TITLE 24, PART 6 | 2028 CODE CYCLE

Process Steam: Condensate Return

Codes and Standards Enhancement (CASE) Proposal

Ryan Swanson
October 29, 2025

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Proposal Description

- Code Change Proposal
- Benefits
- Background Information

Proposed Code Change: Condensate Return

- **Require newly constructed process steam systems** and newly added process steam loads that:
  a) have one or more connected boilers with an input rating (capacity) of 10 MMBtu/h or greater,
  b) use indirect-contact heat exchangers, and
  c) generate condensate during normal operation,

  to install a condensate return system to return all uncontaminated condensate to the boiler for reuse.
  - This requirement would only apply to steam systems that meet a set of criteria for **load size** and **condensate return piping length.**
  - Condensate from associated drip legs must also be returned.
  - Condensate return from direct steam injection (that comes in direct contact with the process) is outside of the proposed code change.

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

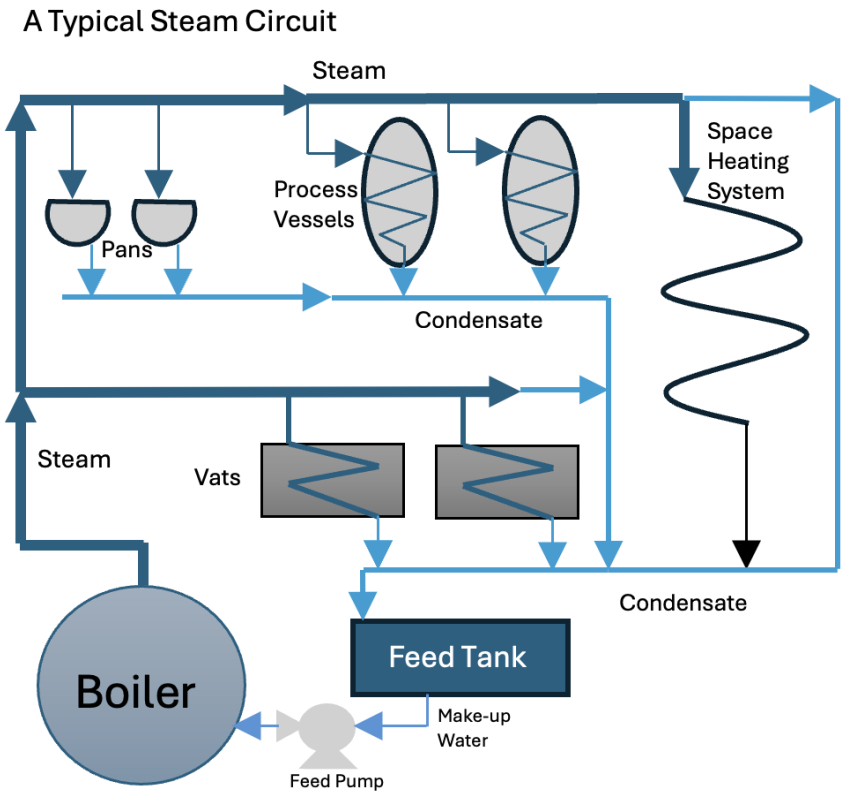
Benefits of the Proposed Change

- **Lowers energy usage** by 5-8% by decreasing the fuel required to preheat fresh makeup water for boiler feedwater and reducing blowdown.
- **Reduces overall water consumption** by minimizing the need for fresh makeup water as condensate is returned to the boiler for reuse.
- **Reduces chemical treatment costs**, as condensate is already treated.
- **Provides significant cost savings,** including fuel, water, wastewater, and chemical treatment costs – making this a highly **cost-effective measure** with paybacks from 1.5-3 years.

"Condensate return [is one of the] top three things we recommend every time."
– Boiler manufacturer

Background Information

- After steam is used in process loads, hot condensate remains. Condensate is essentially distilled water, requiring no chemical treatment.
- This condensate can be drained to wastewater or returned to the boiler for reuse.
- Condensate that is drained to waste must be replaced with fresh, cold makeup water, which requires chemical treatment and heating.
- Condensate return is a widely accepted steam system best practice.
- A DOE steam tip sheet summarizes energy savings potential from additional condensate return.



DOE Tip Sheet: https://www.energy.gov/sites/prod/files/2014/05/f16/steam8_boiler.pdf

Background Information: Current Code Status

- **Title 24 Part 6** process steam requirements only cover steam traps. There are no requirements for condensate recovery.
- **IECC** does not cover condensate return.
- **ASHRAE** does not have a specific standard for condensate return but it has considerations for condensate return in piping design, steam system operation, and energy efficiency.

Marked-up Code Language

See Title24stakeholders.com for marked-up code language

Title 24, Part 1

- No changes.

Title 24, Part 6

- 100.1 Definitions
- 120.6(I) Mandatory requirements for process steam systems (new)
- 141.1(x) Requirements for covered processes in additions, alterations to existing nonresidential and hotel/ motel buildings

Reference Appendices

- Nonresidential Appendix 9 – Process Steam System Qualification Requirements
  - NA9.3 Condensate Return Piping Length Calculations (new)

Market and Technical Considerations

- Current Conditions and Trends
- Potential Barriers and Solutions
- Technical feasibility

Current Market Conditions

- Condensate return is a **well-accepted best practice** for steam systems, with a history of documentation in **DOE** and **ASHRAE**.
  - DOE Tip Sheet #8 states that up to 10% of the total energy content in a steam system is in the condensate.
  - IAC (DOE Industrial Assessment Centers) have seven recommendations for condensate return, including:
    - “Increase amount of condensate returned.”
    - “Use steam condensate for hot water supply.”
  - **Most plants return some condensate** but fall short of best practice targets
    - Most sites can likely return 75-90% of condensate, but this varies by site.
    - New condensate return systems are typically sized to return all viable condensate to decrease payback periods.

IAC Recommendations: https://iac.university/technicalDocs/ARC%20List%20-%20V19.1.pdf DOE Tip Sheet: https://www.energy.gov/sites/prod/files/2014/05/f16/steam8_boiler.pdf

Condensate Return Benchmark 90%:https://invenoeng.com/best-practice-no-72-why-it-is-necessary-to-recover-condensate/#:~:text=2.,steam%20injection%20for%20process%20applications.; https://bsimechanical.com/wp-content/uploads/2017/05/Why-Condensate-Should-Be-Returned.pdf ; https://www.plantservices.com/equipment/electrical-systems/article/11336189/boilers-why-return-condensate-to-the-boiler-the-best-reasons-are-intertwined-with-process-economics-plant-services; ASHRAE Fundamentals of Steam Design; ASHRAE HVAC Systems and Equipment Handbook.

Current Market Conditions, Continued

- The market for condensate return is robust.
  - Components are **highly standard and widely available from many manufacturers.**
  - **Steam system designers understand how to recover condensate.**
  - **Multiple steam equipment manufacturers** have application guides for condensate return.
- The market continues to evolve, promoting further adoption of condensate return.
  - Utility incentive programs for condensate return are typically structured as **custom or performance-based rebates**.
  - The market for condensate return systems is expected to grow due to rising energy and water costs, and growing sustainability mandates.

Market Barriers and Solutions

Market Barriers	Potential Solutions
1. Existing condensate systems may not be sized to handle additional capacity.	1. Cost-effectiveness analysis includes the cost for new equipment (pumps, piping, tanks) to return condensate all the way to boiler.
2. High up-front costs to retrofit steam systems that do not already have any condensate return.	2. Provide a code trigger table that only includes cost-effective combinations of steam loads and return distances.
3. Perceived risk of contamination from unplanned contact with process can make condensate unfit to return.	3. Only require condensate return for non-direct injection steam generated condensate. Contamination from mechanical defects would require repair.
4. Seasonal operation extends payback periods.	4. The code trigger table was created to maintain reasonable payback periods at sites with seasonal system operation.

Code Trigger Table Addresses Cost Effectiveness Concerns

To ensure measure cost-effectiveness, process steam systems are subject to the condensate return **requirement if the distance between the steam load and the nearest condensate tank or the serving boiler** is **less than the maximum linear length*** values in the table below based on the steam flow to the newly added load.

Design Steam Flow (lbs/h)	Maximum Linear Length* (ft)
<1,000	Exempt
≥1,000, <2,000	350
≥2,000, <3,000	600
≥3,000, <3,500	800
≥3,500	1,000

*Linear distance from the load to the condensate return tank or the serving boiler, measured across both horizontal and vertical dimensions. Calculation of linear length will be described in Reference Appendix.

Poll

What percentage of newly added, non-direct injection steam loads return any amount of condensate?

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
g. 61% - 70%
h. 71% - 80%
i. 81% - 90%
j. 91% - 100%
k. Don’t know

Poll

For existing steam-using sites with condensate return systems, what percentage of condensate typically gets returned?

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. 51% - 60%
g. 61% - 70%
h. 71% - 80%
i. 81% - 90%
j. 91% - 100%
k. Don’t know

Current Estimated Market Share: Condensate Return

Market share: percentage of process steam systems that already return steam condensate to the boiler for reuse.

Current Market Share

Values based on SME engineering judgement.

Technical Considerations

The components of a condensate return system include a tank, piping, and (in some cases) a pump.

Technical Considerations – New Construction

- Pump reliability may impact the amount of condensate returned.

Technical Considerations – Additions and Alterations

- Existing condensate tank and pump size may be limiting and require replacement to accommodate additional return.
- Pipe lengths and routes required to return additional condensate loads to the boiler may create additional barriers for implementation. These barriers may include pipe rack load constraints, piping route limitations, and excessive pipe lengths, lowering cost-effectiveness.

Technical Barriers and Solutions

Technical Barriers	Potential Solutions
1. Pump reliability.	1. Include pump maintenance and replacement costs in cost-effectiveness calculations and encourage operators to promptly address pump failures.

Poll

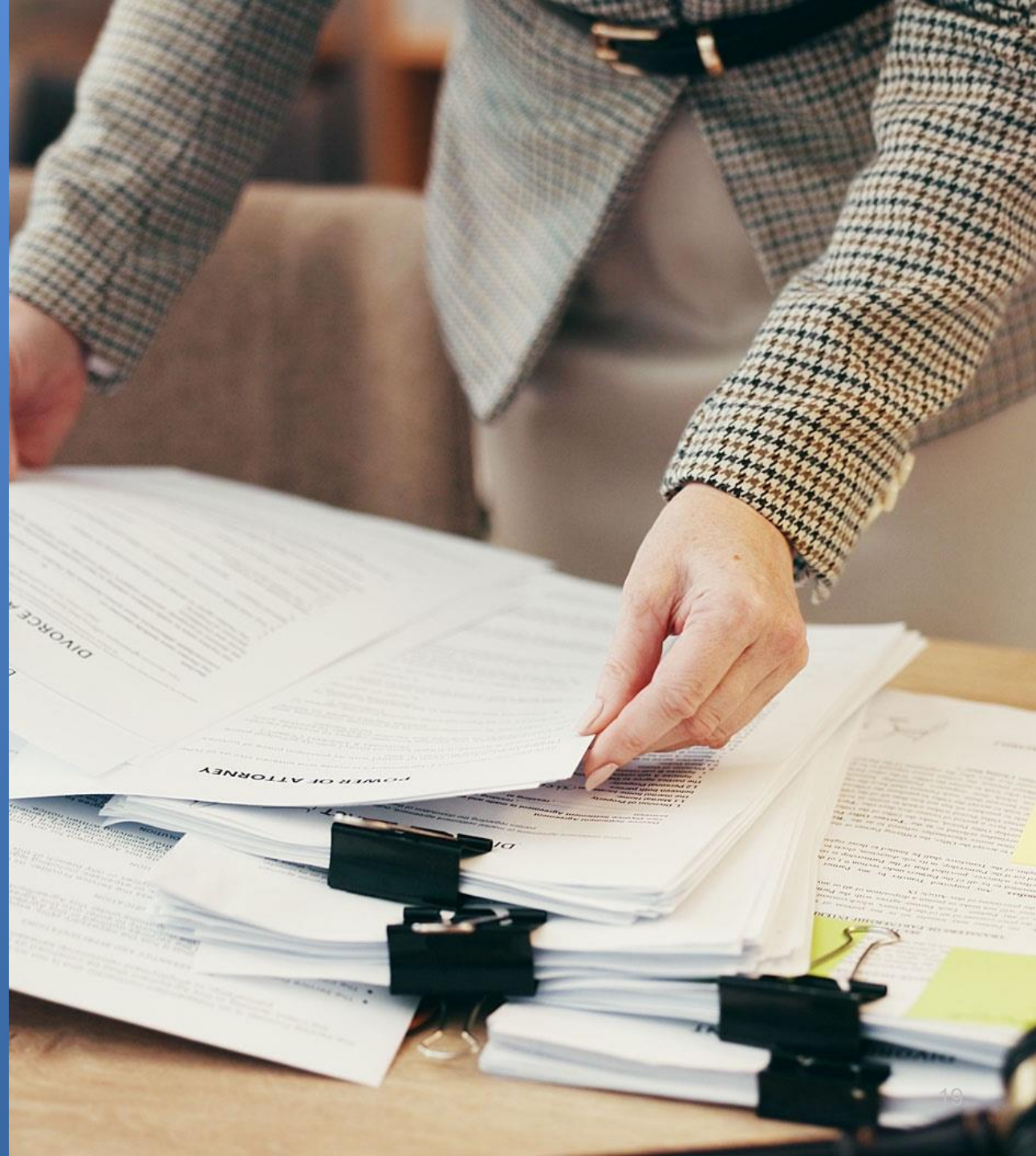
What else should we know? Are there market or technical barriers or solutions we should consider?

Open ended response

Per Unit Energy and Cost Impacts

Methodology and Assumptions

- Energy and Energy Cost Savings
- Incremental Costs



Energy and Energy Cost Savings Methodology

Energy savings from this condensate return measure were calculated in two components:

1. **Deaerator preheating savings.** Replacing cold make-up water with (warm/hot) returned condensate reduces the energy required to heat the deaerator.
   - Returned condensate is typically at 200°F, while cold make-up water is around 65°F.
2. **Blowdown reduction.** Replacing make-up water (containing dissolved solids) with condensate (effectively distilled water) reduces blowdown.
   - Reduction in energy: Blowdown for a 100psig boiler is at 338°F prior to discharge, and reducing blowdown reduces energy losses.
   - Reduction in water use: Excess blowdown requires fresh makeup water, increasing the total amount of water a site must purchase from a utility.

Energy Savings Calculation: Deaerator Preheating Savings

The following equation was used to estimate savings based on **energy difference** due to condensate temperature vs. make-up water temperature:

$$Energy\ Savings\ \left(\frac{Btu}{hr}\right) = \left(\dot{m}_{condp} - \dot{m}_{condb}\right) * \ c_p * \left(T_{con} - T_{mw}\right)$$

$\dot{m}_{condp}$ = proposed condensate flow $\left(\frac{lbs}{hr}\right)$

$\dot{m}_{condb}$ = baseline condensate flow $\left(\frac{lbs}{hr}\right)$

T_{con} = temperature of condensate (°F)

T_{mw} = temperature of makeup water (°F)

c_p = specific heat capacity of water at constant pressure, about 1 Btu/lb·°F

Temperature losses due to condensate pipe length are accounted for in energy savings calculations. Insulation of condensate return pipes is already required by Title 24 Part 6.

Energy Savings Calculation: Blowdown Reduction

Energy Savings from Reduced Blowdown

The following equation was used to calculate energy savings due to decreased blowdown:

$$Blowdown\ Energy\ \left(\frac{Btu}{hr}\right) = (\dot{m}_{bdnb} - \dot{m}_{bdnp}) * (H_{bw} - H_{mw})$$

$\dot{m}_{bdnb}$ = baseline blowdown flow rate in $(\frac{lbs}{hr})$

$\dot{m}_{bdnp}$ = proposed blowdown flow rate in $(\frac{lbs}{hr})$

H_{bw} = enthalpy of boiler water $(\frac{btu}{lb})$

H_{mw} = enthalpy of makeup water $(\frac{btu}{lb})$

Key Assumptions: Cost-Effectiveness Analysis

Standard Design

30% of condensate returned

1. **30%** of condensate returned
2. 79.5% Boiler Efficiency
3. 40% Boiler Load
4. 6,500 hrs/yr operation
5. 65°F Makeup Water Temperature
6. 200°F Condensate Temperature
7. Insulation of condensate return pipes is already required by Title 24 Part 6.

Proposed Design

75% of condensate returned

1. **75%** of condensate returned
2. All other assumptions remain the same.

Poll

What are typical annual operating hours for existing facilities with condensate return systems?

a. ≤ 2,500 hrs
b. 2,500-3,500 hrs
c. 3,500-4,500 hrs
d. 4,500-5,500 hrs
e. 5,500-6,500 hrs
f. 6,500-7,500 hrs
g. 7,500-8,500 hrs
h. Greater than 8,500 hrs

Incremental Cost Framework

Baseline

No condensate return system or full replacement.

First Cost

1. None

30-Year Maintenance Costs

1. N/A

Proposed

75% of condensate returned.

First Cost

1. System design and drawings
2. Equipment cost to return recovered condensate
3. Installation cost of condensate return equipment
4. Startup & commissioning

30-Year Maintenance Costs

1. Equipment replacement (tank, pump)
2. Regular maintenance (tank, pump)
3. Piping insulation repair

Approach for Gathering Costs

The CASE Team plans to:

- Review Code Readiness Steam Trap Fault Detection & Diagnostics (FDD) project data.
- Review RSMeans Mechanical Cost Data for hardware and labor costs.
- Review anonymized pricing data from recent condensate return projects in California.
- Interview stakeholders (vendors, owners, operators, manufacturers) about equipment first costs, installation costs, equipment lifetime, and maintenance cost, type and frequency.
- Evaluate equipment lifetime data from CPUC DEER Database.

Compliance Verification

- Key Aspects of Compliance Verification
- Barriers and Solutions
- Revisions to Compliance Software

Key Aspects of Compliance Verification

- **Design document review** by AHJ plan checkers to verify:
  - Planned installation of condensate return piping, pipe length, and pipe size in construction documents.
  - To qualify for the direct steam injection exception, construction documents must show planned installation of direct steam injection lines.
- **Updates to NRCC-PRC-E (Process Certificate of Compliance form)**
  - Add condensate return requirements.
  - Document calculations of condensate return length in accordance with reference appendix.
- **Updates to NRCI-PRC-E (Process System Certificate of Installation form)**
  - Add condensate return requirement.
- **No Third-Party Verification Requirements**
- **No Updates to Compliance Software**

Compliance Barriers and Solutions

Compliance Verification Barriers	Potential Solutions
1. AHJ plan checkers and inspectors may not be comfortable checking for compliant condensate return system design and installation. 2. Proper sizing for condensate systems can be difficult to verify.	1. Forms and plans would be signed by licensed Professional Engineers (PE). A Compliance Manual section 120.6(I) will be developed to improve understanding of condensate return compliance. A new Reference Appendix section NA9 and the NRCC-PRC forms will provide additional guidance for AHJ plan checker system review. 2. Licensed PE are obligated to size the systems appropriately. AHJ plan checkers are required to review PE stamped drawings.

Compliance Software Updates

This is planned as a mandatory measure so there are no trade-offs in the performance a

No compliance software updates are expected.

Slide not shown

Ryan Swanson
Enesfere
ryan@enesfere.com

Emma Conroy
2050 Partners
emmaconroy@2050partners.com

Please copy: info@title24stakeholders.com

More information on
CEC's 2028 proceeding website.

We want to hear from you!

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Blowdown Flow Rate Calculation

Slide not shown

Blowdown flow rate in (lbs/h) $= \dot{m}_{bdn} = \frac{Steam\ flow}{(COC - 1)}$

$COC = \frac{C_b}{C_{fw}}$

COC = *Cycles of Concentration*

C_b = *average conductivity of boiler water*

C_{fw} = *conductivity of feedwater*

Feed water conductivity: 345 µʊ, based on field data from two industrial sites from prior work with Cascade Energy.

Boiler water conductivity setpoint: 3,000 µʊ.