CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

2019 Title 24, Part 6 Codes & Standards Enhancement (CASE) Proposal

Induction Exhaust Fans

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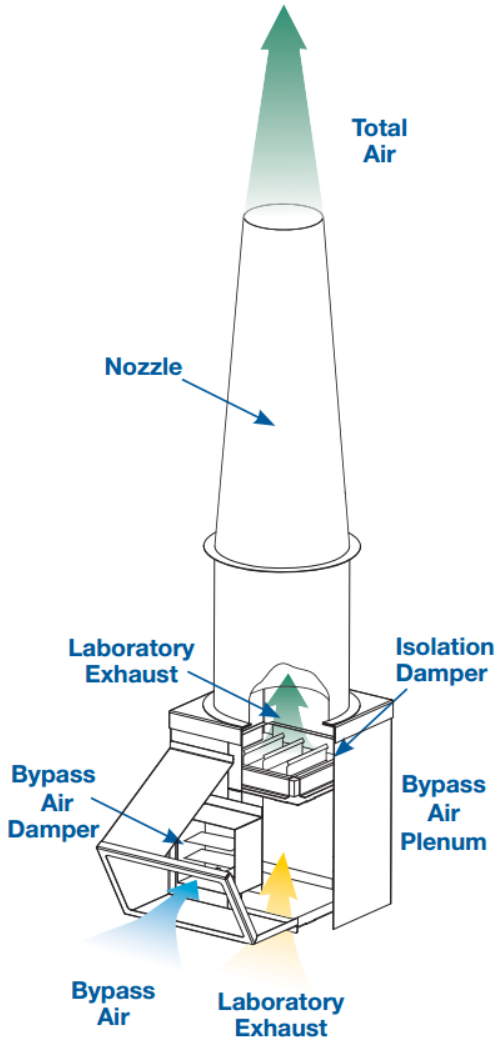
Los Angeles Department of Water & Power | SMUD | SDGE A Sempra Energy utility | SoCalGas A Sempra Energy utility | Southern California Edison An EDISON INTERNATIONAL Company | Pacific Gas and Electric Company

Proposed Code Change Overview

- Proposed measure will impact the selection and implementation of laboratory exhaust systems
- Anticipated type of change
  - Mandatory
  - Prescriptive
- Description of change
  - Require cross wind measure stations be specified whenever induction exhaust fans are selected to control induction fan speed
  - Revise prescriptive fan power equation to include a limited allowance for process discharge exhaust fan power

System Description: Conventional Stack Exhaust

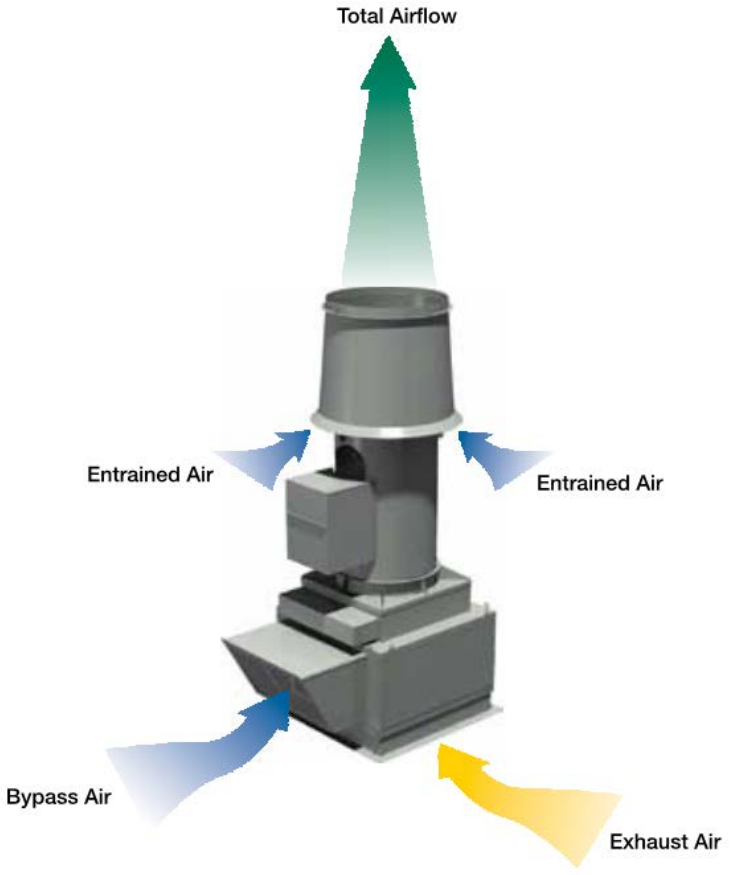
- Releases lab exhaust at height above air intakes at low discharge velocity
- Requires tall exhaust stack



Greenheck Fan Corp.

System Description: Induction Exhaust Fans

- Entrains outdoor air, combined with lab exhaust, to achieve larger momentum→ higher effective plume height
- Allows for shorter exhaust stack → exhaust stack not visible from line of sight → more aesthetically pleasing
- Provides equivalent level of safety as conventional stack



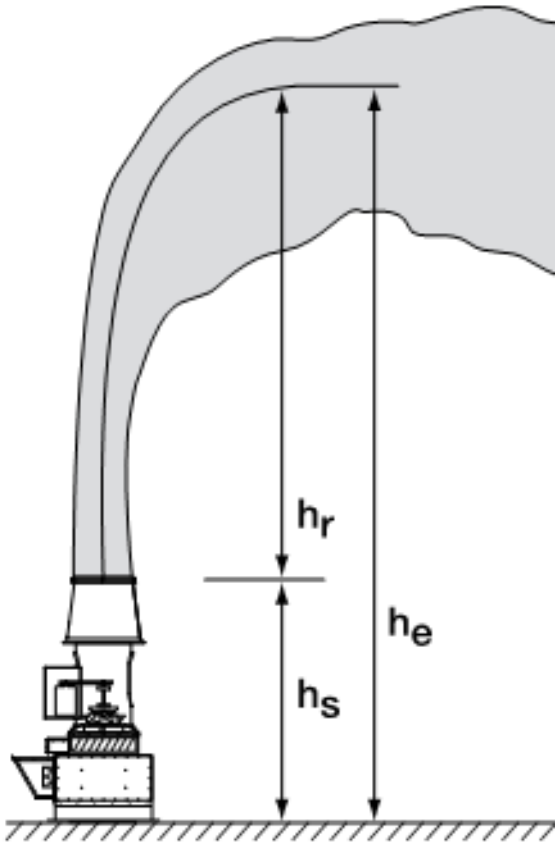
Greenheck Fan Corp.

System Description: Induction Exhaust Fans

- Effective plume height (h_e) dependent on
  - Stack height (h_s)
  - **Mass flow rate**
    - Exit velocity (V)
    - Windband diameter (d)
  - **Wind speed (U)**

$$h_e = \frac{3Vd}{U} + h_s$$

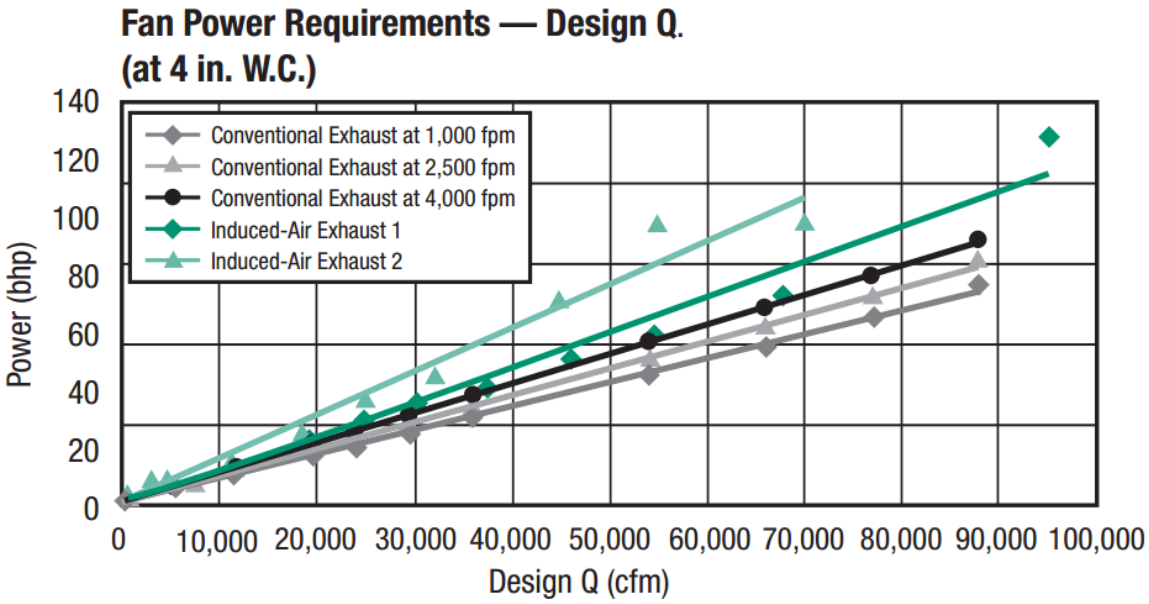
ASHRAE Laboratory Design Guide
Equation 9-2



Greenheck Fan Corp.

System Description: Induction Exhaust Fans

- Induction exhaust fans require higher fan power than conventional stack exhaust



Laboratories for the 21st Century: Best Practices

Proposed Code Change History

- Why are we proposing this measure?
  - While Title 24, Part 6 requires lab and process facility exhaust be capable of reducing zone exhaust to regulated minimum circulation rate
    - Lab and process facility exhaust power demand currently unregulated
    - No existing baseline for lab and process facility exhaust power
    - No requirement to restrict fan power by wind speed → significant savings opportunity through use of cross wind measure stations

Current Code Requirements

- Existing Title 24, Part 6 Requirements
  - 140.4(c) Power Consumption of Fans: Total fan power demand does not include fan system power caused by exempt process loads, including laboratory exhaust
  - 140.9(c) Prescriptive Requirements for Laboratory Exhaust Systems: Variable exhaust and makeup airflow shall be coordinated to achieve varied levels of demand and fan system capacity

Current Code Requirements

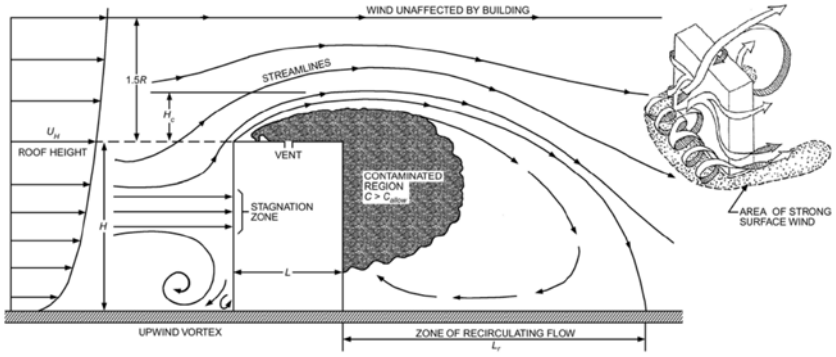
- Existing Model Code Requirements:
  - *American National Standards Institute / American Industrial Hygiene Association Standard Z9.5: Laboratory Ventilation (ANSI/AIHA Z9.5-2012)*
    - Exhaust discharge from stacks shall be in vertical-up direction at minimum of 10 feet above adjacent roof line and located with respect to openings and air intakes to avoid reentry
    - Exhaust discharge shall have discharge velocity of at least 3,000 fpm for stack with internal condensation

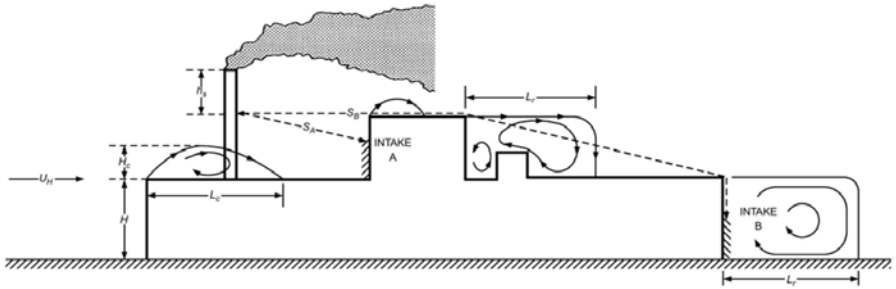
Current Code Requirements

- Existing Model Code Requirements:
  - *National Fire Protection Association Standard 45: Standard on Fire Protection for Laboratories Using Chemicals (NFPA 45-2015)*
    - Air exhausted from laboratory hoods shall be discharged above roof at a location, height, and velocity sufficient to prevent re-entry of chemicals
    - Exhaust stacks should extend at least 10 feet above highest point on roof to protect personnel on roof

Typical Practices

- Current practices
  - Design for constant ASHRAE design wind speed toward inlets
  - Run fans at high speed even during favorable wind conditions
  - Follow design methodology in:
    - ASHRAE Handbook—Fundamentals: Chapter 24: Airflow Around Buildings
    - ASHRAE Handbook—HVAC Applications Chapter 16 Laboratories (section 3.5 Stack Heights and Air Intakes)





Typical Practices

- Trends
  - Specification of induction exhaust fans for aesthetics
  - For high performance buildings
    - Installation of traditional stack
    - Installation of induction exhaust fans with variable frequency drive and rooftop anemometer control
    - Hiring wind consultants to perform wind tunnel testing for recommendation of discharge velocities and stack heights

Market Overview and Analysis

- Current Induction Exhaust Fan Market
  - Market size: $5-6 million/year
  - Market well established: Greenheck, Cook, Strobic, etc.
  - Data gaps: number of induction exhaust fans specified vs. stacks specified
- Current Anemometer Market
  - Market well established: Vaisala, Lufft, etc.
  - Data gaps: number of anemometers specified for induction exhaust

Market Overview and Analysis

- Market impacts
  - Energy consumption by this product in new construction estimated to be 94 GWh/yr
  - Assumptions
    - Average EUI of facility w/ IEF = 250 kBtu/sq.ft.
    - Exhaust accounts for 32% of facility energy
    - 8 million square feet of new lab & process facility construction, half of which designed with IEF

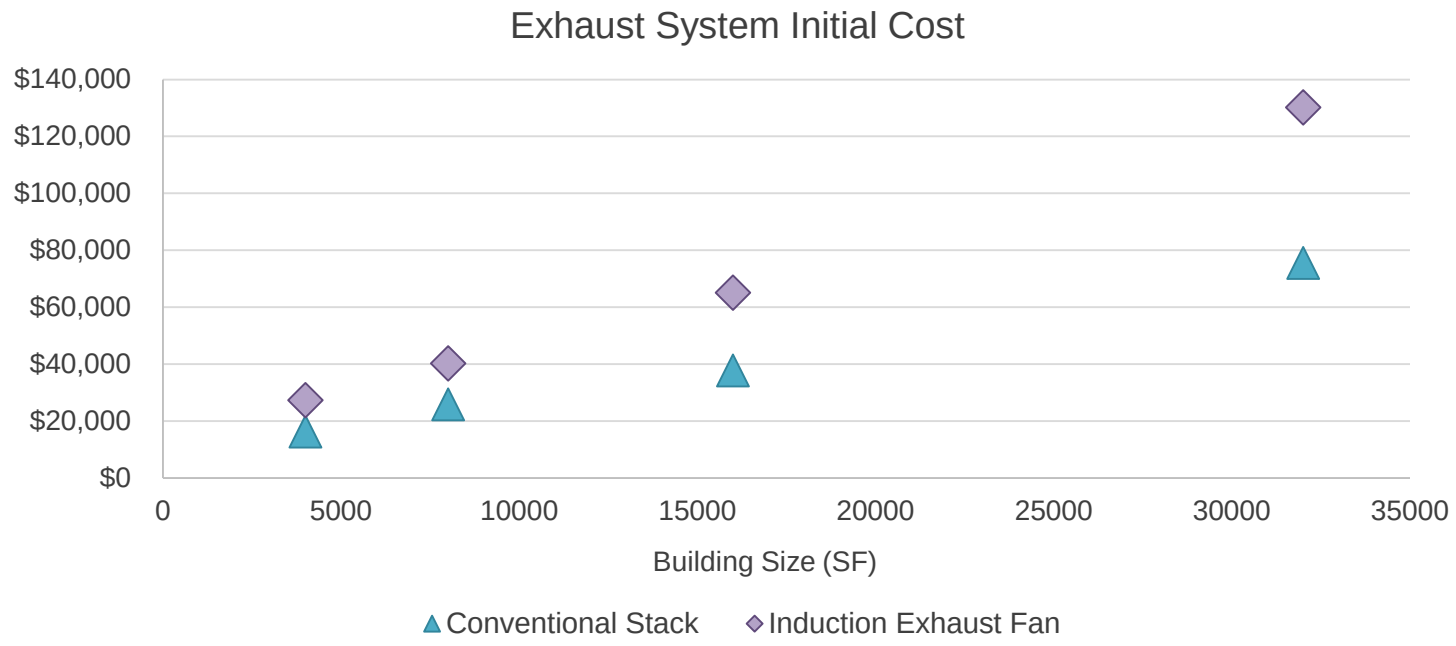
Market Overview and Analysis

- Market barriers
  - Assumption that induction exhaust fans are more effective at diluting pollutants without wind-speed control
  - Hesitancy to rely on wind sensor calibration to ensure safe discharge of pollutant exhaust
  - Not all fans are designed with variable frequency drive
- Other market information sources we should know about?

Incremental Cost Estimation

- How we collected costs of base case technology and proposed technology
  - Interviews with manufacturers & suppliers for equipment initial costs and maintenance costs
- What components of costs did we leave out?
  - Controls design cost
  - Labor cost

Incremental Cost Estimation



- Cost of rooftop anemometer fairly low with respect to cost of fan equipment (about 5%)
- Cost of induction exhaust fans significantly higher than conventional stack and cost difference increases and building size increases

Methodology for Savings Analysis

- Methodology for energy and demand impacts
  - Spreadsheet analysis for all 16 California climate zones
    - Test at varying exhaust types (low concentration, high concentration, etc.)
    - Test at varying building sizes (4,000 – 32,000 sq.ft.)
  - Compare wind speed-controlled fan power to typical-design IEF fan power (designed for ASHRAE 1% extreme wind speed)
    - Hourly wind speed and direction from TMY3 data
    - Fan power reduction from Saving Energy in Lab Exhaust Systems, ASHRAE Journal, June 2011

Assumptions for Energy Impacts Analysis

- Key assumptions
  - Operating hours: 9AM – 5PM
  - 10 ACH during occupied hours, 6 ACH during unoccupied hours
  - Desired plume height: 30 ft.
  - Static pressure: 5 in. wg
  - Minimum exit velocity: 3,000 ft./min
  - Fraction of facilities containing targeted technology: 50%
  - Equal distribution of different size facilities
- Data sources
  - Manufacturer specifications (Cook, Strobic, Greenheck)
  - Laboratories for the 21st Century: Best Practices
  - PG&E High Performance Laboratories Design Guidelines
  - LBNL Design Guide for Energy-Efficient Research Labs

Incremental Cost Savings

- Approach
  - Incremental cost savings are calculated based on TDV cost savings associated with energy savings over the entire period of analysis.
  - Present TDV cost multiplier ($/TDV kBTU)

Preliminary Energy Savings Estimates

Preliminary Energy Savings Estimate				
Annual per Unit Electricity Savings* (kWh/sf-yr)	Annual per Unit Natural Gas Savings* (Therms/sf-yr)	First Year Statewide Electricity Savings (GWh/yr)	First Year Statewide Natural Gas Savings (Million Therms/yr)	Confidence Level (high, medium, low)
5.5	0	22	0	high

Preliminary Cost Effectiveness Estimates

	Benefit (2020$)	Cost (2020$)
Total Per Building Incremental Cost over Period of Analysis		$3,750
• *Incremental first cost (supplies, equipment, installation)*		*$2,500*
• *Incremental maintenance cost (replacement equipment, regular maintenance) over period of analysis*		*$1,250*

Preliminary Cost Effectiveness Estimates

Climate Zone 11 (Worst Case)

Exhaust Zone Size (Sq Ft)	Benefit (2020$/Sq Ft)	Cost (2020$/Sq Ft)	Benefit/Cost Ratio
4,000	4.58	0.94	4.9
8,000	2.29	0.47	4.9
16,000	10.41	0.23	44.4
32,000	10.41	0.12	88.8
TOTAL	6.92	0.44	15.7

Climate Zone 5 (Best Case)

Exhaust Zone Size (Sq Ft)	Benefit (2020$/Sq Ft)	Cost (2020$/Sq Ft)	Benefit/Cost Ratio
4,000	30.67	0.94	32.7
8,000	15.34	0.47	32.7
16,000	11.57	0.23	49.3
32,000	11.57	0.12	98.7
TOTAL	17.28	0.44	39.3

Preliminary Cost Effectiveness Estimates

All Climate Zones (Average)

	Benefit (2020$)	Cost (2020$)
Total Per Sq Ft Incremental Cost over Period of Analysis		$0.44
• *Incremental first cost (supplies, equipment, installation)*		*$0.29*
• *Incremental maintenance cost (replacement equipment, regular maintenance) over period of analysis*		*$0.15*
Per Sq Ft TDV Cost Savings over Period of Analysis	$14.15	
TOTAL	$14.15	$0.44
Benefit/Cost Ratio	32.2	

Compliance and Enforcement- Market Actors

- Who would be involved in implementing this measure?
  - Induction Fan Manufacturers
  - Mechanical Designers
  - Wind Consultants
  - Energy Consultants
  - Installers
  - Building Enforcement Agency – Inspector
  - Building Enforcement Agency – Plan Check
  - Building Owner
- Others?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Induction Fan Manufacturers	- Develop products and equipment that will meet laboratory exhaust design specifications and code regulations - Experts in induction exhaust fan design, manufacturing, and testing Not familiar with Title 24 part 6, but very familiar with Title 20 - Work in a retail setting or supplier warehouse	- The product is successful if it is within compliance and gets sold for use in laboratory exhaust design

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Mechanical Designers	- High level of technical design requirements. Experts in mechanical design and fan sizing. - Knowledgeable of T24 requirements and comfortable with completing compliance forms - Specify the products, performance requirements, and many sequences of operations. -Primarily at design desk, but do field visits after construction has started	- Success is if fan system is designed to the architect's aesthetic requirements, while passing plan check and acceptance tests.

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Wind Consultants	- Perform wind modelling to guide mechanical designers in mechanical layout and product specification to ensure the design meets code and safety requirements - Are not necessarily experts in any specific mechanical system, but have an in depth knowledge of energy/wind - Experts with wind modeling software and tools - Not very familiar with Title 24 Part 6 Work in an office environment	- A successful model captures the specified mechanical system, meets project energy goals, and falls within code compliance

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Energy Consultants	- Moderate level of exhaust fan expertise, have an all-around knowledge of building science - Perform energy modeling, load calculations, and advise the design team on the compliant project approach. - Primarily in the office on the computer	- Building a model that meets the compliance criteria and is accurate to the building to pass plan check.

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Installers	- Installation and operational knowledge of laboratory exhaust system - Should be familiar with Title 24 Part 6 requirements but often are not - Select and install exhaust system - Perhaps conduct acceptance testing - In the field	- Success if it is completed in a timely manner to the designers specifications, falls within compliance, passes field inspection on first visit, and the owner is satisfied - Potentially complete, or assist with acceptance tests.

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Building Enforcement Agency – Plan Check	- General knowledge, sometimes not specialized in HVAC. - Aware of duct leakage and testing requirements. - Review the permit submittal for code compliance, issue construction permit, issue occupancy permit, installation review - Work in an office environment and in the field	- Success is confirming plans are compliant with Part 6, duct sealing is completed and meets requirements

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Building Enforcement Agency – Inspector	-High level of expertise -In the field looking at equipment -Must verify if equipment is registered with Title 24 -Vast amount of information to verify and are only onsite for an avg of 6 min -Must review project for a ton of code sections, not just the energy code.	-Need to minimize number of site visits and avoid re-inspection -Need to get things right the first time

What are we not capturing?

Compliance and Enforcement—Tasks

Market Actor	Task(s)	Success Criteria
Building Owner	- Low knowledge of energy code, they are vaguely aware that codes are a part of a permit	- A complete, code compliant building with satisfied tenants

What are we not capturing?

Compliance and Enforcement—Resources

Market Actor	Resource(s)
Induction Fan Manufacturers	- Compliance Manual - Reference Appendix
Mechanical Designers	- Compliance Manual - Reference Appendix - Compliance Forms
Wind Consultants	- ?
Energy Consultants	- Compliance Manual - Reference Appendix - Compliance Forms

What resources or tools are typically used for compliance?

Compliance and Enforcement—Resources

Market Actor	Resource(s)
Installers	- Compliance Manual - Reference Appendix - Compliance Forms
Building Enforcement Agency – Inspector	- Standards Language - Compliance Forms
Building Enforcement Agency – Plan Check	- Standards Language - Compliance Manual - Reference Appendix
Building Owner	- ?

What resources or tools are typically used for compliance?

Strawman Code Change Language

- Title 24, Part 6 Standards
  - Option 1: New mandatory requirement for covered processes (120.6) and alteration of prescriptive requirement for space conditioning systems (140.4)
    - Allows for tradeoffs between exhaust system and other HVAC fan systems
    - More stringent option (mandatory requirement)
  - Option 2: New prescriptive requirement for covered processes (140.9)
    - Does not allow for tradeoffs in other HVAC fan systems
    - Provides multiple pathways of compliance
    - Requires change in ACM to specify primary prescriptive path for performance method baseline

Strawman Code Change Language Option 1 (Mandatory)

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(f) **Mandatory Requirements for Laboratory and Process Facility Exhaust Systems.**

1. **Induction Exhaust Fans.**
   Where induction exhaust fans are used, the discharge requirements shall meet ANSI Z9.5. For motors greater than 5HP, the motor speed shall vary based on measuring wind speed taken from a calibrated rooftop station.

Strawman Code Change Language Option 1 (Prescriptive V1)

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(c) **Power Consumption of Fans.** Each fan system used for space conditioning, including discharging exhaust air in laboratories and process facilities, shall meet the requirements of Items 1, 2, 3 and 4 below. Total fan system power demand equals the sum of the power demand of all fans in the system that are required to operate at design conditions in order to supply air from the heating or cooling source to the conditioned space, and to return it back to the source or to exhaust it to the outdoors.

EXCEPTION to Section 140.4(c): Total fan system power demand need not include (i) the additional power demand caused solely by air treatment or filtering systems with final pressure drops more than 245 pascals or one-inch water column (only the energy accounted for by the amount of pressure drop that is over 1 inch may be excluded), or (ii) fan system power caused solely by exempt process loads.

1. **Constant volume fan systems.** The total fan power index at design conditions of each fan system with total horsepower over 25 hp shall not exceed xx watts per cfm of supply air.
2. **Variable air volume (VAV) systems.**
   a. The total fan power index at design conditions of each fan system with total horsepower over 25 hp shall not exceed xx watts per cfm of supply air; and

Strawman Code Change Language Option 1 (Prescriptive V2)

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(c) **Power Consumption of Fans.** Each fan system used for space conditioning, including discharging exhaust air in laboratories and process facilities, shall meet the requirements of Items 1, 2, 3 and 4 below. Total fan system power demand equals the sum of the power demand of all fans in the system that are required to operate at design conditions in order to supply air from the heating or cooling source to the conditioned space, and to return it back to the source or to exhaust it to the outdoors.

1. **Fan Power Limitations.** Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (Option 1) or fan system bhp (Option 2) as show in Table 140.4-A. Single-zone variable-air-volume systems shall comply with the constant-volume fan power limitation.

   Exceptions:

   1. Individual exhaust fans with motor nameplate horsepower of 1 hp or less.
   2. Fan system power caused solely by exempt process loads.

Table 140.4-A Fan Power Limitation Pressure Drop Adjustment

Device	Adjustments
Credits	
…	…
Pollutant exhaust discharge	6 in. wc

Strawman Code Change Language Option 2

SECTION 140.9 – PRESCRIPTIVE REQUIREMENTS FOR COVERED PROCESSES

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

1. **Fan Power Limitations.** The fan system for a laboratory or process facility exhaust system shall meet the discharge requirements in ANSI Z9.5 and comply with one of the following:
   A. The allowable fan system static pressure design conditions shall not exceed xx in. wc.; or
   B. The motor speed shall vary based on measuring wind speed taken from a calibrated rooftop station; or
   C. The fan system shall have no bypass and shall utilize staging of multiple exhaust fans.

Feedback Request from Stakeholders

If you have any additional information or feedback, please send an email to Jlandsman@integralgroup.com. It's hugely appreciated!

Thank you.

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