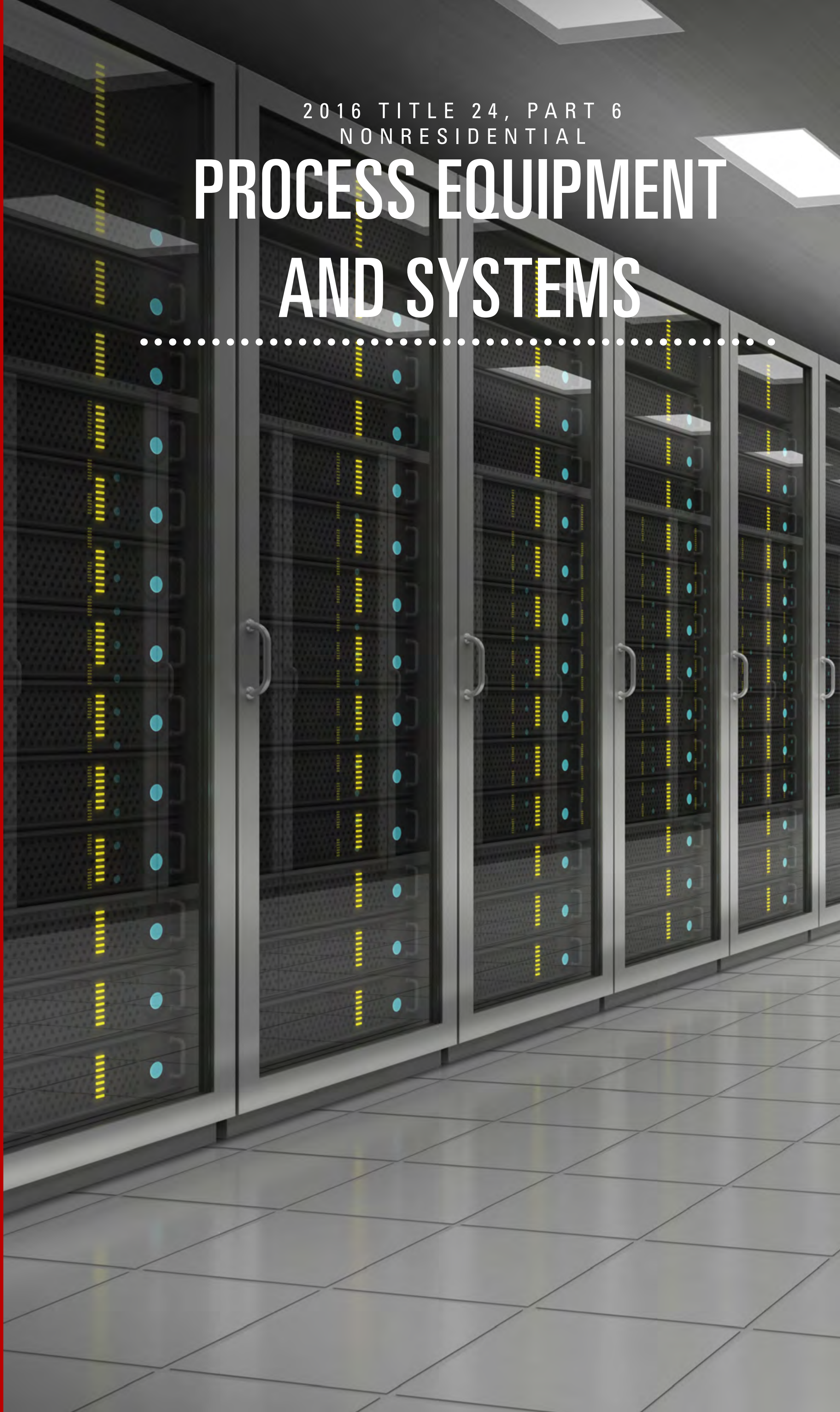
2016 TITLE 24, PART 6
NONRESIDENTIAL

# PROCESS EQUIPMENT AND SYSTEMS



Energy Code Ace™
HELPING YOU PLAY YOUR CARDS RIGHT

This guide is designed to help builders and industry professionals become more familiar with the nonresidential covered process portion of California's 2016 Building Energy Efficiency Standards (Title 24, Part 6).

The guide provides information on current technologies, design terms and principles, and best-practice recommendations.

This guide was developed and provided by Energy Code Ace, a sub-program of the California Statewide Codes & Standards Program, which offers free energy code training, tools and resources for those who need to understand and meet the requirements of Title 24, Part 6 and Title 20.

To learn more, visit EnergyCodeAce.com

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**NONRESIDENTIAL
PROCESS EQUIPMENT AND SYSTEMS
APPLICATION GUIDE**

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CHAPTER 1

# INTRODUCTION

## The Benefits of Efficiency

The California Energy Commission has been expanding the influence of California's Building Energy Efficiency Standards (Energy Standards) for many years. The process elements included in the 2013 Energy Standards began to impact energy use systems that were not previously regulated and allowed for energy efficiency opportunities in a new series of equipment and building types.

### Expanding Best Practices

These new process regulations increased energy savings for the State and introduced energy conservation strategies that were previously known only as "Best Practices" amongst a handful of designers and industry owners.

### Economic Savings

Energy efficiency related to process equipment in buildings dominated by process systems could result in significant savings each month on utility bills. Requirements in the Energy Standards must go through economic studies to ensure cost-effectiveness that results in consistent savings for owners or tenants.

## About This Guide

This is one of seven guides designed to help builders, designers, contractors, and others involved in the compliance process become more familiar with California's 201. Title 24, Part 6 residential and nonresidential standards as they apply to projects. They are designed to serve as a resource for industry professionals involved in the design, construction, or retrofit of California's buildings. The guides include compliance requirements and recommendations for implementing the Energy Standards in new construction, addition and renovation projects.

This application guide provides guidance on process elements introduced in previous Energy Standards as well as the updated 2016 requirements. It also provides design teams, owners, and facility managers a clear strategy to comply with the Energy Standards and identifies efficiency measures beyond minimum energy code.

### Compliance Process Overview

The guide begins with an overview of the compliance proces. in Chapter 2 including the responsibilities, requirements and documentation involved in each phase of the project, from design to final inspection.

*Compressor Station at a Factory*

## What is a covered process?

The Energy Standards use the term covered processes to identify process loads that are regulated under Title 24, Part 6 which include but are not limited to computer rooms, laboratory exhaust, garage exhaust, commercial kitchen ventilation, refrigerator warehouses, supermarket refrigeration systems, compressed air systems, process cooling towers and process boilers.

Processes are defined as an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

## Concepts & Principles

Chapter 3 is devoted to process concepts and principles such as what is considered a process load (within the Energy Standards), and the role these loads play in a building's energy use profile.

## Technology, Systems and Compliance Strategies

Chapter 4 describes each covered process regulated by the Energy Standards, as well as compliance strategies and typical project scenarios.

***All seven guides can be found at EnergyCodeAce.com***

| APPLICATION GUIDE | WHAT'S COVERED |
|---|---|
| NONRESIDENTIAL ENVELOPE AND SOLAR READY | • Climate specific design<br>• Insulation<br>• Cool Roofs<br>• Solar Zone<br>• Fenestration<br>• Compliance documentation details |
| NONRESIDENTIAL LIGHTING AND ELECTRICAL POWER DISTRIBUTION1 | • Lighting design strategies<br>• Controls<br>• Electrical power distribution |
| NONRESIDENTIAL HVAC AND PLUMBING | • Mechanical Systems and Plumbing Systems<br>• Commissioning, HERS Process & Acceptance Testing |
| NONRESIDENTIAL PROCESS EQUIPMENT AND SYSTEMS | • Process loads<br>• Applicable products and systems such as kitchen hoods, parking garage ventilation, laboratory fume hoods, elevators and moving walkways, escalators, and compressors |
| RESIDENTIAL ENVELOPE AND SOLAR READY (Low-Rise and Single Family) | • Single Family Homes<br>• Duplexes<br>• Low-rise residential building envelope<br>• Climate specific design<br>• Insulation<br>• Cool Roofs<br>• Solar Zone<br>• Fenestration<br>• Prescriptive vs. Performance compliance<br>• Compliance documentation details |
| RESIDENTIAL LIGHTING[1] (Low-Rise and Single Family) | • Lighting design strategies<br>• Compliant Products<br>• Controls |
| RESIDENTIAL HVAC AND PLUMBING (Low-Rise and Single Family) | • HVAC terminology<br>• Heating and cooling system types<br>• Hot Water system types |

[1] Created by the California Lighting Technology Center (CLTC) in collaboration with Energy Code Ace.

# New in 2016: An Overview of Updates

## Elevators, Escalators, and Moving Walkways

No significant changes were made in the 2016 Energy Standards to the process elements introduced in the 2013 Energy Standards. A few sections are added to §120.6 to include new regulations for elevators, escalators, and moving walkways. These new sections add previously unregulated energy uses to the mandatory requirements; there are no prescriptive compliance paths to these new requirements.

The new language does not necessarily regulate the mechanical efficiency or total power for elevators or applicable escalators and moving walkways, but rather manages how they are run in occupied and unoccupied modes. For example, when elevator cabs are unoccupied, they are now required to setback lighting and ventilation with occupancy sensors. The new §120.6 (f) introduces lighting power density allowances in the elevator cab as well. For escalators and moving walkways, the equipment is required to set back to minimum permitted speeds, saving energy, when not conveying passengers.

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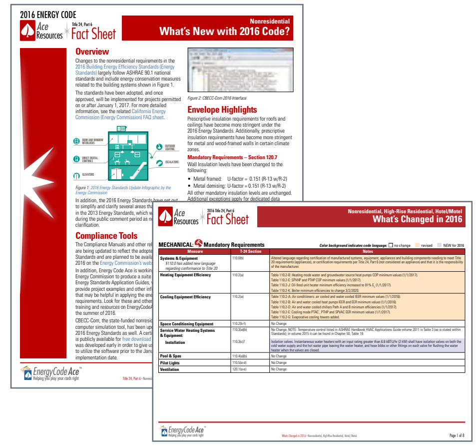



*What's New and What's Changed Fact Sheets*

These two documents present 2016 Title 24, Part 6 updates at a glance.

Find Fact Sheets here: energycodeace.com/content/resources-fact-sheets

Ace Training™

### Title 24: Where We're Headed with the 2016 Standards

Offered in traditional classroom and virtual formats, this class presents what's new in the Title 24, Part 6 Energy Standards.

Find dates for upcoming classes: energycodeace.com/training

### Decoding 2016 Title 24, Part 6: Let's Talk About What's New

A free, 2-hour interactive online event that discussed, reviewed and decoded the new 2016 code requirements for Title 24 Part 6.

Access the recorded talk here: energycodeace.com/content/decoding-talks/

CHAPTER 2

# COMPLIANCE PROCESS

The California Energy Commission has been expanding the influence of California's Building Energy Efficiency Standards (Energy Standards) for many years. The process elements included in the 2013 Energy Standards began to impact energy use systems that were not previously regulated and allowed for energy efficiency opportunities in a new series of equipment and building types.

The following is an overview of the steps to compliance for nonresidential covered process systems. Additional information and resources, including the 2016 Nonresidential Compliance Manual and forms, can be found on the California Energy Commission website: energy.ca.gov/title24/2016standards/index.html

## Step 1: Discuss and Define Energy-Related Project Goals

Designers, project owners and builders have the most opportunity to identify and pursue energy savings strategies at the beginning of a project. Early coordination with as many project team members as possible is recommended to clearly define energy related project goals and understand potential opportunities and constraints.

## Step 2: Determine and Design for...

### Applicable Mandatory Measures

All nonresidential buildings that are regulated occupancies must be designed and built to comply with the mandatory measures of Title 24, Part 6. Mandatory measures are discussed in Chapter 4 of this guide for each unique covered process.

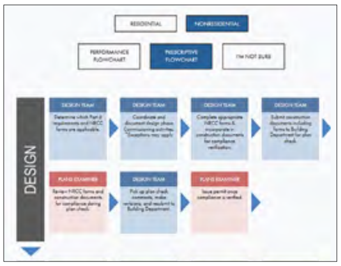
### Applicable Performance or Prescriptive Requirements

In addition to meeting the mandatory requirements, buildings also must comply with additional requirements specified within the Energy Standards. Two approaches may be taken to meet these requirements:

The **Performance Approach** provides one path to compliance. It requires using software approved by the California Energy Commission and is best suited for only a handful of the covered processes covered in this guide.

*Moving Walkway*

Ace Navigator™




The Navigator Ace™ is your roadmap to energy code compliance, illustrating the compliance process step by step from the big picture down to the fine details, including links to resources and tips and tricks.

Find the tool here: energycodeace.com/content/navigator-ace/

| OCCUPANCY GROUP | | EXAMPLE |
|---|---|---|
| A | Assembly | Theaters, Churches |
| B | Businesses | Office Buildings |
| E | Educational Facilities | K-12 Schools |
| F | Factories, Low & Moderate Hazard | Industrial Manufacturing Buildings |
| H | High Hazard Facilities | Laboratories, Refineries |
| M | Mercantile | Grocery Store, Department Store |
| R | Residential | Apartment buildings with four or more habitable stories, hotels/motels, long-term care facilities |
| S | Storage, low & moderate hazard | Industrial warehouse, mini storage |
| U | Utility | Garages, towers |

The **Prescriptive Approach** does not require software or the same level of building science expertise as the Performance Approach. The prescriptive approach is best suited for the majority of the covered process applications described further in this guide.

## Local Energy Standards

There also may be local energy standards that the local jurisdiction will enforce in addition to Title 24, Part 6. These local energy standards are atypical for covered processes but may affect other aspects of the project such as lighting, insulation, HVAC installations, and domestic hot water. Additionally, these local energy standards can require third-party inspections and building certifications. Being aware of local energy standards in the design phase of the project will reduce cost, time, and effort, as well as help to avoid extensive and costly change orders.

energy.ca.gov/title24/2016standards/ordinances/

## *Step 3: Prepare and Submit Permit Application*

Once the design requirements in the Energy Standards have been met, the permit applicant must ensure that the plans include all the documents that building officials will require to verify compliance. Plans, specifications and certificate of compliance forms (NRCC) are submitted to the enforcement agency at the same time as a building permit application. There are some exceptions when plans are not required, and these can be found in Section 10-103 of Title 24, Part 6.

## *Step 4: Pass Plan Check and Receive Permit*

Depending on the type of permit, the building department will issue a permit over the counter or require that the construction documents and plans be reviewed (aka plan check). If a plan check is required, a plans examiner must verify that the design satisfies Title 24, Part 6 requirements and that the plans contain the information to be verified during field inspection. A building permit is issued by the building department after plans are approved.

## *Step 5: Perform Construction*

The construction team must follow the approved plans, specifications and certificate of compliance forms during construction. Coordination will be required between installers, designers, Acceptance Test Technicians and building inspectors to properly select, install, and verify compliant installation. During construction, certificates of installation (NRCI) are completed in preparation for inspection.

## *Step 6: Test and Verify Compliance*

When Acceptance Testing is required by Title 24, Part 6, early coordination is encouraged to understand when inspections and testing are necessary during the construction process and incorporated into the schedule. Many systems inspections are time sensitive as they may be inaccessible after walls or other barriers are installed.

## Commissioning

Commissioning for covered process systems is not required for compliance with §120.8 the Energy Standards, but as a best practice, most elements should be included as part of the normal quality assurance commissioning process. For resources on non-regulated commissioning activities and best practice applications, private non-profit groups like the California Commissioning Collaborative provide guidance through their website: cacx.org/index.html

## Acceptance Testing

Title 24, Part 6 requires that Certified Acceptance Test Technicians (ATTs) review and test lighting controls and eventually mechanical installations, but ATTs are not required for covered process installation acceptance tests. For covered processes the installing contractor may qualify as the test technician.

Test technicians are required to:

- Perform a construction inspection to ensure that what has been installed is consistent with the certificates of compliance, certificates of installation, and associated documentation as approved by the local jurisdiction
- Test installations to ensure controls are positioned and calibrated to operate in compliance with the Energy Standards and the approved certificates and associated documentation
- Check that all necessary set points or schedules are in place as required by the Energy Standards and the approved certificates and associated documentation
- Fill out required Certificates of Acceptance (NRCA) and submit these to the general contractor or the identified responsible person (i.e., engineer, architect, commissioning agent) who will be responsible for submitting them to the enforcement agency

## Step 7: Pass Building Inspection

The local authority having jurisdiction, often the building department, likely will require an inspection before finalizing the permit. Building inspections often are scheduled by the contractor with the building department on behalf of the building owner. Ideally, once all systems are installed & inspected and completed compliance documentation has been verified, a Certificate of Occupancy will be issued by the local jurisdiction. However, temporary, conditional, or partial Certificates of Occupancy are not uncommon for some local jurisdictions.

## Step 8: Provide Documentation to Building Owners

Upon occupancy, the building owner must receive copies of the energy compliance documents along with instructions for operation and maintenance.

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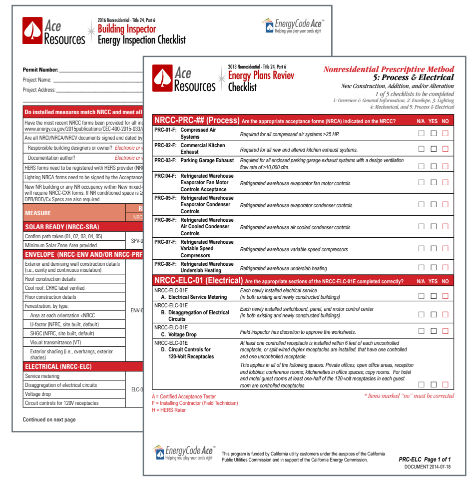



*Plans Examiners and Building Inspector Checklists*

Checklists for Plans Examiners and Building Inspectors are available for applicants to prepare for plan check and inspection as well as to guide department staff through Part 6 compliance verification

Find the checklists here: energycodeace.com/content/resources-checklists/

Ace Training™

### Title 24, Part 6 Essentials Training

Offered in traditional classroom and virtual formats, participants learn about navigating key nonresidential Title 24, Part 6 building standards and compliance options for new construction, alterations and additions, and compliance related documents. This course is available in several versions to fit project roles:

- Title 24 Part 6 Essentials – Nonresidential Standards for Plans Examiners and Building Inspectors
- Title 24 Part 6 Essentials – Nonresidential Standards for Energy Consultants
- Title 24 Part 6 Essentials – Nonresidential Standards for Architects

Find dates for upcoming classes: energycodeace.com/training

## Nonresidential Covered Process Compliance Documents

The compliance process includes the completion of an extensive set of forms to submit for review by a plans examiner within the authority having jurisdiction. Not all forms are required for all projects. Instructions for completing these forms are provided in Section 5.10 of the Energy Commission's Nonresidential Compliance Manual.

## Form Naming Convention

**NRCC-ENV-02-E**

**Nonresidential** (NR)

### Document Category

- CXR = Commissioning Design Review
- ELC = Electrical
- ENV = Envelope
- LTI = Indoor Lighting
- LTO = Outdoor Lighting
- LTS = Sign Lighting
- MCH = Mechanical
- PLB = Plumbing (DHW)
- PRC = Covered Process
- PRF = Performance approach
- SRA = Solar Ready
- STH = Solar Thermal

### Document Type

Certificates of...

- CC = Compliance
- CI = Installation
- CA = Acceptance
- CV = Verification

### Primary User

- E = Enforcement agency
- H = HERS Rater
- F = Field Technician (Contractor)
- A = Acceptance Test Tech

## Certificates of Compliance

The Certificate of Compliance (NRCC) documents the building features required to comply with Title 24, Part 6, for nonresidential, high-rise residential and hotel/motel buildings. These features will vary depending on the particular project and the compliance approach used. NRCCs are submitted to the building department as part of the building permit application (See Step 3 of the compliance process description.)

## Certificates of Installation

The Certificate of Installation (NRCI) documents that the building features actually installed in the field match those required in the Certificates of Compliance. NRCIs must be completed and signed by the installer or builder responsible for installing different building components (See Step 5 of the compliance process description).

## Certificates of Acceptance

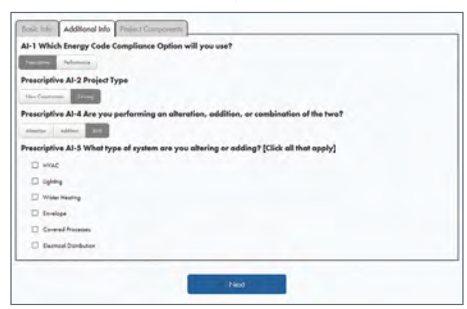
The Certificate of Acceptance (NRCA) certifies that the building systems and equipment, as installed in the field, function and perform the way they were designed. NRCAs must be completed and signed by the test techinician performing the acceptance test. (See Step 6 of the compliance process description.) For some lighting and mechanical tests, the Certificate of Acceptance must be completed and signed by a certified Acceptance Test Technician.


*Compliance Documents*

Compliance Document forms can be found on the Energy Commission website.

Click here to access the forms: energy.ca.gov/2015publications/CEC-400-2015-033/appendices/forms/

Ace Forms™




The Forms Ace aids in determining which compliance forms are applicable to your specific project.

Find the tool here: energycodeace.com/content/forms-ace/

CHAPTER 3

# CONCEPTS & PRINCIPLES

## What is Considered a Covered Process?

The term "covered process" is used to represent an energy end use of some regular mechanical function within the building that is regulated by the Energy Standards. As with the typical industry terminology, process loads are those that are not resulting from space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

The process elements which are regulated represent large energy users, and all tend to be on the periphery of traditional commercial building loads.

### 1. Covered Processes with Mandatory Requirements

- Refrigerated Warehouses
- Commercial Refrigeration
- Enclosed Parking Garages
- Process Boilers
- Compressed Air Systems
- Elevators
- Escalators & Moving Walkways

### 2. Covered Processes with Prescriptive Requirements

- Computer Rooms
- Commercial Kitchen Ventilation
- Laboratory Exhaust Systems

## The Role of Process Loads in Energy Load Profiles

Process loads can be significant energy loads, sometimes the most significant in the building. One example is commercial refrigeration systems within a grocery store, which dominate energy consumption for this occupancy type. Another is refrigerated warehouses, where nearly the entire building load is considered process, but was only recently regulated by the Energy Standards. In the past these "necessary" processes would be left unchecked without much thought about how to efficiently and reliably minimize loads. However, best practices for efficient design and utility incentive programs have effectively develope. standard efficient practices within these industries. These standard efficient practices have started making their way into the Energy Standards.

*Refrigerated Grocery Case*

CHAPTER 4

# TECHNOLOGY, SYSTEMS AND COMPLIANCE STRATEGIES

## Compliance Requirements

There are two basic steps to comply with the Energy Standards:

1. Meet all mandatory requirements by installing required systems, equipment and devices, and ensure that they perform all functions required by the Energy Standards.
2. Select your method of compliance by choosing either the Performance Approach or the Prescriptive Approach.

### Mandatory Requirements

All nonresidential buildings which include covered processes must meet a set of mandatory requirements within §120.6. Compliance with the process elements of the 2016 Energy Standards is fairly straightforward since the majority of the requirements are mandatory with limited exceptions and only minor prescriptive path requirements for specific building systems listed in Chapter 3.

### Prescriptive Approach

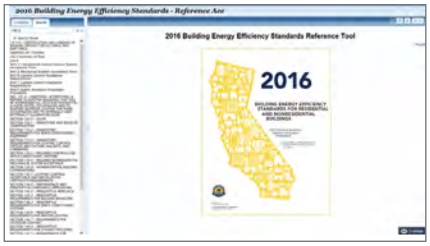
In general, the prescriptive approach is considered the most direct path to compliance. It is a set of prescribed performance levels for various building components where each component must meet or exceed the requirement. There are a handful of process requirements that are included in the prescriptive path options in §140.9.

### Performance Approach

The performance approach builds on the prescriptive approach by allowing energy allotments to be traded between building systems. This compliance approach requires using energy analysis software that has been approved by the Energy Commission. For covered processes, compliance strategies may evolve in the future but there are very limited performance based tools that have the capability to model processes like refrigerated warehouses, compressed air systems, or process boiler energy use. The only covered processes that currently can be included in the performance approach are commercial kitchens, computer rooms and laboratory exhaust.

*Commercial Kitchen Ventilation*

Ace Reference™




The Reference Ace™ tool helps you navigate the Standards, Compliance Manual and Reference Appendices using key word search capabilities, hyperlinked tables and related sections.

Find the tool here: energycodeace.com/content/reference-ace-2016-tool


*Energy Commission Resource: Blueprint Newsletter*

The March-April 2015 issue of the CEC's Blueprint Newsletter includes Q&A related to covered processes that are exempt from the Energy Standards.

Find the Blueprints here: energy.ca.gov/efficiency/blueprint

# Navigating Title 24, Part 6

The Energy Standards contain energy requirements for all newly constructed buildings, additions and alterations. The Energy Standards are divided into three general categories: mandatory requirements that apply to all buildings, nonresidential building requirements (including high-rise residential and hotel/motel buildings) and residential building requirements (including low-rise residential buildings). The Title 24, Part 6 Building Energy Efficiency Standards are available from the Energy Commissions and may be downloaded here:

Title 24, Part 6 Building Energy Efficiency Standards

The following table provides references to sections of the Energy Standards for nonresidential covered process requirements and categorized by mandatory measures, prescriptive approach and performance approach. All sections listed in the table are hyperlinked to the Refernce Ace Tool.

| | MANDATORY | PRESCRIPTIVE | PERFORMANCE |
|---|---|---|---|
| Refrigerated Warehouses | §120.6(a) | | |
| Commercial Refrigeration | §120.6(b) | | |
| Enclosed Parking Garages | §120.6(c) | | |
| Process Boilers | §120.6(d) | | |
| Compressed Air Systems | §120.6(e) | | |
| Elevators | §120.6(f) | | |
| Escalators & Moving Walkways | §120.6(g) | | |
| Computer Rooms | | §140.9(a) | NR ACM |
| Commercial Kitchen Ventilation | | §140.9(b) | NR ACM |
| Laboratory Exhaust | | §140.9(c) | NR ACM[1] |

Note: See §100.0 Scope and Table 100.0-A Application of Standards for additional information on which sections of Title 24, Part 6 apply to any given project, in particular which code sections apply to conditioned versus unconditioned space.

[1] Nonresidential Alternative Calculation Method Reference Manual: Establishes the rules for the process of creating a building model, describing how the proposed design (energy use) is defined, how the standard design (energy budget) is established, and ending with what is reported on the Performance Compliance Certificate (PRF-01). The NR ACM can be found here: energy.ca.gov/2015publications/CEC-400-2015-025/CEC-400-2015-025-CMF.pdf

# Refrigerated Warehouses

Industrial refrigeration plants serve a variety of processes and storage spaces including refrigerated warehouses. Refrigerated warehouses are mainly dedicated to process cooling, food storage, production, and shipping facilities.

The Energy Standards do not address walk-in coolers and freezers—these are covered by the Appliance Efficiency Regulations (Title 20). A walk-in is defined as a refrigerated space that is less than 3,000 ft² in floor area. Coolers are defined as refrigerated spaces designed to operate at or above 28°F and at or below 55°F. Freezers are defined as refrigerated spaces designed to operate below 28°F.

The Energy Standards regulate refrigerated warehouse and refrigerated space square footage separately. The 2016 Energy Standards apply to refrigerated warehouses 3,000ft² or larger per §120.6(a). A refrigerated warehouse may be comprised of one or more refrigerated spaces served by the same system. The intention of the Energy Standards is that either Title 24, Part 6 or Title 20 would apply. If the sum of the spaces served by a refrigeration system is > 3,000 ft², it would be considered a refrigerated warehouse, and §120.6(a) applies. If the sum of the spaces is less than 3,000 ft², Title 20 applies. See the sidebar for project scenario examples.

All energy efficiency requirements for refrigerated warehouses are mandatory. That means no trade-offs using prescriptive or performance compliance paths are permitted, such as installing more insulation to offset a less efficient compressor, etc. However, there are several exceptions to the mandatory requirements.

A suction group refers to compressors that are connected to refrigeration loads whose suction inlets share a common suction header or manifold. In many situations, one suction group can serve multiple functions including quick chilling, process refrigeration, refrigerated space cooling, or any use. While these suction groups are still regulated by §120.6(a), they may qualify for exceptions to specific subsections (§120.6(a)4A,B and §120.6(a)5B) based on percentage refrigeration capacity allocated to refrigerated space. The Energy Standards apply to new refrigerated facilities, as well as expansions and modifications to an existing plant or facility. There are exceptions for existing refrigeration equipment and for additions and alterations.

## Code in Practice

If two 2,000ft² spaces in a building are served by two separate systems both are regulated by Title 20 only. There are no Title 24 requirements for this case under §120.6(a)

However, if the two 2,000ft² spaces are served by a shared system, then both spaces are regulated by Title 24 and all seven subsections of 120.6(a) apply.

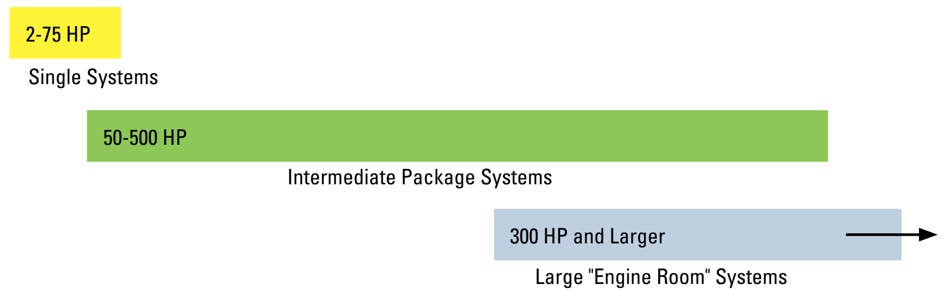

*Large "built-up" industrial refrigeration plant*

## Refrigerated Facilities

The purpose of many refrigerated warehouses is to maintain the storage conditions of its product, but many refrigerated warehouses also incorporate production facilities. Refrigerated facilities include private warehouses that store product the company distributes or produces elsewhere and also public refrigerated warehouses that store product for others. Private facilities often have a similar mix of products and loads throughout the year. Public warehouses can see significant variations throughout the year and from year to year. Distribution centers for supermarkets also are types of refrigerated warehouses.

## Refrigeration System Size and Attributes

Industrial business establishments use refrigeration systems that vary in size. For comparison purposes, industrial refrigeration systems are divided into three "unofficial" sizes: single systems, intermediate packaged systems, and large "engine room" systems.




Intermediate packaged systems usually are engineered parallel systems that use semi-hermetic reciprocating or small screw compressors. Intermediate packaged systems utilize halocarbon refrigerants and range in size from 50 HP up to 500 HP. They can be either air- or evaporatively-cooled.


*High Rise Freezer Design*

## Single Systems

Single systems are primarily factory packaged units, often are split systems, and can be ordered from manufacturers "out of the catalog." Compared with other systems, the single packaged units usually have a lower first cost, but have higher operating and maintenance costs.

## Intermediate Package Systems

Intermediate packaged systems provide a great deal of flexibility in meeting varying system load requirements and application conditions.

## Large Built-Up Engine Room Systems

Built-up systems are typically what are envisioned when industrial refrigeration is mentioned. As the name implies, system equipment such as evaporators, compressors, and condensers are selected individually to meet the needs of the customer and integrated by a system designer who also sizes the interconnecting piping and valves. The system components are assembled in the field. Because the system is customized, the controls also are customized.

Most of these systems use ammonia (R-717) as the refrigerant (some do use halocarbons) and they nearly always use evaporative condensers.

*Refrigeration Compressors*

*California Climate Zones*

California has widely varying climate conditions across the state, resulting in a division of 16 Climate Zones. The Energy Commission has established typical weather data, prescriptive packages and energy budgets for each geographic area, which are defined by zip code.

California's Building Climate Zone Areas can be found here: energy.ca.gov/maps/renewable/building_climate_zones.html

## Insulation Requirements

The insulation requirements vary between coolers and freezers for walls, roof, and floors. The mandatory insulation levels in Table 120.6-A from the Energy Standards reproduced below are the same throughout the 16 climate zones. The main reason they are mandatory is that they are highly cost effective. This is because of the extreme temperature difference between outdoor and indoor temperatures and the energy use required to maintain indoor conditions.

| SPACE | SURFACE | MINIMUM R-VALUE (°F-hr-ft²/Btu) |
|---|---|---|
| Freezers | Roof/Ceiling | R-40 |
| | Wall | R-36 |
| | Floor | R-35 |
| | Floor with all heating from productive refrigeration capacity[1] | R-20 |
| Coolers | Roof/Ceiling | R-28 |
| | Wall | R-28 |

[1] All underslab heating is provided by a heat exchanger that provides refrigerant subcooling to other means that result in productive refrigeration capacity on the associated refrigerated system.

Table 120.6-A Refrigerated Warehouse Insulation

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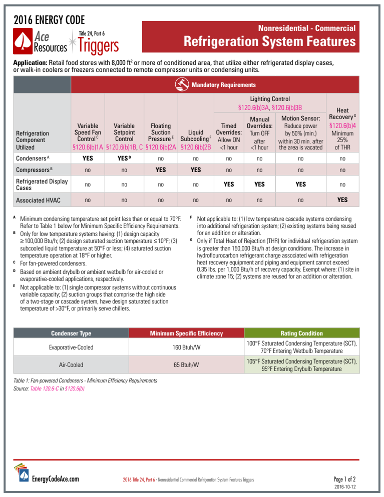


2016 ENERGY CODE

Ace Resources Title 24, Part 6 Triggers

Nonresidential - Commercial

**Refrigeration System Features**

**Application:** Retail food stores with 8,000 ft² or more of conditioned area, that utilize either refrigerated display cases, or walk-in coolers or freezers connected to remote compressor units or condensing units.

| | Mandatory Requirements | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lighting Control §120.6(b)3A, §120.6(b)3B | | | |
| Refrigeration Component Utilized | Variable Speed Fan Control[C] §120.6(b)1A | Variable Setpoint Control §120.6(b)1B, C | Floating Suction Pressure[E] §120.6(b)2A | Liquid Subcooling[F] §120.6(b)2B | Timed Overrides: Allow ON <1 hour | Manual Overrides: Turn OFF after <1 hour | Motion Sensor: Reduce power by 50% (min.) within 30 min. after the area is vacated | Heat Recovery[G] §120.6(b)4 Minimum 25% of THR |
| Condensers[A] | YES | YES[D] | no | no | no | no | no | no |
| Compressors[B] | no | no | YES | YES | no | no | no | no |
| Refrigerated Display Cases | no | no | no | no | YES | YES | YES | no |
| Associated HVAC | no | no | no | no | no | no | no | YES |

[A] Minimum condensing temperature set point less than or equal to 70°F. Refer to Table 1 below for Minimum Specific Efficiency Requirements.
[B] Only for low temperature systems having: (1) design capacity ≥100,000 Btu/h; (2) design saturated suction temperature ≤10°F; (3) subcooled liquid temperature at 50°F or less; (4) saturated suction temperature operation at 18°F or higher.
[C] For fan-powered condensers.
[D] Based on ambient drybulb or ambient wetbulb for air-cooled or evaporative-cooled applications, respectively.
[E] Not applicable to: (1) single compressor systems without continuous variable capacity; (2) suction groups that comprise the high side of a two-stage or cascade system, have design saturated suction temperature of >30°F, or primarily serve chillers.
[F] Not applicable to: (1) low temperature cascade systems condensing into additional refrigeration system; (2) existing systems being reused for an addition or alteration.
[G] Only if Total Heat of Rejection (THR) for individual refrigeration system is greater than 150,000 Btu/h at design conditions. The increase in hydroflourocarbon refrigerant charge associated with refrigeration heat recovery equipment and piping and equipment cannot exceed 0.35 lbs. per 1,000 Btu/h of recovery capacity. Exempt where: (1) site in climate zone 15; (2) systems are reused for an addition or alteration.

| Condenser Type | Minimum Specific Efficiency | Rating Condition |
|---|---|---|
| Evaporative-Cooled | 160 Btuh/W | 100°F Saturated Condensing Temperature (SCT), 70°F Entering Wetbulb Temperature |
| Air-Cooled | 65 Btuh/W | 105°F Saturated Condensing Temperature (SCT), 95°F Entering Drybulb Temperature |

*Table 1: Fan-powered Condensers - Minimum Efficiency Requirements*
*Source: Table 120.6-C in §120.6(b)*

EnergyCodeAce.com 2016 Title 24, Part 6 - Nonresidential Commercial Refrigeration System Features Triggers Page 1 of 2 2016-10-12

*Commercial Refrigeration Trigger Sheet*

Trigger Sheets summarize sections of the Title 24, Part 6 energy code that are triggered based on project scope. The sections indicated on these trigger sheets can help identify energy code requirements for your project.

Commercial Refrigeration Trigger Sheet: energycodeace.com/content/resources-fact-sheets

## Underslab Heating

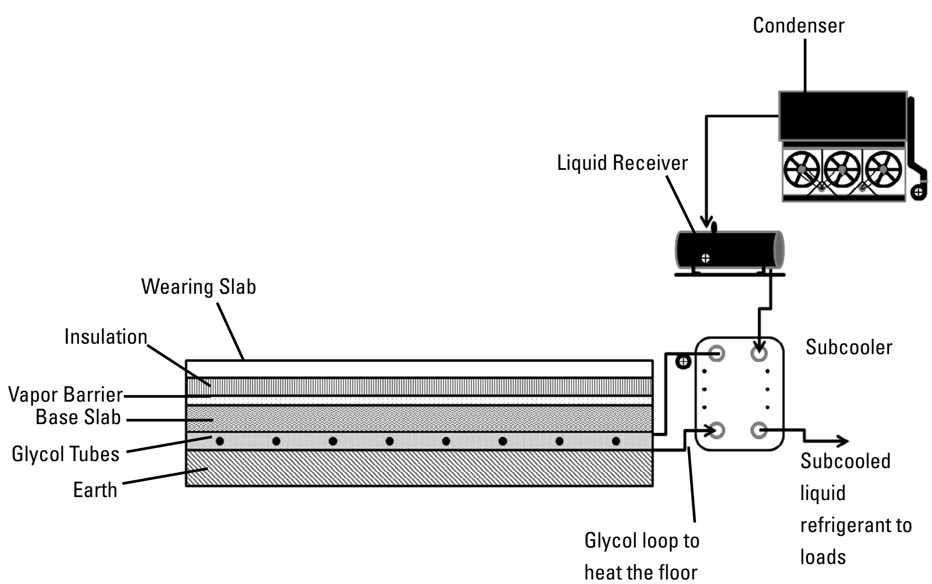
With the extreme temperatures required on the interior surfaces, the concrete slabs for these buildings often are installed with supplementary heating systems that prevent cracking and movement.

Any refrigerated facility that operates at subfreezing temperatures with a concrete finished floor over insulation runs the risk of ice forming under the slab. As the temperature of the soil falls below freezing, the moisture in the soil freezes and becomes large ice crystals. These crystals will form under the slab, expand the soil, and cause the floor to heave upward. Underslab (or underfloor) heating systems are used under frozen storage warehouses to prevent soil freezing and expansion. They can be electric resistance, forced air, or heated fluid.

The Energy Standards allow electric resistance heating in these underslab systems. However, the underslab systems must be disabled during summer on-peak cooling time frames, as defined by the local electrical utility.

## Pumped Fluid Method for Underslab Heating

The pumped fluid method uses heated glycol fluid pumped through pipe circuits embedded below the slab. The glycol is heated using an electric water heater, a natural gas water heater, or through heat recovery (free heat) from the refrigeration system. A lower floor insulation R-value of R-20 is allowed if all of the underslab heat is provided by an underslab heating system that increases productive refrigeration capacity. An example of an underslab heating system utilizing heat from a refrigerant liquid subcooler is shown in the diagram below.




ENERGY CODE ACE

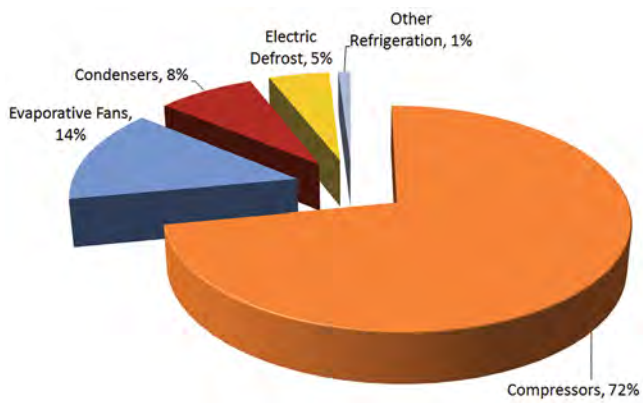
## Evaporators

Of the entire electrical load of the refrigerated facility, the amount of energy going to the motors and fans of the evaporators is substantial. The pie chart below breaks down a typical refrigerated facility electric demand by end use.

With some exceptions, refrigeration systems for refrigerated warehouses are required to have variable speed capability on evaporator fans. This can be electronically commutated motors (ECM) of less than 1HP or motors with a minimum NEMA Standard efficiency of 70%. The intent is that evaporator fan speed is controlled in response to space temperature or humidity. A handful of exceptions apply mainly for additions without speed controllers, such as areas for quick chilling, and for areas that are designed to always operate at 100% of fan power as certified by a professional engineer.

When using variable speed drives with evaporators, there is generally room for energy savings without reducing fan speed so low as to risk operation problems. A small 20% speed reduction can produce large savings and it can be argued that most facilities are seldom more than 80% loaded, given typical design safety factors and average operations.


*The type of industrial evaporator shown above has fan motors that are from 2 to 10 HP and are commonly 460 V 3-phase motors.*




SOUTHERN CALIFORNIA EDISON

## Condensers

Condensers on refrigerated space served by a shared refrigeration system that serve 3,000 ft² or larger within a refrigerated warehouse must meet all of the condenser sizing, fan control, and efficiency requirements in §120.6(a)4. Insulation, underslab heating, evaporators, and infiltration barrier requirements are based on the refrigerated warehouse exceeding 3,000 ft² on a shared system. The goal of the Energy Standards is to optimize the entire system, so where variable speed evaporator fans are required, similar variable speed condensers are required as well.

In applications where a suction group serves multiple functions beyond refrigerated space cooling, there are exceptions to condensing temperature control requirements providing the suction group refrigeration capacity has less than 80% dedicated to refrigerated space (at least 20% dedicated to quick chilling, process refrigeration, and process refrigeration cooling for other than a refrigerated space).

### Evaporative Condensers

Evaporative condensers are widely used in industrial refrigeration. This type rejects heat through the evaporation of water into an airstream that is blown or drawn across the condensing coil.

## Air-Cooled Condensers

*Microchannels And Microchannel Condenser*

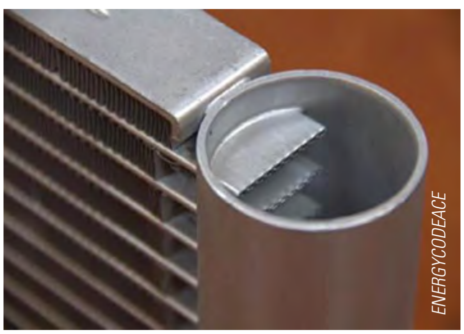
Air-cooled condensers use air as the condensing medium. With air-cooled condensers, a fan blows or draws air across the condensing coil and the air picks up the heat given off by the refrigerant as it flows through the condensing coil. Air-cooled condensers range in size up to around 200 tons. For systems with larger capacities, multiple condensers are used in parallel.

In inland California locations for systems larger than 75-100 HP, air-cooled condensers generally have a greater installed cost and use more energy than evaporative condensers. This is less the case with the application of variable speed.

Condensers on applicable new refrigeration systems must meet condenser sizing, fan control, and efficiency requirements. However, the condensers included in air-cooled condensing units do not need to meet the sizing requirements for air-cooled condensers. Condensing units include the compressor, condenser, liquid receiver, and control electronics packaged in a single unit. This exception applies only if the compressors in the condensing units have a nameplate size that total less than 100 horsepower.

Condensers must meet a minimum specific efficiency. Condenser specific efficiency is a way to evaluate the effectiveness of a condenser. Specific efficiencies are called out in the Energy Standards for various types and sizes of condensers. This value considers the condenser only, at full capacity, unrelated to the compressor performance. Specific efficiency is not published in manufacturer catalogs, but is easily calculated.

## Microchannel Style Condensers




*Micro-channel Condenser*

Another important consideration for condensers is fin spacing. An exception is listed in the Energy Standards that excludes microchannel condensers from fin spacing limitations. Small air-cooled condensers are evolving, with more manufacturers offering microchannel style condensers. The picture above and to the left show the headers on the side and a typical microchannel style condenser.

## Condensers and Floating Head Pressure

Condenser fan power can be reduced by variable speed control of both single and multiple condenser motors. Variable speed control provides the most precise regulation and facilitates other strategies such as floating head pressure.

Floating head pressure, also referred to in the Energy Standards as continuously variable speed, refers to decreasing the discharge pressure (condensing temperature) as ambient temperature drops. Lowering the head pressure will reduce energy consumption.

Floating head pressure is usually the largest energy saving opportunity. Floating head pressure reduces the amount of work the compressor must do during the majority of the time when outdoor temperatures are below the refrigeration system design temperature. This can provide energy savings for a majority of the year.

## Compressors

New compressors on new refrigeration systems that serve 3,000 ft$^2$ or larger of refrigerated space within a refrigerated warehouse must meet all of the compressor operating and control requirements in §120.6(a)5, which sets minimum condensing temperatures, as well as compressor speed and volume ratio control requirements. Like the condenser regulations, the compressor regulations of §120.6(a) apply to refrigerated space square footage, not the total warehouse square footage.

In applications where a suction group serves multiple functions beyond refrigerated space cooling, there are exceptions to saturated suction temperature control requirements providing the suction group refrigeration capacity has less than 80% dedicated to refrigerated space (at least 20% dedicated to quick chilling, process refrigeration, and process refrigeration cooling for other than a refrigerated space).

### Compressor Variable Speed Capacity Control

New open-drive compressors must vary compressor speed as the primary means of capacity control. One possible way to vary capacity of a screw compressor is the use of variable speed drives (VSD). Variable speed control also may help extend the life of compressors which otherwise frequently cycle on and off. There are two exceptions to the mandatory requirements.

### Infiltration Barriers

The Energy Standards require that passageways between freezers and higher-temperature spaces and passageways between coolers and non-refrigerated spaces have an infiltration barrier such as strip curtains, automatically closing doors, or air curtains. The passageways are typically used by people, forklifts, pallet lifts, handtrucks, or conveyor belts.

Strip curtains are flexible plastic strips made for providing a passageway to refrigerated openings to preserve the temperatures of the subject spaces. Examples are shown to on the left.

## Acceptance Testing Requirements

For refrigerated warehouses, the Energy Standards have acceptance test requirements. These tests essentially make sure everything is operating as it should. These acceptance tests do not require a certified Acceptance Test Technician. For covered processes the installing contractor may qualify as the test technician.

| Form | Purpose |
|---|---|
| NRCA-PRC-04-F | Refrigerated Warehouse-Evaporator Fan Motor Controls |
| NRCA-PRC-05-F | Refrigerated Warehouse-Evaporative Condenser Controls Acceptance |
| NRCA-PRC-06-F | Refrigerated Warehouse-Air-Cooled Condenser Controls Acceptance |
| NRCA-PRC-07-F | Refrigerated Warehouse - Variable Speed Compressor Acceptance |
| NRCA-PRC-08-F | Refrigerated Warehouse-Electric Resistance Underslab Heating System |

## Exceptions

1. Refrigeration plants with more than one dedicated compressor per suction group.
2. Compressors and condensers on a refrigeration system for which more than 20 percent of the total design refrigeration cooling load is for quick chilling or freezing, or process refrigeration cooling for other than a refrigerated space.


*Strip Curtain*

*High-speed Doors and Roll-ups*

## Maintenance, Repairs, Additions, and Alterations

In addition to an all-new refrigerated facility, the Energy Standards cover expansions and modifications to an existing facility and an existing refrigeration plant. The Energy Standards do not require that all existing equipment must all comply when a refrigerated warehouse is expanded or modified and is using existing refrigeration equipment.

- An addition is a change to an existing refrigerated warehouse that increases refrigerated floor area and volume. Additions are treated like new construction.
- An alteration is a change to an existing building that is not an addition or repair. In this case for example, alterations to a refrigeration system do not affect the already existing refrigeration system components.

Most newly added equipment must comply, but existing systems don't typically trigger the Energy Standards. Exceptions are stated in the individual equipment requirements.

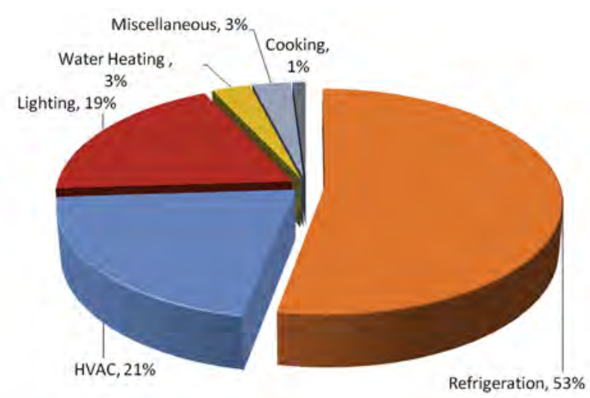
# Commercial Refrigeration

Commercial business establishments that use refrigeration vary in size from small "mom-and-pop" convenience stores, to supermarkets of all sizes, an. includes larger industrial and commercial applications as well.

Commercial refrigeration uses a significant amount of electricity on a year-round basis.

- These systems use more kWh per ton of refrigeration than commercial air-conditioning systems (HVAC)
- Many systems are old, operate inefficiently, and have had few if any alterations to upgrade performance
- In a typical supermarket, refrigeration accounts for about half of the overall electrical usage

Therefore, saving energy on refrigeration can have a significant impact on the bottom line, as illustrated in the chart below.




U. S. ENERGY INFORMATION ADMINISTRATION


*Display Case*

## Energy Standards for Commercial Refrigeration

All commercial retail food refrigeration Energy Standard measures are mandatory. Mandatory measures always must be met, but may be exceeded, and generally focus on controls and minimum equipment efficiency. Every application must comply with all mandatory measures — unless there are exceptions cited in the Energy Standards. There are no trade-offs using prescriptive or performance compliance paths. Through the last decade, most large grocery store chains already have adopted the mandatory measures as standard practice.

Commercial refrigeration facilities that must comply with the 2016 Energy Standards are retail food facilities with 8,000ft² or more of conditioned floor area using refrigerated display cases, walk-in coolers or freezers that are connected to remote compressor units or condensing units.

Convenience stores range in size from 800 to 4,000 ft², and the average is about 2,500 ft². The freezers and coolers in these facilities are not affected by the covered process requirements (§120.6) of the Title 24 Part 6 standards.

Self-contained refrigerated display cases do not need to comply with the Energy Standards. "Self-contained" units do not have remote compressor units or condensing units; they are considered appliances, and are covered by Title 20 (Appliance Standards) and the Federal Energy Independence and Security Act of 2007.

The Energy Standards also do not have efficiency requirements for walk-ins, which also are covered by Title 20. Walk-ins are defined as refrigerated spaces with less than 3,000 ft² of floor area that are designed to operate at 55°F or below. However, if the walk-in is in a store larger than 8000 ft² and connected to remote compressor or condenser and has a glass door display case, the display lighting must meet the control requirements of 120.6(b)3 regardless of walk-in size.

The Energy Standards for commercial refrigeration cite specific requirements for:

- Condenser.
- Compressors
- Lighting controls for refrigerated display cases
- Heat recovery from refrigeration equipment

For commercial refrigeration the Energy Standards refer to three types of construction projects that dictate specific actions:

- Newly constructed — a new building, not previously occupied
- Addition — adding conditioned floor area (CFA) and conditioned volume (CV) to an existing structure
- Alteration — changing components or systems within a building, but not adding CFA and CV to an existing structure.

## Code in Practice

### Alteration

If you were removing all the refrigeration systems from an existing retail food store and putting in all new systems, that would be considered an alteration to the building — as long as the area or volume of the conditioned space doesn't change.

### Addition

As another example, if you were adding an all-new display case line-up, along with a new condensing system and compressor rack to support it, in an existing store it would be considered an alteration — not an addition — as long as the store's conditioned floor area and volume remain the same.

## Condenser Requirements

In simple terms, the role of a condenser in a refrigeration system is to reject heat from the refrigerant to the outside. In the condenser, heat is given up by the refrigerant and is removed by the condensing medium which is usually water, air, or a combination of both.

The requirements apply to all stand-alone condensers, including:

- Air-cooled condensers
- Evaporative-cooled condensers
- Air-cooled and water-cooled fluid coolers
- Cooling towers

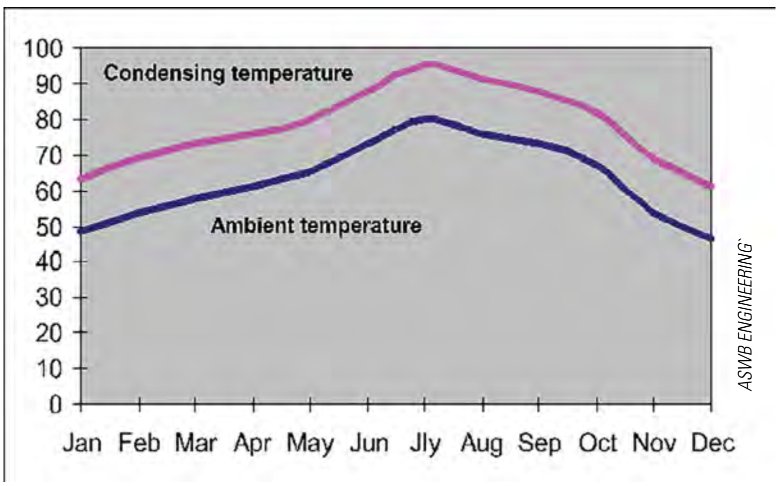
The Energy Standards require the following for condensers in commercial refrigeration:

- The fans for all types of condensers must be continuously variable speed
- The controls for air-cooled and evaporative-cooled condensers must have variable setpoint control logic to reset the condensing temperature setpoint in response to ambient condition.
- There are specific efficiency requirements for air-cooled condensers including fin density

### Condensers and Floating Head Pressure

To minimize the combined compressor and condenser fan power usage, the condensing temperature control setpoint must be continuously reset in response to ambient temperatures, rather than using a fixed setpoint.

Condenser fan power can be reduced by variable speed control of both single and multiple condenser fan motors. Variable frequency control provides the most precise regulation and facilitates other strategies such as floating head pressure by maintaining a steady head pressure at the minimum conditions.




Floating head pressure is usually the largest energy saving opportunity. This measure reduces the amount of work the compressor must do during the majority of the time when outdoor temperatures are below the refrigeration system design temperature. This can provide energy savings for a majority of the year, in mild California climates.

### Specific Efficiency

Condenser specific efficiency is a way to evaluate the energy consumption of a condenser. Specific efficiencies are called out in the Energy Standards for various types and sizes of condensers. This value considers the condenser only, at full capacity, unrelated to the compressor performance. Specific efficiency is not published in manufacturer catalogs, but is easily calculated.

### Condenser Fins

Air-cooled condensers are required to have a fin density no greater than 10 fins per inch (fpi). A relatively low fin density (fewer fins per inch) prevents fouling with air-borne debris in traditional tube-and-fin condensers.

## Exceptions

An exception to the condenser requirements pertains to new condensers that are replacing existing condensers when the attached compressor system Total Heat of Rejection does not increase and less than 25% of both the attached compressors and the attached display cases are new.

Another exception is that the condenser mandatory requirements apply only to stand-alone condensers. They do not apply to condensers that are part of a unitary condensing unit.

## Exceptions

There are several exceptions to the condenser specific efficienc. and condenser fin requirements.

1. If the store is located in Climate Zone 1 (the cool coastal region in northern California). See the sidebar on page 21 for more about California Building Climate Zone Areas.
2. If an existing condenser is reused for an addition or alteration.
3. If the condenser capacity is less than 150,000 Btuh at the specific efficiency rating conditions. The definition of condenser specific efficiency is provided in §100.1 of the Energy Standards.
4. .Exceptions to the fin density requirement include micro-channel condensers, and existing condensers that are reused for an addition or alteration.

## Exceptions

1. Existing compressor systems that are reused for an addition or alteration.
2. Single compressor systems that do not have continuously variable capacity capability.
3. Suction groups that have a design saturated suction temperature of 30°F or higher, or suction groups that comprise the high stage of a two-stage or cascade system or that primarily serve chillers for secondary cooling fluids.
4. For liquid subcooling, low temperature cascade systems that condense into another refrigeration system rather than condensing to ambient temperature.

## Compressor Requirements

The role of a compressor in a commercial refrigeration system is to compress the vapor refrigerant from low pressure to high pressure with a smaller volume and higher temperature so that the heat in the refrigerant can be rejected.

The Energy Standards require compressor controls that include floating suction pressure logic to reset the target saturated suction temperature (SST). The SST is reset based on the temperature requirements of the attached refrigeration display cases or walk-ins. There are a few exceptions to this requirement, shown on page 30.

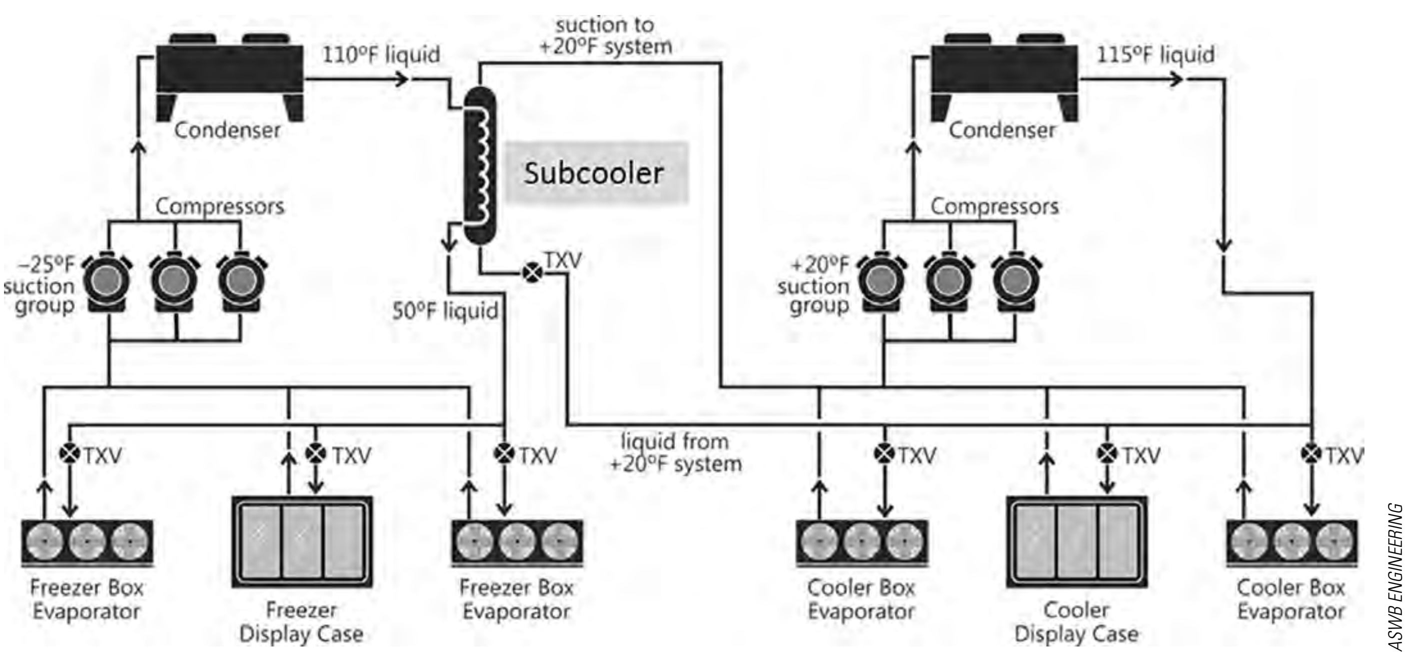
### About Floating Suction Pressure

The Energy Standards require floating suction pressure,which helps improve the refrigeration effect and saves energy. Floating suction pressure refers to adjusting the suction pressure setpoint when unloading of the system occurs. Suction pressure or equivalent temperature of the compressor inlet (suction) can be adjusted to maintain the temperature requirements of the coldest evaporator in the system. This control strategy is an active, automatic means of optimizing suction pressure on a continual basis.

This measure is cost-effective for all system configurations in all climate zones, and is a standard practice in most supermarkets. The control logic is included in most rack controllers. A rack controller is a controller for multiple compressor systems. Multiple compressors are referred to as a rack. Typically no additional hardware is required. The cost associated with floating suction pressure primarily consists of labor costs to commission and fine-tune the controls, plus ongoing maintenance costs. Computer control of temperatures in the display cases and walk-ins also is a standard feature.

### About Liquid Subcooling

The Energy Standards require liquid subcooling for certain low temperature compressor systems. The term subcooling refers to a liquid that is at a temperature below its normal




*Parallel Low-and Medium Temperature Refrigerator systems with Subcooling* saturation temperature. Subcooling the refrigerant improves the refrigeration effect and saves energy.

The Energy Standards require liquid subcooling for all low temperature compressor systems with a design cooling capacity of 100,000 Btu/h or greater and with a design saturated suction temperature of -10°F or lower. Liquid subcooling applies to low temperature parallel compressor systems. It involves cooling the liquid refrigerant after it has been condensed, using capacity from a higher-temperature compressor group. There are overall exceptions for compressors and liquid subcooling requirements for smaller compressor systems.

## Refrigerated Display Case Lighting Control

For retail stores equal to or greater than 8,000 ft$^2$, lighting in refrigerated display cases and installed on glass doors of walk-in coolers and freezers must be controlled by automatic time switch controls or motion sensor control. These controls save energy by either turn off the lighting or reduce light power when no one is there, or at close of business.


*Motion Sensor*

## Heat Recovery for Refrigeration Systems

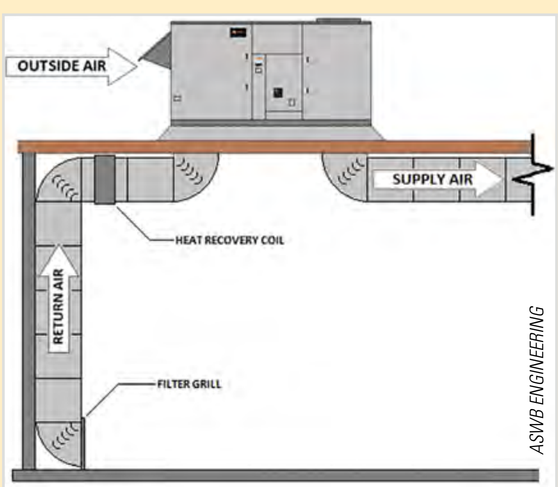
Heat recovery from refrigeration systems in supermarkets is applied to HVAC systems for space heating and has been employed for more than 50 years. The heat recovery requirements apply only to space heating.

There are many possible heat recovery design configurations. System design including the controls, piping, valves, heat exchangers, etc., must meet other requirements in the Energy Standards such as floating condensing temperature and others.

Unless properly designed, commissioned, and maintained, heat recovery from refrigeration systems can result in significant refrigerant loss and greater costs. This can lead to a decline in use of heat recovery to the point only a small amount of annual heating needs being met with heat recovery.

By adding a heat recovery coil and the associated piping to the system, along with other technical considerations, the required amount of refrigerant typically will increase in the system. The Energy Standards limit the increase in HFC refrigerants associated with refrigeration heat recovery to ≤0.35 lbs per 1,000 Btuh heat recovery heating capacity. It is the responsibility of the system designer to fully understand how the heat recovery system affects overall refrigerant charge.

### Code in Practice




This graphic shows one way of implementing heat recovery that is incorporated into rooftop HVAC units by installing the heat recovery coil inside the cabinet or by installing the coil in the return air duct upstream of the unit.


EZZEX

# Enclosed Parking Garages

The 2016 Energy Standards have requirements for enclosed parking garages with mechanical ventilation systems with a total exhaust rate > 10,000 cfm. Although the Energy Standards don't directly define an enclosed parking garage, if the parking garage requires mechanical ventilation by other parts of the California Building Code, and the system is sized for > 10,000 cfm, the requirements in §120.6(c) apply.

The 2016 Energy Standards also require a Carbon Monoxide Demand Control Ventilation (CO DCV) system to be mandatory feature for enclosed parking garages that have a total design exhaust rate greater than or equal to 10,000 cfm. Reducing the amount of ventilation required, based on carbon monoxide (CO) concentration in the garage, can achieve significant energy savings.

## Exceptions

The Energy Standards provide exemptions for garages, or portions of a garage, where more than 20 percent of the vehicles are expected to be non-gasoline combustion engines. Also, additions and alterations to existing garages where less than 10,000 cfm of new exhaust capacity is being added are exempt.

## Carbon Monoxide Demand Control Ventilation (CO DCV)

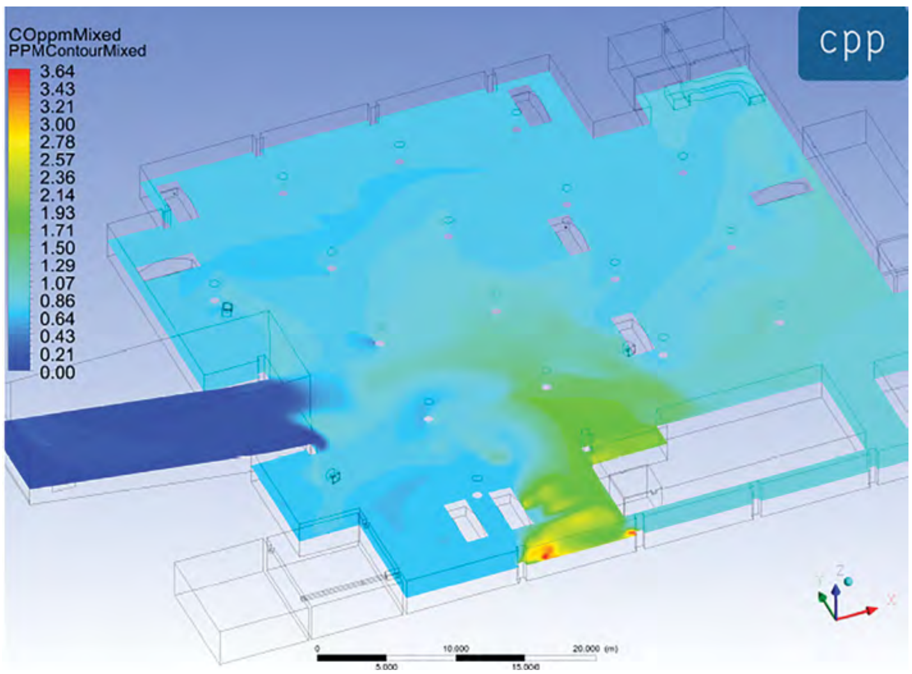
Enclosed parking garages need to be ventilated to prevent the buildup of carbon monoxide, (CO) which is a poisonous gas that gasoline- and diesel-powered vehicles produce. Prior to this standard, many parking garages operated their exhaust systems full time, wasting energy when vehicles may not be present or CO concentrations are low or nonexistent. In a typical parking garage, CO builds up when vehicles enter and leave the garage; particularly in the morning when cars enter, midday during the lunch hour when cars both leave and enter, and at the end of day when cars leave.

During peak vehicle activity, CO concentrations are high and require exhausting to maintain safe air quality. Outside of peak vehicle activity, there is very little CO produced and the exhaust system can operate at a reduced capacity. A ventilation control system known as Demand Control Ventilation (DCV) can be employed to adjust exhaust fan airflow to maintain CO concentration at safe levels while minimizing energy use.

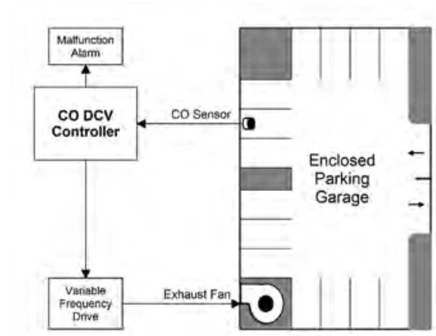
### CO DCV Control System Requirements

The CO DCV control system must automatically detect CO concentration levels and then adjust the exhaust fan airflow rates to 50 percent or less while maintaining acceptable CO concentration levels of 25 ppm of CO. To ensure good air quality, a minimum ventilation rate of 0.15 cfm/ft$^2$ of the parking garage space must be maintained when the parking garage is scheduled to be occupied.

In order to prevent gases and fumes from being drawn into adjacent inhabited areas, the control system must maintain the parking garage pressure at neutral or negative with respect to the adjacent areas. This is only required when the parking garage is scheduled to be occupied. In order to guarantee energy savings, the exhaust fan system must reduce power to 30% or less of design wattage when operating at 50 percent of design airflow. This requirement can be achieved by using either a two speed motor or a variable speed drive (VSD).




*CFD Analysis by CPP Wind, Inc. (cppwind.com)*




ASWB ENGINEERING

*CO DCV System Diagram*

## Carbon Monoxide Sensor Number And Location

CO sensors communicate with a monitoring system that tracks the CO levels in the garage and communicates the data to the fan control system. The 2016 Energy Standards have requirements for how many CO sensors are required and their optimal location in the parking garage.

The Energy Standards require a minimum of two CO sensors per proximity zone, which is defined as an area that is separated from other areas by floors, walls, or other impenetrable obstructions. Each CO sensor can only serve an area up to 5,000 ft$^2$.

The CO sensors must be located where the highest concentration of carbon monoxide is to be expected in the parking garage. The industry's best practice for the location of CO sensors is to locate them near exhaust air intake or in areas where there is little air movement.

### Carbon Monoxide Sensor Requirements

The 2016 Energy Standards have requirements for CO sensors used in enclosed parking garages:

- Certified by the manufacturer to be accurate within plus or minus 5 percent of measurement
- Certified by the manufacturer to drift only 5 percent or less per year
- Certified by the manufacturer to require calibration no more than once per year
- Be factory calibrated

The sensor also must be monitored for failure by a control system. If the sensor does fail, the control system must reset the ventilation system to the design ventilation rates and transmit an alarm to the facility operators.

## Acceptance Testing Requirements

For enclosed parking garages, the 2016 Energy Standards require acceptance testing for compliance, as specified in NA7.12. These tests essentially make sure everything is operating as it should. A certified Acceptance Test Technician is not required, as discussed with other covered processes, the installing contractor may qualify as the test technician.

| Form | Purpose |
|---|---|
| NRCA-PRC-03-F | Enclosed Parking Garage Exhaust System Acceptance |

## Additions and Alterations

The requirements in the Energy Standards apply to all new construction of enclosed parking garages. It also applies to additions and alterations to existing garages where 10,000 cfm, or more, of new exhaust capacity is being added.

Refer to section 10.2 of the 2016 Title 24 Nonresidential Compliance Manual for further details.


# Process Boilers

A process boiler serves a commercial or industrial process not related to space conditioning, service water heating, or building ventilation. The 2016 Energy Standards for process boilers or water heaters apply to all nonresidential process boilers with a capacity of at least 300,000 British Thermal Units per hour (Btu/h), which are about the size of a typical office desk.

The Energy Standards requirements for process boilers are mandatory. That means there are no trade-offs using the prescriptive or performance compliance paths. The requirements include combustion air shut-off, combustion air fan efficiency requirements, and controls to manage the air-fuel ratio.

## Combustion Air Positive Shut Off Requirement

In certain situations, the 2016 Energy Standards require a method of combustion air positive shut-off for process boilers with a capacity of 2.5 MMBtu/h or greater.

| Boiler Capacity | Natural Draft Boiler | Forced Draft Boiler |
|---|---|---|
| Under 2.5 MMBtu/h | Exempt | Exempt |
| One boiler per stack, above 2.5 MMBtu/h | Required | Exempt |
| Two or more boilers per stack, combined above 2.5 MMBtu/h | Required | Required |

Combustion air positive shut-off can be achieved using flue dampers and vent dampers to close the flue pipe when the burner is off. It is possible to interlock the dampers with the gas valve so the dampers close when the burner has cycled off. By closing off the dampers, air flow through the heat transfer surfaces is minimized, resulting in less standby heat losses. When the burner ignites, the vent dampers automatically open.

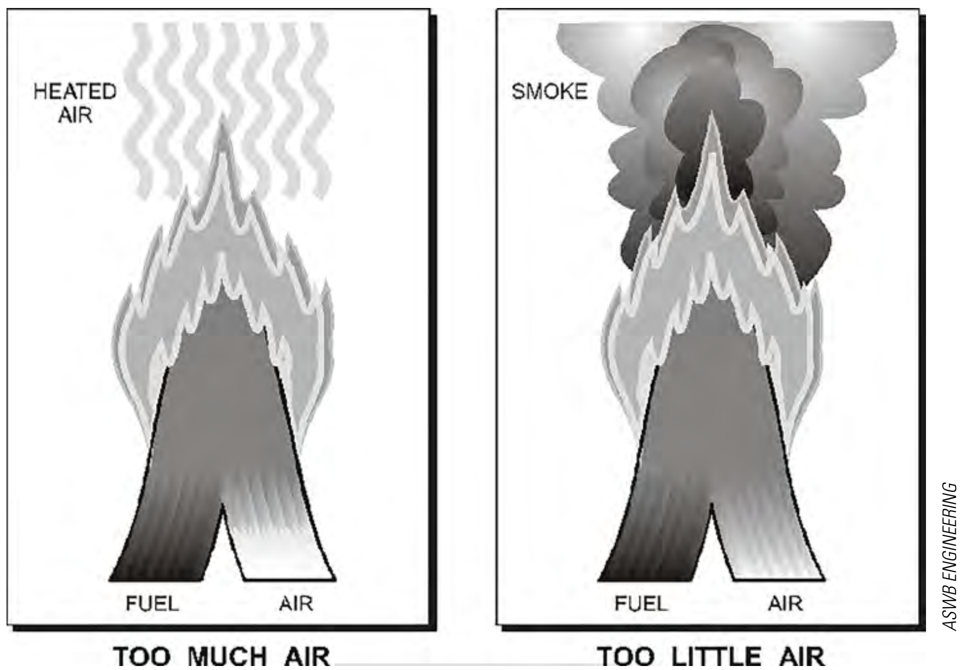

Vent Damper

## Combustion Air Fan Requirements

The 2016 Energy Standards require any process boiler combustion air fan of 10 horsepower or larger to have either a variable speed drive or controls that limit the fan motor demand to 30% or less of the total design wattage at 50% of design air volume.

## Theoretical Complete Combustion and Excess Oxygen (Air/Fuel Ratio Control)

Maximum boiler efficiency occurs when there is slightly more air than necessary to a complete combustion, which means the fuel has just enough air to completely burn. For theoretically complete combustion, every Carbon atom in the reactant combines with oxygen in the air to form $CO_2$ molecules in the product, with no excess oxygen remaining (0% $O_2$ by volume). Complete, perfect combustion is called stoichiometric combustion. In other words, given ideal burning conditions, for all fuels there is a theoretical quantity of air that will completely burn the fuel with no excess oxygen remaining. In actual applications continuous stoichiometric combustion is a goal that is difficult to achieve.




*Effect of poor combustion air/fuel ratios*

At some point, continuing to reduce the amount of air going into the chamber for combustion, there will not be enough oxygen available for complete combustion. The result will be the creation of carbon monoxide (CO), and hydrocarbon soot and smoke.

A small amount of excess air is typically provided to make sure all fuel is burned inside the boiler and little or no combustibles appear in the flue gas, at the cost of efficiency. Operating a boiler with a minimum amount of excess air will decrease stack heat loss and will increase combustion efficiency. It is easy to detect and monitor excess air since oxygen that is not used for combustion is heated and discharged with the exhaust gasses.

## Excess Oxygen Requirements and How to Meet Them

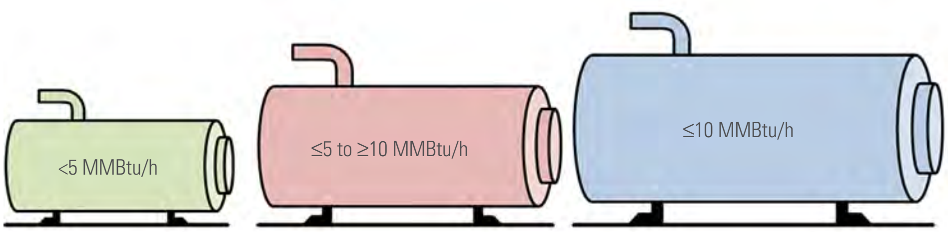
Newly installed process boilers are subject to a maximum excess oxygen limit based on their input capacities. The requirements can be seen in the following table.

| Capacity | Maximum Percentage of Tolerable Excess Oxygen | Firing Rates Applicable to Requirement |
|---|---|---|
| < 5 MMBtu/h | No requirement | Not applicable |
| ≥ 5 MMBtu/h to ≤ 10 MMBtu/h | 5% | 20 - 100% |
| > 10 MMBtu/h | 3% | 20 - 100% |

The maximum allowable excess oxygen percentages are determined by volume on a dry basis. The Energy Standards prohibit the use of common gas combustion air control linkage or jack shaft, which has been a common control method until the fairly recent arrival of affordable digital controls. Possible methods to meet these requirements are described below.

## Basic Controls

Boilers are operated by controls that vary the input of the fuel to the boiler to match certain pressure or temperature requirements. Although not specifically required by the Energy Standards, there are several basic types of burner controls typically used with boilers of varying sizes:




On-off controls

Staged or sequenced controls that match the heat delivered to load requirements in discrete steps

Modulating controls that provides variable matching (across the entire range) of heat delivered to load requirements

Modulating controls vary the fuel input from 100% down to a selected minimum set point. (The ratio of maximum to minimum is the turndown ratio.) The minimum input is usually between 5 and 33% (which provides ratios of 20 to 1 down to 3 to 1). High turndown ratios in non-condensing boilers must be carefully considered in order to prevent condensation at the lower firing rates.

Modulating controls typically offer more precise water temperature control and higher efficiency than on-off or high-low controls, if the airflow through the boiler is modulated along with the input of fuel.

## Oxygen Trim Control

Oxygen trim systems provide feedback to the burner controls using a controller to automatically minimize excess combustion air and optimize the air-to-fuel ratio over the operating range.

Oxygen trim controls do this by operating at the point where the combined efficiency losses due to unburned fuel and excess air losses is minimized. An oxygen trim system measures the excess oxygen in the combustion products and adjusts the airflow accordingly for peak combustion efficiency.

Oxygen trim systems benefit situations where there is a wide operating range for a given boiler (significant and frequent load variation) or where the oxygen level in the combustion zone can be difficult to tune or control. The cost effectiveness of this control type increases with boiler size.

Oxygen trim controls can work well if:

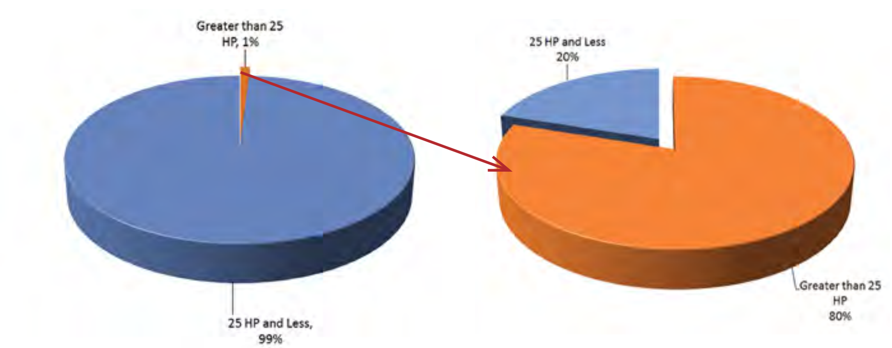
- They are adequately designed
- They are properly applied to suitable boilers
- The process being controlled is understood
- The unique problems presented by each boiler are determined

# Compressed Air Systems

In industrial processes, compressed air systems are one of the largest users of power. Compressed air can be thought of as a "utility," essentially a form of energy, much like electricity and natural gas.

Facility owners and operators, plant maintenance supervisors, plant engineers, plant managers, and others must make wise use of their compressed air systems and pursue methods for reducing power use and operational costs. This can be accomplished with energy efficient system design, prudently managed operation, and close attention to system maintenance.

Compressed air systems have numerous uses and are found in most industrial facilities. Plant air compressor systems can vary in size from units as small as 5 horsepower (hp) to huge systems with more than 50,000 hp.




Compressors Sold    Compressor Energy Use by Size

*The Energy Standards focus on compressors of 25HP or more, because they use 80% of the total air compressor energy, even though they are relatively uncommon.*

## Exception

Centrifugal compressors are typically larger than 100 hp. The Energy Standards provide an exception for alterations of existing compressed air systems that include one or more centrifugal compressors. This exception is because this type has inherently efficient unloading.

## Basic Compressed Air System

The components of a basic compressed air system often are divided into the following main categories:

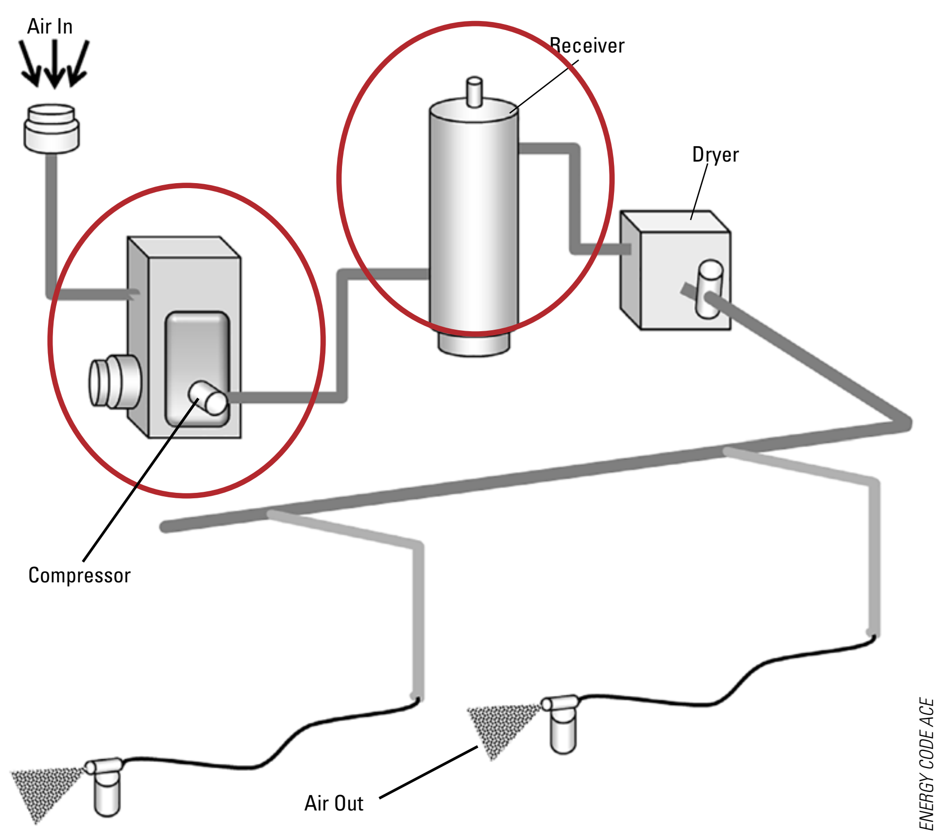
- Compressor, drive, and drive controls used to create the compressed air.
- Conditioning (or "clean-up") equipment, which make the air usable
- Air distribution system
- The end-use equipment which are the devices or tools that use the air to operate

Compressed air systems have "supply" and "demand" sides. Both the supply and the demand sides of the system and how the two interact must be addressed in order to improve operations and maintain peak system performance.

## Controlling The System

Each type of compressor may use any of several different types of control systems to regulate the output of compressed air to the end-use equipment (the system "load"). Industrial compressed air systems are typically designed to operate at a fixed pressure and to deliver a variable volume. Compressors are sized to deliver the maximum capacity to meet the highest demand.

Control systems are used to reduce the compressor output to match the system load—that is, "unload" the compressor to match the air volume and pressure to the demand. Most of the Energy Standards address improving air compressor control, and in particular under unloaded conditions since most applications have highly variable loads or demands.




*In a basic compressed air system, the compressor and receiver, circled in red, is the component which is affected by Title 24, Part 6 code.*

There are some industrial applications of compressed air systems that have constant demand, but most industrial plant air demand profiles are variable and end-use devices use air intermittently. Systems typically operate at less than full capacity part of the time. Often there will be short periods of high demand followed by long periods of little demand.

Part-load operation is defined as compressor operation at a level of compressed air output that is less than full capacity. In other words, anything less than 100% output is part load. When compressors operate at less than full capacity, they do not make the most efficient use of energy. An efficient system depends upon the type of compressor and the control system that is used for operation at part load.

Proper control is essential to efficient system operation and high performance.

- The objective of a control strategy is to shut off unneeded compressors or delay bringing on additional compressors.
- All units which are on should be run at full-load, except for one unit for "trimming."

Four common ways to control air compression systems are:

- On-off control (start-stop)
- Modulation
- Load/unload control
- Adjustable speed drives (speed modulation control of the compressor motor)

Air Compressor

## Energy Standards Compliance For Compressed Air Systems

The 2016 Energy Standards apply to all new compressed air systems and all additions or alterations to a compressed air system with a total installed compressor capacity of 25 hp or more. The Energy Standards only apply to compressors and related controls that provide compressed air and does not apply to any equipment or controls that use or process the compressed air.

Triggers for 2016 Title 24, Part 6 for Compressed Air Systems are shown in the table below.

| | Mandatory Requirements | | |
|---|---|---|---|
| Compressed Air System Component | Minimum Trim Capacity with VSD Compressor(s) [A] §120.6(e)1A | Minimum Trim Capacity without VSD Compressors[A] §120.6(e)1B | Multiple Compressor Controls [B] §120.6(e)2 |
| Compressor(s) | YES [C] | YES [D,E] | YES [F] |
| Primary Storage | YES [G] | YES [H] | no |

[A] Does not apply to systems where less than 50% of online capacity is being added or replaced, or where it has been demonstrated that air demand requirements on the system fluctuate <10%.

[B] Applies only to multiple-compressor systems with a combined horsepower rating above 100 hp.

[C] The total combined capacity of the VSD compressor(s) acting as trim compressors must be at least 1.25 times the largest net capacity increment between combinations of compressors.

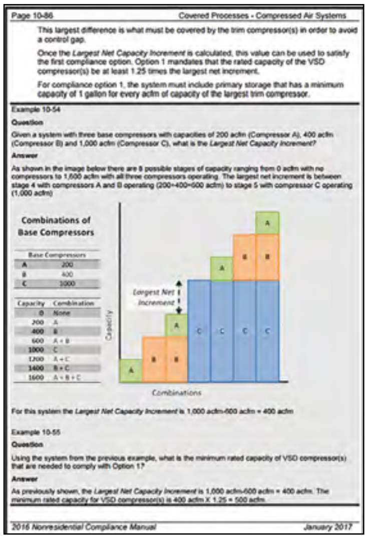
[D] The system must include compressor(s) with total effective trim capacity at least the size of the largest net capacity increment between combinations of compressors, or the size of the smallest compressor, whichever is larger.

[E] For single compressor systems, the total effective trim capacity shall cover the range from 70 percent to 100 percent of rated capacity, at a minimum.

[F] The system must operate with a controller able to choose the most efficient combination of compressors for current air demand, as measured by a sensor.

[G] The system shall include primary storage of at least one gallon per actual cubic feet per minute (acfm) of the largest trim compressor.

[H] The system shall include primary storage of at least 2 gallons per acfm of the largest trim compressor.



Page 10-86 Covered Processes - Compressed Air Systems

This largest difference is what must be covered by the trim compressor(s) in order to avoid a control gap.

Once the *Largest Net Capacity Increment* is calculated, this value can be used to satisfy the first compliance option. Option 1 mandates that the rated capacity of the VSD compressor(s) be at least 1.25 times the largest net increment.

For compliance option 1, the system must include primary storage that has a minimum capacity of 1 gallon for every acfm of capacity of the largest trim compressor.

Example 10-54

**Question**

Given a system with three base compressors with capacities of 200 acfm (Compressor A), 400 acfm (Compressor B) and 1,000 acfm (Compressor C), what is the *Largest Net Capacity Increment?*

**Answer**

As shown in the image below there are 8 possible stages of capacity ranging from 0 acfm with no compressors to 1,600 acfm with all three compressors operating. The largest net increment is between stage 4 with compressors A and B operating (200+400=600 acfm) to stage 5 with compressor C operating (1,000 acfm)

Combinations of Base Compressors

| Base Compressors | |
|---|---|
| A | 200 |
| B | 400 |
| C | 1000 |

| Capacity | Combination |
|---|---|
| 0 | None |
| 200 | A |
| 400 | B |
| 600 | A + B |
| 1000 | C |
| 1200 | A + C |
| 1400 | B + C |
| 1600 | A + B + C |



For this system the *Largest Net Capacity Increment* is 1,000 acfm-600 acfm = 400 acfm

Example 10-55

**Question**

Using the system from the previous example, what is the minimum rated capacity of VSD compressor(s) that are needed to comply with Option 1?

**Answer**

As previously shown, the *Largest Net Capacity Increment* is 1,000 acfm-600 acfm = 400 acfm. The minimum rated capacity for VSD compressor(s) is 400 acfm X 1.25 = 500 acfm.

*2016 Nonresidential Compliance Manual* *January 2017*

The 2016 Nonresidential Compliance Manual includes multiple examples illustrating calculations for largest net capacity increment, minimum rated capacity, primary storage capacity and effective trim capacity.

Systems that fall under these criteria must meet the three requirements discussed below.

## Trim Compressor and Storage

The system must be equipped with an appropriately sized trim compressor and primary storage (receiver). There are two ways to comply:

1. A trim compressor provides part-load operation to handle a short-term variable load of end uses. The system must include one or more variable speed drive (VSD) compressors to serve as the "trim" compressor. This method must include primary storage with a minimum capacity of one gallon for every actual cubic feet per minute (acfm) of capacity of the largest trim compressor.
2. Or, if efficiency criteria is met, the system may include a compressor or compressors as the trim compressor, without requiring a VSD-controlled compressor.

Both of these methods aim to reduce the amount of cycling of fixed speed compressors by using a compressor that operates well at part-load. Refer to §120.6(e)1 A and B for the full requirements.

There is a mathematical approach described in the 2016 Nonresidential Compliance Manual that is used to determine an acceptable efficiency, as well as identify the required primary storage size. A person knowledgeable about this subject matter should perform these calculations.

A receiver is a tank that stores a large reserve of compressed air. The receiver tank feeds a piping system that carries air throughout the facility. Receivers provide a supply buffer to meet short-term demand which can exceed the compressor capacity, and to boost the delivery capability of the system. Receiver tanks make the compressed air system easier to control.

The more storage there is in a system, the more accurately pressure fluctuations can be controlled to provide a stable operating pressure to all users. The more storage capacity, the slower the rate of change in pressure in the system.

A compressed air system without proper storage will operate at an elevated pressure level all of the time. Without storage, the system must operate continuously with enough compressor power to support any change or event that might occur in the system.

### Controls

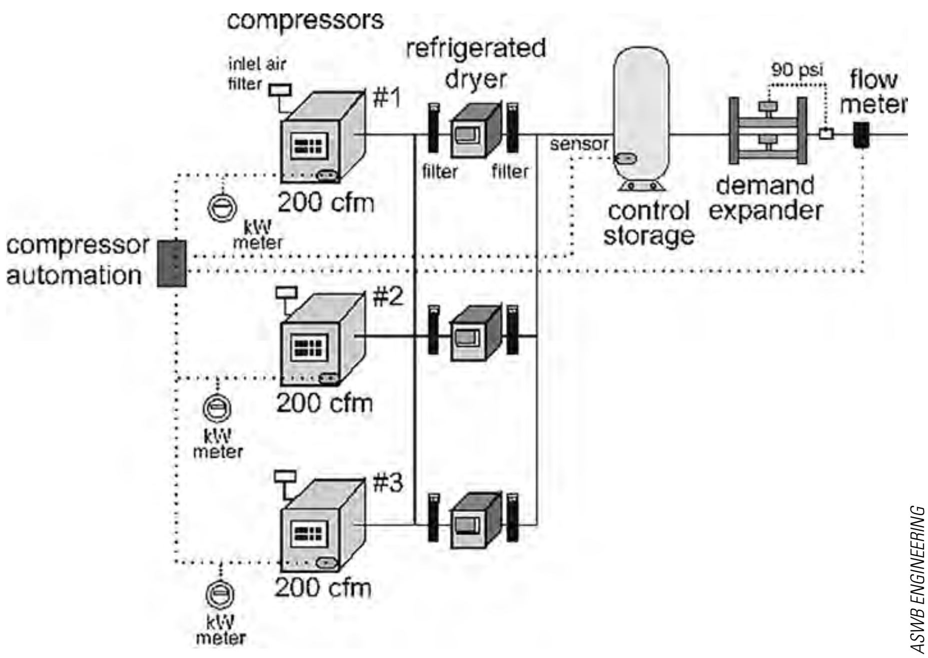
In addition to a trim compressor, an automated controller is required with systems that have a combined horsepower greater than or equal to 100 hp to stage the compressors in the most efficient manner. These microprocessor-based controllers are available from compressor manufacturers as well as independent control providers. Some specific sensors are required as part of this control system.

In this diagram we can see the compressor automation unit (the controller) and how it is receiving data from the compressed air system components.

## System Acceptance

Before a regulated compressed air system is issued a permit, it must undergo a construction inspection and functional testing as required by Nonresidential Appendix NA7.13.

| Form | Purpose |
|---|---|
| NRCA-PRC-01-F | Compressed Air Systems |




*Typical Compressed Air System*

## Alterations and Additions

Existing systems that are being altered or are adding compressors and that have a total compressor capacity greater than or equal to 25 hp will trigger the Energy Standard when these replacements or additions are greater than or equal to 50% of the existing capacity. These requirements are triggered by replacing, adding, or removing a compressor. Note that controls in section 120.6(e)2 may still be required. There are many circumstances where these requirements do not apply, such as adding a VSD to a fixed-speed compressor, repairing a compressor, or adding controls.


# Elevators

The 2016 Energy Standards cover all elevators in new construction, as well as elevators receiving major alterations. The Energy Standards add a lighting power density requirement for elevator cabins, impose a limit on the ventilation fan power draw at maximum speed, and require lighting and ventilation to shut off after being unoccupied for a set amount of time. Limiting the power consumption of the lighting and ventilation systems, as well as reducing the hours of operation, can produce significant energy savings.

Prior to 2016, there were no standards or specified energy regulations for elevators in the Energy Standards. The new requirements have been included in §120.6(f).

## Lighting Power Density

The 2016 Energy Standards call for a Lighting Power Density (LPD) of 0.6 watts or less per square foot ($W/ft^2$) in elevator cabins, excluding signal, display, and emergency lights. The total wattage limit for the elevator lighting is determined by multiplying the square footage of the elevator cabin by a factor of 0.6. The LPD of 0.6 $W/ft^2$ was meant to encourage the selection of more efficient lighting methods without directly specifying that a certain type of lighting be used.

LED lights are the most practical way to meet the LPD requirement. LEDs not only are more efficient than their fluorescent and incandescent counterparts, but also are more cost effective for long-term use. Despite the higher initial cost, LEDs are typically a better choice in the long term. In addition to the energy savings associated with greater efficiency, LEDs have a significantly longer expected life, which will reduce the frequency of elevator lighting maintenance.

## Ventilation Requirements

The 2016 Energy Standards set a limit of 0.33 watts per cubic foot per minute (W/CFM) of air being ventilated in the cabin when the fan is operating at maximum speed. This requirement is excluded from any elevator cabin with space conditioning, and only applies to unconditioned elevator cabins. This requirement should be considered when the ventilation system is designed and a fan is selected.

## Occupant Detection

In order to further save electricity, the 2016 Energy Standards include provisions for a vacancy-based automatic shutdown of lighting and ventilation. After 15 minutes of unoccupied status, the lighting and ventilation must shut off until the elevator is needed again. The Energy Standards do not specify the exact method of passenger detection that must be used. Options could include motion detectors, door beam sensors, or weight detection. The occupancy detection method should be thoroughly tested to ensure a passenger is not inside the elevator when the lighting and ventilation shut off. Additionally, sensors should be set up in such a way that pedestrian traffic in front of the elevator cabin does not accidentally trigger the lighting and ventilation to turn on, which should only occur when someone enters the cabin. .

## Acceptance Testing Requirements

The Energy Standards have acceptance test requirements for elevators. These tests essentially ensure everything is operating as it should. For covered processes, the installing contractor may qualify as the test technician.

| Form | Purpose |
|---|---|
| NRCA-PRC-12-F | Elevator Lighting and Ventilation Controls |

## Maintenance, Repairs, Additions, And Alterations

In addition to a newly installed elevator, the Energy Standards cover alterations to an existing installation. Existing elevators do not have to comply with the new Energy Standards, unless they undergo a significant alteration. Simple repairs do not trigger requirements in the Energy Standards. Refer to section 10.10.4 of the Title 24 2016 Compliance Manual for an explanation of what is considered an alteration versus a repair.

# Escalators and Moving Walkways

The 2016 Energy Standards apply to escalators and moving walkways that are located in airports, hotels, and transportation function areas. A transportation function area is defined in the Energy Standards as the ticketing area, waiting area, baggage handling areas, or concourse in an airport terminal, bus or rail terminal or station, subway or transit station, or a marine terminal.

The scope of the speed control requirement was limited by facility type to help ensure that it would only be applicable in likely cost-effective applications. By targeting operations where escalator usage is likely 24 hours a day, there is a larger potential for energy savings. The energy savings associated with this requirement only occur when the escalator is running and unoccupied. It would not save as much energy in a situation where the escalator is expected to experience heavy, consistent pedestrian traffic while operating, and then shut off when not in use (department stores, sports arenas, etc.).

Prior to 2016, there were no specified energy regulations for escalators and moving walkways in the Energy Standards. With the inclusion of §120.6(g)1, a newly adopted requirement regulating escalator and moving walkway speed control, it became necessary to add a section for escalators into the Covered Processes section of the Energy Standards.

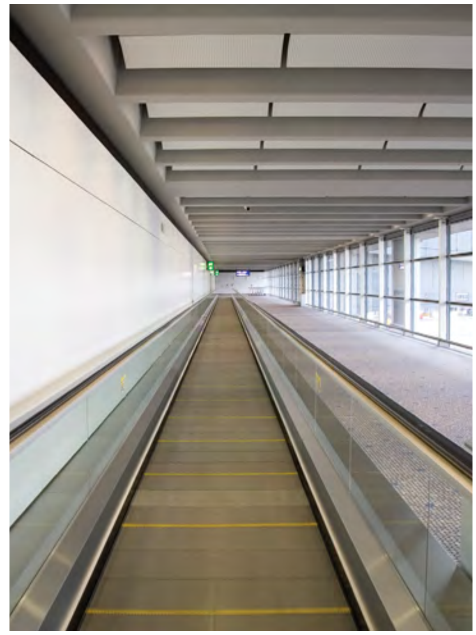
## Speed Variation Requirements

Escalators and moving walkways that fall under the jurisdiction of the 2016 Energy Standards must slow down to a minimum permitted speed when unoccupied for a set amount of time. Before this measure was added into the Energy Standards, speed variation during escalator and moving walkway operation was prohibited. This is because speed changes that are performed improperly while a pedestrian is on board potentially could result in a loss of balance, leading to injury.

The American Society of Mechanical Engineers (ASME) created a series of safety requirements and limitations that would safely allow for the variation of escalator and moving walkway speed variation. These requirements and limitations were adopted as part of the Energy Standards, which means they must be met in order to achieve compliance. These mandatory requirements include:

- Limiting the acceleration and deceleration rates
- Ensuring passengers are not on the escalator or moving walkway when the speed change occur.
- Programming alarms to sound when passengers approach a slowed down escalator or moving walkway from the wrong direction

Refer to Section 10.11.2.1 of the Title 24 2016 Compliance Manual for a summary of the ASME requirements for speed variation.



*Moving Walkway*

## Passenger Detection

Passenger detection is a very important component of compliance for escalators and moving walkways and is the primary input for whether or not the escalator or moving walkway may slow down or speed up. The Energy Standards do not specify the exact method of passenger detection that must be used. However, they do stipulate that approaching passengers should be detected with enough time in advance to allow the escalator to increase to full speed before the passenger can board when walking at a standard pace. For this reason, it is important that the passenger detection system is implemented in such a way that minimizes the chances of a passenger reaching the escalator or moving walkway undetected. Additionally, passenger detection must be present at both the entrance and exit of each escalator or moving walkway. The sensor at the entrance of the system will trigger the increase to maximum speed, and the sensor at the exit will sound off a warning alarm when someone approaches the escalator or moving walkway in the wrong direction.

The most suitable method of passenger detection uses a typical motion-based occupancy sensor, which should be tested from multiple angles of approach to ensure the passenger detection cannot be cheated, while minimizing false signals. In open areas with more varied pedestrian traffic, minimizing false signals may prove difficult. Other methods of passenger detection may be more practical in situations where pedestrian traffic and approach direction is limited, such as hallways or tunnels.

## Acceptance Testing Requirements

For escalators and moving walkways, the Energy Standards have acceptance test requirements. These tests essentially make sure everything is operating as it should. For covered processes the installing contractor may qualify as the test technician.

| Form | Purpose |
|---|---|
| NRCA-PRC-13-F | Escalator and Moving Walkway Speed Control |

## Maintenance, Repairs, Additions, and Alterations

In addition to a new installation escalator or moving walkway, the Energy Standards cover alterations to an existing installation. Existing escalators and moving walkways do not have to comply with the new Energy Standards, unless they undergo a significant alteration. Simple repairs do not trigger requirements in the Energy Standards . Refer to section 10.11.4 of the Title 24 2016 Compliance Manual for an explanation of what is considered an alteration versus a repair.


# Prescriptive Process Requirements: Computer Rooms

## Space Conditioning

The 2016 Energy Standards have placed new prescriptive requirements on computer rooms outlined in §140.9. The California Energy Commission has not instituted any language regarding the amount or type of computer equipment one can install, but the Commission does devote some attention to how that equipment will be conditioned. Before the implementation of the 2013 Energy Standards computer room space conditioning had a number of exemptions from the economizer requirements because of the potential to damage the computer equipment. Large energy savings are available through using economizer air or water side economizing when outside air temperatures are below 55°Fdb/50°wb.

Limitations are placed on space conditioning systems to eliminate active reheat energy an. adiabatic humidification systems (e.g. direct evaporative ultrasonic). In this occupancy type the only allowed humidification is from direct evaporative cooling or ultrasonic systems.

## Size & Application

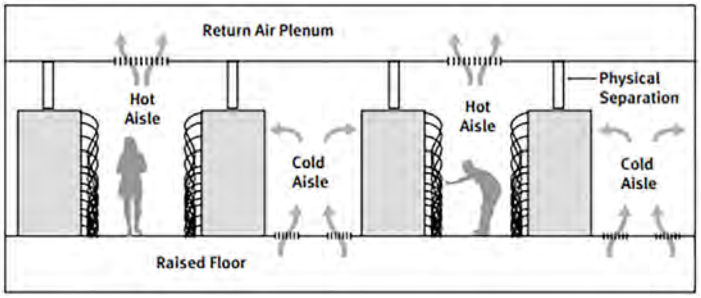
The economizer requirements impact all new computer rooms with an equipment power density greater than 20 watts per square foot and 5 tons or more of cooling required. Above these thresholds, an air side economizer is required that allows for 100% free cooling (compressor free) below 55°F dry bulb and 50°F wetbulb temperatures. An alternate to the air based economizer is a water side economizer capable of covering 100% of the load at an outside air temperature of 40°F drybulb and 35°F wetbulb temperatures. Either approach will satisfy the new construction requirements for economizers or "free cooling". A handful of exceptions apply to this rule if the computer room is served by a main building system.

### Exceptions

1. The economizer system is sized to meet the design cooling load of the computer room when the other spaces within the building are at 50 percent of their design load; and
2. The economizer system has the ability to serve only the computer room, e.g. shut off flow to other spaces within the building when unoccupied; and
3. The noneconomizer system does not operate when the outside air drybulb temperatures is below 60°F and, the cooling load of other spaces within the building served by the economizer system is less than 50 percent of design load. For liquid subcooling, low temperature cascade systems that condense into another refrigeration system rather than condensing to ambient temperature.

## Power Consumption of Fans

A two-speed or variable speed fan power and control is required for unitary air conditioning systems exceeding 60,000 Btu/h ( 5 tons) of cooling. The fan should be capable of reducing 50% of the designed fan wattage at 66% of the design fan speed. Prescriptively the total fan power is not to exceed 27 watts/kBtu of net sensible cooling capacity. This is an element that may be traded off in the performance approach.




*Containment Barriers*

## Code in Practice

A computer room is a room within a building whose primary function is to house electronic equipment and that has a design equipment power density exceeding 20 watts/ft2 (215 w/m$^2$) of conditioned floor area.

## Containment

Outlined in §140.9 (a) 6 a section titled "Containment" dictates a separation of the supply cooling air from the hot return air for computer rooms that exceed 175kW per room. This is an efficiency measure that has long been championed by data center design guidelines to optimize the airflow in computer rooms. There are a few methods to achieve this containment including the "Hot Aisle/Cold Aisle" separation. Generally, cold air supplied from the normal underfloor plenum or an overhead system does not effectively cool the racks unless directed to do so. A "thermal bypass" of the racks directly to the return air plenum or return duct can severely decrease the cooling effectiveness. A few other strategies are outlined in PG&E's Data Center's Best Practices Guide including flexible barriers and ventilated racks.

## Existing Buildings & Retrofits

Special exceptions apply to existing building configurations. If the new computer room and cooling system is added to the existing building and has a designed load more than 20 tons, then a new economizing system – air or water – must be provided per §140.9 requirements.

If a new cooling and fan system is added to an existing computer room in a building, the Energy Standards only require economizers on systems mare than 50 tons of cooling. The California Energy Commission recognizes the cost of adding economizing capability to existing buildings can be both costly and extremely difficult to construct, hence the requirement is triggered by large system upgrade versus system alterations.

Expansions of existing data centers do not have to comply with the containment sections of the Energy Standards, but it is highly recommended if the space can easily be retrofitted. The energy savings potential of the separation of hot and cold aisles can have very quick paybacks with inexpensive flexible barriers.

## Performance Approach

The economizer controls for both computer room air conditioners (CRAC) and computer room air handlers (CRAH) can be modeled for compliance at this time. Performance tradeoffs for higher performance air handlers with economizers can be applied to computer rooms. Guidance is provided in the Nonresidential Alternative Calculation Method (ACM) Reference Manual.

## Acceptance Testing Requirements

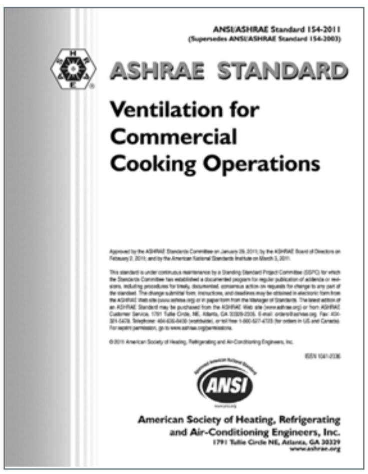
For computer room air conditioners and economizers all of the applicable mechanical system acceptance tests required by the main HVAC sections of the standards apply, and may trigger the need for a certified ATT once the CEC has approved use of only mechanical acceptance test technicians..


*Data Center Best Practices Guide*

This Guide provides viable alternatives to inefficient data center design and operating practices, and addresses energy efficient retrofit opportunities.

Find the Guide here: pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/DataCenters_BestPractices.pdf

# Prescriptive Process Requirements: Commercial Kitchen Ventilation


ANSI/ASHRAE Standard 154-2011
(Supersedes ANSI/ASHRAE Standard 154-2003)

ASHRAE STANDARD

Ventilation for Commercial Cooking Operations

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

ASHRAE Standard 154-2011 is a good reference document for hood types, appliance duty and net exhaust flow rate.

Kitchen hoods have been an unregulated process for a long period of time because removing smoke, heat, and smells from the cooking area was deemed necessary for worker safety. The exhaust air system has compounding energy use besides the energy for the exhaust fan that pulls air from the cooking areas. The make-up air for kitchen hoods in most commercial kitchens is fully air conditioned, wasting enormous amounts of energy for heating, cooling, and fans for the main HVAC systems in addition to the exhaust fan energy.

Starting with the 2013 Energy Standards kitchen hoods have been a prescriptively regulated process system. Section 140.9(b) dictates both supply air and exhaust air compliance strategies.

## Kitchen Exhaust Systems

As described above, a significant opportunity for energy savings is related to replacement air used by kitchen exhaust systems. Replacement air may be derived from one or more of the following: makeup air, portions of supply air, transfer air, or infiltration air.

The Energy Standards include a requirement that replacement air introduced directly into the hood cavity must not exceed 10% of the hood exhaust airflow rate. This requirement limits "short-circuiting" of replacement air. Short-circuiting occurs when replacement air is ducted or otherwise supplied directly to the hood canopy. This is a somewhat outdated strategy that was originally implemented to meet standard practice exhaust rates using tempered but not fully conditioned replacement air (intended as an energy efficiency measure!. As exhaust rates have been dialed in, short-circuiting has become unnecessary and even wasteful as it requires higher exhaust rates to effectively capture and contain contaminated air.

The second requirement limits net exhaust rates per linear foot of hood length in Type I and Type II hoods with rates greater than 5,000 cfm. Table 140.9-A in the Energy Standards includes maximum exhaust flow rates per linear foot based on type of hood (wall-mounted, single island, eyebrow, etc.). If the design results in 75% of the replacement air being made up of transfer air that would otherwise be exhausted, Table 140.9-A does not apply.

## Kitchen Ventilation

In addition to exhaust, the Energy Standards also regulate the supply of replacement air. To avoid mechanically heated or cooled replacement air, any makeup air supplied to a space with a kitchen hood must not exceed the greater of:

- The supply flowrate required to meet space heating and cooling load; or
- The hood exhaust flow minus the available transfer air from adjacent spaces.

For Type I and II hoods with exhaust airflow rates greater than 5,000 cfm, there are four options for designing the supply of replacement air:

- At least 50% of replacement air is transfer air OR
- Demand control ventilation (DCV) (smoke and heat sensors) on at least 75% of exhaust air OR
- Heat recovery devices with 40% effectiveness on at least 50% of total exhaust air OR
- 75% or more of make-up air volume is unconditioned.

There are additional controls requirements related to the option to use demand controlled ventilation, outlined in §140.9(b)2Bii. Depending on the type of kitchen, demand controlled fume hoods have quick payback potential. Kitchens that provide more than one meal service normally have potential for both exhaust and make up air energy savings between meal preparations where the grills and other equipment are idle.

## Existing Buildings & Retrofits:

Kitchen hoods that are not being replaced as part of an addition or alteration project do not need to comply with this section of the Energy Standards. If upgrading either the exhaust or make up air systems compliance with §140.9 (b) will be required for the system being altered. If both are altered, each will have to comply with the Energy Standards.

## Performance Approach

The CBECC-Com software certified for compliance includes modeling capability for kitchen fume hood exhaust systems. The current software includes a baseline exhaust flowrate that tracks the design flowrate, and thereby does not allow the user to input a design flowrate less than the baseline for performance credit. The software does allow the design flowrate to exceed the baseline resulting in a performance penalty. Modeling guidance is given in the Nonresidential ACM.

## Acceptance Testing Requirements

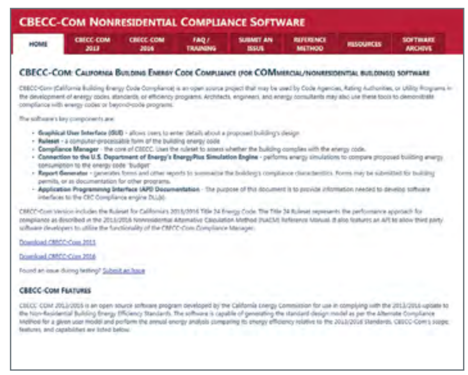
Kitchen exhaust systems have been added to the acceptance testing requirements and must be tested prior to occupancy. Nonresidential Appendix (NA) 7.11 includes a description of acceptance testing requirements that include but are not limited to confirming thermal plume and smoke are completely captured at full load operating conditions, verifying space pressurization is appropriate, measuring exhaust rates and functionally testing DCV systems.

A certified Acceptance Testing Technician is not required for documenting compliance. The installing contractor may be the responsible party for testing, startup, and final signatures on this document.

| Form | Purpose |
|---|---|
| NRCA-PRC-02 | Kitchen Exhaust |


The Food Service Technology Center supported by the State's major Investor Owned Utilities (IOU's) has done extensive research around kitchen hood exhaust.

Find the case study here: fishnick.com




California Building Energy Code Compliance for Commercial (CBECC-Com) software is an open-source software program developed by the California Energy Commission for use in demonstrating compliance with the Nonresidential Energy Standards. In addition to other components, it includes a compliance manager, which must be used by third party software interfaces (such as EnergyPro, Simergy or IES Virtual Environment) to demonstrate compliance.

Visit the CBECC-Com webpage to download the software or find more information: bees.archenergy.com/index.html


# Prescriptive Process Requirements. Laboratory Exhaust Systems

Laboratory exhaust systems have been another area traditionally unregulated by the Energy Standards. After years of research and implementation by industry throughout the commercial, educational, and other research laboratories, unoccupied setback for laboratory fume hoods was prescriptively required starting with the 2013 Energy Standards. No changes to this language were made for the 2016 Energy Standards update, but significant exceptions to the requirements remain.

Energy Standards §140.9 (c) requires setback control for labs with exhaust systems with designed air change rates of 10 or less per hour. Facilities which require air change rates above 10 ACH are exempt from the setback requirements. Significant energy savings are possible with this prescriptive strategy for both main space conditioning systems and the exhaust air systems. The system shall be capable of reducing zone exhaust and make up airflow to the regulated minimum air exchange rates, or the minimum required to maintain pressurization requirements in the space.

If the jurisdiction having authority of the building requires constant volume for a laboratory exhaust system of 10 ACH or less otherwise regulated by this Energy Standard, the local jurisdiction may exempt the space from the setback requirements for health and safety reasons.

## Existing Buildings & Retrofits

New zones added to existing constant volume systems may be exempted from the control strategies. Conversely, if new zones are added to a main variable air system with the capability of setback, then the zonal setback controls must show compliance.

## Acceptance Testing Requirements

No acceptance testing requirements for laboratory fume hoods are required in this section but the main air handlers serving this space, if regulated by the Energy Standards, would have to pass the appropriate acceptance testing requirements. Commissioning is not required for any of the covered processes per Title 24 but is highly recommended on these complex setback controls.


High Performance Laboratories: A Design Guidelines Sourcebook.

Find the guide here: pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/Labs_BestPractices.pdf

## Performance Approach

The CBECC-Com software certified for compliance includes modeling capability for lab fume hood exhaust systems. The current software includes a baseline exhaust flowrate that tracks the design flowrate, and thereby does not allow the user to input a design flowrate less than the baseline for performance credit. The software does allow the design flowrate to exceed the baseline resulting in a performance penalty. Modeling guidance is given in the Nonresidential ACM.


Aircuity case study

University of California, Irvine

Significant Energy Savings through Smart Lab Design and Demand Control Ventilation

"What really make the labs smart are the reports and dashboards. Not only can we spot failed components sooner, but we can determine what aspect of the operation is driving energy use and target it."

University of California, Irvine

AIRCUITY

The Aircuity Case Study by University of California, Irvine shows significant Energy Savings through Smart Lab Design and Demand Control Ventilation

Read the entire case study here: i2sl.org/elibrary/documents/Aircuity-Case-Study_UCI.pdf