Proposal Summary

2022 California Energy Code (Title 24, Part 6)

Pipe Sizing, Leak Testing, and Language Revisions for Compressed Air Systems

November 6, 2019

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Introduction

The document summarizes proposed revisions to the California Energy Code (Title 24, Part 6) that will be discussed during a utility-sponsored stakeholder meeting on November 7, 2019 The Statewide Utility Codes and Standards Enhancement (CASE) Team is seeking input and feedback. To provide your comments, email info@title24stakeholders.com by November 21, 2019.

Measure Description

Pipe Sizing

The Statewide CASE Team is proposing to require standardized compressed air distribution piping design for the minimization of frictional losses and resulting excessive compressor discharge pressure setpoints.

The pipe sizing measure would standardize the diameters of compressed air distribution piping according to the system pressure and flow at different points in the system. Pipe diameters should be optimized across the air distribution system based on airflow requirements. Improper pipe sizing can decrease energy efficiency since undersized piping can result in excessive frictional losses. In that case, the compressor must discharge at a higher pressure than otherwise necessary to ensure that pressures at end-use locations are maintained. Additionally, inefficient pipe layouts with excessive fittings increases frictional losses by adding effective length the system. Pipe design should also take this into account and minimize fittings, component pressure drops, and sharp bends wherever possible.

To make up for pressure drops in the distribution piping, the compressor must work harder than otherwise necessary. As a general rule, energy consumption increases by about 1% for every 2 psi increase in setpoint. Optimized pipe design can reduce these sources of losses. The Compressed Air Handbook, Compressed Air Challenge, Compressed Air and Gas Institute, and other sources have recommended pipe sizes for various operating conditions that will inform code requirements.

Leak Testing, Remediation, and Metering

The Statewide CASE Team is proposing to require leak detection and metering of compressed air systems as part of the commissioning of new systems and new sections of piping as well as for ongoing operations in a plant.

This measure would establish requirements for leak testing and repair for new piping of compressed air systems. Compressed air leaks unavoidably develop over time and commonly account for 20 to 30 percent of a compressed air system's load. Leaks develop due to vibration, valve degradation, and general wear and tear of piping and machine components. Properly installed new systems likely have smaller leak load fractions, but leak mitigation and commissioning are still necessary. Leaks not only waste energy but can cause other operational losses, such as decreased functionality and efficiency of air end-uses, reduced system capacity, longer run times and duty cycles, shorter system lifetimes, maintenance burdens, and lower productivity.

According to the Compressed Air Challenge (*Piping System Tips for Energy* Efficiency, Marshall 2014) proactive leak detection and repair can limit leaks to less than 10 percent of compressor output. Leak detection is typically achieved through two methods: 1) monitoring and testing of system pressure drops and airflow and 2) inspection. In the case of monitoring and testing of pressure drops and airflow, observation of system pressure and airflow by plant operators can provide indications that leaks are present. By comparing pressure drops, cfm, or compressor runtimes to established operating profiles or during downtimes (absence of end-use loads), the presence of leaks can be inferred. However, while this can establish the presence of leaks, it will not provide the location. Inspection of the system piping, fittings, and end-uses is typically necessary to locate leaks. Standard practice is to use a handheld, portable ultrasonic leak detector to pinpoint leak locations. These leaks are then repaired at once or tagged for later correction.

The proposed measures will address leaks in two ways:

- Pressure testing and leak correction of newly installed hard piping upstream of end-use take-offs. This hard piping is very difficult to repair and replace once a system is operational and leaks present during installation are unlikely to be repaired as part of the typical, ongoing maintenance that most plants conduct.
- Metering of the system will show changes in load patterns, compressor speed, and compressor energy consumption over time. This monitoring will enable plant operators and owners to flag leaks through baseload load growth unrelated to production changes, thereby streamlining, encouraging, and enhancing the typical O&M practices that are not always observed. Over time, FDD development will improve the effectiveness of this measure.

There may be automatic leak detection products available in the market that can preclude the need for (1) labor-intensive operating profile evaluation or (2) proactive ultrasonic leak inspection. The Statewide CASE team will explore the market options for such automatic leak detection (i.e. fault detection and diagnostics – FDD) and whether they can complement or facilitate the proposed measure.

Language Clean-up

The Statewide CASE Team is proposing simplifying existing language to facilitate ease of compliance with existing 2019 requirements. There have been some discussions and feedback over code cycles that describe difficulties with understanding the coverage and triggers of existing language as well as some questioning of exceptions. The Statewide CASE Team is currently aware of several primary points:

- Confusion around the term "online" and what it means in practice. The original intent was to have requirements apply to compressors that are typically used (as opposed to redundant or backup compressors).

- Why centrifugal compressors are excluded from the requirements when trim compressors are advisable for any system with load variation, even if baseload compressors are centrifugal.
- When code is triggered under different scenarios.

The Statewide CASE Team will review the existing language and recommend changes or clarifications in the compliance manual to address this stakeholder feedback.

Draft Code Language

The proposed changes to the Standards and Reference Appendices are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions). In addition to the changes outlined below, existing language will be cleaned up for clarity and simplicity but those changes are not reflected here.

Standards

Section 120.6 – Mandatory Requirements for Covered Processes

120.6(e) Mandatory Requirements for Compressed Air Systems. All new compressed air systems, and all additions or alterations of compressed air systems where the total combined ~~online~~ horsepower (hp) of the compressor(s) is 25 horsepower or more shall meet the requirements of Subsections 1 through ~~3~~5. These requirements apply to the compressors and related controls that provide compressed air and do not apply to any equipment or controls that use or process the compressed air.

~~**EXCEPTION 1 to Section 120.6(e):** Alterations of existing compressed air systems that include one or more centrifugal compressors.~~

EXCEPTION 1~~2~~ to Section 120.6(e): ~~Compressed Air Systems, including medical gas, serving~~ Medical gas compressed air systems in healthcare facilities.

1. **Trim Compressor and Storage.** The compressed air system shall be equipped with an appropriately sized trim compressor and primary storage to provide acceptable performance across the range of the system and to avoid control gaps. The compressed air system shall comply with Subsection A or B below:

   A. The compressed air system shall include one or more variable speed drive (VSD) compressors. For systems with more than one compressor, 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. The compressed air system shall include primary storage of at least one gallon per actual cubic feet per minute (acfm) of the largest trim compressor; or,

   B. The compressed air system shall include a compressor or set of compressors 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. The total effective trim capacity of single compressor systems shall cover at least the range from 70 percent to 100 percent of rated capacity. 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. The system shall include primary storage of at least 2 gallons per acfm of the largest trim compressor.

EXCEPTION 1 to Section 120.6(e)1: Compressed air systems in existing facilities that are adding or replacing less than 50 percent of the online-capacity of the system.

EXCEPTION 2 to Section 120.6(e)1: Alterations where all added or replaced compressors are variable speed drive (VSD) compressors and at least one gallon of storage is added per actual cubic feet per minute (acfm) of added compressor capacity.

EXCEPTION 3 to Section 120.6(e)1: Compressed air systems where total horsepower of non-centrifugal compressors is less than 25 hp.

EXCEPTION ~~2~~4 to Section 120.6(e)1: Compressed air systems that have been approved by the Energy Commission Executive Director as having demonstrated that the system serves loads for which typical air demand fluctuates less than 10 percent.

2. **Controls.** Compressed air systems with more than ~~one~~ two compressor~~s online, having~~ and a combined horsepower rating of more than 100 hp~~,~~ must operate with a controller that is able to choose the most energy efficient combination of compressors within the system based on the current air demand as measured by a sensor.

3. **Metering.** Compressed air systems having a combined horsepower rating greater than 100 hp shall have an energy and air demand monitoring system that records energy consumption and air demand of the compressed air system every 15 minutes and reports the data at least hourly, daily, monthly, and annually. The data shall be graphically displayed. The system shall be capable of maintaining all data collected for a minimum of 36 months.

4. **Leak Testing of Compressed Air Piping.** Any newly added piping to a compressed air system greater in than 100 feet in total length shall be isolated from the rest of the system, pressurized to the design pressure, and test pressures shall be held with no perceptible drop in pressure for a length of time satisfactory to the Authority Having Jurisdiction, but in no case for less than 30 minutes. All other new piping or replacement piping is not required to be pressure-tested provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other leak-detecting methods approved by the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder. Test gauges used in conducting tests shall be in accordance with Section 318.0 of the California Plumbing Code (Title 24, Part 5).

5. **Pipe Sizing.** Compressed air piping shall be designed and installed to minimize frictional losses between the flow controller or receiver and end-uses and piping should be sized according to guidelines in the Compressed Air Handbook. Pressure loss between the flow controller or receiver and end-uses shall not be greater than 10% of the compressor discharge pressure.

   EXCEPTION 1 to Section 120.6(e)4: Replacement piping which is no less diameter than the piping it is replacing.

~~3~~6. **Compressed Air System Acceptance.** Before an occupancy permit is granted for a compressed air system subject to Section 120.6(e), the ~~following~~ equipment and systems shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA 7.13.

Reference Appendices

NA7.13 Compressed Air System Acceptance Tests

NA7.13.1 Construction Inspection

Prior to functional testing, a compressed air system must verify and document the following:

(a) Size (hp), rated capacity (acfm), and control type of each air compressor.

(b) Total ~~online~~ system capacity (the sum of the individual capacities).

(c) System operating pressure.

(d) Compressor(s) designated as trim compressors.

(e) Method for observing and recording the states of each compressor in the system, which shall include at least the following states:

Off
Unloaded
Partially loaded
Fully loaded
Short cycling (loading and unloading more often than once ~~per~~ every three minutes)
Blow off (venting compressed air at the compressor itself)

NA7.13.2 Functional Testing

Step 1: As specified by the test methods outlined in the Construction Inspection, verify that these methods have been employed, so that the states of the compressors and the current air demand (as measured by a flow sensor or otherwise inferred by system measurements) can be observed and recorded during testing.

Step 2: Run the compressed air supply system steadily at as close to the expected operational load range as can be practically implemented, for a duration of at least 10 minutes.

Step 3: Observe and record the states of each compressor and the current air demand during the test.

Step 4: Confirm that the combinations of compressors states meet the following criteria:

(a) No compressor exhibits short-cycling (loading and unloading more often than once per minute).

(b) No compressor exhibits blowoff (venting compressed air at the compressor itself).

(c) For new systems, the trim compressors shall be the only compressors partially loaded, while the base compressors will either be fully loaded or off by the end of the test.

NR Compliance Manual

Changes to the NR Compliance Manual will guide stakeholders to proper implementation of existing and new measures. Examples and language will be cleaned up to minimize confusion around measure applications, coverage, and exceptions.

Proposal Summary

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 California Energy Code (Title 24, Part 6)

Covered Processes: Refrigeration

Updated: October 16, 2019

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Introduction

The document summarizes proposed revisions to the California Energy Code (Title 24, Part 6) that will be discussed during a utility-sponsored stakeholder meeting on November 7, 2019 The Statewide Utility Codes and Standards Enhancement (CASE) Team is seeking input and feedback. To provide your comments, email info@title24stakeholders.com by November 21, 2019.

Measure Description

The California Energy Code (Title 24, Part 6) currently includes mandatory efficiency requirements for refrigeration systems serving refrigerated warehouses and retail spaces with walk-in coolers or freezers or refrigerated display cases. This measure proposes code change proposals that will improve energy performance end reduce greenhouse gas (GHG) emissions from refrigeration systems in refrigerated warehouse, retail stores, and commercial kitchens. Requirements for commercial kitchens would apply to a variety of building types including restaurants, schools, and hospitals.

Submeasure A: Establish Design and Control Requirements for Transcritical CO_2 Systems

Historically, refrigeration systems have used halocarbon refrigerants that have high global warming potential (GWP), but use of these high GWP refrigerants is being phased out in California (Health and Safety Code Section 39730.5). Many types of refrigerants will no longer be allowed for us in supermarket refrigeration or refrigerated cold storage by the time the 2022 Title 24, Part 6 standards take effect in January 2023. As high GWP refrigerants are being phased out, transcritical CO2 systems are becoming more prominent. Specific code requirements will be determined as part of the advocacy effort but may include requirements for sizing and efficiency of gas coolers for heat rejection, implementing parallel compression system configuration, and heat pressure control strategies. The requirements would apply to refrigeration systems in refrigerated warehouses, retail spaces (e.g., supermarkets), and commercial kitchens.

This measure will establish design and control requirements for transcritical CO_2 systems utilized in both commercial refrigeration and refrigerated warehouses. Proposed measures include minimum sizing for gas coolers, minimum gas cooler specific efficiency, floating head pressure control, parallel compression, and gas ejectors. These measures would not mandate that CO2 systems be required, but it would establish mandatory design and control requirements that will optimize energy performance should a designer elect to use these systems.

Submeasure B: Establish Design and Control Requirements for Large Packaged Systems

As part of an effort to reduce the ammonia charge as compared to what is required for typical built up central ammonia systems, multiple manufacturers have developed large packaged systems for use in refrigerated warehouses. This measure will establish design and control requirements for these large packaged systems. Proposed measures primarily will address condenser sizing and condenser specific efficiency, as the current code requirements for traditional central systems may not be economical/applicable to packaged systems.

Submeasure C: Evaporator Minimum Specific Efficiency for Refrigerated Warehouses

This measure will define mandatory minimum specific efficiency requirements for evaporators in refrigerated warehouses. Specific efficiency is a metric that determines the amount of cooling an evaporator can provide per unit of input power required. This is similar to the metric of specific efficiency currently defined in Title 24 for evaporative, air cooled, and adiabatic condensers. Specific efficiency requirements are expected to be defined for different refrigerants and evaporator types.

Submeasure D: Require Automatic Door Closers

This measure would require walk-in coolers to have automatic door closures. There are two types of closures. One is the spring or gravity/cam hinge that closes the door from a standing-open position to a closed position. The second is the closure devices that snaps the door tightly closed (when magnetic gaskets are not applicable). This code change proposal would define both types of closures and require them both for walk-ins.

Submeasure E: Acceptance Testing for Commercial Refrigeration

This proposed measure would add acceptance testing to verify compliance with existing code requirements for commercial refrigeration systems.

Draft Code Language

Submeasure A: Establish Design and Control Requirements for Transcritical CO_2 Systems

Transcritical CO2 Refrigeration Systems. New transcritical CO2 refrigeration systems utilized in refrigerated warehouses shall conform to the following:

A. Gas coolers shall meet the specific efficiency requirements listed in TABLE 120.6-X.

CONDENSER TYPE	MINIMUM SPECIFIC EFFICIENCY	RATING CONDITIONS
Evaporative	XX Btuh/Watt	TBD
Air Cooled	XX Btuh/Watt	TBD
Adiabatic	XX Btuh/Watt	TBD

B. Design leaving gas temperature for evaporative-cooled gas coolers and water-cooled gas coolers served by fluid coolers or cooling towers shall be less than or equal to the wetbulb temperature plus the temperature difference values defined in TABLE 120.6-X.

DESIGN WETBULB	TEMPERATURE DIFFERENCE
Wetbulb ≤ XX°F	XX°F
XX°F < Wetbulb > XX°F	XX°F
Wetbulb Temperature ≥ XX°F	XX°F

C. Design leaving gas temperature for air-cooled gas cooler shall be less than or equal to the design drybulb temperature plus XX°F

D. Design leaving gas temperature necessary for adiabatic gas coolers to reject the design total heat of rejection of a refrigeration system assuming dry mode performance shall be less than or equal to the design drybulb temperature plus XX°F

E. While operating below the critical point, the gas cooler pressure shall be controlled in accordance to 120.6(a)4F

F. While operating above the critical point, the gas cooler pressure shall be controlled TBD

G. Systems shall be designed with one or more of the following:
   i. Parallel compression
   ii. Gas ejectors
   iii. Expanders

   EXEMPTION: Systems installed in climate zones TBD

Language repeated for commercial refrigeration.

Submeasure B: Establish Design and Control Requirements for Large Packaged Systems

DEFINTIONS: Large Packaged Units: TBD

Large Packaged Refrigeration Systems. Large packaged refrigeration systems utilized in refrigerated warehouses shall conform to the following:

A. Fan-powered condensers in large packaged systems shall meet the minimum condenser specific efficiency requirements listed in TABLE 120.6-X. Condenser efficiency is defined as the Total Heat of Rejection (THR) capacity divided by all electrical input power including fan power at 100 percent fan speed, and power of spray pumps for evaporative condensers.

CONDENSER TYPE	**REFRIGERANT TYPE**	**MINIMUM SPECIFIC EFFICIENCY**	**RATING CONDITIONS**
Evaporative	All	XX Btuh/Watt	TBD
Air Cooled	All	XX Btuh/Watt	TBD
Adiabatic	All	XX Btuh/Watt	TBD

B. Design saturated condensing temperatures for evaporative-cooled condensers and water-cooled condensers served by fluid coolers or cooling towers shall be less than or equal to the wetbulb temperature plus the temperature difference values defined in TABLE 120.6-X.

DESIGN WETBULB	TEMPERATURE DIFFERENCE
Wetbulb ≤ XX°F	XX°F
XX°F < Wetbulb > XX°F	XX°F
Wetbulb Temperature ≥ XX°F	XX°F

C. Design saturated condensing temperatures for air-cooled condensers shall be less than or equal to the design drybulb temperature plus XX°F

D. Design saturated condensing temperatures necessary for adiabatic condensers to reject the design total heat of rejection of a refrigeration system assuming dry mode performance shall be less than or equal to the design drybulb temperature plus XX°F

E. Packaged systems with a rated cooling capacity larger than XX tons shall have at least two steps of compressor and evaporator capacity control.

i. Evaporators shall utilize controls that reduce airflow by at least 40 percent for at least 75 percent of the time when the compressor is not running

F. Packaged system condensers shall comply with 120.6(a)4D, 4E, 4F, and 4H

Submeasure C: Evaporator Minimum Specific Efficiency for Refrigerated Warehouses

A. Fan-powered evaporators shall meet the evaporator efficiency requirements listed in TABLE 120.6-X and 120.6-X. Evaporator efficiency is defined as the refrigeration capacity (Btu/h) divided by the electrical input power at 100 percent fan speed rated at 10°F of temperature difference between the incoming air temperature and the saturated evaporating temperature. Ratings used in calculating specific efficiency shall be certified in accordance with AHRI Standard 420 or otherwise derated by 10%

TABLE 120.6-X EVAPORATOR SPECIFIC EFFICIENCY FOR FREEZER APPLICATIONS

EVAPORATOR TYPE	**REFRIGERANT TYPE**	**MINIMUM EFFICIENCY (Btuh/Watt)**
Direct Expansion	Halocarbon	XX Btuh/Watt
	Ammonia	XX Btuh/Watt
	CO2	XX Btuh/Watt
Flooded/Recirculated Liquid	Halocarbon	XX Btuh/Watt
	Ammonia	XX Btuh/Watt
	CO2	XX Btuh/Watt

TABLE 120.6-X EVAPORATOR SPECIFIC EFFICIENCY FOR COOLER APPLICATIONS

EVAPORATOR TYPE	**REFRIGERANT TYPE**	**MINIMUM EFFICIENCY (Btuh/Watt)**
Direct Expansion	Halocarbon	XX Btuh/Watt
	Ammonia	XX Btuh/Watt
	CO2	XX Btuh/Watt
Flooded/Recirculated Liquid	Halocarbon	XX Btuh/Watt
	Ammonia	XX Btuh/Watt
	CO2	XX Btuh/Watt

EXCEPTION to Section 120.6(a)3D: Evaporators used in process cooling or process freezing applications.

EXCEPTION to Section 120.6(a)3D: Evaporators used in a penthouse configuration will be allowed a minimum specific efficiency of XX% less than the values in TABLE 120.6-X

B. Penthouse ductwork shall be design with an external static pressure not to exceed XX

Note: stakeholder discussion is required to gain input on efficient penthouse ductwork design vs. constrained inefficient ductwork, what is the impact overall

Submeasure D: Require Automatic Door Closers

Infiltration Barriers for Refrigerated Warehouses

B. Passageways between freezers and higher-temperature spaces, and passageways between coolers and nonrefrigerated spaces that are used for the passage of people shall have a mechanism which automatically closes the door from a stand open position in addition to an automatic tight sealing mechanism when the door is closed.

EXEMPTION 1: Passageways used for the passage of pallet jacks or pallets

EXEMPTION 2: Passageways utilizing insulated double acting swing doors

Infiltration Barriers for Commercial Refrigeration TBD

Submeasure E: Acceptance Testing for Commercial Refrigeration

NA7.XX Commercial Refrigeration System Acceptance Tests

NA7.XX.1 Condensers and Condenser Fan Motor Variable Speed Control

NA7.XX.1.1 Air-Cooled Condensers and Adiabatic Condenser Fan Motor Variable Speed Control

Conduct and document the following functional tests on all air-cooled and adiabatic condensers.

1.1.1.1.1.1.1.1 NA7.XX.1.1.1 Construction Inspection

Same as RWH (Section NA7.10.3.1.1)

1.1.1.1.1.1.1.2 NA7.XX.1.1.2 Functional Testing

Same as RWH (Section NA7.10.3.1.2)

NA7.XX.1.2 Evaporative Condensers and Condenser Fan Motor Variable Speed Control

1.1.1.1.1.1.1.3 NA7.XX.1.2.1 Construction Inspection

Same as RWH (Section NA7.10.3.2.1)

1.1.1.1.1.1.1.4 NA7.XX.1.2.2 Functional Testing

Same as RWH (Section NA7.10.3.2.2)

NA7.XX.2 Compressor Floating Suction Controls

The purpose of this test is to confirm proper operation of compressor floating suction control. This control measure is intended to reduce compressor lift by allowing the suction pressure setpoint to increment higher during periods of low loads.

The following test methods are general in nature, with the understanding that refrigeration systems are commonly custom designed, with many design choices, as well as varying load profiles. Since refrigeration systems generally operate year-round, the subject control methods will apply in all weather, whereas the acceptance tests may need to be applied at a specific time of the year. For all of these reasons, a thorough understanding of both refrigeration system design and refrigeration control system operation is necessary to effectively conduct these tests.

The measurement devices used to verify the refrigeration system controls shall be calibrated to a NIST traceable reference, with a calibration reference dated within the past two years. The calibrated measurement devices to be used in these acceptance tests are called the "standard" and shall have the following measurement tolerances: The temperature measurement devices shall be calibrated to +/- 0.7°F between -30°F and 200°F. The pressure measurement devices shall be calibrated to +/- 2.5 psi between 0 and 500 psig.

NA7.XX.2.1 Construction Inspection

Prior to functional testing, document the following:

(a) Review and document design information for the refrigeration system to determine information, for each applicable suction group, including:

  - The design compressor saturated suction temperature (SST) for each suction group
  - The cooling circuit(s) designated for use in floating suction temperature control, associated with each suction group, including the manner in which floating suction is maintained if a “float” circuits are in defrost
  - Design air temperature for the cooling circuits used for floating suction control
  - The floating suction temperature range (defined in SST), designated by the design engineer, for each system
  - The methodology used for floating suction group, either direct temperature reading or indirect indication of system load via electronic suction regulator (ESR) position, or other method that results in suction pressure floating before cooling is otherwise reduced for the critical circuit(s)

(b) Verify accuracy of refrigerant pressure-temperature conversions and consistent use of either temperature or pressure for controlling suction setpoint in the control system.

  - The saturated suction temperature has an equivalent pressure for a given refrigerant.

    - Either pressure or temperature may be used in the control system as the controlled variable to maintain suction pressure (saturated suction temperature), as long as the setpoint value is similarly expressed in pressure or temperature.
    - For refrigerants with boiling point transition (glide), verify that SST values derived from pressure, or pressure values derived from SST are defined using the midpoint temperature, i.e. the average of bubble point and dew point.
    - Documentation may be achieved through pictures of control system screens or control system documentation, supported by sample calculations of observed pressures or temperatures and associated conversion values, as available in the control system interface.

(c) Verify the suction pressure sensors read accurately, using a NIST traceable reference pressure gauge or meter, and with pressure checked for at least two pressures within the typical operating range. Calibrate if needed. Replace if outside manufacturers recommended calibration range.

(d) For systems with mechanical evaporator pressure regulators (EPRs) or thermostat and solenoid control, verify that the EPR valves or the solenoid temperature control settings, on the circuit(s) used for floating suction logic, are set below the normal control range (i.e. lower than what would otherwise be required to maintain design temperature) such that these controls do not inhibit floating suction pressure. Note: this refers to the permanent setpoint condition, not a temporary setting for the purpose of compliance testing.

NA7.XX.2.2 Functional Testing

Planning: Floating suction pressure control raises the suction setpoints when the attached circuits are not at design load and cooling can be met with a higher suction temperature. Cooling load is affected by store temperature and operations, with loads significantly higher when cases are stocked and during peak shopping periods. Be cognizant of weather conditions and store operations in scheduling Functional Testing such that the assessment is made during average store conditions and operations, to the extent possible.

Where possible and particularly where graphical trends are available, tests performed on two successive days will often provide greater accuracy by normalizing the effect of store operations, defrosts, etc. Where possible, use control system user interface trends, screen pictures and available history to document the conditions over a full day.

Step 1: Turn off floating suction pressure control and allow at least two hours for system to stabilize at the fixed suction setpoint. Document the following from the control system:

(a) Fixed SST setpoint
(b) Average operating suction pressure and SST
(c) Operating temperature of each float circuit
(d) Note any control circuits that are in defrost

Step 2: Verify the reasonableness of the fixed suction pressure setpoint.

(a) The average operating SST for each system should not normally be more than 5 F below the design SST for the temperature. If the operating SST is lower than a 5 F difference, either:

    - Adjust the fixed setpoint to a higher value, if it will still maintain the required circuit temperatures during peak loads
    - Document the design variance that requires the fixed setpoint to be lower.
    - Record the final fixed SST if changes are made.

Step 3: Restore floating suction pressure control and allow at least two hours for system to stabilize. Record the following data over the two hour period using control system trending if available.

(a) Average SST setpoint
(b) Average operating pressure and SST

(c) Operating temperature of each float circuit
(d) Note if any control circuits that are in defrost
(e) If necessary due to defrost, heavy case stocking, required control system adjustments, or other complicating factors, repeat testing to determine an accurate result for each system.

Step 4: Record floating suction pressure performance by documenting the following:

(a) Design SST (noted in construction inspection)
(b) Design floating suction temperature range (noted in construction inspection)
(c) Calculate average degrees of suction float, based on the average SST determined in Step 3.a minus the final fixed SST in Step 1.a
(d) To the extent possible, include user interface trends or history graphs showing the fixed setpoint and varying floating suction pressure setpoint
(e) Determine if suction pressure setpoint increased during Step 3 and if average degrees of suction float was positive.
(f) Provide a narrative of the floating suction pressure performance in the context of the store conditions and operations during the test period, to provide context with the fact that floating suction varies through the day, week and year.

NA7.XX.3 Liquid Sub-cooling

The purpose of this test is to confirm proper operation of the subcooler.

The measurement devices used to verify the refrigeration system controls shall be calibrated to a NIST traceable reference, with a calibration reference dated within the past two years. The calibrated measurement devices to be used in these acceptance tests are called the "standard" and shall have the following measurement tolerances: The temperature measurement devices shall be calibrated to +/- 0.7°F between -30°F and 200°F. The pressure measurement devices shall be calibrated to +/- 2.5 psi between 0 and 500 psig.

NA7.XX.3.1 Construction Inspection

Prior to functional testing, document the following:

(a) Review and document subcooler design information for each subcooler, including:
    - ☐ System design condensing temperature (i.e. subcooler entering temperature)
    - ☐ Design subcooler leaving liquid temperature
    - ☐ Design subcooler saturated suction temperature
(b) Verify accuracy of refrigerant pressure-temperature conversions and consistent use of either temperature or pressure for the controlled variable setpoint in the control system.
(c) Verify the suction pressure sensors, discharge or condenser pressure sensors, and subcooler entering and leaving temperature sensors read accurately, using NIST traceable instruments, including verification of at least two different ambient readings. Calibrate if needed. Replace if outside manufacturers recommended calibration range.

NA7.XX.3.2 Functional Testing

To the extent possible, include user interface trends or history graphs showing the condensing temperature and subcooled liquid temperature

Step 1: Adjust condensing temperature to increase load

(a) Record current SCT setpoint value
(b) If required based on prevailing ambient conditions and system operation, temporarily increase the system condensing temperature setpoint to a value within ten degrees of the system design SCT and allow system operation to stabilize for at least 30 minutes

Step 2: Verify performance and record subcooler performance at increased load

(a) Measure and record the system saturated condensing temperature (via pressure measurement)
(b) Measure and record the subcooler entering liquid temperature
(c) Measure and record the subcooler leaving liquid temperature
(d) Measure and record the saturated suction temperature (via pressure measurement) at the subcooler suction
(e) Verify each subcooler maintains an average leaving liquid temperature equal to the design value or lower, and maintains subcooling at all times, with temperature control variance within +/-10 F. If required, take corrective action to achieve design leaving temperature and stable temperature control

Step 3: Adjust condensing temperature to decrease load

(a) Set the SCT setpoint to minimum SCT value or the lowest value as weather permits. Record SCT setpoint value and allow system to stabilize for at least 30 minutes.
(b) Turn off circuit loads as necessary to reduce subcooler loads and document the circuit ID(s)

Step 4: Verify performance and record subcooler performance at reduced load

(a) Measure and record the system saturated condensing temperature (via pressure measurement)
(b) Measure and record the subcooler entering liquid temperature
(c) Measure and record the subcooler leaving liquid temperature
(d) Measure and record the saturated suction temperature (via pressure measurement) at the subcooler suction
(e) Verify each subcooler maintains an average leaving liquid temperature equal to the design value or lower, and maintains subcooling at all times, with temperature control variance within +/-10 F. If required, take corrective action to achieve design leaving temperature and stable temperature control

Step 5: Restore SCT to initially recorded value in Step 1a restore circuit loads turned off in Step 3b.

NA7.XX.4 Refrigerated Display Cases Lighting

The purpose of these tests is to confirm proper operation refrigerated display case lighting control.

The measurement devices used to verify lighting power reduction shall be calibrated to a NIST traceable reference, with a calibration reference dated within the past two years. The calibrated measurement devices to be used in these acceptance tests are called the "standard" and shall have the following measurement tolerances: The current measurements shall be calibrated to +/- 1% between 1% and 100% of rated primary current.

NA7.XX.4.1 Motion Sensor based control

1.1.1.1.1.1.1.5 **NA7.XX.4.1.1 Construction inspection**

Prior to functional testing, document the following:

(a) Motion sensor has been located to minimize false signals.
(b) Desired sensor coverage is not blocked by obstructions that could adversely affect performance.

1.1.1.1.1.1.1.6 **NA7.XX.4.1.2 Functional Testing**

For stores with up to a total of five (5) motion sensors controlling refrigerated display cases, all motion sensors shall be tested. For stores with more than a total of five (5) motion sensors controlling refrigerated display cases, sensors can be sampled by creating groups of sensors. Group size cannot be more than 5 motion sensors. If the first sensor in the sample group passes the acceptance test, all sensors and the display cases controlled by them in the sample group also pass. If the first sensor in the sample group fails the acceptance test, the rest of the sensors in that group shall be tested and any failed sensor in the sample group shall be repaired or replaced and retested until the sensor passes the test. Sample sizes should be such that at least five (5) sensors are tested.

Step 1: Simulate motion in area under lights controlled by the sensor. Verify and document the following:

(a) Status indicator operates correctly.
(b) Lights controlled by sensors turn on immediately upon entry into the controlled display cases area.
(c) Signal sensitivity is adequate to achieve desired control.
(d) For stores which dim display case lighting to save power, measure the current drawn by the lighting circuit using an appropriate standard with lights on at 100% lighting level.

Step 2: Simulate no motion in area with lighting controlled by the sensor. Verify and document the following:

(a) At least half the lights controlled by the sensor turn off within a maximum of 30 minutes from the start of an unoccupied condition for stores with no light dimming.
(b) For stores which dim display case lighting to save power, measure the current drawn by the lighting circuit using an appropriate standard with lights at dimmed lighting levels.
(c) For stores which dim display case lighting to save power, lights controlled by the sensor reduce power consumption (confirmed by measuring current using appropriate standard) by at least 50 percent within a maximum of 30 minutes from the start of an unoccupied condition.
(d) The sensor does not trigger a false “on” from movement outside of the controlled area.
(e) Signal sensitivity is adequate to achieve desired control.

NA7.XX.4.2 Automatic Time Switch Control

1.1.1.1.1.1.1.7 **NA7.XX.4.2.1 Construction Inspection**

Prior to functional testing, confirm and document the following:

(a) Verify the automatic scheduling control is installed.
(b) Verify the control is programmed with acceptable schedules (i.e. the lights are scheduled to turn off during non-business hours).

(c) Demonstrate and document for the lighting control programming including both ON schedule and OFF schedule, for weekday, weekend, and holidays (if applicable).
(d) Verify the correct time and date is properly set in the lighting control panel.

1.1.1.1.1.1.1.8 NA7.XX.4.2.2 Functional Testing

Verify and document the following:

Step 1: Document all settings on the control system.

(a) Document the schedule used.
(b) Change the time of disabling the lights to a few minutes in the future. Record value as the test time.
(a) Verify that all display case lights or lights on glass doors installed on walk-in coolers/freezers turn off at the test time.

Step 2: Manually override the timer to turn on the lights in line-ups or walk-in cases during a scheduled OFF period.

(a) Verify that lights turn off after one hour.

Step 3: Reset all settings back to earlier conditions as recorded in Step 1.

NA7.XX.5 Refrigeration Heat Recovery

The purpose of these tests is to confirm proper operation of the heat recovery system.

The measurement devices used to verify the refrigeration system controls shall be calibrated to a NIST traceable reference, with a calibration reference dated within the past two years. The calibrated measurement devices to be used in these acceptance tests are called the "standard" and shall have the following measurement tolerances: The temperature measurement devices shall be calibrated to +/- 0.7°F between -30°F and 200°F. The pressure measurement devices shall be calibrated to +/- 2.5 psi between 0 and 500 psig.

NA7.XX.5.1 Construction Inspection

Prior to functional testing, document the following:

(a) Verify that the pump (if any) for heat recovery is functional.
(b) Verify the discharge pressure sensors read accurately, using a NIST traceable reference pressure gauge or meter, and with pressure checked for at least two pressures within the typical operating range. Calibrate if needed. Replace if outside manufacturers recommended calibration range.
(c) Verify the entering and leaving temperature sensors for the heat reclaim coil (direct system) or heat recovery heat exchanger (indirect system) read accurately, using a NIST traceable reference pressure gauge or meter, and with pressure checked for at least two pressures within the typical operating range. Calibrate if needed. Replace if outside manufacturers recommended calibration range.

NA7.XX.5.2 Functional Testing

Step 1: Document initial system setpoints. Change system setpoints if necessary such that HVAC system enters “heating mode”. Allow one hour for the system to stabilize.

Step 2: Document the following:

(a) Verify that the control system has activated heat recovery devices.
(b) For a direct heat recovery system, measure the entering air temperature to the heat reclaim coil, or for an indirect heat recovery system, measure the entering fluid temperature entering the heat recovery heat exchanger
(c) For a direct heat recovery system, measure the leaving air temperature to the heat reclaim coil, or for an indirect heat recovery system, measure the leaving fluid temperature entering the heat recovery heat exchanger
(d) Determine if there was a temperature rise in the air or fluid.

Step 3: Restore all settings back to setpoints recorded in Step 1.

Proposal Summary

2022 California Energy Code (Title 24, Part 6)

Covered Processes: Steam Traps Monitoring

Updated: October 31, 2019

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Introduction

The document summarizes proposed revisions to the California Energy Code (Title 24, Part 6) that will be discussed during a utility-sponsored stakeholder meeting on November 7, 2019. The Statewide Utility Codes and Standards Enhancement (CASE) Team is seeking input and feedback. To provide your comments, email info@title24stakeholders.com by November 21, 2019.

Measure Description

The proposal for the steam traps monitoring code change requires mandatory automatic monitoring equipment in new construction, and additions and alterations for large installations of all steam trap types. The change impacts all industries using steam traps from oil and gas producers to food processing, hospitals, and universities. The site installation size limits proposed are intended to trigger the code for sites that will be installing a significant number of steam traps and thereby generate a significant savings potential while allowing the smaller users to operate using manual inspection and monitoring methods which are more suited to their specific usage groups.

Automated monitoring provides a method that reports any failure instantly and eliminates the labor required to manually check the traps. Steam traps separate live steam from condensate and non-condensables (e.g. air). Most steam traps have moving parts and eventually fail. Additionally, solid contaminants in the steam system can clog steam traps or result in the traps becoming failed in a partially open condition. When steam traps fail open or leak, steam is vented to the atmosphere through the condensate return system resulting in the loss of significant amounts of energy and treated water. Steam trap monitoring systems are available from multiple sources including the manufacturers of steam traps and manufacturers of industrial and building controls.

Automatic steam trap monitoring systems use steam trap fault detection sensors which monitor the conditions of the traps. Data collected can include temperature, ultrasonic signals, and other information that makes it possible to diagnose steam trap malfunction. Either wired or wireless systems can be used to remotely transmit signals that reports the trap condition, enabling plant operators to capture real-time steam trap operation data and quickly correct malfunctions. Signals are received by a software application that measures, monitors, and manages this information.

Installing strainers upstream of steam traps increases their life and renders it less likely that the steam trap will experience a failure. Together with remote monitoring, this code proposal would codify what are steam system best practices.

Using the steam trap orifice size provides the best estimate of steam losses from failed traps, but orifice size can be difficult to confirm in the field. The pipe outlet size of the steam trap is easy to confirm visually but is a less accurate indication of the magnitude of the energy risk associated with an unrepaired steam trap. The team will conduct a sensitivity analysis of the trade-offs between accuracy and enforceability of steam trap thresholds based on orifice size versus outlet pipe diameter. Both are shown in the sample language below but one or the other would be selected for the final proposal.

Draft Code Language

The proposed changes to the Standards and Reference Appendices are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions). Expected sections or tables of the proposed code (but not specific changes at this time) are highlighted in yellow.

Standards

Section 120.6 – Mandatory Requirements for Covered Processes

120.6(h) Mandatory Requirements for Process Steam Traps

1. Automatic Steam Traps Monitoring. All newly installed and replaced steam traps with nominal [Option A/B] diameter equal to or greater than the values listed in table 120.6-D shall conform to the following:

A. Central steam trap monitoring. Central steam trap monitoring shall be provided when item 120.6(h)(1)(B) of this section requires steam trap fault detection sensors for any steam trap in the facility. The status of all steam trap fault detection sensors shall be updated at no greater than 1-hour intervals. If a fault signal is transmitted by a steam trap sensor, the central steam trap monitoring system shall automatically transmit an alarm to the facility operator and identify which steam trap has the fault.

B. Steam Trap Fault Detection Sensors. All newly installed and replaced steam traps shall have automatic fault detection sensors when their nominal [Option A/B] diameter is equal to or greater than the value listed in table 120.6-D for the applicable steam line pressure. Steam trap fault detection sensors shall communicate their operational state to the central steam trap monitoring system as described in item 120.6(h)(1)(A) of this section.

2. Steam trap quality installation. All steam traps shall have an integral strainer and blow-off valve or shall be installed downstream within 3 feet of a strainer and blow-off valve.

EXCEPTION 1 to Section 120.6(h) 1&2: Steam systems with a total combined maximum boiler output rating less than xxx [TBD] MMBtu/hr.

EXCEPTION 2 to Section 120.6(h) 1&2: Steam systems where annual operating hours are less than yyy [TBD] hours annually.

EXCEPTION 3 to Section 120.6(h) 1&2: Steam systems where less than zz% [TBD] of total facility steam traps are replaced.

EXCEPTION to Section 120.6(h) 2: Steam trap replacements.

TABLE 120.6-D Automatic Steam Trap Monitoring Mandatory Requirement (values subject to change depending upon results of cost-effectiveness analysis)

	Option A and Option B are currently being evaluated. Input for feasibility desired. Only one option will be included in the 2022 code language.	
LINE OPERATING PRESSURE (psig)	**Option A** **MINIMUM STEAM TRAP ORIFICE DIAMETER (inches)**	**Option B** **STEAM TRAP NOMINAL OUTLET PIPE DIAMETER (inches)**
< 15	N/A	N/A
≥15 but <50	1/4	≥ x
≥50 but <150	5/32	≥ y
≥150	3/32	≥ z

3. **Automatic Steam Trap Monitoring System Acceptance.** Before an occupancy permit is granted for a steam system subject to 120.6(h), the equipment and systems shall be certified as meeting the Acceptance Requirement for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA7.16.

Reference Appendices

NA7.16 Process Steam Trap Acceptance Tests

NA7.16.1 Construction Inspection

Prior to functional testing, steam trap systems must verify and document the following:

(a) Rated capacity (MMBtu/h) and steam supply pressure (psig) of each connected steam boiler.

(b) Distribution system steam trap arrangement and design specifications (type, pipe diameter, line operating pressure) equipped with automatic steam trap monitoring were installed as designed including presence of monitoring equipment, strainer, and strainer blow-off valve.

(c) Visual confirmation of central steam trap monitoring system installation, operation and programmed as designed.

(d) Confirm central steam trap monitoring system displays status of all installed steam trap sensors with a descriptive label or cross-references to a look-up table with location of sensor.

NA7.16.2 Functional Testing

For buildings with up to seven (7) steam traps required to have fault detection in accordance with Section 120.6(h)1, all steam traps shall be tested. For buildings with more than seven (7) steam traps; sampling shall include a minimum of 1 steam trap for each group of up to 7 additional steam traps. If the first steam trap in the sample group passes the acceptance test, the remaining steam traps in the sample group also pass. If the first steam trap in a sample group fails, the rest of the steam traps in that group must be tested. If any tested steam trap fault detection sensor fails it shall be repaired, replaced or adjusted until it passes the test.

For each fault detection sensor, test the following:

Step 1: Identify the status of the steam trap (attached to an operating steam line or attached to a non-operating steam line).

Step 2: Confirm that central steam trap monitoring system is receiving a signal that reflects the status of the steam trap.

Step 3: Generate a fault at the steam trap sensor for each tested steam trap.

Step 4: Verify that the central steam trap monitoring system detects the fault and reports the fault detection to the operator.

Step 5: Reconnect steam trap sensor and verify the fault detection sensor is communicating with the central steam trap monitoring system.

Step 6: Verify that central steam trap monitoring system does not report a fault.