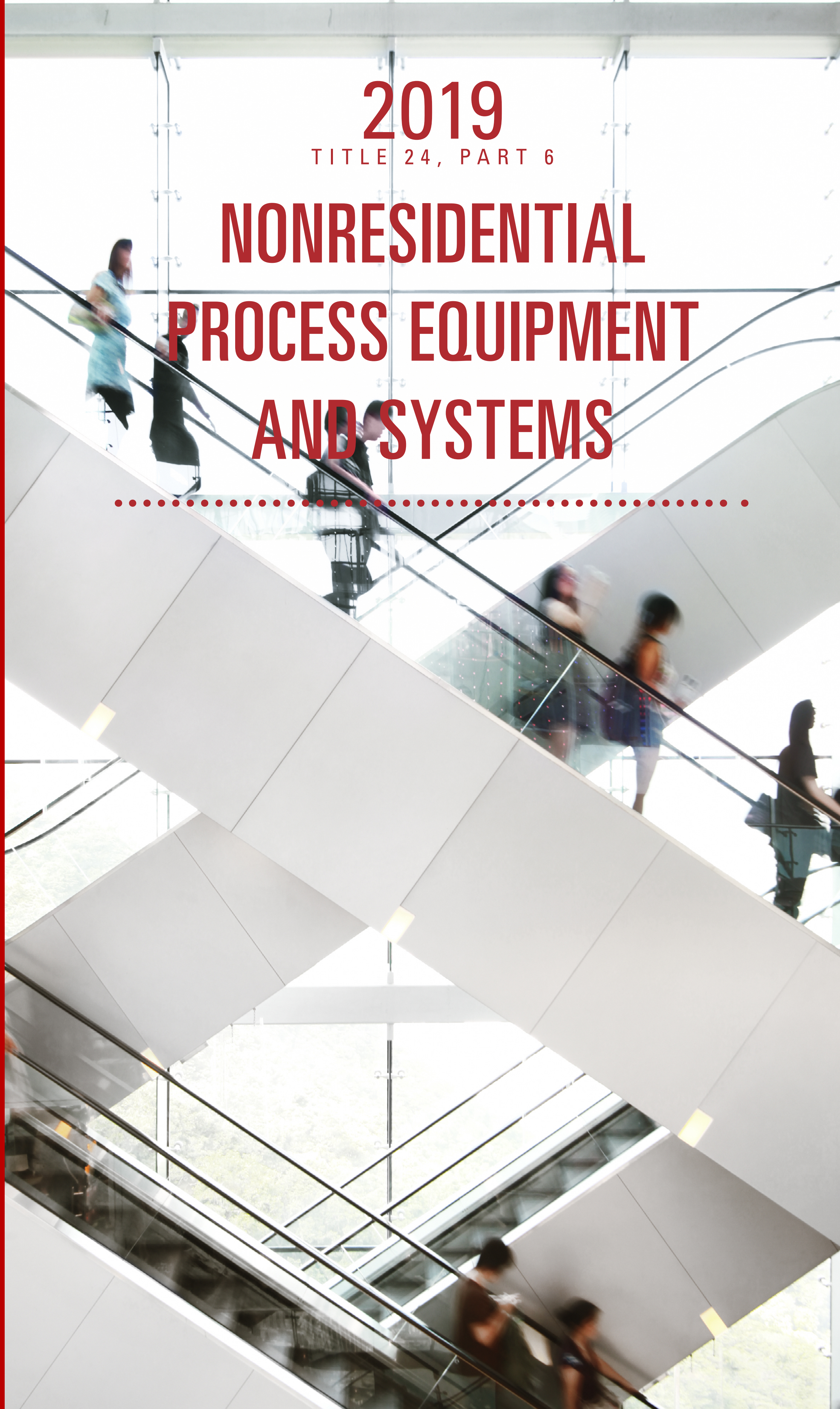
2019

TITLE 24, PART 6

NONRESIDENTIAL PROCESS EQUIPMENT AND SYSTEMS



Energy Code Ace™

This guide is designed to help builders and industry professionals become more familiar with the nonresidential Covered Process portion of California's 2019 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 no-cost energy code tools, training 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

CONTENTS


94-4

CHAPTER 1

INTRODUCTION

The Benefits of Efficiency

The California Energy Commission has been expanding the influence of California's Building Energy Efficiency Standards (Energy Code) for many years. The process elements included in the 2013 Energy Code 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 California 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 Code 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 Title 24, Part 6 residential and nonresidential code 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 Code in New Construction, Addition and renovation projects.

This application guide provides guidance on process elements introduced in previous Energy Codes as well as the updated 2019 requirements. It also provides design teams, owners and facility managers a clear strategy to comply with the Energy Code and identifies efficiency measures beyond minimum Energy Code.

Compliance Process Overview

The guide begins with an overview of the compliance process 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 Code uses 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, refrigerated 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 Code), 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 Code, 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 • Insulation • Cool Roofs • Solar Zone • Fenestration • Compliance documentation details
NONRESIDENTIAL LIGHTING AND ELECTRICAL POWER DISTRIBUTION[1]	• Lighting design strategies • Controls • Electrical power distribution
NONRESIDENTIAL HVAC AND PLUMBING	• Mechanical Systems and Plumbing Systems • Commissioning, HERS Process & Acceptance Testing • Dynamic Prescriptive Forms NRCC MCH-E and NRCC-PLB-E • Integrated Design Process • Prescriptive vs. Performance compliance
NONRESIDENTIAL PROCESS EQUIPMENT AND SYSTEMS	• Process loads • Applicable products and systems such as kitchen hoods, parking garage ventilation, laboratory fume hoods, elevators and moving walkways, escalators, and compressors
RESIDENTIAL ENVELOPE, SOLAR READY AND PV (Low-Rise and Single Family)	• Single Family Homes • Single Family building envelope • Climate specific design • Insulation • Cool Roofs • Single Family Solar Ready including Solar Zones • Solar PV (Photovoltaics) and Battery Storage • Fenestration • Prescriptive vs. Performance compliance • Compliance documentation details
RESIDENTIAL LIGHTING[1] (Low-Rise and Single Family)	• Lighting design strategies • Compliant Products • Controls
RESIDENTIAL HVAC AND PLUMBING (Low-Rise and Single Family)	• HVAC terminology • Heating and cooling system types • Hot Water system types

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

New in 2019: An Overview of Updates

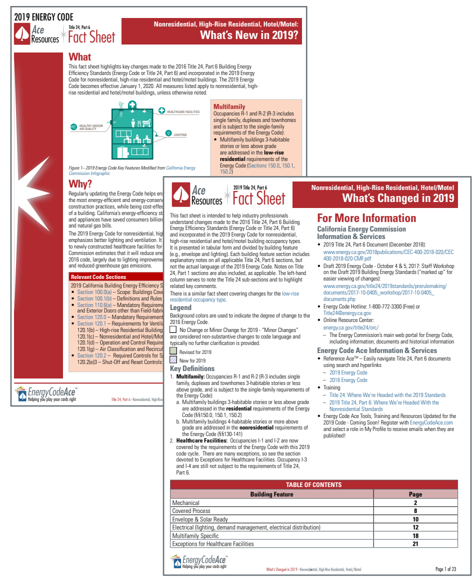
New Efficiency Requirements

No significant changes were made in the 2019 Energy Code to the process elements in the previous 2016 Energy Code. Section 120.6 – Covered Processes describes the Mandatory requirements for refrigerated warehouses, commercial refrigeration applications, parking garages, process boilers, compressed air systems, escalators and elevators. Section 140.0 – Performance and Prescriptive Compliance Approaches describes the Prescriptive requirements for laboratory and factory exhaust systems and lab and process facility exhaust systems.

The new language helps to clarify what square footage constitutes a refrigerated warehouse and how all types of condensers, including adiabatic, should be sized, tested, and controlled. Also, there is additional language accommodating transcritical CO2 refrigeration systems.

This section also captures new lighting power density calculation exceptions for elevators, excluding interior signal lighting, interior display lighting and any elevators located in licensed healthcare facilities.

The most significant changes in the 2019 Energy Code are in Section 140.9(c). This includes additional regulations on Prescriptive requirements for laboratory and factory exhaust systems and fume hoods. This section does exclude licensed healthcare facilities, but for all other applications, laboratory and factory exhaust systems need to be monitored and regulated for power, volume flow rate and contaminant presence. Additionally, any fume hoods in intensive laboratories must be equipped with automatic sash closure. Both the fume hood automatic sash closure and laboratory and factory exhaust systems new measures require Acceptance Testing prior to occupancy.



What's New and What's Changed in 2019 Fact Sheets

These two documents present 2019 Title 24, Part 6 updates at a glance.

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

2019 Title 24, Part 6: Where We're Headed With the Nonresidential Standards

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

Find dates for upcoming classes: energycodeace.com/training

Decoding What's New: Let's Talk 2019 Title 24, Part 6 - Nonresidential

A free, 2-hour interactive online event that discussed, reviewed and decoded the new 2019 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 Code) for many years. The process elements included in the 2013 Energy Code 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 2019 Nonresidential Compliance Manual and forms, can be found on the Energy Commission website: energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency

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 Code. 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.

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.

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/tools-ace/tool=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
I	Instututional	Healthcare Facility*
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

* Healthcare Facilities licensed under the Health and Safety Code (HSC) §1204 or §1250 meet the new "Healthcare Facility" definition in the Energy Code and are eligible for the Healthcare Facility exceptions.

Local Energy Ordinances

There also may be local energy ordinances that the local jurisdiction will enforce in addition to Title 24, Part 6. These local energy ordinances 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 ordinances can require third-party inspections and building certifications. Being aware of local energy ordinances in the design phase of the project will reduce cost, time and effort, as well as help to avoid extensive and costly change orders.

Step 3: Prepare and Submit Permit Application

Once the design requirements in the Energy Code 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 (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 of the Energy Code, 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 as of October 1, 2021, 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 Code and the approved certificates and associated documentation
- Check that all necessary set points or schedules are in place as required by the Energy Code 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 or commissioning provider) who will be responsible for submitting them to the enforcement agency

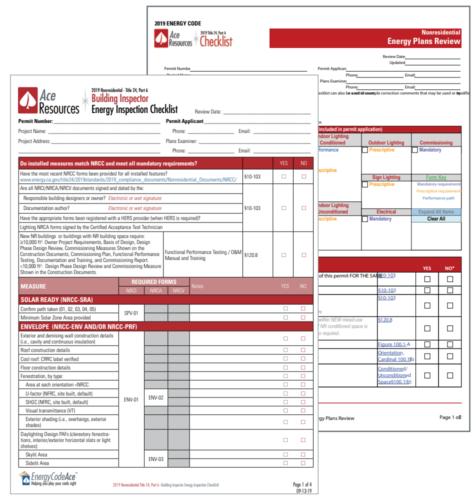
Step 7: Pass Building Inspection

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. 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.

Ace Resources™



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

Plans examiner: energycodeace.com/download/34327/file_path/fieldList/NR%20PE%20Chklist%202019

Building inspector: energycodeace.com/download/33914/file_path/fieldList/2019%20NR%20BldgInspectorCkLst

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:

- 2019 Title 24, Part 6 Essentials – Nonresidential Standards for Architects & Designers
- 2019 Title 24, Part 6 Essentials – Nonresidential Standards for Energy Consultants
- 2019 Title 24, Part 6 Essentials – Nonresidential Standards for Plans Examiners & Building Inspectors

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-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

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

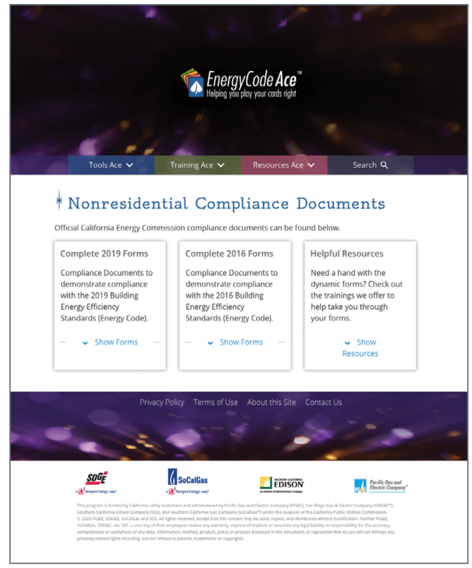
The Certificate of Compliance (NRCC) documents the building features required to comply with Title 24, Part 6, for nonresidential, high-rise residential and hotel or motel buildings. These features will vary depending on the particular project and the compliance approach used. NRCCs are submitted to 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 as of October 1, 2021, mechanical tests, the Certificate of Acceptance must be completed and signed by a certified Acceptance Test Technician.

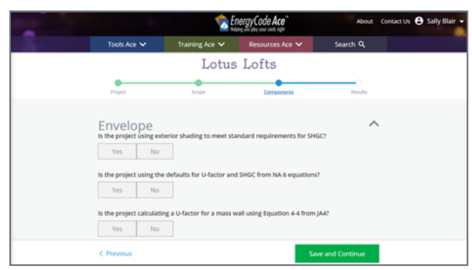


Compliance Documents

Compliance documents can be found on Energy Code Ace.

Click here to access the forms: energycodeace.com/nonresidentialforms

Ace Forms™



The Forms Ace is home to the official California Energy Commission Energy Code forms.

Here you can download, get guidance to complete online or get help figuring out which forms you need for your project.

Find the tool here: energycodeace.com/content/tools-ace/tool=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 Code. 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. Examples of Covered Processes for healthcare facilities include ventilation for enclosed parking garages and large boilers serving steam sterilization systems.

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 and Exhaust
- Laboratory and Factory 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 Code. In the past, these "necessary" processes would be left unchecked without much thought about how to efficiently and reliably minimize loads. Best practices for efficient design and utility incentive programs have effectively developed standard efficient practices within these industries. These standard efficient practices have started making their way into the Energy Code.

Refrigerated Grocery Case

CHAPTER 4

TECHNOLOGY, SYSTEMS AND COMPLIANCE STRATEGIES

Compliance Requirements

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

1. Meet all Mandatory requirements by installing required systems, equipment and devices, and ensure that they perform all functions required by the Energy Code.
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 2019 Energy Code 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

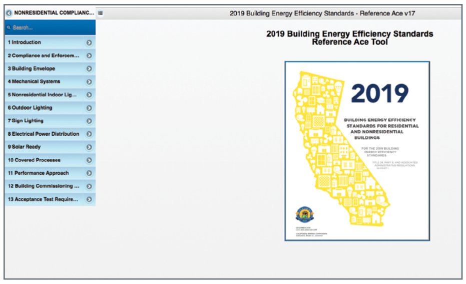
In general, the Prescriptive Approach is considered the most direct path to compliance. It is a set of prescribed performance levels for various building components where each component must meet or exceed the requirement. There are a handful of process requirements that are included in the Prescriptive 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 for covered processes, 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 and factory 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-2019-tool


BLUEPRINT
CALIFORNIA ENERGY COMMISSION
EFFICIENCY DIVISION

Energy Commission Resource: Blueprint Newsletter

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

Find the Blueprints here: energy.ca.gov/newsroom/blueprint-newsletter

Navigating Title 24, Part 6

The Energy Code contains energy requirements for all Newly Constructed buildings, Additions and Alterations. The Energy Code is divided into three general categories: Mandatory requirements that apply to all buildings, nonresidential building requirements (including high-rise residential and hotel or 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 Code 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 Reference 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 and Moving Walkways	§120.6(g)		
Computer Rooms		§140.9(a)	NR ACM
Commercial Kitchen Ventilation and Exhaust		§140.9(b)	NR ACM
Laboratory and Factory 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: energycodeace.com/site/custom/public/reference-ace-2019/Documents/1introduction2.htm

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 Code does 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 ft^2 in floor area. Coolers are defined as refrigerated spaces designed to operate between 28°F and 55°F. Freezers are defined as refrigerated spaces designed to operate below 28°F.

The Energy Code regulates refrigerated warehouse and refrigerated space square footage separately. The 2019 Energy Code applies to refrigerated warehouses 3,000ft^2 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 Code 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 ft^2, it would be considered a refrigerated warehouse and §120.6(a) applies. If the sum of the spaces is less than 3,000 ft^2, 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 Paths are permitted, such as installing more insulation to offset a less efficient compressor. 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 C and §120.6(a)5B) based on percentage refrigeration capacity allocated to refrigerated space. The Energy Code applies 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 2,000 ft^2 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)

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

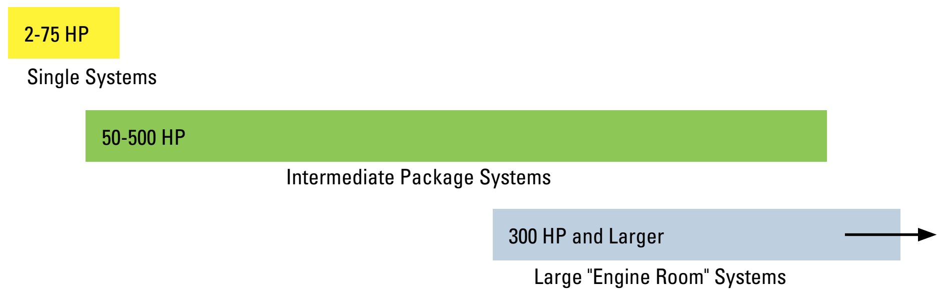
Large "built-up" industrial refrigeration plant

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.



High Rise Freezer Design

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 evaporatorativelу-cooled.

Single Systems

Single systems are primarily factory packaged units, are often 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 they have higher operating and maintenance costs.

Intermediate Package Systems

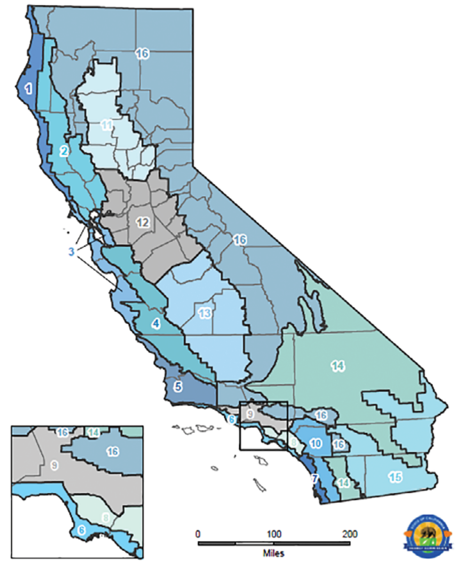
Intermediate packaged systems provide a great deal of flexibility in meeting varying system load requirements and application conditions.

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/programs-and-topics/programs/building-energy-efficiency-standards/climate-zone-tool-maps-and

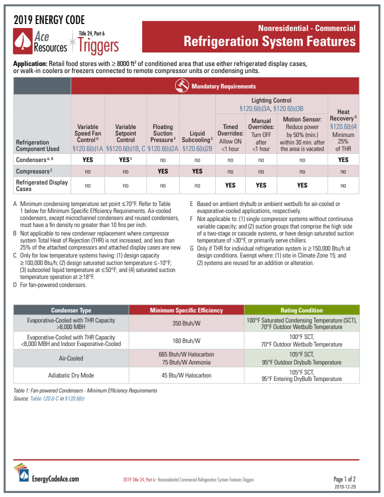
Insulation Requirements

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 Code 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 or other means that result in productive refrigeration capacity on the associated refrigerated system.

Table 120.6-A Refrigerated Warehouse Insulation



2019 ENERGY CODE

Ace Resources Title 24, Part 6 Triggers

Nonresidential - Commercial

Refrigeration System Features

Application: Retail food stores with ≥ 8000 ft² of conditioned area that use 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 Used	Variable Speed Fan Control[D] §120.6(b)1A	Variable Setpoint Control §§120.6(b)1B, C	Floating Suction Pressure[F] §120.6(b)2A	Liquid Subcooling[C] §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, B]	**YES**	**YES**[E]	no	no	no	no	no	**YES**
Compressors[C]	no	no	**YES**	**YES**	no	no	no	no
Refrigerated Display Cases	no	no	no	no	**YES**	**YES**	**YES**	no

A Minimum condensing temperature set point ≤70°F. Refer to Table 1 below for Minimum Specific Efficiency Requirements. Air-cooled condensers, except microchannel condensers and reused condensers, must have a fin density no greater than 10 fins per inch.

B Not applicable to new condenser replacement where compressor system Total Heat of Rejection (THR) is not increased, and less than 25% of the attached compressors and attached display cases are new.

C 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; and (4) saturated suction temperature operation at ≥18°F.

D For fan-powered condensers.

E Based on ambient drybulb or ambient wetbulb for air-cooled or evaporative-cooled applications, respectively.

F Not applicable to: (1) single compressor systems without continuous variable capacity; and (2) suction groups that comprise the high side of a two-stage or cascade systems, or have design saturated suction temperature of >30°F, or primarily serve chillers.

G Only if THR for individual refrigeration system is ≥150,000 Btu/h at design conditions. Exempt where: (1) site in Climate Zone 15; and (2) systems are reused for an addition or alteration.

Condenser Type	Minimum Specific Efficiency	Rating Condition
Evaporative-Cooled with THR Capacity >8,000 MBH	350 Btuh/W	100°F Saturated Condensing Temperature (SCT), 70°F Outdoor Wetbulb Temperature
Evaporative-Cooled with THR Capacity <8,000 MBH and Indoor Evaporative-Cooled	160 Btuh/W	100°F SCT, 70°F Outdoor Wetbulb Temperature
Air-Cooled	665 Btuh/W Halocarbon 75 Btuh/W Ammonia	105°F SCT, 95°F Outdoor Drybulb Temperature
Adiabatic Dry Mode	45 Btu/W Halocarbon	105°F 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 2019 Title 24, Part 6 - Nonresidential Commercial Refrigeration System Features Triggers Page 1 of 2 2019-12-29

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

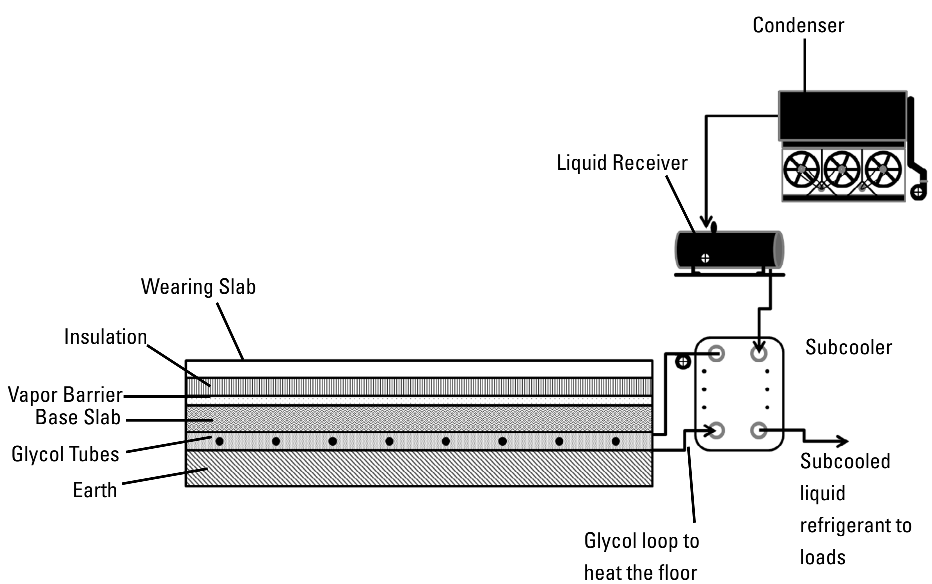
With the extreme temperatures required on the interior surfaces, the concrete slabs for these buildings often are installed with supplementary heating systems that prevent cracking and movement.

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 Code allows electric resistance heating in these underslab systems. 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.



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. 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 generally is 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.


PG&E CASE INITIATIVE

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.

Condensers

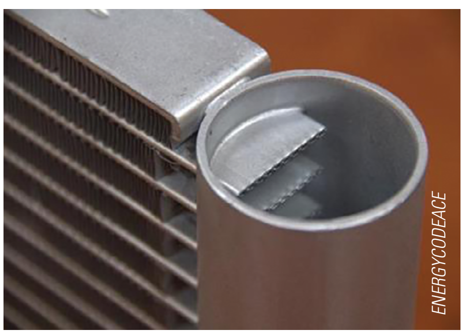
Condensers on refrigerated space served by a shared refrigeration system that serve 3,000 ft² or larger within a refrigerated warehouse must meet all of the condenser sizing, fan control and efficiency requirements in §120.6(a)4. Insulation, underslab heating, evaporators and infiltration barrier requirements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

In applications with new refrigeration systems that serve multiple functions beyond refrigerated space cooling, there are exceptions to compressor speed control requirements. The exceptions apply provided that the refrigeration cooling load has less than 80% dedicated to refrigerated space (more than 20% dedicated to quick chilling, process refrigeration or freezing 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.

Microchannels And Microchannel Condenser



Micro-channel Condenser

Air-Cooled Condensers

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. 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 Code 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.

Adiabatic Condensers

Adiabatic condensers are new to the 2019 Energy Code. They are now captured under §120.6(a)4C and must meet condenser sizing, fan control and efficiency requirements.

Adiabatic assisted air-cooled condensing involves a two-step process: in the first step (pre-cool mode) the ambient air is evaporatively pre-cooled; in the second step (dry mode) the air enters the air-cooled condenser. This colder air entering the air-cooled condenser improves the system efficiency. Evaporative pre-cooling is generally used on the hottest days. On cooler days, adiabatic cooling is typically not utilized, and the system reverts to dry mode with standard air-cooled condensing.

Microchannel Style Condensers

Another important consideration for condensers is fin spacing. An exception is listed in the Energy Code 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 Code 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.

There are now exceptions for sizing, control, and efficiency of condensers for transcritical CO_2 refrigeration systems.

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 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 with new refrigeration systems that serve multiple functions beyond refrigerated space cooling, there are exceptions to compressor speed control requirements. The exceptions apply provided that the refrigeration cooling load has less than 80% dedicated to refrigerated space (more than 20% dedicated to quick chilling, process refrigeration or freezing 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 Code requires 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 for openings equal to or greater than 16 ft^2. 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 right.

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% 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

Acceptance Testing Requirements

For refrigerated warehouses, the Energy Code has 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
NRCA-PRC-16-F	Adiabatic Condensers

Maintenance, Repairs, Additions and Alterations

In addition to an all-new refrigerated facility, the Energy Code covers expansions and modifications to an existing facility and an existing refrigeration plant. The Energy Code does 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 Code. Exceptions are stated in the individual equipment requirements.

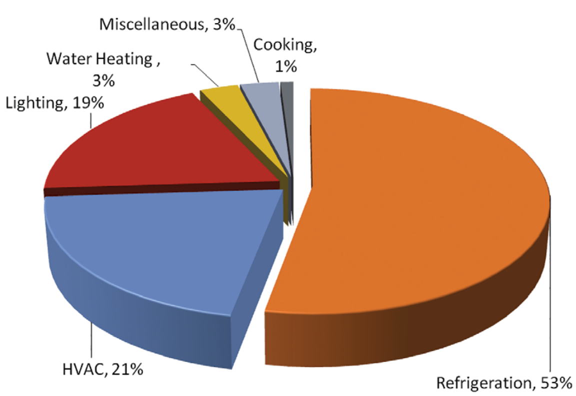
Commercial Refrigeration

Commercial business establishments that use refrigeration vary in size from small "mom-and-pop" convenience stores, to supermarkets of all sizes and 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 Code for Commercial Refrigeration

All commercial retail food refrigeration Energy Code 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 Code. There are no trade-offs using Prescriptive or Performance Approaches. 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 2019 Energy Code are retail food facilities with 8,000 ft^2 or more of conditioned floor area using refrigerated display cases, walk-in coolers or freezers.

Convenience stores range in size from 800 to 4,000 ft^2, with the average size being about 2,500 ft^2. The freezers and coolers in these facilities are not affected by the Covered Process requirements (§120.6(b)) of the Energy Code.

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

The Energy Code also does 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 ft^2 of floor area that are designed to operate at 55°F or below. If the walk-in is in a store larger than 8000 ft^2 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 Code for commercial refrigeration cites specific requirements for:

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

For commercial refrigeration the Energy Code refers 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.

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
- Adiabatic condensers
- Gas coolers

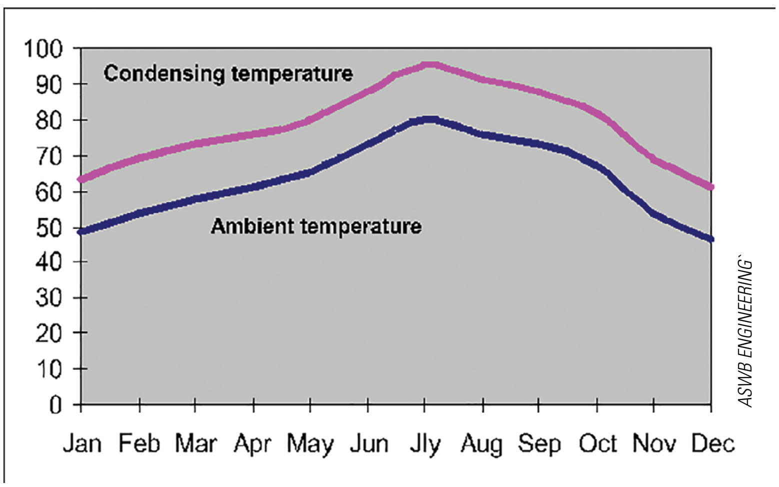
The Energy Code requires the following for condensers in commercial refrigeration:

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

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 Code 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 it 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.

Transcritical CO_2 refrigeration systems have exceptions for condenser sizing, control and efficiency.

Exceptions

There are several exceptions to the condenser specific efficiency 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 Code.
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 Code requires 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 to the left.

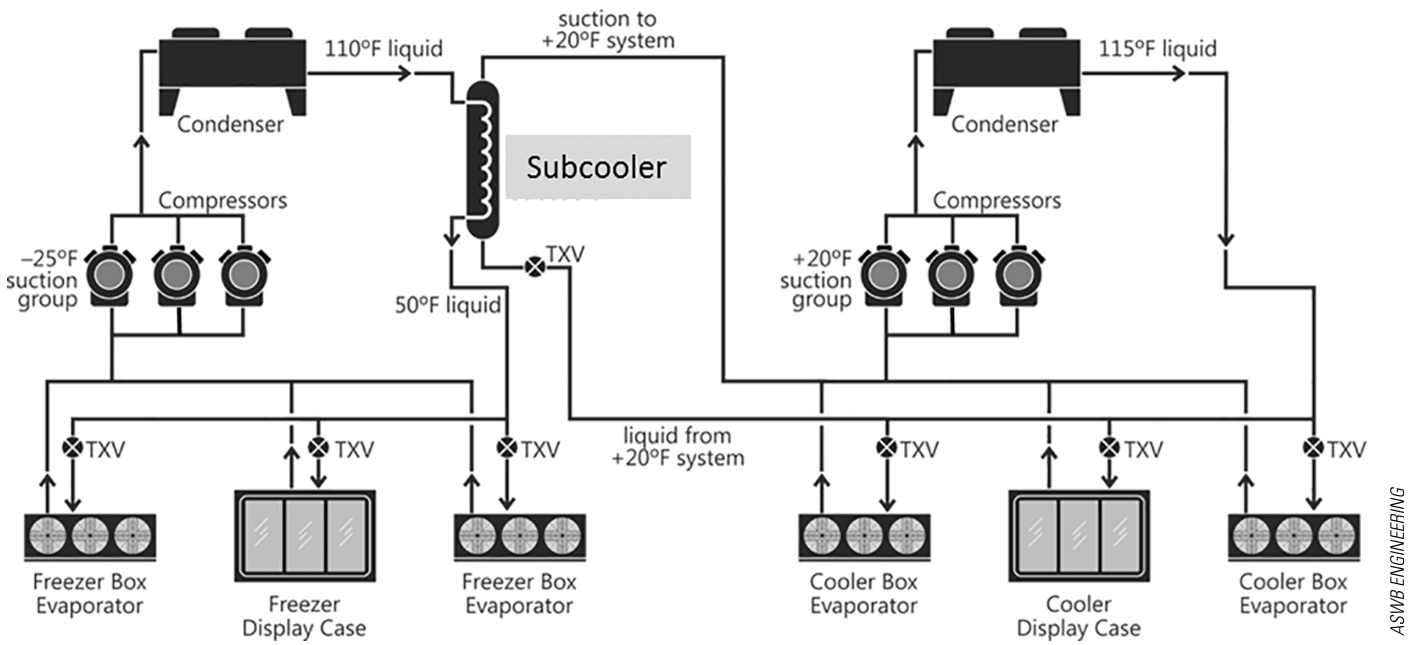
About Floating Suction Pressure

The Energy Code requires 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 Code requires liquid subcooling for certain low temperature compressor systems. The term subcooling refers to a liquid that is at a temperature below its normal saturation temperature. Subcooling the refrigerant improves the refrigeration effect and saves energy.



Parallel Low-and Medium Temperature Refrigerator systems with Subcooling

The Energy Code requires 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 ft², 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 turning off the lighting or reducing light power when no one is there or at close of business.

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 and shows large efficiency savings when correctly implemented.

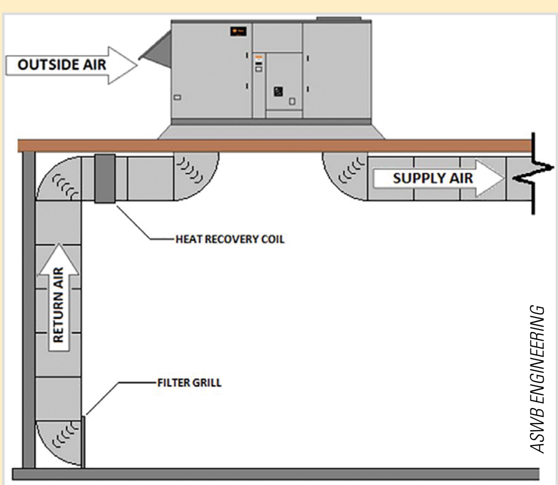
There are many possible heat recovery design configurations. System design including the controls, piping, valves and heat exchangers must meet other requirements in the Energy Code such as floating condensing temperature and others.

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 Code limits the increase in HFC refrigerants associated with refrigeration heat recovery to ≤0.35 lbs per 1,000 Btu/h heat recovery heating capacity. There are two exceptions for refrigeration heat recovery, including stores located in Climate Zone 15 or systems that are reused for an Addition or Alteration. It is the responsibility of the system designer to fully understand how the heat recovery system affects overall refrigerant charge.

Motion Sensor

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 2019 Energy Code has requirements for enclosed parking garages with mechanical ventilation systems with a total exhaust rate ≥10,000 cfm. Although the Energy Code doesn'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 2019 Energy Code also requires a Carbon Monoxide Demand Control Ventilation (CO DCV) system to be a Mandatory feature for enclosed parking garages that have a total design exhaust rate ≥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 Code provides exemptions for garages, or portions of a garage, where more than 20% of the vehicles are expected to be non-gasoline combustion engines. Also, Additions and Alterations to existing garages where <10,000 cfm of new exhaust capacity is being added are exempt.

Carbon Monoxide Demand Control Ventilation (CO DCV)

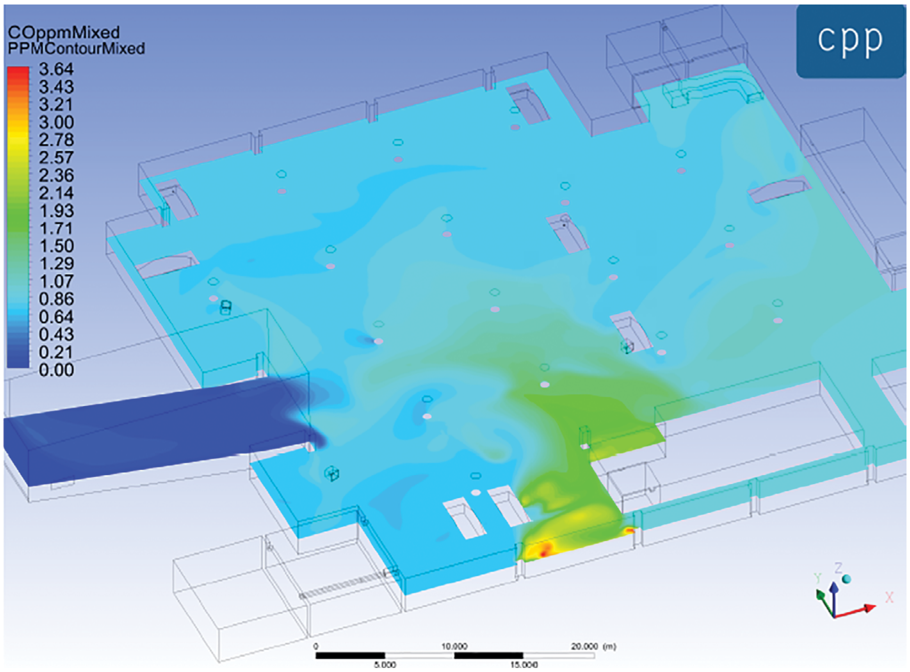
Enclosed parking garages need to be ventilated to prevent the buildup of carbon monoxide (CO), which is a poisonous gas that gasoline- and diesel-powered vehicles produce. Prior to this standard, many parking garages operated their exhaust systems full time, wasting energy when vehicles may not be present 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, as well as 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.

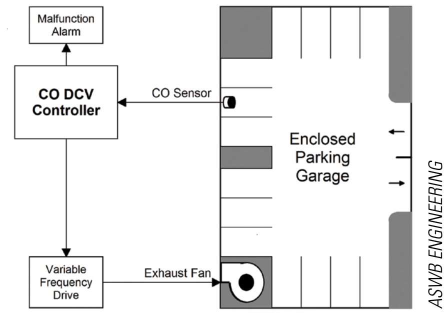
CO DCV Control System Requirements

The CO DCV control system must automatically detect CO concentration levels and then adjust the exhaust fan airflow rates to 50% 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% 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)



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 2019 Energy Code has requirements for how many CO sensors are required and their optimal location in the parking garage.

The Energy Code requires 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 serve an area up to 5,000 ft².

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 2019 Energy Code has requirements for CO sensors used in enclosed parking garages:

- Certified by the manufacturer to be accurate within plus or minus 5% of measurement
- Certified by the manufacturer to drift only 5% 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 Energy Code requires 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 Code applies 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 2019 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 2019 Energy Code for process boilers or water heaters applies 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 Code requirements for process boilers are Mandatory. That means there are no trade-offs using the Prescriptive or Performance Approaches. 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 2019 Energy Code requires 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.

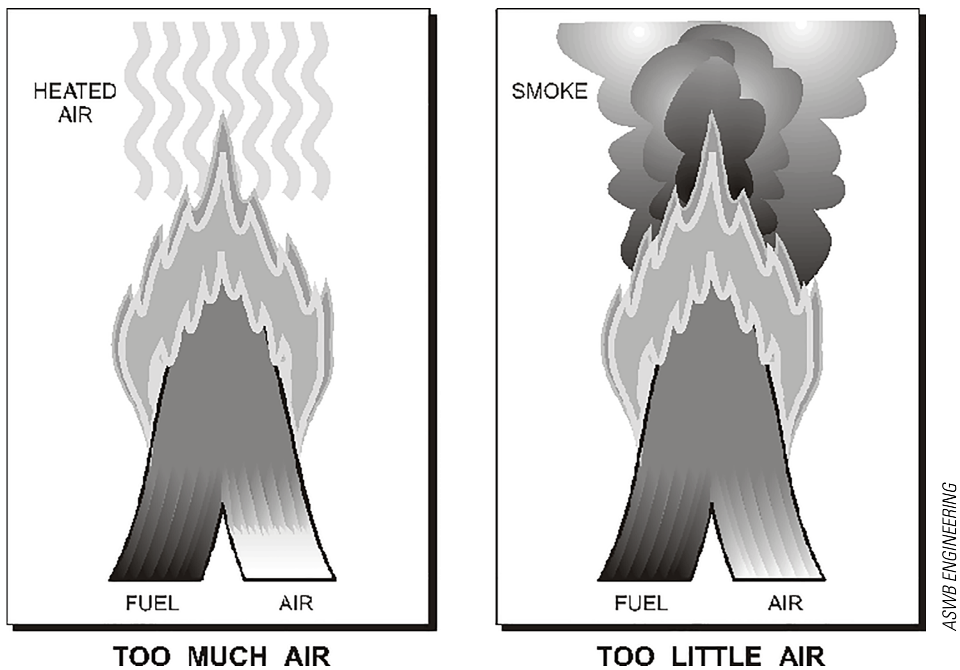
Vent Damper

Combustion Air Fan Requirements

The 2019 Energy Code requires 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), 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

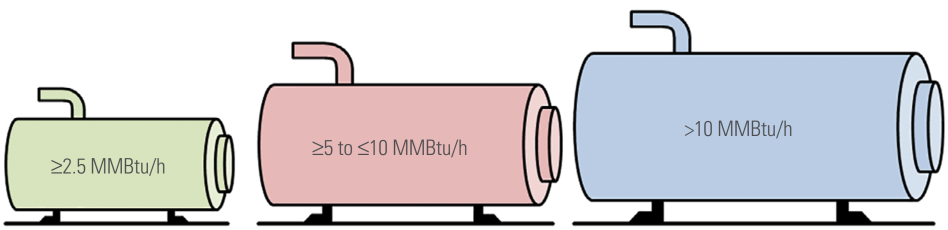
Newly installed process boilers are subject to a maximum excess oxygen limit based on their input capacities. The requirements can be seen in the following table.

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 Code prohibits 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. The Energy Code establishes burner control requirements according to three boiler size categories:



Flue or vent damper

Parallel positioning controls that match the heat delivered to load requirements in discrete steps

Parallel positioning controls and O_2 trim control

Parallel positioning varies 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 considered carefully in order to prevent condensation at the lower firing rates.

Parallel positioning controls typically offer more precise water temperature control and higher efficiency than on-off or high-low controls, as long as 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:

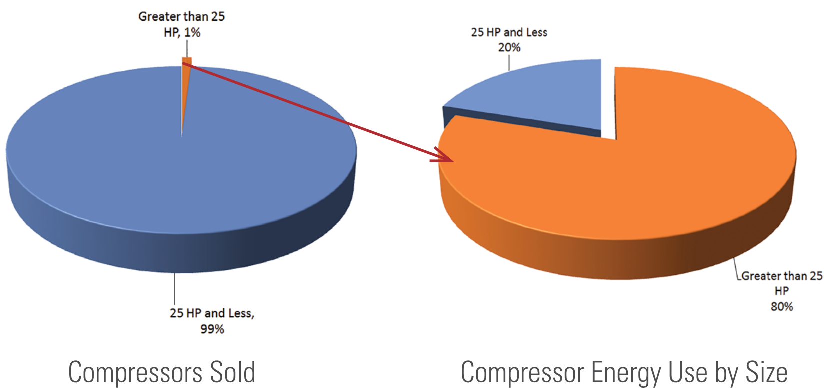
- They are adequately designed.
- They are properly applied to suitable boilers.
- The process being controlled is understood.
- The unique problems presented by each boiler are determined.

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.



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

Exceptions

Centrifugal compressors are typically larger than 100 hp. The Energy Code provides 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.

Compressed air systems serving licensed Healthcare Facilities are excluded from the Mandatory requirements. For example, a medical gas system would be considered a part of this exception.

Basic Compressed Air System

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

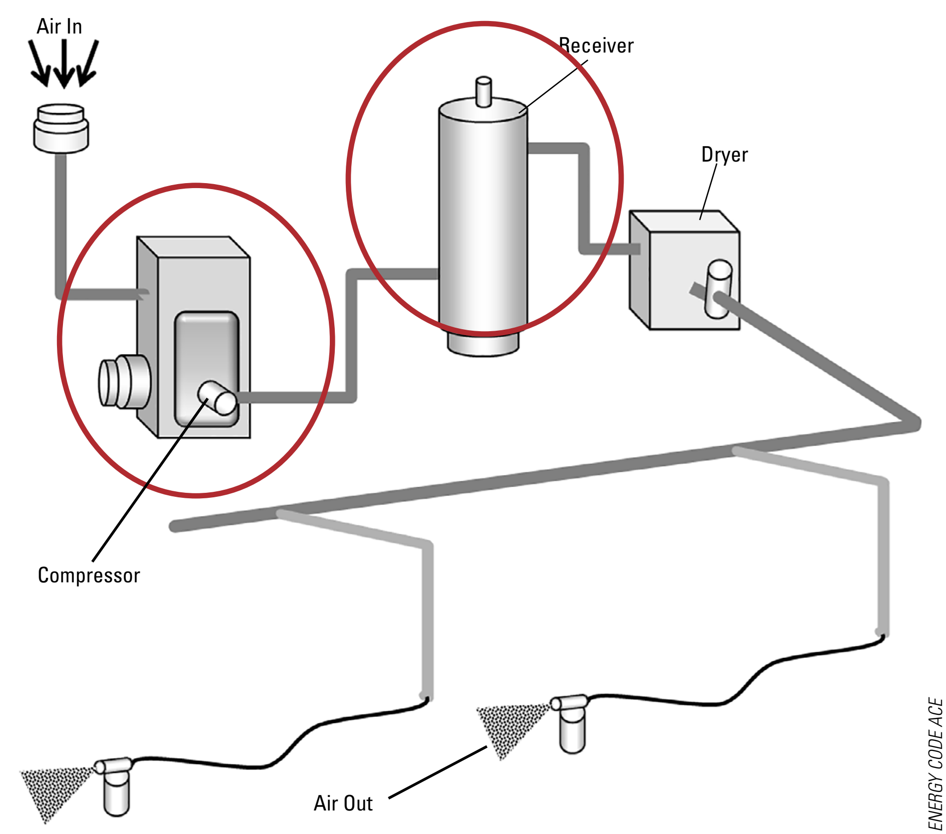
- Compressor, drive and drive controls used to create the compressed air
- Conditioning (or "clean-up") equipment, which make the air usable
- Air distribution system
- The end-use equipment which are the devices or tools that use the air to operate

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 (the system "load") to the end-use equipment. 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 Code addresses 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, are the components which are affected by Title 24, Part 6 Energy 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 Code Compliance For Compressed Air Systems

The 2019 Energy Code applyies 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 Code only applies 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. As stated in the Energy Code, the effective trim capacity of a compressor is the size of the continuous operational range where the specific power of the compressor (kW/100 acfm) is within 15 percent of the specific power at its most efficient operating point. The total effective trim capacity of the system is the sum of the effective trim capacity of the trim compressors.

Triggers for 2019 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.

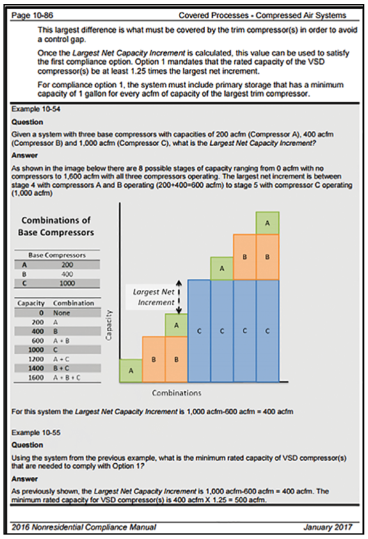
[D] The system must include compressor(s) with total effective trim capacity at least the size of the largest net capacity increment between combinations of compressors or the size of the smallest compressor, whichever is larger.

[E] For single compressor systems, the total effective trim capacity shall cover the range from 70% to 100% 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)

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 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. 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 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

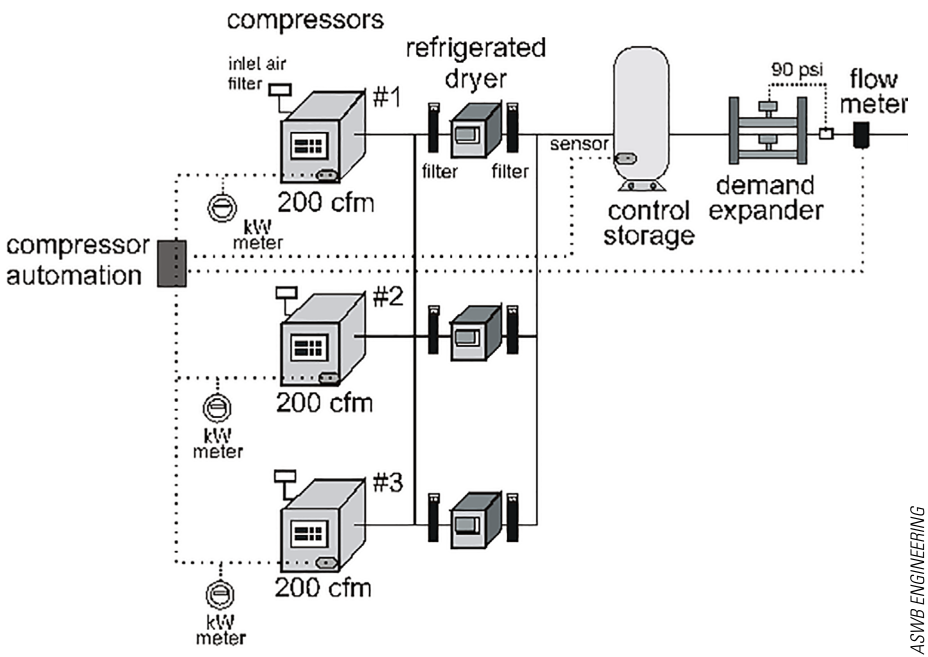
In addition to a trim compressor, an automated controller is required with systems that have a combined horsepower greater than or equal to 100 hp to stage the compressors in the most efficient manner. These microprocessor-based controllers are available from compressor manufacturers as well as independent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

In the following 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 occupancy 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 Code when these Alterations 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 §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 2019 Energy Code covers all elevators in New Construction, as well as elevators receiving major alterations. The Energy Code adds a lighting power density requirement for elevator cabins, imposes a limit on the ventilation fan power draw at maximum speed and requires 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.

There is a new exception that excludes elevators located in healthcare facilities.

Lighting Power Density

The 2019 Energy Code calls 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 2019 Energy Code sets 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 2019 Energy Code includes 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 Code does 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 Code has 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 Code covers Alterations to an existing installation. Existing elevators do not have to comply with the new Energy Code, unless they undergo a significant Alteration. Simple Repairs do not trigger requirements in the Energy Code. Refer to Section 10.10.4 of the Title 24 2019 Nonresidential Compliance Manual for an explanation of what is considered an Alteration versus a Repair.

Escalators and Moving Walkways

The 2019 Energy Code applies to escalators and moving walkways that are located in airports, hotels and transportation function areas. A transportation function area is defined in the Energy Code as the ticketing area, waiting area, baggage handling areas or concourse within an airport terminal, subway or transit station, bus station, rail terminal 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).

Speed Variation Requirements

Escalators and moving walkways that fall under the jurisdiction of the 2019 Energy Code must slow down to a minimum permitted speed when unoccupied for a set amount of time. Before this measure was added into the Energy Code, 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 Code, which means they must be met in order to achieve compliance. These Mandatory requirements include:

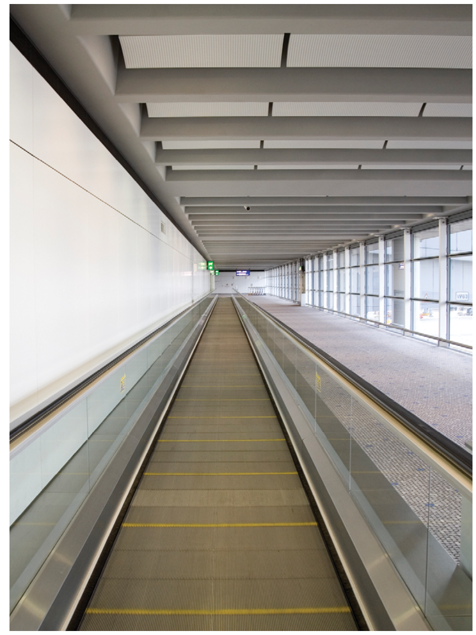
- Limiting the acceleration and deceleration rates
- Ensuring passengers are not on the escalator or moving walkway when the speed change occur
- Programming alarms to sound when passengers approach a slowed down escalator or moving walkway from the wrong direction

Refer to Section 10.11.2.1 of the Title 24 2019 Compliance Manual for a summary of the ASME requirements for speed variation.

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 Code does not specify the exact method of passenger detection that must be used. The Energy Code does 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. 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.



Moving Walkway

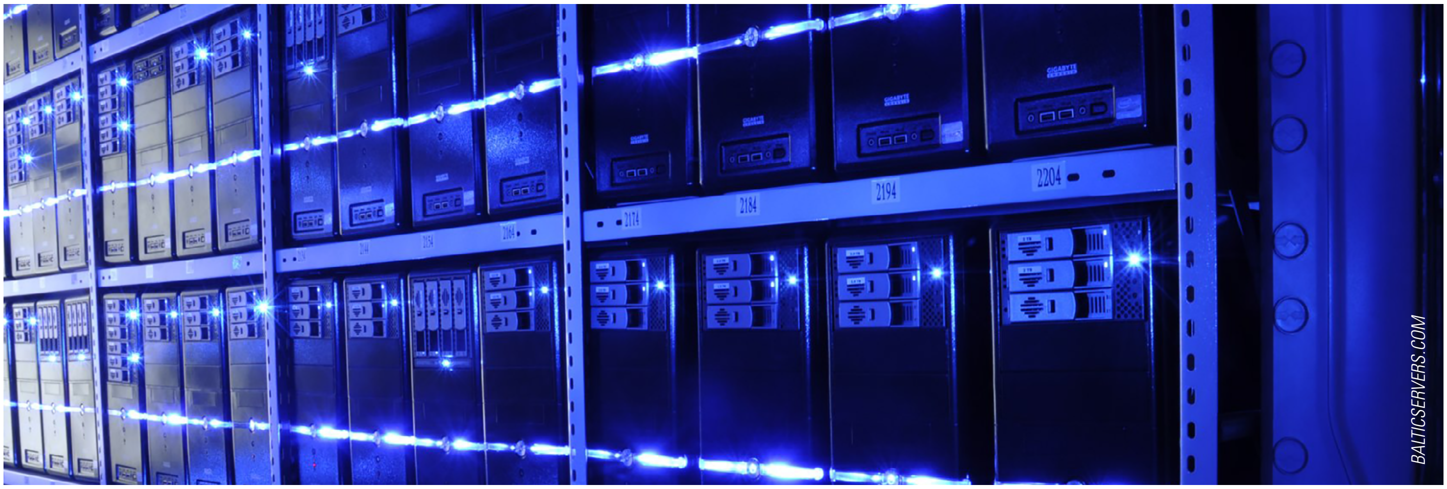
Acceptance Testing Requirements

For escalators and moving walkways, the Energy Code has 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 Code covers Alterations to an existing installation. Existing escalators and moving walkways do not have to comply with the new Energy Code, unless they undergo a significant Alteration. Simple Repairs do not trigger requirements in the Energy Code . Refer to Section 10.11.4 of the Nonresidential Compliance Manual for an explanation of what is considered an Alteration versus a Repair.



Prescriptive Process Requirements: Computer Rooms

Space Conditioning

The 2019 Energy Code has placed new Prescriptive requirements on computer rooms outlined in §140.9. The Energy Commission has not instituted any language regarding the amount or type of computer equipment one can install, but the Energy Commission does devote some attention to how that equipment will be conditioned. Before the implementation of the 2013 Energy Code computer room space conditioning had a number of exemptions from the economizer requirements because of the potential to damage the computer equipment. Computer rooms located in healthcare facilities are excluded from these prescriptive requirements. Large energy savings are available through using economizer air or water side economizing when outside air temperatures make using these systems beneficial.

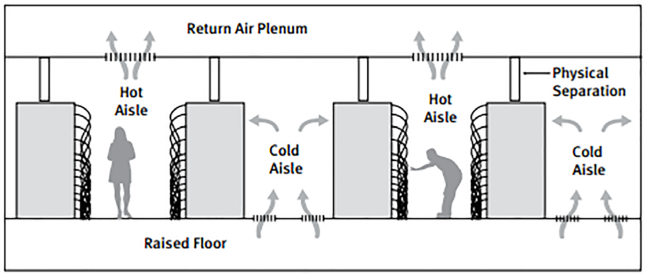
Limitations are placed on space conditioning systems to eliminate active reheat energy and non-adiabatic humidification systems (e.g., those that boil water). In this occupancy type the only allowed humidification is from direct evaporative cooling or ultrasonic systems.

Size and 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 and be equipped with a fault detection and diagnostic devices as specified by §120.2(i). An alternative 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 few exceptions apply for new cooling systems serving computer rooms in existing buildings or that are served by a central fan system that conditions spaces other than the computer room. .

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/ft^2 (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 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. One exception states that the containment requirement does not apply to computer racks with a design load less than 1kW/rack. A "thermal bypass" of the racks directly to the return air plenum or return duct can decrease the cooling effectiveness severely. 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 are added to the existing building and have 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 Code only requires economizers on systems more than 50 tons of cooling in a building that was originally built without an economizer. The 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 in a building that was originally built without any economizers.

Expansions of existing data centers do not have to comply with the containment sections of the Energy Code, but it is highly recommended if the space can be retrofitted easily. 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 Energy Code apply and may trigger the need for a certified ATT as of October 1, 2021.

Data Center Best Practices Guide

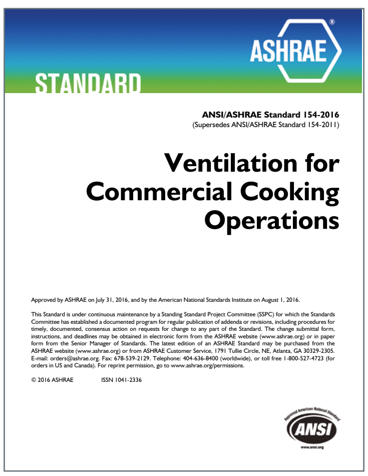
This Guide provides viable alternatives to inefficient data center design and operating practices, and addresses energy efficient retrofit opportunities.

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

Prescriptive Process Requirements: Commercial Kitchen Ventilation

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 Code kitchen hoods have been a prescriptively regulated process system. §140.9(b) dictates both supply air and exhaust air compliance strategies.



STANDARD

ASHRAE

ANSI/ASHRAE Standard 154-2016
(Supersedes ANSI/ASHRAE Standard 154-2011)

Ventilation for Commercial Cooking Operations

Approved by ASHRAE on July 31, 2016, and by the American National Standards Institute on August 1, 2016.

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ASHRAE Standard 154-2016 is a good reference document for hood types, appliance duty and net exhaust flow rate.

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 Code includes 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 total rates greater than 5,000 cfm. If the total hood flow rate exceeds 5,000 cfm, Type I hoods must follow Table 140.9-A in the Energy Code for maximum exhaust flow rates per linear foot based on type of hood (wall-mounted, single island, eyebrow). Type 2 hood flow rates are only used to determine the total flow rate. 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 Code also regulates 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
- The hood exhaust flow minus the available transfer air from adjacent spaces

For Type I and II hoods with a combined total exhaust airflow rates of 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
- Demand control ventilation (DCV) (smoke and heat sensors) on at least 75% of exhaust air
- Heat recovery devices with 40% effectiveness on at least 50% of total exhaust air
- 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 Code. 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 Code.

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 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

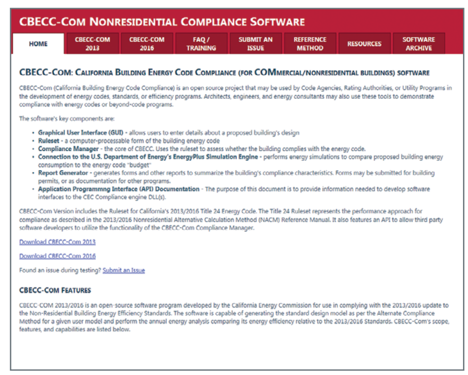
Kitchen exhaust systems have been added to the Acceptance Testing requirements and must be tested prior to occupancy. Nonresidential Appendix (NA) 7.11 includes a description of Acceptance Testing requirements that include but are not limited to confirming thermal plume and smoke are completely captured 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-F	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 Energy Commission for use in demonstrating compliance with the Nonresidential Energy Code. In addition to other components, it includes a compliance manager, which must be used by software interfaces (such as EnergyPro or IES Virtual Environment) to demonstrate compliance.

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

Prescriptive Process Requirements Laboratory and Factory Exhaust Systems

Laboratory and factory exhaust systems have been another area traditionally unregulated by the Energy Code. 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 Code. The 2019 Energy Code changes the code to include factory exhaust systems in addition to laboratory exhaust systems in all applications except Healthcare Facilities.

Airflow Reduction Requirements

Energy Code §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.

In the 2019 Energy Code, the fan system power consumption is now regulated for any new exhaust system serving a laboratory or factory with more than 10,000 cfm. This newly installed exhaust fan system must meet discharge requirements per ANSI Z9.5-2012 and either fan watt draw, or wind based flow control, or contaminant concentration control. With these requirements, it will be determined if an occupancy permit will be granted through Acceptance Testing.

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 Code, the local jurisdiction may exempt the space from the setback requirements for health and safety reasons.

In addition to the new fan system power consumption requirement, the 2019 Energy Code added a requirement for exhaust system transfer air. This requirement states where conditioned supply air is delivered to a space with mechanical exhaust, §140.4(o) must be followed for supply, ventilation and transfer air flow rate requirements. Biosafety level classified laboratories 3 or higher, vivarium spaces, spaces maintained with positive pressure, healthcare facilities and spaces that have a high amount of transfer air used for exhaust makeup air and are maintaining a negative pressure are exempt from this requirement.

High Performance Laboratories: A Design Guidelines Sourcebook.

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

Fume Hood Automatic Sash Closure:

In the 2019 Energy Code, VAV laboratory fume hoods with vertical only sashes specifically located in intensive laboratories require an automatic sash closure system. The fume hood automatic sash must pass an Acceptance Test with detection of people or obstructions in the area near the fume hood, an automatic closure of no more than 10 lbs and have a manual option for opening.

Existing Buildings and 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

Acceptance Tests for laboratory exhaust ventilation systems are included in Nonresidential Appendix NA7.16. Fume hood automatic sash closure systems also require Acceptance Testing per Nonresidential Appendix NA7.17.

Form	Purpose
NRCA-PRC-14-F	Lab Exhaust Ventilation Systems
NRCA-PRC-15-F	Fume Hood Automatic Sash Closure

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.

Zone Exhaust ACM Section 5.6.6.3:

For laboratory systems with minimum exhaust flow rates exceeding 10 ACH exhaust, the exhaust minimum air flow rate is equal to the proposed design minimum. For VAV laboratory systems with variable flow and variable speed drive exhaust fan control, the exhaust minimum air flow rate is the greater of the Proposed Design minimum exhaust air flow rate and 20% of the design exhaust air flow rate.

Exhaust schedules for laboratory spaces are prescribed and specified in Appendix 5.4B, and dependent on whether the exhaust is constant or variable volume. If the exhaust is variable flow, the compliance software shall automatically use either the no sash control or sash control laboratory variable exhaust schedule or a volume-weighted interpolated average of the two schedules if only a fraction of the exhaust hoods have sash control.

For laboratory spaces, the Standard Design is constant volume if the proposed exhaust system is constant volume and has a minimum exhaust air flow rate greater than 10 ACH. Otherwise, the Standard Design is variable volume. If the Standard Design is variable volume and the proposed laboratory space is fume hood intense (as defined in Table 140.9-B) then the Standard Design will use the Appendix 5.4B modified VAV schedule for hoods with sash controls, volume weighted by the fraction of exhaust that is served by exhaust hoods with vertical-only sashes. If the Standard Design is variable volume and the proposed space is not fume hood intense then the Standard Design shall use the VAV exhaust schedule for non-controlled sashes.

Aircuity case study

University of California, Irvine

Significant Energy Savings through Smart Lab Design and Demand Control Ventilation

The University of California, Irvine (UCI) is one of ten campuses that are a part of the University of California System and is home to over 28,000 students, 1,100 faculty and 9,000 staff members. UCI is among the fastest-growing UC campuses and is consistently ranked among the nation's best universities. Offering a total of 80 undergraduate majors and 64 undergraduate minors, recent additions to UC Irvine's academic and professional programs continue to grow with the addition of programs in law, public health, pharmaceutical sciences and nursing science.

Sue and Bill Gross Hall - A CIRM Institute

As a signatory of the American College and University Presidents' Climate Commitment, UCI is dedicated to saving energy and reducing their carbon foot print. The University committed to build all new laboratory buildings to a minimum of a LEED® Silver rating and established the goal of beating California's Energy Code, Title 24, by 50%. UCI was also among the first to commit to the government's Better Building Challenge. By committing to the challenge the University pledged to become 20% more efficient by the year 2020.

AN INNOVATIVE LAB DESIGN

With laboratories consuming 2/3 of the total energy used on a college campus, and using 100% fresh air ventilation, they are prime targets for energy efficiency measures. Based on this information UCI engineers worked together to create the Smart Lab design to significantly reduce energy use in their laboratory buildings. UCI was already receiving significant energy savings through previous installations of Aircuity's centralized demand control ventilation system, OptiNet®, therefore it became one of the core components of the Smart Lab design. Aircuity's Centralized Demand Control Ventilation (DCV) technology continually senses and analyzes laboratory environments and provides ventilation inputs to adjust the air changes per hour (ACH) in those facilities as needed, moving away from a model of constant or fixed ventilation rates. Aircuity Advisor™ Services provides UCI with the ability to monitor multiple locations around campus and aids in continuous commissioning, troubleshooting issues within the space and analyzing energy drivers to achieve maximum energy savings. "What really make the labs smart are the reports and dashboards," says Matt Gudorf, campus energy manager. "Not only can we spot failed components sooner, but we can determine what aspect of the operation is driving energy use and target it."

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Matt Gudorf, Campus Energy Manager
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

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