



TITLE 24, PART 6

2028 CODE CYCLE



Boiler Stack Oxygen Concentration

Codes and Standards Enhancement (CASE) Proposal -
Comment Letter

Shafi Amoni
February 17, 2026

Current Process Boiler Regulations in California

Statewide requirement in 2025 Title 24, Part 6 120.6(d)3:

Newly installed process boilers with an input capacity greater than 5 MMBtu/h (5,000,000 Btu/h) shall maintain stack-gas oxygen concentrations at less than or equal to 3% by volume on a dry basis over firing rates of 20 to 100%.

Local Air Quality Management District (AQMD) requirements:

- Set **specific NOx emissions limits** for process boilers, often varying by boiler size (input capacity).
- To keep NOx emissions under these limits, manufacturers employ techniques such as **flame shaping** and **flue-gas recirculation (FGR)** to reduce flame temperature and limit thermal NOx formation.

Stack Oxygen and NOx Emissions Can Be At Odds

- **Low- NOx boilers that comply** with California’s local air quality district emission limits **require higher amounts of excess oxygen** to maintain flame stability—often above 3%.
- **8 docketed comments** address this potential incapability between Title 24, Part 6 and local AQMD NOx emissions limits.
 - *“Running boilers at 3%, it is very hard to get single digit NOx. Not even the biggest boiler or burner manufacturer is stating that they have a technology that can do that.”* – Philip Sondervan, 10/31/25

Figure 10: Oxides of Nitrogen Emissions Results

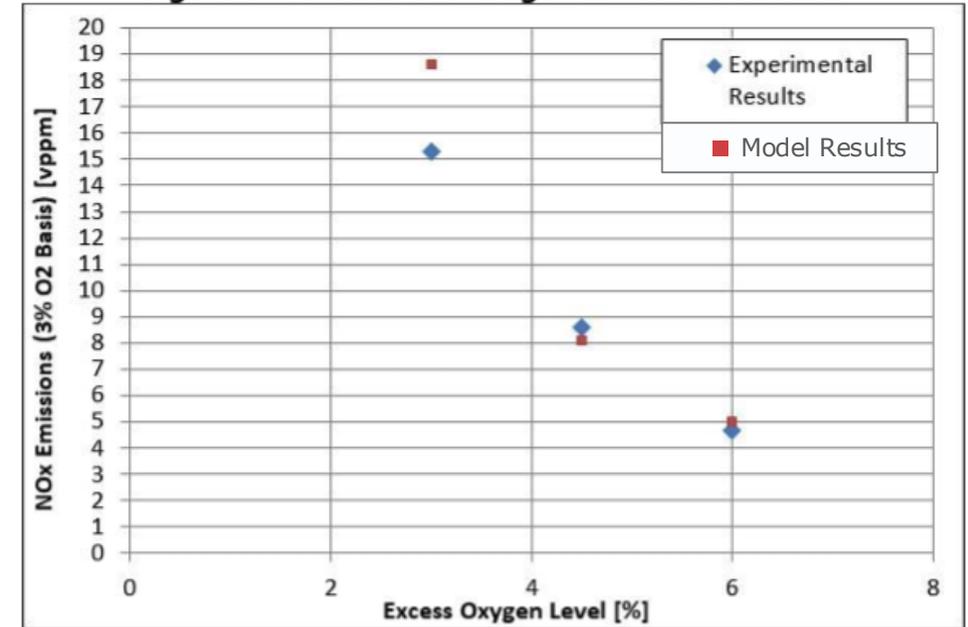


Image from CEC Project Report: [Demonstration of a Novel Ultra-Low Oxides of Nitrogen Boiler for Commercial Buildings, 2021](#)

Image source: Gas Technology Institute

Poll

Strategies currently used to meet NOx limits include:

- Ultra-low-NOx burners (mesh or non-mesh)
- Selective Catalytic Reduction (SCR)

Are you aware of any non-SCR technology available today that can meet strict NOx emissions limits at 3% operating stack oxygen?

[Open ended response]

Proposed Update to Stack Oxygen Requirements

- Updating Title 24, Part 6 requirements to **allow for oxygen concentrations higher than 3%** would allow boilers compliant with California's local air quality district requirements to also comply with Title 24, Part 6.
- The proposed requirements would **account for different burner types and emissions reduction strategies** that require different oxygen concentrations to maintain efficiency.
- This proposal **would not change the exception** for boilers with steady state full-load combustion efficiency of 90% or higher.

[See Title24stakeholders.com](https://www.title24stakeholders.com)
for proposal description,
justification, draft code
language, and requested data

Proposed Code Language

Newly installed process boilers with an input capacity greater than or equal to 5 MMBtu/h (5,000,000 Btu/h) shall meet the following requirements at 25% of burner input capacity or at the boiler's lowest firing rate during normal operations, whichever is higher:

A. Process boilers with **mesh burners** shall maintain stack-gas oxygen concentrations at less than or equal to **8%** by volume on a dry basis.

B. Process boilers equipped with **Selective Catalytic Reduction (SCR)** systems shall maintain stack-gas oxygen concentrations at less than or equal to **4%** by volume on a dry basis.

C. **All other process boilers** shall maintain stack-gas oxygen concentrations at less than or equal to **6%** by volume on a dry basis.

Questions for the audience (chat or hand raise):

- 1. Are these appropriate (lowest feasible) stack oxygen concentration limits for each boiler/burner type?*
- 2. Is it clear in this code language that there are no requirements for specific turndown capabilities?*

Poll

What is the current market share of each of the following boiler or burner types in California?

- Mesh burners
- Non-mesh burners
- Boilers equipped with Selective Catalytic Reduction (SCR) systems

Poll

What stack oxygen concentration do each of these types typically operate at?

- Mesh burners
- Non-mesh burners
- Boilers equipped with Selective Catalytic Reduction (SCR) systems



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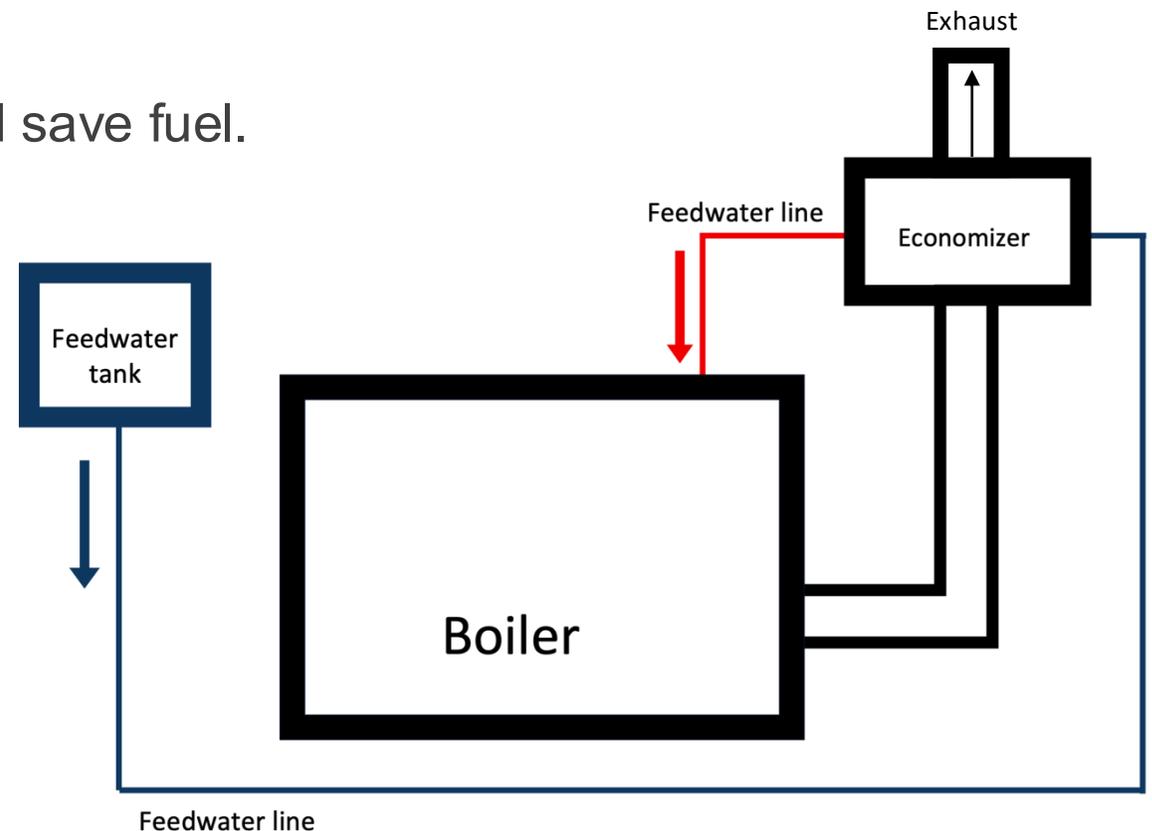
Process Boiler #1: Stack Economizer

Codes and Standards Enhancement (CASE) Proposal

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Stack Economizer Background and Requirement

- A stack economizer is a heat exchanger in the boiler exhaust stream which uses the waste heat from exhaust gases to pre-heat the boiler feedwater.
- A stack economizer is essentially a heat exchanger, and they have no controls or software components.
- Stack economizers reduce load on the boiler and save fuel.
- The use of boiler stack economizers has been listed in DOE literature as a best practice since at least the early 2000s.
- This proposal would **require boiler stack (non-condensing) economizers on all new process boilers with input capacities at or above 10 MMBtu/hr**, including replacement boilers, with exceptions for:



Proposed Stack Economizer Requirement Exceptions

1. Boilers with stack temperatures below 340°F at their lowest firing rate without an economizer.
2. Boiler systems designed to burn biofuels.
3. Boilers employing other methods of stack heat recovery, such as a heat exchanger that serves an industrial heat pump or process drying application.
4. Newly installed indoor replacement boilers at existing facilities with roof clearance less than 88 to 116 inches (varies by boiler capacity).
5. Low use boilers?

Questions for the audience:

- How often are newly installed boilers designated as 'low use boilers'? Why?
- Are any other exceptions needed?

Stack Economizer Current Market

In the experience of the CASE Team:

- Boiler system vendors and contractors are **generally familiar** with stack economizers and they are **widely available**.
- Despite its cost-effectiveness, this measure often goes **unimplemented because of its first cost** and a general lack of owner and operator awareness of the energy benefits.

Current Estimated Market Share
(percentage of new boiler systems that are installed with a stack economizer):



35%

Questions for the audience:

- Are there any concerns with **product reliability** or **maintenance**?
- Differing estimates of **current market share from 35%**?

Stack Economizer Costs and Effective Useful Life

The CASE Team currently estimates the following first and maintenance costs:

First Cost

1. Stack economizer purchase cost
2. Stack economizer installation cost

Boiler Capacity	Stack Economizer Total First Cost
12 MMBtu/h	\$68,000
19 MMBtu/h	\$98,000
33 MMBtu/h	\$150,000
71 MMBtu/h	\$242,000
143 MMBtu/h	\$443,000
739 MMBtu/h	\$1,191,000

30-Year Maintenance Costs

1. Stack economizer retubing every 7 years
 - 20% of total first cost
2. Stack economizer replacement every 15 years
 - 100% of total first cost

Any feedback on or concerns with these cost estimates?

Stack Economizer Stack Temperature Drop

The CASE Team currently estimates an **80°F stack temperature drop** across the stack economizer for boilers 10-25 MMBtu/h and a **100°F stack temperature drop** for boilers 25+ MMBtu/h as an assumption for statewide savings.

Question for the audience:

- Thinking about the typical stack temp drop across economizer...
 - What is a conservative stack temperature drop?
 - What's middle of the road estimate?
 - What is an estimate for a stack economizer with great performance?

Stack Economizer Electricity Use Impacts

- Stack economizers have no dedicated pump or fan.
- Negligible impact on feedwater pump energy usage, as most systems use valves to maintain boiler water level.
- Increased electricity usage of the combustion fan, which would have to run slightly higher to overcome the pressure drop of the economizer.
- Electricity use calculation assumptions:
 - 0.5-inch to 1.5-inches of water column based on boiler size

Boiler Capacity (MMBtu/hr)	Increased Electricity Use (kWh/yr)
12	346
19	600
33	1,182
71	4,100
143	12,365
739	64,000

Question for the audience:

- Any electricity impacts we are missing?

Poll

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

Open ended response



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Process Boiler #2: Automatic Blowdown & Deaerator Pressure

Codes and Standards Enhancement (CASE) Proposal

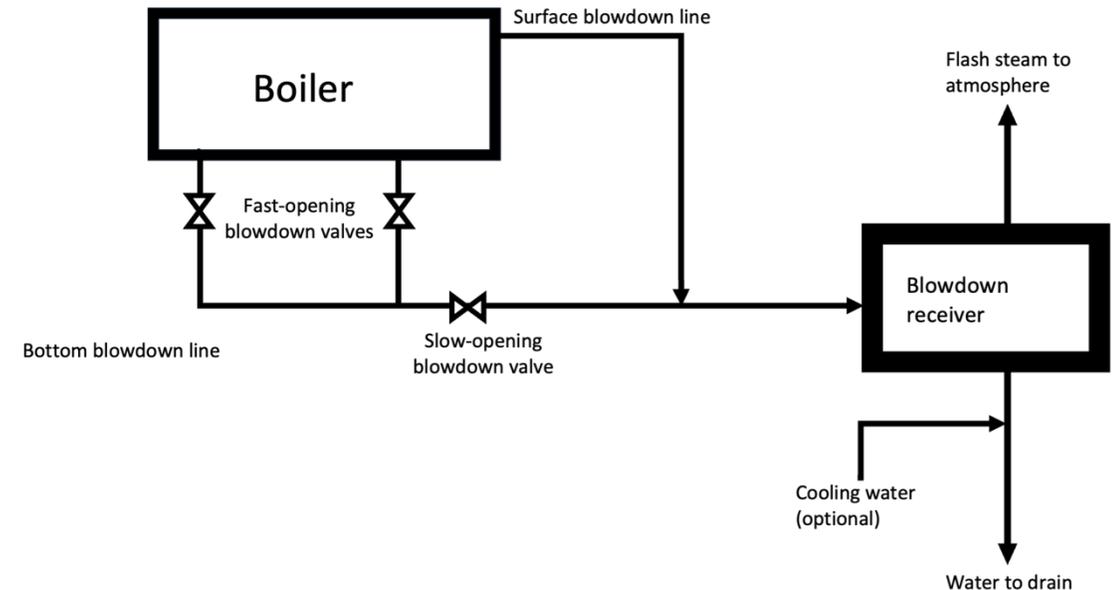
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Proposed Code Change: Automatic Blowdown

This proposal would add the following requirement for **all newly installed process steam boiler systems with capacities at or above 10 MMBtu/h**:

- Boilers must have an **automatic blowdown controller** that is programmed to be **controlled by conductivity**.
- **Exceptions** include:
 - New construction and addition* boiler systems with condensate return above 90%.
 - Boilers with makeup water treated by an RO system.

Blowdown System Diagram



*Additions where the boiler systems are contained in the addition.

Automatic Blowdown Market Share

Estimated Automatic Blowdown Market Share:

Boiler Capacity	Est. Market Share
10-15 MMBtu/h	25%
15-25 MMBtu/h	30%
25-50 MMBtu/h	35%
50-100 MMBtu/h	40%
100-200 MMBtu/h	45%
200+ MMBtu/h	75%

Questions for the audience:

- Any feedback on estimated market share?

Automatic Blowdown System Costs

First Cost

1. Cost of blowdown valve, valve controller, and conductivity probe
2. Installation
3. Additional startup & commissioning

*Total automatic blowdown system first cost:
Ranges from \$10,000 to \$30,000 as boiler
size increases*

30-Year Maintenance Costs

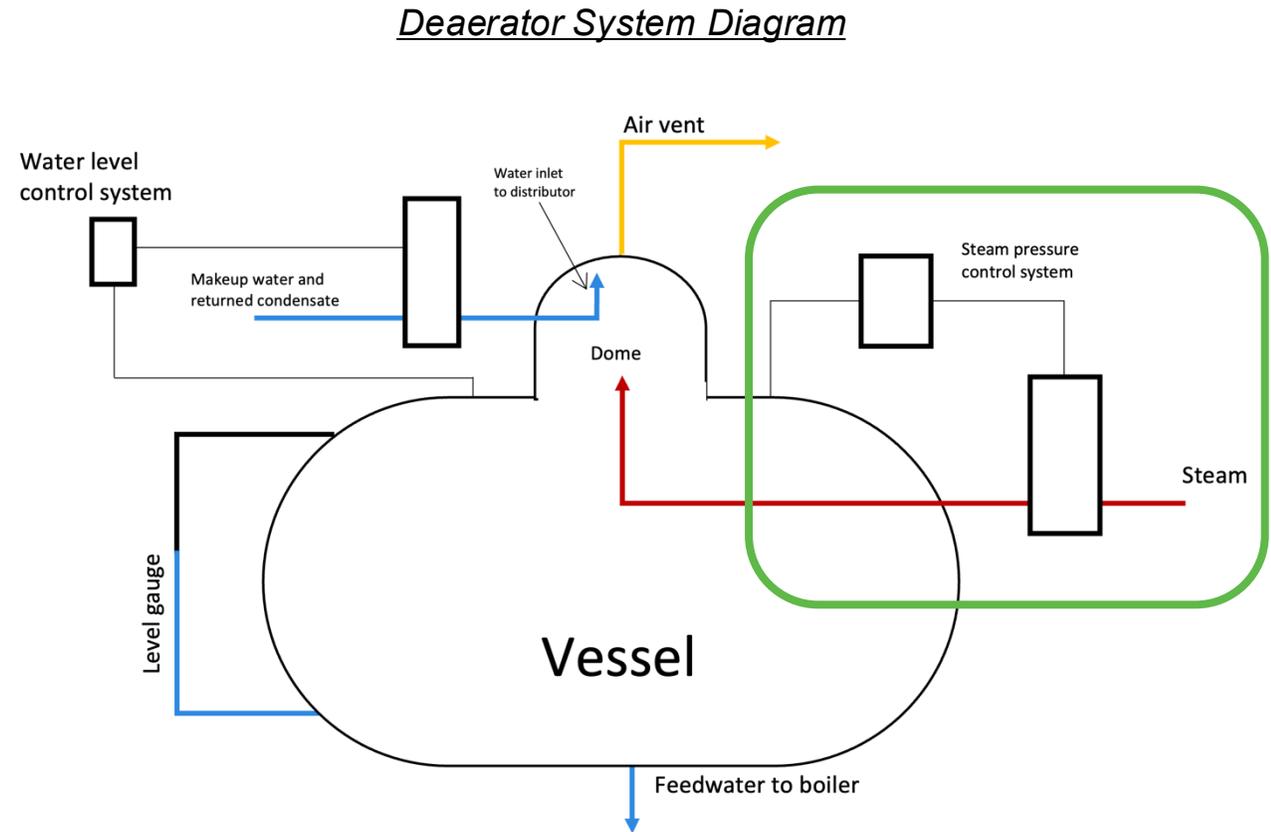
1. Probe and valve replacement every 3 years
 1. Probe replacement cost: \$500
 2. Valve replacement cost: \$1,000
2. Full system replacement every 15 years

Questions for the audience:

- Any feedback on costs?
- Any maintenance concerns?

Background Information: Deaerator Pressure

- Deaerators **remove dissolved gases** from steam boiler feedwater **to protect the system** from corrosion and ensure high heat transfer rates.
- A deaerator is a pressurized vessel that **heats the feedwater** to temperatures that release the dissolved gases (such as O₂ and CO₂) from the water.
- At **higher pressures**, water boils at a higher temperature, so higher pressure setpoints heat the feedwater to higher temperatures, **using more energy**.
- As pressures increase, more dissolved gases are removed. A higher deaerator pressure provides a **greater margin of assurance** for removing dissolved gases but also results in **greater steam losses**.



Proposed Code Change: Deaerator Pressure

This proposal would add the following requirement for all newly installed process steam boiler systems with capacities at or above 10 MMBtu/h:

- For systems that use the boiler steam header to pressurize the deaerator, **the steam supply line pressure regulator serving the deaerator must be set at or under 5 psig.**
- For boilers with tubes not rated for oxidizing conditions, the steam supply line pressure regulator serving the deaerator must be set between (and inclusive of) 2 and 5 psig.
- **Exception** for the requirement:
 - Systems with swings in make-up water equal to or above 20% of feedwater flow.

Questions for audience:

- Are there any concerns with qualification for the above exception being determined by the PE during design?
- Are any other exceptions needed?

Deaerator Pressure Market and Costs

Current CASE Team assumptions include:

- Percentage of steam boilers with deaerator systems set above 5 psig: **20%**
- Percentage of sites that serve the deaerator with high-pressure, high-temp condensate: **5%**
- Percentage of sites with swings in make-up water equal to or above 20% of feedwater flow: **2.5%**
- *Total percentage of sites that would be impacted by the code change: $20\% - 5\% - 2.5\% = 12.5\%$*
- No first or maintenance costs other than \$200 (1 hr) of labor for acceptance testing.

Questions for the audience:

- Any feedback on or concerns with these assumptions?

Poll

What else should we know?

Are there additional market or technical barriers or solutions we should consider?

[Open End]

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More information on
[CEC's 2028 proceeding website](#)

We want to hear from you!