DOCKETED

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Variable Exhaust Flow Control

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Pre-Rulemaking Workshop
Art Rosenfeld Hearing Room
June 6th, 2017

Acknowledgements

Codes and Standards Enhancement (CASE) Initiative

2019 California Building Energy Efficiency Standards

Variable Exhaust Flow Control

Measure Number: 2019-NR-MECH3-D

Nonresidential Covered Processes

Authors:

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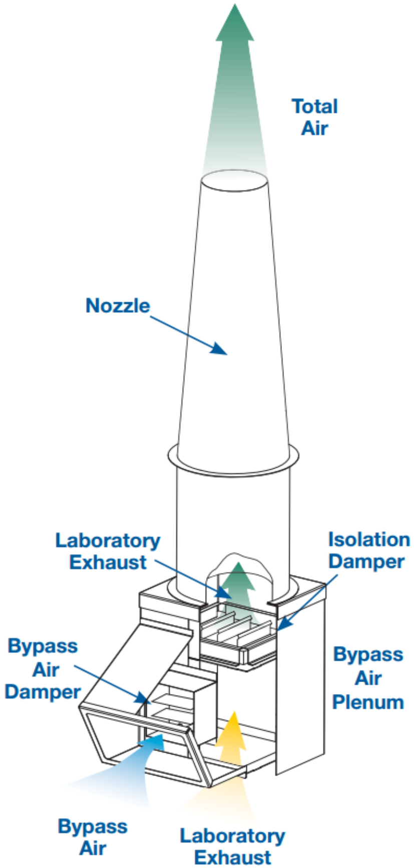
Integral Group

Overview

- Current code sets no limit on exhaust fan energy for laboratory and process facilities
- Proposed measure will set a limit on process exhaust fan energy
  - Exceptions given for variable speed fan control based on two methods
    - Wind speed sensor
    - Contaminant sensor

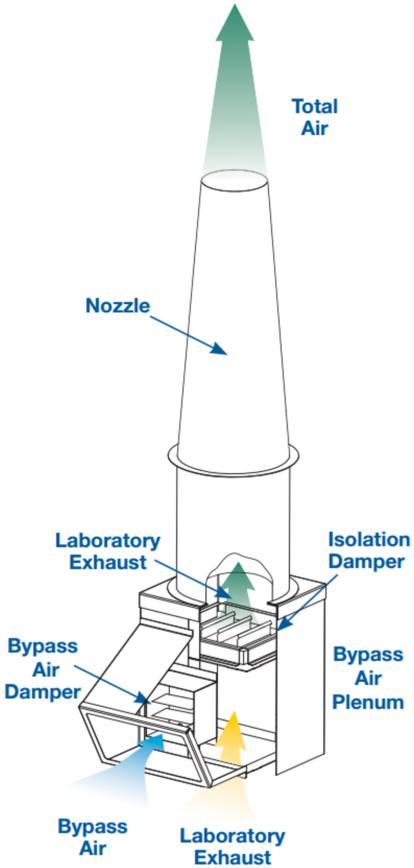


Source: Greenheck Fan Corp.

Background: Exhaust Stack Design

Conventional Stack Exhaust

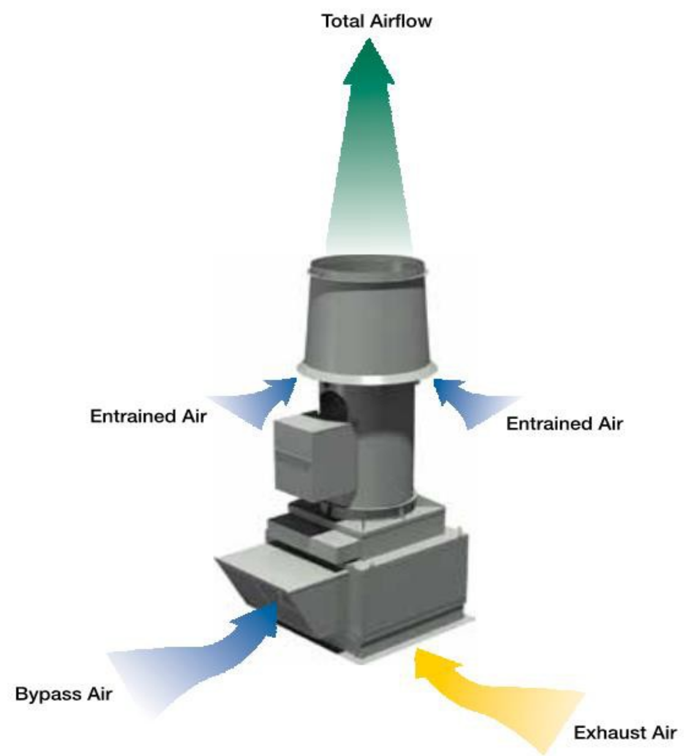
- Stack height allows for release of exhaust above air intakes.
- Relatively low discharge velocity
  - Lower exhaust energy
- Less aesthetically pleasing than shorter exhaust stacks.



Source: Greenheck Fan Corp.

Induction Exhaust Fans

- Lower stack height requires additional momentum to achieve effective plum height of conventional stack.
- Relatively high discharge velocity combined with entrainment of outdoor air
  - Higher exhaust energy
- Typically not visible from ground level.
  - More aesthetically pleasing

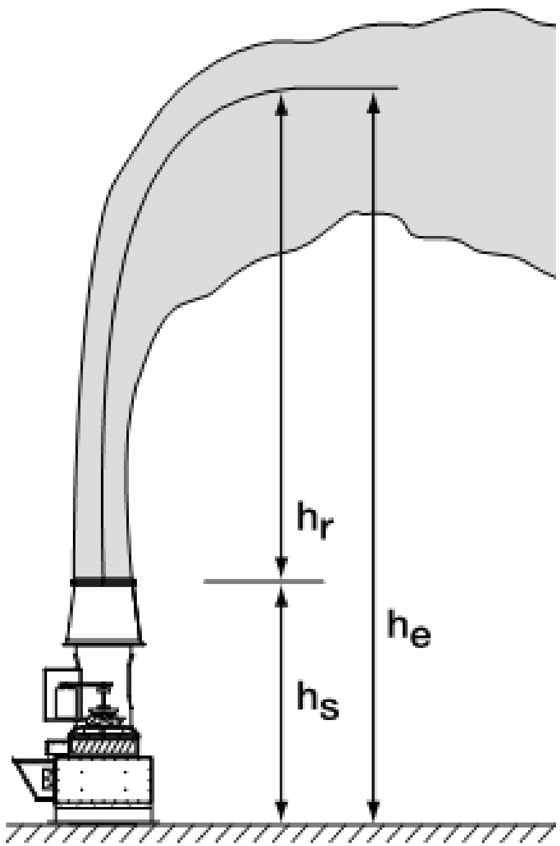


Source: Greenheck Fan Corp.

Induction Exhaust Fans: Effective Plume Height

- Effective plume height (h_e) must be great enough to not allow exhaust re-entrainment or contamination of surrounding buildings.
- h_e dependent on:
  - Stack height (h_s)
  - Mass flow rate
    - Exit velocity (V)
    - Windband diameter (d)
  - Wind speed (U)
  - $h_e = \frac{3Vd}{U} + h_s$

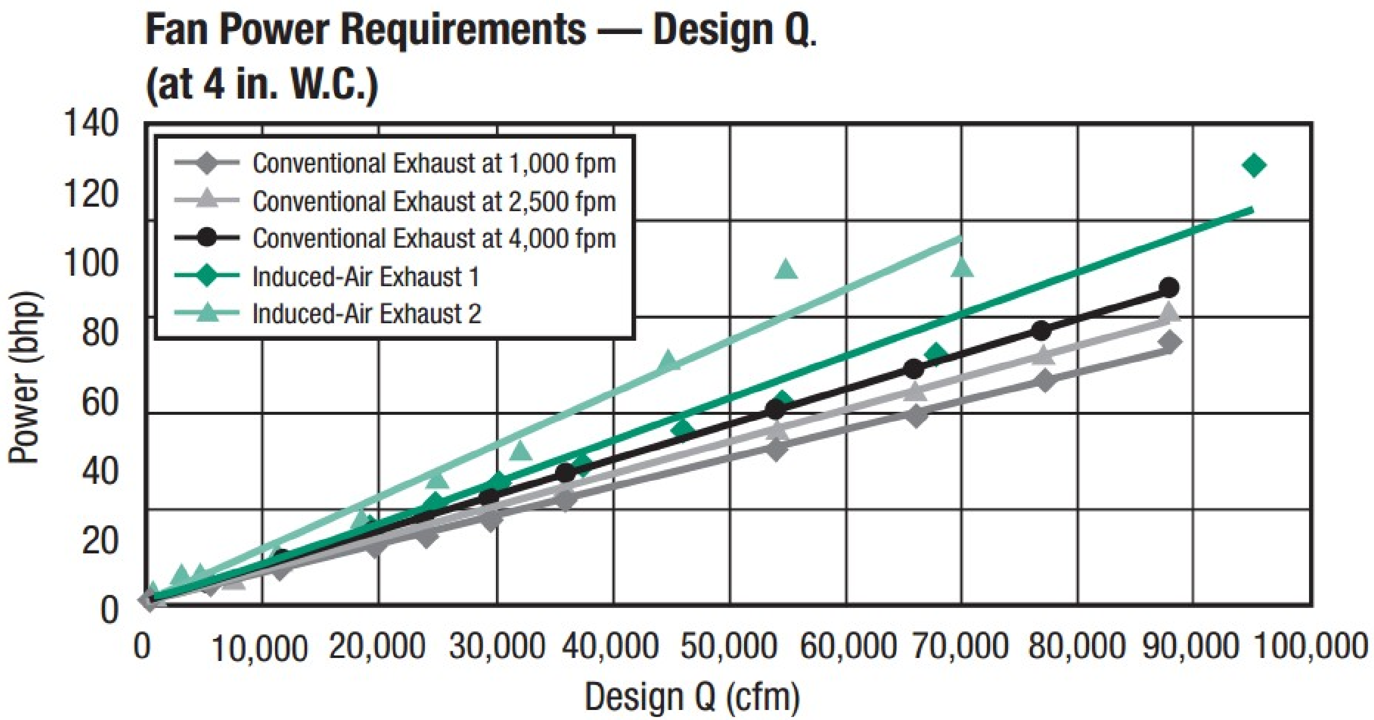
ASHRAE Laboratory Design Guide Equation 9-2



Source: Greenheck Fan Corp.

Induction Exhaust Fans: Fan Power

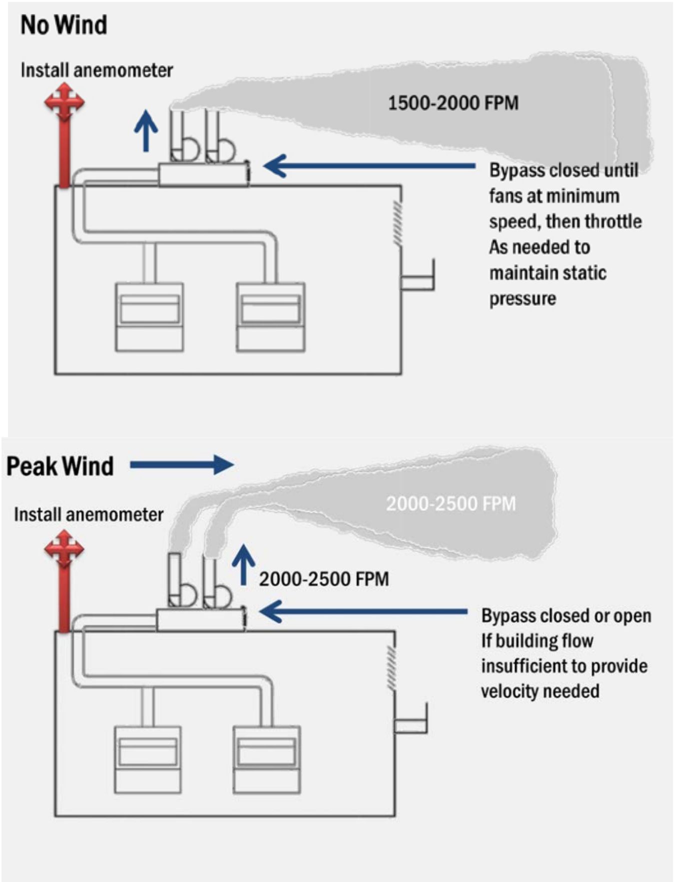
- Induction exhaust fans require higher power than conventional stack exhaust systems.



Laboratories for the 21st Century: Best Practices

Variable Speed Exhaust: Anemometer Control

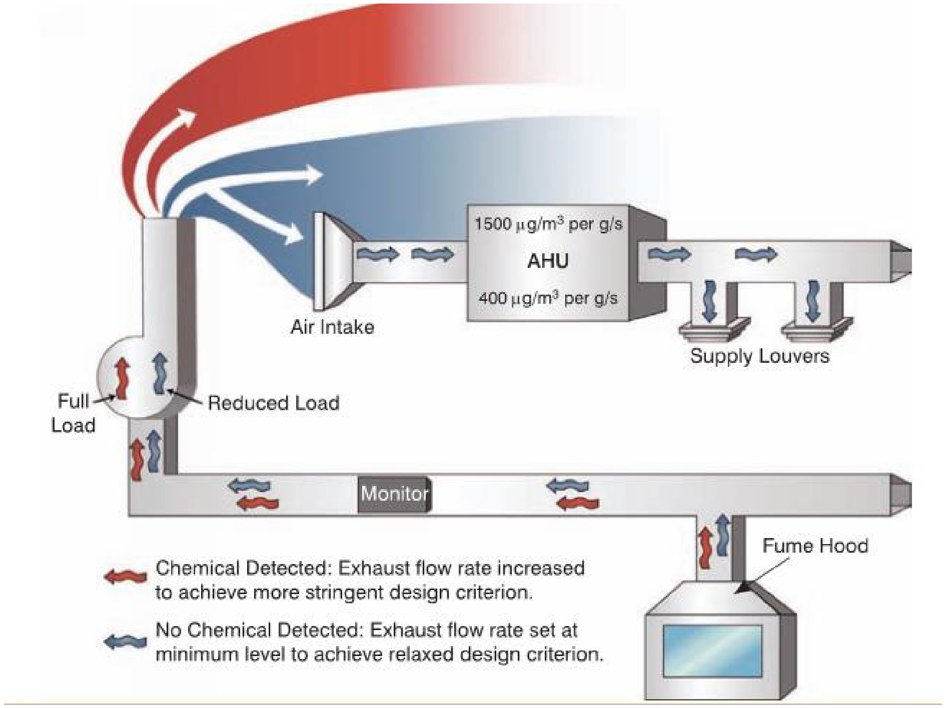
- Effective plume height is highly dependent on wind speed
  - Low wind speed: Higher effective plume height
  - High wind speed: Lower effective plume height
  - Exhaust velocity can be decreased during low wind speed events to save energy
  - Anemometer control automatically adjusts fan speed based on wind speed to maintain design effective plume height



Source: Safely Cut Your Laboratory Energy Usage in Half, Labs21

Variable Speed Exhaust: Chemical Monitor

- Exhaust dilution is dependent on contaminant concentration
  - Low contaminant level (<0.5ppm): less dilution needed
  - High contaminant level (>0.5ppm): more dilution needed
  - Fan speed can be reduced when chemical level is below the safe level.



Source: Safely Cut Your Laboratory Energy Usage in Half, Labs21

Proposed Code Change Overview

- What's being proposed for 2019?
  - Adding prescriptive requirements for newly constructed laboratory or process facility exhaust systems
    - Requirement only for systems greater than 10,000 CFM
    - Must meet requirements of ANSI Z9.5-2012
    - Must meet one of the below options
      a) Exhaust fan system power limit currently set at 0.45 watt/cfm
      b) Fan motor speed control based on a local wind station
      c) Fan motor speed control based on an exhaust plenum contaminant sensor
    - Will require acceptance testing

Methodology for Savings Analysis

Energy Savings Methodology

- Fan power energy savings
  - Spreadsheet modeling to isolate reduced exhaust fan power
- Model Assumptions
  - Operating 9AM-5PM
  - Exhaust airflow rate of 10ACH
  - 40% turndown during unoccupied hours
  - Effective plume height of 20 ft
  - Static pressure of 2.5 in
  - Max contaminant concentration of 400 (µg/m3)/(g/s)
  - Labs of size 1,000 sf, 2,000 sf, 5,000 sf, 10,000 sf, and 20,000 sf
  - Fans sized for 10 mph wind speed
  - 50% facilities containing targeted technology
- Baseline Conditions
  - Fans running for assumed constant 10 mph wind speed
- Proposed Conditions
  - Fan speed varies based off anemometer wind speed

Energy and Cost Savings Data

Incremental Costs

- Incremental Costs Per lab
  - Calibrated anemometer ($1,500)
  - Low temperature range ($300)
  - Cable ($250)
  - Mounting adapter ($200)
  - Bird screen ($250)
  - Total Incremental First Cost: $2,500
- Incremental maintenance costs over 15 – year period
  - Sensor replacement ($1500)
  - Total Incremental Maintenance Cost: $1500
- Total Incremental Cost over 15/30 – year period: $4000

Incremental Cost Savings

- Energy Cost Savings: 15 – year period:
  - Total Energy Cost Savings Per ft^2: \$39.32 to \$92.07 depending on climate zone

First-Year Energy Impacts Per Square Foot New Construction and Alterations

Climate Zone	Electricity Savings (kWh/year)	Peak Electricity Demand Reduction (kW)	Natural Gas Savings (therms/year)	TDV Energy Savings (TDV kBtu/year)
1	31	0	N/A	875
2	38	0	N/A	1,034
3	24	0	N/A	662
4	31	0	N/A	848
5	28	0	N/A	801
6	32	0	N/A	836
7	34	0	N/A	947
8	37	0	N/A	1,006
9	35	0	N/A	969
10	36	0	N/A	982
11	18	0	N/A	527
12	25	0	N/A	696
13	35	0	N/A	954
14	16	0	N/A	442
15	23	0	N/A	637
16	30	0	N/A	857

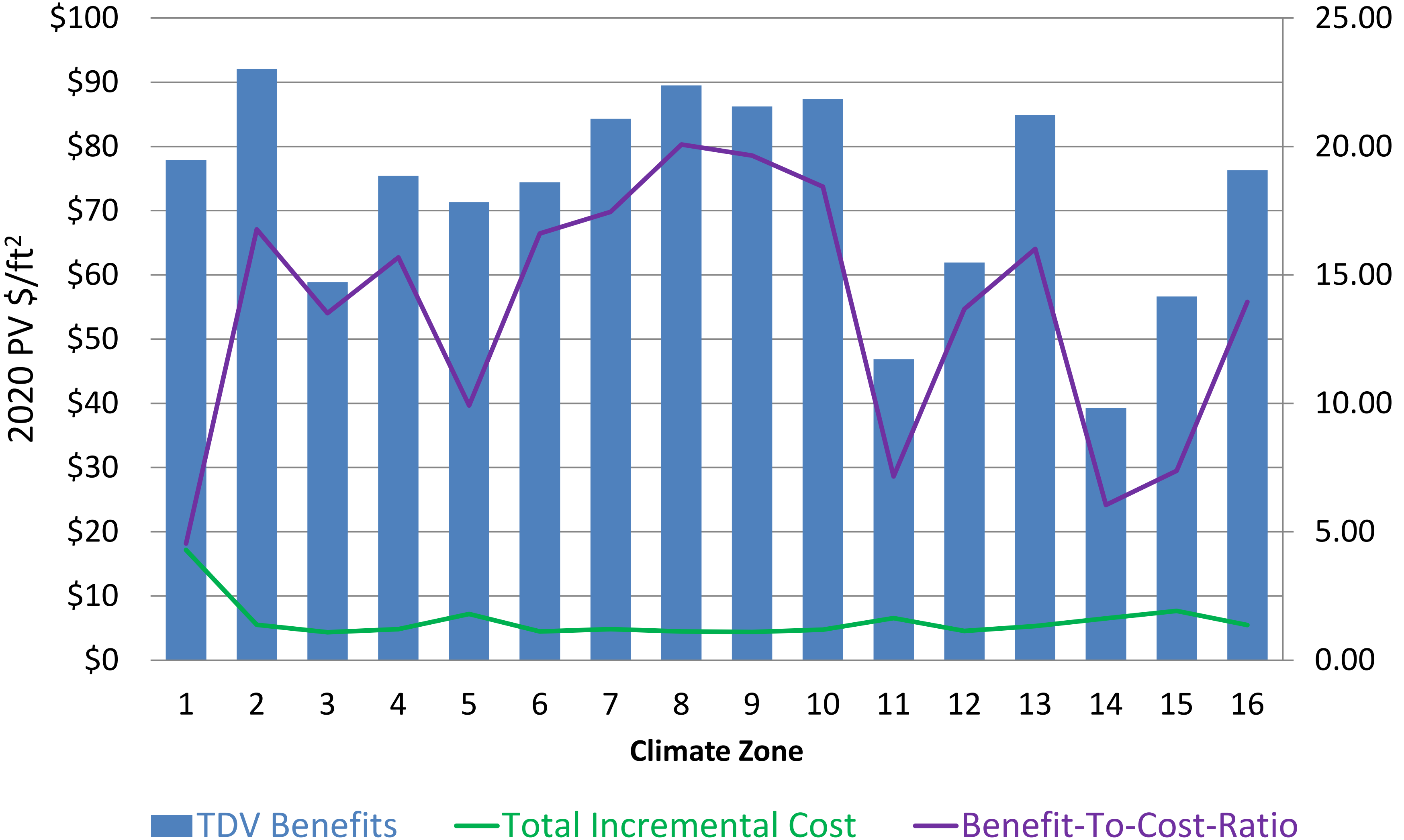
TDV Energy Cost Savings Per Square Foot: 15-Year Period

Climate Zone	15-Year TDV Electricity Cost Savings (2020 PV $)	15-Year TDV Natural Gas Cost Savings (2020 PV $)	Total 15-Year TDV Energy Cost Savings (2020 PV $)
1	$77.85	$0.00	$77.85
2	$92.07	$0.00	$92.07
3	$58.90	$0.00	$58.90
4	$75.44	$0.00	$75.44
5	$71.33	$0.00	$71.33
6	$74.42	$0.00	$74.42
7	$84.30	$0.00	$84.30
8	$89.52	$0.00	$89.52
9	$86.24	$0.00	$86.24
10	$87.40	$0.00	$87.40
11	$46.87	$0.00	$46.87
12	$61.92	$0.00	$61.92
13	$84.88	$0.00	$84.88
14	$39.32	$0.00	$39.32
15	$56.66	$0.00	$56.66
16	$76.30	$0.00	$76.30

Lifecycle Cost-Effectiveness Summary

Climate Zone	Benefits TDV Energy Cost Savings + Other PV Savings (2020 PV $/ft^2)	Costs Total Incremental Present Valued (PV) Costs (2020 PV $/ft^2)	Benefit-To-Cost-Ratio
1	77.85	17.15	4.5
2	92.07	5.49	16.8
3	58.9	4.36	13.5
4	75.44	4.81	15.7
5	71.33	7.19	9.9
6	74.42	4.48	16.6
7	84.3	4.83	17.5
8	89.52	4.46	20.1
9	86.24	4.39	19.6
10	87.4	4.74	18.4
11	46.87	6.55	7.2
12	61.92	4.53	13.7
13	84.88	5.3	16.0
14	39.32	6.51	6.0
15	56.66	7.68	7.4
16	76.3	5.47	13.9

Lifecycle Cost Effectiveness



Proposed Code Change Summary

- What's being proposed for 2019?
  - New prescriptive requirement for covered processes
  - Would set prescriptive fan power limit on laboratory and process exhaust systems greater than 10,000 CFM.
    - Currently proposed limit of 0.45 watt/CFM
    - Exceptions for fan control by rooftop wind sensor or contaminant sensor
  - Prescriptive requirement to comply with ANSI Z9.5
  - Building types impacted: Nonresidential Scientific Laboratories and Process Facilities
  - Applies to additions and alterations
  - Aligns with all existing relevant codes and standards
  - Does not modify existing code language, but rather appends to it to ensure savings are achieved from the VAV exhaust system

Proposed Changes to Code Language

- Building Energy Efficiency Standards
  - New prescriptive requirements for laboratory and process facility exhaust
    - Limited Fan system power limit with exceptions
      - Motor speed control: wind or contaminant
      - System size below 10,000 CFM
  - Reference Appendices
    - New section with acceptance test documentation in support of the proposed prescriptive requirements
  - Nonresidential ACM Reference Manual
    - Modifications describing, performance method calculations, Standard Design, and Proposed Building restrictions

Proposed Code Language (slide added for posting)

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

(C) Prescriptive Requirements for Laboratory and Process Facility exhaust systems.

1. **Fan System Power Consumption.** All newly installed fan systems for a laboratory or process facility exhaust system greater than 10,000 CFM, shall meet the discharge requirements in ANSI Z9.5-2012 and at least one of the requirements of Items 140.9(c)1A, B, or C. Exhaust fan system power demand equals the sum of the power demand of all fans in the exhaust system that are required to operate at design conditions in order to exhaust air from the conditioned space to the outdoors. Exhaust air does not include bypass air or entrained air, but does include all exhaust air from fume hoods, hazardous exhaust flows, or other manifolded exhaust streams.

   A. The allowable exhaust fan system power demand shall not exceed 0.45 watts per cfm of exhaust air; or

   B. The motor speed shall vary based on measuring wind speed taken from a calibrated local station. Wind speed controls must reduce the exhaust exit velocity by no less than 50% when the wind speed falls below a threshold determined by a certified wind engineer, while maintaining a dilution of 3000 :1; or

   C. The motor speed shall vary based on measuring contaminants in the exhaust plenum from a calibrated contaminant sensor. Contaminant concentration controls must maintain a dilution in the exhaust plenum of 750 :1 when the contaminant concentration falls below 0.5 ppm and a dilution in the exhaust plenum of 3000:1 when the contaminant concentration exceeds 0.5 ppm.

2. Exhaust Control Devices

   A. For each system with wind-speed controlled exhaust, a wind speed sensor shall be installed on the roof next to the exhaust plenums that meets the criteria of Section 140.9(c)1;

   B. Wind speed sensors shall be certified by the manufacturer to be accurate within plus or minus 60 fpm when measured at sea level and 25°C, factory calibrated, and certified by the manufacturer to require calibration no more frequently than once every 5 years. Upon detection of sensor failure, the system shall provide a signal which resets to exhaust the minimum quantity of air to achieve the criteria of Section 140.9(c)1B at the ASHRAE 1% design wind speed;

   C. For each system with contaminant concentration controlled exhaust, a contaminant sensor shall be installed within each exhaust plenum that meets the criteria of Section 140.9(c)1;

   D. Contaminant concentration sensors shall be Photo Ionization Detectors (PID) certified by the manufacturer to be accurate within plus or minus 5% when measured at sea level and 25°C, factory calibrated, and certified by the manufacturer to require calibration no more frequently than once every 6 months. Upon detection of sensor failure, the system shall provide a signal, which resets to exhaust the minimum quantity of air to achieve the criteria of Section 140.9(c)1C at a contaminant concentration above 0.5 ppm.

Proposed Code Language (slide added for posting)

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES (continued)

3. **Airflow Reduction Requirements.** For buildings with laboratory exhaust systems where the minimum circulation rate to comply with code or accreditation standards is 10 ACH or less, the design exhaust airflow shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation rate, or the minimum required to maintain pressurization requirements, whichever is larger. Variable exhaust and makeup airflow shall be coordinated to achieve the required space pressurization at varied levels of demand and fan system capacity.

SECTION 141.1 –REQUIREMENTS FOR COVERED PROCESSES IN ADDITIONSIONS, TO EXISTING BUILDINGS THAT WILL BE NONRESIDENTIAL, HIGH-RISE RESIDENTIAL

f) Lab and Process Facility Exhaust Systems. Lab and process facility exhaust systems comply with this section if they comply with the applicable requirements of Sections 140.9(c).

Key Web-Links/Resources

2019 Title 24 Utility-Sponsored Stakeholder Info

http://www.title24stakeholders.com/

Building Energy Efficiency Program

http://www.energy.ca.gov/title24/

Docket for Comments

https://efiling.energy.ca.gov/EComment/EComment.aspx?docketnumber=17-BSTD-01

Compliance Software

http://www.bwilcox.com/BEES/BEES.html

Energy Standards Hotline

title24@energy.ca.gov or (800)-772-3300 or (916)-654-5106

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Questions?