Lab Exhaust Design Guidelines

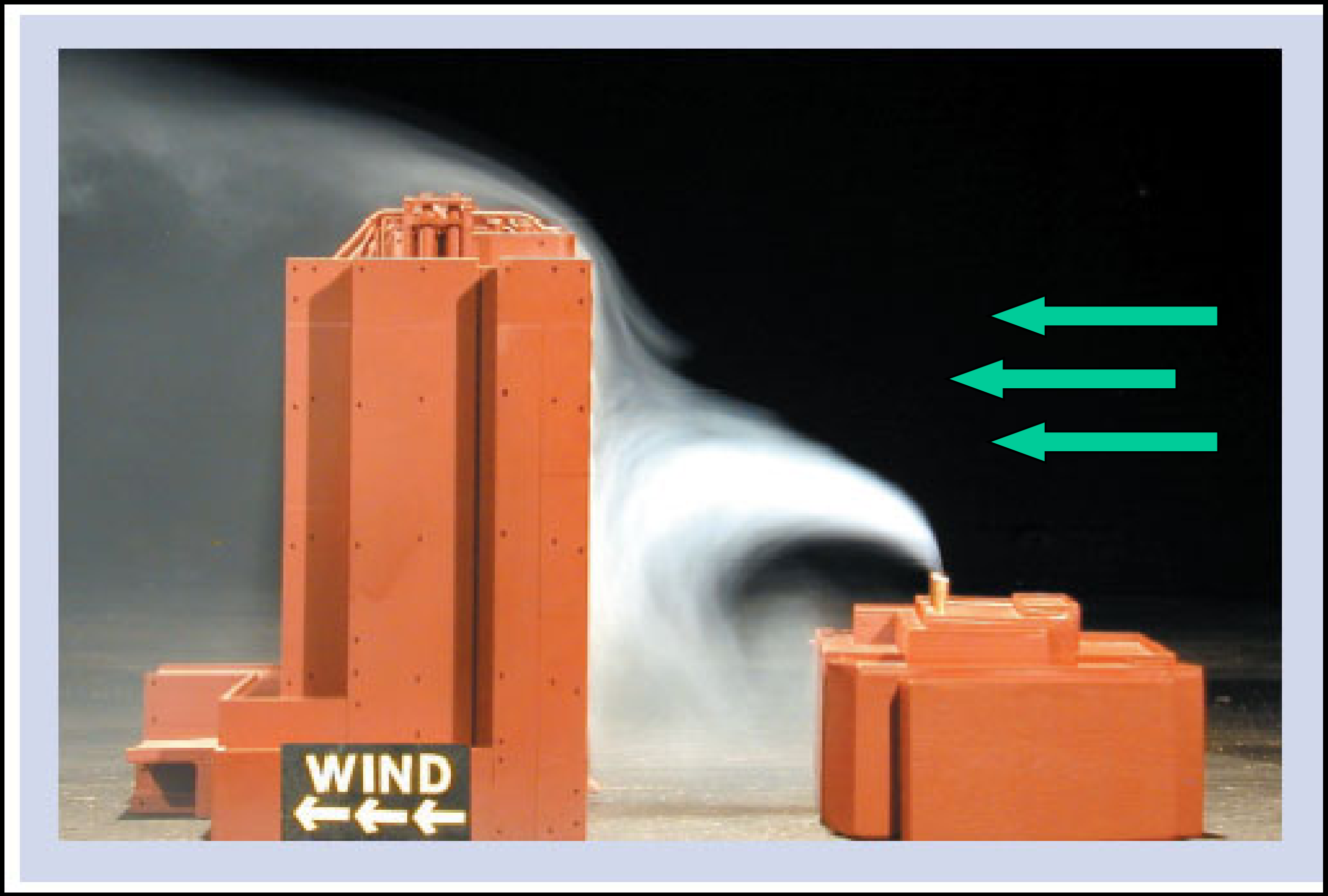


Photo Courtesy of CPP, Ft. Collins, CO

Lab Exhaust Design Guidelines

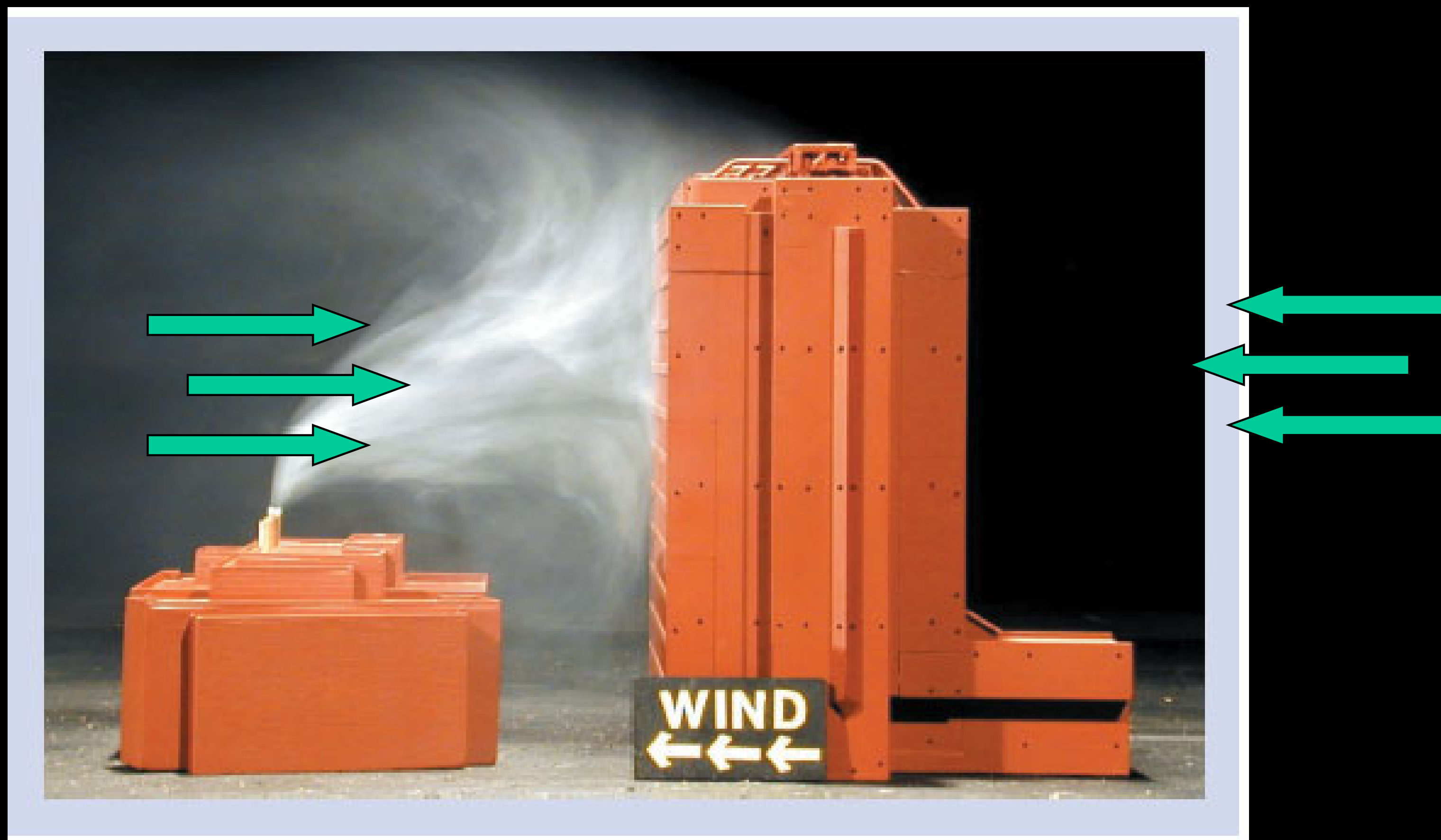
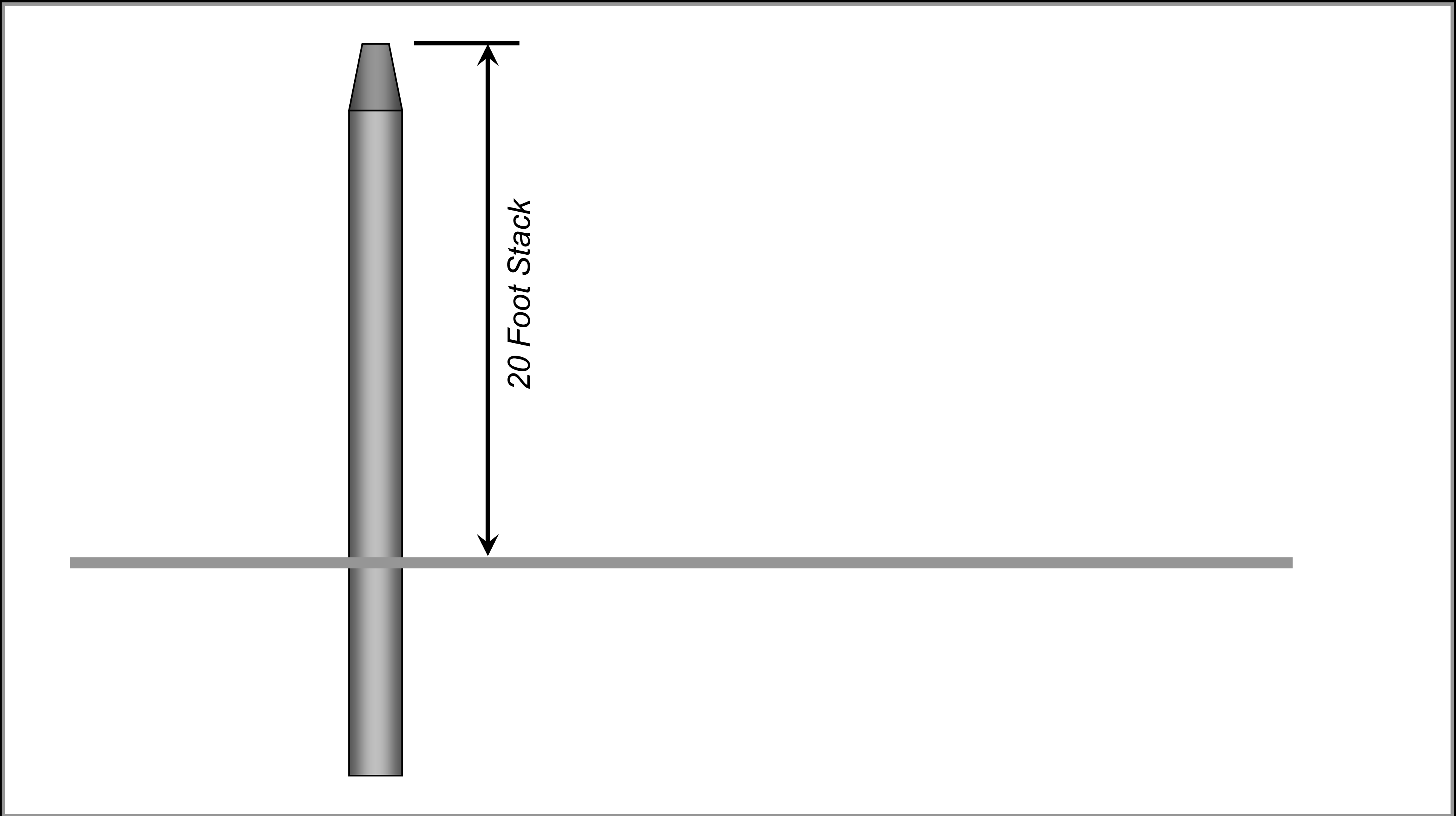
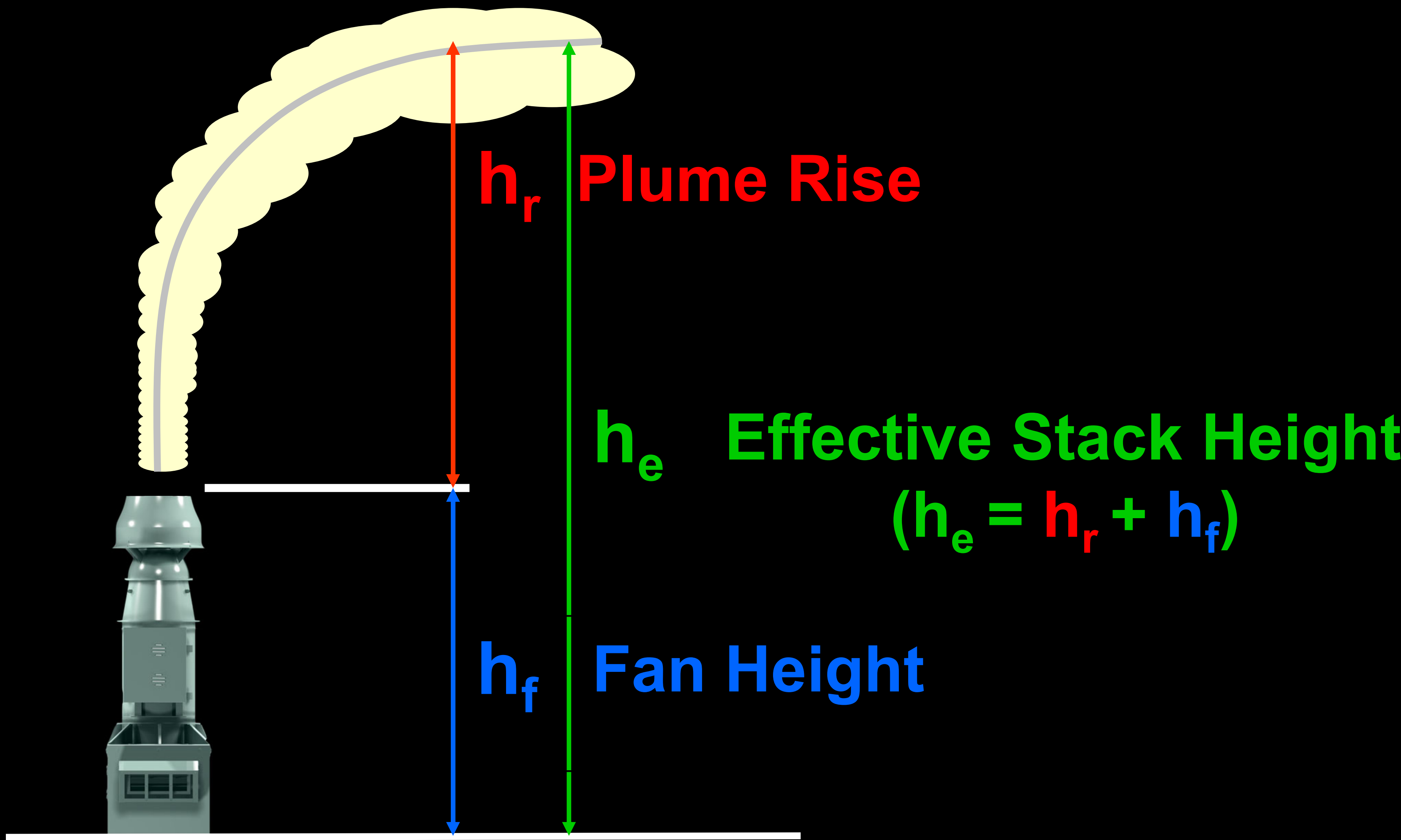


Photo Courtesy of CPP, Ft. Collins, CO


20 Foot Stack

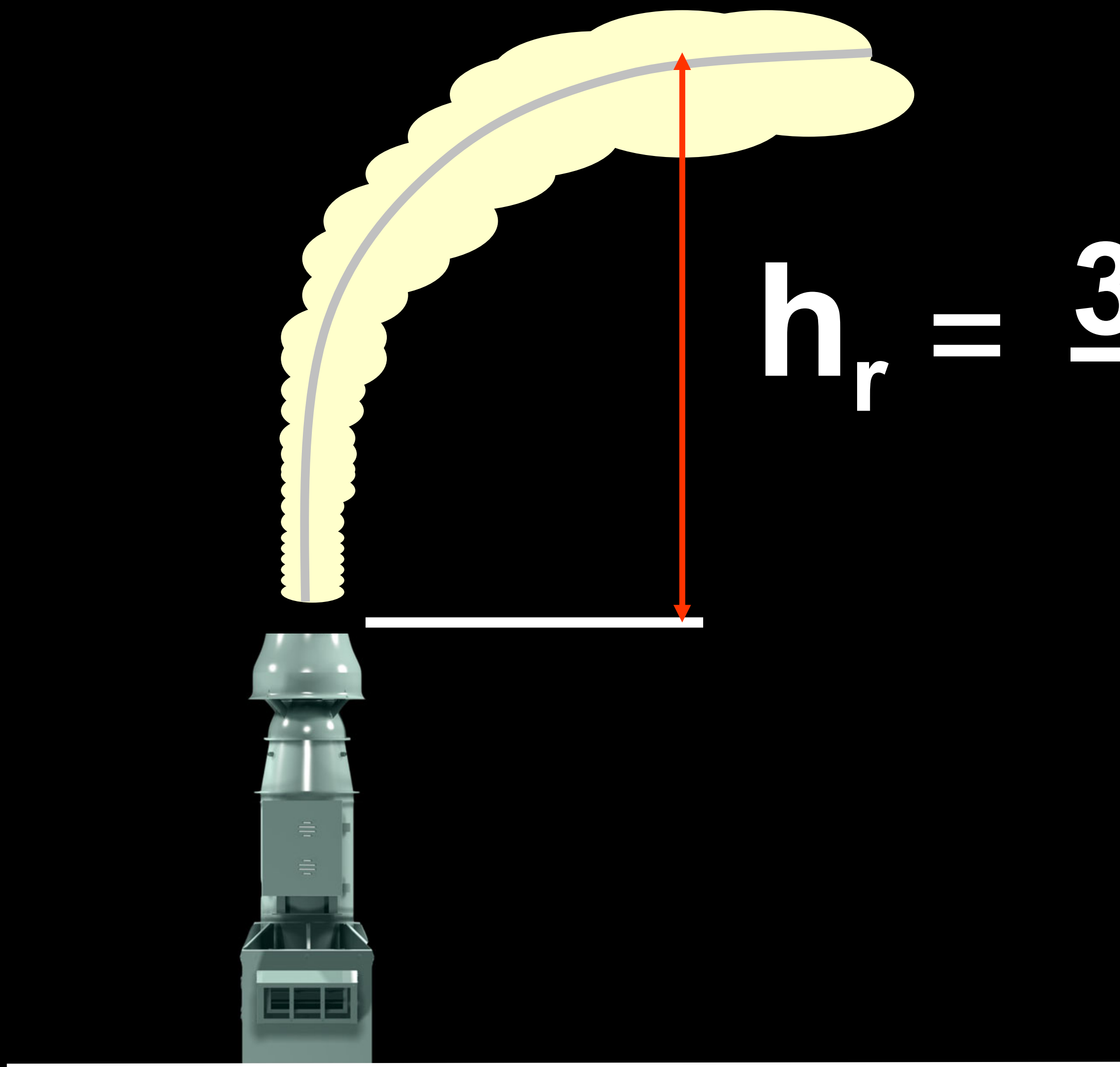
Lab Exhaust Design Guidelines

Effective Stack Height



Lab Exhaust Design Guidelines

(Briggs) Plume Rise , h_r equation



$$h_r = \frac{3Vd}{U}$$

Lab Exhaust Design Guidelines

(Briggs) Plume Rise , h_r equation

$$h_r = \frac{3Vd}{U}$$

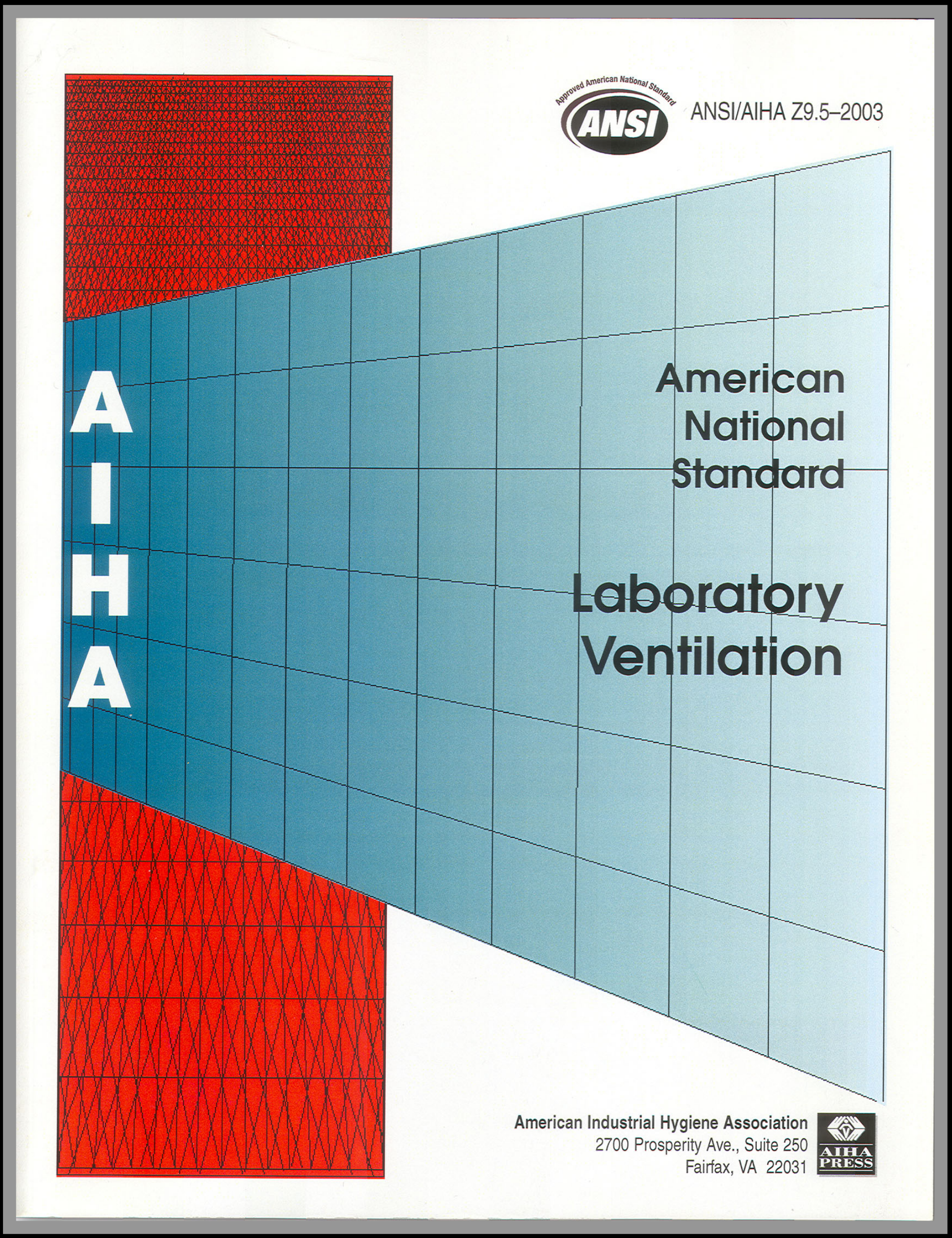
h_r = plume rise, feet

V = discharge velocity, fpm

d = nozzle diameter, feet

U = wind speed, ft/min

Lab Exhaust Design Guidelines



AIHA Z9.5-2003

Endorsed by ANSI

Covers:

- Exhaust System Reliability
- Exhaust Fan Location
- Exhaust Stack Discharge

A minimum discharge velocity of 3000 fpm (15.2 m/s) is required unless it can be demonstrated that a specific design meets the dilution criteria necessary to reduce the concentration of hazardous materials in the exhaust to safe levels (see Section 2.1) at all potential receptors.

Esthetic conditions concerning external appearance shall not supersede the requirements of Sections 5.3.4 and 5.3.5.

A discharge velocity of 2500 fpm (12.7 m/s) prevents downward flow of condensed moisture within the exhaust stack. It is good practice to make the terminal velocity at least 3000 fpm (15.2 m/s) to encourage plume rise and dilution.

These factors affect the dilution of the exhaust stream and the plume trajectory. High discharge velocity and temperature increase plume rise, but high velocity is generally less effective than increased stack height.

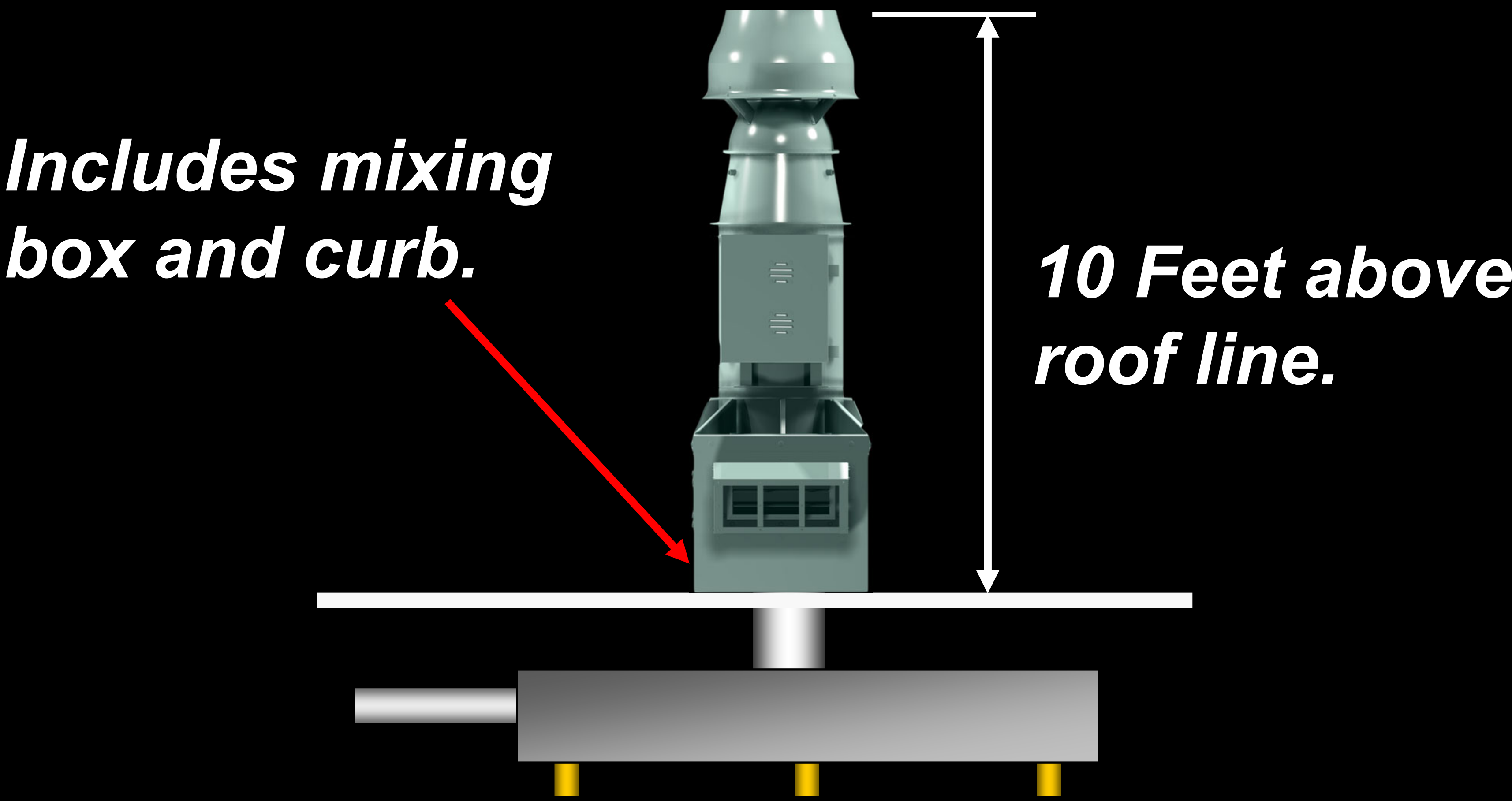
In case there is a conflict, the requirements of Section 5.3.4 take priority. Some solutions that may be used are:

ANSI/AIHA Z9.5–2003

In any event the discharge shall be a minimum of 10 ft (3 m) above adjacent roof lines and air intakes and in a vertical up direction.

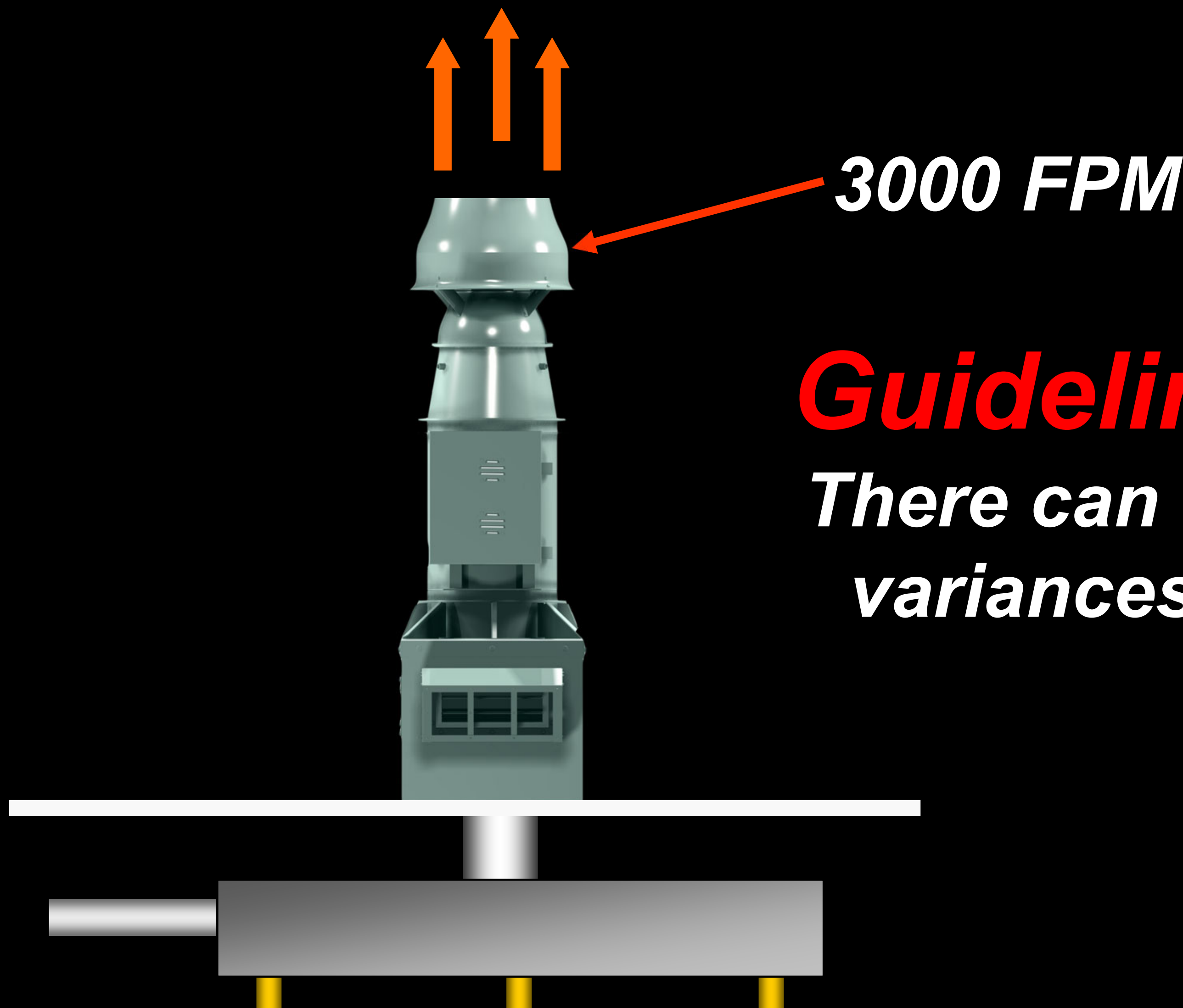
The 10 ft (3 m) height above the adjacent roof line called for by this standard is primarily intended to protect maintenance workers from direct exposure from the top of the stack. However, this minimum 10 ft (3 m) height may be insufficient to guarantee that harmful contaminants won't enter the outside air intake of the building or of nearby buildings.

Lab Exhaust Design Guidelines



Stack height shall not be less than 10 feet above roof line.

Lab Exhaust Design Guidelines



Guideline

There can be variances!

Minimum stack discharge velocity = 3000 FPM.

“High Plume” Lab Fans

Most commonly used on lower exhaust hazards…

Middle / High Schools, Community Colleges, Research Facilities without high hazard exhaust…

Primarily used to eject adverse smells and mild chemical irritants…

“High Plume” Lab Fans

These style units only eject the volume of air which flows through the fan…

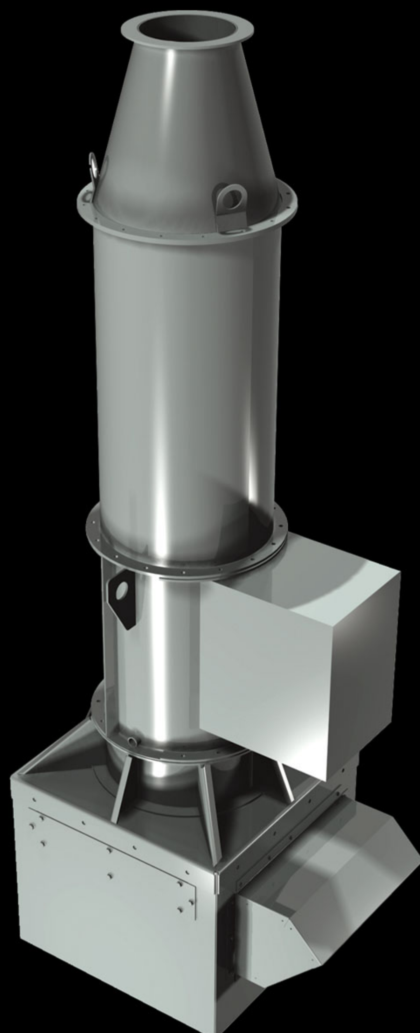
There is no “entrainment” of additional volume of air at the discharge…

These style units are also subject to more wind effects and less dilution of hazardous exhaust per CFM per horsepower than with a High Plume / Dilution unit…

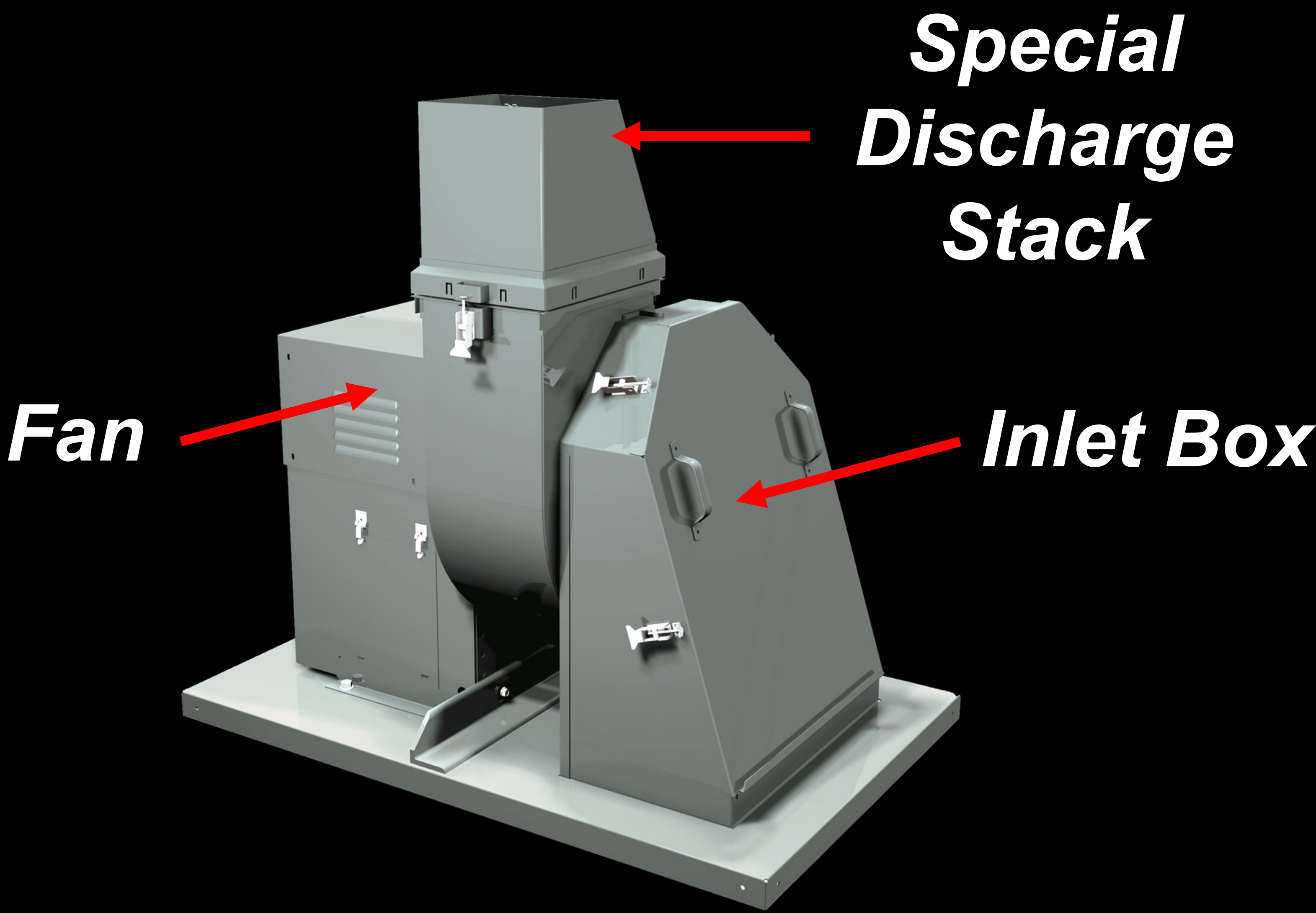
“High Plume” Lab Fans

Small Laboratory

Stack and Inlet Box



Utility Set



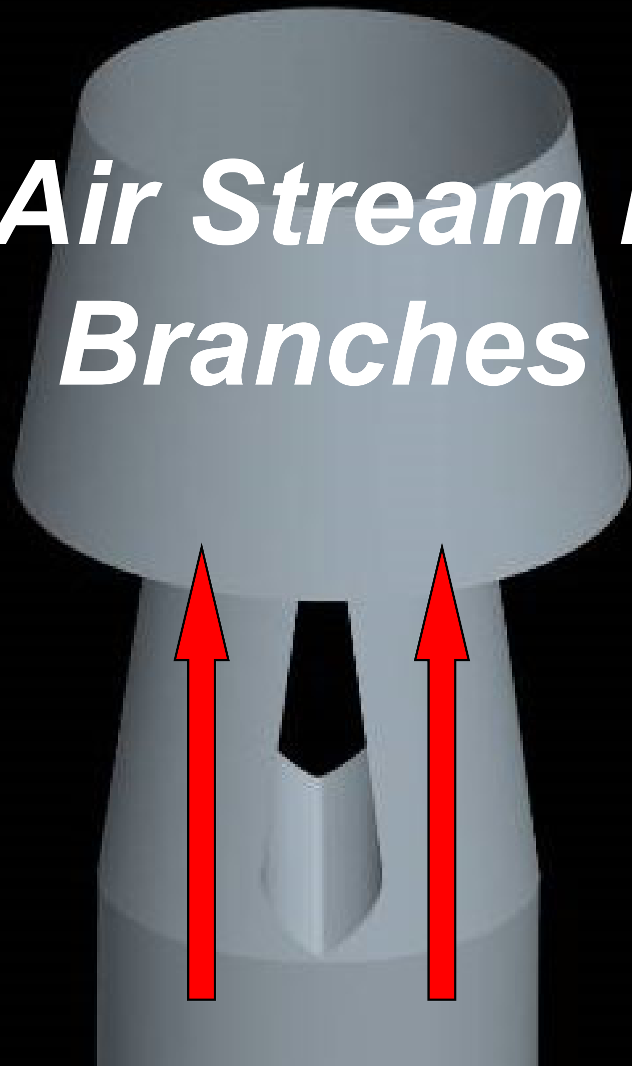
High Plume / Dilution Lab Fans

This style unit is used with chemical irritants and high hazard exhausts…

Codes, Guidelines, OSHA and fear of lawsuits normally dictate their use…

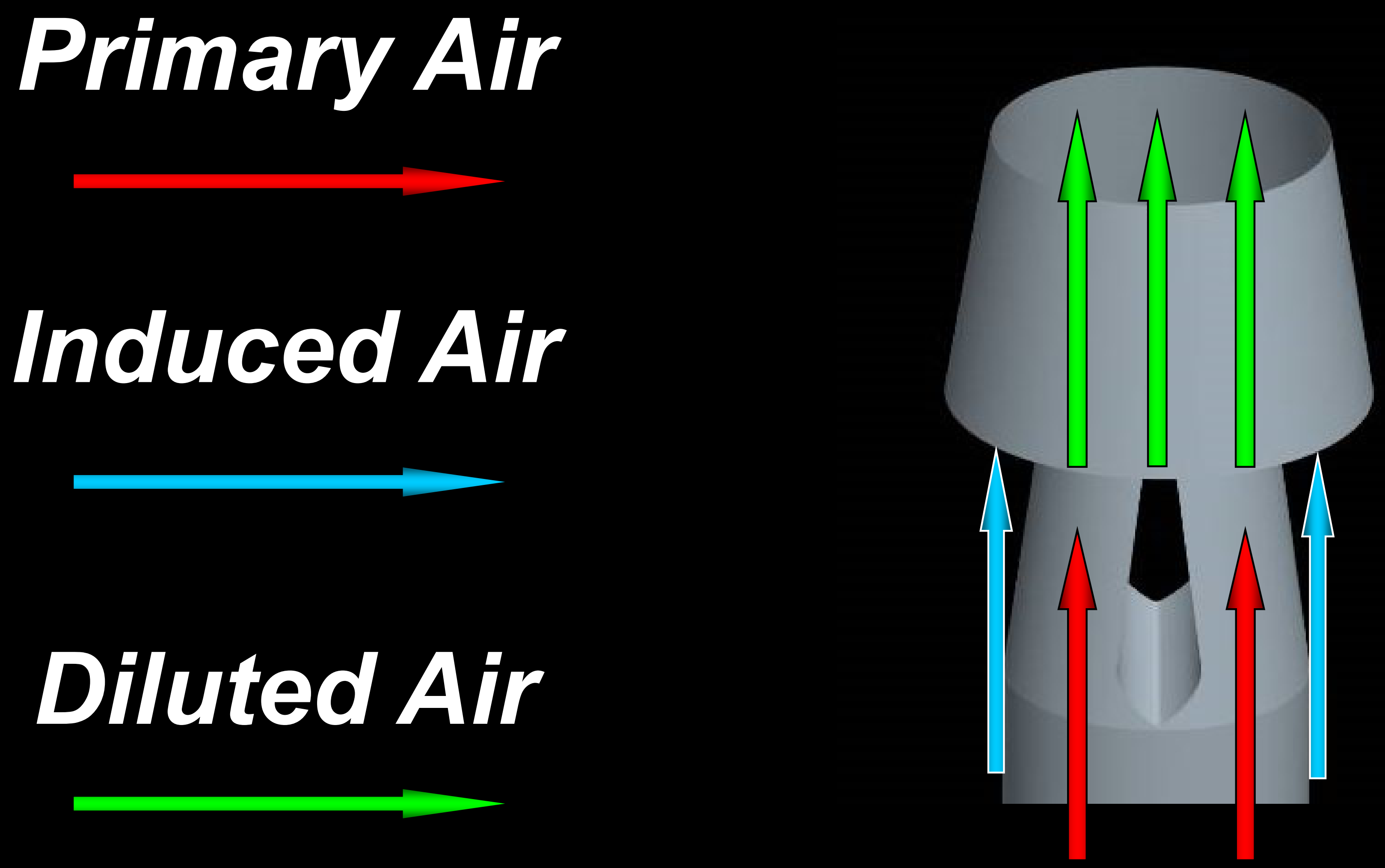
Large Research Laboratory

Dividing the Air Stream into Two Branches

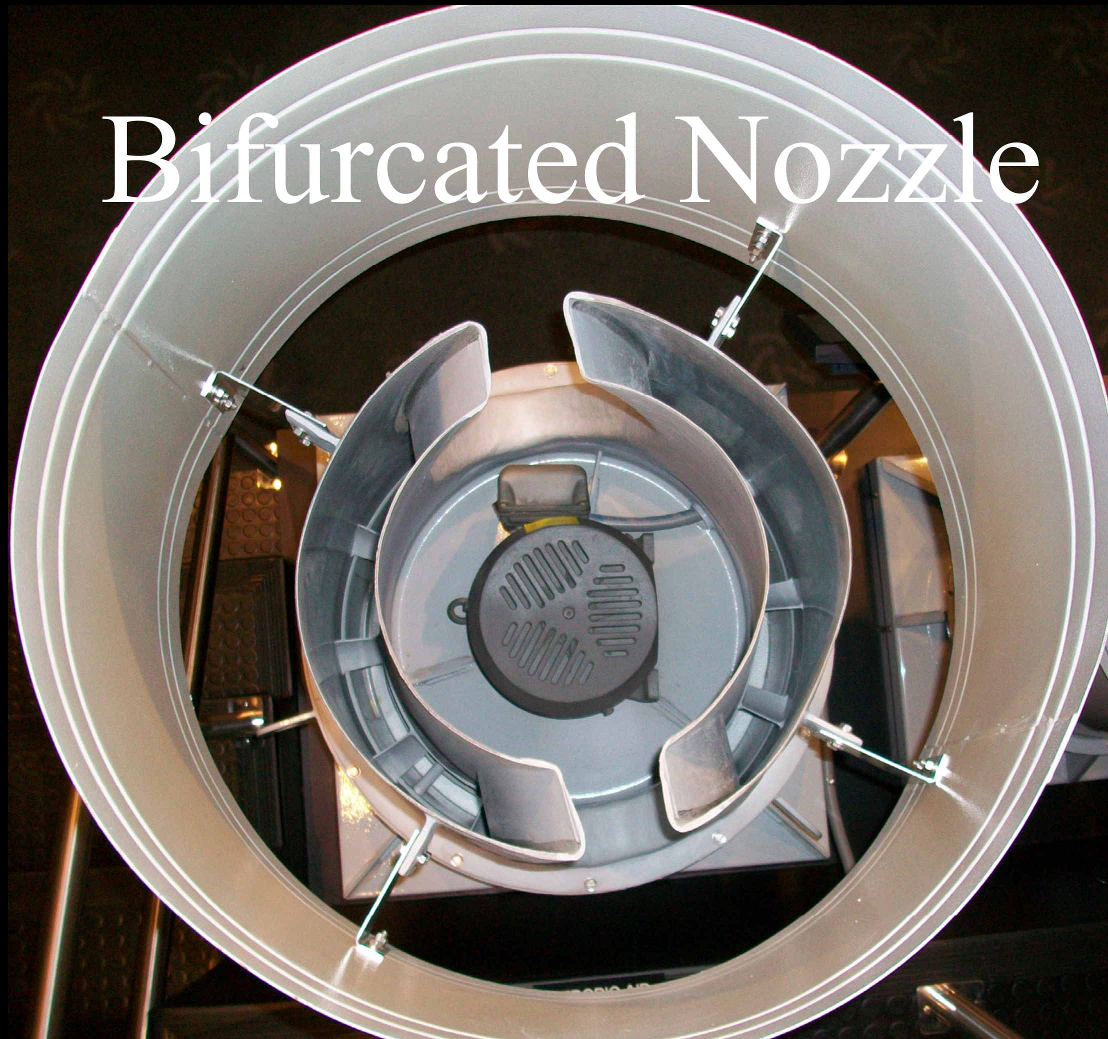


Bifurcated

Bifurcated Nozzle Study

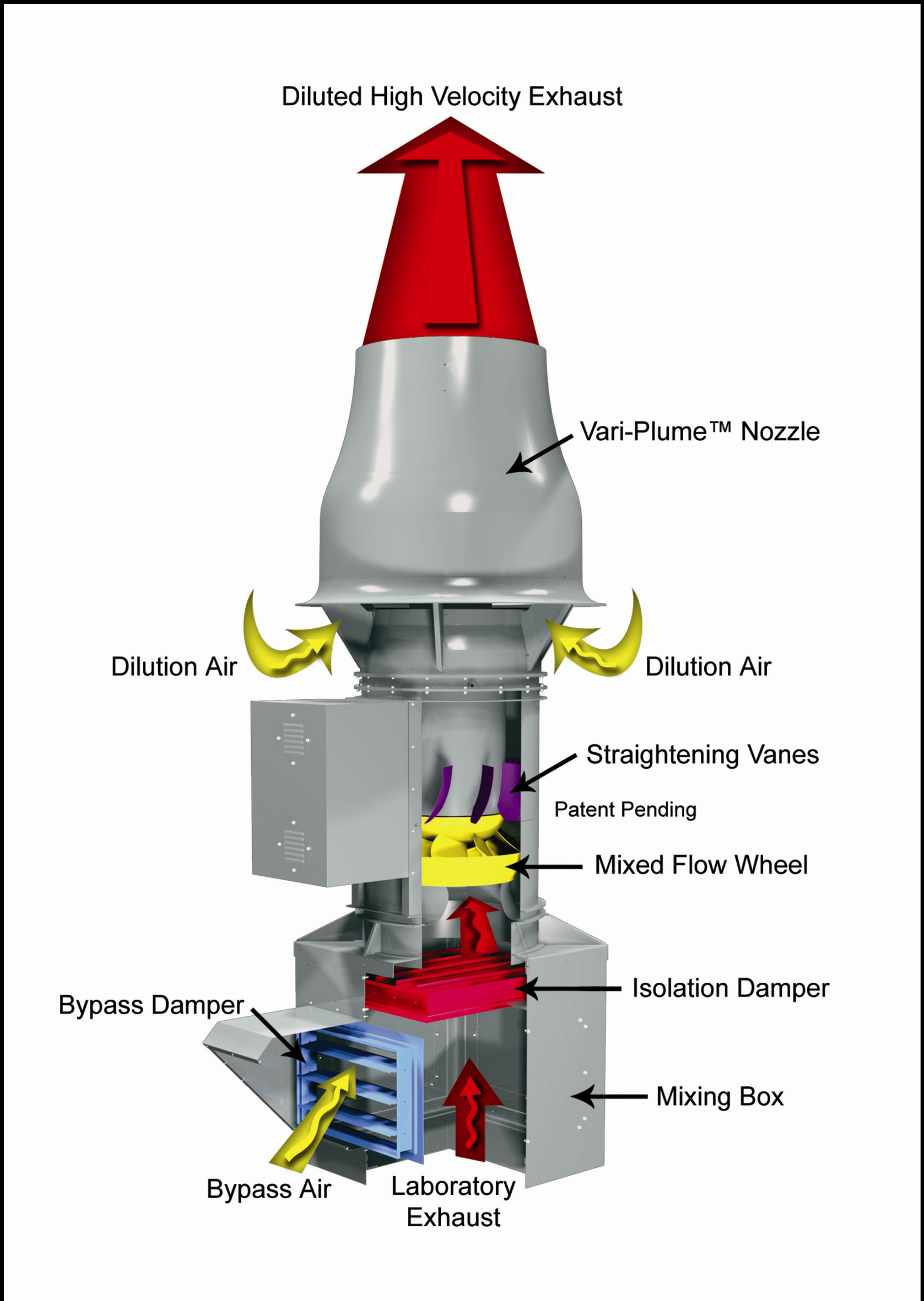


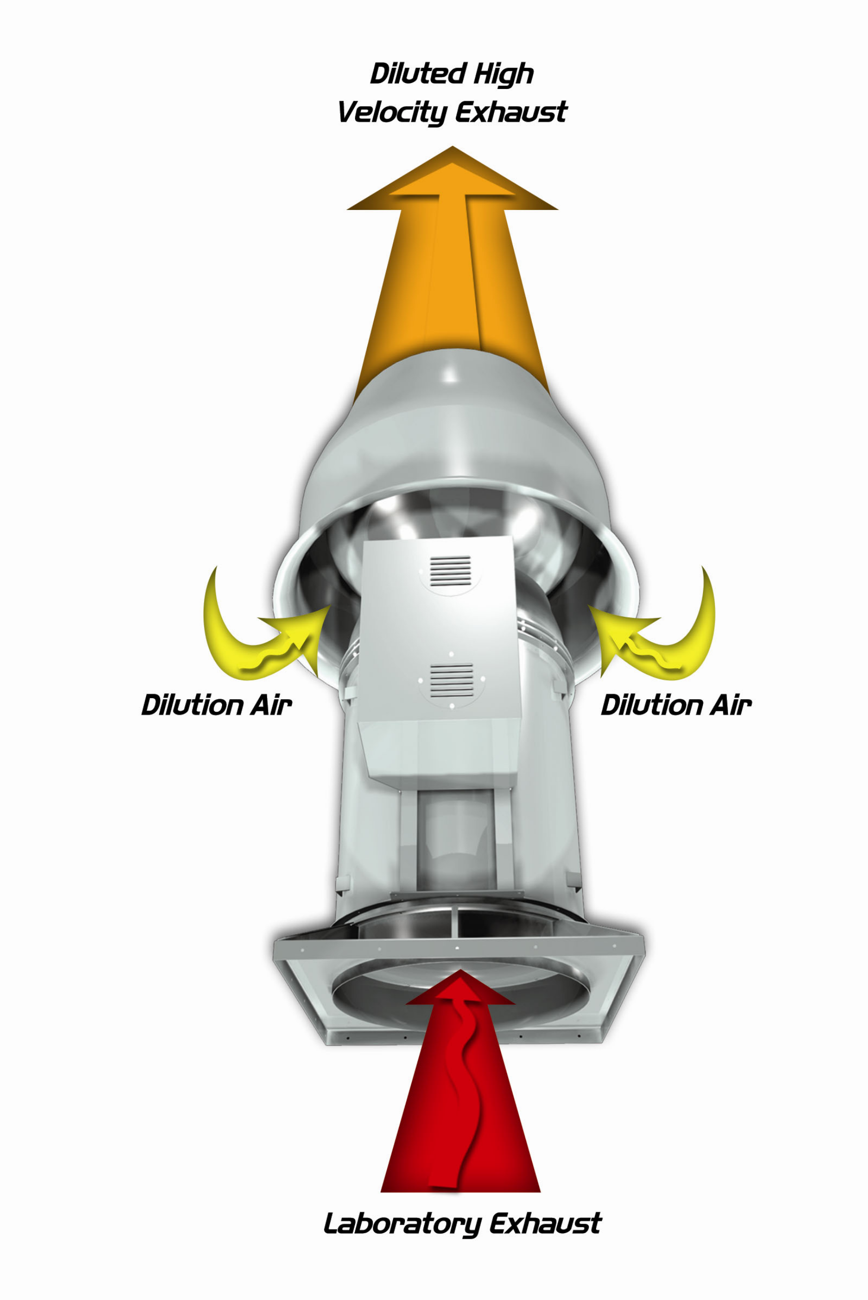
Bifurcated Nozzle



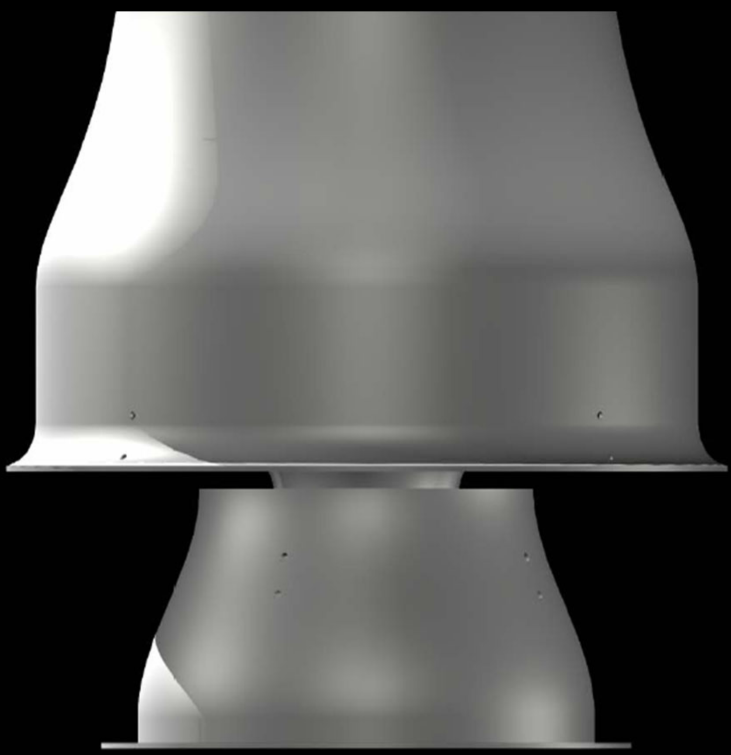
Concentric Nozzle

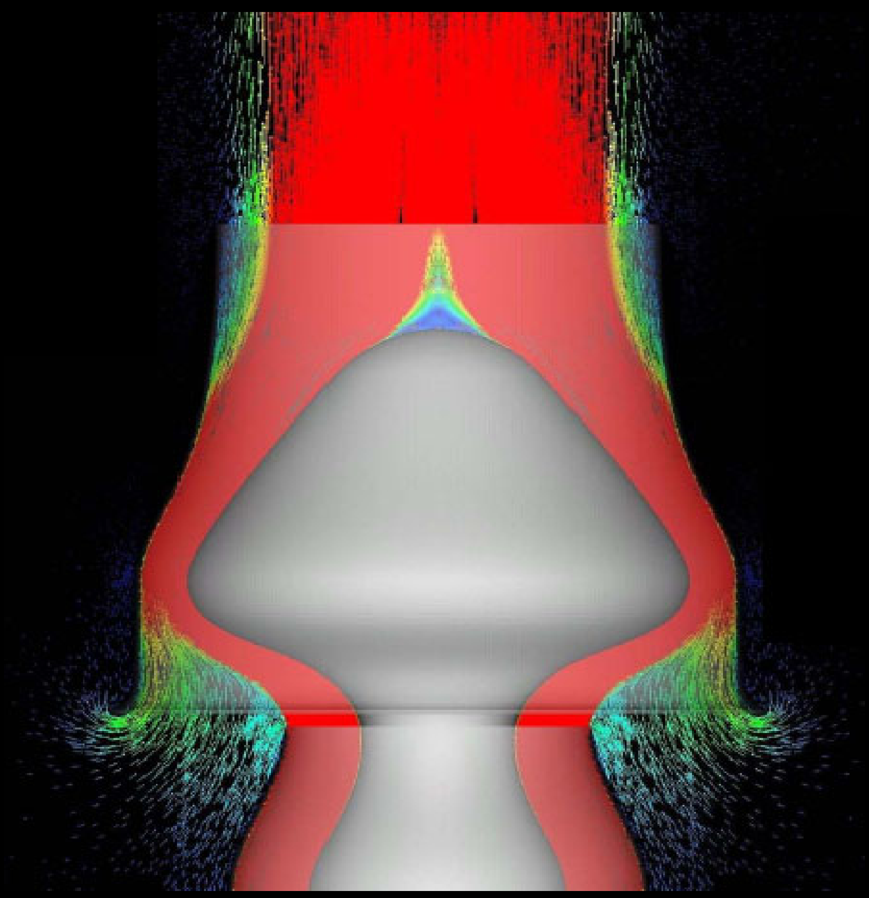
Lab Fan Discharge


Diluted High Velocity Exhaust
Vari-Plume™ Nozzle
Dilution Air
Dilution Air
Straightening Vanes
Patent Pending
Mixed Flow Wheel
Isolation Damper
Bypass Damper
Mixing Box
Bypass Air
Laboratory
Exhaust

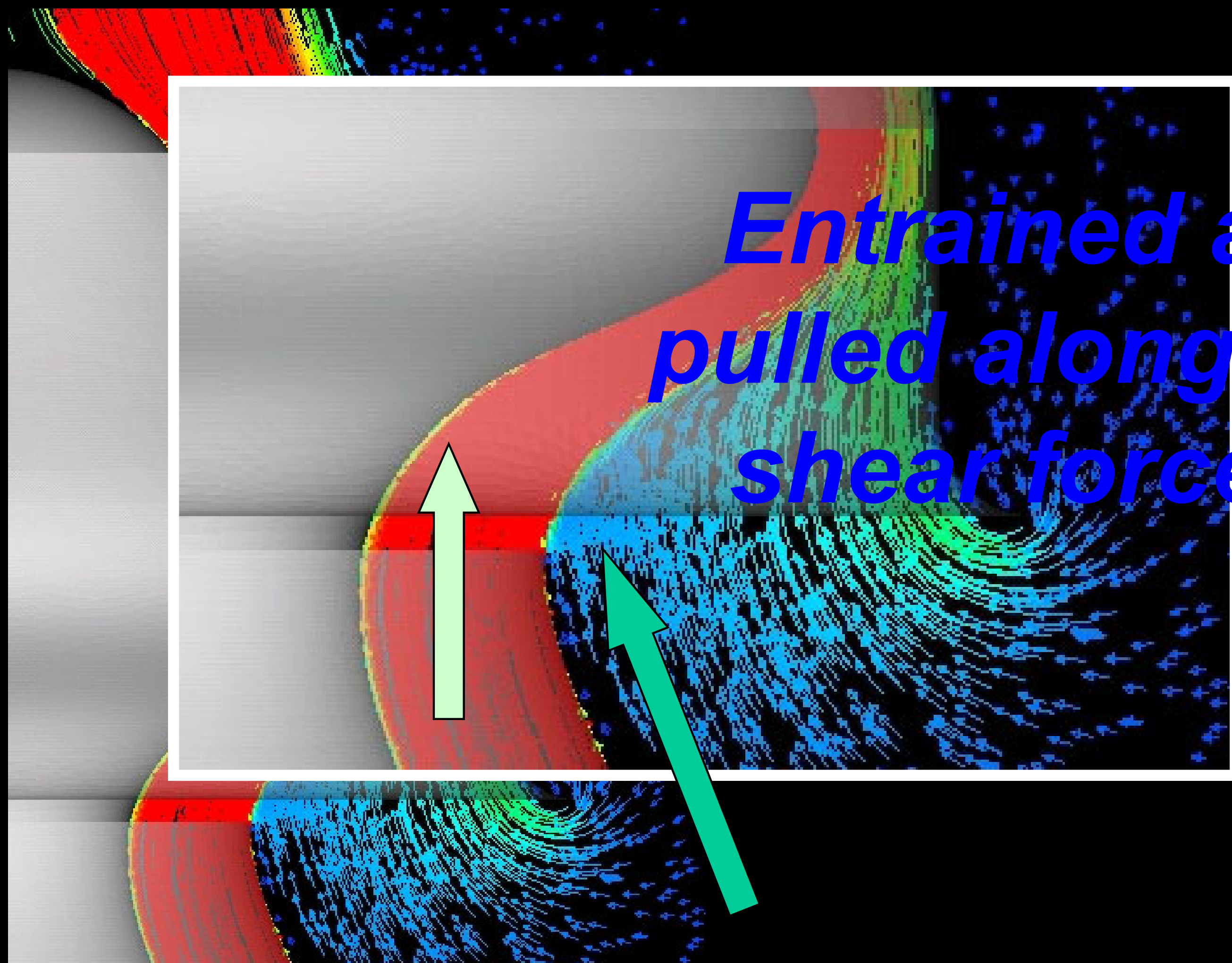

Diluted High
Velocity Exhaust
Dilution Air
Dilution Air
Laboratory Exhaust

Entrainment Characteristics

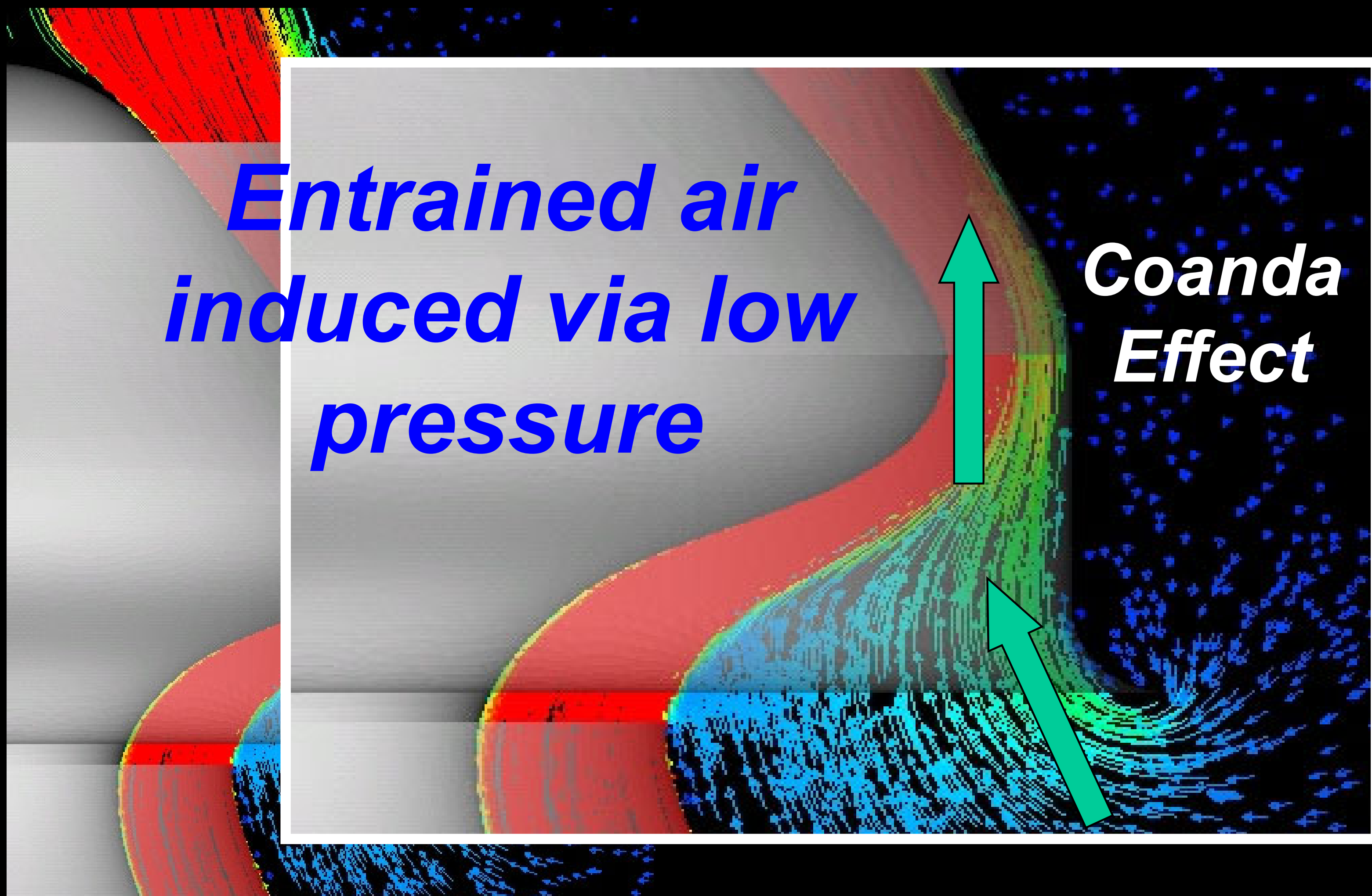




Entrainment Characteristics



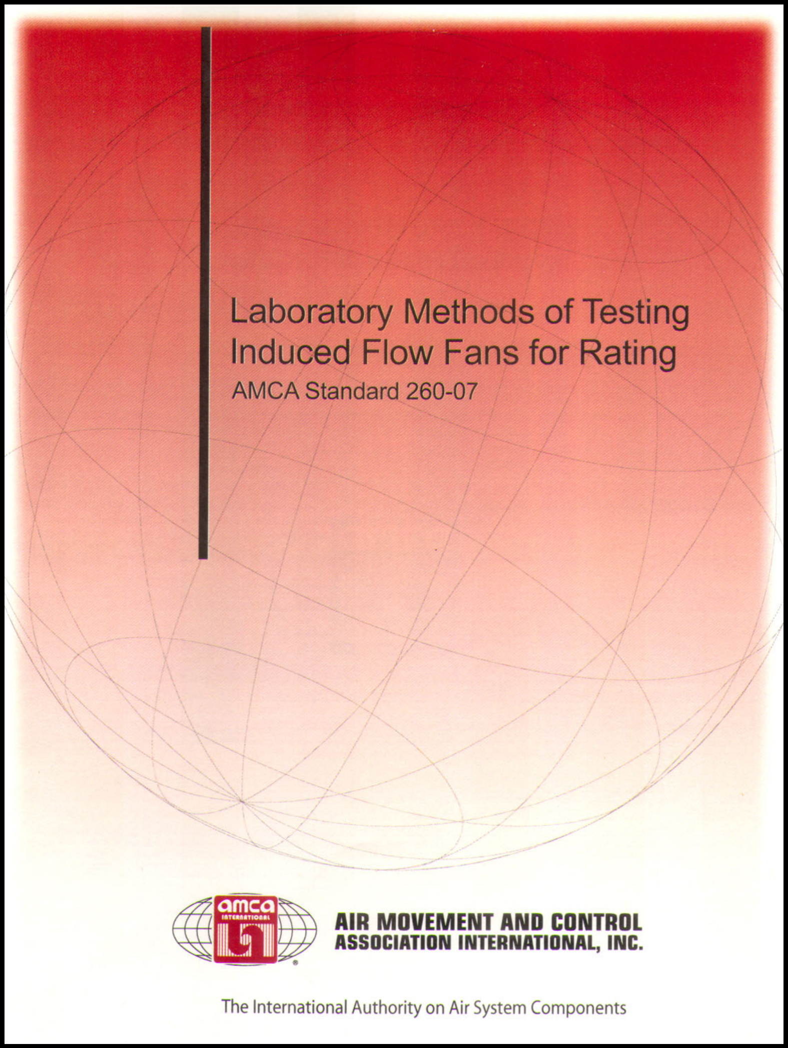
Entrainment Characteristics



Multiple Lab Fans on common plenum

Induced Flow Certification

AMCA Certified Ratings Program



Induced Flow Certification

AMCA Standard 260

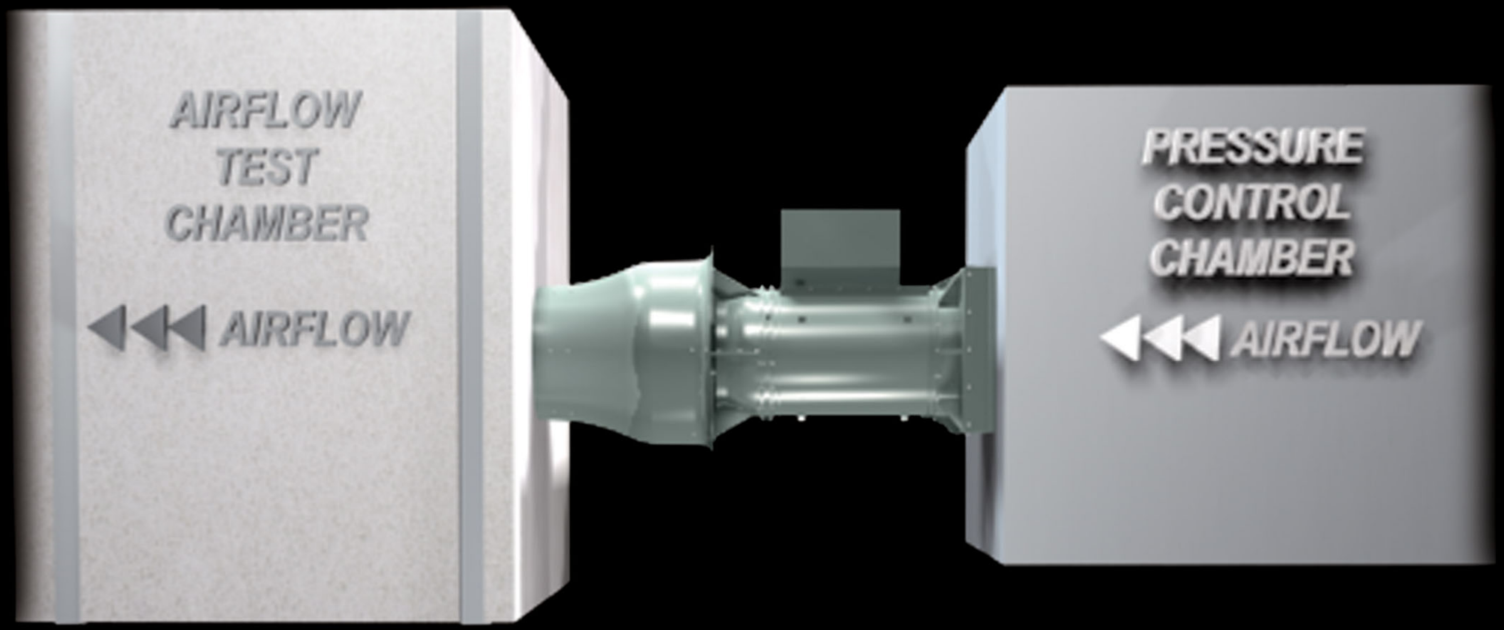
Setup #1

This test determines inlet airflow (CFM), inlet SP, RPM and HP.

Induced Flow Certification

AMCA Standard 260

Setup #2

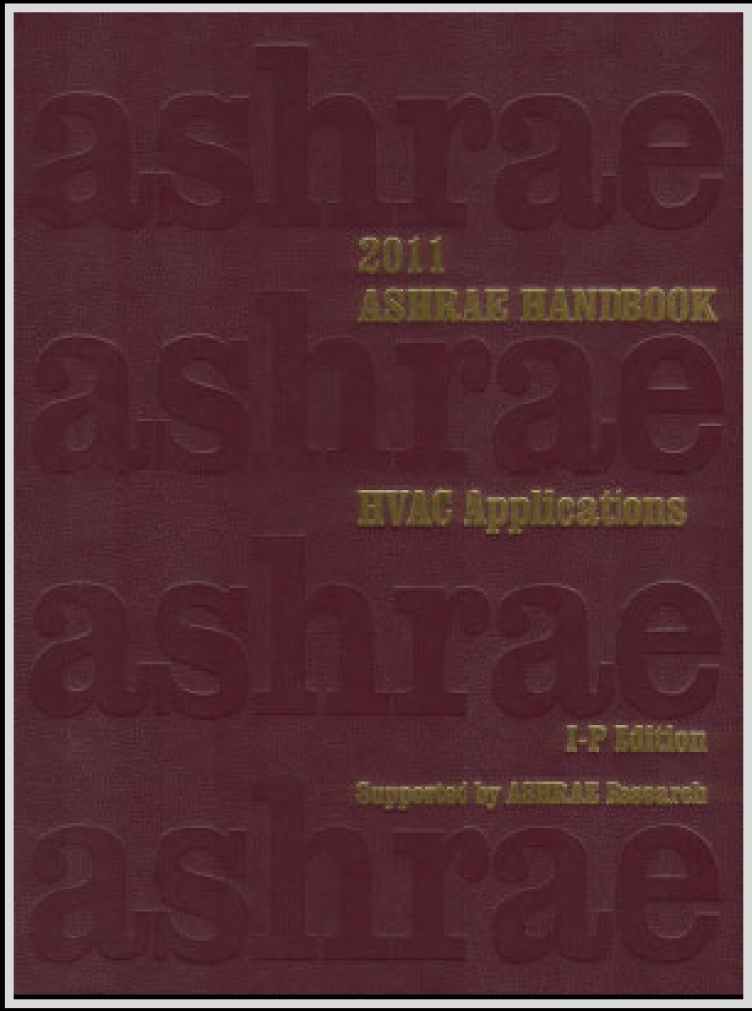


This test determines the outlet airflow (CFM).
Tested at the inlet SP conditions measured in test Setup #1.

Fan with tapered discharge

Fan with Entrainment Discharge

ASHRAE 2019 Guideline



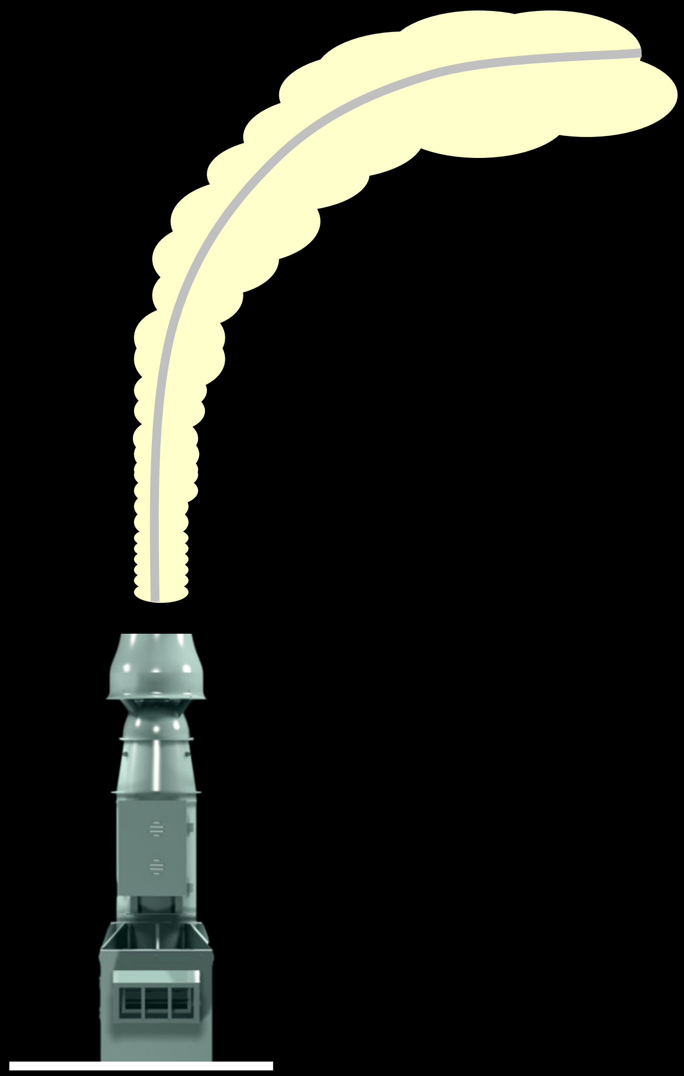
ASHRAE 2019 Chapter 45

ASHRAE 2019 Guideline

New Focus: Terrain Category

Terrain Category	
1 Flat, Water, Desert	0.03
2 Flat, Airport, Grassland	0.16
3 Suburban	2.10
4 Urban	6.00

ASHRAE 2019 Guideline



Terrain Category 1:

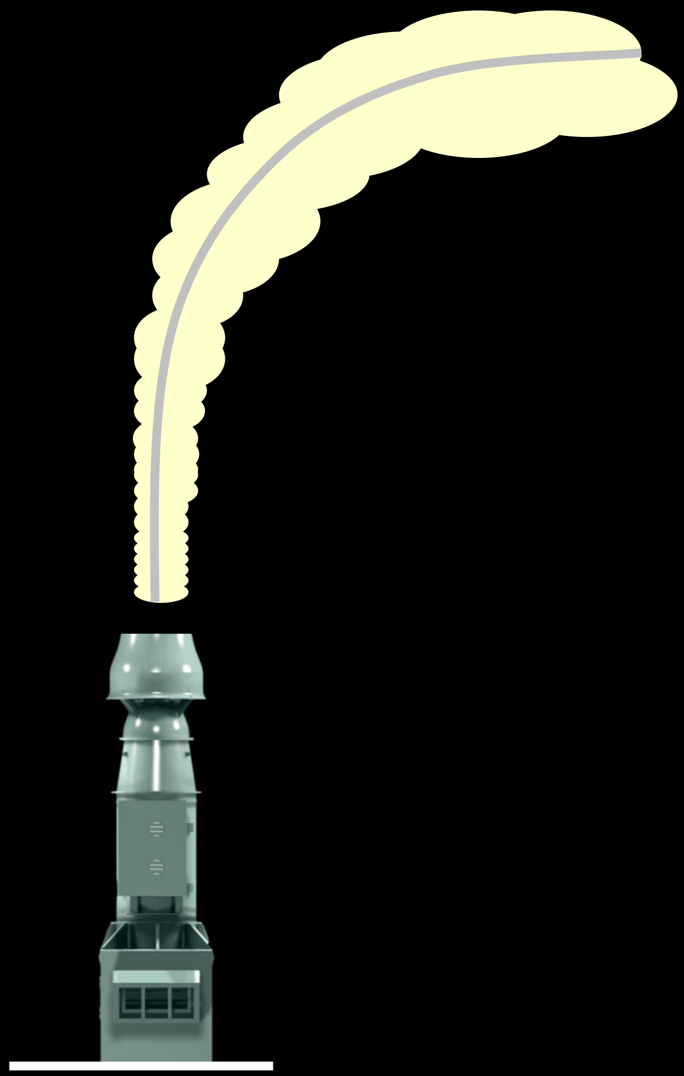
Flat, Water ,Desert

Wind band Outlet Airflow (CFM)	15,000	
Wind band Outlet Velocity (FPM)	3,000	(ANSI Z9.5)
Wind speed (MPH)	10	
Building Height (FT)	20	
Terrain Category	1	(ASHRAE 2019)

Plume Rise **(Does Not Include Building Height)**

2019	***24.90 FT***
2007	***25.80 FT***

ASHRAE 2019 Guideline



Terrain Category 2:

Flat, Airport, Grassland

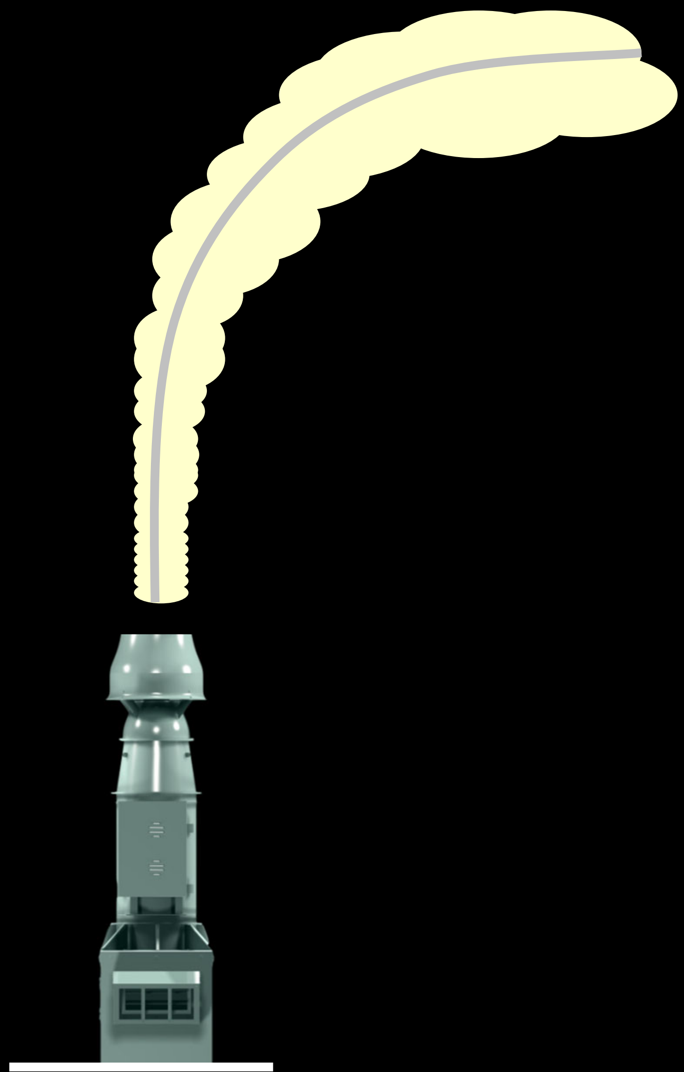
Wind band Outlet Airflow (CFM)	15,000	
Wind band Outlet Velocity (FPM)	3,000	(ANSI Z9.5)
Wind speed (MPH)	10	
Building Height (FT)	20	
Terrain Category	2	(ASHRAE 2019)

Plume Rise (Does Not Include Building Height)

2019 21.46 FT

2007 25.80 FT

ASHRAE 2019 Guideline



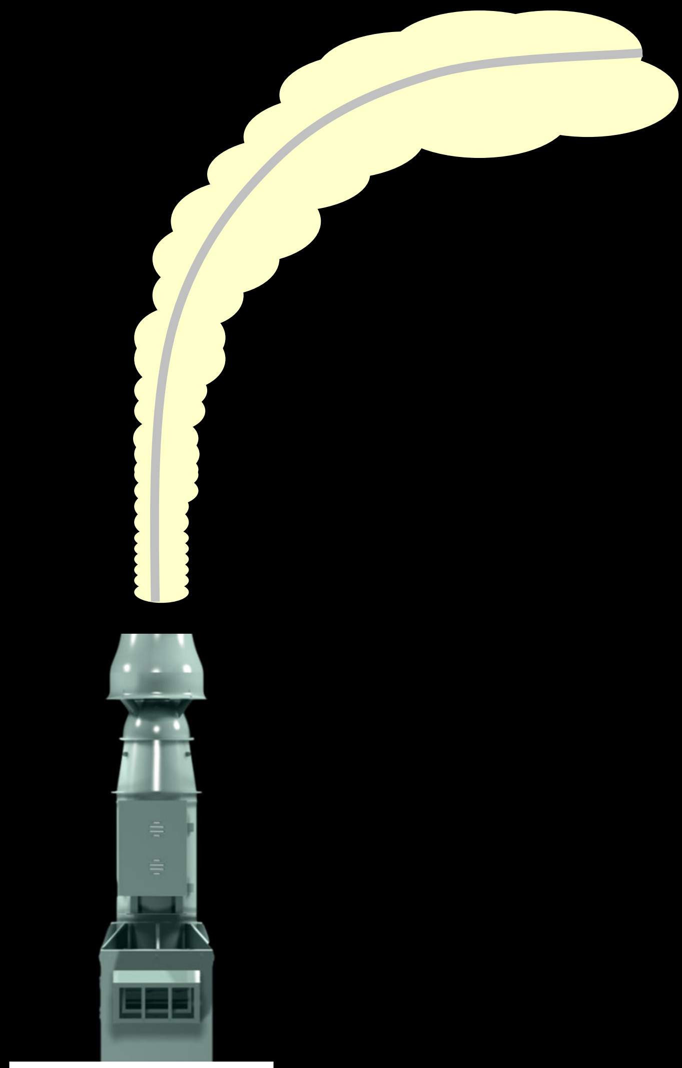
Terrain Category 3:
Suburban

Wind band Outlet Airflow (CFM)	15,000	
Wind band Outlet Velocity (FPM)	3,000	(ANSI Z9.5)
Wind speed (MPH)	10	
Building Height (FT)	20	
Terrain Category	3	(ASHRAE 2019)

Plume Rise (Does Not Include Building Height)

2019	**14.66 FT**
2007	**25.80 FT**

ASHRAE 2019 Guideline



Terrain Category 4:
Urban

Wind band Outlet Airflow (CFM)	15,000	
Wind band Outlet Velocity (FPM)	3,000	(ANSI Z9.5)
Wind speed (MPH)	10	
Building Height (FT)	20	
Terrain Category	4	(ASHRAE 2019)

Plume Rise **(Does Not Include Building Height)**

2019	***10.72 FT***
2007	***25.80 FT***

Lab Exhaust Fans

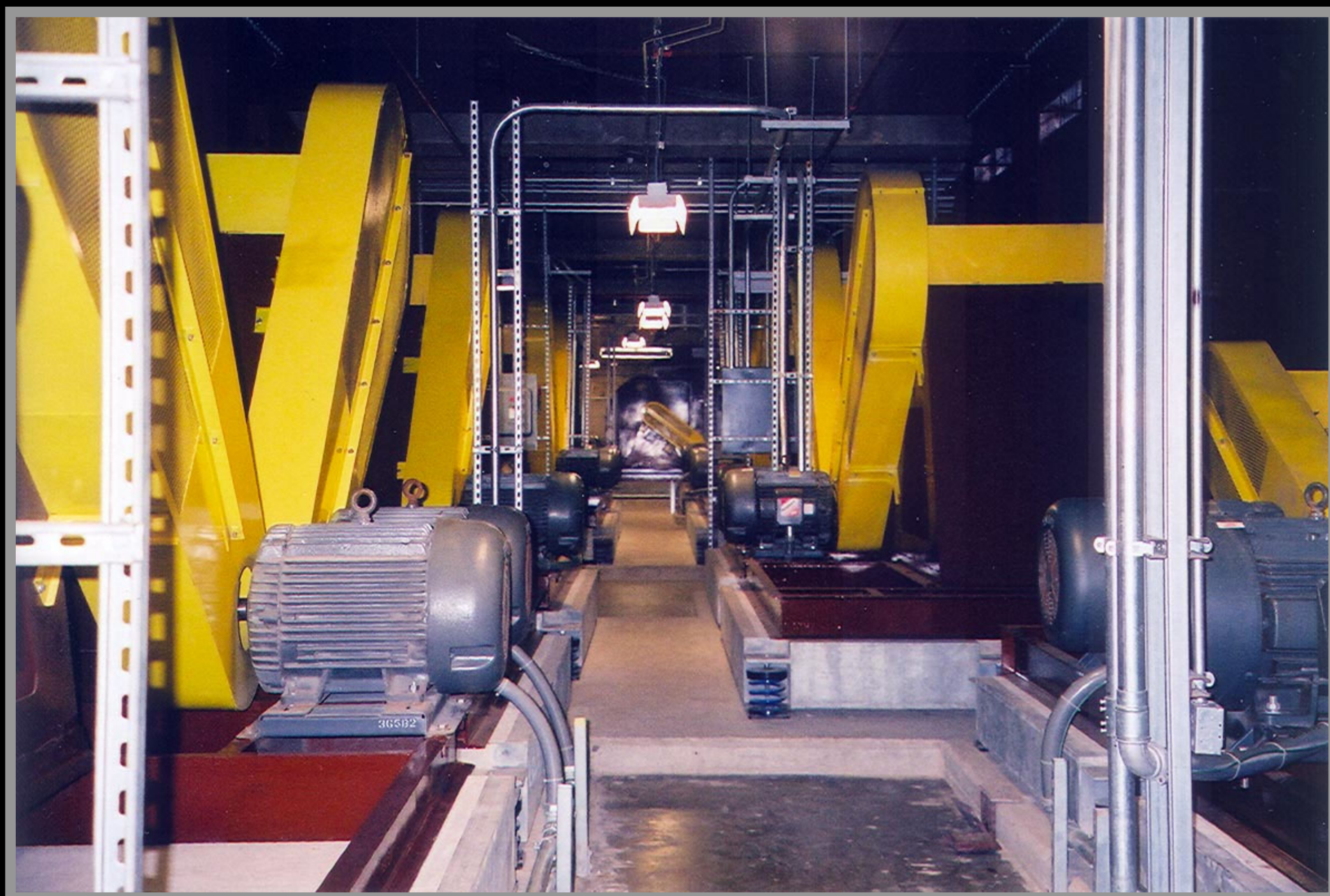


Photo Courtesy of Sutton Group, Houston, TX

Lab Exhaust Fans


Photo Courtesy of Sutton Group, Houston, TX

CA-SWSI

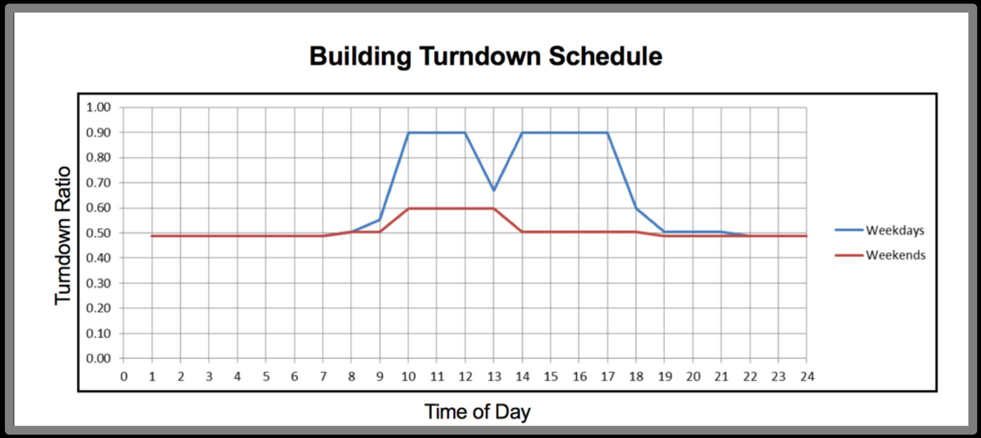
- Isolation Base
- Inertia Base
- OSHA Belt Guard
- Indoor Installation
- Phenolic Epoxy

Requirements:

- Specified Plume
(ASHRAE 2011 Calculations)

- Dilution Requirement

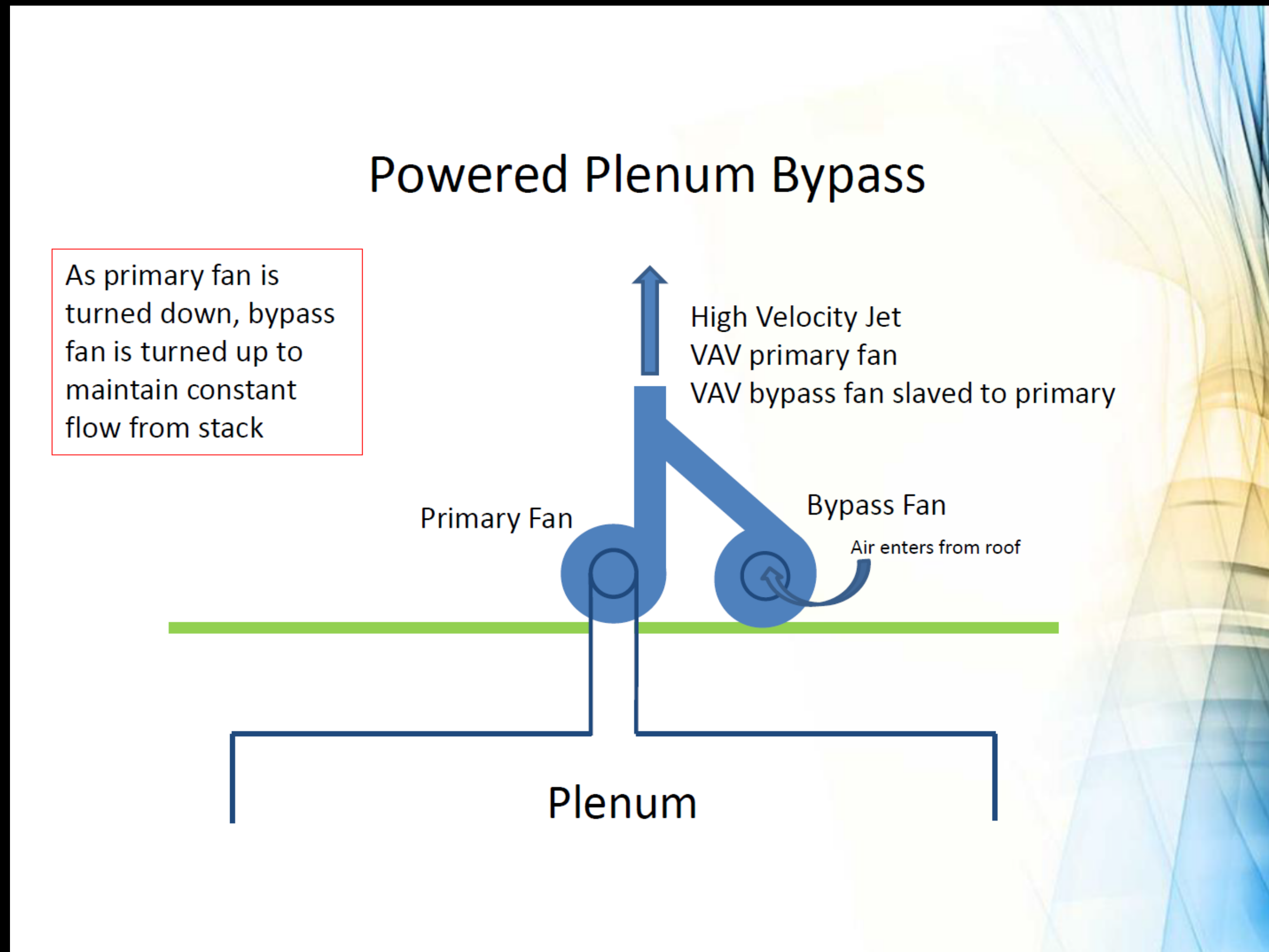
- Lab Turn Down Schedule



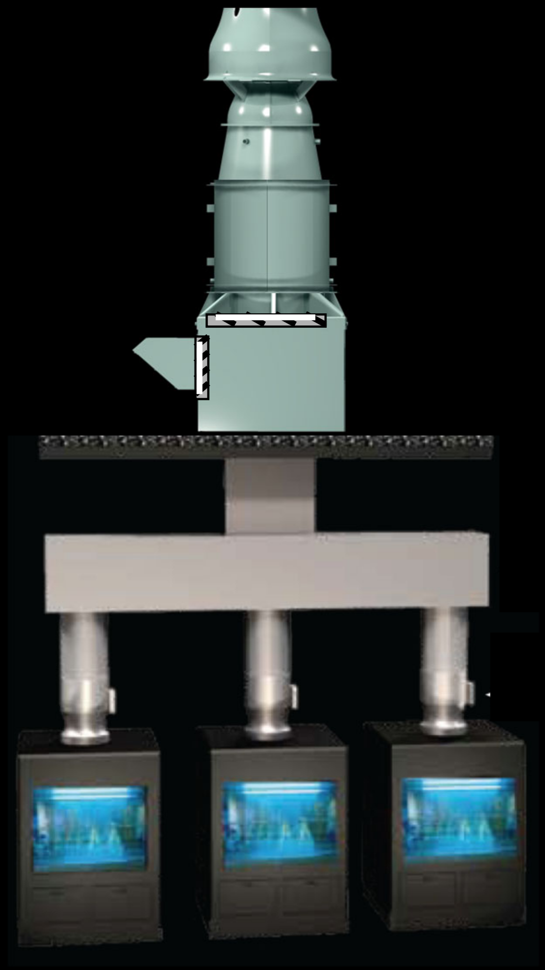
"Powered Induction for Energy Savings"

Energy Efficient

Power Plume

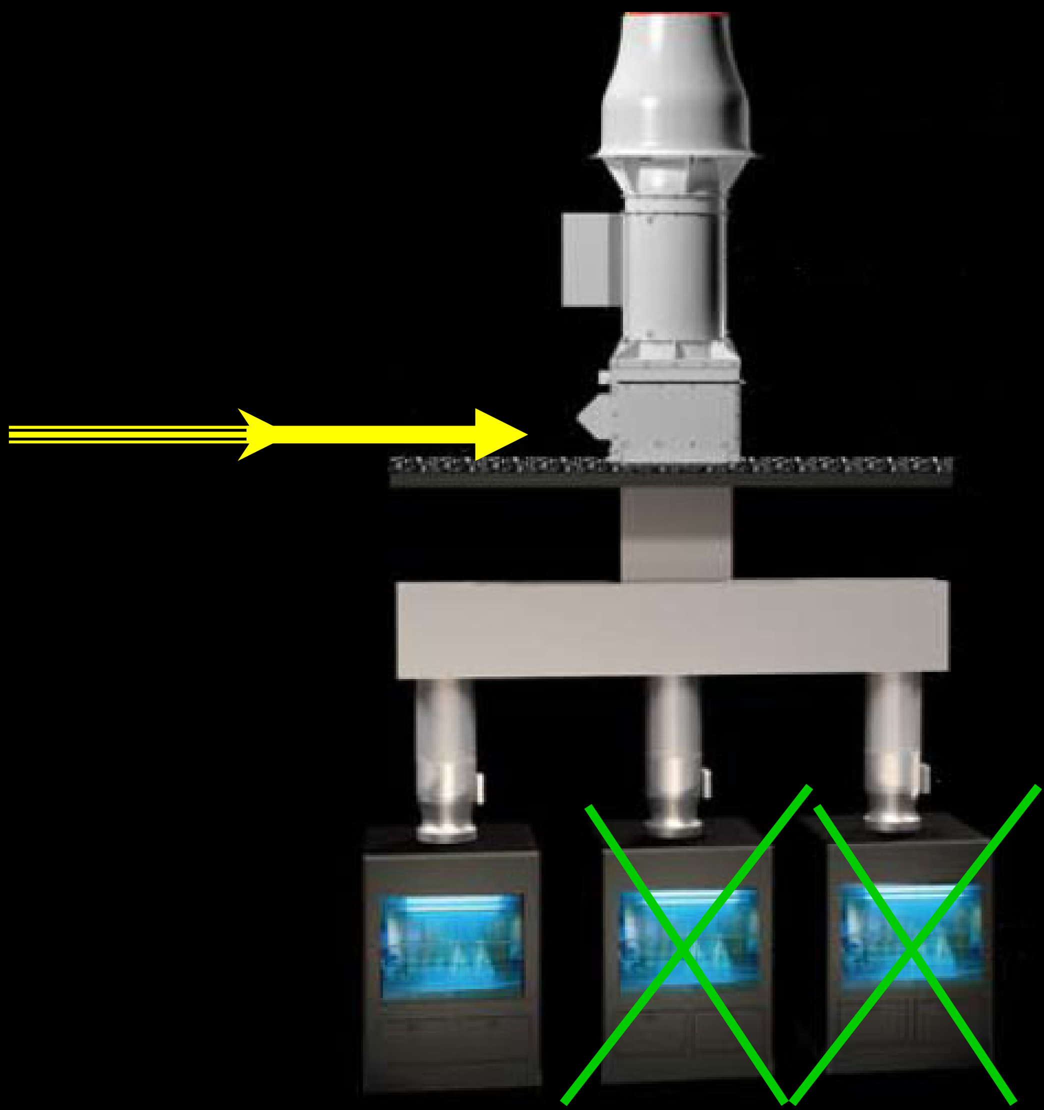


Energy savings with a two fan lab system……..

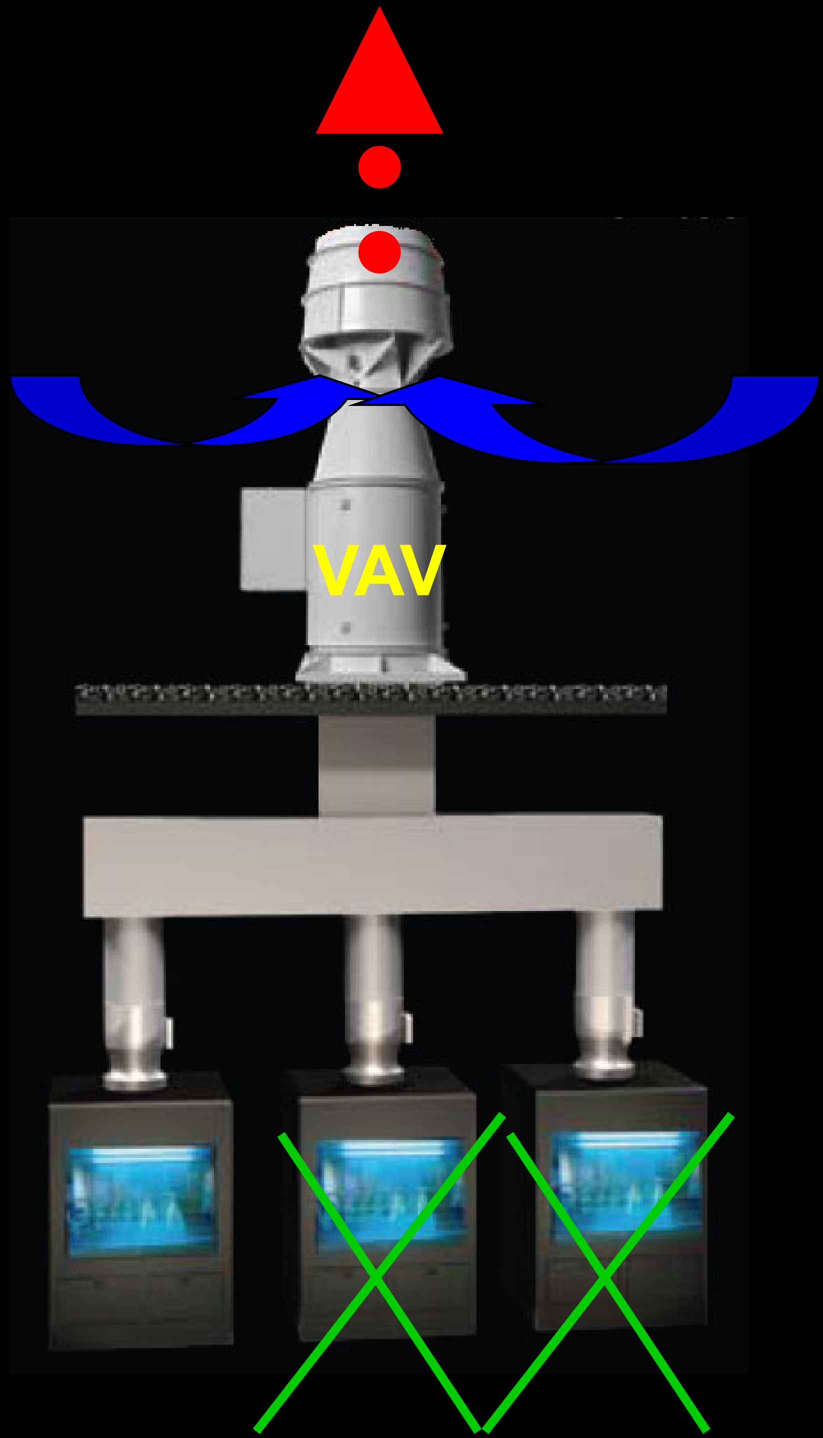


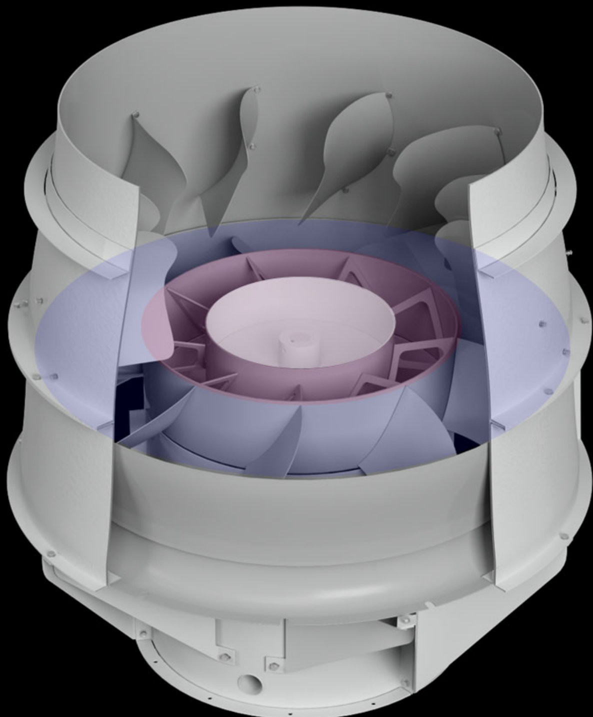
- *Energy Efficient Alternative to Induced Flow Lab Systems*

Typical Induced Flow

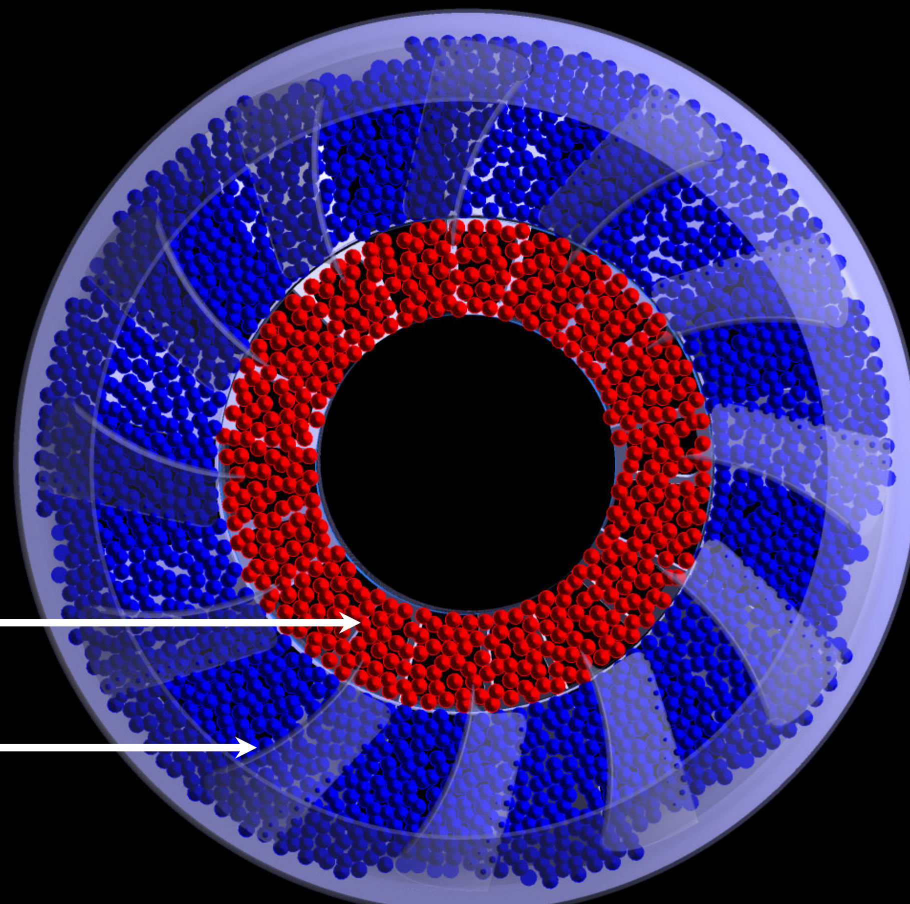


®

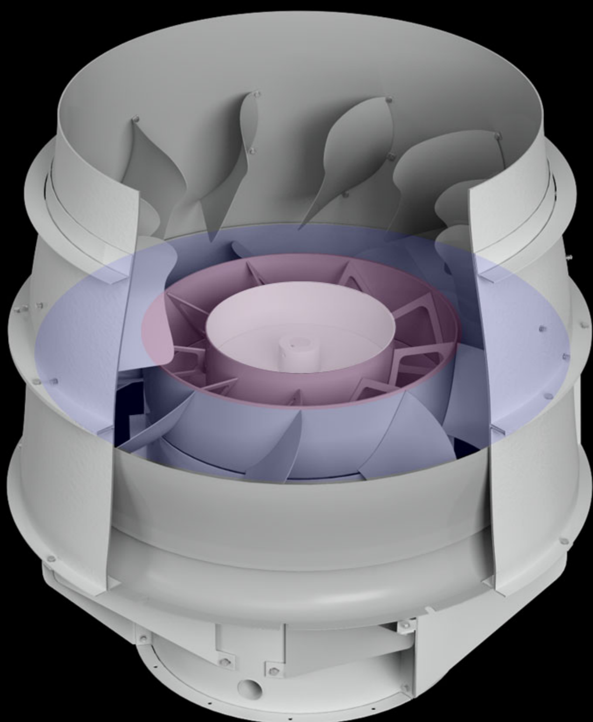

VAV

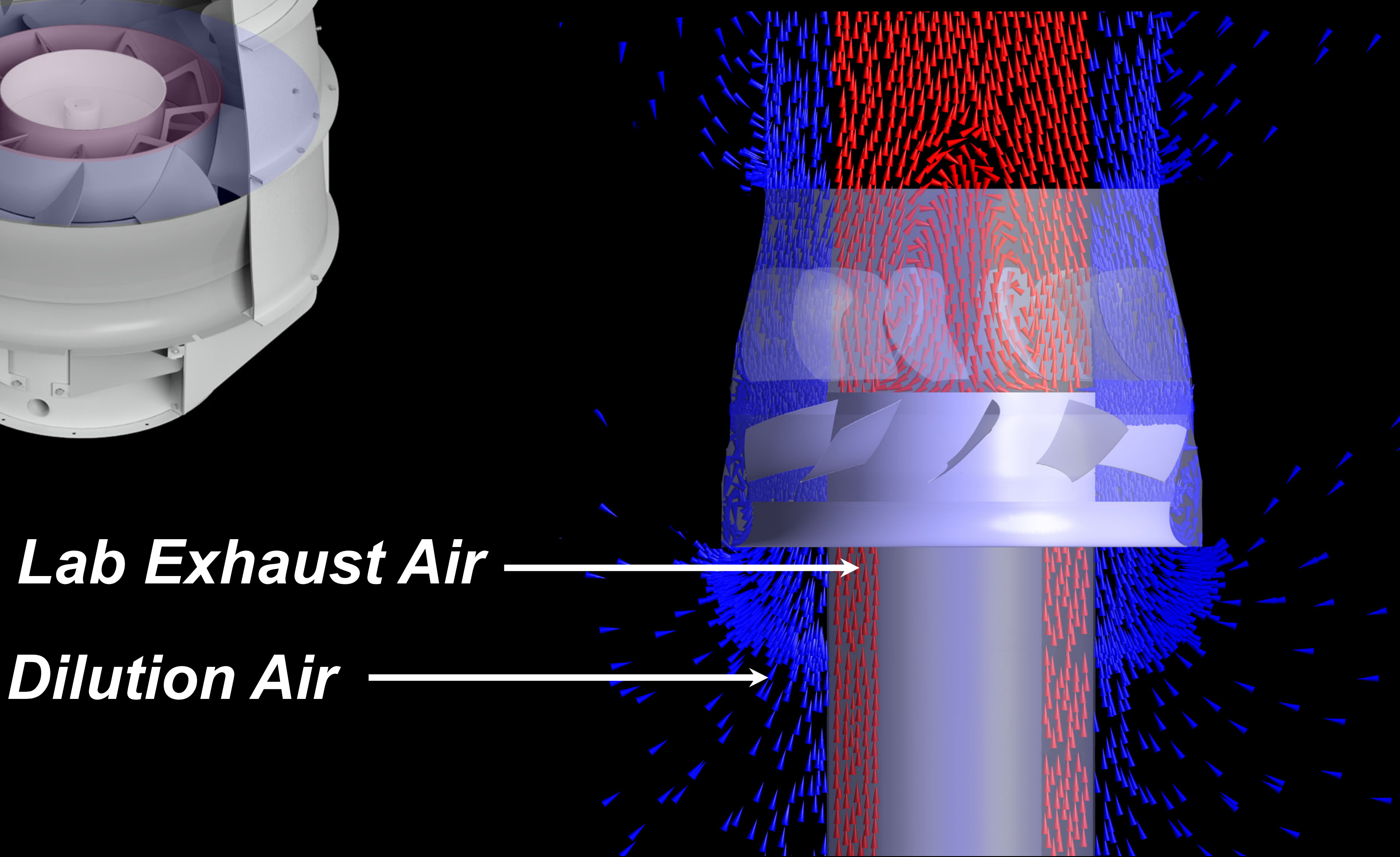


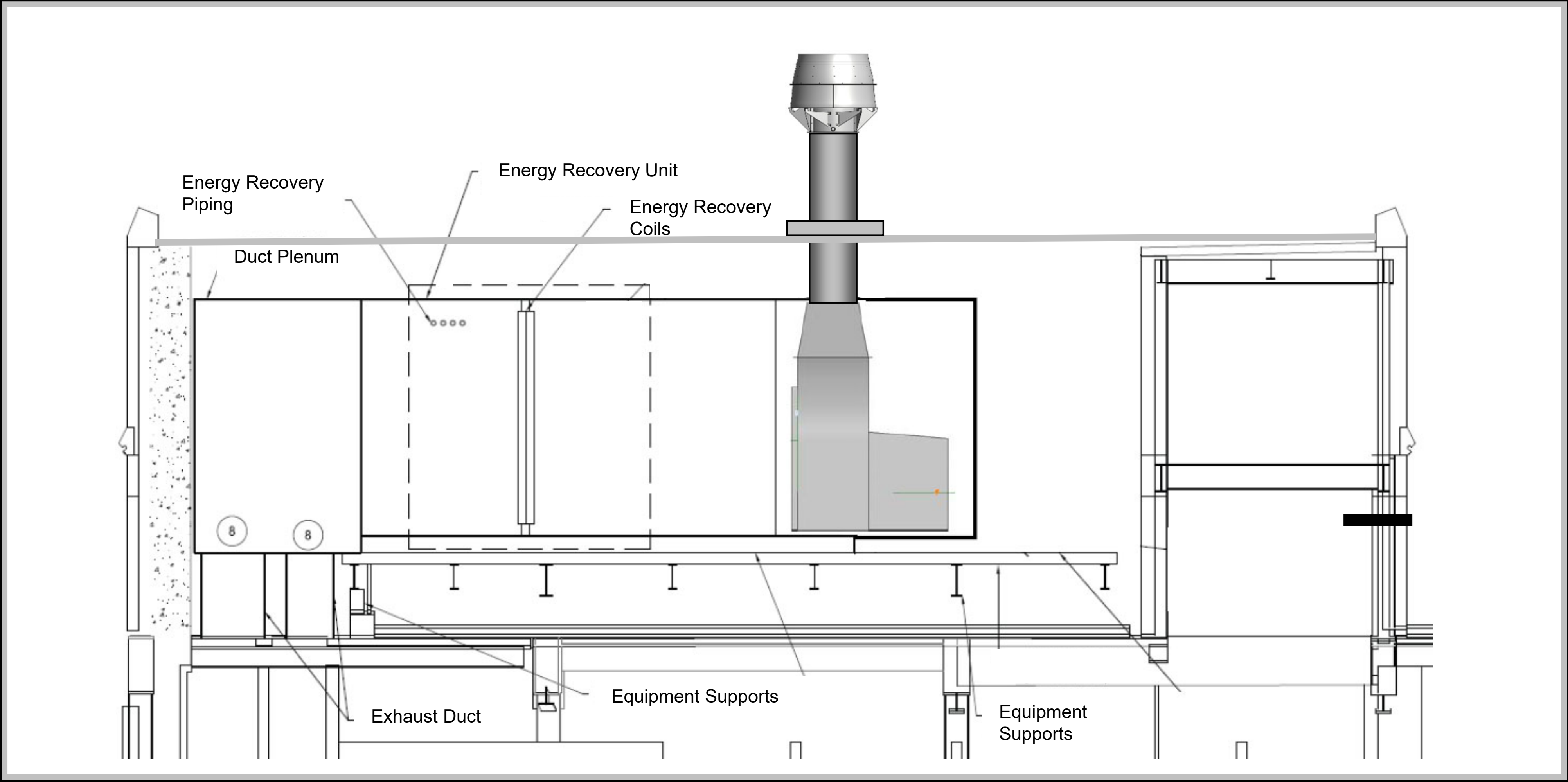
Dilution Air Encapsulates Contaminated Lab Exhaust



Dilution Air Encapsulates Contaminated Lab Exhaust

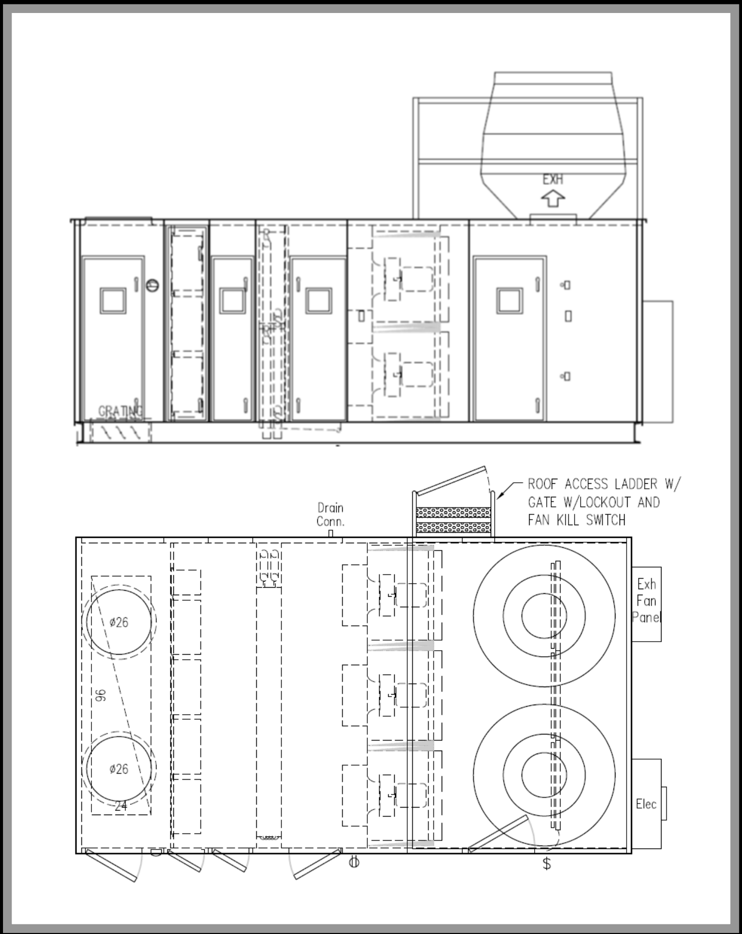






Energy Recovery

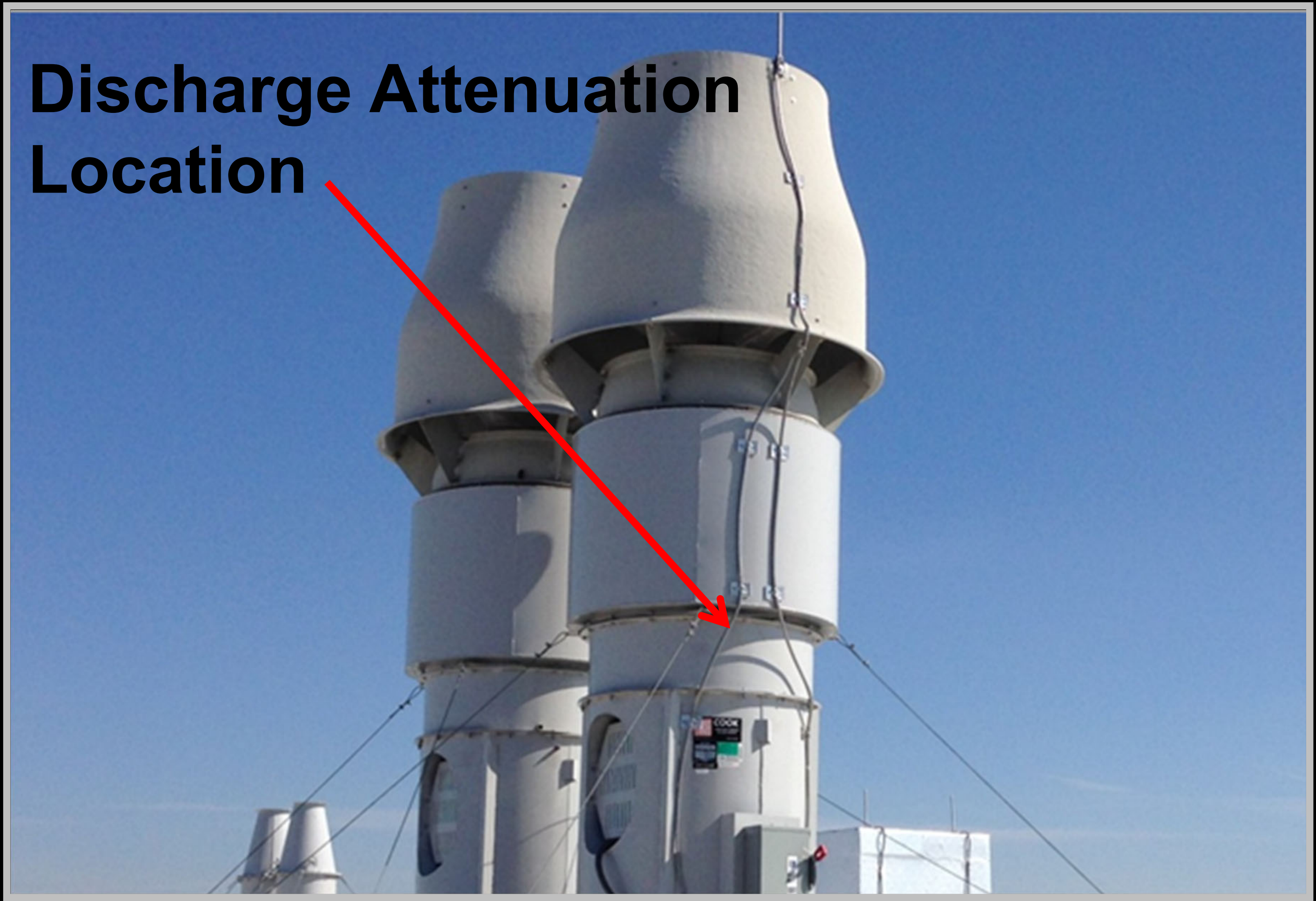
Energy Recovery



Sound Attenuation

Sound Attenuation

Discharge Attenuation:



Sound Attenuation

Bypass Attenuation:

TESTING THE APPLICABILITY OF BRIGGS EQUATIONS TO LAB EXHAUST FANS

PART 1: FIELD MEASUREMENTS OF PLUME RISE FROM VARIOUS LABORATORY EXHAUST SYSTEMS

I2SL Annual Conference
September 2016

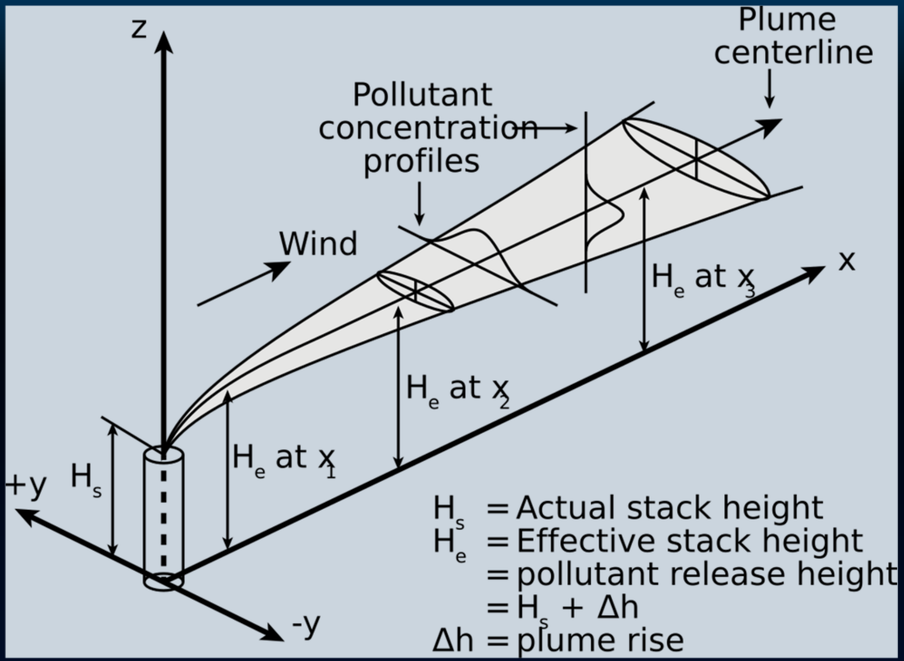
Chet Wisner

Jim Meats


Lab Roofs
Briggs

BRIGGS

- Atmospheric Dispersion Modeling – 1960's
- Observation of flue gas emissions of stacks from fossil-fuel fired devices such as steam boilers
- Stack velocities – 1200 to 6000 fpm
- Gas temperatures – 250 to 500 F
- Equations have been broadly applied to include predicting plume rise of laboratory exhaust fans



$$h_r = \frac{3Vd}{U}$$

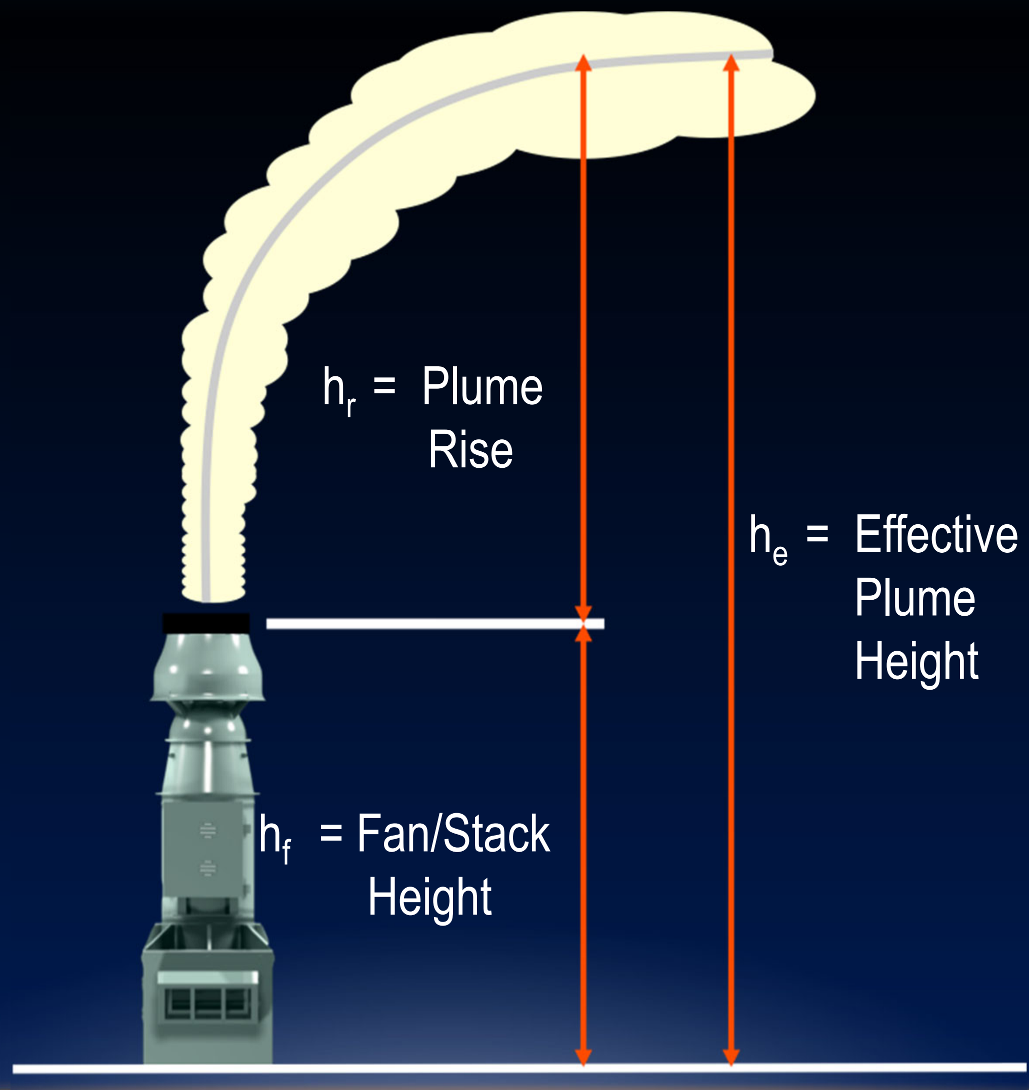
h_r = plume rise (ft)

V = discharge velocity (fpm)

D = nozzle diameter (ft)

U = wind speed (fpm)

EFFECTIVE PLUME HEIGHT

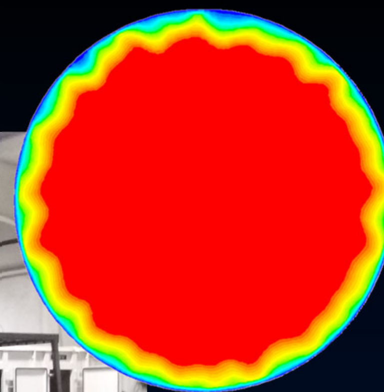


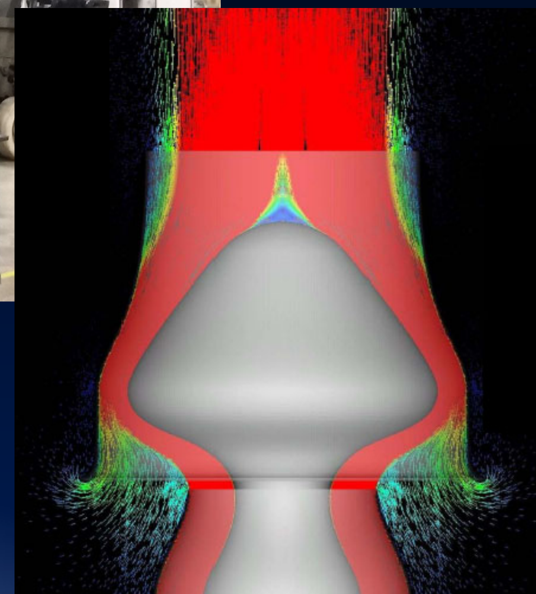
STANDARDS AND GUIDELINES

- Lab Vent Systems – ANSI/AIHA Z9.5-2003
- Non-Induced Flow Fan Testing – AMCA 210
- Induced Flow Fan Testing– AMCA 260
  - Characterizing plume was discussed but rejected when originally drafted 2005
- 2015 ASHRAE ‘HVAC Applications’ – Chapter 45

ANALYSIS TOOLS

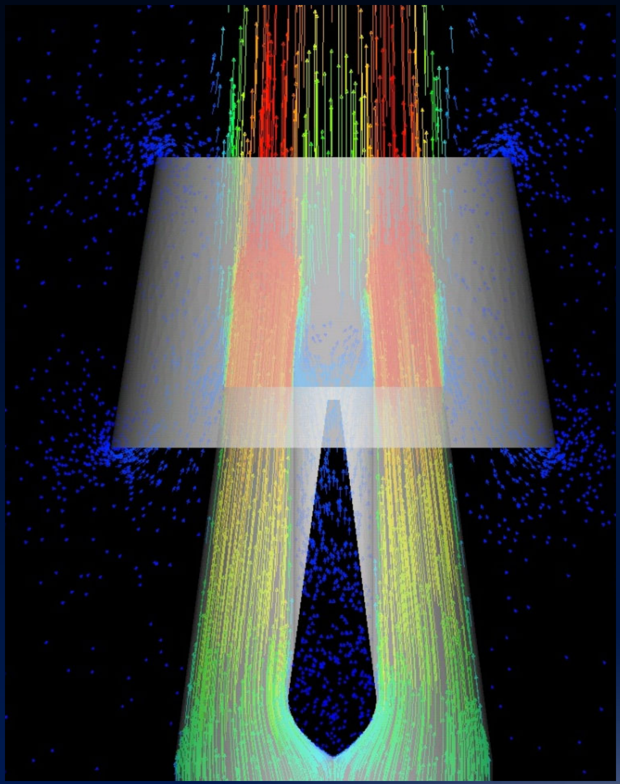
- CFD Modeling
- Smoke Testing
- Velocity Probe Array

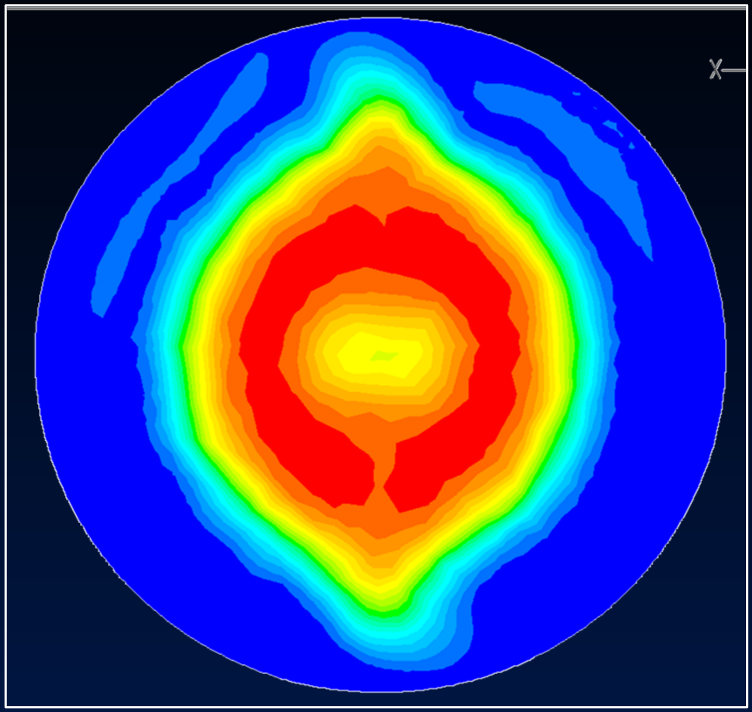




DISCHARGE PROFILE – BIFURCATED NOZZLE

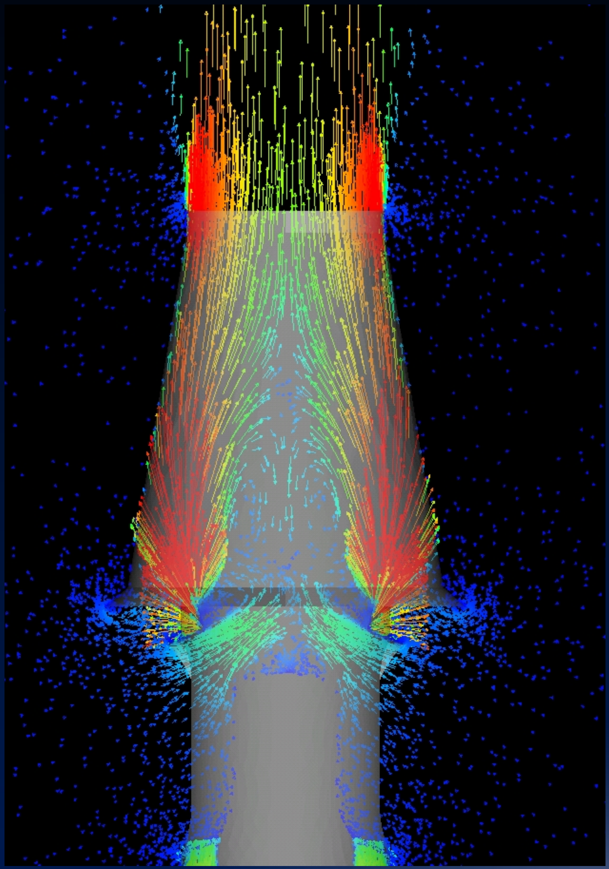
- CFD Prediction

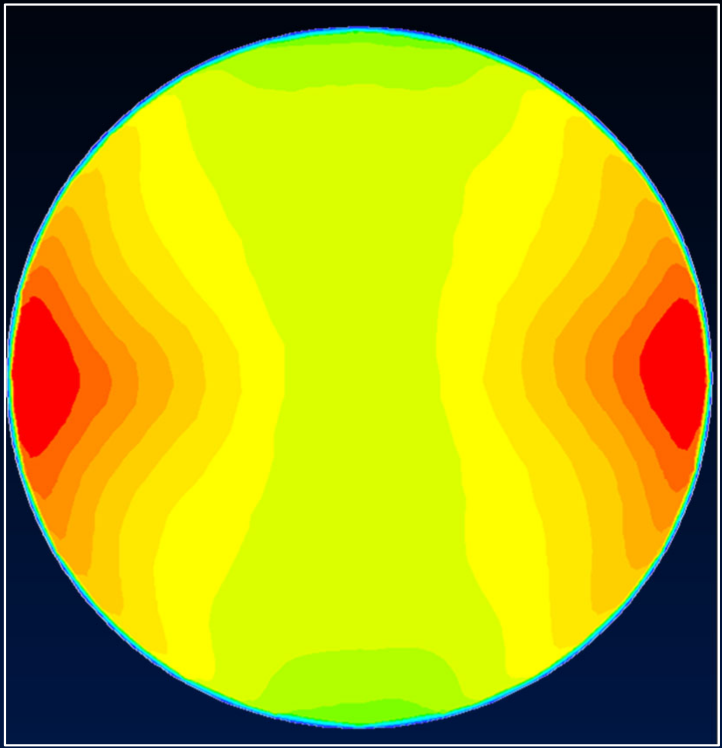




DISCHARGE PROFILE – BIFURCATED HOUSING

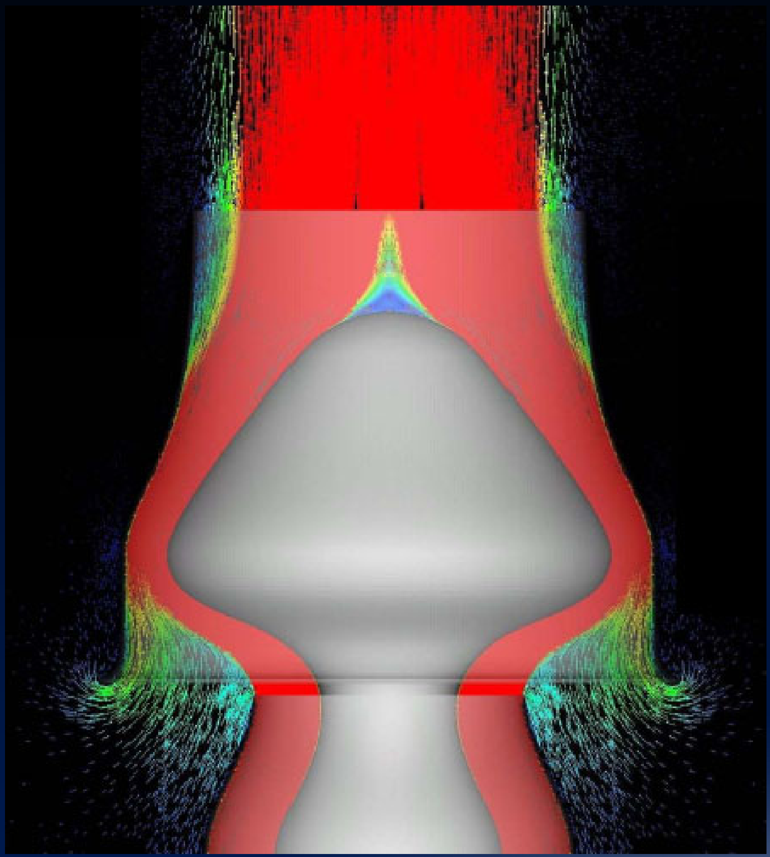
- CFD Prediction

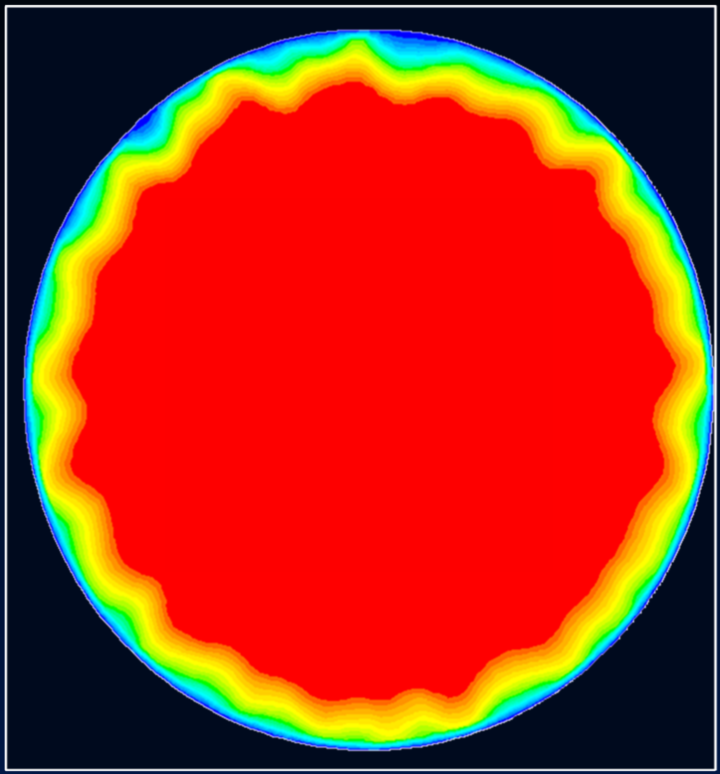




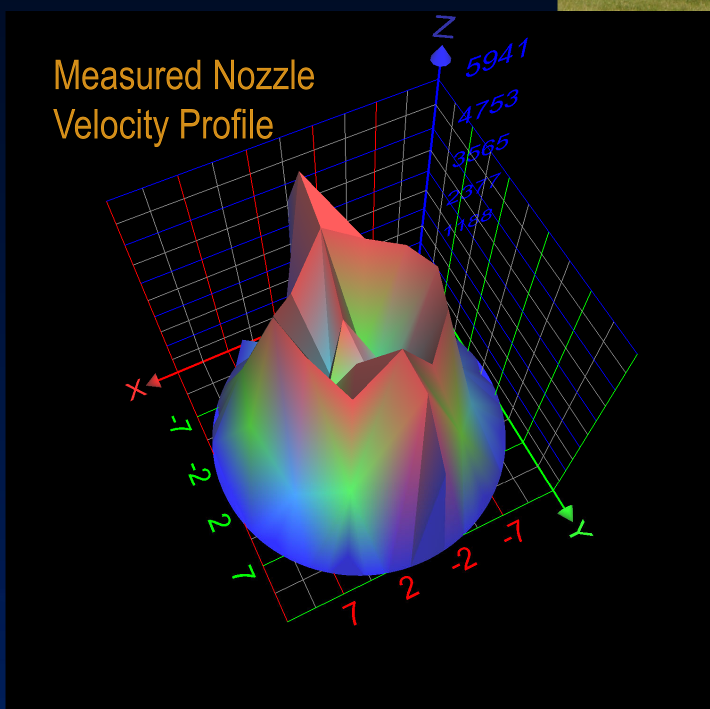
DISCHARGE PROFILE – CONCENTRIC NOZZLE

- CFD Prediction



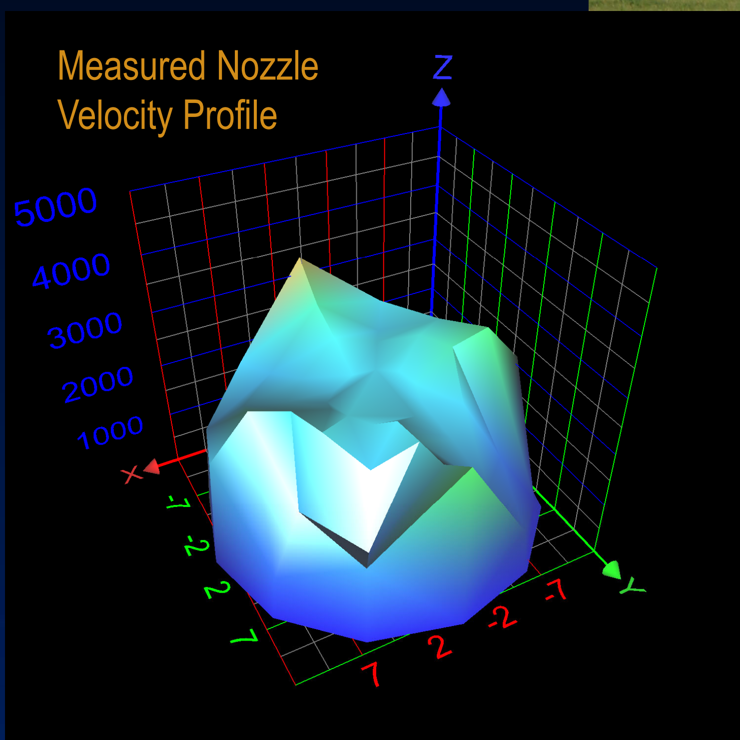


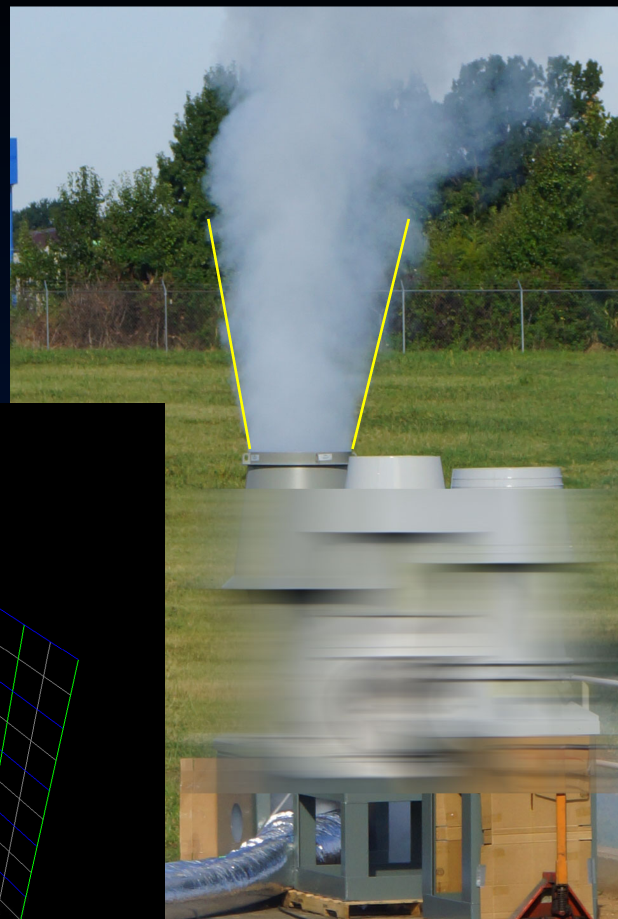
PLUME COHERENCE – BIFURCATED NOZZLE



- Widely varying velocity profile across discharge
- High turbulence within plume
- Plume has a wide divergence angle and rapidly loses plume cohesiveness

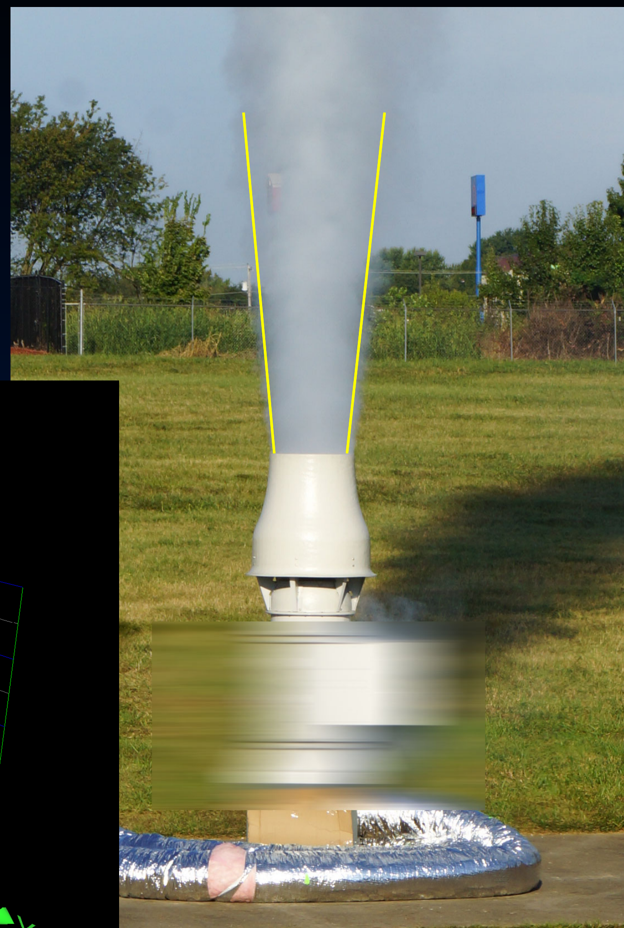
PLUME COHERENCE – BIFURCATED HOUSING

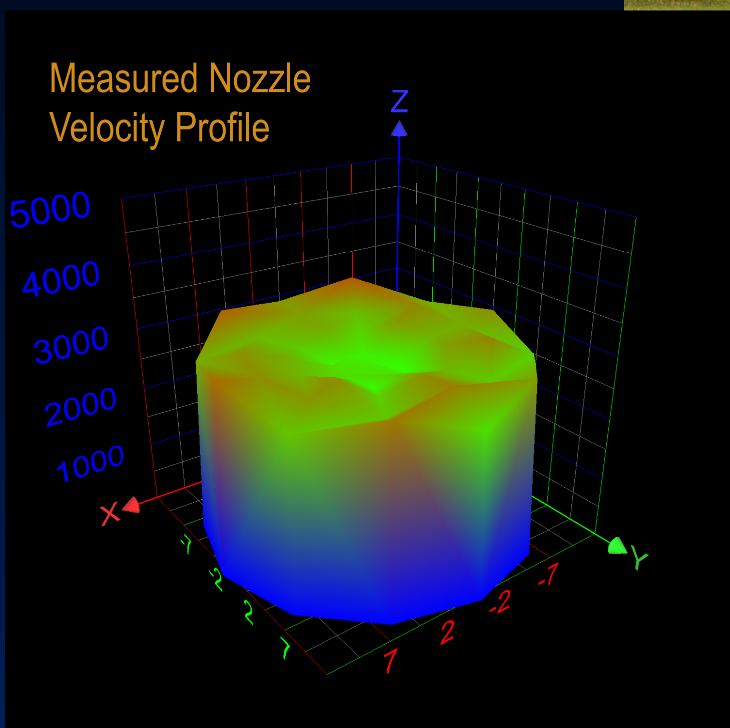




- Somewhat varying velocity profile across discharge
- Medium turbulence within plume
- Plume has an average divergence angle. Turbulence shows in momentum loss

PLUME COHERENCE – CONCENTRIC NOZZLE



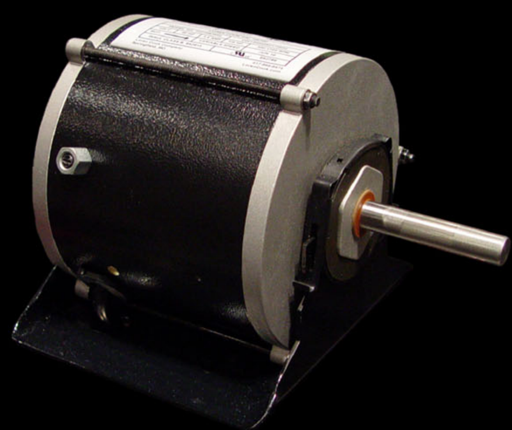


- Uniform velocity profile across discharge
- Low turbulence within plume
- Plume has a minimal divergence angle and maintains cohesiveness

GOING FORWARD

- Evidence suggests that plume performance is affected by discharge characteristics
- Capturing this information as part of product performance should improve selections
- Understanding this relationship is important to selection, proper prediction, and modeling of lab exhaust products and systems

Electronically Commutated Motors and Controls



Efficiency
Controllability
Flexibility

STANDARD EC	**PROGRAMMABLE** EC	**PROGRAMMABLE** PM
		

STANDARD EC

- Provides basic functions and features along with outstanding performance and efficiency
- On-board potentiometer provides simple adjustment with a flat head screwdriver
- Internal/external control is triggered by 24V control signal

PROGRAMMABLE EC

- Programmed from the factory to meet fan and application needs
- User interface with LED display shows RPM and percent of full load for precise speed adjustment
- User interface can be mounted up to 16" from fan
- Simple two-wire connection for external control

PROGRAMMABLE PM

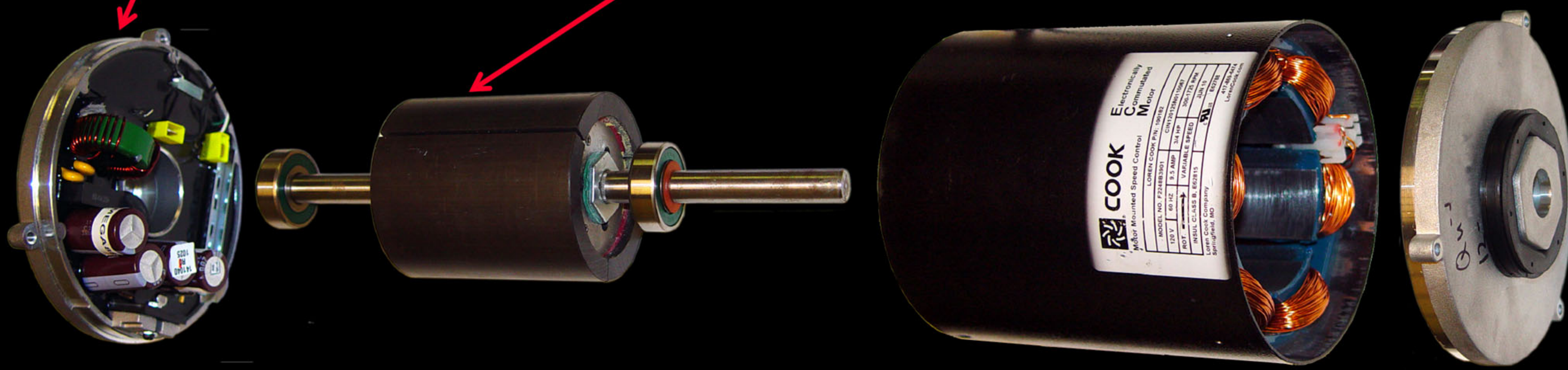
- Offers the most functions and features of any of the Vari-Flow motors
- Comes equipped with a compatible and easy to use motor controller
- All PM packages come pre-programmed and pre-wired for easy start-up

Electronically Commutated Motors and Controls

What is different about an EC Motor?

The motor requires a ‘commutator to operate

The rotor windings are replaced with permanent magnets

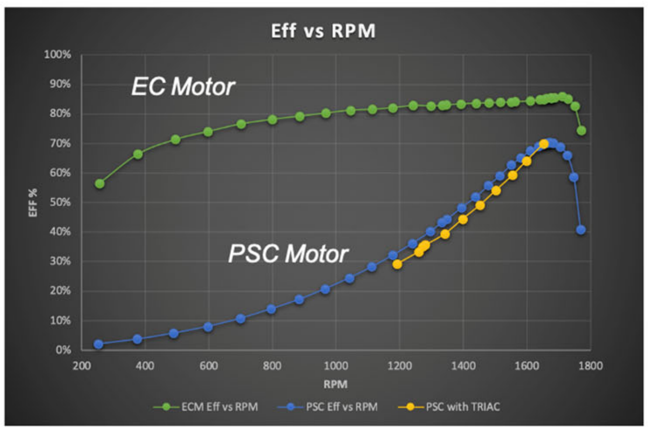


Permanent Magnet Motor

Motor Controller

EC Motor

Built-in Controller



Speed vs. Efficiency

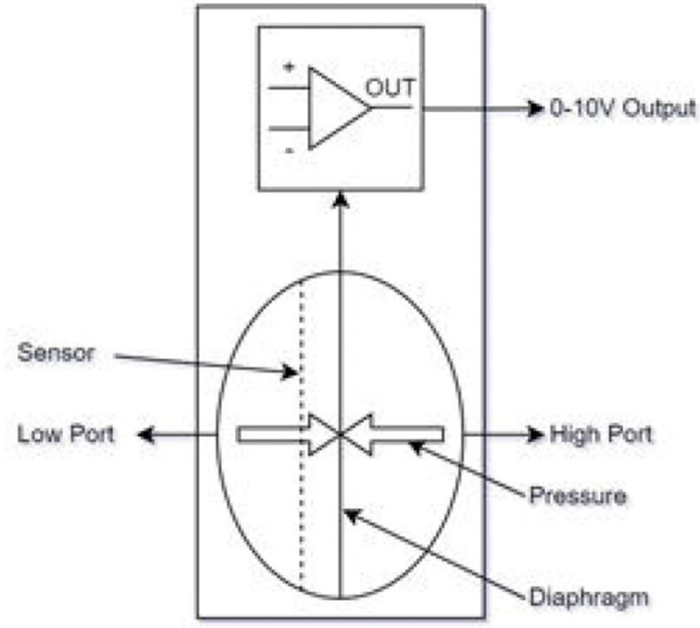
Are Vari-Flow EC motors more efficient than a traditional AC induction motors? If so, why?

- *EC (and PM) motors use permanent magnets to replace the squirrel cage in the rotor.*
- *Motor rotors in AC induction motors incur losses due to phenomena known as hysteresis, eddy currents, and ohmic losses.*
- *By using magnets in the rotor, up to 20% of motor losses are eliminated. These losses increase significantly at part load due to increased motor slip. EC motors are 'no-slip' motors, so losses are relatively flat over the speed range.*

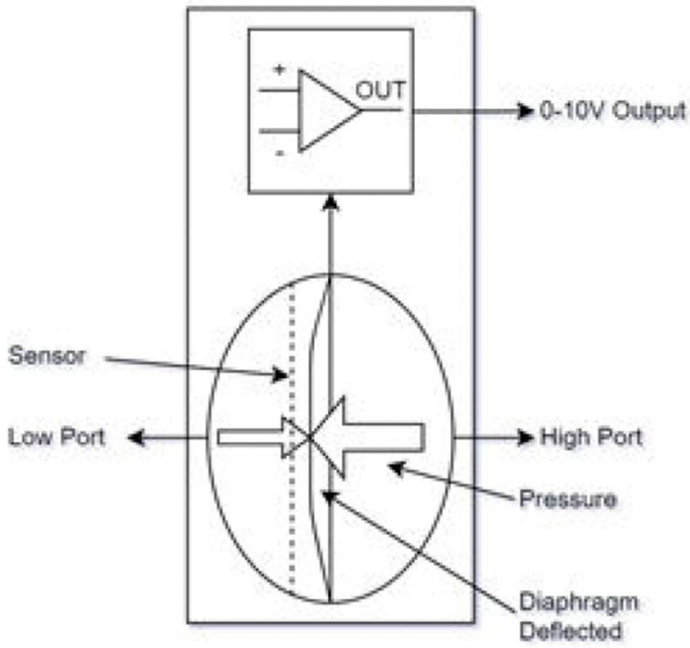
PRESSURE CONTROL BASICS

On the right is a schematic diagram of a pressure controller. Two of its primary components are a pressure transducer (shown on the bottom) and a signal output device (shown at the top).

Let's take a look at the pressure transducer. Similar to our u-tube manometer, we have two ports. Instead of water in a tube, we have a diaphragm that moves with a difference in pressure and a sensor that measures the amount of diaphragm movement



High = Low : 0V Output



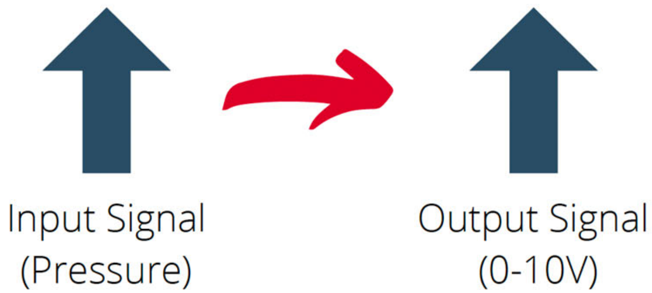
High > Low : +V Output

In this transducer, the diaphragm only moves to the left. In order to properly measure the difference in pressure between the ports, the higher pressure must always applied to the HIGH port and the lower pressure to the LOW port

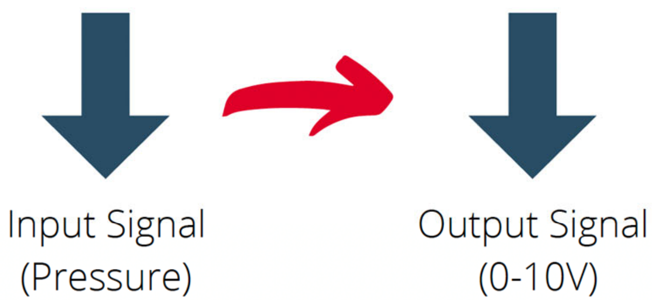
If the transducer is connected incorrectly (pressures reversed), the diaphragm will not move and the sensor will not sense a difference in pressure.

DIRECT ACTING PRESSURE CONTROL

When an **INCREASE** in input signal (pressure) requires an **INCREASE** in output signal (0-10V) to reduce the difference between the setpoint and the actual pressure to '0'. For our purposes, we will refer to the difference between setpoint and actual pressure as the 'error'.

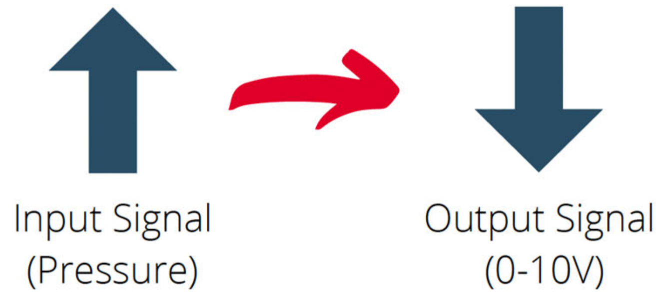


Inversely, when a **DECREASE** in input signal (pressure) requires a **DECREASE** in output signal (0-10V) to correct the 'error'.

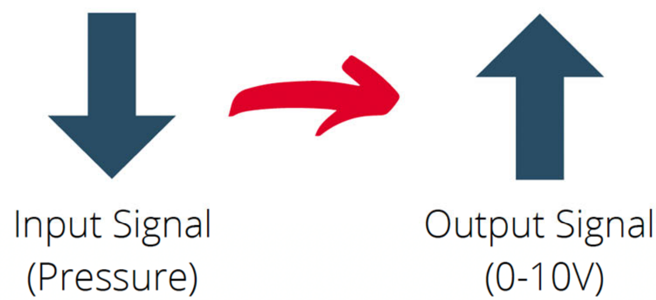


REVERSE ACTING PRESSURE CONTROL

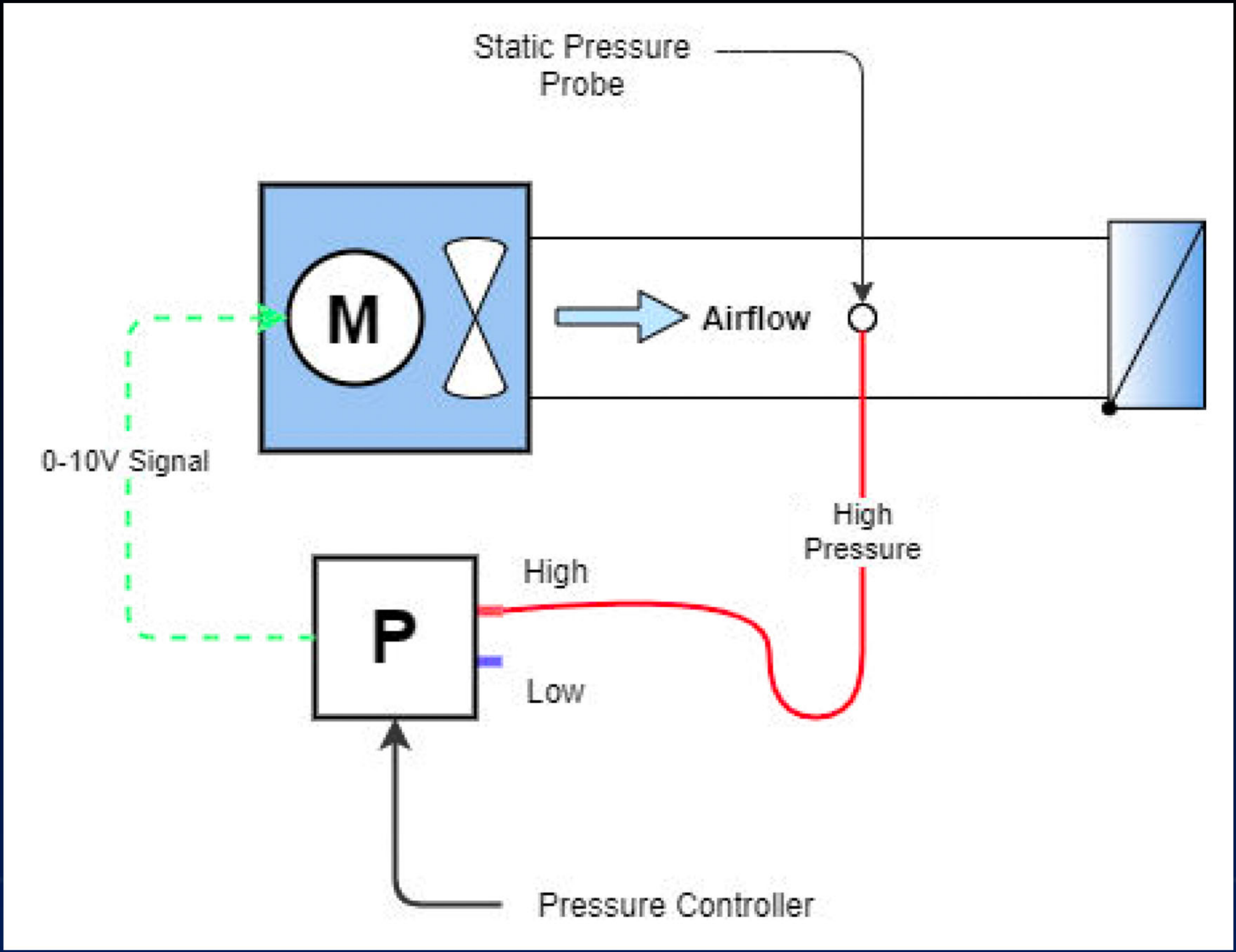
When an **INCREASE** in input signal (pressure) requires an **DECREASE** in output signal (0-10V) to reduce the difference between the setpoint and the actual pressure to '0'.



Inversely, when a **DECREASE** in input signal (pressure) requires a **INCREASE** in output signal (0-10V) to correct the 'error'.



DUCT STATIC PRESSURE CONTROL



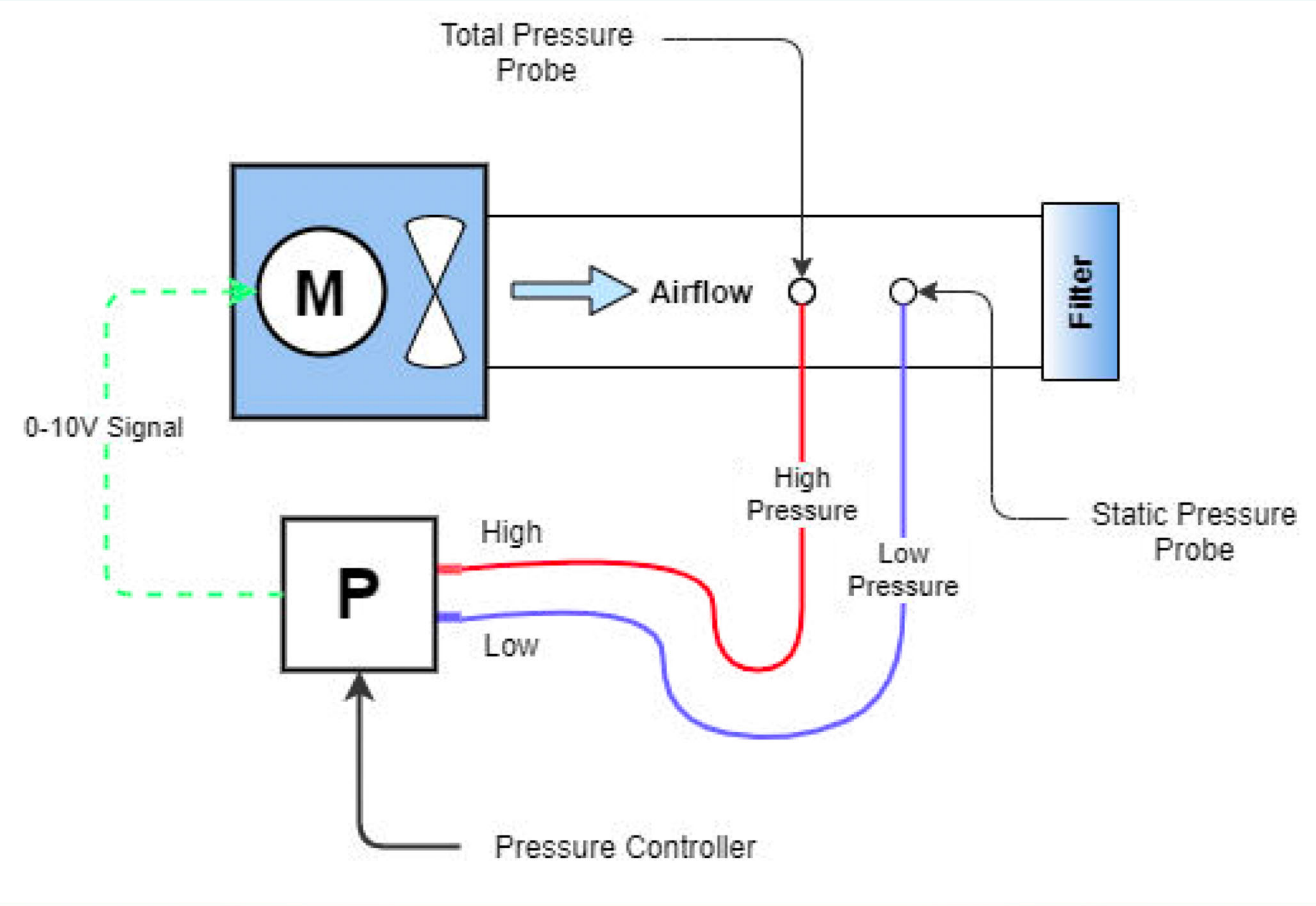
CONSTANT VELOCITY OR AIRFLOW CONTROL

First, we look at the relationship between air velocity and velocity pressure:

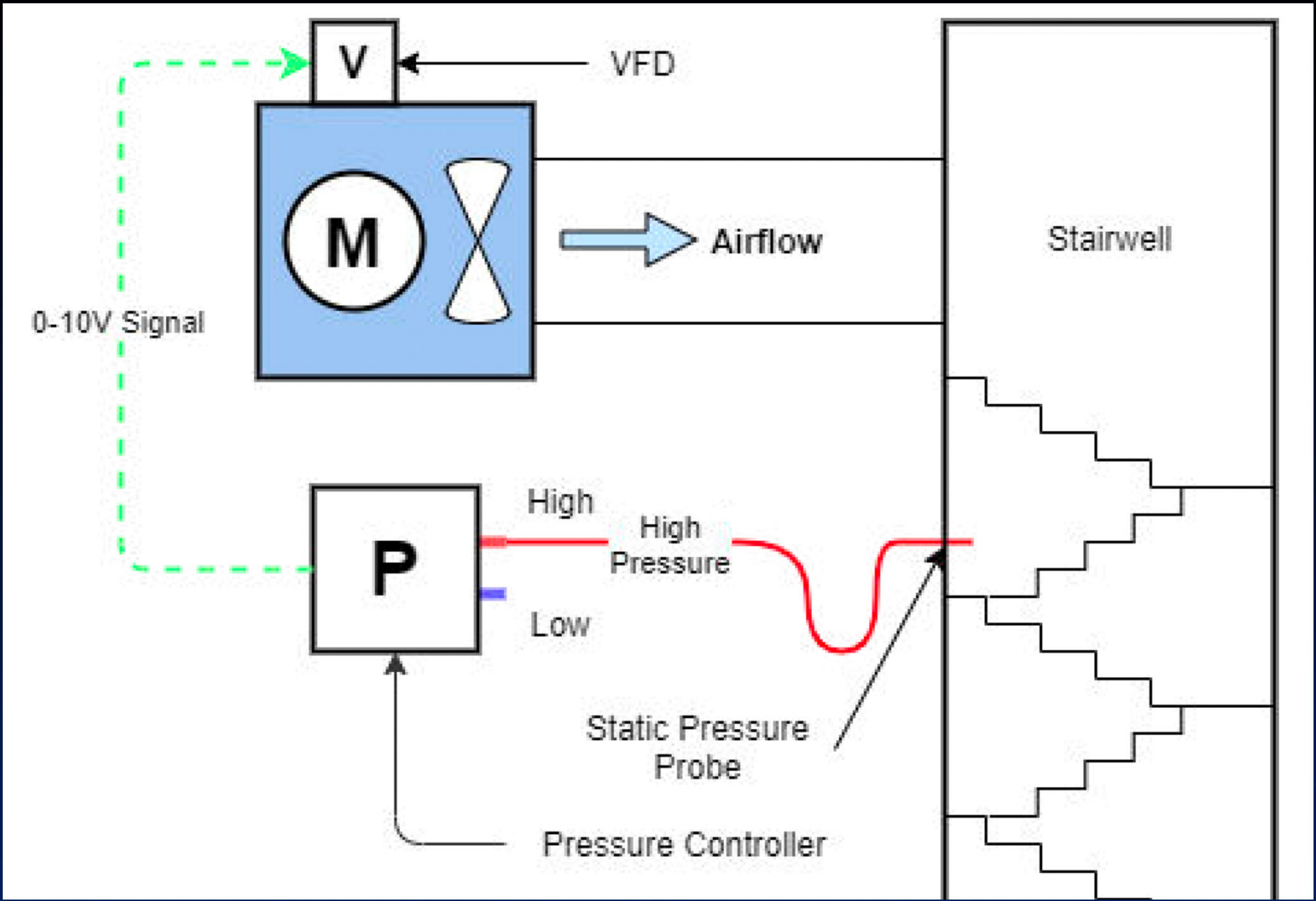
$$Velocity\ Pressure = (Velocity \div 4005)^2$$

We also will need to know the relationship between the airflow and the duct velocity:

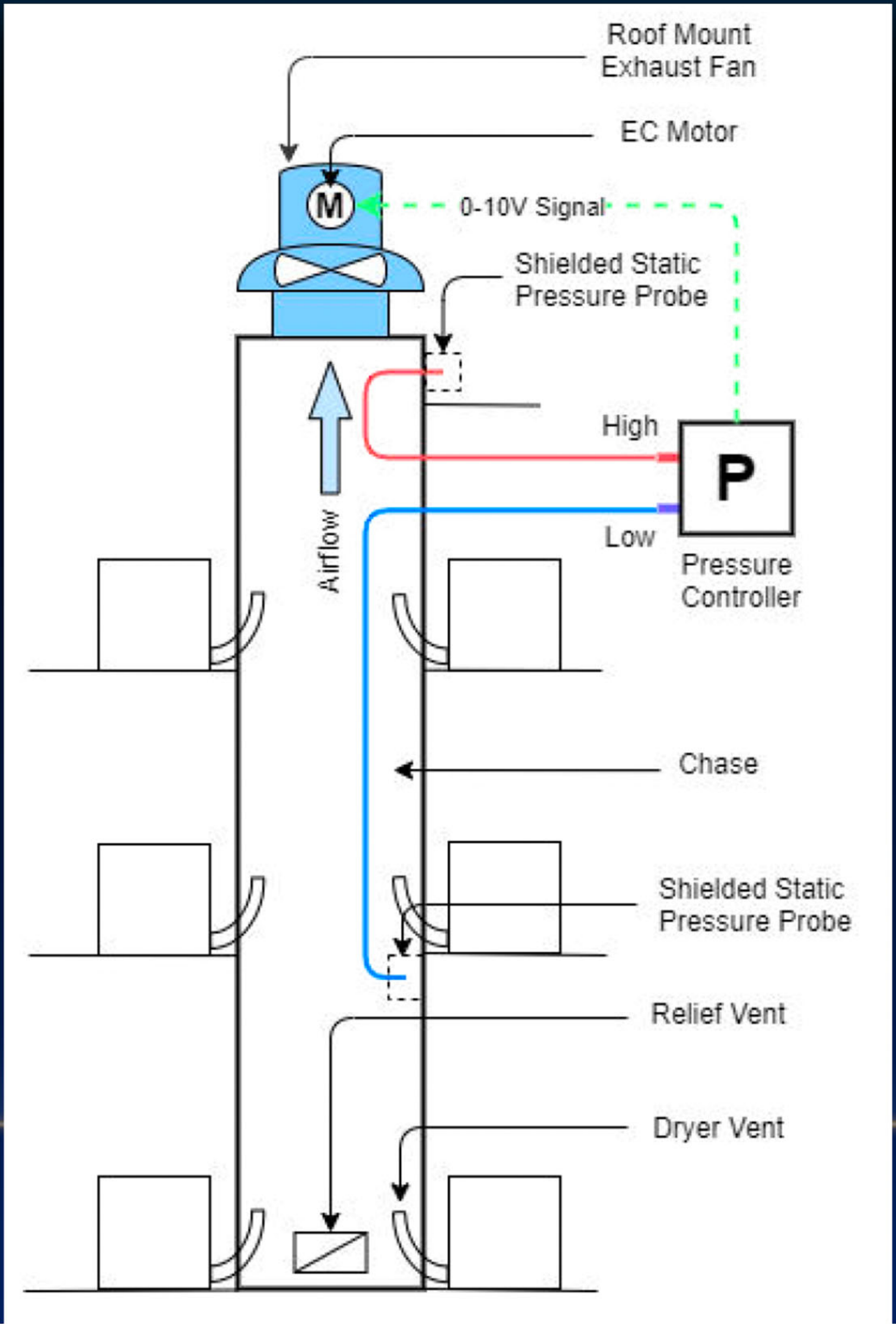
$$CFM \div Area = Velocity$$


Total Pressure
Probe
M
Airflow
Filter
0-10V Signal
High
Pressure
Low
Pressure
Static Pressure
Probe
High
P
Low
Pressure Controller

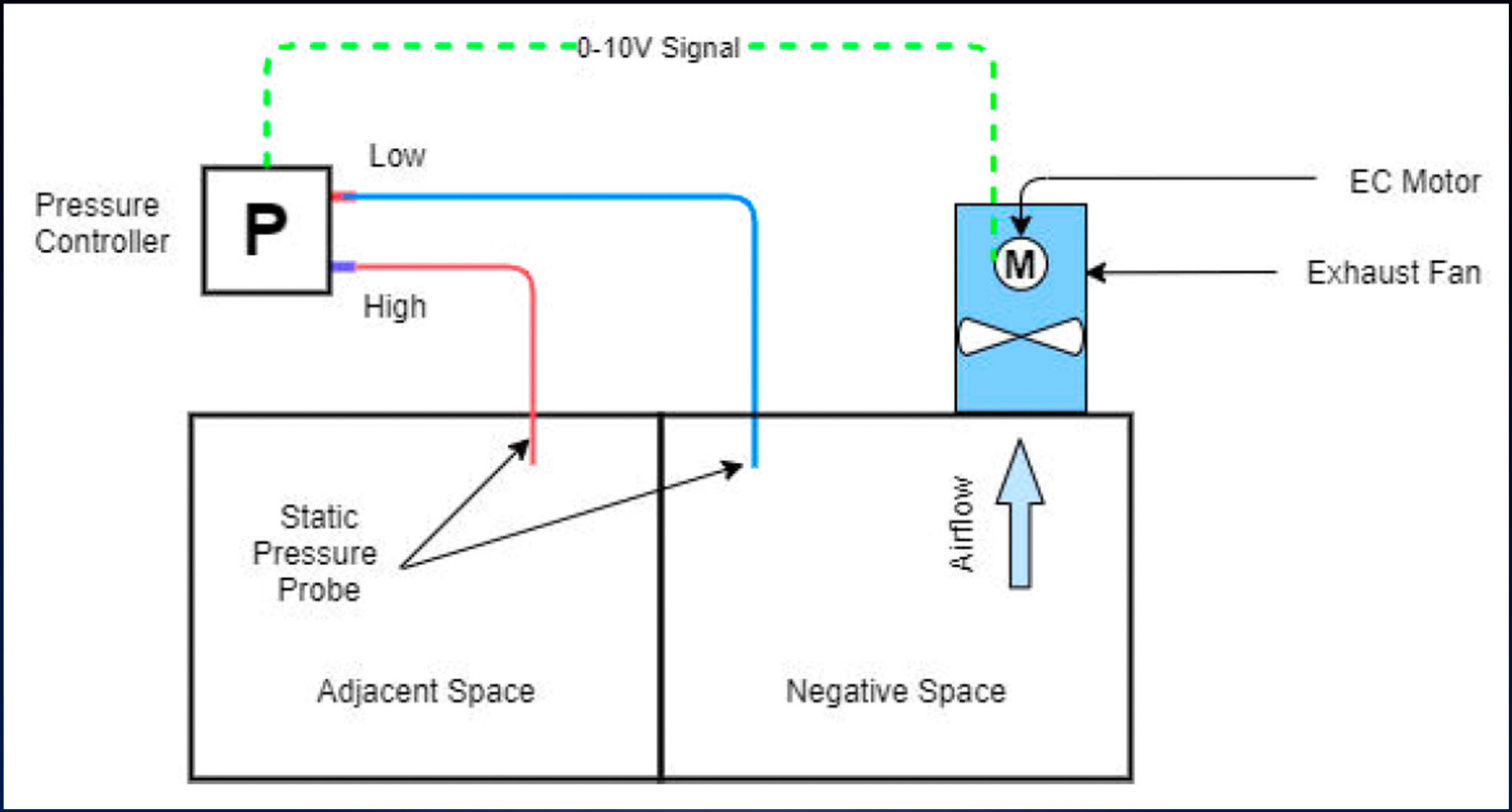
STAIRWELL PRESSURIZATION



DRYER EXHAUST



NEGATIVE PRESSURE CONTROL | EXHAUST FAN



Positive Pressure Control | Exhaust Fan