TITLE 24, PART 6 | 2028 CODE CYCLE

Welcome to the Statewide CASE Team's Utility Sponsored Stakeholder Meeting

Topics: Updates to Hydronic Heat Pump Requirements: Alignment with Boiler and Chiller Requirements

Presenter Name: Bob Hendron
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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Agenda

- Proposal Description
- Market and Technical Consideration
- Technical Barriers and Solutions
- Per Unit Energy and Cost Methodology
- Compliance and Enforcement
- Discussion and Next Steps

Proposal Description

- Code Change Proposal
- Benefits
- Background Information

Photo credit: Red Car Analytics

Proposed Code Change

1. Align automatic water flow shut-off requirements for non-operating air-to-water heat pump (AWHP) and water-to-water heat pump (WWHP) plants with multiple units with those for chillers and boilers
2. Requires the same testing as chillers and boilers to verify leak-free valves
3. Applies to all non-residential new construction except hotels/motels and mixed-use, and to additions and alterations in all climate zones

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

Benefits of the Proposed Change

The Proposed recommendations will

- Clarify which hydronic system requirements for boilers and chillers also apply to hydronic heat pumps
- Increase average installed efficiency of hydronic heat pump systems in non-residential buildings by eliminating unnecessary pump energy and thermal losses when unused units are turned off
- Intervene before improper hydronic heat pump design practices become difficult to change as the market rapidly increases in the coming years

Background Information

- Recent studies have indicated that installed hydronic heat pump efficiency in non-residential buildings can be significantly below expectations (as much as 37% lower COP at rated conditions)[1]
- One observed cause was pumps that circulate water even when heat pumps are not operating
- Multi-unit AWHP/WWHP systems can waste pump energy, suffer heat losses, and fail to deliver water at the proper temperature if unused heat pumps are not isolated or reduced to the minimum flow rate specified by the manufacturer
- Several stakeholders pointed out that some manufacturers advocate strongly for continuous flow even when individual units are turned off, partly for simplicity and cost for controls and plumbing, and partly to ensure adequate flow is available during AWHP startup to avoid damaging equipment.
- Stakeholders identified special cases that might require exceptions in the code language, such as flow just prior to startup to avoid equipment damage, or a minimum flow rate during cold weather to prevent burst or frozen pipes.

1. Weitze, H., Stober, W., and Gantley, M., Nonresidential Hydronic Heat Pumps: System Operation Field Study and Analysis, PGNE Code Readiness Final Project Report ET21PGE7201-2, October 2024. https://etcc-ca.com/reports/code-readiness-final-project-report-nonresidential-hydronic-heat-pumps-system-operation

Flow Shutoff under Proposed Hydronic Heat Pump Isolation Measure (Dedicated Pumps)

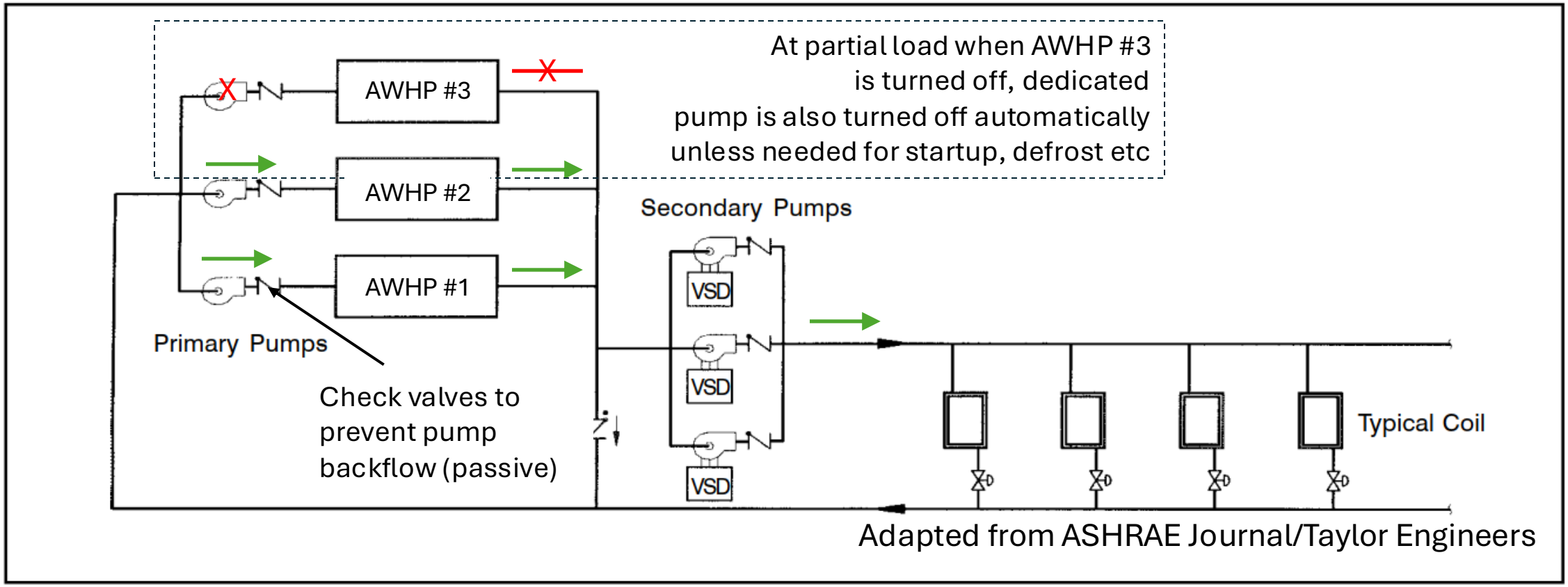


Figure 2: Conventional primary-secondary system.

Flow Shutoff under Proposed Hydronic Heat Pump Isolation Measure (Central Pump)

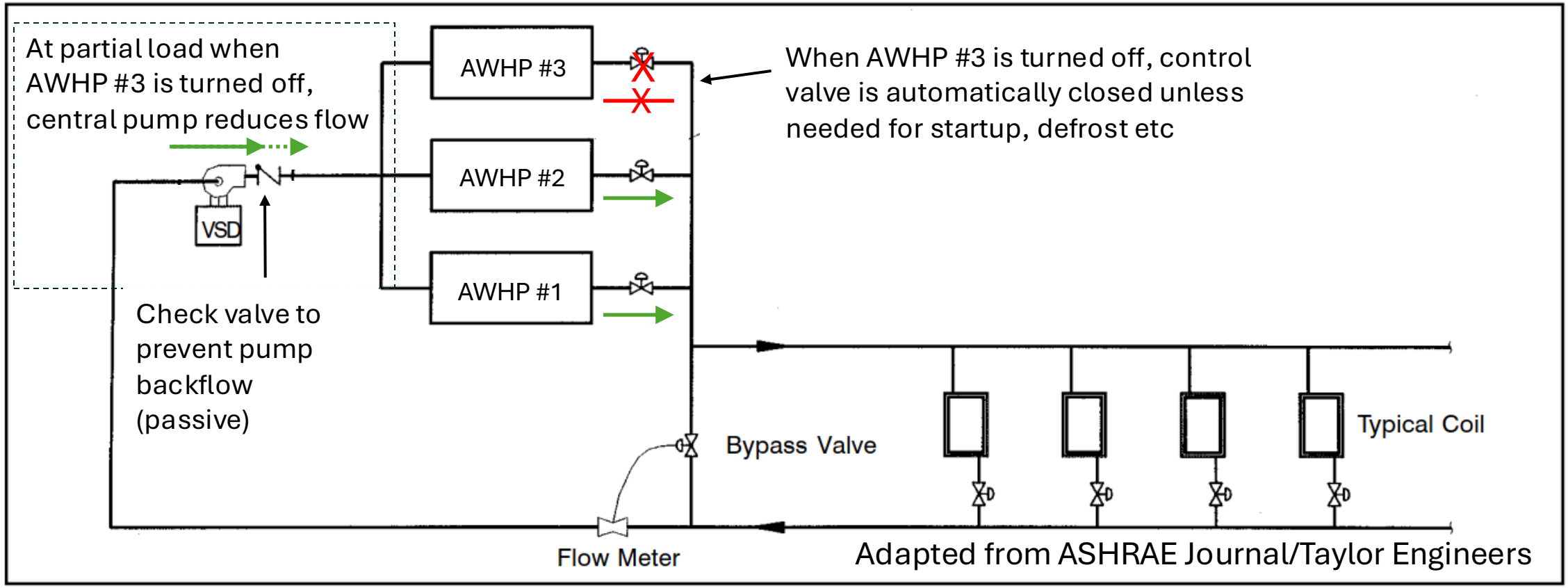


Figure 1: Primary-only system.

Marked-up Code Language

See Title24stakeholders.com for marked-up code language

Title 24, Part 1	Title 24, Part 6	Reference Appendices
▪ No changes	▪ Add Section140.4(k)2C to the prescriptive path, making AWHP/WWHP isolation requirements match those for chillers and boilers (140.4(k)2-3). Flow through any hydronic heat pump must be automatically reduced to the manufacturer's recommended minimum flow rate or turned off when it is not operating.	▪ No changes to reference appendices, but AWHP/WWHPs that require control valves as specified by Section 140.4(k)2 would be tested in accordance with NA7.5.7

Market and Technical Considerations

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

Current Market Conditions

- In California, the number of installed AWHPs is small, probably under 10%
- The 2025 Energy Code introduced new prescriptive requirements in most climate zones for AWHPs to serve office and school buildings no greater than 150,000 square feet with multi-zone equipment.
- Other new policies encouraging all-electric buildings, new AWHP product lines reaching the market, new financial incentives for AWHPs, and more clear and comprehensive code requirements are expected to encourage a rapid increase in market adoption for all non-residential building types
- Market penetration is likely to grow to at least 20% for all building types in the coming years, and 30% for small and medium offices and schools, given that about 60% of non-residential buildings nationwide currently use hydronic heating (primarily boilers)
- Uncertainty of installed performance based on lack of field studies of AWHPs in non-residential buildings presents a significant market barrier

Market Barriers and Solutions

Market Barriers	Potential Solutions
1. Unclear requirements for multi-unit hydronic heat pump systems in Title 24 2. Difficulty modeling water flow isolation accurately using performance path	1. Reconcile treatment of AWHPs and WWHPs with chillers and boilers where appropriate 2. Clearer guidance in ACM

Current Market Share

Market share: percentage of buildings that already use the proposed technology or design practice (at or above the proposed stringency level)

Current Market Share: Percent of non-residential buildings with multi-unit hydronic heat pumps that already meet the requirements of the proposed measure, based on stakeholder interviews

Technical Considerations

- Installed and operating performance of hydronic heat pumps in non-residential buildings often do not match expectations/advertised performance
- Energy can be wasted through unnecessary pump power and loss of energy if heated/cooled water passes through heat pumps that are not operational in a staged system
- Flow through non-operating heat pumps can result in improper delivery temperature for the system as a whole
- Possible energy losses have not been quantified previously
- Limitations are needed at certain times:
  - During compressor start-up
  - Defrost cycles
  - Freeze protection during cold weather

Technical Barriers and Solutions

Technical Barriers	Potential Solutions
1. Multi-unit AWHP and WWHP systems are uncommon and standard practice for isolating unused units is unclear 2. Average energy savings for the measure is challenging to calculate because of the numerous non-residential design configurations and control strategies 3. Limitations and exceptions may be needed	1. Interviews with designers and installers have indicated that water flow through non-operating hydronic heat pumps is fairly common, perhaps 35% of new systems. Additional stakeholder inputs are being sought. 2. Model savings for Title 24 prototype buildings using EnergyPlus once standard design practice has been determined for several common system configurations. 3. Inputs from stakeholders on current limitations in Draft CASE Report

Poll

Do the following assumptions seem realistic?

- **20-30% market penetration of hydronic heat pumps in 2029**
- **65% of relevant buildings already turn off water flow to non-operating heat pumps**

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

- Using CEC's methodology and metrics for non-residential buildings
- Model New Construction with default standard design
- Model Alterations with modified standard design
- For the purpose of cost-effectiveness analysis
  - Standard Design includes water being pumped through non-operating AWHPs in prototype building types with a staged central plant
  - Proposed Design turns off water flow around non-operating AWHPs, or reduce flow to manufacturer's specified minimum level if appropriate

Energy Modeling Assumptions

- Simulated energy savings in EnergyPlus with CBECC rulesets
- Simulated using the following prototypical buildings and climate zones

Prototypical Buildings

- For the Draft CASE Report, only the large school prototype
- For the Final CASE Report, all non-residential building types with established prototypes except hotels and mixed-use retail
- Existing HVAC replaced with multi-unit AWHPs for heating and cooling, but not hot water

Climate Zones

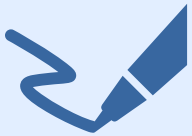
- All climate zones

Key Modeling Assumptions

Prototype: All building types likely to have multi-unit AWHP/WWHP systems except hotels and mixed-use retail

Standard Design

1. The standard design represented typical practice for AWHP systems that continue to provide water flow at full capacity when individual units are inactive.



Proposed Design

1. The proposed case used the default pump control in the model, which increased or decreased flow based on the heating and cooling load being served.

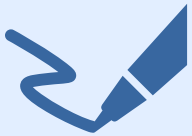
Incremental Cost Framework

Prototype(s): All building types likely to have multi-unit AWHP/WWHP systems except hotels and mixed-use retail

Baseline

First Cost

1. Equipment controls and plumbing consistent with standard practice for multi-unit systems
2. Standard commissioning practice
3. No incremental first cost



Proposed

First Cost

1. Flow controls and plumbing necessary to avoid circulation of conditioned water through unused AWHPs
2. Acceptance testing consistent with NA7.5.7
3. Incremental first cost for the proposed measure was estimated as $60/ton for systems larger than 100 tons and $100/ton for smaller systems

Approach for Gathering Costs

- For Draft CASE Report, estimated first cost for proper AWHP isolation compared to typical installation practices through interviews with designers and installers
- For Final CASE Report, incremental cost will be estimated by an HVAC design firm based on a representative 180-ton AWHP system design for a medium-size office building
- Energy cost savings modeled using EnergyPlus

Initial Cost-Effectiveness Estimates

- Based on best estimates of cost and energy savings, measure is cost-effective (benefit-cost ratio >1) in five Climate Zones

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV$)	Costs Total Incremental PV Costs (2029 PV$)	Benefit-to-Cost Ratio
1	0.20	0.22	0.89
2	0.05	0.22	0.21
3	0.01	0.22	0.03
4	0.13	0.22	0.60
5	0.05	0.22	0.22
6	0.07	0.22	0.31
7	0.02	0.22	0.08
8	0.21	0.22	0.96
9	0.16	0.22	0.70
10	0.28	0.22	1.24
11	0.32	0.22	1.45
12	0.06	0.22	0.28
13	0.41	0.22	1.83
14	0.61	0.22	2.72
15	1.49	0.22	6.65
16	0.11	0.22	0.47

Compliance Verification

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

Key Aspects of Compliance Verification

- Compliance with prescriptive requirements would be enforced in the same manner as it would be for boilers and chillers under Section 140.4(k).
- Performance path form NRCC-PRF-E may need revisions to document whether the prescriptive requirement was met and how the proposed design was modeled.
- There may be additional entries for hydronic heat pumps on Compliance Forms NRCC-MCH-E and NRCI-MCH-E to make verification easier for the plan reviewer, but it appears that hydronic heat pump isolation is already included.
- Ensure verification of isolation controls according to the test procedures in NA7.5.7
- Compliance software may need a minor update to penalize systems that don't meet the prescriptive requirements

Compliance Barriers and Solutions

Compliance Verification Barriers	Potential Solutions
1. Verification of AWHP/WWHP isolation 2. Compliance software is not clear about pump flow control assumptions	1. Compliance verification procedures will be the same as those used for boilers and chillers, with minor changes to compliance and installation forms (NRCC and NRCI) 2. Compliance software may need to be modified to include entries for actual pump flow control strategy

Compliance Software Updates

- Compliance software updates may be needed to model pump flow control accurately and demonstrate that all requirements are met, or to derate system performance if the requirements are not met.
- WWHP systems and gas-driven hydronic heat pumps may need to be added with mostly the same inputs as AWHPs

Bob Hendron
Frontier Energy
530-285-0918
bhendron@frontierenergy.com

Please copy: info@title24stakeholders.com

More information on
CEC's 2028 proceeding website.

We want to hear from you!

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