Welcome to the California Statewide Codes and Standards Enhancement (CASE) Team's Stakeholder Meeting on

Nonresidential Covered Processes Part 2

We'll get started shortly.

In the meantime, please fill out the polls below.

California Energy Codes & Standards
A Statewide Utility Program

Welcome: Connect Your Audio

Audio – there are **three** options for connecting to the meeting audio:

To view options, click on the icon on the top ribbon, then select *Connect My Audio.*

1. **Dial-out:** receive a call from the meeting. *Please note this feature **requires a direct line.***
2. **Dial-in:** dial-in to the conference via phone. Conference phone number and room number code provided. *Please then **identify your line** by entering your unique user ID on your phone.*
3. Use the **microphone** from your computer/device.

Above: audio conference settings pop-up box

2022 TITLE 24 CODE CYCLE, PART 6

First Utility-Sponsored Stakeholder Meeting

Covered Processes Part 2

Statewide CASE Team
November 7, 2019

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Meeting Guidelines

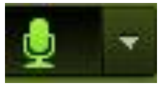
Muting Guidelines

Once you turn on your preferred audio connection, please **MUTE** your microphone.

- Please keep yourself **MUTED.**
- Wait for instructions and/or permission to unmute yourself during designated Q&A periods.

Phone users – please mute your phone line.

Computer/device users – please mute your microphone by clicking on the microphone icon on your top ribbon.



NOT MUTED

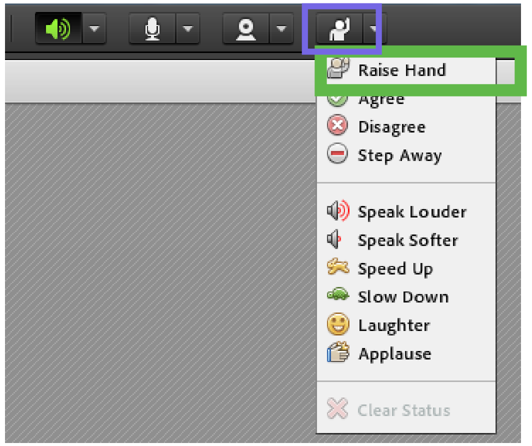
MUTED

Meeting Guidelines

Participation Guidelines

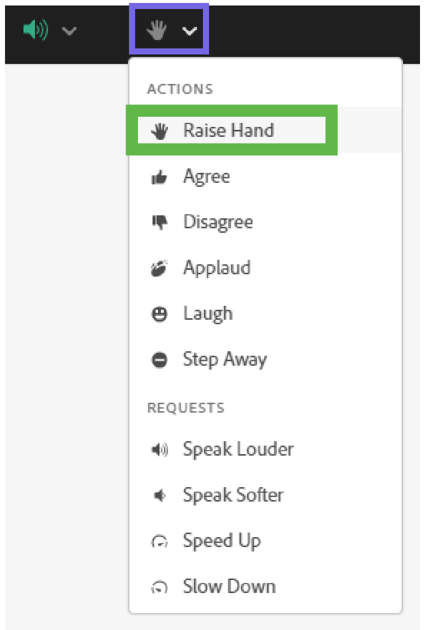
- **Questions & Comments**
    - Click **“*Raise Hand*”** if you would like to speak. Those with a hand raised will be called on by the speaker.
    - All questions and comments are also welcome via the chat window.

- **Other Meeting Feedback**
    - Provide live meeting feedback from the **top toolbar drop-down**.



Above: *feedback view for Adobe Connect app users.*

Below: *feedback view for HTML users.*



Meeting Ground Rules

- **We want to hear your thoughts**
  - Supporting and opposing viewpoints are welcome
- **When making comments**
  - Unmute yourself
  - Clearly state your name and affiliation prior to speaking
  - Speak loudly for phone audio
  - Place yourself back on mute
- **Calls are recorded** for note development, recordings will not be publicized
- Notes and presentation material will be posted on Title24Stakeholders.com

Agenda

1	**Meeting Guidelines**	*8:30 am*
2	**Opening Remarks** from the California Energy Commission	*8:35 am*
3	**Overview & Welcome** from the Statewide Utility Team	*8:40 am*
4	**Presentation I:** Pipe Sizing and Leak Testing for Compressed Air Systems	*8:45 am*
	Presentation II: Refrigeration System Opportunities	*9:30 am*
	5 Minute Break	
	Presentation III: Steam Trap Monitoring	*10:50 am*
9	**Closing**	*12:00 pm*

Opening Remarks: California Energy Commission

Policy Drivers: Building Standards

The following policy documents establish the goal for new building standards:

- **2008 CPUC/CEC Energy Action Plan** – ZNE for Residential buildings by 2020 and nonresidential buildings by 2030
- **SB 100** – Clean electricity by 2045
- **B-55-18** – Governor Jerry Brown's Executive Order to achieve carbon neutrality
- **AB 3232** – Assess the potential for the state to reduce the emissions of greenhouse gases from the state's residential and commercial building stock by at least 40% below 1990 levels by January 1, 2030

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2022 Standards Schedule

Estimated Date	Activity or Milestone
November 2018 - April 2019	Updated Weather Data Files
November 2018 - July 2019	Measures Identified and Approved (Internal at the Energy Commission)
November 2018 - July 2019	Compliance Metrics Development
April 24, 2019	Efficiency Measure Proposal Template for public to submit measures
October 17, 2019	Compliance Metrics and Climate Data workshop
November, 2019	Final Metrics Workshop
November, 2019	Research Version of CBECC Available with new weather data files and updated Metrics
July 2019 - March 2020	Utility-Sponsored Stakeholder Workshops
March, 2020	All Initial CASE/PUBLIC Reports Submitted to Commission
March - August 2020	Commission-Sponsored Workshops
July, 2020	All Final CASE/PUBLIC Reports Submitted to the Commission
July - September 2020	Express Terms Developed
January, 2021	45-Day Language posted and set to list serve, Start of 45-Day review/comment period
January, 2021	Lead Commissioner Hearing
April, 2021	Adoption of 2022 Standards at Business Meeting
May - November 2021	Staff work on Software, Compliance Manuals, Electronic Documents
May - November 2021	Final Statement of Reasons Drafted and Approved
October, 2021	Adoption CALGreen (energy provisions) - Business Meeting
December, 2021	CBSC Approval Hearing
January, 2022	Software, Compliance Manuals, Electronic Documents Available to Industry
January - December 2022	Standards Training (provided by 3rd parties)
June 1, 2022	6 Month Statutory Wait Period Deadline
January 1, 2023	Effective Date

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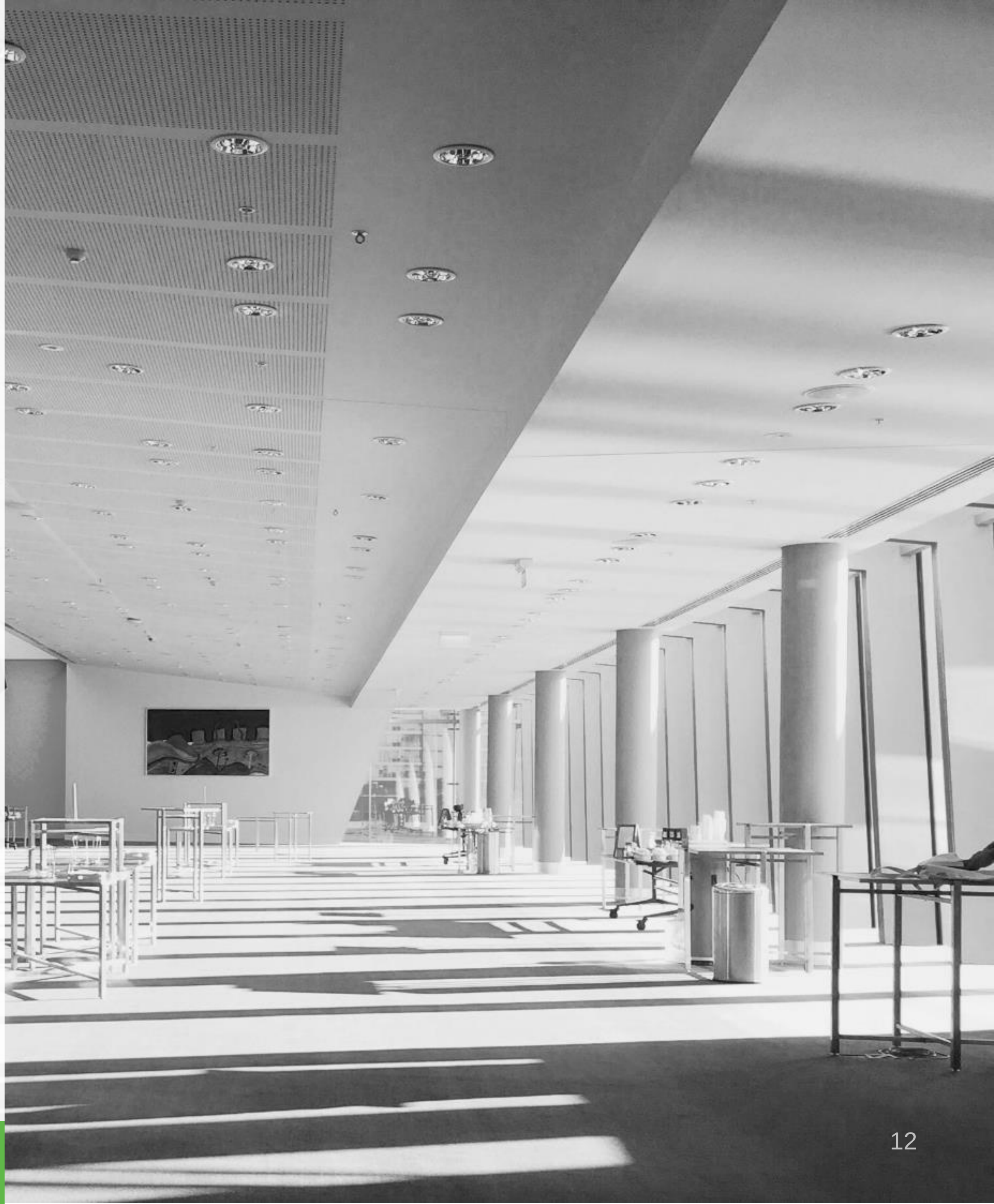
More information on pre-rulemaking for the 2022 Energy Code at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Title 24, Part 6 Overview

Kelly Cunningham
Codes and Standards
Pacific Gas & Electric



Statewide Utility Codes and Standards Team

- **Actively supporting the California Energy Commission** in developing proposed changes to the California Energy Code (Title 24, Part 6)
- Achieve significant energy savings through the development of **feasible**, **enforceable**, **cost-effective, and non-proprietary** code change proposals for the 2022 code update, and beyond

Requirements for a Successful Code Change Proposal

The utilities support the California Energy Commission by proposing changes to the Energy Code that are:

Feasible | Cost effective | Enforceable | Non-proprietary

Utility-Sponsored Stakeholder Meetings

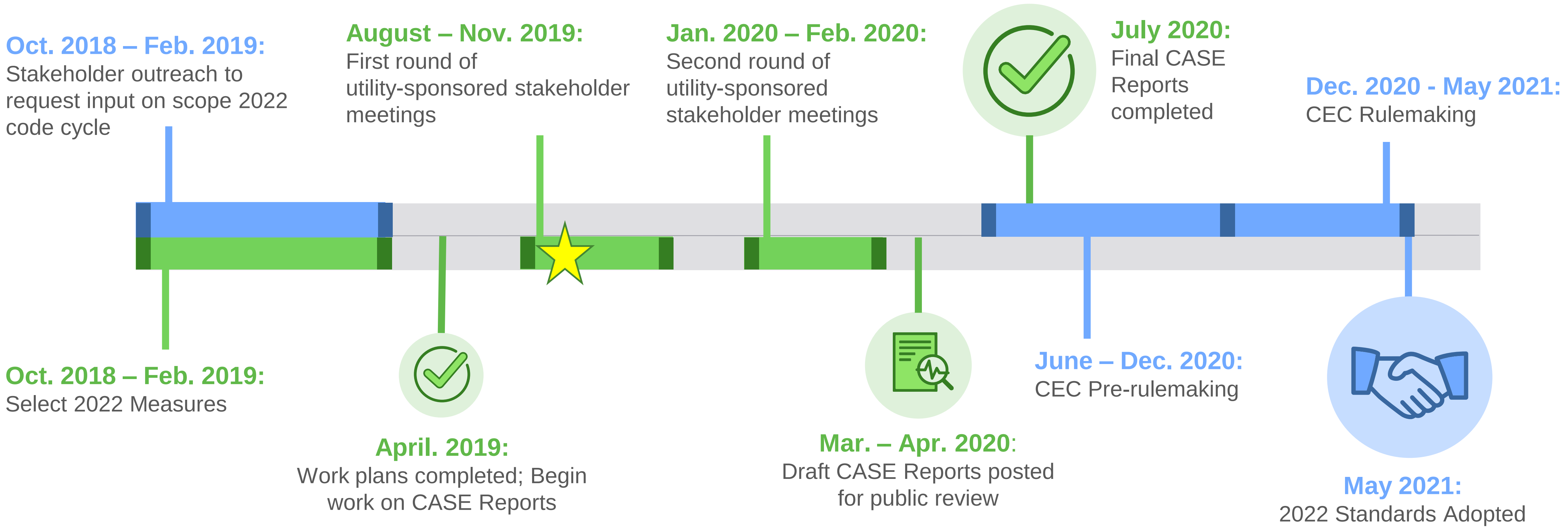
- All meetings can be attended **remotely**
- Check Title24Stakeholders.com/events for information about meetings and topic updates
- Sign up to receive email notifications

First Round Utility-Sponsored Stakeholder Meetings

Meeting Topic	Building Type	Date
Multifamily HVAC and Envelope	MF, NR	Thursday August 22, 2019
Outdoor Lighting and Daylighting	MF, NR	Thursday September 5, 2019
Indoor Lighting	NR	Thursday September 12, 2019
Covered Processes Part 1: Controlled Environment Horticulture	NR	Thursday, September 19, 2019
Multifamily & Nonresidential Water Heating	MF/NR	Thursday, October 3, 2019
Single Family HVAC	SF	Thursday, October 10, 2019
Nonresidential HVAC Part 1: Data Centers, Boilers, & Controls	NR	Tuesday, October 15, 2019
Nonresidential Envelope Part 1	NR	Thursday, October 24, 2019
Nonresidential HVAC and Envelope Part 2: Air Distribution, & Controls	NR	Tuesday, November 5, 2019
Covered Processes Part 2: Compressed Air, Steam Traps, & Refrigeration	NR	Thursday, November 7, 2019
Single Family Whole Building & Nonresidential Software Improvements	SF/NR	Tuesday, November 12, 2019

Sign up for all meetings at title24stakeholders.com/events/

2022 Code Cycle – Key Milestones



This program is funded by California utility customers and administered by Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E®), Southern California Edison Company (SCE), and Southern California Gas Company (SoCalGas®) under the auspices of the California Public Utilities Commission.

EnergyCode Ace™
Helping you play your cards right

The **Codes and Standards Reach Codes Program** provides technical support to local jurisdictions considering adopting a local energy efficiency ordinance.

www.LocalEnergyCodes.com

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

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

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Covered Processes

M M Valmiki, PE

AESC, Inc.

November 7, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

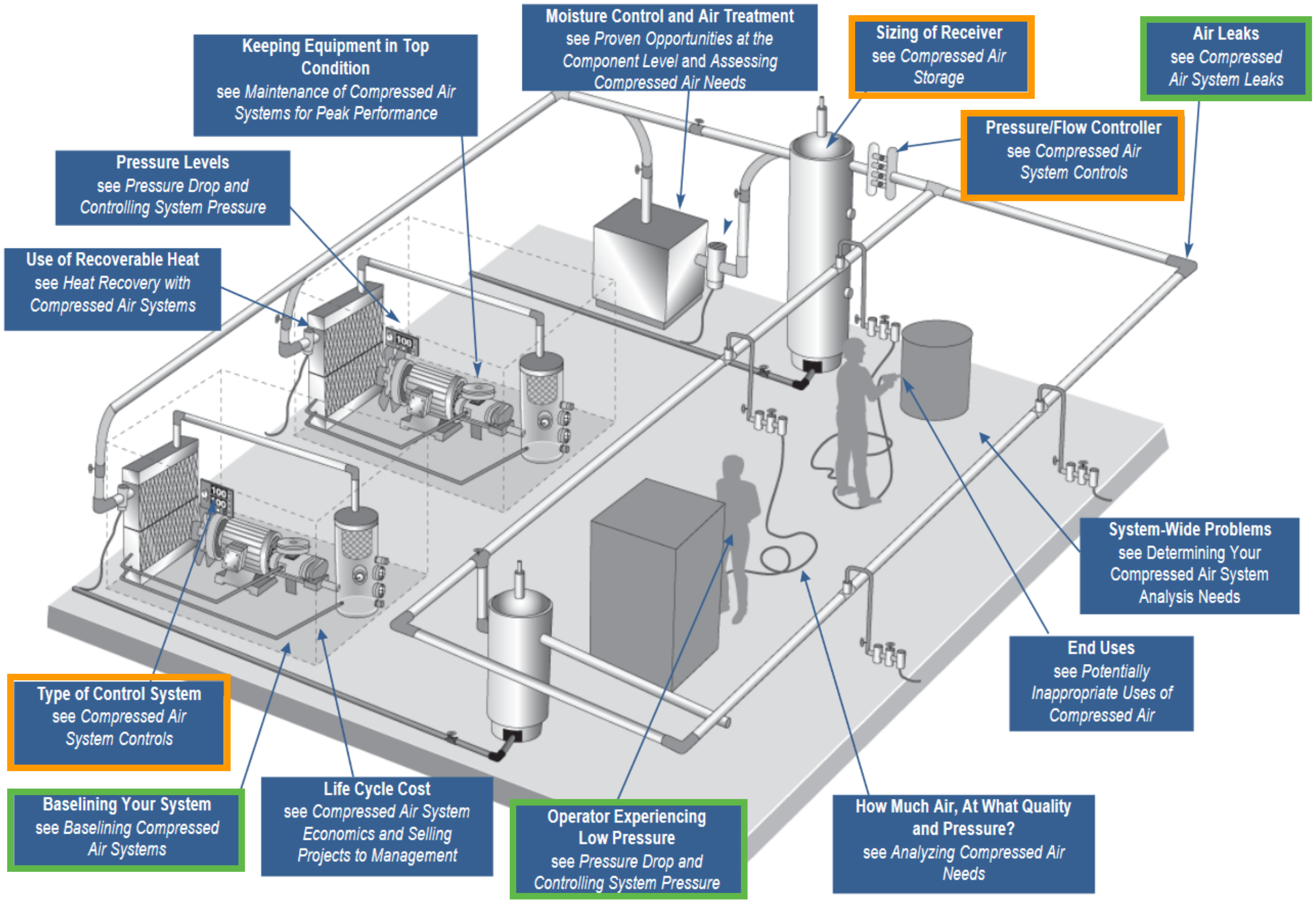
Code Change Proposal – Summary

This proposal addresses three submeasures of compressed air systems applicable to all nonresidential buildings and any construction types:

- Pipe sizing
- Leak testing and monitoring
- Existing language revisions

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Covered Processes	Mandatory	No

Compressed Air Systems – Past And Proposed Code



Current Code

Code Proposal

Source: https://www.compressedairchallenge.org/data/sites/1/media/library/sourcebook/Improving_Compressed_Air-Sourcebook.pdf

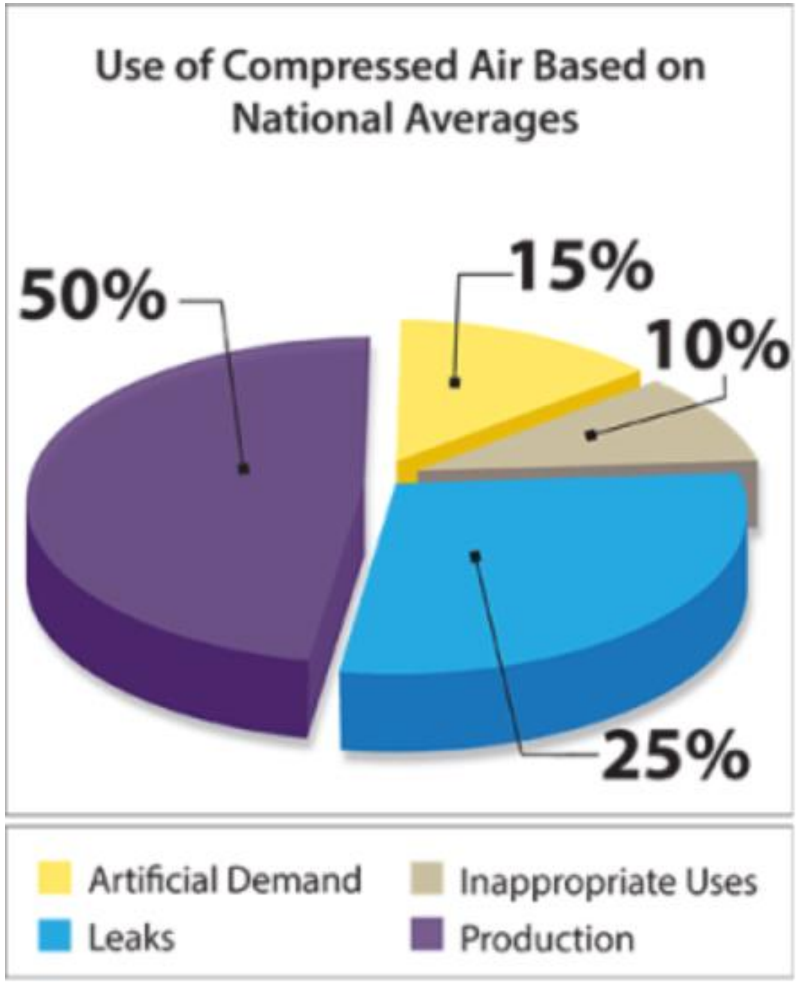
Problem Statement: Compressed Air System Losses

Production efficiency – 2013 Code Focus

- Trim compressor requirement (>25 hp)
  - VSD sized to 125% of largest net capacity increment
  - Effective trim capacity within 15% of peak specific power (kW/100 cfm)
- Compressor sequencing control (>100 hp)

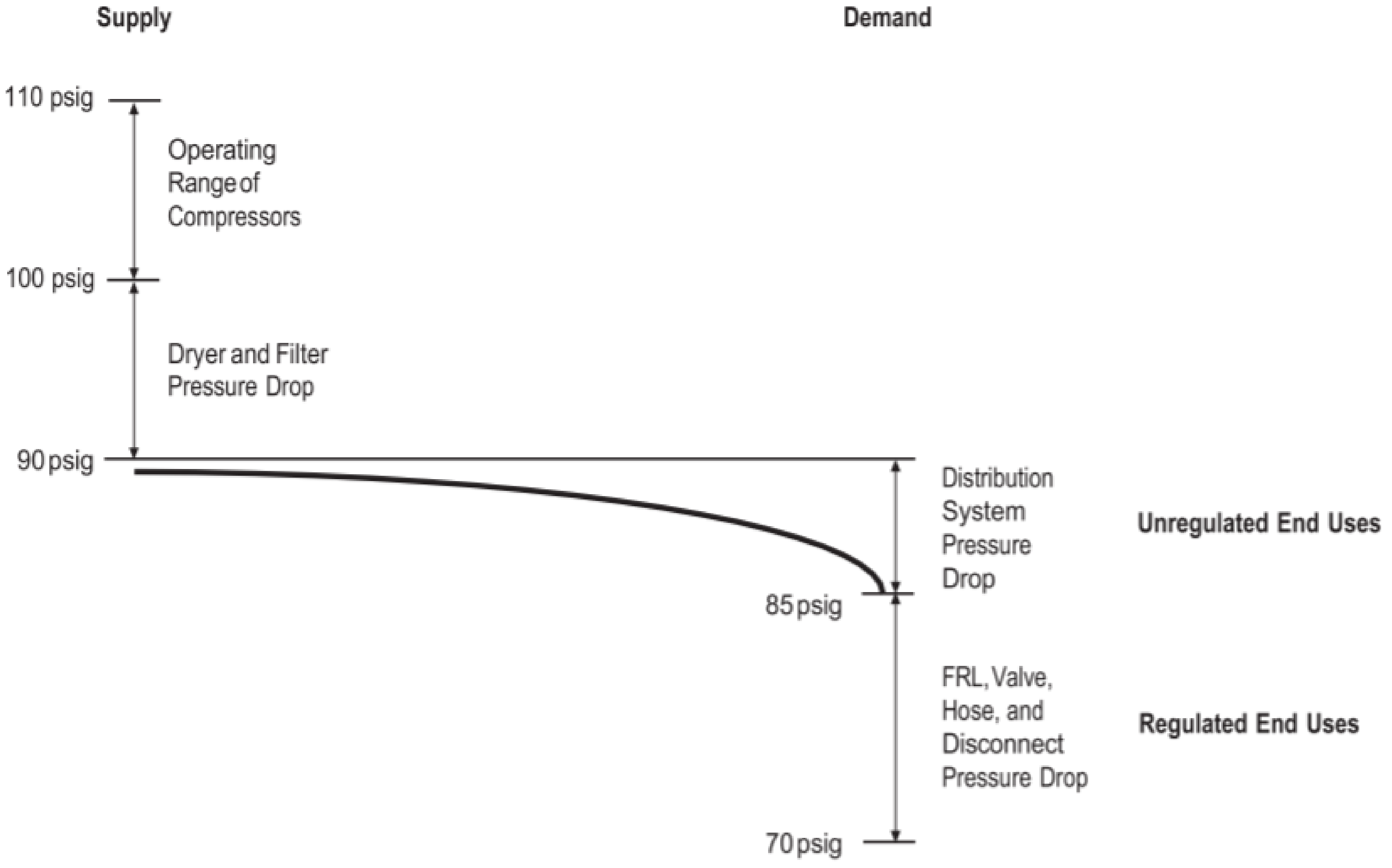
Losses – 2022 Code Proposal Focus

- Pressure drop
- Air leaks



https://iwrc.uni.edu/compressed-air

Pressure Loss - Context and History



https://www.compressedairchallenge.org/data/sites/1/media/library/sourcebook/Improving_Compressed_Air-Sourcebook.pdf

Context and History – Pipe Sizing

- Title 24, Part 6 does not have language regulating pipe sizing
  - The Statewide CASE Team is unaware of voluntary programs
- Pipe Sizing
  - Improper pipe sizing decreases energy efficiency
    - Small pipes can result in excessive frictional pressure losses
    - Rule of thumb: 1% energy increase for every 2 psi of pressure increase
    - Excess velocity can also entrain liquids
  - Several instances of custom program projects, but piping retrofits are uncommon for energy efficiency purposes

Pipe Pressure Drop Best Practice

- Compressed Air Challenge (CAC) recommends that the pressure differential across the **distribution system** from the compressor discharge to the end use, before end-use filters and regulators, should be **less than 10%**
- This differential includes compressor room **dryers and filters**, typically accounting for **5-6%**
- This means that **piping should be designed for no more than 4-5% pressure differential at peak flows**, preferably less
- Discharge pressure setpoints are higher than necessary if distribution pressure losses are excessive

https://www.plantservices.com/articles/2013/01-designing-compressed-air-piping-system/

Poll

In your experience, how often are compressor room and main branch pipes undersized? *Select one.*

a. Always
b. Frequently
c. Occasionally
d. Rarely
e. Never

Compressor Power with Respect to Pressure

Each 1% increase in pressure ~1/2% increase in power.

Power proportional to:

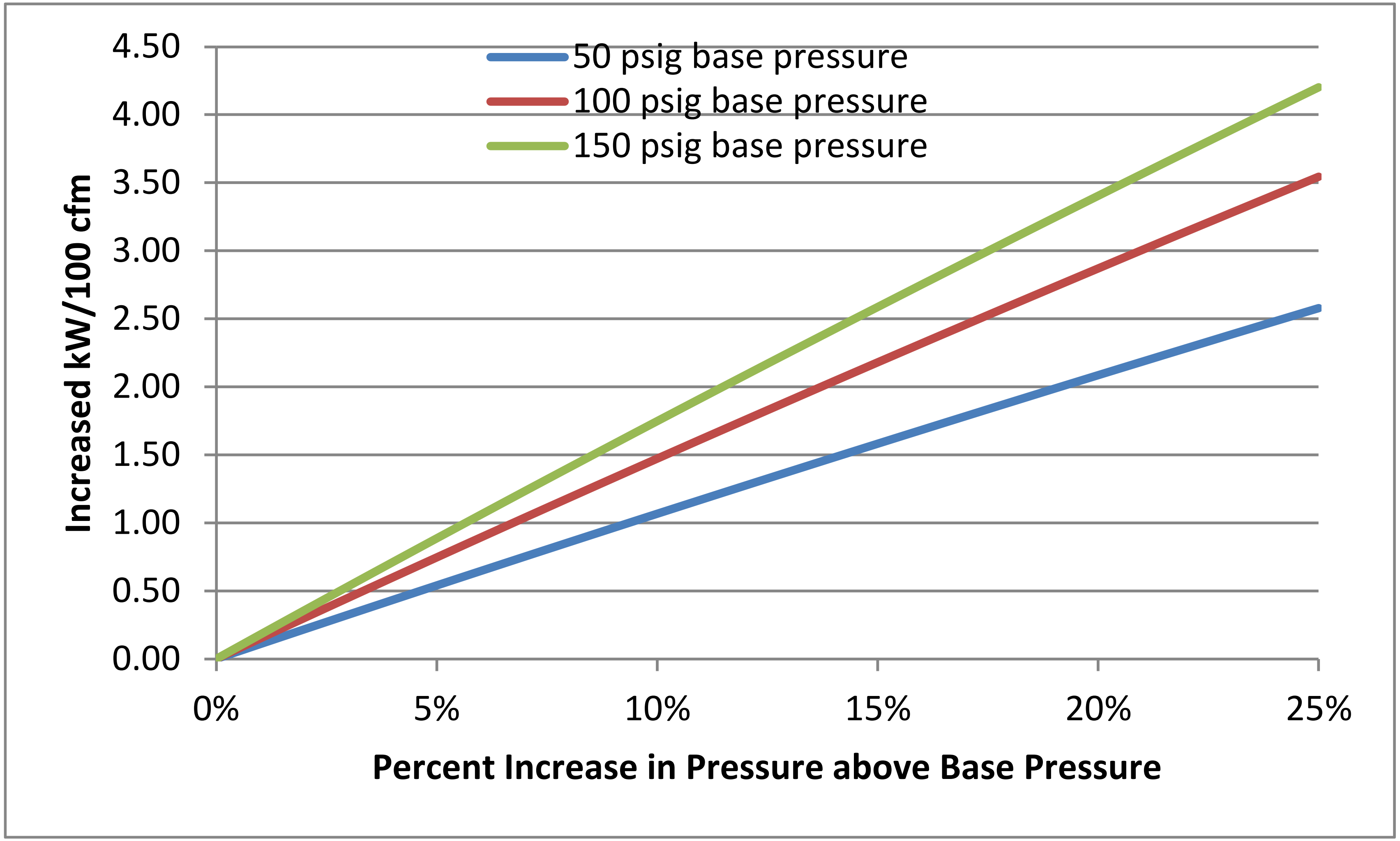
$$\left[\left(\frac{P_d}{P_i}\right)^{\frac{k-1}{Nk}} - 1\right]$$

P_d = discharge pressure

P_i = inlet pressure

k = specific heat ratio of air, 1.4

N = polytropic efficiency, 0.8 for screw compressor



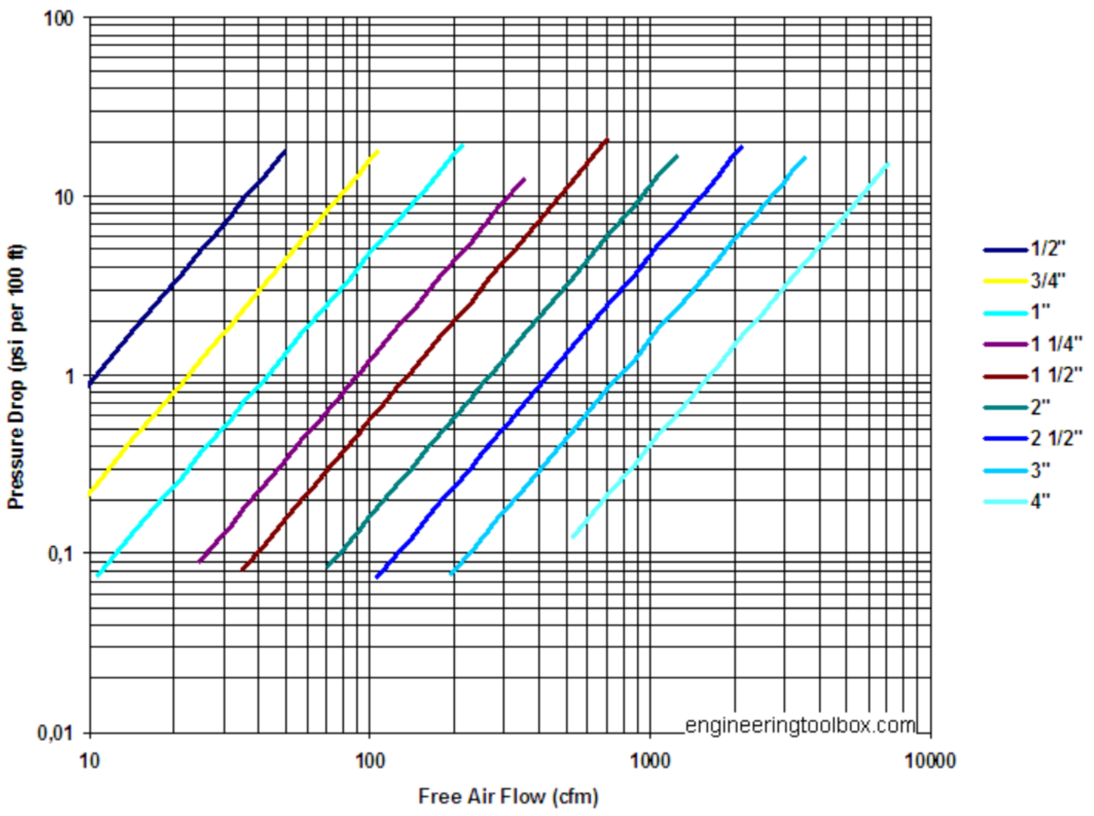
Pipe Sizing

- Standardize the diameter and pipe design methods for minimum losses

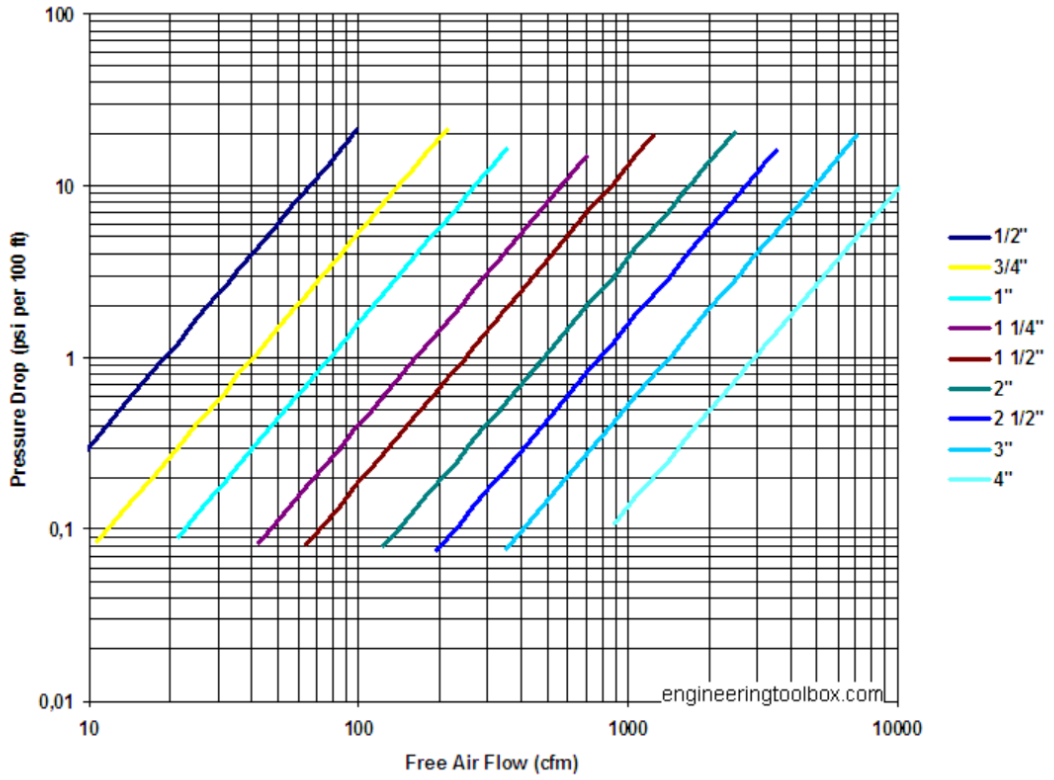
Pressure loss due to friction (in psi per 1,000 feet of pipe)

Cfm free air	Nominal Diameter					
	0.5	**0.75**	**1**	**1.25**	**1.5**	**2**
20	25.9	3.90	1.11	0.25	0.11	
30	58.2	9.01	2.51	0.57	0.26	
40		16.0	4.45	1.03	0.46	
50		25.1	9.96	1.61	0.71	0.19
60		36.2	10.0	2.32	1.02	0.28
70		49.3	13.7	3.16	1.40	0.37

Pipe Sizing



Applied Pressure = 50 psi



Applied Pressure = 150 psi

Tables: Pressure Drop with Respect to Pipe Diameter and Flowrate (psi/100 linear ft)

https://www.engineeringtoolbox.com/compressed-air-pipe-pressure-d_36.html

Context and History – Leak Testing and Monitoring

- **Title 24, Part 5** (California Plumbing Code) requires pressure testing of new natural gas piping. Piping alterations require leak detecting fluid test (CPC §1213.3).
- **Title 24, Part 6** does not have language regulating pipe leak testing
  - The Statewide CASE Team is unaware of voluntary programs
- **Leak Testing**
  - 20-30% of load in existing systems but can be minimized with best practices
  - Wasted energy and other losses (decreased useful capacity and longer run times)
  - Detection would be achieved through monitoring, tests, and inspection
  - Differentiation between hard piping and end-use take-offs, hosing, tools, etc.

Static Pressure Testing of Compressed Air Piping

- Same approach as testing natural gas piping in the California Plumbing Code
- Newly installed piping more than **100 ft** isolated, capped and tested for at least **30 minutes** with no loss in pressure
- Shorter lengths of pipe or replacement sections of pipe, tested with **noncorrosive leak-detecting fluid.**

Poll

How frequently is new compressed air piping tested for leaks (by pressurizing and observing pressure drop or otherwise)? *Select one.*

a. Always
b. Frequently
c. Occasionally
d. Rarely
e. Never

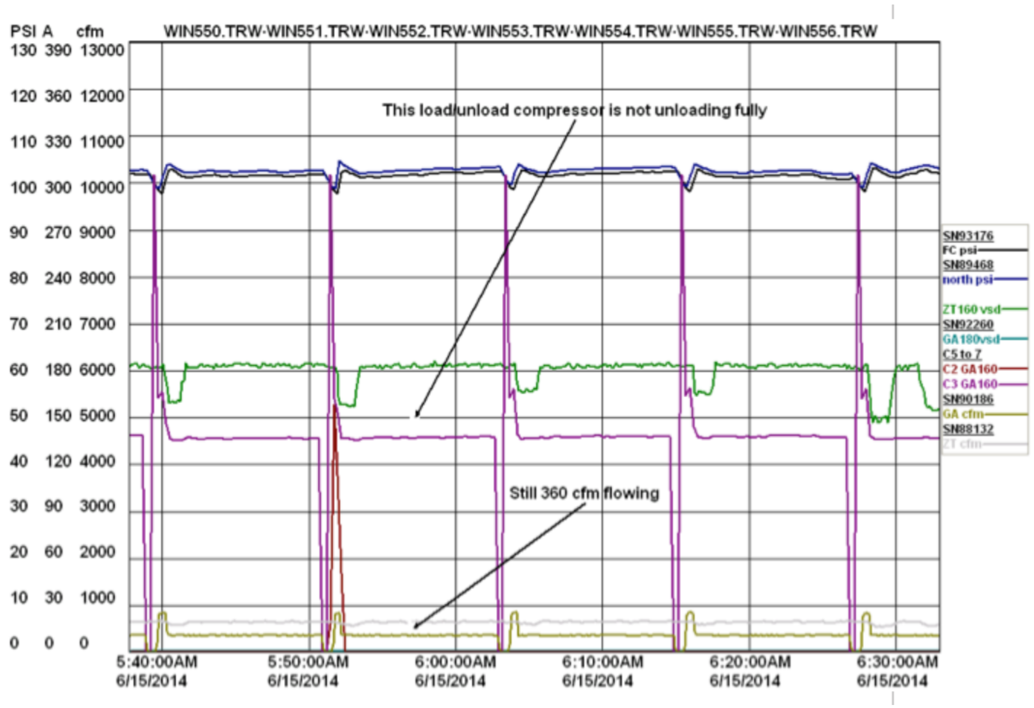
Poll

What percentage of leak load occurs in hard-piping (versus hoses, tools and others)? In other words, for every 100 cfm of leaking air, how much occurs in the hard-piping? *Select one.*

a. 0-10%
b. 11-20%
c. 20-30%
d. 30-40%
e. Over 50%

Continuous Commissioning – Monitoring of Specific Efficiency, Loads, and Leaks

- 2013 code requires measurement of air demand for sequencing controls (>100 hp)
- Monitoring both power and air flow rate provides continuous commissioning
- Specific power (kW/100 cfm) increasing over time – problem with controls or compressor
- Demand during shift changes and after hours indicates leak severity (especially growth)
- Identify issues before failure – increases compressed air system reliability



https://www.airbestpractices.com/technology/instrumentation/6-reasons-log-your-compressed-air-system
http://airleakdetection.net/automation/

Existing Language Revisions

- **Title 24, Part 6** has existing language for air compressor controls
  - VSD compressor or trim capacity and primary storage
  - Sequencing
- **Existing Language Revisions**
  - There has been confusion on requirements and coverage of existing language
  - “Online” capacity has been a source of confusion
  - Centrifugal compressor exception interpretation
  - Language will be revised for simplicity and transparency while maintaining intent and originating CASE Report (2013)

Review - 2019 Code Requirements

- There are no existing code requirements for pipe sizing or leak detection. The Statewide CASE Team is aware of no existing model code requirements, but industry standard guidelines and similar standards exist
- Other codes may be relevant (e.g. plumbing code, ASME B31.3, metering, disaggregation)

2019 Code Requirements in Title 24, Part 6, Section 120.6(e) [paraphrased]

Section	Requirement	Exception
120.6(e)	Systems ≥25 hp must comply with following	Centrifugal compressors and medical gas
120.6(e)1	A.VSD compressor with storage B. Multiple compressor trim capacity and storage	Additions or alterations of <50% of capacity Systems with load variation <10%
120.6(e)2	Systems >100 hp with multiple compressors must have optimizing staging controls	
120.6(e)3	Acceptance requirements NA 7.13	

Review - Proposed Code Changes

- See the proposal summary and mark-up language in the **resources box**
- Description of changes:
  - Piping shall be designed to minimize excessive pressure losses
  - Leaks shall be detected and mitigated in new pipe lengths
  - Load and power monitoring for leak growth mitigation
  - Existing language shall be revised and cleaned up
    - Simplify language for transparency and ease of compliance
    - Removal of “online” capacity without increasing stringency
    - Centrifugal compressor exception altered to better reflect intent and typical applications

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - About 9,000 GWh per year for California manufacturing
  - 10% of overall manufacturing electricity consumption
  - Strategic Energy Management (SEM) programs may encompass any instances of leak repairs
- Market Trends
  - Controls, monitoring, and data processing algorithms tailored for advanced compressed air systems are being developed and offered
  - Some end-use and system leak FDD available, as well as other alarms and monitoring capabilities

Market Overview and Analysis

- Market Barriers
  - Compressed air piping may not always undergo a thorough or standardized design process (especially additions)
  - Fault Detection and Diagnostic (FDD) products are relatively new but product lines and availability is growing
    - The Statewide CASE Team will conduct research to determine most-appropriate stringency of monitoring or FDD

Compressed Air Usage by Industry Group

SIC	Industry Group	Compressed Air System GWh/Year	Total Motor System GWh/Year	Comp. Air as % of Motor System Use	Comp. Air as % of Total Electric Use
28	Chemicals and Allied Products	39,960	144,362	27.7%	20.1%
33	Primary Metal Industries	12,609	87,935	14.3%	8.3%
29	Petroleum and Coal Products	7,930	51,938	15.3%	15.9%
37	Transportation Equipment	5,519	29,549	18.7%	14.0%
30	Rubber and Miscellaneous Plastics Products	4,767	36,610	13.0%	10.9%
26	Paper and Allied Products	4,533	99,594	4.6%	3.7%
36	Electronic and Other Electric Equipment	3,008	13,243	22.7%	9.1%
20	Food and Kindred Products	2,898	37,797	7.7%	4.5%
22	Textile Mill Products	2,392	16,750	14.3%	7.2%
24	Lumber and Wood Products	1,901	22,946	8.3%	8.7%
34	Fabricated Metal Products	1,777	7,296	24.4%	5.2%
35	Industrial Machinery and Equipment	1,172	7,378	15.9%	3.6%
38	Instruments and Related Products	721	6,487	11.1%	4.9%
32	Stone, Clay, and Glass Products	566	2,231	25.4%	1.6%
25	Furniture and Fixtures	460	3,694	12.5%	6.9%
27	Printing and Publishing	437	5,961	7.3%	2.5%
23	Apparel and Other Textile Products	398	1,168	34.1%	5.1%
31	Leather and Leather Products	1	491	0.3%	0.2%
20-39	Overall Manufacturing	91,050	575,428	15.8%	10.0%

https://www.energy.gov/sites/prod/files/2014/05/f16/newmarket5.pdf

Compressed Air Usage by Industry Group

SIC	INDUSTRY GROUP	PERCENT OF TOTAL ESTABLISHMENTS WITH		
		No CA System	Small CA System*	Full CA System
20	Food and Kindred Products	13%	34%	53%
22	Textile Mill Products	0%	24%	76%
23	Apparel and Other Textile Products	9%	0%	91%
24	Lumber and Wood Products	8%	10%	82%
25	Furniture and Fixtures	0%	0%	100%
26	Paper and Allied Products	19%	21%	61%
27	Printing and Publishing	95%	0%	5%
28	Chemicals and Allied Products	8%	7%	84%
29	Petroleum and Coal Products	0%	16%	84%
30	Rubber and Miscellaneous Plastics Products	0%	12%	88%
32	Stone, Clay, and Glass Products	0%	0%	100%
33	Primary Metal Industries	5%	13%	82%
34	Fabricated Metal Products	8%	61%	31%
35	Industrial Machinery and Equipment	1%	0%	99%
36	Electronic and Other Electric Equipment	9%	0%	91%
37	Transportation Equipment	0%	8%	92%
38	Instruments and Related Products	11%	0%	89%
20-39	Overall Manufacturing	18%	12%	70%

https://www.energy.gov/sites/prod/files/2014/05/f16/newmarket5.pdf

Compressed Air Operating Hours

Hours of Operation/Week	CA Market Assessment (n = 218)	PG&E Survey (n= 268)
40 hours or less	12%	19%
41 - 80 hours	25%	36%
81 -120 hours	21%	22%
121 - 167 hours	18%	6%
168 hours/week (7 days x 24 hours per day)	24%	17%

https://www.energy.gov/sites/prod/files/2014/05/f16/newmarket5.pdf

Compressor Management and Monitoring

- CASE Controls
- OmniMetrix AIRGuard
- Airleader
- Energair Solutions AIRMATICS
- Zira Lightapp
- Quincy Scales Smart Sequencer
- Kaeser Sigma Air Manager
- Ingersoll Rand X-Series and Xe-Series
- Atlas Copco Smartlink

Please indicate companies and products we did not list in the chat window

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Design and installation practices may vary
- Sizing to pressure drop versus sizing to air velocity
- Pressure drop savings only occur during loaded operation
- Welded versus threaded joints
- Compressor room and main branch piping versus end-use drops
- Measure life of leak repairs
- Leaks less significant in new systems and only a portion of leaks will be in hard-piping
- Metering locations and quantity
- Piping pressure testing methods
- Control differences between centrifugal and positive displacement compressors

Potential Barriers and Solutions

- **Inspection of pipe sizing is burdensome**
  - Plans will be leveraged in compliance process
  - Widely available, commonly accepted guidelines: Compressed Air Challenge, Compressed Air Handbook, etc.
- **Compressed air piping pressure and leak testing**
  - Even if uncommon for compressed air, pipe testing is common and a regular practice otherwise
- **Maintenance and operating staff cannot be expected to evaluate raw data**
  - Visualization and alarming
- **Leak repair is a manual process**
  - Aided and made more cost-effective through evaluation of metering data, load changes, and FDD

Energy and Cost Impacts
Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- **Calculation methodologies** will adhere to established, approved approaches
  - AirMaster+ and equivalent methods (similar to past CASE and other statewide efforts)
  - Parametric analysis of modeling results across influential variables (pressures, load profile, etc)
  - Pressure drops based on piping, flow, and pressure
- **Industrial facilities prototype buildings and parameters**
- **Impacts will not vary with climate zone**
- **Period of evaluation:** 15 years on time-dependent valuation (TDV) basis
- **Statewide impacts**: based on compressor life of 20 years and California industrial compressed air energy usage
  - Roughly 100,000 hp installed per year (equivalent to four-hundred 250 hp units)

Baseline and Proposed Conditions

Baseline

- Minimally compliant with 2019 Code
- 4,160 hrs/yr (16 hours x 5 days/week)
- 80% baseload, 20% variable trim
- Title 24, Part 6 receiver capacity
- 10% leakage in air distribution (new)
- 20-30% leakage in air distribution (existing)
- Pressure drop for minimally undersized piping (~15%) + 5% for other pressure drops

Proposed

- Minimally compliant with 2019 Code
- 4,160 hrs/yr (16 hours x 5 days/week)
- 80% baseload, 20% variable trim
- Title 24, Part 6 receiver capacity
- <10% leakage after mitigation
  - 0% in hard piping
  - 10% in end-use take-offs, hoses, etc.
- Pressure drop from proper pipe design for given flow and pressure (< 5%) +5% for other pressure drops

Initial Data and Findings

- Energy and cost-effectiveness analysis will provide results for second stakeholder meeting in 2020.
  - Leak repairs typically have payback under 1 year
- Information gaps to be addressed:
  - Market size
  - Standard pipe design and installation practices
  - Leak development rate and new system leak load fractions
  - Measure costs
  - Leak FDD product availability and metering product capabilities

Incremental Per Unit Cost

Pipe Sizing

- Incremental installation labor and material costs
- RS Means costing using California cost adjustment factors

Pressure Test (hard pipe)

- New construction – installed cost of fitting for pressure gauge and pressure gauge, outlet plugs
- Added piping – isolation valve, installed cost of fitting for pressure gauge and pressure gauge, outlet plugs

Leak Detection and Monitoring

- Metering and monitoring costs
- Leak audit and repair costs (done in base case but less frequently or similar frequency but less effective?)

Do any of these not make sense? Any additional costs not captured here?

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Facility or designers size piping according to flowrates and pressures at points in system
  - Using accepted design guidelines and best practices
- Power and flow monitoring system detailed on plans and specifications

2. Permit Application Phase

- Pipe design review
- New documentation of piping pressure tests
- Presence of monitoring system

Compliance Verification Process

3. Construction phase

- Right-sized piping is installed in the facility
- New piping leak detection and repair performed by testing ability of piping to maintain pressure (same as natural gas line test)
- Inspector observes no loss in pressure over 30 minutes

4. Inspection Phase

- Existing - Observation of sequencing control order of operations
- New - Pipe size installed same as approved plans
- New - Isolated pipe section able to maintain pressure for a test duration (similar to natural gas line leakage test)
- New – Monitoring system displays power and airflow

Market Actors

- Air compressor and controls manufacturers
- Air system designers
- Air system and piping installers, service providers, and contractors
- Building and plant owners and operators
- Compressed air masters and consultants
- Building inspectors and acceptance test technicians
- Commissioning agents

We are interviewing stakeholders for a variety of input and feedback over the coming months. Please help us gather all the data we can so we can provide useful recommendations that balance all stakeholders' needs as much as possible!

Proposed Code Changes

- Draft Code Change Language

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**:
  - New pipe sizing language
  - New leak testing and monitoring language
  - Revisions to existing language
- **What is most important to specify for these measures?**
- **What acceptance tests and compliance thresholds are feasible?**
- **What is confusing or inappropriate in existing 2019 language?**

Discussion and Next Steps

Data Requests

- Compressed air piping layouts for factories
  - With calculated flowrates for each end-use device
  - Design procedures and plans
- Measured pressure drops in factories and piping design case studies
- Compressed air system configurations
  - Number of compressors, type, and horsepower
  - Control optimization strategies
- Compressed air management systems and their capabilities:
  - Monitoring, trending, and visualization
  - Alarming (leaks and load growth or otherwise)

Please indicate in the chat window if you can share any of this data and we will follow-up with you offline.

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency
- **Comments on this measure** are due by November 21, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions? Input? Feedback?

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Automatic Steam Trap Monitoring

Codes and Standards Enhancement (CASE) Proposal

Nonresidential | Covered Processes

Kevin Johnson, AESC, Inc.

November 7, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

The proposal for the steam traps code change requires mandatory automatic monitoring equipment in new construction and alterations/additions for large installations on all required steam traps. A best practice requirement for strainers is also being considered.

Building Types	System Type	Type of Change	Software Updates Required
Nonresidential	Covered Processes	Mandatory	No

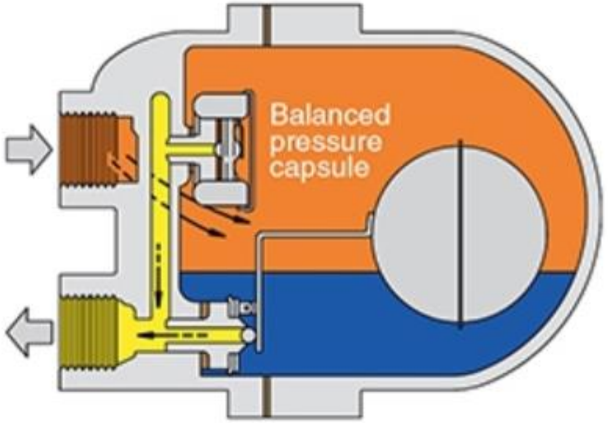
- All industries using steam traps will be impacted
- Smaller users may continue to perform manual inspections

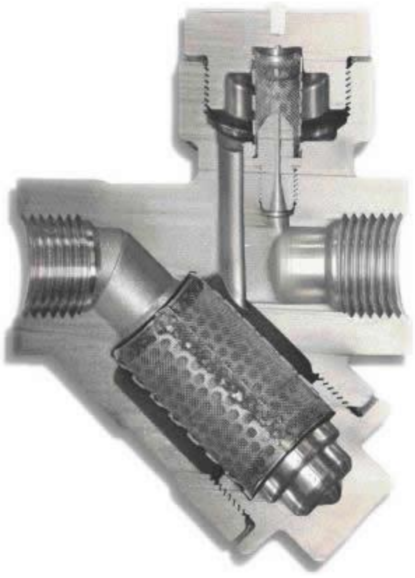
Context and History

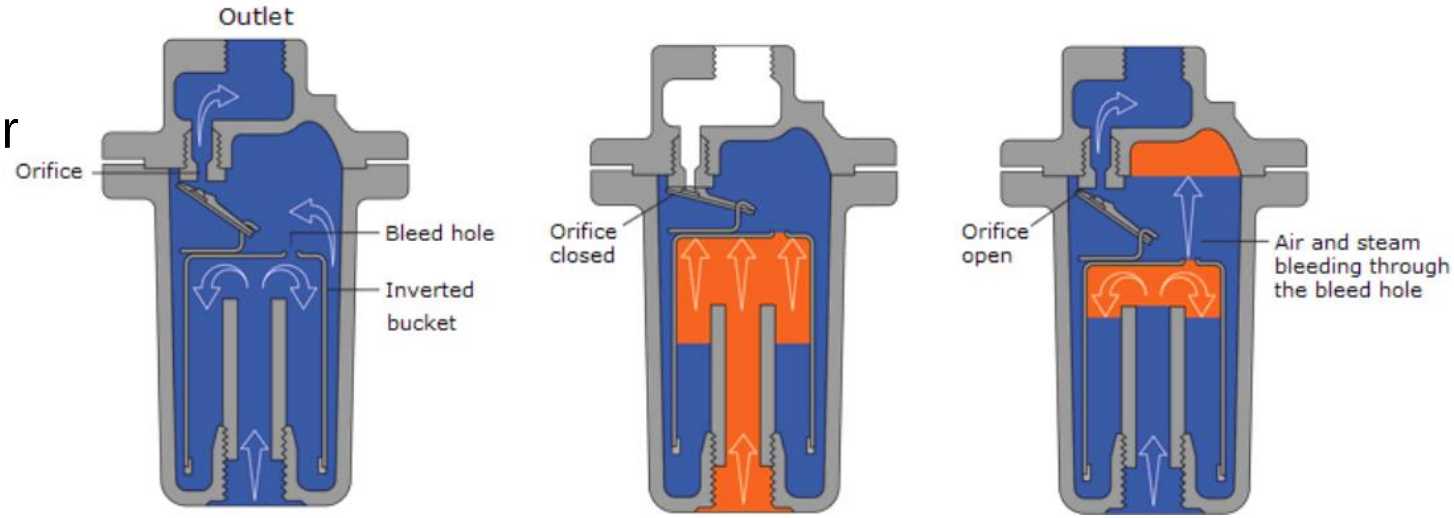
- Historically, **energy assessments** are most common method of promoting industrial energy efficiency
- The **2005 California Title 24, Part 6** building efficiency standards started regulating lighting in unconditioned spaces including process spaces
- The **2008 California Title 24, Part 6** regulated of process loads
  - Refrigerated warehouses: insulation, controls, variable speed fans, equipment efficiency
- The **2013 California Title 24, Part 6** expanded regulation of process loads
  - Includes, refrigeration systems for commercial and industrial facilities, cooling of data centers, fume hood ventilation systems, process boilers and compressed air
- Many process measures under consideration for 2022 California Title 24, Part 6

What Steam Traps Do

- **Holds back steam** so it condenses and gives up latent heat to heating process
- **Lets air condensate and pass** into condensate system and deaerator tank
  - Deaerator tank condensate (hot water) is pumped back into the boiler







Bucket trap modes of operation

Sources: Disk trap - http://www.peerless-inc.com/wp-content/uploads/2018/11/steam-trap-cutaway.jpg
Ball float trap and Bucket Trap - http://www.wermac.org/steam/steam_part6.html

US Industrial Steam Use by Sector

Table E.4. Manufacturing sector NAICS codes and net steam use

Sector	NAICS code	Sector net steam* (TBtu)
All manufacturing	31-33	3,810
Aluminum and alumina	3313	12
Cement	327310	18
Chemicals	325	1,134
Computers, electronics, and electrical equipment	334-335	19
Fabricated metals	332	26
Food and beverage	311-312	443
Forest products	321-322	1,198
Foundries	3315	2
Glass	272, 32799	15
Iron and steel	3311-3312	118
Machinery	333	15
Petroleum refining	324110	581
Plastics	326	52
Textiles	313-316	66
Transportation equipment	336	45

*The net steam use (in units of Trillion British Thermal Units or TBtu) by sector numbers are calculated by using EIA MECS offsite steam numbers and input fuel data for conventional boilers and combined heat and power (CHP) systems (and associated assumptions of boiler and CHP efficiency) to calculate the total amount of steam produced in each industry. EIA MECS does not allocate this steam to different end uses.

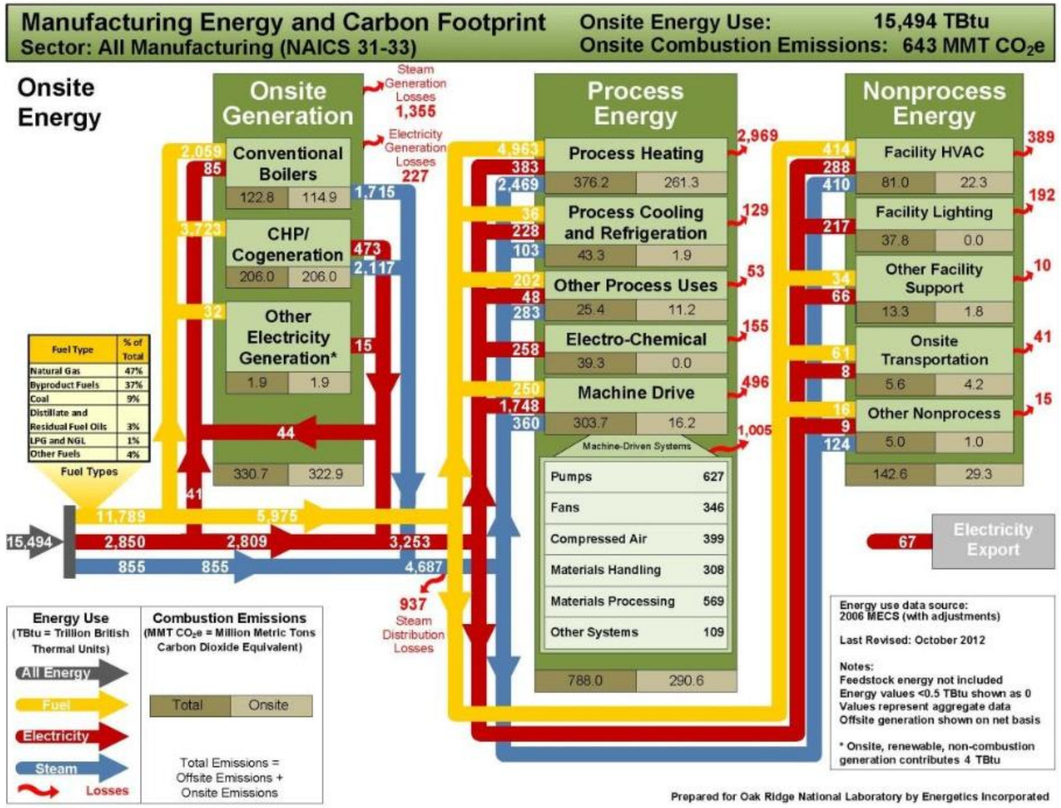
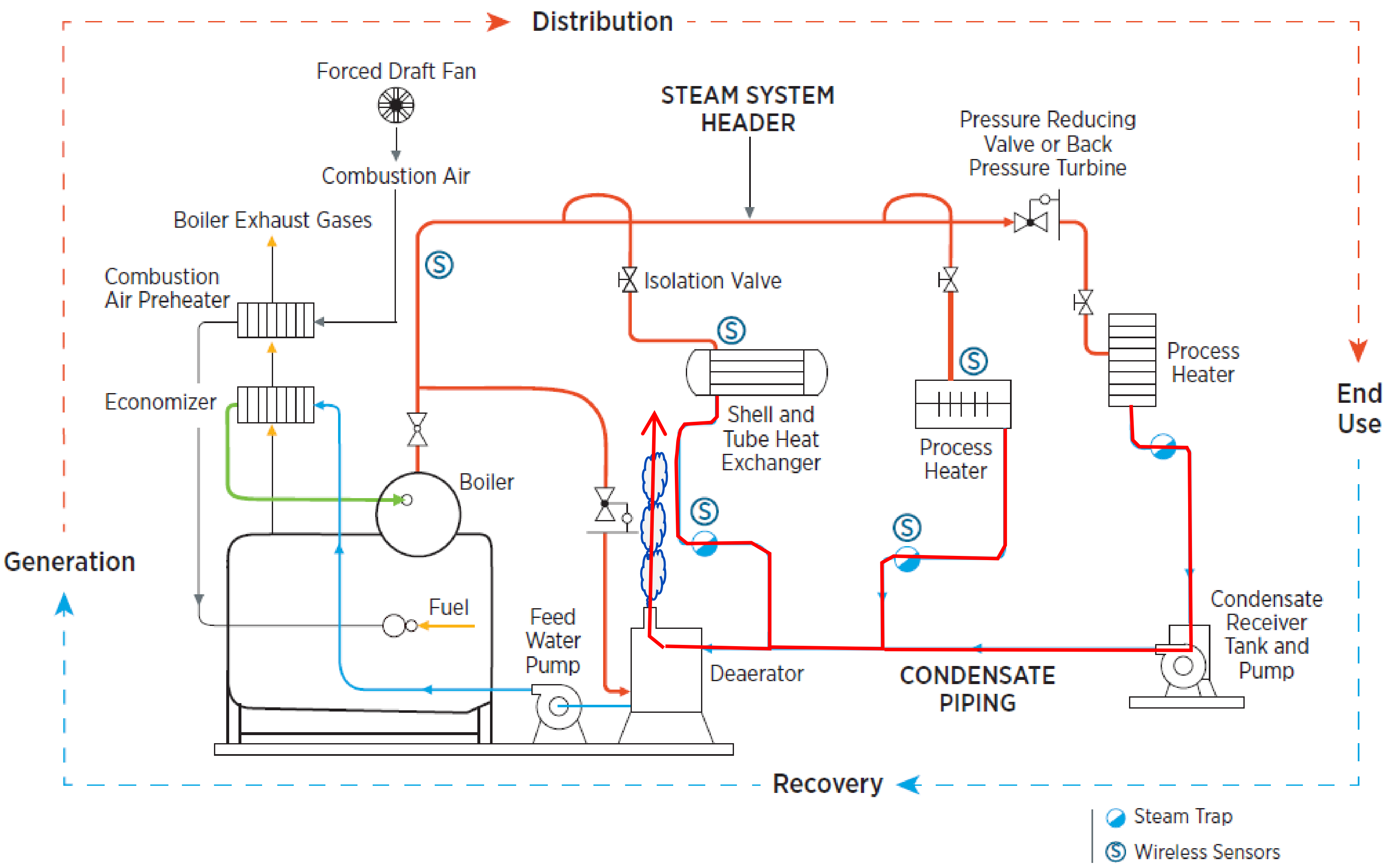


Fig. E.2. Manufacturing energy and carbon footprint for U.S. manufacturing - onsite energy

For California, Industrial Steam Use comes to ~4,348 Million therms/year when accounting for sectors operating in the State. New steam system construction may be ~145 Million therms/year in the State.

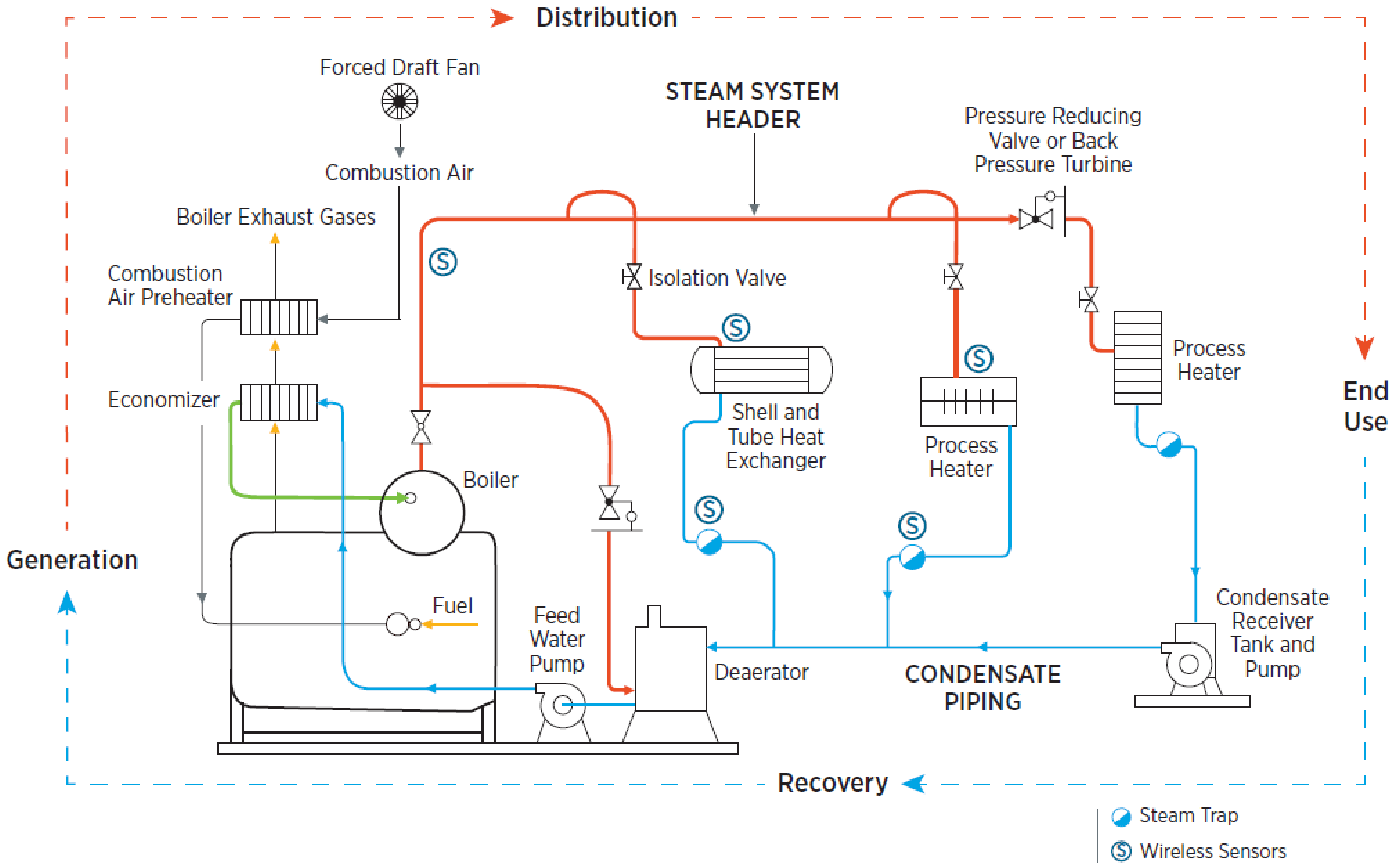
Source: ORNL/TM-2012/504 U.S. Manufacturing Energy Use And Greenhouse Gas Emissions Analysis
https://www.energy.gov/sites/prod/files/2013/11/f4/energy_use_and_loss_and_emissions.pdf

Steam Trap Failure Fundamentals



- If steam traps fail closed, heating stops in the upstream device and is often quickly remedied
- However, if steam traps fail open, upstream device is still being heated and traps may go unrepaired for a long time
- Stream passes through trap and is released to the environment through condensate system

Automatic Steam Trap Monitoring System (ASTMS) Proposal



- Monitoring sensors on steam traps indicate failure has occurred
- Traps are ideally fixed as quickly as possible, so less steam is lost through condensate piping and out of deaerator tank vent
- According to USDOE, typical steam trap losses in commercial buildings with an average proactive manual detection program are around 6%
- With monitoring sensors, the steam trap failure will be identified more quickly, and reduced steam losses will be realized

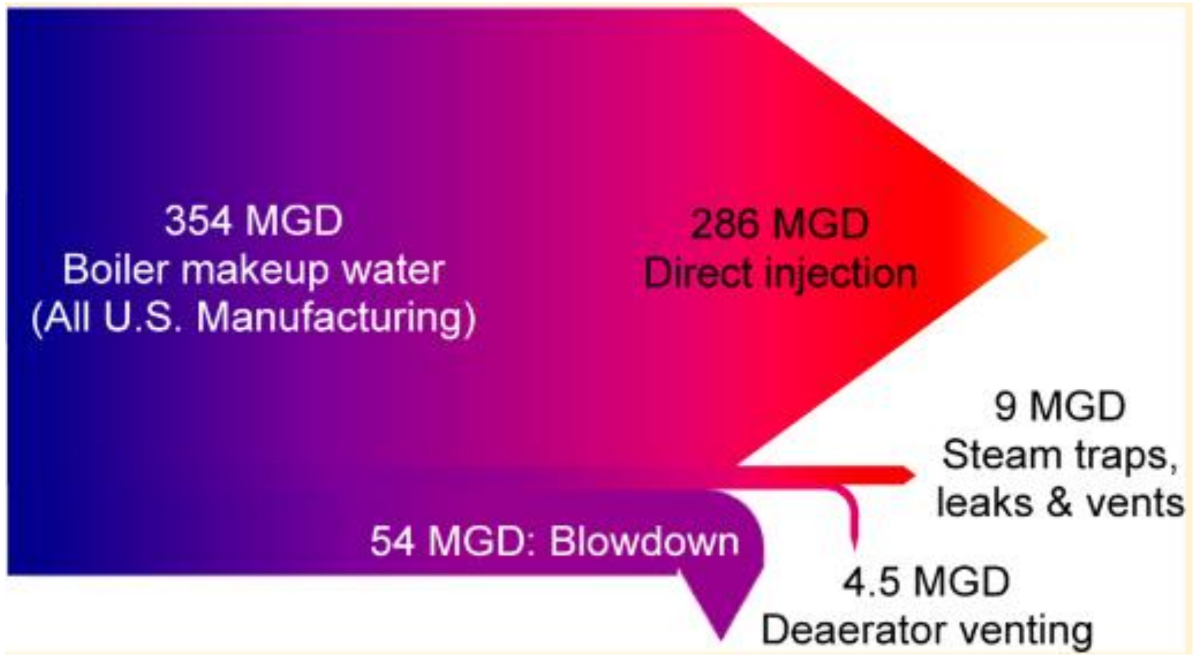
USDOE Improving Steam System Performance: A Sourcebook for Industry. https://www.energy.gov/sites/prod/files/2014/05/f15/steamsourcebook.pdf

USDOE (FEMP) Steam Trap Performance Assessment

- Approximately **20%** of the steam leaving a central boiler plant is lost via leaking traps in typical space heating systems **without proactive assessment programs**.
- A “simple” program would use rudimentary portable test equipment once a year. An “intermediate” program would use more sophisticated portable test equipment twice year. The “best” program would use permanently installed test equipment allowing continuous monitoring and evaluation.
- If the **average loss rate** for a **proactive program is 6%,** then a **minimal program** (using rudimentary test equipment) might reduce losses to about **8%** and an **intermediate program** (using good portable equipment and more frequent testing) should yield better results, **reducing losses to perhaps 4%**
- **Fixed test equipment**, combined with a proactive and immediate repair program, allowing continuous monitoring and evaluation, can reduce **losses to less than 1%.**

Steam Trap Performance Assessment. https://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf

Water Usage by US Industrial Steam Systems



- For sites without direct steam injection, leaks, vents and steam traps account for around 13% of steam boiler water make-up use.
- Additional costs are associated with water treatment chemicals for the makeup water lost by leaking steam traps.

Industrial Steam Systems and the Energy-Water Nexus. https://pubs.acs.org/doi/pdf/10.1021/es403715z

First Year Statewide Savings (Initial Estimate)

2.9 Million therms/year natural gas savings

- Assumed boiler load subject to new permitting requirements is around ~145 Million therms/year
- Conservative 2% savings for automated monitoring sensors versus well implemented ongoing manual steam trap detection program

15,800 Metric Tonnes/yr CO_2e GHG reduction

- Based on an emissions factor for natural gas of 5,454 Metric Tonnes CO_2e/Million therms

25.6 Million gal/yr water savings + associated water treatment chemicals

- Assuming 70% of mass of leaked steam leaves deaerator tank, the other 30% condenses on the way to the deaerator tank

Steam trap energy loss prevention, maintenance savings potential TBD

Is the proportion of steam leakage leaving deaerator tank (70%) reasonable?

Context and History

Technological approach to energy savings

- Steam traps separate live steam from condensate (liquid) and non-condensables (air)
  - Moving trap parts eventually fail
  - Upon failure in the open position, steam vents to the atmosphere and results in significant loss of energy

Mandatory automatic monitoring equipment

- Provides instant reporting of failures
- Reduces labor required to manually check steam traps
- Data collected: temperature, fluctuations in steam flow, etc.
- May be appropriate at facilities using steam pressure greater than 15 psig

2019 Code Requirements for Process Steam

- Section 120.6 (d) Mandatory Requirements for Process Boilers
  - Vent dampers on atmospheric combustion boilers
  - VSD on boiler combustion air fans > 10 hp
  - Parallel positioning gas and air control (< 5% O2) 5 to 10 MMBtu/hr
  - O2 trim control (< 3% O2) > 10 MMBtu
- No existing Title 24, Part 6 (Covered Processes) code requirements for Steam, Steam Trap or Steam Trap Monitoring Systems
  - Baseline is manual inspection of traps, some facilities are more systematic than others
  - Many using ultrasonic or thermographic detection

Poll

What operating pressure is most common in process steam systems? Please select the closest pressure. Use chat window for added comments.

A. 15 psig
B. 50 psig
C. 100 psig
D. 150 psig
E. 250 psig
F. 500+ psig
G. None of the above
H. Not sure

Proposed Code Change Overview

- Description of change:
  - Cover all nonresidential facilities exceeding 15 [TBD] psig operating steam pressure:
    - New construction
    - Evaluating steam process additions or alterations
    - Evaluating trigger based on steam trap replacement quantity over a certain size
  - Require installation of an automatic steam trap monitoring system
    - Each subject steam trap would be equipped with a monitoring sensor; integrated or add-on
    - Sensor communicates with central network to report failures and provide alarm function
- **What are triggers for automated monitoring control?**
- **Boiler size? Operating pressure?**
  - **Number of steam traps?**
  - **Size of steam traps?**

Proposed Code Change Overview

- **Exceptions**
  - Steam systems under a XXX [TBD] MMBtu/hr
  - Seasonal steam processing systems where annual operating hours are less than YYY [TBD] hours annually
  - Minimum steam trap quantity ZZZ [TBD] % of total traps
- **Acceptance Requirements**
  - Construction Inspection to verify installation [TBD]
  - Functional Testing Requirement to ensure proper function [TBD]
- **What other exceptions should be considered?**
- **What are reasonable acceptance requirement qualification alternatives?**
- See proposal summary and mark-up language in **resources tab**

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- **Current Market**
  - About 4.4 billion therms per year consumed in statewide industrial sector alone
    - Steam trap market is well established, automated monitoring is still emerging into widespread use
  - Boiler load subject to new permitting requirements subject to measure: ~145 Million therms/year
  - Unsure of load impacted by additions and alterations
  - Steam trap failure rate is approximately 10% in the presence of an average maintenance program

Steam trap periodic manual assessment is considered best practice, but is it standard practice?

- **Market Trends**
  - Based on initial stakeholder feedback, steam trap automatic monitoring is not standard practice in new steam installations
  - Unsure what currently drives adoption of steam trap automatic monitoring systems. Process criticality? Process safety?

Do you agree with this description? What else should we know?

Steam Trap Monitoring Products and Services

- **Armstrong International:** AIM   Armstrong Intelligent Monitoring, SteamEye
- **Cypress Envirosystems:** Noninvasive Wireless Steam Trap Monitor
- **Emerson:** Rosemount Wireless Transmitter with Software for real time conditions and energy use
- **Everactive**: Steam Trap Monitor
- **GESTRA, Inc.:** Conductivity meters upstream and wireless ultrasonic meters
- **Honeywell**: OneWireless Steam Leak Detection (acoustic transmitter)
- **Spirax Sarco:** STAPS Spirax Total Acoustic Performance Solutions
- **SteamIQ**: SteamIQ Steam Trap Monitoring
- Any others?

If you know of other steam trap monitoring products, please enter the company name and contact information in the chat window.

Market Overview and Analysis

- **Market Barriers**
  - Builder processes
    - Builders may not be accustomed to designing systems with steam trap monitoring
    - Design process leaves the selection of steam traps to installer
  - Capital cost
    - Cost-effectiveness of steam trap maintenance is well documented in available literature
    - Simple payback period of trap maintenance varies between 0.5 - 6 years, depending on technology
    - Despite upfront costs, automated detection would cost-effectively prevent energy loss for many operating conditions
- **Will ASTMS drive operational change in steam trap repair practices?**
- **Will ASTMS increase or decrease maintenance costs facilities?**
- **Do you agree with this description? What else should we know?**

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations – Steam Trap Monitoring

- **Technical Considerations**
  - Change in standard design processes is required
  - Multiple types of equipment available for automatic monitoring
    - Wired vs. Wireless Installation- what variables impact the wireless installation method?
      - Various networking conditions- local network(s), cellular, cloud, etc.
    - Sensor type- Temperature, ultrasonic, etc.
    - Integrated package, add-on equipment
- **Technical Barriers and Potential Solutions**
  - Fault detection methods
    - Different types of monitoring rely on different reporting methods and will be evaluated
  - Acceptance test method does not currently exist
    - Will measure only need desk-based review or site inspection (and functional test)?
- **What else should we know?**

Poll

What is the frequency that a steam trap fails in an open position versus closed? Please select the closest fraction. Use chat window for added comments.

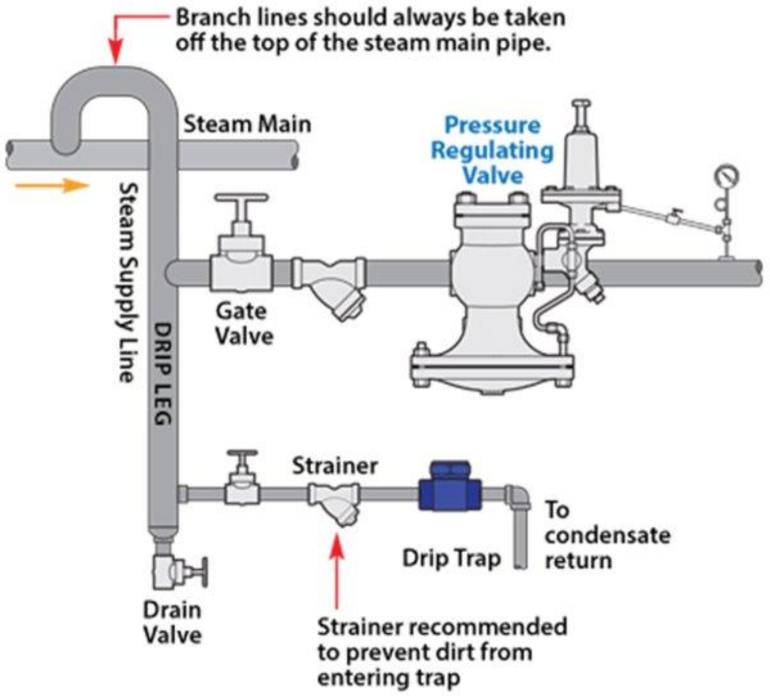
A. 0% Failed Open
B. 25% Failed Open
C. 33% Failed Open
D. 50% Failed Open
E. 66% Failed Open
F. 75% Failed Open
G. 100% Failed Open
H. Not sure

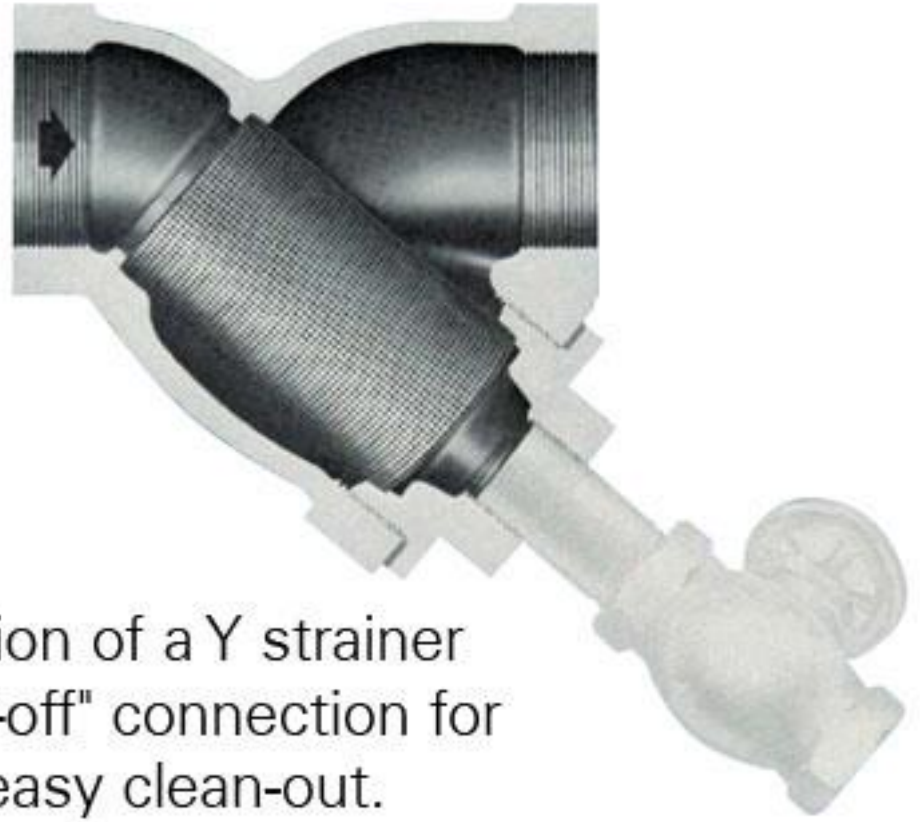
Technical Considerations – Strainer installation

- **Consider requiring installation of strainer and blow-off valve in addition to automatic steam trap monitoring system**
  - Strainer would protect against dirt, particles of carbonates, rust, etc.
  - Manufacturer recommended best practice
  - Increases steam trap life and reduces blockage and partial failures
  - Does requires maintenance: removal of particulates from screen
  - Uses blow-off valve (plug or ball valve)
- **Is there significant energy savings associated with the installation of strainers?**
- **Are there any significant costs or reasons to not include a strainer requirement?**
- **Steam trap periodic manual assessment is considered best practice, but is it standard practice?**

Technical Considerations – Strainer

- Strainer protects against dirt, particles of carbonates, rust, etc. and uses a blow-off valve





Cross-section of a Y strainer with "blow-off" connection for quick and easy clean-out.

Poll

In the absence of an associated strainer, what is the average expected time between steam trap failures?

Please pick the closest value. Use chat window for added comments.

A. 1 year
B. 2 years
C. 3 years
D. 4 years
E. 5 years
F. 6 years
G. 7+ years

Strainer Energy Savings Hypothesis: Two Mechanisms

Energy savings in addition to savings from ASTMS

1. Longer Times between Failure

- When ASTMS system detects failure there is a time lag between detection and repair (T weeks?)
- Periods between steam trap failure with strainer is extended from A Years to B Years.
- Using A = 2 and B = 5, over 15 years without strainer 7.5 replacements, with strainer 3 replacements
- Savings over 15 years = 4.5 x T weeks of steam leak loss.

2. Reduces low level trap leaks not large enough to be captured by ASTMS

- Strainers catches small particles that lodge in steam trap – causing a partially open failure
- Small particles damage mating surfaces of steam trap

How long between steam trap detection and repair?

What is the mean time before steam trap failure with and without strainer protecting the trap?

Strainer Energy Loss Hypothesis, Cont.

- During times that a steam trap is clogged (failed closed), staff may use strainer blow-off valve to bypass the steam trap and condensate system and keep live steam passing through process device. This results in:
  - Greater steam loss
  - Safety hazard
  - Steam and condensate discharged in area by strainer.
- **When a steam trap is clogged, how likely is this scenario? (Never, Rarely, Occasionally, Frequently)**
- **When bypassed, how long would this scenario be allowed to occur? (minutes, hours, days?)**
- **Are there some locations (outdoors?) or applications where this is more likely?**

Strainer Life Cycle Analysis

Cost Side of Life Cycle Cost Calculation

- Installed cost
- Incremental periodic replacement cost discounted by time value of money when it occurs
- Present value of periodic maintenance cost (blow-down of strainer)

Savings Side of Life Cycle Cost Calculation

- Present value of energy savings over 15 years
- Present value of reduction in periodic steam trap repairs

What is the replacement cost of a strainer including labor? What is the replacement cost including labor of replacing/repairing a steam trap?

Strainer Questions

- What fraction of steam traps have strainers?
- Are there certain applications where strainers are not desirable?
- What applications are strainers almost always used?
- How frequently is strainer blowdown performed?
- How long does it take to conduct blowdown on 10 strainers?
- What is the approximate cost for end-user to do blowdown? Alternatively what is the labor rate ($/hr) for staff doing strainer blowdown?

Poll

What is the average expected time between steam trap failures for steam traps equipped with a strainer (integral or external)? Please select the closest value. Use chat window for added comments.

A. 1 year
B. 2 years
C. 3 years
D. 4 years
E. 5 years
F. 6 years
G. 7+ years
H. Not sure

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Methods and assumptions are yet to be fully established
- Initial energy savings and cost savings potential presented
- Calculation methodologies will adhere to established approaches
  - Statewide workpapers
  - DOE Research
  - Custom spreadsheet analysis is likely necessary
- Industrial facilities will not have established prototype buildings or parameters
- Impact varying by climate zone will be determined (likely for non-industrial facilities)
- **Should scope be limited to industrial facilities?**

Poll

How often do you conduct a steam leak assessment? Please select the closest frequency. Use chat window for added comments.

A. Quarterly
B. Bi-annually
C. Annually
D. Every 2-3 years
E. 5+ years
F. Never
G. Not sure

Assumptions for Energy Impacts Analysis

- Program life cycle evaluation period 15 years based on monitoring system estimated EUL
- Typical mechanical steam trap average life is 3-5 years before rebuild/replacement necessary
- Monitoring system equipment may have estimated useful life between 5-10 years
- Estimating 10% of steam traps fail on an annual basis between routine annual inspections based on stakeholder feedback
- Savings potential only present when traps fail open versus closed, assume 67% of time
- Average time a non-critical failed open trap is repaired is 3-6 months based on stakeholder feedback
- Current natural gas prices average $0.70/therm[a]
- Unclear how to correlate steam trap per unit savings to statewide market savings
- Turn over (new construction and end of useful life replacement) is approximately 145 Million Therms/year
- Need to investigate market by steam system pressure, what operating pressures are common?

What else should we know? Is the industrial market the majority of the market?

[a] EIA California Natural Gas Industrial Price (Dollars per Thousand Cubic Feet)

Poll

How soon following identification of a failed open steam trap is a repair/replacement conducted?

Please pick closest duration. Use chat window for added comments.

A. Immediately
B. 1 week
C. 1 month
D. 3 months
E. 6 months
F. 1+ year
G. Never
H. No opinion

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Minimally compliant with 2019 Code
- Manual assessment conditions vary, might be a function of steam pressure and steam trap criticality
  - Amount of time failed open trap remains unrepaired important
- 10% average failed steam trap rate

Proposed Conditions

- Assume that ASTMS' immediate reporting of fault detection drives operational change, resulting in faster repair of non-critical failed open steam traps
- Assume strainer improves system cleanliness, reducing partial failures and extending steam trap life

Initial Data and Findings

- Preliminary savings estimates based on industrial market size, potential market impacted by proposed code language, steam trap failure reduction potential.
- Energy and cost-effectiveness analysis will provide results for second stakeholder meeting in 2020
  - Preliminary research suggests paybacks as low as 6 months
- Information gaps to be addressed
  - Market size (industrial versus non-industrial)
  - System size, system pressure and steam trap orifice size across sectors
  - Manual steam trap assessment occurrence rate(s)
  - Failure occurrence rate
  - Measure costs (steam trap monitoring equipped steam traps vs upstream monitoring, central control systems)

Parametric Energy Savings Estimates

Napier's Equation; Losses (lbm/hr) = 24.24 * Pabs * D^2

P_{abs}= Absolute Pressure, psia

D = Steam trap orifice diameter, inches

Assumptions:

- 3.75 rebuilds over 15 years, 6 months failure each time
- 67% chance on failure to fail in open position
- 50% of de-rate flow on orifice size
- 83% boiler efficiency
- $1.07/therm cost of natural gas (average estimate over 15 years)

Savings model: https://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf

Parametric Energy Savings

Estimate of Steam Savings (Therms/Trap-Year)

	Steam Loss, therms/trap-year							
Orifice Diameter, in	**System Pressure, psia**							
	30	**45**	**65**	**85**	**100**	**115**	**140**	**165**
1/32	3.64	5.49	7.99	10.49	12.37	14.26	17.40	20.56
1/16	14.55	21.98	31.94	41.95	49.48	57.03	69.62	82.23
3/32	32.74	49.45	71.87	94.39	111.33	128.31	156.64	185.01
1/8	58.21	87.91	127.77	167.81	197.92	228.11	278.47	328.91
5/32	90.95	137.36	199.64	262.20	309.25	356.42	435.10	513.92
3/16	130.96	197.80	287.48	377.57	445.32	513.24	626.55	740.04
7/32	178.26	269.22	391.30	513.91	606.13	698.58	852.80	1,007.28
1/4	232.83	351.64	511.08	671.23	791.68	912.43	1,113.86	1,315.63
9/32	294.67	445.04	646.84	849.53	1,001.97	1,154.79	1,409.73	1,665.09
5/16	363.79	549.43	798.57	1,048.80	1,237.00	1,425.67	1,740.41	2,055.66
11/32	440.19	664.82	966.27	1,269.05	1,496.78	1,725.06	2,105.90	2,487.35
3/8	523.86	791.19	1,149.94	1,510.27	1,781.29	2,052.96	2,506.19	2,960.16
13/32	614.80	928.54	1,349.58	1,772.47	2,090.54	2,409.38	2,941.29	3,474.07
7/16	713.03	1,076.89	1,565.20	2,055.64	2,424.53	2,794.31	3,411.20	4,029.10
15/32	818.53	1,236.23	1,796.78	2,359.80	2,783.26	3,207.76	3,915.92	4,625.25
1/2	931.30	1,406.55	2,044.34	2,684.92	3,166.73	3,649.71	4,455.45	5,262.50

Present Value Energy Cost Savings

Estimate of Present Valued Steam Cost Savings per Trap

	Steam Loss Cost Avoided, $/trap-year							
Orifice Diameter, in	System Pressure, psia							
	30	45	65	85	100	115	140	165
1/32	$ 58	$ 88	$ 128	$ 168	$ 198	$ 228	$ 278	$ 329
1/16	$ 233	$ 352	$ 511	$ 671	$ 792	$ 912	$ 1,114	$ 1,316
3/32	$ 524	$ 791	$ 1,150	$ 1,510	$ 1,781	$ 2,053	$ 2,506	$ 2,960
1/8	$ 931	$ 1,407	$ 2,044	$ 2,685	$ 3,167	$ 3,650	$ 4,455	$ 5,263
5/32	$ 1,455	$ 2,198	$ 3,194	$ 4,195	$ 4,948	$ 5,703	$ 6,962	$ 8,223
3/16	$ 2,095	$ 3,165	$ 4,600	$ 6,041	$ 7,125	$ 8,212	$ 10,025	$ 11,841
7/32	$ 2,852	$ 4,308	$ 6,261	$ 8,223	$ 9,698	$ 11,177	$ 13,645	$ 16,116
1/4	$ 3,725	$ 5,626	$ 8,177	$ 10,740	$ 12,667	$ 14,599	$ 17,822	$ 21,050
9/32	$ 4,715	$ 7,121	$ 10,349	$ 13,592	$ 16,032	$ 18,477	$ 22,556	$ 26,641
5/16	$ 5,821	$ 8,791	$ 12,777	$ 16,781	$ 19,792	$ 22,811	$ 27,847	$ 32,891
11/32	$ 7,043	$ 10,637	$ 15,460	$ 20,305	$ 23,948	$ 27,601	$ 33,694	$ 39,798
3/8	$ 8,382	$ 12,659	$ 18,399	$ 24,164	$ 28,501	$ 32,847	$ 40,099	$ 47,363
13/32	$ 9,837	$ 14,857	$ 21,593	$ 28,359	$ 33,449	$ 38,550	$ 47,061	$ 55,585
7/16	$ 11,408	$ 17,230	$ 25,043	$ 32,890	$ 38,792	$ 44,709	$ 54,579	$ 64,466
15/32	$ 13,096	$ 19,780	$ 28,748	$ 37,757	$ 44,532	$ 51,324	$ 62,655	$ 74,004
1/2	$ 14,901	$ 22,505	$ 32,709	$ 42,959	$ 50,668	$ 58,395	$ 71,287	$ 84,200

Relationship between Orifice Size and Outlet Pipe Size

- Examining two options to establish ASTMS requirements:
  - Steam Trap Orifice Diameter – directly determines steam loss
  - Steam Trap Outlet Pipe Diameter – directly observable by compliance official or building inspector
- Steam trap outlet pipe diameter may be easier to enforce than steam trap orifice diameter
- Steam trap orifice diameter decreases as steam pressure increases

Can outlet pipe diameter be correlated to steam trap orifice diameter?

Outlet Piping Size and Capacity - Rule of Thumb

Maximum Condensate Load (gpm)	Equipment Outlet Piping Size nominal diameter
< 1	1/2"
1 to 2	3/4"
2 to 4	1"
4 to 8	1-1/4"
8 to 12	1-1/2"
12 to 20	2"
>20	2-1/2" to 4"

- Potentially easier to enforce steam trap requirements based on outlet pipe size
  - Directly observable
  - Less pressure dependent – directly related to capacity
- Less precise calculation of savings
- **Do you find this method to be reasonable?**
- **Are there alternative methods which should be considered?**

https://www.tlv.com/global/US/steam-theory/steam-trap-selection-part-2.html

Example Size Thresholds for Steam Trap Monitoring

[Example values presented below]	Option A and Option B are currently being evaluated. Input for feasibility desired. Only one option will be included in the 2022 code language.	
SYSTEM 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	≥ 1”
≥50 but <150	5/32	≥ 3/4”
≥150	3/32	≥ 1/2”

Incremental Cost Information

- How we collected costs of base case technology and proposed technology
  - Web based sources from installers
  - Department of Energy studies
  - Stakeholder feedback
- Costs were found to be between $500 - $5,000 per ASTMS control point
  - Unknown costs include: control integration (including hardware, software and programming), engineering design and other compliance related costs
- **What components of costs have not been accounted for?**
- **Do you find these costs to be reasonable?**

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Facility or designers specify sensor type and communication method according to necessary plant operations
  - Flowrates
  - Temperature
  - Criticality
  - Location in system, etc.

2. Permit Application Phase

- Still investigating method of compliance, may require adjustment to permitting process
  - Approaches include:
    - Certificate of Compliance at Plan Check

Compliance Verification Process

3. Construction phase

- ASTMS is installed as designed on mandatory required steam traps.
  - Approaches include:
  - Certificate of Installation at Building Inspection

4. Inspection Phase

- Inspection approach dependent on compliance, TBD
  - Acceptance Test Technician confirms construction compliance
  - Acceptance Test Technician confirms functional test

Stakeholder Outreach: Market Actors

- Steam system components (steam traps and strainers) and controls manufacturers
- Steam trap automatic monitoring system manufacturers (previously mentioned)
- Steam system designers, installers and consultants
- Building and plant owners/operators
- Cal/OSHA, Building/Permit inspectors, Mechanical ATTs
- DOE, IAC, IOU, research institutions and energy consultants
- Industry/Trade associations

We are currently interviewing stakeholders for a variety of input and feedback discussed in the presentation. We need help to gather relevant information, concerns and data so we can provide meaningful recommendations that capture all stakeholders' perspective.

If interested in providing assistance, please enter your name and email in the chat box!

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Proposed draft code language available in the resources tab
  - New process steam trap language
  - What Exceptions should be considered?
    - Boiler capacity
    - Steam system pressure
    - Steam trap specification(s)
    - Steam trap quantity
    - Facility operating hours
- Acceptance and Compliance testing methods- Construction, Visual, Functional
- **What is most important to specify for these measures?**
- **What acceptance tests and compliance thresholds are feasible?**
- **What is potentially confusing or inappropriate code language?**

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

- **Comments on this measure** are due by November 21, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

2022 CALIFORNIA ENERGY CODE (TITLE 24, PART 6)

Refrigeration System Opportunities

Codes and Standards Enhancement (CASE) Proposal

Nonresidential

Trevor Bellon, *VaCom Technologies*

November 7, 2019

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Agenda

1. Submeausure A: Design and Control Requirements for Transcritical CO2 Systems (RWH and Commercial Refrigeration)
2. Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)
3. Submeasure C: Evaporator Specific Efficiency for RWH
4. Submeasure D: Automatic Door Closers
5. Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure A: Design and Control Requirements for Transcritical CO_2 Systems (RWH and Commercial Refrigeration)

Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)

Submeasure C: Evaporator Specific Efficiency for RWH

Submeasure D: Automatic Door Closers

Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure A- CO2 Systems

Background

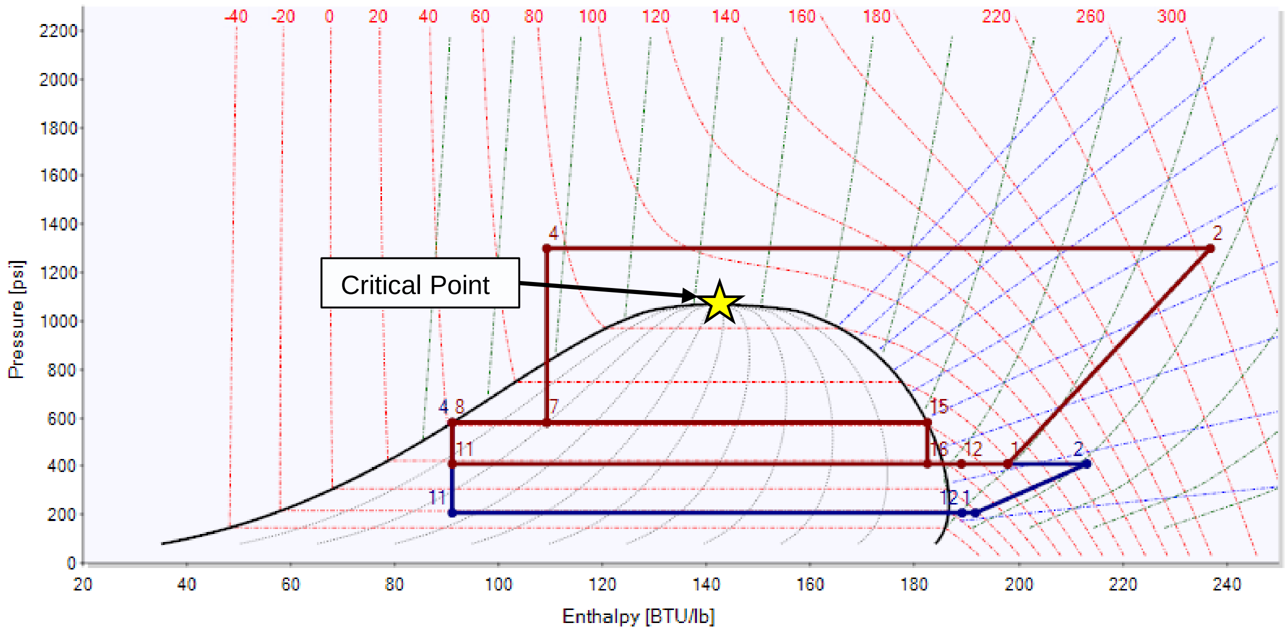
- Context and History
- 2019 Code Requirements
- Code Change Proposal

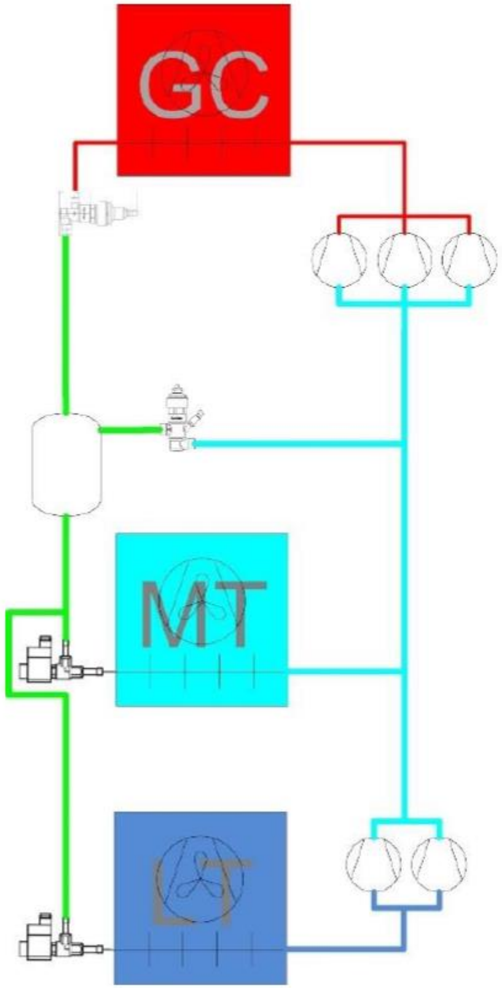
Context and History

- **Why are we proposing this measure?**
  - Phase out of high GWP halocarbon refrigerants
  - Transcritical CO_2 systems are increasing in popularity
  - Current gap in Title 24 measures which do not include transcritical CO_2 systems
  - Significant savings opportunity for new installations
  - Clarify appropriate design practice for owners and designers interested in CO_2 systems

Context and History

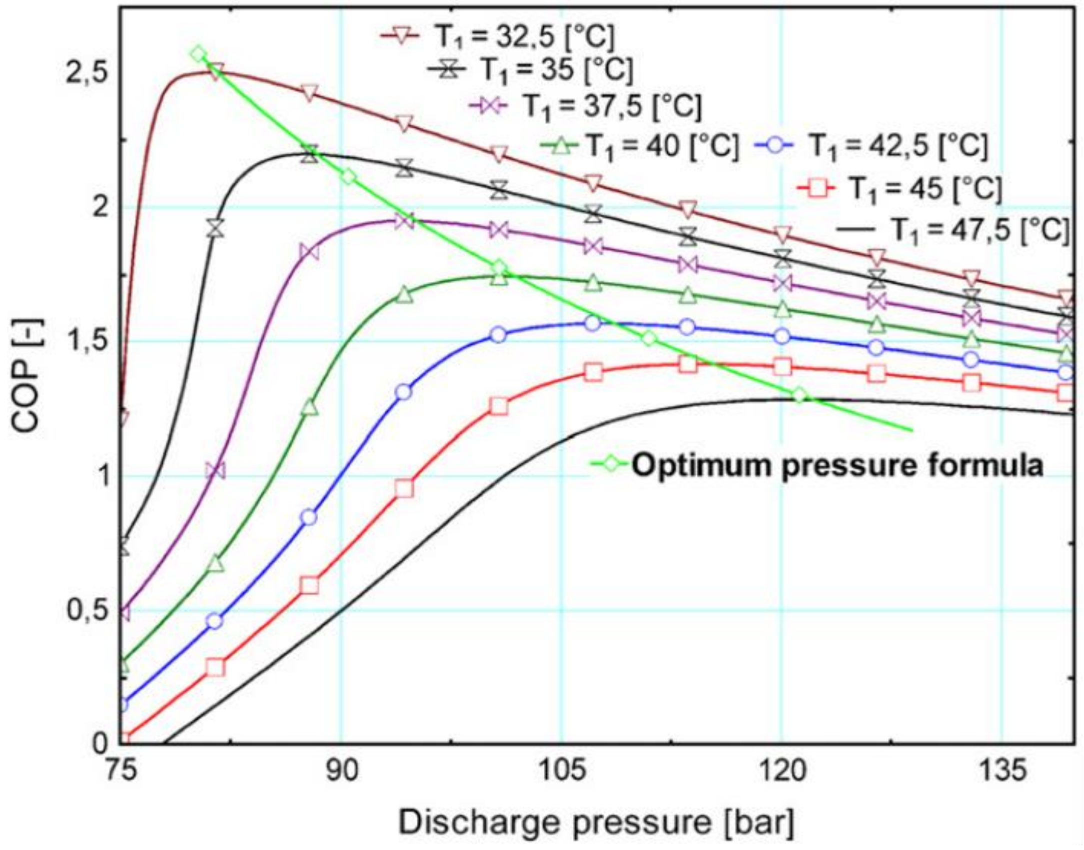
- Transcritical CO2 Systems
  - System with CO2 as only working fluid
  - Low critical point (~87F SCT)
  - System efficiency significantly decrease during transcritical operation





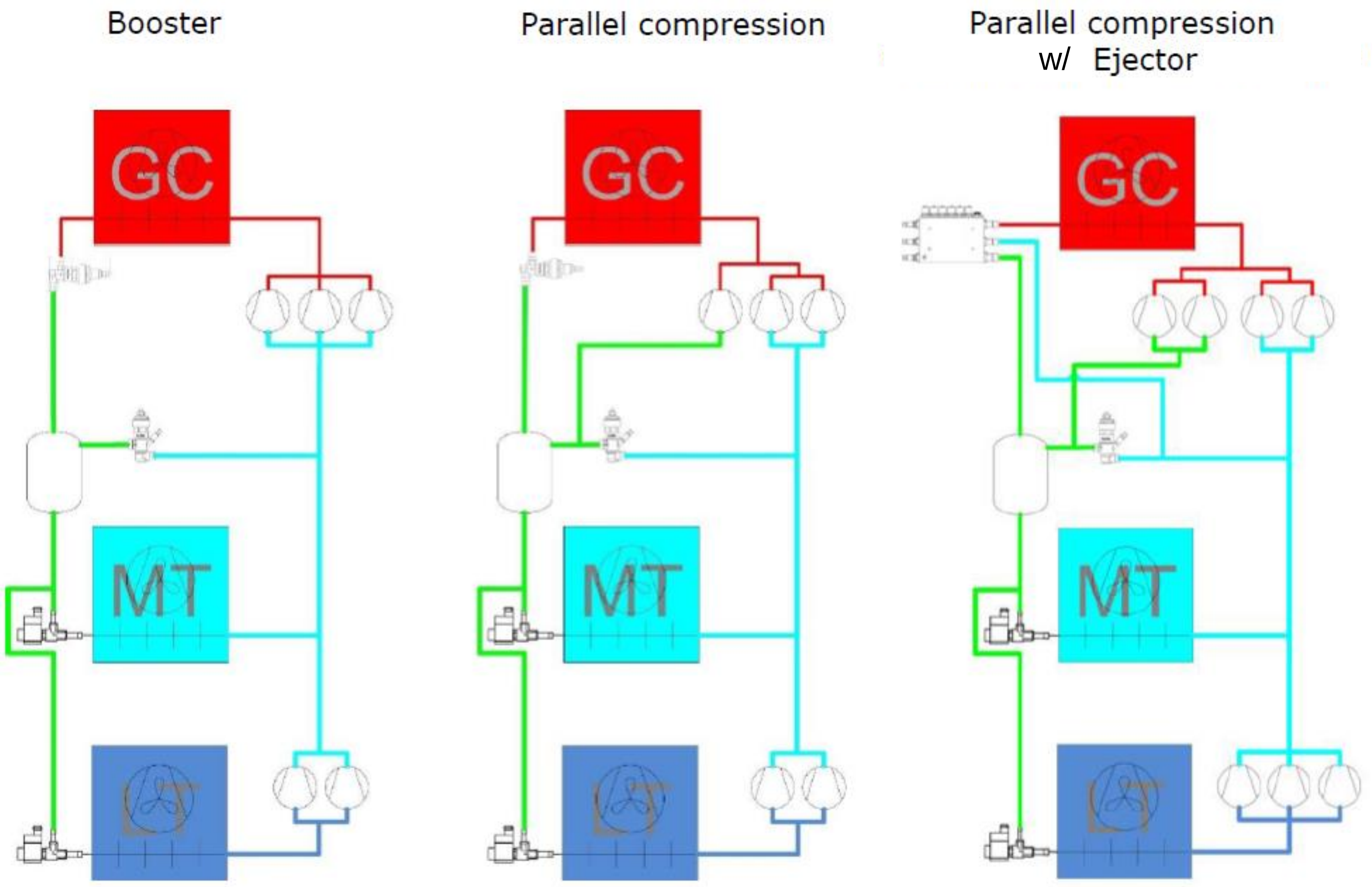
Context and History

- Gas cooler sizing
  - Trade off between first cost and minimizing transcritical hours (i.e., reducing annual operating costs)
- Gas cooler pressure control
  - Optimized pressure control (transcritical)
  - Typical ambient temperature following control (subcritical)
- Possible requirements could mandate gas cooler type in certain climate zones (adiabatic)



Context and History

- Parallel Compression
- Gas ejectors for improved COP in transcritical mode
- Active new technology development, particularly around high ambient efficiency



Code Change Proposal – Summary

Addition of design and control requirements for transcritical CO_2 booster systems Title 24, Part 6 Section 120.6(a) and 120.6(b)

Building Types	System Type	Type of Change	Proposed Measures
Refrigerated Warehouses (RWH)	New construction transcritical CO_2 booster systems	Mandatory	• Minimum gas cooler sizing • Minimum gas cooler specific efficiency • Floating head pressure control • Minimum saturated condensing temperature • Parallel compression • Gas ejectors • Gas cooler pressure control during transcritical operation
Commercial Refrigeration	New construction transcritical CO_2 booster systems	Mandatory	• Minimum gas cooler sizing • Minimum gas cooler specific efficiency • Floating head pressure control • Minimum saturated condensing temperature • Parallel compression • Gas ejectors • Gas cooler pressure control during transcritical operation

Submeasure A- CO2 Systems

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - As of November 2017, 290 transcritical CO_2 systems were installed in the U.S. (Shecco)
  - Many large manufacturers producing transcritical CO_2 equipment
- Market Trends
  - Major food retailers choosing to install transcritical CO_2 systems to avoid future compliance costs (“Future proof”)
  - Cold storage facilities also adopting CO_2 system technology
- Market Barriers
  - Owner and contractor knowledge gap, limited installation base
  - CO_2 systems operate at much higher pressures (~1200 psi)
    - Unique expertise required in installation, operation compared to traditional halocarbon systems
  - Proposed code would remove roadblocks to market adoption by allowing owners to understand baseline CO_2 design and efficiency
- **Do you agree with this description? What else should we know?**

Submeasure A- CO_2 Systems

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Measures directly affect design practices for selecting and sizing gas coolers
- Need to ensure control practices recommended in code are well understood and achievable
- Need to understand transcritical operation on the economics of heat reclaim
- Barriers and Potential Solutions
  - Possibility of limited contractor experiencing installing ejectors
  - Different learning curve with CO_2 systems and properly implemented controls and equipment
  - Equipment manufactures publish installation guides and provide contractor training

Do you agree with this description? What else should we know?

Submeasure A- CO2 Systems

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Develop a “standard practice” transcritical CO2 booster system
- “Standard practice” system will be developed through
  - Interviews and discussions with key stakeholders (contractors, manufacturers, design engineers)
  - Review of refrigeration design legends for recent CA installations
- Important information needed to develop standard practice:
  - Gas cooler sizing (and understanding heat reclaim impacts)
  - Gas cooler control
    - Fan speed control
    - When adiabatic mode enabled
    - Gas cooler pressure control (subcritical vs. supercritical)
  - Typical design pressure of intermediate receiver

Methodology for Energy Impacts Analysis

- Simulate proposed measures and estimate energy savings compared to developed baseline
  - Utilize DOE2.2R models from previous code cycles
- All 16 California climate zones to be simulated as transcritical CO_2 system energy usage is sensitive to climate variations
- Statewide savings to be calculated by taking the kWh saved per SF for cost effective measures and multiplying by the projected SF of new construction forecast, adjusting for % of CO_2 systems
- No preliminary savings to present at this time

Assumptions for Energy Impacts Analysis

- Key assumptions (preliminary)
  - Large Refrigerated Warehouse Prototype (92,000 SF)
    - 35F Cooler Space; -10F Freezer Space; 40F Dock Space
    - Lighting/Construction/Insulation per 2019 Title 24 Code Requirements
    - -23F SST suction group for Freezer loads
    - +22F SST suction group for Cooler/Dock loads
    - **+30F saturated pressure for intermediate pressure vessel**
    - Approx. 50TR design Freezer loads
    - Approx. 84TR design Cooler/Dock loads (higher due to respiration loads)

Assumptions for Energy Impacts Analysis

- Key assumptions (preliminary)
  - Commercial refrigeration analysis focused on single prototype
  - Large Supermarket Prototype (60,700 SF)
    - Lighting/Construction/Insulation per 2019 Title 24 Code Requirements
    - -22F SST suction group for LT Case/Walk in Freezer Loads
    - +16F SST suction group for MT Case/Walk in Cooler Loads
    - **+25F saturated pressure for intermediate pressure vessel**

Assumptions for Energy Impacts Analysis

- Key assumptions (preliminary)
  - Baseline gas cooler sizing
    - Design temperature difference **between gas cooler outlet and ambient temperature** TBD
    - Design ambient temperature based on Appendix JA2 climate data
  - Baseline head pressure control during subcritical operation
    - **Fixed head pressure of 80F SCT**
    - Variable fan speed control to maintain discharge pressure
    - If modeling adiabatic, assume adiabatic mode is switched ON when ambient temperature above the MCWB temperature

Assumptions for Energy Impacts Analysis

- Key assumptions (preliminary)- *Continued*
  - Baseline head pressure control during transcritical operation
    - **Fixed discharge pressure at 1200 psi**
    - Variable fan speed control to maintain constant TD between gas cooler outlet and ambient temperature

Do you agree with these recommended assumptions? What else should we know?

Should transcritical operating hours always be minimized, or does heat reclaim make higher number of transcritical operating hours cost effective?

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Standard practice transcritical CO_2 system
- LT and MT suction groups
- Common practice gas cooler sizing

Proposed Conditions

- Transcritical CO_2 system
  - Optimized gas cooler sizing
  - Parallel Compression
  - Ejectors
- Optimized system controls

2023 Construction Forecast

Building Types	2023 New Construction Forecast	% New Construction Impacted	Total New Construction Impacted
Refrigerated Warehouses	1.3M SF	30%	0.4M SF
Commercial Refrigeration	6.9M SF	60%	4.1M SF

Incremental Cost Information

- Gas Coolers
  - Collect anonymized cost data from manufacturers
  - Develop average $/MBH for gas coolers to determine incremental cost associated with the minimum required size measure
- Parallel Compressors
  - Interview CO_2 rack manufacturers to understand cost increase with parallel compression configuration compared to typical booster
  - Additional compressor(s), piping, controls
  - Additional equipment requiring commissioning
- Ejectors
  - Interview equipment manufactures for cost of ejectors
  - Additional piping required
  - Added mechanical installation cost (refrigeration contractor)
  - Additional control requirements

Recommendations for additional items required to determine incremental cost?

Submeasure A- CO2 Systems

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Size loads and determine required suction group temperatures
- Selection of gas cooler based on design total heat of rejection, design ambient conditions
- Determine additional efficiency improvements and controls specifications

2. Permit Application Phase

- Review relevant Title 24, Part 6 compliance sheet
- Determine if submitted CO2 system design meets gas cooler sizing requirements/control requirements
- Provide plan check comments if items are not within Title 24 specification

Compliance Verification Process

3. Construction phase

- Install CO_2 system (with gas cooler and control system)
- Commissioning

4. Inspection Phase

- Verify installed gas cooler equipment matches submitted plans
- Verify controls system/system operation is within Title 24, Part 6 specifications

Market Actors

Market actors involved in implementing this measure include:

- Design engineers
- Installation contractors
- Owners/end users
- Equipment manufacturers
- Controls manufacturers
- Code officials and regulators

Submeasure A- CO_2 Systems

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Are there any recommended rating conditions for gas cooler specific efficiency?**

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

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Typical sizing best practices? (Leaving gas cooler temperature + TD)**

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

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Typical gas cooler pressure control during transcritical?**
- **Subcritical operation assumed to follow existing control strategies for condensers**

Submeasure A: Design and Control Requirements for Transcritical CO2 Systems (RWH and Commercial Refrigeration)

Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)

Submeasure C: Evaporator Specific Efficiency for RWH

Submeasure D: Automatic Door Closers

Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure B- Packaged Systems

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Addition of design and control requirements for large package systems
Title 24, Part 6 Section 120.6(a)

Building Types	System Type	Type of Change	Proposed Measures
Refrigerated Warehouses	• New construction large packaged systems	Mandatory	• Minimum condenser sizing • Minimum condenser specific efficiency

Context and History

- **Why are we proposing this measure?**
  - Large packaged systems are increasing in popularity for refrigerated warehouse applications
  - Allows for lower charge systems
  - Increases available footprint for cold storage
    - No engine room
    - Equipment located on roof
  - These newly developed systems need to be defined
  - Clarify appropriate design practice for owners/end users interested in large packaged systems

Context and History

- Large packaged system
  - Packaged equipment that contains compressors, vessels, condensers in single package
  - May have integrated evaporators, or “split system” with evaporators installed separately in refrigerated space
  - Normal vapor compression cycle refrigeration system
  - Located on rooftop instead of central engine room
- Existing condenser requirements for sizing and specific efficiency may not apply to packaged units

Image Source: Evapco

Submeasure B- Packaged Systems

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis – Large Packaged Systems

- Current Market
  - At least 5 manufacturers offering packaged system products for RWH applications
  - Some manufacturers already offer “Title 24 compliant” equipment options
- Market Trends
  - Early adoption phase of large packaged systems
- Market Barriers
  - Limited contractor/owner experience as product is still relatively new
- **Do you agree with this description? What else should we know?**

Submeasure B- Packaged Systems

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Measures directly affect design practices for selecting and sizing integrated condensers
- Condenser sizing and specific efficiency requirements may limit economic viability
- Stepped/variable capacity control viable based on available options in market?
- Barriers and Potential Solutions
  - Discussions with manufacturers is necessary to identify barriers and ensure these systems can be cost-effectively and efficiently applied in California
  - Package efficiency metrics are not established, current efforts to establish metrics (SCE/EPRI) need to be understood to determine how that may impact Title 24 requirements

Do you agree with this description? What else should we know?

Submeasure B- Packaged Systems

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Simulate proposed measures and estimate energy savings compared to developed baseline
- Utilize DOE2.2R models from previous code cycles
- All 16 California climate zones to be simulated
- Statewide savings to be calculated by taking the kWh saved per SF for cost effective measures and multiplying by the projected SF of new construction forecast, adjusting for % of large packaged systems
- No preliminary savings to present at this time

Assumptions for Energy Impacts Analysis

- Key assumptions (preliminary)
  - Large Refrigerated Warehouse Prototype (92,000 SF)
    - 35F Cooler Space; -10F Freezer Space; 40F Dock Space
    - Lighting/Construction/Insulation per 2019 Title 24 Code Requirements
    - -23F SST suction group for Freezer loads
    - +22F SST suction group for Cooler/Dock loads
    - +30F saturated pressure for intermediate pressure vessel
    - Approx. 50TR design freezer loads
    - Approx. 84TR design cooler/dock loads (higher due to respiration loads)

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Base case condenser sizing and efficiency
- No step capacity control

Proposed Conditions

- Stepped capacity control
- Proposed condenser efficiency and sizing

2023 Construction Forecast

Building Types	2023 New Construction Forecast	% New Construction Impacted	Total New Construction Impacted
Refrigerated Warehouses	1.3M SF	30%	0.4M SF

Incremental Cost Information

- Evaporator Fan VFDs
  - VFD
  - Additional controls
  - Added electrical installation cost
- Stepped/Variable capacity control
  - Additional controls, programming, sensors
  - Additional installation cost
  - Additional commissioning cost
- Condenser sizing/specific efficiency
  - Increased coil size, possible cascading effects for overall package design

Recommendations for additional items required to determine incremental cost?

Submeasure B- Packaged Systems

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Size loads and determine required suction group temperatures
- Specify size and number of packaged required to meet design loads

2. Permit Application Phase

- Review relevant Title 24, Part 6 compliance sheet
- Determine if submitted packaged systems have compliant condensers
- Determine if submitted packaged systems offer compliant head pressure and stepped capacity control
- Provide plan check comments if items are not within Title 24, Part 6 specification

Compliance Verification Process

3. Construction phase

- Install packaged systems
- Commissioning

4. Inspection Phase

- Verify installed packages utilize stepped capacity control
- Verify compliant equipment sizing

Market Actors

Market actors involved in implementing this measure include:

- Design engineers
- Installation contractors
- Owners/end users
- Equipment manufacturers
- Controls manufacturers

Submeasure B- Packaged Systems

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Input on typical condenser sizing practices and specific efficiency?**

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

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

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Draft language assumes existing code language for condenser control applies to packaged systems**
- **Recommended package size (TR) before stepped capacity control requirements are mandates?**

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

Submeasure A: Design and Control Requirements for Transcritical CO2 Systems (RWH and Commercial Refrigeration)

Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)

Submeasure C: Evaporator Specific Efficiency for RWH

Submeasure D: Automatic Door Closers

Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure C- Evaporator Specific Efficiency

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Code Change Proposal – Summary

Addition of evaporator specific efficiency requirements for refrigerated warehouses to Title 24, Part 6 Section 120.6(a)(3)

Building Types	System Type	Type of Change	Proposed Measures
Refrigerated Warehouses	Vapor Compression Refrigeration System	Mandatory	• Minimum evaporator specific efficiency

Context and History

- **Why are we proposing this measure?**
  - Evaporators utilize significant amount of energy in refrigerated warehouses
  - Specific efficiency of installed evaporators will be a large determinant in annual energy usage, even with efficient use of VFD speed control
  - Large statewide savings opportunities to define cost effective minimum efficiency requirement
  - Measure previously explored in earlier code cycles
  - More information/standardization of evaporator capacity ratings make this a viable measure compared to past studies

Context and History

- $\text{Specific Efficiency} = \dfrac{\text{Evaporator Capacity}\ (\frac{\text{BTU}}{\text{h}})}{\text{Input Power (Watts)}}$
- Evaporator capacity specified at 10F TD between entering air temperature and saturated suction temperature
- Input power is the 100% speed fan power of the evaporator at applied conditions
- No current minimum efficiency requirement in Title 24
- High specific efficiency evaporators incentivized in past Savings By Design program over a minimum Btuh/W baseline

Submeasure C- Evaporator Specific Efficiency

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - Well established market with many evaporator manufacturers supplying new construction
- Market Trends
  - Trend toward higher specific efficiency evaporators as equipment designs improve
- Market Barriers
  - No known market barriers as evaporators are already a well-established product

Do you agree with this description? What else should we know?

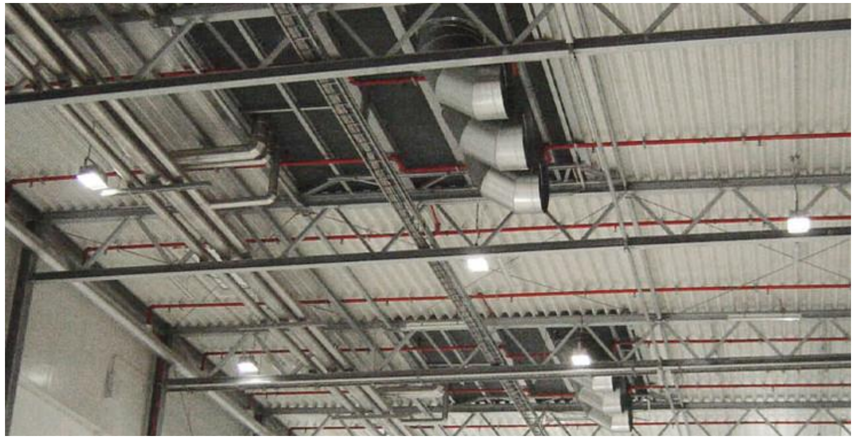
Submeasure C- Evaporator Specific Efficiency

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Consistent capacity and power rating basis across all manufacturing types
- Minimum requirement should not be overly punitive and targets should be reasonable
- Need to provide requirements for different refrigerants and uses, particularly for process loads which may be exempt
- How to address penthouse units with additional pressure drop due to ducting



Technical Considerations

- Technical Barriers and Potential Solutions
  - Obtaining data for evaporators at specific conditions as manufacturer testing methods have been inconsistent, generating some uncertainty in a standard
    - Manufacturer testing has improved, with more advanced testing and focus on two main types of ratings

Do you agree with this description? What else should we know?

Submeasure C- Evaporator Specific Efficiency

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Methodology for energy and demand impacts
  - Use anonymized existing equipment performance data to develop range of available evaporator efficiencies based on refrigerant type and use
  - Review Savings By Design installation data and interview manufacturers, contractors, end users to understand efficiency trends
  - Analyze prototypes with varying evaporator efficiency levels using DOE2.2R models from previous code cycles

Prototype Buildings	Size	System Configuration
Large Refrigerated Warehouse	92,000 sqft	Single Stage; LT, MT Suction Groups
Small Refrigerated Warehouse	26,000 sqft	Separate LT and MT systems

  - All 16 California climate zones to be analyzed
  - No preliminary savings to present at this time

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Standard evaporator specific efficiency for refrigerant and use
  - 34 Btuh/W

Proposed Conditions

- Defined minimum evaporator specific efficiency
- Optimized for savings vs incremental cost

2023 Construction Forecast

Building Types	2023 New Construction Forecast	% New Construction Impacted	Total New Construction Impacted
Refrigerated Warehouses	1.3M SF	100%	1.3M SF

Incremental Cost Information

- Evaporators
  - Collect anonymized cost data from manufacturers
  - Develop average $/Btuh/W for evaporators across different refrigerants and evaporator types to determine incremental cost associated with more efficient equipment

Recommendations for additional items required to determine incremental cost?

Submeasure C- Evaporator Specific Efficiency

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Design loads calculated
- Required CFM calculated
- Selection of evaporators determined based on design load and required CFM

2. Permit Application Phase

- Review Title 24, Part 6 compliance forms to determine if installed evaporators meet efficiency requirements
- Provide plan check comments if evaporators are outside Title 24, Part 6 specifications

Compliance Verification Process

3. Construction phase

- Evaporators installed

4. Inspection Phase

- Determine if equipment matches what was submitted in the Title 24, Part 6 compliance forms

Market Actors

Market actors involved in implementing this measure include:

- Design engineers
- Installation contractors
- Owners/end users
- Equipment manufacturers

Submeasure C- Evaporator Specific Efficiency

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- **Do you agree with different values being applied based on refrigerant, application and liquid feed type as shown here?**

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

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**

- **Should only certified ratings apply to calculating specific efficiency to ensure proper compliance?**

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%

- **Reasonable to limit external static pressure for penthouse units? If so what value (in WC)**

Submeasure A: Design and Control Requirements for Transcritical CO2 Systems (RWH and Commercial Refrigeration)

Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)

Submeasure C: Evaporator Specific Efficiency for RWH

Submeasure D: Automatic Door Closers

Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure D- Door Closers

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Context and History

- Why are we proposing this measure?
  - “Automatically-closing door” presented as one of three options for infiltration control for RWH passageways
  - Different types of automatic door closures are commonly used for walk in coolers/freezers in supermarkets today:
    - Spring or gravity/cam hinge that closes the door from a standing-open position to a closed position
    - Closure device which snaps the door tightly closed
  - Opportunity to separately define and require these types of door closures for man doors used in refrigerated warehouses

Current Code Requirements

- Passageways between freezers and higher-temperature spaces, and passageways between coolers and nonrefrigerated spaces, shall have an infiltration barrier consisting of strip curtains, an automatically-closing door, or an air curtain designed by the manufacturer for use in the passageway and temperature for which it is applied

Code Change Proposal – Summary

Addition of automatic door closer requirements for refrigerated warehouses to Title 24, Part 6 Section 120.6(a)

Building Types	System Type	Type of Change	Proposed Measure
Refrigerated Warehouses	Coolers/Freezers	Mandatory	Require automatic door closers (both types) for man doors

Submeasure D- Door Closers

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

- Current Market
  - There is a well established automatic door market, with many supermarkets utilizing the two types currently
- Market Trends
  - New installations typically use automatic door closers
- Market Barriers
  - No known market barriers

Do you agree with this description? What else should we know?

Submeasure D- Door Closers

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- Technical Considerations
  - Collection of feedback from owners and operators is critical to understanding the effectiveness of closures
  - Effectiveness will help determine assumptions on infiltration reduction
  - Need to evaluate exceptions and options to door closers
    - Exceptions for double acting doors
    - Understanding of how closer types vary with size of door
  - Develop understanding of door closers in the context of how doors are used for traffic
- Technical Barriers and Potential Solutions
  - No major technical barriers

Do you agree with this description? What else should we know?

Submeasure D- Door Closers

Energy and Cost Impacts

Methodology and Assumptions

- Energy Impacts Methodology
- Cost Impacts Methodology
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Methodology for energy and demand impacts
  - Utilize existing large RWH prototype

Prototype Buildings	Size	System Configuration
Large Refrigerated Warehouse	92,000 sqft	Single Stage; LT, MT Suction Groups

  - Analyze performance using DOE2.2R models from previous code cycles
  - All 16 California climate zones to be analyzed
  - No preliminary savings to present at this time

Assumptions for Energy Impacts Analysis

- Key assumptions
  - Assume baseline model includes strip curtains on doors
  - XX openings per day
  - XX Time spent open per opening
  - 50% reduction of time stand open when utilizing automatic closer (to be finalized)
  - 10% reduction in infiltration load due to tighter door seal (to be finalized)
  - Energy savings based on improved infiltration barrier and related decrease in refrigeration load

Definition of Baseline and Proposed Conditions

Baseline Conditions

- Passageways with no automatic door closures
- Strip curtains

Proposed Conditions

- Passageways with automatic door closures

2023 Construction Forecast

Building Types	2023 New Construction Forecast	% New Construction Impacted	Total New Construction Impacted
Refrigerated Warehouses	1.3M SF	100%	1.3M SF

Submeasure D- Door Closers

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance Verification Process

1. Design Phase

- Specify in design that automatic door closers are required for passageways between refrigerated spaces

2. Permit Application Phase

- Review plans and verify doors are designed with automatic closers

Compliance Verification Process

3. Construction phase

- Install doors with closers

4. Inspection Phase

- Verify doors are installed with both types of closers

Market Actors

Market actors involved in implementing this measure include:

- Installation contractors
- Owners/end users
- Door equipment manufacturers

Submeasure D- Door Closers

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- Existing code language for infiltration barriers would remain
- Additional language specifying for passageways specifically meant for people shall have automatic door closers of both types
- Are there any additional exclusions that should be considered?

Submeasure A: Design and Control Requirements for Transcritical CO2 Systems (RWH and Commercial Refrigeration)

Submeasure B: Design and Control Requirements for Large Packaged Systems (RWH)

Submeasure C: Evaporator Specific Efficiency for RWH

Submeasure D: Automatic Door Closers

Submeasure E: Acceptance Testing for Commercial Refrigeration Measures

Submeasure E- Acceptance Testing

Background

- Context and History
- 2019 Code Requirements
- Code Change Proposal

Context and History

- **Why are we proposing this measure?**
  - In Appendix JA7 there are no acceptance testing procedures for commercial refrigeration measures
    - Condenser control
    - Floating suction pressure control
    - Liquid subcooling
    - Display case lighting control
    - Heat recovery
  - Acceptance testing language drafted in 2019 code cycle but not adopted – this language will be updated for the 2022 code cycle
  - Proposal to resubmit acceptance testing language for CEC consideration to help improve compliance
  - Will also include updated language for RWH to improve clarity

Submeasure E-Acceptance Testing

Proposed Code Changes

- Draft Code Change Language
- Proposed Software Updates

Draft Code Change Language

- Please take a minute to review the draft code language available in the **resources tab**
- Comments are welcome after further detailed review

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2022 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Comments on this measure are due by **November 21**, please send to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

Questions?

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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Thank you for your participation today

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Please complete the closing polls below

Upcoming Meetings

Meeting Topic	Building Type	Date
Single Family Whole Building & Nonresidential Software Improvements	SF, NR	Tuesday, November 12, 2019

Stay tuned for our schedule for **Round 2** of Utility-Sponsored Stakeholder Meetings in January/February 2020!