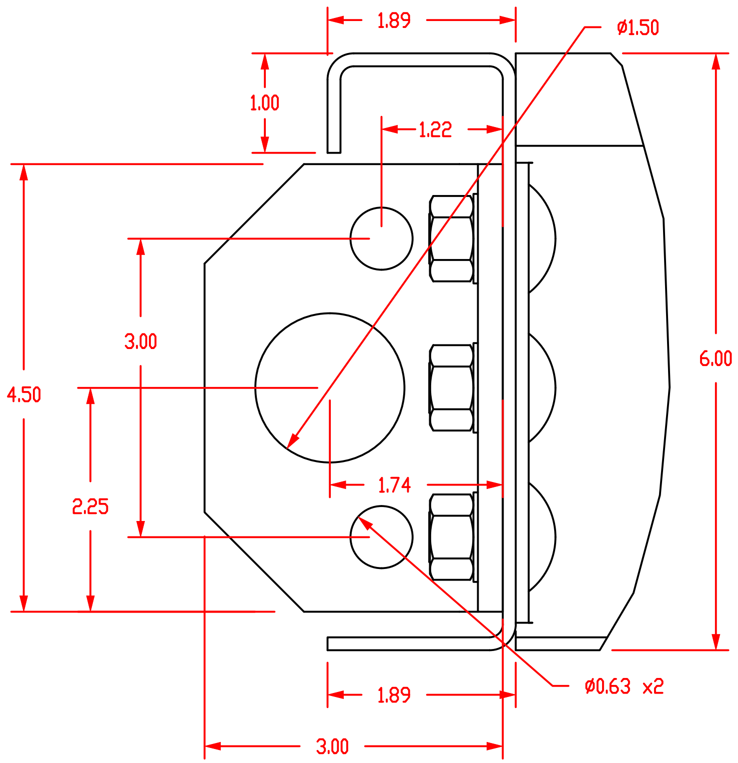
39MW

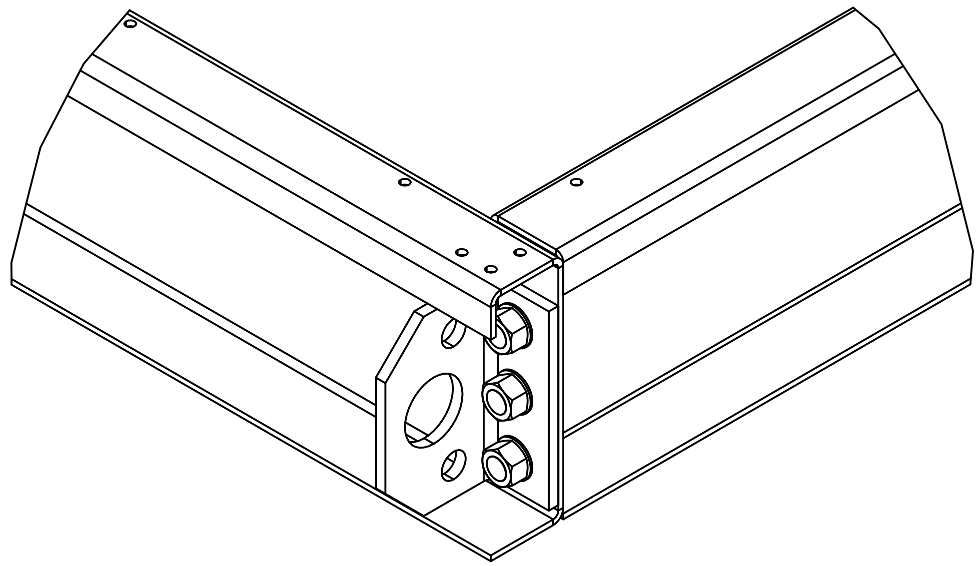
DRAW-THRU



DATE	AHUBuilder	39M Central Station Air-Handler, Size 30W	REVISION
4/29/2024	v7.01	Central Library - Rare Room: AHU-1 and AHU-2 Condensate Trap Dimensions	End View

39MW



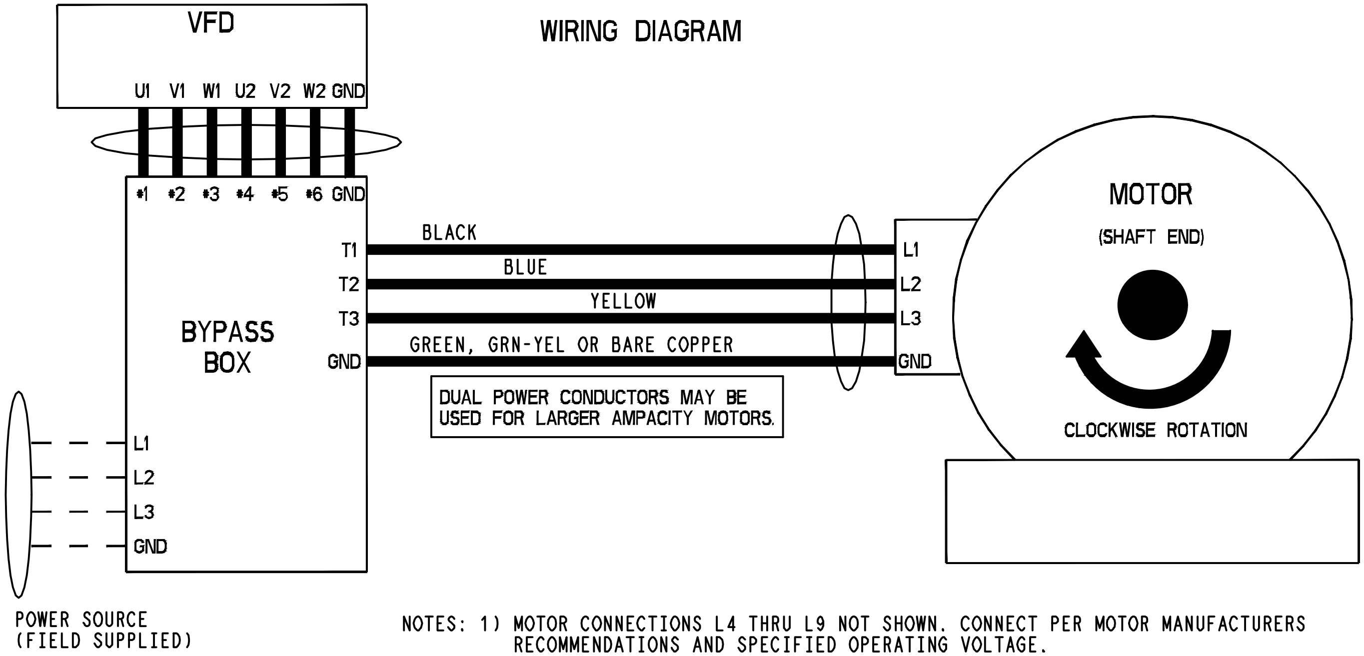


Carrier

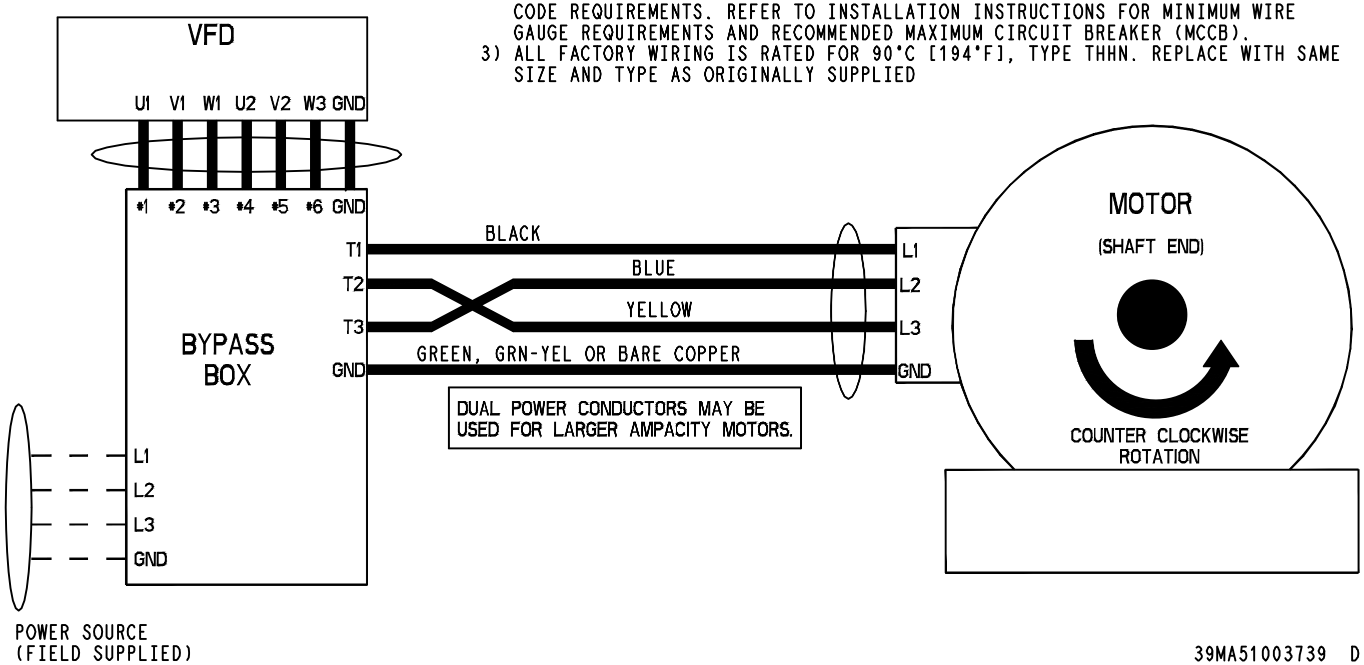
39M

DATE 2024-04-29	AHUBuilder v7.01	39M Central Station Air-Handler, Size: 03 - 110 6" Baserail and Lifting Lug Detail	REVISION

WIRING DIAGRAM



NOTES: 1) MOTOR CONNECTIONS L4 THRU L9 NOT SHOWN. CONNECT PER MOTOR MANUFACTURERS RECOMMENDATIONS AND SPECIFIED OPERATING VOLTAGE.
2) FIELD WIRING TO BYPASS BOX MUST BE IN ACCORDANCE WITH "NEC" CODE AND "LOCAL" CODE REQUIREMENTS. REFER TO INSTALLATION INSTRUCTIONS FOR MINIMUM WIRE GAUGE REQUIREMENTS AND RECOMMENDED MAXIMUM CIRCUIT BREAKER (MCCB).
3) ALL FACTORY WIRING IS RATED FOR 90°C [194°F], TYPE THHN. REPLACE WITH SAME SIZE AND TYPE AS ORIGINALLY SUPPLIED



39MA51003739 D

Component wiring for reference only. When components are factory installed, wiring will be factory installed unless otherwise noted.
When components are provided by the factory for field installation, wiring is not included or installed.

DATE	AHUBuilder	39M Central Station Air-Handler	REVISION
2024-04-29	v7.01	Three Phase VFD with Bypass Wiring Detail	

39M

APPLICATION DATA

Product Data

Aero® Indoor and Weathertight Outdoor Air Handlers

1,500 to 60,500 Nominal cfm

39MN,MW 03-110 Indoor and Weathertight Outdoor Air Handlers

Application data

Central station air handler

The central station air handler is a heating, ventilating, or air-conditioning unit that is centrally located in, or on, a building or structure. The air handler distributes air to desired areas through a system of ducts.

The 39M factory packaged unit

Individual components, such as fans, coils, and filters, are assembled at the factory.

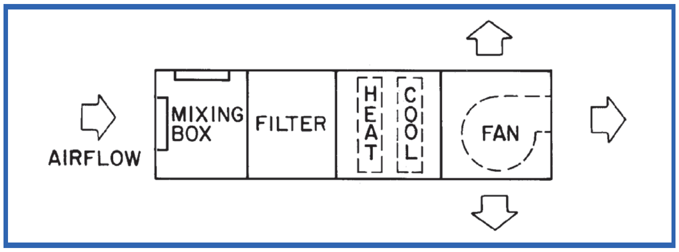
Packaged equipment is less costly than field-fabricated equipment and does not require assembly.

The basic air-handling unit consists of a fan section and a coil section. Other components, such as filter sections, air-mixing boxes, access sections, and damper sections, may also be provided.

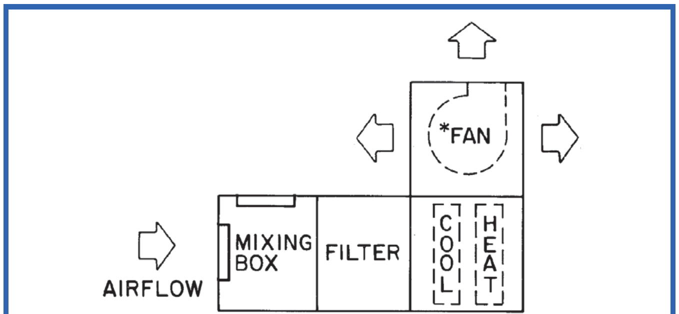
Central station configurations

Draw-thru units

Horizontal

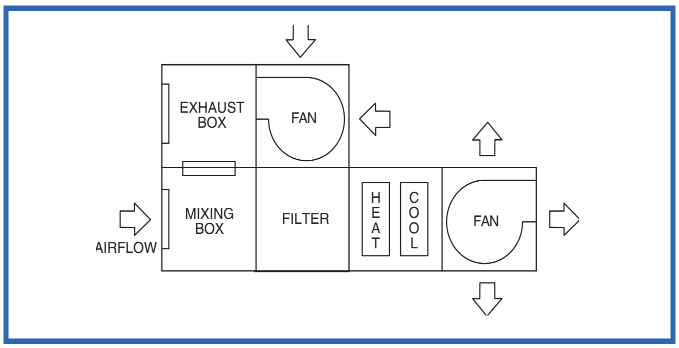


Vertical (indoor unit only)



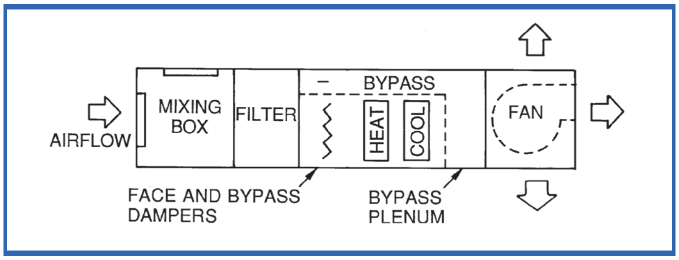
*Fan discharge may be horizontal or upblast.

Stacked return fan



Face and bypass units

Horizontal

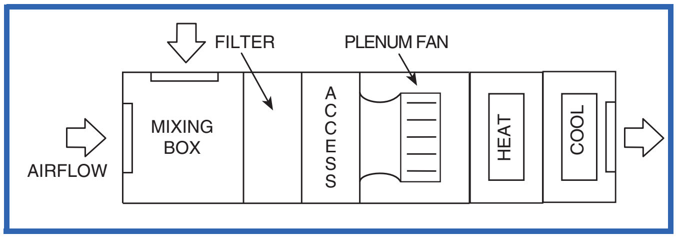


Blow-thru units

Blow-thru arrangements are more suitable on systems with a significant amount of fan (and motor) heat. Fan heat can add 0.3°F to 0.5°F per in. of total static pressure to the airstream. Therefore, on such systems, it is more efficient to use a blow-thru arrangement and add the fan heat before the cooling coil. With a draw-thru unit, the airstream must be subcooled to anticipate the addition of fan heat downstream of the cooling coil. Thermal storage and cold air distribution systems benefit from blow-thru applications.

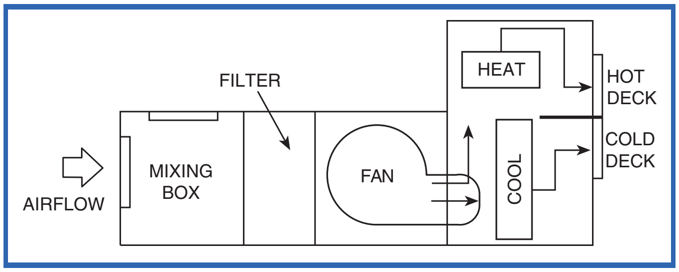
Air mixing using a plenum fan

A static air mixer is only effective between 900 and 1100 fpm. Using a blow-thru plenum fan as the air mixing device assures proper mixing at all airflows. This arrangement is best for VAV (variable air volume) systems and will eliminate the added expense of a static air mixer.



Dual duct

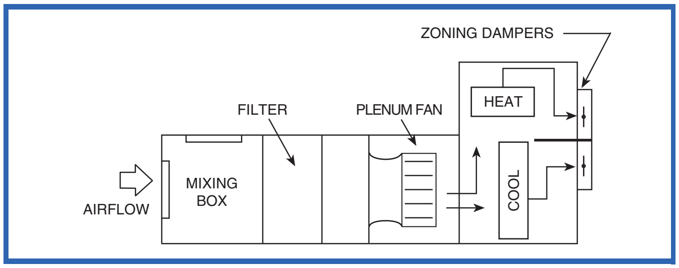
The unit delivers 2 outputs; one outlet produces hot air while the other produces cold air (indoor unit only).



Application data (cont)

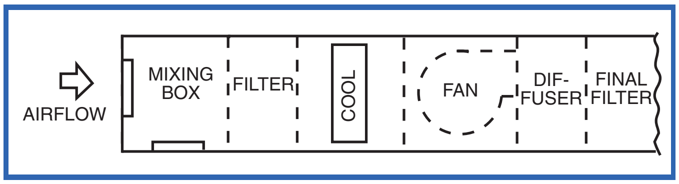
Multizone

Mixing dampers blend hot-deck and cold-deck temperatures to produce a desired temperature for individual zones. Several blending dampers per unit produce independent zones, each responding to its own thermostat (indoor unit only).



High filtration units

High filtration units employ a filter section ahead of the cooling and heating coils. A second filter section, called a final filter, is placed at the end of the unit at the point where the air enters the ductwork.



Fans

The 39M central station air handlers use belt-driven and direct-driven centrifugal fans. A centrifugal fan is one in which the air flows radially through the impeller. Centrifugal fans are classified according to fan wheel and blade construction. The 39M fans can be selected as double width, double inlet (DWDI) with forward curved or airfoil blades. Plenum fans are selected as single width, single inlet (SWSI) with airfoil or backward blades. Standard and small wheels are available on most sizes.

Laws of fan performance

Fan laws are used to predict fan performance under changing operating conditions or by fan size. They are applicable to all types of fans.

The fan laws are stated below. The symbols used in the formulas represent the following variables:

CFM — Volume rate of flow through the fan.
RPM — Rotational speed of the impeller.
P — Pressure developed by the fan.
Hp — Horsepower input to the fan.
D — Fan wheel diameter. The fan size number can be used if it is proportional to the wheel diameter.
W — Air density, varying directly as the barometric pressure and inversely as the absolute temperature.

Application of these laws is limited to cases where fans are geometrically similar.

Fan Laws

VARIABLE	CONSTANT	LAW	FORMULA
SPEED (RPM)	Air Density Fan Size Distribution System	Airflow varies directly with the Speed.	$\frac{CFM_1}{CFM_2} = \frac{RPM_1}{RPM_2}$
		Pressure varies as the square of the Speed.	$\frac{P_1}{P_2} = \left(\frac{RPM_1}{RPM_2}\right)^2$
		Horsepower varies as the cube of the Speed.	$\frac{Hp_1}{Hp_2} = \left(\frac{RPM_1}{RPM_2}\right)^3$
FAN SIZE (D)	Air Density Tip Speed	Capacity and Horsepower vary as the square of the Fan Size.	$\frac{CFM_1}{CFM_2} = \frac{Hp_1}{Hp_2} = \left(\frac{D_1}{D_2}\right)^2$
		Speed varies inversely as the Fan Size.	$\frac{RPM_1}{RPM_2} = \frac{D_2}{D_1}$
		Pressure remains constant.	$P_1 = P_2$
	Air Density Wheel Speed	Capacity varies as the cube of the Size.	$\frac{CFM_1}{CFM_2} = \left(\frac{D_1}{D_2}\right)^3$
		Pressure varies as the square of the Size.	$\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\right)^2$
		Horsepower varies as the fifth power of the Size.	$\frac{Hp_1}{Hp_2} = \left(\frac{D_1}{D_2}\right)^5$
AIR DENSITY (W)	Pressure Fan Size Distribution System	Speed, Capacity, and Horsepower vary inversely as the square root of Density.	$\frac{RPM_1}{RPM_2} = \frac{CFM_1}{CFM_2} = \frac{Hp_1}{Hp_2} = \left(\frac{W_2}{W_1}\right)^{1/2}$
	Airflow Fan Size Distribution System	Pressure and Horsepower vary with Density.	$\frac{P_1}{P_2} = \frac{Hp_1}{Hp_2} = \frac{W_1}{W_2}$
		Speed remains constant.	$RPM_1 = RPM_2$

Fan selection criteria

System requirements

The major factors that influence fan selection are airflow, external static pressure, fan speed, brake horsepower, and sound level. Additional system considerations include the fan control method, overloading, redundancy, and non-standard air density. Fan selection for air-conditioning service usually involves choosing the smallest fan that provides an acceptable level of performance, efficiency and quality.

Pressure considerations

The static pressure is the resistance of the combined system apart from the fan. Contributors to static pressure include other components in the air handler, ductwork, and terminals. The static pressure is dependent on the airflow through the system, which is determined by the air conditioning requirements. As shown in the second fan law in the table on the preceding page, the static pressure varies as the square of the airflow (cfm). This ratio between pressure and airflow determines the system curve for any air-handling system.

The static pressure used to select a fan should be the pressure calculated for the system at design airflow. If the static pressure is overestimated, the increase in horsepower and air volume depends upon the steepness of the fan curves in the selection area.

With forward-curved (FC) fans, if the actual system static pressure is less than the design static pressure, the fan has a tendency to deliver more air and draw correspondingly higher bhp (kW of energy). This higher current draw may overload the motor and trip circuit breakers. This is a common occurrence when FC centrifugal fans are operated before all the ductwork has been installed, or during the pull-down load on a VAV system.

With airfoil (AF) fans (non-overloading), if the actual static pressure is less than the design static pressure, the fan delivers more air with little or no increase in bhp in most applications. In this case, adding a safety factor to the calculated static pressure can increase fan horsepower (and costs) unnecessarily.

Stability

Fan operation is stable if it remains unchanged after a slight temporary disturbance, or if the fan operation point shifts to another location on the fan curve after a slight permanent disturbance. Fan operation is unstable if it fluctuates repeatedly or erratically. There are 2 main types of unstable fan operation:

System surge is a cycling increase and decrease in system static pressure.

Fan stall is the most common type of instability, and it occurs with any type of centrifugal fan when the fan is starved for air.

Normally, the rotation of the fan wheel forces the air through the blade passageway from the low pressure to the high pressure side of the fan. If the airflow is restricted too much, however, there is not enough air to fill the space between the blades and the air distribution between the blades becomes uneven and erratic. Air can flow backwards through the wheel, substantially increasing the noise level. If the fan runs in this condition for a long time, wheel failure will likely occur.

For a given speed, the operating point where a fan stalls is a function of the wheel geometry and wheel speed. In general, the stall point is within 15 to 25% of the airflow obtained at free delivery.

Stability and VAV applications

Special considerations must be made for VAV systems. While the initial fan selection may be acceptable, its operating point could shift to a point of stall at minimum airflow and pressure conditions. The typical minimum airflow is half of the design cooling airflow, which is also often equal to the heating airflow. To determine and plot the minimum airflow versus static pressure, use the following equation. This equation solves for the static pressure at a specific airflow based on a minimum static pressure set point:

$$\left(\left(\frac{CFM_1}{CFM_{DESIGN}}\right)^2 X \quad (SP_{DESIGN} - SP_{MIN})\right) + SP_{MIN} = SP_1$$

$$\left(\left(\frac{7{,}500}{15{,}000}\right)^2 X \quad (4 - 2)\right) + 2 = 2.50 \text{ IN. WG}$$

CFM — Airflow in Cubic Feet Per Minute
SP — Static Pressure

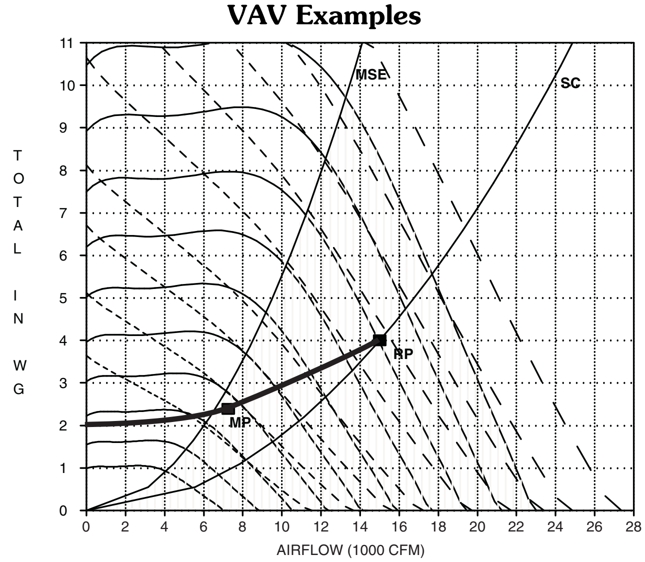
The table below illustrates a system with an airfoil fan wheel at a cooling design of 15,000 cfm and a system static pressure of 4 in. wg. The minimum airflow is 7,500 cfm with a minimum system static pressure set point of 2 in. wg. **The minimum static set point is based on zero airflow and does not coincide with the minimum design airflow.**

Example:

% CFM	CFM	SYSTEM AND FAN STATIC PRESSURE in. wg
100	15,000	4.00
90	13,500	3.62
80	12,000	3.28
70	10,500	2.98
60	9,000	2.72
50	7,500	2.50

As shown on the highlighted VAV curve, the minimum airflow and static pressure (MP) are both well within the fan's acceptable operating conditions.

VAV Examples



MP — Minimum Point
MSE — Maximum Static Efficiency
RP — Rated Point
SC — System Curve

Sound considerations

The fan is one of the main sound sources in an air-conditioning system. Other sources of sound include the duct system and terminals, because they generate turbulence in the air flowing through them. Simply estimating fan sound does not give an accurate picture of total system sound, but fan sound is a major component of system sound, and should be minimized.

To minimize its sound generation, a fan must be correctly sized and selected to operate at or near peak efficiency. Oversized fans can generate much higher sound power levels than necessary, especially in VAV systems operating at low airflows. Undersized fans can also result in higher sound power levels because of increased fan speeds and the higher tip velocity of the air leaving the fan blades.

For VAV systems, the part load point at which the fan operates most of the time should be used to select a fan for lowest sound output.

Variable frequency drives (VFDs) are used to modulate fan volume. A VFD reduces the sound power level as the fan speed is reduced. At 50% load, the sound level is reduced approximately 15 dB compared to the sound level at 100% load. When using variable frequency drives, it is important that the static deflection of the vibration isolators is adequate. At very low fan speeds, the fan frequency may approach the natural frequency of the spring isolation. If this happens, the vibration levels can be amplified and resonant vibration conditions can occur.

When sound level is a major consideration, a blow-thru fan should be considered because of the reduced discharge sound level. This sound reduction is due to the sound absorption of the coil section downstream from the fan. Transition fittings and elbows can be reduced in size or eliminated, thereby eliminating a sound source.

To obtain projected sound data for a selected 39M unit, use the electronic catalog ***AHU*****Builder®** program.

Dirty filtration considerations

Consider selecting an air handler with dirty filters so that, in theory, the unit will have enough horsepower to deliver the same amount of air when the filters are dirty. On a constant volume unit, that would only work if the unit contained an airflow measuring station and could adjust the flow accordingly via a VFD. Otherwise, the point of operation moves along the rpm line as the static pressure in the system changes.

What happens when you order the fan with sheaves selected for dirty filters? Three things:

1. The air balancer forces the selection of a smaller sheave because the airflow is too high. When the filters load up, airflow is reduced.
2. If an air balance is not performed, the cooling coil may exhibit moisture carryover due to the considerable increase in airflow.
3. The fan motor trips out on overload with the forward curve fan because of the increase in bhp.

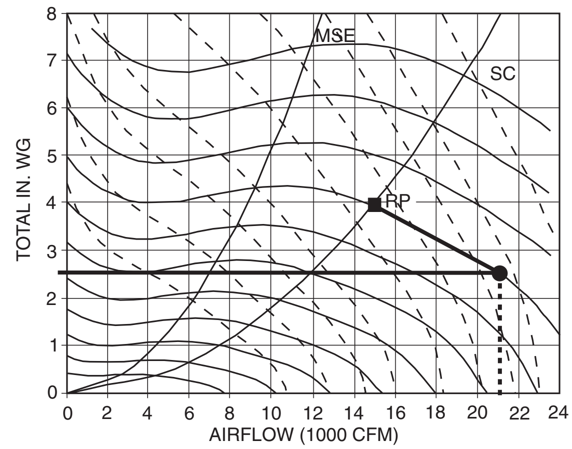
Example:

Forward-Curved Fan, 15,000 cfm, 1010 rpm, 17.8 hp, selected with 100% dirty 60 to 65% cartridge filters and pre-filters. Dirty filters result in a total static pressure (TSP) of 4 inches.

Clean filters result in a TSP of 2.55 inches.

In the following chart, follow the 1010 rpm line down to 2.55 inches.

39M Size 30 Forward-Curved Fan Curve



LEGEND
\ — Rpm
\ — Bhp (Brake Horsepower)
MSE — Max. Static Eff.
RP — Rated Point
SC — System Curve

RPM = 1010
BHP = 17.8
Class II Max RPM = 1217
Max BHP = 15.0
RPMs (x 100, L to R): 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
BHPs (L to R): 3, 5, 7.5, 10, 15, 20, 25, 30, 40

Airflow with a clean filter will be 21,000 cfm. Also note that the horsepower goes from 17.8 bhp to about 28 bhp because the FC fan is an overloading type fan.

So, if dirty filters need to be taken into consideration, do one of the following:

1. Make the final fan selection with the **clean** filter rpm but use the motor horsepower requirement for **dirty** filters.
2. Make the final fan selection with the **dirty** filter rpm and use the motor horsepower requirement for **dirty** filters – **only if** the engineer plans on using a VFD and airflow measurement station or if it is a VAV system.
3. Use an airfoil fan when the difference between dirty and clean filter pressure drop is greater than 1 inch. That way, the difference between clean and dirty airflow is minimized.

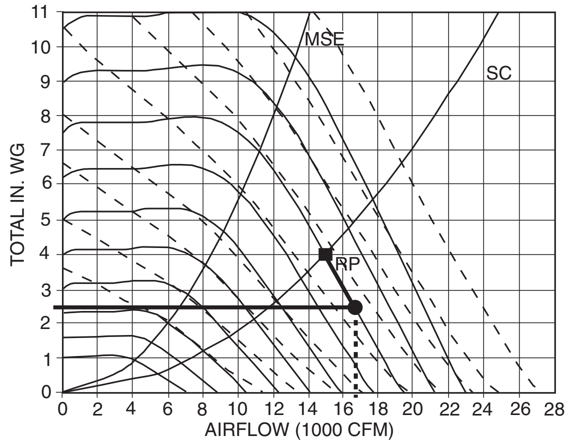
Example:

Airfoil Fan, 15,000 cfm, 2210 rpm, 18.8 hp, selected with 100% dirty 60 to 65% cartridge filters and pre-filters. Dirty filters result in a total static pressure (TSP) of 4 inches.

Clean filters result in a TSP of 2.55 inches.

In the following chart, follow the 2210 rpm line down to 2.55 inches.

39M Size 30 Airfoil Fan Curve



LEGEND

\ — Rpm
\ — Bhp (Brake Horsepower)
MSE — Max. Static Eff.
RP — Rated Point
SC — System Curve

RPM = 2210
BHP = 18.8
Class II Max RPM = 2442
Max BHP = 15.0
RPM's (x 100, L to R): 8, 10, 12, 14, 16, 18, 20, 22, 24, 26
BHP's (L to R): 3, 5, 7.5, 10, 15, 20, 25, 30, 40

Airflow with a clean filter will be 16,700 cfm. Since airfoil fans are non-overloading (bhp lines run parallel with rpm lines) the bhp does not change (actually, bhp decreases).

Fan, motor, and drive heat considerations

The work output of a fan and its motor and drive contribute directly to the airflow and pressure exiting the air handler. Not all of the fan energy output generates airflow, however. Fan motors are not 100% efficient, and their efficiency loss translates directly into heat that must be factored in when calculating the temperature rise across a fan section. Fans also add a certain amount of heat to the airstream due to the effects of compression and bearing friction. Finally, belt drives do not transmit all of the energy generated by the motor. Some of the energy is lost as heat due to belt tension and the type and number of belts. Belt drive bhp losses range from 2 to 6 percent; a 3% loss is typical.

Because the 39M Series air handlers all have fans, motors, and drives located within the airstream, heat losses from these components affect the power requirements, cooling load, and heating load.

Power losses in the motor and drive should be allowed for when determining the motor output (bhp), so that the motor can be correctly sized and the additional heat output can be subtracted from cooling capacity or added to heating capacity. A typical example follows:

Given Fan Operating Point:

13,224 cfm
9.6 Fan bhp
3.0% Estimated drive loss

Calculate the required fan motor output (H_p) due to drive loss.

H_p = (Fan bhp) x (Drive Loss)
H_p = 9.6 x 1.03
H_p = 9.89 hp (select 10 Hp motor)

Calculate the total fan motor heat output (Q) according to motor efficiency:

Q = (Motor Output) ÷ (Motor Efficiency [Typical])
Q = 9.89 ÷ 0.86
Q = 11.5 hp

Convert horsepower to Btu per hour.

11.5 hp x 2545 = 29,268 Btuh

Calculate the increase in leaving-air temperature (ΔT) due to fan and motor heat and drive losses:

Q = 1.1 x cfm x ΔT

29,268 Btuh = 1.1 x 13,224 x ΔT
29,268 Btuh = 14,546.4 x ΔT
ΔT = 2.01 F (use to estimate coil requirements)

Fan application

Certain fans are more efficient in low static pressure systems, while others operate best in higher pressure systems. Some fan types are designed to handle very large air volumes while others are more efficient at lower volumes. See the Fan Type and Application table on page 12.

Forward-curved (FC) fans are typically used for low to medium pressure applications (0 to 5 in. wg total static pressure [TSP]).

The FC fans are reasonably stable over a wide airflow (cfm) range at constant speed. Because of the relatively flat curve, FC fans tolerate modulation in airflow without large increases in static pressure. Most important, FC fans have the lowest first cost.

Airfoil (AF) fans are most efficient at higher static pressures (4.0 to 8.0 in. wg total static pressure).

Because of the shape of the AF fan performance curve, bhp decreases as air volume decreases only when a VAV volume control device, such as a variable frequency drive (VFD), is used.

Airfoil fans are more expensive than FC fans and, in addition, there is a price premium for the volume control device, if required.

Plenum fans (sometimes called "plug" fans) are typically used in medium to high static pressure applications where ductwork requires discharge location flexibility. They can reduce the need for ductwork turns or diffusers, especially when equipment room space is limited.

Plenum fans are less efficient than double-width, double-inlet airfoil fans. General construction also differs from that of FC or AF fans. The fan does not have a scroll to enclose the fan wheel and direct airflow. Instead, the entire interior of the plenum fan section is pressurized by the fan.

Plenum fans have single-width, single-inlet (SWSI) construction. The fan shaft is parallel with the airflow, and the motor and bearings are located inside the plenum in the pressurized airstream. An optional inlet screen and wheel cage [belted plenum fans and direct fans (single or dual only) with NEMA motors] can be installed to help protect personnel during maintenance.

Plenum fans are generally used where there are space limitations, a need for discharge flexibility, a need for reduced discharge sound, or where duct configurations might change in the future. For example, in an application where there is not enough room in the building for a large main duct, several smaller duct runs may approach the mechanical equipment room from all sides. In such an application, several connections can be made to one or more sides of the plenum fan section. Installing contractors can cut outlets in the plenum box at the time of installation to suit the conditions at the jobsite.

Because the casing of a plenum fan section acts as a sound attenuator, plenum fans are also sometimes used when discharge sound levels need to be reduced.

Duct takeoffs from plenum fans can have relatively high pressure losses and can also create turbulence that causes a larger pressure drop across coil and filter sections. When selecting a plenum fan, the pressure drop for the duct takeoffs must be added to the external static pressure for the rest of the system.

To calculate the pressure losses from plenum fan duct takeoffs, use the following formula and refer to the figure at right.

$$P_l = P_p - P_d = (C_v)(V_p)$$

Where P_l is the pressure loss, P_p is the plenum pressure, P_d is the duct pressure, C_v is the pressure loss coefficient, and V_p is the velocity pressure in the duct. Note that for radial duct takeoffs, C_v is 1.5 in. wg, while for axial duct takeoffs, C_v is 2.0 in. wg. To calculate velocity pressure (V_p) in the duct, use the following formula, where V is the air velocity in the duct:

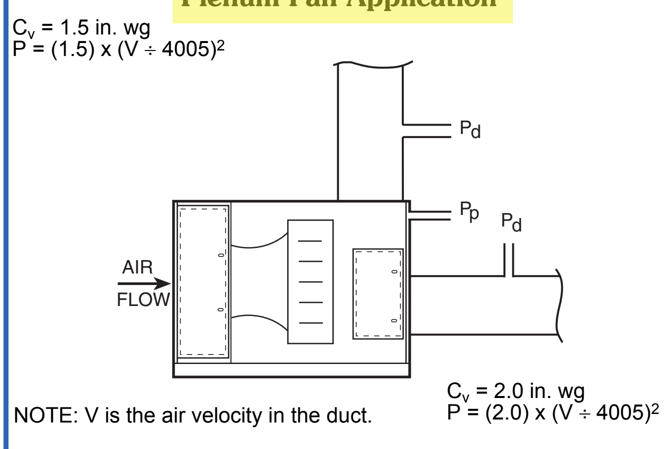
$$V_p = [(V) \div (4005)]^2$$

Also note that with more than one duct takeoff and different duct velocities, the highest duct velocity and highest C_v value should be used in the formulas.

Duct design considerations (system effect prevention)

The discharge ductwork immediately downstream from the fan is critical for successful applications. Poorly designed ductwork can degrade fan performance and contribute to excessive pressure drop and noise.

Plenum Fan Application

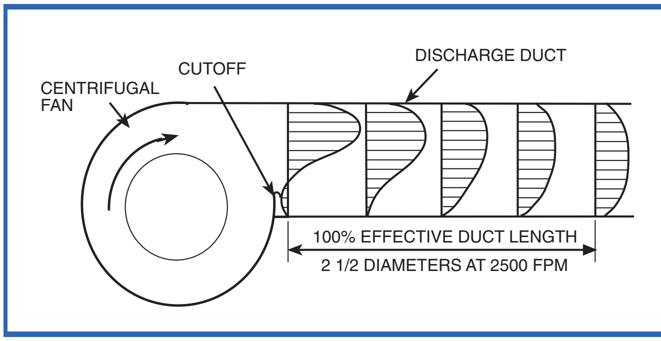


The 39M Series airfoil and forward-curved fans are tested as part of a system with straight discharge ductwork, and the fan ratings are based on this duct design. When designing ductwork in the field, it is important to use a straight discharge duct of the correct dimensions to obtain maximum fan performance. Straight ductwork helps the airflow to develop a uniform velocity profile as it exits the fan and allows the velocity pressure to recover into static pressure. See the figure below.

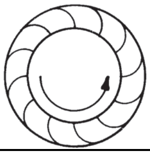
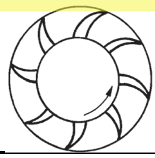
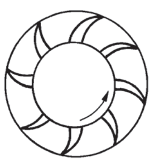
For 100% recovery of velocity pressure into static pressure, the straight portion of the discharge duct must be at least at least 2-1/2 times the discharge diameter in length for velocities of 2500 fpm or less. For each additional 1000 fpm, add one duct diameter to the length of the straight portion of the ductwork.

As an example of how to size the straight portion of duct, assume the fan has a 34 x 34 in. discharge outlet (8.03 sq ft). The equivalent diameter is 39 in., so the straight duct length required would be 8 ft long.

Plenum fans do not require straight ductwork of a particular minimum length, because velocity pressure is converted to static pressure inside the plenum fan section. Outlet ducts, however, should not be installed directly in line with the air discharge from the fan wheel.



Fan Type and Application

TYPE	CHARACTERISTICS	APPLICATION
FORWARD-CURVED (FC) SIDE VIEW 	• Double-width, double-inlet (DWDI) construction. • Best at low or medium pressure (approximately 0 to 5 in. wg). • Horsepower increases continuously with increase in air quantity (overloads) as static pressure decreases. • Less expensive than AF fans. • Runs at relatively low speed, typically 400 to 1200 rpm. • Blades curve toward direction of rotation.	For low to medium pressure air-handling applications.
AIRFOIL (AF) SIDE VIEW 	• Double-width, double-inlet (DWDI) construction. • Best in high capacity and high-pressure applications (4 to 8 in. wg). • Horsepower peaks at high capacities. • Most expensive of centrifugal fans. • Operates at high speeds, typically 1200 to 2800 rpm. About double the speed of FC fan for similar air quantity. • Blades have aerodynamic shape similar to airplane wing and are curved away from direction of rotation.	For medium to high air capacity and pressure applications.
PLENUM, BELT DRIVE OR DIRECT DRIVE WITH NEMA MOTORS (PAF) END VIEW 	• Single-width, single-inlet (SWSI) construction. • Characteristics similar to DWDI airfoil fan. • Blades have aerodynamic shape similar to airplane wing and are curved away from direction of rotation. Fewer blades and wider blade spacing than AF fans. • Available as belt drive or as direct drive shaft mounted on a NEMA “T” frame.	Best in applications with limited space or multiple ducts.
PLENUM, DIRECT DRIVE WITH EC MOTORS (PFEC) END VIEW 	• Single-width, single-inlet (SWSI) construction mounted to rotor of supplier matched electronically commutated motor. • Blades curve away from direction of rotation. • Various combinations of fan sizes and quantities available for fan efficiency optimization.	Best in applications with requirements for limited space, high-efficiency or fan redundancy.

Fan control on variable air volume systems

Introduction

Since VAV systems inherently reduce airflow to meet demand, they are a major source of energy savings. This occurs because fan brake horsepower (bhp) varies with the amount of air delivered.

The degree to which bhp savings are realized, however, is also affected by the type of fan volume control selected and the effectiveness of its application. Effective fan control ensures proper duct pressure for the required control stability of the air terminals and provides quiet terminal unit operation when “riding the fan curve.”

Consider the following when selecting a fan volume control method:

1. System parameters
   a. Airflow (cfm)
   b. Static pressure
   c. Percent volume reduction (turndown)
2. Fan type and selection point
   a. Design point efficiency
   b. Part load efficiency (especially the point where the fan will be operating most of the time)
   c. Part load stability
3. Ease of control installation and use
4. Motor selection
   a. Higher bhp inputs due to efficiency of VAV control method
   b. Compatibility with VAV control
5. Sound levels
   a. Fan-generated sound
   b. Terminal sound
   c. Control-generated sound
   d. System sound (ducts, fittings)
6. Initial cost and operating cost
7. Reliability and ease of maintenance

System parameters

Before a fan type or control is selected, the system must be analyzed at both the design point and part load. The fan is likely to be operating at part load a large percentage of the time.

Methods of fan air-volume control

- “Riding the fan curve” with terminal throttling (forward curved fans)
- Variable frequency drives (VFDs)
- Electronically commutated motors (ECMs)

A short description of air-volume control methods follows. A summary comparison table is provided at the end of the section.

Application data (cont)

Forward-curved (FC) fans with terminal throttling (riding fan curve)

This is the simplest, most reliable, and most economical first-cost method of air volume control on VAV systems, since no accessories are required. This type of VAV control can be used on forward-curved fans with flat pressure characteristics and in systems where static pressure changes at the terminals are moderate. Air volume reduction is produced solely by throttling of terminal units in response to load reduction. As the units throttle, system resistance changes.

The chart below, Forward-Curved Fan with Air Terminal Throttling, illustrates the reduction in bhp and airflow at constant speed. Point A is the peak airflow operating point. Note the required bhp at this airflow. As airflow is reduced by terminal throttling, move along the fan constant rpm curve to point B. Note the lower cfm and bhp values at B.

At reduced airflow conditions, the total system static pressure may undergo little or no change, although air pressure loss through the air-handling unit decreases. This means that duct pressure increases as pressure loss across the terminal unit increases. For low-static and medium- static pressure systems, this increase in duct pressure should not result in noticeable sound level changes. However, at higher design static pressures, sound levels and duct leakage may increase and the control method should be reviewed to determine if it is feasible.

Variable frequency drives

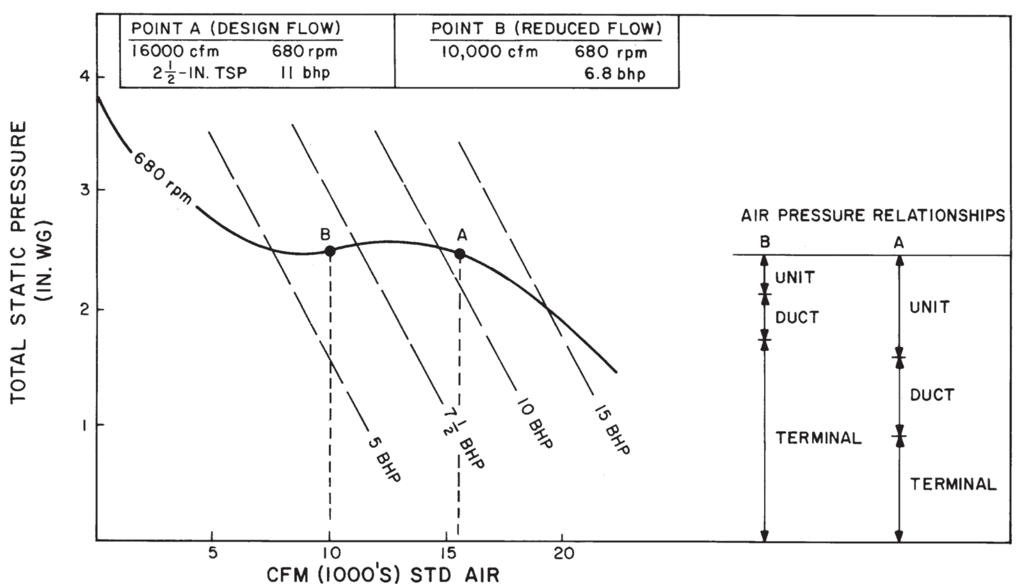
Variable frequency drives (VFDs) modulate the fan motor speed in response to air volume requirements. To vary the motor speed, a VFD changes the input frequency and line voltage into a wide range of frequency and voltage outputs, while maintaining a constant frequency to voltage ratio.

Variable frequency drives convert input ac power to dc power and then convert the dc power to a different ac power output using an inverter. The inverter creates the ac output by rapidly switching the polarity of the voltage from positive to negative. Power output from the VFD is not a smooth sine wave, but has many "steps" in the wave form. This type of power output can cause a standard fan motor to exceed its rated temperature range. The stepped power output also results in motor efficiency losses that must be considered when calculating the energy savings offered by the VFD.

Due to the stepped power output generated by VFDs, fan motors rated for inverter duty are recommended. If a standard motor is used with a VFD, the motor should not be operated at the full service factor.

Variable frequency drives can be an effective way to control air volume and save energy. At reduced load requirements, fan speed is reduced proportionately with resulting lower airflow, lower static pressure, lower bhp requirements, and lower sound levels.

Forward-Curved Fan with Air Terminal Throttling
Variations in BHP at Constant RPM



Application data (cont)

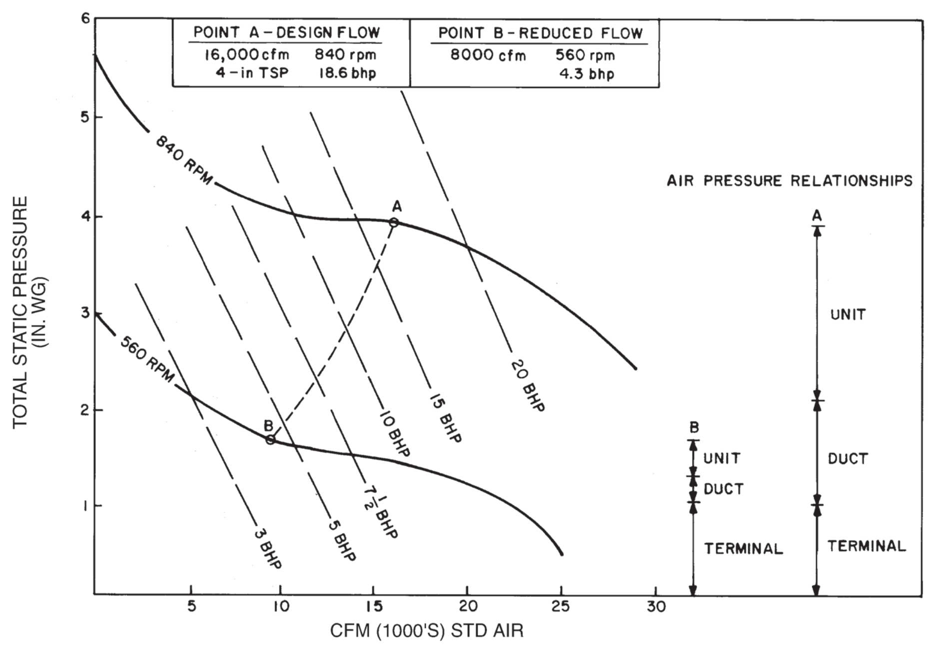
As the load decreases in a VAV system and the terminal units throttle, duct static pressure increases. A static pressure sensor in the duct system detects the pressure increase and initiates a fan speed change through the VFD or EC motor. Fan speed is reduced until the duct sensor detects a satisfactory duct pressure.

The Variable Frequency Fan Speed Control chart illustrates the results of fan speed reduction as operation shifts from Point A to Point B. If duct pressure begins to fall due to terminal units opening, the duct sensor signals the VFD or EC motor to increase fan speed.

This method of air volume control permits fan speed reduction down to as low as 10% of the design speed. With FC fans riding the fan curve at the lower rpm, airflow may be as low as 10% of peak design, as long as motor rpm is not less than 1/6 of motor synchronous speed.

The method may be applied to any size VAV system with any type of fan. It is particularly cost effective on systems with high turndown requirements where the full speed reduction capability can be used.

Variable Frequency Fan Speed Control



Fan Summary Comparison

TYPE OF CONTROL	FIRST-COST RANK	SOUND GENERATION RANK*	ENERGY-SAVINGS RANK	APPLICATION RANGE — NORMAL FOR AIR COND.	COMMENTS
FC FAN TERMINAL THROTTLING (RIDING FAN CURVE)	1 (Lowest Cost)	4	4	TSP 0 to 4.5 in. wg Cfm 3,000 to 35,000	For moderate turndown systems with a flat fan curve and low to medium static pressure and cfm range.
FC FAN WITH VARIABLE FREQUENCY DRIVE	3	1 (Quietest)	3	TSP 0 to 4.5 in. wg Cfm 3,000 to 35,000	For high turndown, low to medium static pressure systems. Fast payback. Fan generates least sound.
AF AND PLENUM FAN WITH VARIABLE FREQUENCY DRIVE	4	1 (Quietest)	2	TSP 4.5 to 8.0 in. wg Cfm 5,000 to 63,000	For high turndown, medium to high static pressure systems. Fan generates least sound.
PLENUM FAN WITH EC MOTOR	2	2	1 (Best)	TSP 0 to 8 in. wg Cfm 1,000 to 63,000	For high turndown, low to high static pressure systems. Best energy savings.

LEGEND
AF — Airfoil
EC — Electronically Commutated
FC — Forward Curved
TSP — Total Static Pressure

*Including part load.

NOTE: Rank is based on a relative scale of 1 to 4. Some methods have comparable rating.

Unit control arrangements with Carrier Direct Digital Controls

Supply fan control

In a VAV system, supply fan control is used to match the supply fan delivery to the airflow required by the load. This is done by maintaining a constant static pressure in the supply duct at a point approximately 2/3 of the distance from the supply fan discharge.

The DDC processor uses a control loop to provide the capability. This processor measures the static pressure at the pick-up probe, compares it to the desired set point, and modulates the fan volume control device. See the Supply Fan Control figure. The volume control device can be a factory-installed or field-installed variable frequency drive (VFD) or EC motor.

The VFD or EC motor provides the ability to maintain control over a much larger airflow range (it has a higher turndown ratio). The following guideline should be used to ensure proper control:

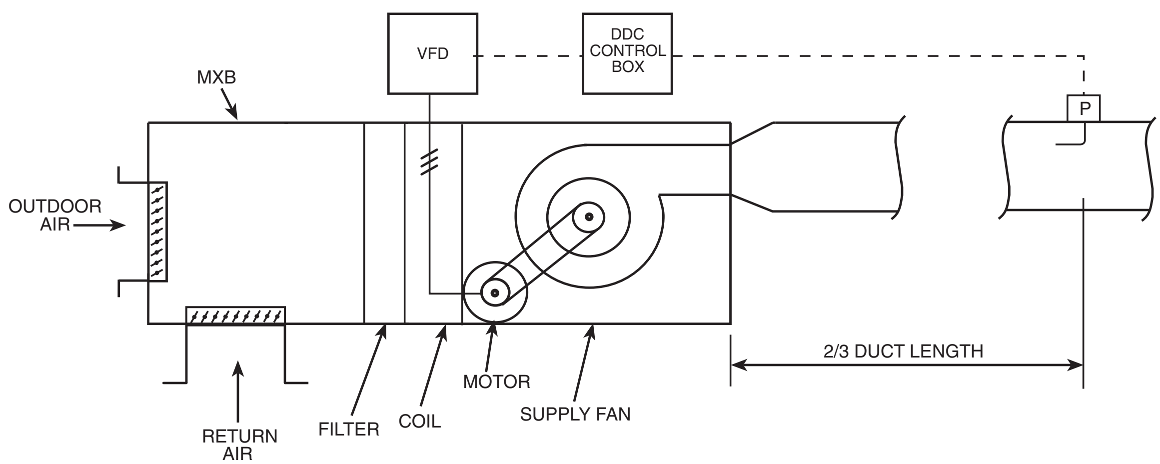
- Variable frequency drives should not be operated at below 1/6 motor synchronous speed.

For supply fan applications, the DDC processor option maintains the duct static pressure at a desired set point between 0.2 and 4.5 in. wg to within ±0.1 in. wg throughout the fan control range. In applications where more than 100 ft of pneumatic tubing is required, the transducer must be removed from the control box and remotely mounted near the static pressure pickup.

Indoor air quality (IAQ) applications

The CO_2 demand-controlled ventilation (DCV) override increases the minimum ventilation level in order to maintain the CO_2 level at or below the maximum level per person. By ventilating only to the actual rate required, rather than the maximum design occupancy rate, energy savings are achieved. When combined with Product Integrated Controls, this feature automatically adapts and changes ventilation quantity without operator set point adjustments. The CO_2 DCV override feature has user-selectable values for minimum mixed-air temperature override, maximum damper ventilation override position, and supply air tempering (when hot water/steam heat is used).

Supply Fan Control



LEGEND

DDC — Direct Digital Control
MXB — Mixing Box
VFD — Variable Frequency Drive

P — Static Pressure Pick-Up

ACCESSORY DETAILS & CUT SHEETS

VFD Submittal

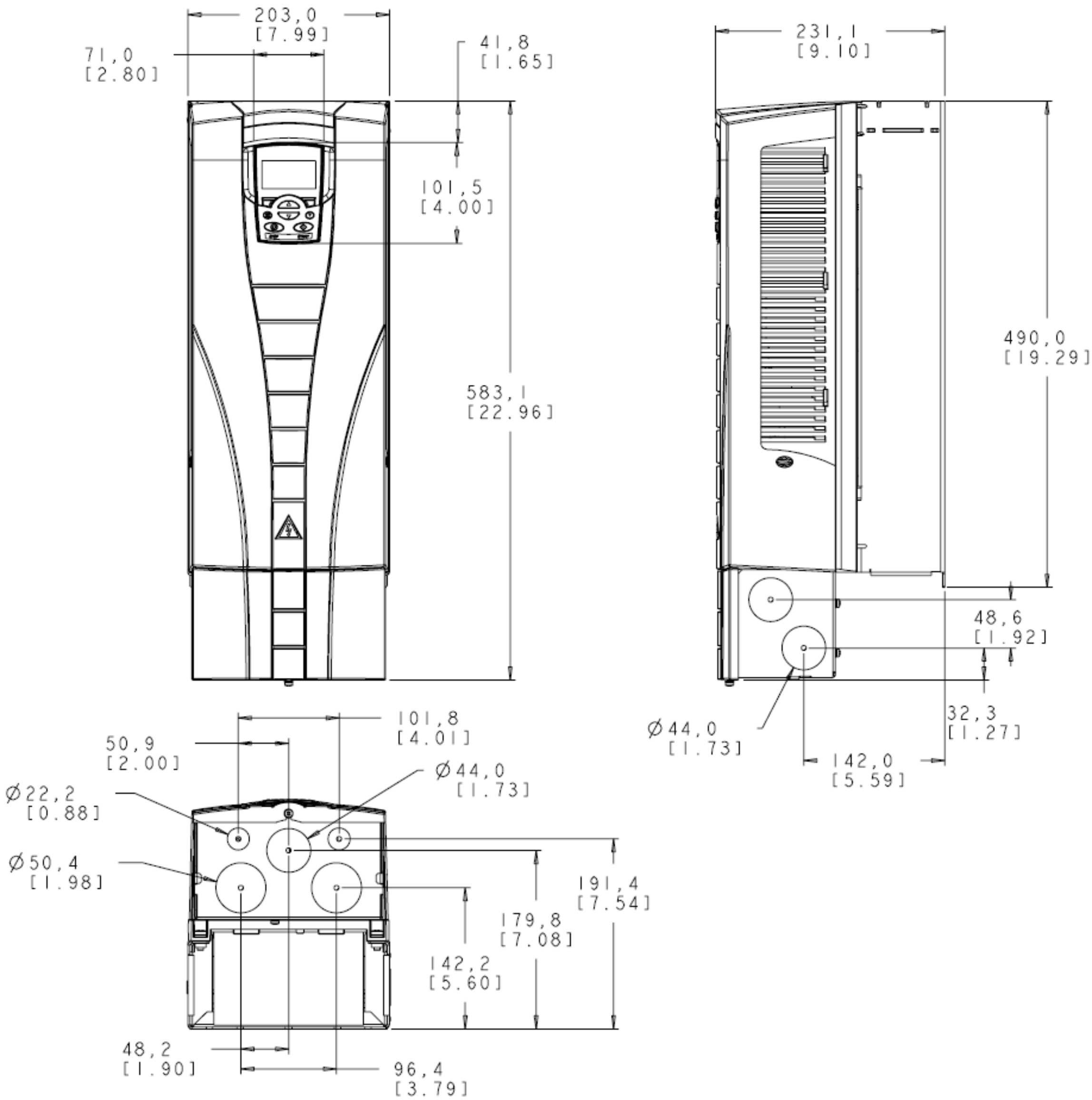
Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Manufacturer Part Number	ACH550-UH-038A-4
Voltage	460 Volts 3 Phase 60Hz
Frame Size	R3
Application Horsepower	25 HP
Maximum Continuous Output (A)	38
UL Class T Fuse Amps	50

R3

General Dimensions

Height (in.)	23
Width (in.)	8
Depth (in.)	9.1
Shipping Weight (lbs.)	35



Note: Unbracketed dimensions listed in millimeters [Bracketed dimensions listed in inches]

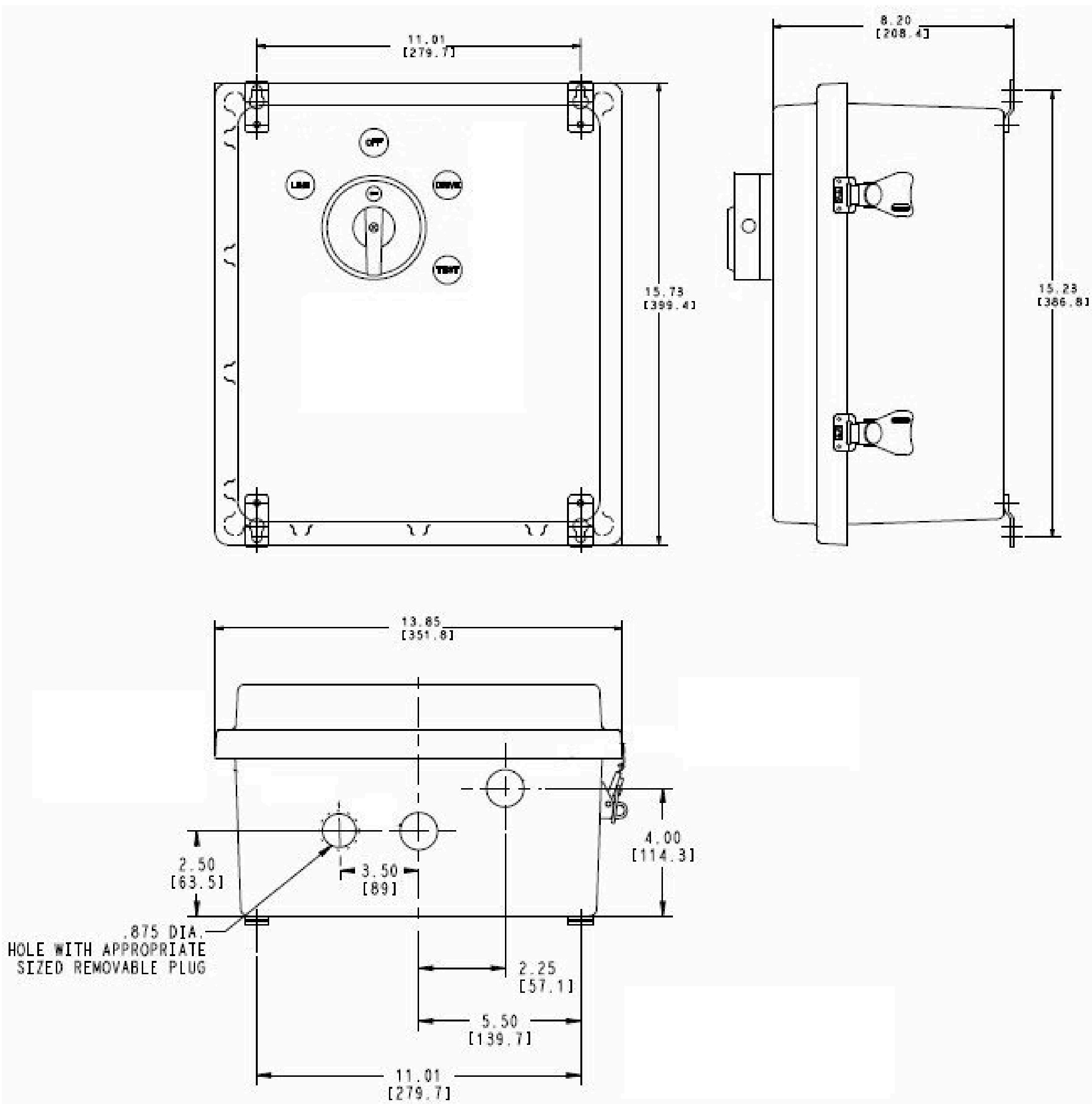
Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Manufacturer Part Number	139319B
Voltage	460 Volts 3 Phase 60Hz
Application Horsepower	25 HP
Overload Amp Range (A)	30-40

F2

General Dimensions

Height (in.)	16
Width (in.)	14
Depth (in.)	8
Shipping Weight (lbs.)	24



Note: Unbracketed dimensions listed in millimeters [Bracketed dimensions listed in inches]

Air Filter Submittal

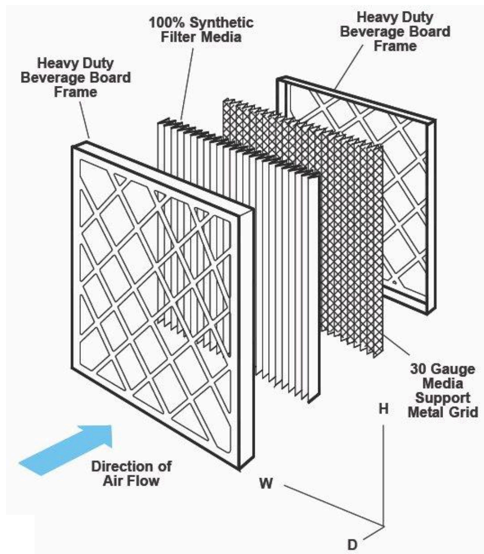
Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

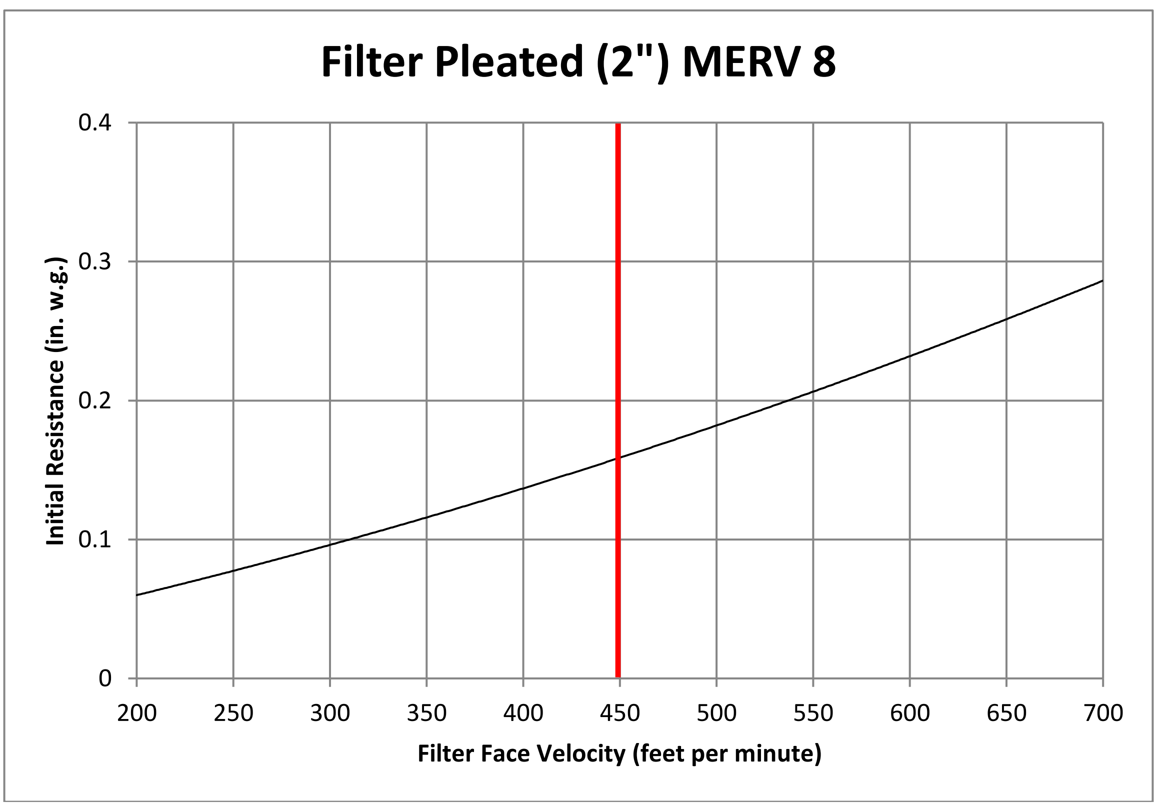
Carrier Part Number	31K2B0000001020244
Kit Description	Filter Kit
Unit Airflow, CFM	15000
Filter Velocity, FPM	450
Filter Sizes and Quantities	Qty (10) 20in. x 24in.

DFpro

MERV 8 Pleated Filter

The 100% synthetic graduated density media is continuously bonded to a 30 gauge galvanized, corrosion resistant, expanded metal support grid with an effective open area of 96%. The media is resistant to a wide range of chemicals, does not absorb moisture and will not support microbial growth.
The controlled pleat spacing maximizes surface area and dust holding capacity and is bonded to the enclosure frame to prevent dust bypass. The enclosure frame is constructed of high wet strength moisture resistant beverage board. The diagonal support members of the frame are bonded to the entering and exiting apexes of each pleat to prevent pleat collapse and filter bowing.





Air Filter Submittal

Project: Central Library - Rare Room
Unit Tag: AHU-1 and AHU-2

Carrier Part Number 31K2C0000001020244
Kit Description .... Filter Kit
Unit Airflow, CFM 15000
Filter Velocity, FPM 450
Filter Sizes and Quantities .... Qty (10) 20in. x 24in.

DFpro

MERV 13 Pleated Filter

The 100% synthetic graduated density media is continuously bonded to a 30 gauge galvanized, corrosion resistant, expanded metal support grid with an effective open area of 96%. The media is resistant to a wide range of chemicals, does not absorb moisture and will not support microbial growth.
The controlled pleat spacing maximizes surface area and dust holding capacity and is bonded to the enclosure frame to prevent dust bypass. The enclosure frame is constructed of high wet strength moisture resistant beverage board. The diagonal support members of the frame are bonded to the entering and exiting apexes of each pleat to prevent pleat collapse and filter bowing.