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California IOUs CASE Response Title 20 45-Day Language Water Topics

Additional submitted attachment is included below.

Faucets, Toilets & Urinals

Codes and Standards Enhancement (CASE) Initiative
For PY 2015: Title 20 Standards Development

Response to 45-Day Language for Faucets, Toilets and Urinals

Docket: #15-AAER-1, Water Appliances

April 2, 2015

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY	SOUTHERN CALIFORNIA EDISON	SAN DIEGO GAS AND ELECTRIC	SOUTHERN CALIFORNIA GAS COMPANY

Prepared by:
Heidi Hauenstein, ENERGY SOLUTIONS
Nate Dewart, ENERGY SOLUTIONS

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1 Executive Summary

The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas & Electric (SDG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. The comments provided in this document are made in response to the California Energy Commission's 45-Day Language for faucets, toilets and urinals. The comments include a number of recommendations regarding the draft regulations and also detailed research and analysis regarding hot water wait times and opportunistic pathogens, found in section 2.5 and in the appendices. Following the Governor's Executive Order B-29-15 on April 1st regarding extreme drought conditions, we urge the Energy Commission to act accordingly and to adopt emergency regulations that maximize all possible water savings.

One key highlight regarding faucets: While the CASE Team maintains that the best recommended cost-effective efficiency standard for residential lavatory faucets is a maximum flow rate of 1.0 gpm at 60 psi, a key revision to the IOU comments at the March 17th Public Hearing is that the CASE Team suggests the CEC consider a proposed maximum flow rate of 1.2 gpm. The CASE Team also suggests the CEC consider removing the minimum flow rate, previously at .5 gpm at 20 psi, to allow even lower flow products to be sold, considering the urgency for responding to the extreme drought conditions. These cost-effective levels would result in savings beyond the CEC proposal by over 4.5 billion gallons per year after full stock turnover. This is more than the annual residential water use of 160,000 Californians—roughly the population of Sacramento's largest suburb, Elk Grove.

This document includes proposed revisions to the requirements for showerheads so the Title 20 standards are consistent with the most recent Federal Appliance Efficiency Standards. Revisions to the showerhead requirements were included in this document so all of the CASE Team's proposed revisions to standards for plumbing fittings and plumbing fixtures were contained in the version of the language presented in Section 3. The CASE Team will be submitting a separate document that compiles all proposed revisions to Title 20 to ensure the Title 20 standards are consistent with the Federal Standards.

2 Comments on 45-day Language: Justification for Proposed Revisions

2.1 Definitions (Section 1602)

2.1.1 Harmonize Definitions with Federal Standards and National Consensus Standards

The CASE Team agrees with other interested parties, including Plumbing Manufacturers International (PMI) and several of the manufacturers that PMI represents, that the definitions in Title 20 should be harmonized with definitions in the Federal Appliance Efficiency Standards and national consensus standards, namely ASME A112.18.1-2011 and ASME A112.19.2-2013. The CASE Team has identified a number of definitions in the 45-day language that are not consistent with definitions in the Federal Appliance Efficiency Standards or ASME standards. The CASE Team has recommended revisions to the definitions of the following terms that are already included in Title 20 to harmonize with definitions in the Federal Appliance Efficiency Standards[1]:

Plumbing Fittings

- Hand-held showerhead
- Showerhead
- Plumbing fitting

Plumbing Fixtures

- Blowout water closet
- Dual-flush water closet
- Flushometer tank
- Flushometer valve
- Urinal
- Water Closet

The following definitions in Title 20 are not defined in the Federal Appliance Efficiency Standard. The revisions the CASE Team suggested will harmonize the Title 20 definitions with definitions in ASME A112.19.2-2013:

Plumbing Fixtures

- Blowout action
- Blowout bowl[2]
- Electro-hydraulic water closet
- Non-water consuming urinal

The CASE Team's suggested revision to the term "dual-flush effective flush volume" will harmonize the Title 20 definitions with definitions in the WaterSense Specification for Tank-type Toilets.

2.1.2 Establish Definitions for Faucet Accessories and Flush Devices

The CASE Team has recommended adding definitions for the following terms that are not currently defined in Title 20. The definition of flushing device is based on ASME A112.19.2.2013. We are recommending that all references to "aerator" in the definitions section and throughout the standards be replaced by "accessory" as the Standards should apply to all flow restriction and flow regulating devices, including but not limited to: aerators, laminar flow devices, and spray devices. It is important to establish efficiency standards for flush devices and faucet accessories to prevent backsliding of the efficiency gains that were accomplished by establishing more stringent standards. It is not desirable to allow the purchase a replacement accessory or flush device that will result in an increases the water use of a compliant product.

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[1] The Final Rule for the Test Procedure for Showerheads, Faucets, Water Closets, Urinals, and Commercial Pre-rinse Spray Valves, issued October 23, 2013 presented the most recent revisions to the definitions for plumbing fixture and plumbing fittings in the Federal Appliance Efficiency Standards (78 FR 62970, Oct 23, 2013).

[2] The CASE Team has recommended revisions to the definition of "blowout bowl" to harmonize the definition in Title 20 with the definition in ASME A112.19.2-2013. However, we believe the definition of "blowout bowl" could be deleted with no effect on the stringency, compliance, or enforcement of the Standards.

2.2 Test Methods (Section 1604)

The CASE Team agrees with PMI and other stakeholders who have suggested referencing ASME A112.19.2-2013 Section 7.10.The test method for toilet waste extraction performance is preferred over referencing the Maximum Performance (MaP) Toilet Fixture Performance Testing Protocol. The protocol that MaP developed has been incorporated into the national consensus standard, ASME 112.19.2-2013. Although the test method is the same in the MaP protocol and the ASME standard, it is preferable to reference a national consensus standard in the Title 20 standards. However, the CASE Team does want the toilet waste extraction performance to be tested up to 1000 grams, and recommends that the ASME test be conducted at the following levels: 350g, 400g, 500g, 600g, 800g, and 1000g.

We understand that California is preempted from adopting a test procedure other than the Federal Test procedure to measure water efficiency of toilets. However, we do not believe that California is preempted from adopting a test procedure that will be used to determine a metric that is not covered in the federal standards. In this case, toilet waste extraction performance is not covered by the Federal Standards, and there is no Federal test procedure to determine toilet waste extraction performance. As such, California can adopt its own test procedure to measure toilet waste extraction, and the state would not be preempted from adopting Section 7.10 of ASME A112.19.2-2013 for that purpose.

2.3 Standards for Federally Regulated (Section 1605.1)

The CASE Team recommends several editorial revisions to the requirements for plumbing fittings and plumbing fixtures in Section 1605.1. These changes include:

- Update requirements for showerheads so the Title 20 standard is consistent with the Federal Standard, which was revised in the Final Rule for the Test Procedure for Showerheads, Faucets, Water Closets, Urinals, and Commercial Pre-rinse Spray Valves, issued October 23, 2013. (78 FR 62970, Oct 23, 2013). The proposed revision includes separating the requirements for showerheads from requirements for other plumbing fittings by assigning the showerhead requirement its own section number (1605.1(h)1)
- Clarify that the requirements in Section 1605.1 only apply to metering faucets – not all faucets – by updating the heading to Section 1605.1(h)2 so it reads "*metering* faucets and wash fountains".
- Strike the efficiency requirements for replacement aerators from Table H-1. The proposed changes to Title 20 establish the minimum efficiency standards for kitchen and lavatory faucets at 1.8 gpm and 1.5 gpm, respectively. Allowing aerators to use 2.2 gpm could result in the savings from faucets backsliding because people can replace 1.8 gpm or 1.5 gpm aerators with 2.2 gpm aerators. Alternatively, *accessories* should have the same efficiency levels as kitchen faucets and lavatory faucets (see proposed revisions to Section 1605.3 Table H-3).
- Add "lavatory faucet accessories" and "kitchen faucet accessories" to the list of products that are covered in Section 1605.3.

2.4 State Standards for Federally Regulated Appliances (Section 1605.2)

The CASE Team recommends an editorial modification to direct readers to Section 1605.*3*(i) for efficiency standards for plumbing fixtures.

2.5 State Standards for Non-federally Regulated Appliances (Section 1605.3)

2.5.1 Faucets

The CASE Team maintains that the best recommended cost-effective efficiency standard for lavatory faucets is a maximum flow rate of 1.0 gpm at 60 psi. At the same time, however, the CASE Team also understands that some stakeholders are concerned about how the more efficient fixtures will be integrated with existing plumbing systems in buildings. Despite the absence of conclusive data to support these concerns (discussed briefly below and in the appendices of this document), the CASE Team suggests the CEC consider adoption of a maximum flow rate of 1.2 gpm at 60 psi. The CASE Team also suggests the CEC consider removing the minimum flow rate, previously at.5 gpm at 20 psi, to allow even lower flow products to be sold considering the urgency for responding to the extreme drought conditions. The removal of the minimum flow rate for these products also aligns with the current and proposed regulations for kitchen and public lavatory faucets, as these products have no minimum flow rate requirement.

At less than $5 incremental cost using more efficient aerators for up to 1.0 gpm, as highlighted in the CASE Report and in Acquacraft 2004, this standard would optimize water use and customer satisfaction, allowing high-efficiency, low-flow faucets to be sold in state. Adopting the maximum flow rate of 1.2 gpm as opposed to 1.5 gpm will result in savings of over 4.5 billion gallons per year after full stock turnover, the annual residential water use of 160,000 Californians—roughly the population of Sacramento's largest suburb, Elk Grove. Given the state of emergency from drought conditions and the Governor's Executive Order B-29-15 on April 1st, we urge the CEC to adopt these proposed standards to maximize water savings.

2.5.1.1 ***Hot Water Wait Time***

We recognize that some researchers have voiced concern that the reduction of lavatory faucet water use in residential buildings could lead to the unintended consequences of longer hot water wait times leading to wasted water and energy (PMI 2014). This concern is addressed in Appendix A of this document. While the variability in water distribution system design makes it difficult to quantify the potential wasted water associated with reducing faucet flow rates, some of the assumptions made in the PMI 2014 may result in an overstatement of wait times and wasted water and energy estimates. Moreover, using PMI's assumptions about water wasted when waiting for hot water to arrive reduces the water and embedded energy savings of the proposed measure by only about 6 percent relative to previous estimates. Natural gas and electricity savings from heating water are reduced by about 11 percent relative to our previous estimates. The proposed standard of 1.0 gpm and the considered 1.2 gpm still result in significant, cost effective water and energy savings. Moreover, surveys indicate that despite claims that hot water wait times could increase significantly, consumers were very satisfied when their 2.2 gpm lavatory faucets were replaced with 1.0 gpm faucets (Aquacraft 2004).

2.5.1.2 Opportunistic Pathogens

The CASE Team also recognizes that some researchers have raised concerns about the potential link of green plumbing systems to increased risk of exposure to opportunistic pathogens. This issue is addressed in Appendix B of this document. After completing a review of published research on opportunistic premise plumbing pathogens (OPPPs), the CASE Team has concluded that the existing body of research is insufficient to prove hypotheses researchers have made that faucet flow rate is correlated to an increased risk of exposer to opportunistic pathogens. Research sited in Appendix B provides no evidence that a faucet's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies. While reducing flow rate of all fixtures within the house can increase retention time and longer retention times have been hypothesized (but not proven) to increased growth of Legionella in buildings where Legionella is already present, there is no conclusive evidence that a reduction of flow rate of faucets, especially a reduction from 1.5 gpm to 1.0 or 1.2 gpm will lead to either the prominence of or increased concentration of Legionella.

2.5.1.3 Summary of Proposed Editorial Revisions to 45-day Language

The CASE Team has identified a number of editorial errors in the language pertaining to standards for faucets. The CASE Team has recommended the following revisions:

- Update Table H-3 to clarify that proposed standards apply to both lavatory faucet accessories and kitchen faucets accessories. The proposed changes to Title 20 establish the minimum efficiency standards for kitchen and lavatory faucets at 1.8 gpm and 1.5 gpm, respectively. Omitting efficiency requirements for accessories at the same efficiency level could result in the savings from faucets backsliding because people can replace 1.8 gpm or 1.5 gpm accessories with accessories that consume more water.

2.5.2 Water Closets

The CASE Team is recommending two revisions to the standards for water closets. First, we recommend adding a requirement to Section 1601.3(h) to clarify that dual-flush toilets cannot use more than 1.6 gpf at full-volume flush. This revision aligns the Title 20 full-volume flush standard with the federal efficiency standard for dual-flush toilets, which requires that dual-flush toilets not exceed 1.6 gpf on the full-volume flush. Although proposed Title 20 standard for dual-flush toilets achieve an effective flush volume of 1.28 gpf or less, the State will be on safer grounds regarding preemption if the Title 20 standard also ensures that the full-volume flush cannot exceed the federal efficiency level of 1.6 gpf.

Second, the CASE Team recommends that tank-type toilets meet the appropriate requirements as specified in the WaterSense® Specification for Tank-Type Toilets – Version 1.2. Several commenters argued that the Title 20 Standard, particularly a performance standard, should be based on WaterSense and using a metric other than WaterSense Specification, which was developed with substantial contributions and participation from industry and other interested parties, could harm the WaterSense brand. After reviewing comments and further discussions with interested parties, the CASE Team supports requiring tank-type toilets to meet the relevant requirements in the WaterSense Specification.

2.5.3 Urinals

The CASE Team is pleased to see that the 45-day language includes a requirement that urinals use no more than 0.125 gpf. The CASE Report and subsequent information submitted for this rulemaking provides clear justification that this efficiency level is appropriate and recommended.

Upon further review, we are recommending that the efficiency requirement for floor-mounted urinals also be set at 0.125 gpf.

2.5.4 Establishing standards for flush valves for toilets and urinals

The CASE Team maintains the recommendation presented in the CASE Report that Title 20 should include efficiency standards for flush valves for water closets and urinals. Senate Bill 407 (Padilla 2009) requires that, on or before January 1, 2019, all noncompliant plumbing fixtures (i.e., toilets over 1.6 gpf and urinals over 1.0 gpf) in single-family residential, multifamily residential and commercial buildings built before 1994 be replaced with water-conserving plumbing fixtures.[3] Pursuant to SB 407, after January 1, 2019 there would be no lawful purpose in shipping valve designed for more than 1.6 gpf for toilets and 1.0 gpf for urinals as all toilets and urinals in the State should meet the minimum efficiency levels of 1.6 gpf and 1.0 gpf by that date.

The specific revisions to Title 20 standards to accomplish the goal of preventing the efficiency gains that are achieved through SB 407 from slipping by way of installing valves that exceed the minimum efficiency levels of 1.6 gpf and 1.0 gpf for toilets and urinals include:

- Add definitions of "flush device" to Section 1601(i).
- Add efficiency requirements for flush valves for water closets and urinals to Section 1605.3(i).
- Add "waster closet flush device" and "urinal flush device" as permissible answers for plumbing fixture type in Table x in Section 1606.

2.6 Filing by Manufacturers; Listing of Appliances in Database (Section 1606)

3 Proposed Revisions to 45-day Language

CEC's proposed changes to Title 20 Standards, as proposed in the 45-day language, are marked with <u>single underlining</u> (additions to existing language) and ~~single strike-out~~ (deletions to existing language). The CASE Team's recommended revisions to the 45-day language are highlighted in yellow and marked with <u>double underlining</u> (additions to 45-day language) and ~~double strike-out~~ (deletions to 45-day language).

Section 1601. Scope.

(h) Plumbing fittings, which are showerheads, lavatory faucets, kitchen faucets, metering faucets, <u>kitchen faucet</u>~~replacement~~ ~~aerators~~ <u>accessories</u>, <u>lavatory faucet accessories</u>, wash fountains, tub spout diverters, <u>public lavatory faucets</u>, and

[3] Buildings constructed in 1994 or later were subject to Federal efficiency standards established by the Energy Policy Act of 1992 that required toilets and urinals to consume no more than 1.6 gpf and 1.0 gpf, respectively.

Section 1602. Definitions

(h) Plumbing Fittings.

"Commercial pre-rinse spray valve" means a hand-held device designed and marketed for use with commercial dishwashing and ware washing equipment that sprays water on dishes, flatware, and other food service items for the purpose of removing food residue before cleaning the items.

"Faucet" means a lavatory faucet, kitchen faucet, metering faucet, or ~~replacement~~ accessory ~~aerator~~ for a lavatory or kitchen faucet.

"Flow rate" means the rate of water flow of a plumbing fitting, as determined using the applicable test method in Section 1604(h).

"Hand-held showerhead" means a showerhead that can be held or fixed in place for the purpose of spraying water onto a bather and that is connected to a flexible hose.

"Kitchen faucet" means a faucet designed for discharge into a kitchen sink.

~~"Kitchen replacement aerator" means an aerator sold as a replacement, separate from the kitchen faucet to which it is intended to be attached.~~

"Kitchen faucet accessory" means all devices designed to regulate water flow including but not limited to: pressure compensating devices, restricting devices, aerator devices, laminar devices, and spray devices that are sold separately from the kitchen faucet to which it is intended to be attached.

"Lavatory" means a basin or bowl designed for washing the face and hands.

"Lavatory faucet" means a plumbing fitting designed for discharge into a lavatory.

~~"Lavatory replacement aerator" means an aerator sold as a replacement, separate from the lavatory faucet to which it is intended to be attached.~~

"Lavatory faucet accessory" means all devices designed to regulate water flow including but not limited to: pressure compensating devices, restricting devices, aerator devices, laminar devices, and spray devices that are sold separately from the lavatory faucet to which it is intended to be attached.

"Leakage rate" means the rate of leakage through a tub spout diverter directly into the bathtub when the diverter is in the diverting position, as determined using the applicable test method in Section 1604(h).

"Lift-type tub spout diverter" means a tub spout diverter that is operated by lifting the control.

"Metering faucet" means a faucet that, when turned on, will gradually shut itself off over a period of several seconds.

"Plumbing fitting" means a device that controls and guides the flow of water ~~in a supply system~~. Examples include showerhead, lavatory faucet, kitchen faucet, metering faucet, lavatory faucet ~~replacement aerators~~ accessory, kitchen faucet ~~replacement aerators~~ accessory, wash fountain, commercial pre-rinse spray valves, or tub spout diverter.

"psi" means pounds per square inch.

"Public lavatory faucet" means a faucet intended to be installed in non-residential bathrooms that are exposed to walk-in traffic.

"Pull-type tub spout diverter" means a tub spout diverter that is operated by pulling the control.

"Showerhead" means a component or set of components distributed in commerce for attachment to a single supply fitting, for spraying water onto a bather, typically from an overhead position, excluding safety showers. ~~device through which water is discharged for a shower bath. Showerhead means any showerhead (including a hand held showerhead), except a safety showerhead.~~

~~"Showerhead" means a device through which water is discharged for a shower bath.~~

"Showerhead-tub spout diverter combination" means a group of plumbing fittings sold as a matched set and consisting of a control valve, a tub spout diverter, and a showerhead.

(i) Plumbing Fixtures.

"Blowout action" is a means of flushing a water closet whereby a jet of water directed at the bowl outlet opening pushes the bowl contents into the upleg, over the weir, and into the gravity drainage system.

"Blowout type bowl" means a non-siphonic ~~type~~ water closet bowl ~~that is designed for a blowout action, and that has~~ with an integral flushing rim, a trap~~way~~ at the rear of the bowl, and a visible or concealed jet that operates with a blowout action.~~, a wall outlet, and, if wall mounted, a three bolt hole configuration.~~

"Blowout water closet" means a water closet that uses a non-siphonic bowl with an integral flushing rim, a trap at the rear of the bowl, and a visible or concealed jet that operates with a blowout action. ~~with a blowout type bowl.~~

"Dual-flush effective flush volume" means the composite average flush volume of two reduced flushes and one full flush.

"Dual-flush water closet" means ~~is~~ a water closet incorporating a feature that allows the ~~a~~ user to flush the water closet with either a reduced or a full volume of water.

"Electro~~mechanical~~-hydraulic water closet" means a water closet with a non-mechanical trap seal incorporating an electric motor and controller to facilitate flushing.~~that utilizes electrically operated devices, such as, but not limited to, air compressors, pumps, solenoids, motors, or macerators in place of or to aid gravity in evacuating waste from the toilet bowl.~~

"Flushometer tank" means a device whose function is defined in flushometer valve, but ~~that is~~ integrated within an accumulator vessel affixed and adjacent to the ~~a~~ plumbing fixture inlet so as to cause an effective enlargement of the supply line immediately before the unit ~~fixture~~.

"Flushometer tank water closet" means a water closet utilizing a flushometer tank.

"Flushometer valve" means a flushing device ~~that is~~ attached to a pressurized water supply pipe and ~~that is~~ so designed so that when actuated, it opens the line for direct flow into the fixture at a rate and ~~predetermined~~ quantity to properly operate the fixture, and then gradually closes ~~in order~~ to provide trap reseal in the fixture in order ~~and~~ to avoid water hammer. The pipe to which this~~e~~ device is connected is~~,~~ in itself~~,~~ of sufficient size, that when open, shall allow the device to deliver water at a sufficient rate of flow for flushing purposes.

"Gallons per flush (gpf)" means gallons per flush as determined using the applicable test method in Section 1604(i).

"Gravity tank-type water closet" means a water closet that includes a storage tank from which water flows into the bowl by gravity.

"Plumbing fixture" means a water closet or a urinal.

"Prison-type urinal" means a urinal designed and marketed expressly for use in prison-type institutions.

"Prison-type water closet" means a water closet designed and marketed expressly for use in prison-type institutions.

"Flush valve" means a flushing device for delivering water into a water closet bowl or urinal including, but not limited to: pressurized flushing device, flushometer tank, or flushometer valve that is sold separately from the water closet bowl or urinal.

"Trough-type urinal" means a urinal designed for simultaneous use by two or more persons.

"Urinal" means a plumbing fixture ~~that~~ which receives only liquid body waste and, on demand, conveys the waste through a trap seal into a gravity drainage system.

"Vacuum-type urinal" means a urinal whose bowl is evacuated by the application of a vacuum.

"Vacuum-type water closet" means a water closet whose bowl is evacuated by the application of a vacuum.

"Water closet" means a plumbing fixture that has ~~having~~ a water-containing receptor which ~~that~~ receives liquid and solid body waste, and upon actuation, conveys the waste through an exposed integral trap seal into a gravity drainage system.

"Water use" means the quantity of water flowing through a water closet or urinal at point of use, determined in accordance with test procedures under Appendix T of subpart B of 10 C.F.R. part 430.

"Waste Extraction Performance ~~MaP~~" means maximum mass of test media that was successfully flushed in accordance to the test procedure defined in Section 1604(i)b. ~~flushing performance.~~

"Nonwater consuming ~~Waterless~~ urinal" means a urinal that conveys liquid body waste through a trap seal into a gravity drainage system without the use of water. ~~designed to be used without the application of water for flushing.~~

Section 1604. Test Methods for Specific Appliances.

(i) Plumbing Fixtures.

The test methods for plumbing fixtures ~~is~~ are: follows:

(1) The test method for water efficiency is 10 CFR Section 430.23(t) (Appendix T to Subpart B of part 430).

(2) ~~MaP Testing Toilet Fixture Performance Testing Protocol Version 5 – March 2013.~~ The test method for water closet waste extraction performance is ASME A112.19.2-2013/CSA B45.1-13 Section 7.10 but the test shall be completed using 350 grams, 400 grams, 500 grams, 600 grams, 800 grams, and 1000 grams of test media with the results recorded as "pass" or "fail" for each increment.

…

The following documents are incorporated by reference in Section 1604.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.19.2-2013 / CSA B45.1-13	Ceramic Plumbing Fixtures
Copies available from:	ASME International Three Park Avenue New York, NY 10016-5990 www.asme.org Phone: (800) THE-ASME (U.S./Canada) 95-800-843-2763 (Mexico) (973) 882-1167 (Outside North America)

~~GAULEY ASSOCIATES, LTD. KOELLER & COMPANY~~

~~Maximum performance (map) testing:~~	~~MaP Testing Toilet Fixture Performance Testing Protocol Version 5 (March 2013)~~
~~Copies available from:~~	~~Koeller and Company~~ ~~5962 Sandra Drive,~~ ~~Yorba Linda, CA., 92886-5337~~ ~~Tel (714) 777-2744 Mobile (714) 757-0679~~ ~~www.map-testing.com~~

Section 1605.1. Federal and State Standards for Federally-Regulated Appliances.

(h) Plumbing Fittings.

(1) **Showerheads.** The flow rate of showerheads shall not be greater than the applicable values in Table H-1. When used as a component of any such showerhead, the flow-restricting insert shall be mechanically retained at the point

of manufacture such that a force of 8.0 pounds force (36 Newtons) or more is required to remove the flow-restricting insert, except that this requirement shall not apply to showerheads for which removal of the flow-restricting insert would cause water to leak significantly from areas other than the spray face.

(2) **Metering Faucets~~,~~ ~~Aerators,~~ and Wash Fountains.** The flow rate of ~~showerheads~~, ~~lavatory faucets, kitchen faucets, lavatory replacement aerators, kitchen replacement aerators~~, wash fountains, and metering faucets shall be not greater than the applicable values shown in Table H-1. ~~Showerheads shall also meet the requirements of ASME/ANSI Standard A112.18.1M-1996, 7.4.4(a).~~

Table H-1 Standards for Plumbing Fittings

Appliance	Maximum Flow Rate
Showerheads	2.5 gpm at 80 psi
~~Lavatory faucets~~	~~2.2 gpm at 60 psi1.2~~
~~Kitchen faucets~~	~~2.2 gpm at 60 psi~~
~~Replacement aerators~~	~~2.2 gpm at 60 psi~~
Wash fountains	$2.2 \text{ x } \frac{\text{rim space (inches)}}{20}$ gpm at 60psi
Metering faucets	0.25 gallons/cycle[~~3,4~~ 1,2]
Metering faucets for wash fountains	$2.5 \text{ x } \frac{\text{rim space (inches)}}{20}$ gpm at 60psi [1,2 ~~3,4~~]

[~~1~~] ~~**Sprayheads with independently-controlled orifices and manual controls.** The maximum flow rate of each orifice that manually turns on or off shall not exceed the maximum flow rate for a lavatory faucet.~~

[~~2~~] ~~**Sprayheads with collectively controlled orifices and manual controls.** The maximum flow rate of a sprayhead that manually turns on or off shall be the product of (a) the maximum flow rate for a lavatory faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).~~

[1~~3~~] **Sprayheads with independently controlled orifices and metered controls.** The maximum flow rate of each orifice that delivers a pre-set volume of water before gradually shutting itself off shall not exceed the maximum flow rate for a metering faucet.

[2~~4~~] **Sprayheads with collectively-controlled orifices and metered controls.** The maximum flow rate of a sprayhead that delivers a pre-set volume of water before gradually shutting itself off shall be the product of (a) the maximum flow rate for a metering faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

~~(2) Showerhead-Tub Spout Diverter Combinations. Showerhead-tub spout diverter combinations shall meet both the standard for showerheads and the standard for tub spout diverters.~~

(3) **Tub Spout Diverters**. See Section 1605.3(h) for standards for tub spout diverters.

(4) **Commercial Pre-rinse Spray Valves.**

(A) The flow rate of commercial pre-rinse spray valves manufactured on or after January 1, 2006 shall be equal to or less than 1.6 gpm at 60 psi.

(B) See Section 1605.3(h) for design standards for commercial pre-rinse spray valves.

~~(5)~~ **Lavatory faucets, kitchen faucets lavatory faucet accessories, kitchen faucet accessories, and public lavatory faucets.** See Section 1605.3(h)(2) for standards for all lavatory faucets, kitchen faucets, and public lavatory faucets sold or offered for sale in California.

(i) Plumbing Fixtures.

~~The water consumption of water closets and urinals shall be not greater than the values shown in Table I.~~

Table I

Standards for Plumbing Fixtures

~~**Appliance**~~	~~**Maximum Gallons per Flush**~~
~~Gravity tank-type water closets~~	~~1.6~~
~~Flushometer tank water closets~~	~~1.6~~
~~Electromechanical hydraulic water closet~~	~~1.6~~
~~Blowout water closets~~	~~3.5~~
~~Trough-type urinals~~	~~Trough length (inches) / 16~~
~~Other urinals~~	~~1.0~~

Water closets and urinals. See Section 1605.3(i) for standards for all water closets and urinals sold or offered for sale in California.

Section 1605.2. State Standards for Federally-Regulated Appliances.

(i) Plumbing Fixtures.

See Section 1605.~~1~~3(i) for water efficiency standards for plumbing fixtures ~~that are federally-regulated consumer products~~.

Section 1605.3. State Standards for Non-Federally-Regulated Appliances.

(h) Plumbing Fittings.

(1) **Tub Spout Diverters** and Showerhead Tub Spout Diverter Combinations**.** The leakage rate of tub spout diverters manufactured on or after March 1, 2003 shall be not greater than the applicable values shown in Table H-2. Showerhead-tub spout diverter combinations shall meet both the standard for showerheads and the standard for tub spout diverters.

~~(2) Showerhead-Tub Spout Diverter Combinations. Showerhead-tub spout diverter combinations shall meet both the standard for shower heads and the standard for tub spout diverters.~~

(2) **~~Showerheads,~~ Faucets~~,~~ and Faucet Accessories ~~Aerators, and Wash Fountains~~.** The flow rate of ~~showerheads,~~ lavatory faucets, kitchen faucets, ~~replacement~~ accessories, lavatory faucet ~~replacement~~ accessories ~~aerators~~, and kitchen faucet ~~replacement~~ accessories ~~aerators, wash fountains, and metering faucets~~ shall be not greater than the applicable values shown in Table H- 3. ~~Showerheads shall also meet the requirements of ASME/ANSI Standard A112.18.1M-1996, 7.4.4(a).~~

Table H-3: Standards for Plumbing Fittings

Appliance	***Maximum Flow Rate***	
	Manufactured prior to May 1, 2016	***Manufactured on or after May 1, 2016***
Lavatory faucets and lavatory faucet accessories	2.2 gpm at 60 psi [1,2]	1.0 gpm at 60 psi [1, 2] ~~and no less than 0.8 gpm at 20 psi~~
Kitchen faucets and kitchen faucet accessories	2.2 gpm at 60 psi	1.8 gpm with optional temporary flow of 2.2 gpm at 60 psi
Public lavatory faucets	2.2 gpm at 60 psi	0.5 gpm at 60 psi
[1] **Sprayheads with independently-controlled orifices and manual controls.** The maximum flow rate of each orifice that manually turns on or off shall not exceed the maximum flow rate for a lavatory faucet. [2] **Sprayheads with collectively controlled orifices and manual controls.** The maximum flow rate of a sprayhead that manually turns on or off shall be the product of (a) the maximum flow rate for a lavatory faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters))		

(i) Plumbing Fixtures.

(1) The water consumption of water closets, and urinals, other than those designed and marketed exclusively for use at prisons or mental health care facilities, shall be no greater than the values shown in Table I-2.

~~See Section 1605.1(i) for water efficiency standards for plumbing fixtures that are federally-regulated consumer products.~~

Table I-2 Standards for Water Closets and Urinals

Appliance	***Maximum Gallons per Flush or ~~Average Flush for Dual Flush~~***	
	Manufactured on or after January 1, 2014	***Manufactured on or after May 1, 2016***
Dual-flush water closets (full-flush volume)	1.6	1.6
Dual-flush water closet (effective flush volume)	1.28	1.28
All water closets	1.28	1.28
Trough-type urinals	Trough length (inches) / 16	Trough length (inches) / 16
~~Wall mounted~~ other urinals	0.5	0.125
~~Floor-mounted urinals~~	~~0.5~~	~~0.5~~

(2) Water closets shall achieve a ~~MaP~~ waste extraction performance score of no less than 350 grams. Tank-type water closets shall meet the applicable water closet requirements specified in the WaterSense Specification for Tank-Type Toilets, Version 1.2.

(3) Water closet and urinal flush valves shall not be designed to deliver flush volumes greater than the values shown in Table I-2.

Table I-3.

Standards for Water Closet and Urinal Flush Valves

Appliance	***Maximum Gallons per Flush*** *(Effective January 1, 2019)*
Water closet flush valve	1.6

Urinal flush valve	1.0

~~See Section 1605.1(i) for water efficiency standards for plumbing fixtures that are federally-regulated consumer products.~~

…

The following documents are incorporated by reference in Section 1605.3.

WATERSENSE® SPECIFICATION FOR TANK-TYPE TOILETS VERSION 1.2

Copies available from: US EPA
WaterSense
Office of Wastewater Management (4204M)
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460.
www.epa.gov/WaterSense

Section 1606. Filing by Manufacturers; Listing of Appliances in Database.

Table X - Data Submittal Requirements

	Appliance	***Required Information***	***Permissible Answer***
H	Plumbing Fittings	*Type	Showerhead, lavatory faucet (independent or collective), public lavatory faucet, kitchen faucet, metering faucet (independent or collective), lavatory faucet ~~replacement~~ ~~aerators~~ accessory, kitchen faucet ~~replacement~~ ~~aerators~~ accessory, wash fountain, lift-type tub spout diverter, turn-type tub spout diverter, pull-type tub spout diverter, push-type tub spout diverter
		Flow Rate (Maximum)	
		Pulsating (for showerheads only)	Yes, no
		Rim Space (for wash fountains only)	
		Tub Spout Leakage Rate When New	
		Tub Spout Leakage Rate After 15,000 Cycles	
I	Plumbing Fixtures	*Type	Blowout water closet, dual-flush water closet, gravity flush tank ~~type~~ water closet, electro~~mechanical-~~hydraulic water closet, flushometer tank water closet, prison-type water closet, flushometer valve water closet, vacuum-type water closet, urinal, nonwater consuming ~~waterless~~ urinal, prison-type urinal,

			trough-type urinal, vacuum-type urinal, urinal flush valve, water closet flush valve
		Water Consumption (~~dual-flush~~ effective flush volume for dual-flush water closet)	
		~~MaP~~ Waste Extraction Performance Score (for water closet only)	
		Trough Length (trough-type urinals only	

Appendix A: CA IOUs Response to Comments on Wasted Water and Energy When Waiting for Hot Water to Arrive

Faucets

Codes and Standards Enhancement (CASE) Initiative
For PY 2015: Title 20 Standards Development

Comments regarding draft regulations:
Faucets

CA IOUs Response to Comments on Wasted Water and Energy When Waiting for Hot Water to Arrive

Docket: #15-AAER-1, Water Appliances

March 27, 2015

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY | SOUTHERN CALIFORNIA EDISON | SAN DIEGO GAS AND ELECTRIC | SOUTHERN CALIFORNIA GAS COMPANY

Prepared by:
Heidi Hauenstein, ENERGY SOLUTIONS
Nate Dewart, ENERGY SOLUTIONS

This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

1 Summary

Some researchers have voiced concern that the reduction of lavatory faucet water use in residential buildings could lead to the unintended consequences of longer hot water wait times leading to wasted water and energy (PMI 2014). While the variability in water distribution system design makes it difficult to quantify the potential wasted water associated with reducing faucet flow rates, some of the assumptions made by PMI may result in an overstatement of wait times and wasted water and energy estimates. Moreover, even when using PMI's assumptions about wasted water when waiting for hot water to arrive, updating California's lavatory faucet efficiency standard from 2.2 gallons per minute (gpm) to 1.0 gpm will result in significant water and energy savings and the proposed standard remains cost effective. Moreover, surveys indicate that despite claims that hot water wait times could increase significantly, consumers are very satisfied when their 2.2 gpm lavatory faucets are replaced with 1.0 gpm faucets (Aquacraft 2004).

The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about hot water delivery times. Updating standards for the sizing and design of hot water distribution systems will help ensure that hot water wait times are minimized in newly constructed buildings. In parallel with efforts to update the plumbing fixture efficiency levels in Title 20, the CA IOUs have been advocating for revisions to the California Building Code (Title 24) to help minimize hot water wait time.

2 Hot Water Distribution System Design and Hot Water Wait Times

Assessing the performance of residential hot water distribution systems is complex. Hot water wait time and the amount of water that is wasted when waiting for hot-enough water to arrive depends on many factors including: hot water temperature, initial pipe temperature, ambient temperature, pipe material, pipe size, pipe length, pipe insulation, fixture flow rate, and time between hot water draws (CEC 2005). Given the number of factors that contribute to hot water wait time and the reality that hot water distribution systems within existing buildings in California have not been well characterized, it is difficult to determine how much water will be wasted statewide when waiting for hot water to arrive at lavatory faucets.

The following observations about the assumptions PMI (2014) used in its test set up suggest that PMI's analysis might overstate the statewide average hot water wait time and wasted water and energy that is wasted when waiting for hot water to arrive:

- **Warm Enough:** First, PMI (2014) assumed that "warm-enough" water is 110^{o}F whereas the CEC (2005) analysis assumes warm-enough water is 105^{o}F.[4] Secondly and perhaps more importantly, it is commonly the case that for many activities, such as hand washing, very hot water is not required or even waited for by users. Each individual will perceive warm-enough water differently. California's mild climates mean that in most buildings "cold" water is not "freezing" cold, and some people feel that the "cold" water that comes

[4] For the CASE Report energy and water savings analysis, it was assumed that water was heated to 124^{o}F at the hot water heater. The temperature at the faucet was not factored into the energy savings calculations.

from the faucet immediately is warm-enough for hand washing and other tasks performed at lavatory faucets. In fact, a 2012 CEC study presents results of a user behavior survey that evaluated how people use hot water in residential buildings. Only one-quarter of the approximately 500 respondents (respondents lived primarily in the greater Los Angeles area and San Francisco Bay Area where cold water temperatures are reasonably warm) said that they waited for hot water to arrive at the bathroom or kitchen faucets. That is, 75% of respondents *did not* wait for hot water to arrive (CEC 2012). Moreover, the Aquacraft 2004 study demonstrated that the installation of high efficiency aerators in Tampa homes resulted in the same duration of faucet use (roughly 10 min pre and post retrofit), and the use of less water. In other words, the households likely spent no additional time waiting for hot water. These studies indicate that in many cases warm- enough water is well below 110°F and is often actually cold water. Some offices and other nonresidential sinks are not even supplied with any hot water, which may accustom users to these conditions at their homes. PMI's assumption that warm-enough water is 110°F is hotter than the assumed warm-enough temperature used in other similar research efforts and is hotter than many peoples' perception of warm enough. Assuming that the statewide average warm-enough temperature for all people that use lavatory faucets in California is 110°F will result in an overstatement of the wasted water and energy when waiting for hot water to arrive.

- **Number of Cold Starts:** A cold start is defined as a hot water event in which the entire volume of water between the hot water source and the outlet is cold when the user turns on the hot water outlet. PMI assumed that there would be 2 cold starts per lavatory faucet per day. The CA IOU CASE Report did not quantify cold starts, but on average, each faucet would be used 15.73 times per day and that 50 percent (or 7.9) of those uses would be hot water draws.[5] Additionally, subsequently found data indicates that hot water draws tend to be clustered together in a relatively short period of time, so absolute cold starts are not common. A report Lawrence Berkeley National Laboratory published in 2012 (Lutz 2012), found that 75 percent of all hot water draws (including draws from all outlets in the home) occur within less than 15 minutes from the previous draw and 50 percent of draws occur with less than 3 minutes of the previous draw. Since hot water events tend to be clustered, warm enough water will oftentimes occupy at least a portion of water in the distribution system when the user turns on the faucet, so hot water will arrive sooner than it would in a cold start. The CA IOUs are not aware of any data to verify PMI's assumption of 2 cold starts per faucet per day. This estimate may be accurate for some users, though it may result in an overestimate of wasted water for statewide estimates.

- **Entrained Volume:** The volume of water inside the hot water pipes between the hot water source (usually the water heater, but could also be the recirculation loop), and the point of use is referred to as the entrained volume. PMI assumed an entrained volume of 1.5 and/or 1.38 gallons per 100 foot (both numbers are cited in the report), but there is some data that suggests these numbers could be high for the typical California home.

  A 2012 CEC study (CEC 2012) evaluated hot water distribution systems in 97 newly constructed single family homes and compared results to a previous study conducted in 2006. The researchers found that, on average, a typical 2,000 square foot home built in

[5] See CASE Report for more information about assumptions the CA IOUs used in energy and water savings analysis (CA IOUs 2013).

2011 held one gallon of water in the pipes between the hot water source and the point of use. This finding was consistent with findings from the survey completed in 2006. While the 2012 CEC study was not a comprehensive review of all plumbing systems in existing buildings in California, the results are representative of buildings that have been built in the past decade.

The 2012 CEC study also describes the conditions of older homes that could result in the same amount of entrained volume as newer homes. On the one hand, over the past ten to fifteen years copper pipe has been replaced with plastic pipe as the standard piping material. Plastic pipe has lower entrained volumes per 100 feet than copper pipe. The 2012 CEC report found that there is 20-30 percent less water entrained in ½ inch and ¾ inch PEX pipe than copper pipe (see Figure 1). On the other hand, while PEX has a lower entrained volume per 100 feet, the CEC report also notes that "one of PEX's main positive attributes (flexible pipe promotes ease of installation) has also resulted in abuses in terms of inefficient plumbing layouts." So, the benefits of the lower entrained volume of PEX relative to copper may be diminished because plumbing layouts that use PEX may use longer pipe lengths. PMI's analysis assumed entrained volume(s) are larger than the average volume observed in newly constructed homes in 2006 and 2011, and may be on the high-end of typical entrained volumes for all existing California residential buildings. As a result, PMI's estimates water and energy wasted statewide when waiting for hot water to arrive water may be overstated.

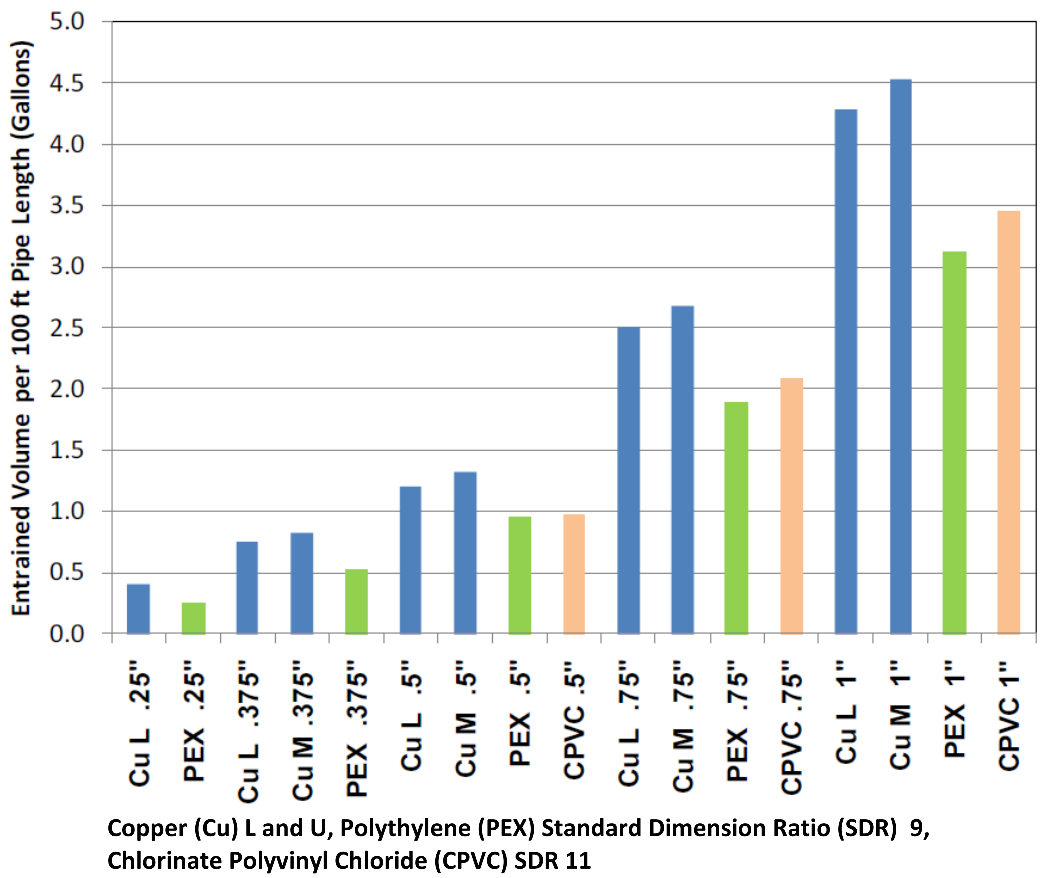

Figure 1: Entrained Pipe Volume Comparison – Copper versus Plastic Pipe

Source: CEC 2013

- **Pipe Insulation:** PMI 2014 did not specify if the pipe used in the analysis was insulated, but the CASE Team confirmed with the author that the pipe was not insulated for the analysis. As a result, PMI's results are not representative of the many buildings in California that have insulated pipes, and using PMI's estimates in a statewide savings analysis may result in an overstatement of water wasted when waiting for hot water to arrive. Pipe insulation has a significant impact on hot water delivery times; insulated pipes cool-down time 200-400 percent slower than un-insulated pipes (CEC 2005). Extending the period of time that water is at a useful temperature within the pipes reduces the number of times that warm water needs to be purged. Pipe insulation is particularly important because, as mentioned below, hot water draws tend to be clustered together in time. Pipe insulation has also been shown to reduce the hot water delivery times for cold starts, particularly when flow rates are low and pipes are in high heat-loss environments (CEC 2005).

In addition to the specific observations about PMI's assumptions listed above, PMI's results came from one set of measurements on one possible plumbing layout. Given the diversity of hot water distribution systems in California's buildings, the results of PMIs analysis should be considered judiciously, especially when evaluating wait times. As discussed in the next section, even when PMI's results are used for estimating wasted hot water, the savings from a faucets standard set at 1.0 gpm at 60 psi are still significant and cost-effective.

A 2005 CEC PIER report highlights the variability by providing more context as to how hot water distribution systems perform (CEC 2005). The study evaluated the impact of the following factors on wait times and the volume of water wasted when waiting for hot water to arrive: hot water temperature, initial pipe temperature, ambient temperature, length of pipe, pipe insulation and flow rate. The study found that performance of hot water delivery systems varies widely based on the plumbing system design, temperature settings, and ambient conditions. **Figure 2** and **Figure 3** present the results of testing performed for the 2005 CEC PIER Report. The tests were conducted on ¾ inch insulated (Figure 1) and un-insulated (Figure 2) PEX pipes.[6]

The CASE Team has not included a direct comparison between PMI's analysis and 2005 CEC PIER analysis, given that the two studies used different types of ¾ inch PEX pipe. The PEX pipe CEC used held 2.0 gallons per 75 feet of length whereas PMI's pipe held 1.38 gallons per 75 feet. While a direct comparison is not possible, the CEC PIER analysis provides additional data points for consideration. Note that both the PMI analysis and the 2005 CEC PIER study evaluate water wasted during cold starts as discussed above. As mentioned previously, hot water draws tend to be clustered together in time, so cold starts are not as common as draws in which warm enough water is closer to the outlet.

[6] The 2005 PIER Report did not evaluate impacts on ½ inch PEX pipe.

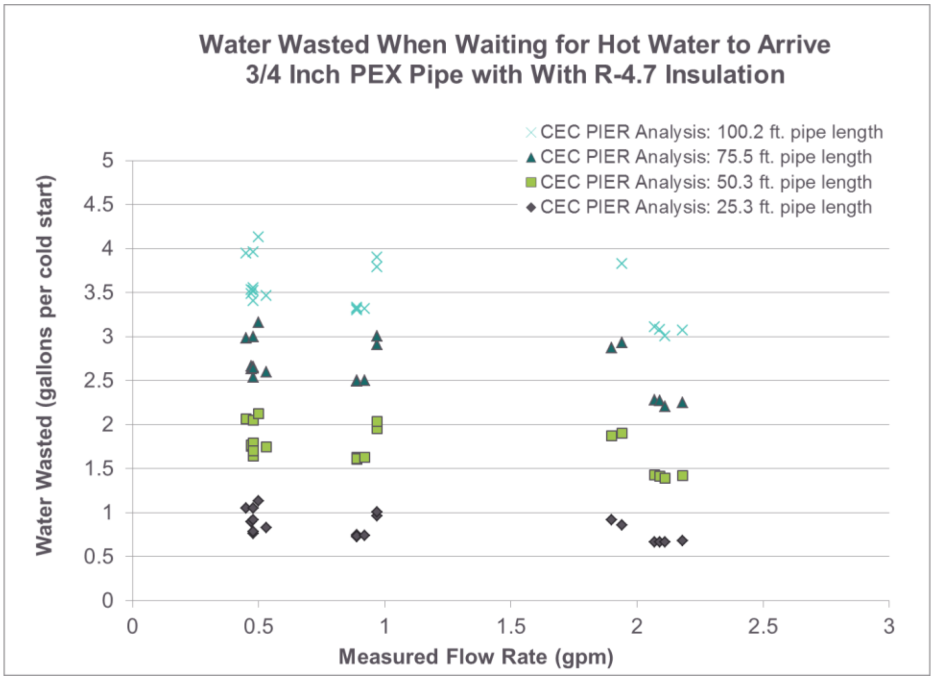

Figure 2: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through ¾ inch PEX Pipe with R-4.7 Insulation

Source: CEC 2005

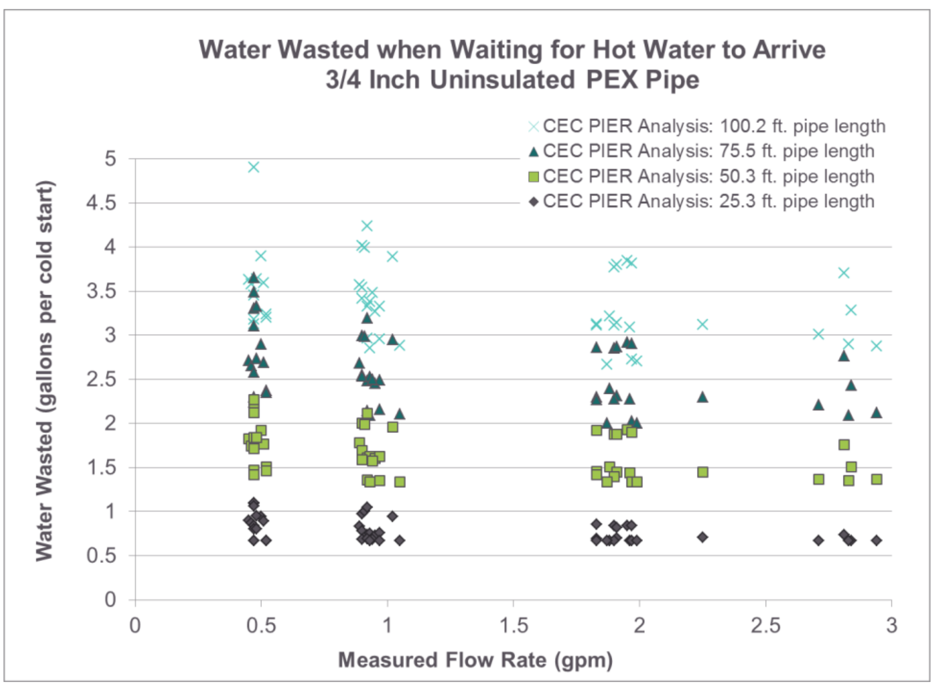

Figure 3: Results of CEC PIER Study (2006) Showing Wasted Water When Waiting for Hot Water to Arrive Through <u>Uninsulated</u> ¾ inch PEX Pipe

Source: CEC 2005

3 Impact of Wasted Water on Energy Savings and Cost Effectiveness of 1.0 GPM Faucet Standard

As described above, the assumptions PMI used in its analysis may overstate the average estimate to use for statewide savings estimates. In an effort to establish the upper level of possible water and energy waste, however, the CASE Team has provided below the water and energy savings analysis of the proposed 1.0 gpm faucet standard factoring in PMI's assumptions about water and energy wasted when waiting for hot water to arrive.

In summary, discounting the water savings to account for water wasted when waiting for hot water to arrive reduces the water and embedded energy savings of the proposed measure by about 6 percent relative to previous estimates. Natural gas and electricity savings from heating water are reduced by about 11 percent relative to our previous estimates.[7] The proposed standard of 1.0 gpm still results in significant, cost effective water and energy savings.

3.1 Implications on Water Savings

Table 1 presents the results of PMI's analysis on water wasted per faucet when waiting for hot water to arrive. PMI concluded that at low water pressures, a 1.0 gpm faucet will waste 0.4 gallons per faucet per day more than a 2.2 gpm faucet. Similarly, at low water pressure, a 1.0 gpm faucet will waste 0.14 gallons per faucet per day relative to a 1.5 gpm faucet. In the analysis presented in the CASE Report, the CASE Team found that of the lavatory faucets sold in California that do not already meet the 1.0 gpm level, 43 percent are rated at 1.5 gpm and 57 percent are rated at 2.2 gpm. That is, the baseline water use estimates used in the CASE Team's analysis assumes a weighted average of 1.5 gpm and 2.2 gpm faucets. Applying this same weighting factor to PMI's results, rather than assuming 100% of the baseline is 2.2 gpm as PMI did, the statewide average wasted water of moving from a baseline faucet to a 1.0 gpm faucet would be 0.24 gallons per faucet per day at high pressure or 0.29 gallons per faucet per day at low pressure. To be conservative, the CASE Team assumed that on average, 0.29 gallons of water would be wasted per faucet per day when waiting for hot water to arrive.

Table 1: PMI's Conclusions on Wasted Water per Faucet per Day

Faucet Flow Rates	Water Wasted per Faucet Per Day (gallons/faucet/day)	
	High Water Pressure	Low Water Pressure
2.2 gpm faucet to 1.0 gpm faucet	0.34	0.40
1.5 gpm faucet to 1.0 gpm faucet	0.10	0.14
Statewide Average*	0.24	0.29

* Assumes 57% of noncompliant faucets are 2.2 gpm and 43% are 1.5 gpm.

Before accounting for the wasted water when waiting for hot water to arrive, the CASE Team estimated that revising the Title 20 standard from 2.2 gpm to 1.0 gpm will result in water savings of 5.07 gallons per faucet per day. Applying PMI's estimated wasted water estimates (0.29 gallons per faucet per day on average statewide); the daily water savings is reduced to 4.78 gallons per faucet per day. As mentioned previously, the CASE Team assumed that, on average, each faucet

7 Assumes that all water wasted during cold start events (i.e., average 0.29 gallons per faucet per day) is for hot water events and results in energy impacts from heating water.

would be used 15.7 times per day, each event lasts 37 seconds on average, and 50 percent of the faucet events would use hot water. On a high level, more than 2 gallons are saved every day from events that do not use hot water; savings from events that do not use hot water far exceed the amount of water wasted during cold start events when using PMI's assumptions. In total, discounting the water savings to account for water wasted when waiting for hot water to arrive reduces the water and embedded energy savings of the proposed measure by about 6 percent relative to previous estimates._See the CASE Report (CA IOUs 2013) for more assumptions about the energy savings analysis and cost effectiveness analysis, including assumptions about how faucet flow rates are derated to account for the impacts of lower water pressure and users not opening the faucets fully for every event.[8]

3.1.1 Correction Regarding PMI's Analysis of Natural Gas Savings

PMI's analysis claims that updating the Title 20 requirements from 2.2 gpm to 1.0 gpm would result in 28.3-32.9 million therms of wasted natural gas per year after stock turn over and would be three times larger than the CASE Team's estimate of natural gas savings after stock turn over. However, the CASE Team actually estimated that the proposed code change would result in over 90 million therms of savings per year after the stock turns over in 2024. Using PMI's results, natural gas savings would be reduced by to 31 to 37 percent, not by nearly 300%. Moreover, PMI's estimates of statewide natural gas waste are overstated because the analysis: 1) did not take into account that 5 percent of lavatory faucets sold in California already meet the 1.0 gpm standard, so wasted natural gas from those faucets should not be counted as an impact of the standard; 2) did not take into account that 43 percent of the lavatory faucets sold in California that do not already meet the proposed efficiency level of 1.0 gpm are 1.5 gpm – not 2.2 gpm, and therefore overestimated the wasted natural gas from 43 percent of faucets; and 3) assumed that all buildings in California have natural gas water heating while in reality only about 90 percent of California's buildings have natural gas water heating. The CASE Team's analysis provides a more accurate representation of the impacts associated with water wasted when waiting for hot water to arrive:, natural gas savings would be about 11 percent (10.6 million therms per year) lower than originally estimated after stock turn over in 2024, when using PMI's assumptions.

3.2 Implications on Cost-Effectiveness

The CASE Team found very little price difference between higher and lower efficiency faucets and faucet accessories. For example, the NEOPERL 2012 Wholesale catalog indicates no cost difference between non-qualifying (1.5 gpm) and qualifying faucet accessories (1.0 gpm). Basic faucet accessories cost about $1-2 dollars wholesale, and even the most expensive are less than $10 wholesale. It can be assumed that a 1.0 gpm faucet can cost the same as a 2.2 gpm faucet. Some manufacturers might choose to transition from using a non-pressure compensating 2.2 gpm aerator to a pressure compensating 1.0 gpm aerator, which could add several dollars to the overall cost of the faucet.

Table 2 presents the incremental costs and lifecycle (10-year) cost savings of the proposed faucet standard. The analysis was completed on a per faucet basis. It was assumed that the incremental cost would be $5 per faucet. The water cost savings over the 10-year period of analysis was estimated to be $72. The cost savings from water heating over the 10-year period was $158 if there

[8] Assumed a derating factor of 0.67 for 2.2 and 1.5 gpm faucets and 0.75 for 1.0 gpm faucets. See CASE Report (CA IOUs) for more information about derating factors.

is an electric water heater and $45 if there is a natural gas water heater. Overall, if the faucet is installed in a building with electric water heating, the net cost benefit would be $225 and the benefit/cost (B/C) ratio would be 46.0. If the faucet is installed in a building with natural gas water heating, the net cost benefit would be $112 and the benefit/cost (B/C) ratio would be 23.4. **The proposed measure remains cost effective, even if manufacturers opt to use a more expensive pressure compensating aerator**.

Table 2: Per Faucet Cost and Cost Savings

Electric Water Heating					
Costs: (per Faucet)		**Benefit: Lifecycle Cost Savings (per Faucet)**		**Net Lifecycle Cost Benefit**	**Benefit / Cost Ratio**
Incremental Cost	$5.00	Water Cost Savings	$72		
		Electricity Cost Savings	$158		
TOTAL	**$5.00**	**TOTAL**	**$230**	**$225**	**46.0**
Natural Gas Water Heating					
Costs: (per Faucet)		**Benefit: Lifecycle Cost Savings (per Faucet)**		**Net Lifecycle Cost Savings**	**Benefit / Cost Ratio**
Incremental Cost	$5.00	Water Cost Savings	$72		
		Natural Gas Cost Savings	$45		
TOTAL	**$5.00**	**TOTAL**	**$117**	**$112**	**23.4**

4 User Satisfaction with Low Flow Faucets

Three studies conducted by Aquacraft, Inc. Water Engineering Management suggest that users are satisfied with low-flow faucets (Aquacraft 2000, Aquacraft 2003, and Aquacraft 2004). In Tampa, Florida 1.0 gpm faucets were installed, and 89 percent of study participants felt the high-efficiency faucets performed the same or better than their old fixtures. Based on this evidence that users are satisfied with faucets that consume less water, we are not expecting significant dissent from consumers regarding an updated California standard.

While research has shown that users are satisfied when existing lavatory faucets are replaced with 1.0 gpm fixtures, there are several ways existing buildings can be retrofit to reduce hot water wait time. Existing plumbing can be retrofitted to include a recirculation system between the water heater and any points-of-use so that water that has cooled while remaining stagnant in the pipes is circulated back to the hot water heater and freshly heated water is sent to the point-of-use. Recirculation systems can be self-installed and can be upgraded to include a higher speed pump, which further reduces hot water wait time. Adding insulation to hot water pipes can prolong the time warm enough water remains in the pipes, thereby reduce hot water wait time for draws that occur in close time proximity. Small electric water heaters can also be installed in between the heat source and the point-of-use (and can even be installed inside of bathroom vanity cabinets) to provide an additional heat source and reduce hot water wait time. While these retrofit options described above are available to home owner, the CASE Team does not expect these retrofits will be necessary as consumer satisfaction we anticipate most people will be satisfied with 1.0 gpm faucets.

5 Conclusions

Updating California's lavatory faucet efficiency standard from 2.2 gallons per minute (gpm) to 1.0 gpm will result in significant water and energy savings and the proposed standard remains cost effective, even after discounting the savings to account for wasted water when waiting for hot water to arrive. The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about hot water delivery times.

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Appendix B: CA IOUs Response to Comments on Opportunistic Pathogens

Faucets

Codes and Standards Enhancement (CASE) Initiative
For PY 2015: Title 20 Standards Development

Comments regarding draft regulations:
Faucets

CA IOUs Response to Comments on Opportunistic Pathogens

Docket: #15-AAER-1, Water Appliances

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Prepared for:

PACIFIC GAS & ELECTRIC COMPANY	SOUTHERN CALIFORNIA EDISON	SAN DIEGO GAS AND ELECTRIC	SOUTHERN CALIFORNIA GAS COMPANY

Prepared by:
Heidi Hauenstein, ENERGY SOLUTIONS
Nate Dewart, ENERGY SOLUTIONS

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1 Summary

Some researchers have voiced concern that green plumbing practices that reduce water use in buildings and reduce hot water temperatures in buildings could lead to an increased risk of pathogen growth (Edwards, et. al. 2014, Klein 2014, etc.).

The information in this Appendix is intended to provide additional information on opportunistic pathogens, pathogen growth in water distribution systems, and research that has evaluated the correlation between faucets and faucet flow rates with pathogens in potable water. After completing a review of published research on opportunistic premise plumbing pathogens (OPPPs), the CASE Team has concluded that the existing body of research is insufficient to prove hypotheses researchers have made that faucet flow rate is correlated to an increased risk of exposure to opportunistic pathogens. In fact, research cited in this document indicates that pathogen growth does not depend on faucet type, type of faucet accessory, or faucet flow rate. Marc Edwards, a lead researcher in the field of OPPPs, confirmed that research is inconclusive when discussing the matter on a phone call with the CA IOUs in January 2014. During this call, Mr. Edwards stated that the only published research to date that directly evaluated the impact of flow rate on pathogen growth (Liu, et. al. 2006) resulted in the researchers concluding that they were "unable to demonstrate that stagnant conditions promote Legionella colonization."

As explained in more detail below, it is known that pathogens grow within biofilms in water distribution systems, including in plumbing within buildings (premise plumbing). It is hypothesized that the rate of pathogen grown depends on: 1) water temperature, 2) pipe reactivity, 3) pipe surface area to water volume ratio, and 4) water retention time, surface area to water volume. While minimizing exposure to pathogens should be a priority, the lack of evidence that demonstrates faucets or faucet flow rate have a significant impact on whether pathogens colonize in potable water distribution systems, especially the lack of a 1.5 gpm to 1.0 gpm comparison, concerns about pathogen exposure should not halt the adoption of efficiency standards for faucets that will result in the most cost-effective water and energy savings in the State. Colonization of opportunistic pathogens can and should be addressed through sound engineering of water treatment and distribution systems, including the design of potable water plumbing within the building. The CA IOUs recommend that California proceed with updating fixture flow rates and continue efforts to promote intelligent plumbing design, which will help address concerns about both pathogen colonization and hot water delivery times, in parallel.

2 What are Opportunistic Pathogens

Opportunistic pathogens are infectious microorganism such as bacteria, viruses, fungi, or protozoan infections that usually do not harm its host, but they can cause disease if the host's immune system is compromised. Opportunistic pathogens occur naturally in the environment and can survive water treatment and live within water distribution systems. Although there are regulations in place to manage opportunistic pathogens, opportunistic pathogens are the leading cause of waterborne disease in developed countries. The spread of opportunistic pathogens within potable water distribution systems is a growing concern. As discussed below, there are many reasons why pathogens colonize in water distribution systems, including longer water retention times due to water efficiency if water supply equipment sizing is not adjusted appropriately. There are also many factors that contribute to increased risk of exposure, including a trend towards lower water temperatures within buildings to help mitigate risk of scalding.

In the United States, there have been several actions taken to address water quality and address pathogens. The Safe Drinking Water Act of 1974 directed the United Stated Environmental Protection Agency (EPA) to establish standards for drinking water quality in all public water systems in the United States. Since the Safe Drinking Water Act was enacted, EPA has issued standards for Cryptosporidium, Giardia, Legionella, coliform bacteria and enteric viruses. Public water systems are required to regularly monitor water for contaminants and submit regular reports to consumers and agencies overseeing the public water systems. Violations of the Safe Drinking Water Act can result in fines to the public water systems.

Opportunistic pathogens, including Legionella, are present in all segments of potable water supply systems, including water treatment facilities, municipal potable water distribution systems, and within buildings themselves. As discussed below, Legionella thrives in biofilms that colonize throughout water distribution systems. Because biofilms are resistant to water treatment techniques, biofilms provide an opportune location for Legionella propagation (EPA 2001).

In the United States, Legionella is the most commonly reported pathogen identified in drinking water-associated outbreaks (CDC 2013). The remainder of this document focuses on Legionella because it is the most prominent opportunistic pathogen.

3 Opportunistic Pathogens in Water Distribution Systems

There is a lack of sound scientific consensus of the growth of pathogens within the water distribution system, including within buildings (in premise plumbing). Generally speaking, the conditions within premise plumbing systems can provide conditions for pathogen growth, and there can be numerous locations within premise plumbing systems for pathogens to grow to occur. Premise plumbing systems can also provide direct sources of transmission to humans by way of ingestion, inhalation of aerosols or skin contact. Conditions inside a building's plumbing system contribute to pathogen growth (Wang 2013). These conditions include:

- **Warm temperatures:** Warm water in building pipes can increase the rate of pathogen reproduction. Water heater temperature is considered a critical determining factor for Legionella colonization in household plumbing. Increasing water temperature beyond the point of pathogen reproduction is often an effective way of combating Legionella in premise plumbing.
- **Reactive pipes:** Corrosion in pipes leads to dissolved metals, which can provide nutrients to pathogens. Colonization of Legionella has been found to have a positive correlation with trace metals of zinc and manganese; different studies have found both positive and negative correlation with copper
- **High surface area to water volume ratio**: Plumbing systems within buildings provide many points of contact between water and solid surfaces where biofilms can grow.
- **Old water (high retention time):** Retention time may increase the concentration of pathogens as residual treatment chemicals diminish.

Buildings with complex hot water distribution systems such as those in hospitals and large commercial buildings are particularly prone to pathogen growth. Opportunistic pathogen colonization is quite common in large buildings, and is not uncommon in small commercial or single-family residential buildings, although the studies have found that the number of homes colonized with Legionella appeared to be low (Pedro-Botet, Stout and Yu 2002).

When Legionella does colonize within residential buildings, the plumbing within the building can provide conditions for Legionella to multiply. Wang (2013) evaluated the concentration of bacteria in water that has been stagnant in pipes for a period of time (~ 8 hrs) versus concentrations in water after the pipes had been flushed. Samples that were taken after pipes were flushed are representative of water arriving from the municipal distribution system. Bacteria concentrations were 2 to 3 times higher before the system was flushed. This indicates that conditions of premise plumbing can have a significant impact on Legionella growth (Wang 2013).

Legionella was detected more frequently in homes that used electricity to heat water, probably due to the lower water temperature at the bottom of the storage tank as a result of the placement of the heating coils (Pedro-Botet, Stout and Yu 2002). For example, in a survey of 211 homes in Quebec, Legionella was not found in any of the houses with gas-fired water heaters as compared to 39 percent of those with electric water heaters (Alary and Joly 1991). Given that approximately 90 percent of homes in California use natural gas to heat water, it can be assumed that the risk for Legionella colonization is greatly reduced relative to the country as a whole where about 50 percent of the water heaters are gas fired.

4 Faucet Flow Rate and Risk of Legionella

There has been much discussion and research that looks at the impact of the type of faucet (electronic v. manual) and the impact of aerators on the risk of exposure to Legionella. There has been speculation that the design of electronic faucets and faucet aerators is conducive to biofilm growth and will therefore lead to increased risk of exposure to Legionella.

Recent research published by NRC Research Press concluded that the type of faucet (electronic v. manual) had no direct effect on the presence of Legionella. This study evaluated the presence of Legionella in water from electronic and manual faucets located in various locations within a hospital that was known to have Legionella within the building's plumbing system. Researchers speculated that the location of the faucet within the building's distribution system, frequency of the faucet's use, and where hot and cold water mix may have a larger impact than the faucet itself (Mäkinen et. al. 2013).

Another recent study evaluated the effect of aerators and laminar flow devices on growth of Legionella (Huang and Lin 2007). Testing was completed in a hospital with a history of Legionella colonization. The test system consisted of six faucets arranged in parallel; two faucets had aerators, two had laminar flow devices, and two had no aerator attachment (control). When the water outlet was used at random, water flowed uniformly through all six test faucets. The mean flow rate was 6.0 L/min (1.5 gpm) for faucets with aerators and 1.2 L/min (0.3 gpm) for faucets with laminar water flow devices, compared with 11.0 L/min (2.9 gpm) for the control faucets. The test system is shown in the figure below. The researchers evaluated Legionella concentration in water from each of the six faucets and in biofilm from each of the six faucets. The study concluded that using aerators or laminar flow devices to reduce flow rate do not increase the concentration of Legionella in water or biofilm samples.

Figure 1: Experimental Set Up

FIGURE. Experimental set up of the model plumbing system (1, faucets with aerators; 2, control faucets; 3, faucets with laminar water flow devices).

Source: Huang and Lin 2007

A third study evaluated and compared the presence of Legionella in water within the plumbing system of a hospital and from water collected from faucet outlets (Cristina, et. al. 2014). This study found that there was not a statistically significant difference between the positive Legionella results in the plumbing system and faucet outlet. In other words, the existence of a faucet had no significant impact on the presence of Legionella. The study did find that the concentrations of Legionella were higher at the outlet than within the plumbing system. The study concluded, "The results obtained seem to indicate that contamination by [Legionella] can mainly be attributed to the water system itself, and that the presence of aerators influences the concentration of the microorganisms rather than the percentage of positive samples." Since the study did not look at attributes of the faucet and faucet aerators themselves, it did not draw any conclusions about the impact of faucet flow rate, faucet design, or aerator design on the concentration of pathogens.

Finally, a fourth study published in the Journal of Applied Microbiology in 2006 (Liu et al. 2006) attempted to prove the widely believed hypothesis that stagnation is a key factor in Legionella colonization and growth. The report states:

> "Stagnation within water systems has been cited by numerous authors as a condition favouring Legionella replication (Ciesielski et al. 1984; Harper 1988; Anon 1996). However, the effect of low flow conditions on the presence of Legionella in a water system has not been scientifically evaluated. Therefore, we investigated the effect of flow dynamics on the presence of Legionella in a model plumbing system under controlled conditions.
>
> Turbulent, laminar and stagnant flow conditions were created by regulating flow velocities through identical PVC pipes. The lowest concentration of Legionella was recovered in biofilm samples from the stagnant pipe

in each experiment compared with turbulent and laminar flow pipes. It was also visually apparent that turbulent flow resulted in the greatest accumulation of biofilm in the sampling pipe…."

Table 1: Legionella Concentrations

Table 1 *Legionella* concentrations in biofilm and planktonic samples from turbulent, laminar and stagnation flow pipes after 5 weeks of recirculation

Experiment ($Re_{laminar}$ *vs* $Re_{turbulent}$)	*Legionella* in inlet biofilm (CFU cm^{-2})	*Legionella* in outlet biofilm (CFU cm^{-2})	*Legionella* in planktonic sample (CFU ml^{-1})
1 (750 *vs* 40 000)			
Turbulent	6591	8759	1545
Laminar	635	927	4257
Stagnant	200	328	631
2 (355 *vs* 34 825)			
Turbulent	564	734	5067
Laminar	276	142	11 865
Stagnant	57	25	1938
3 (1400 *vs* 10 000)			
Turbulent	15000	14167	2125
Laminar	4183	2242	3900
Stagnant	392	1358	1074
4 (2000 *vs* 25 000)			
Turbulent	5408	4300	339
Laminar	2183	1817	633
Stagnant	1308	617	164

Source: Liu et al. 2006

Research conducted by Liu et al. 2006 "failed to show that stagnation promoted growth of Legionella." As shown in Table 1, the stagnant flow regime resulted in the lowest concentrations of Legionella in all test cases and turbulent (high) flow actually promoted the growth of Legionella.

In summary, the four studies presented above provide no evidence that a faucet's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies.

5 Conclusion

After completing a review of published research on opportunistic premise plumbing pathogens (OPPPs), the CASE Team has concluded that the existing body of research is insufficient to prove there is a correlation between faucet flow rate and an increased risk of exposer to opportunistic pathogens. Existing research provides insufficient evidence that a faucet's characteristics, including its flow rate, have a significant impact on the growth of Legionella in potable water supplies. While reducing flow rate of all fixtures within the house can increase retention time and longer retention times have been hypothesized (but not proven) to increase growth of Legionella in buildings where Legionella is already present, there is no conclusive evidence that a reduction of flow rate of faucets, especially a reduction from 1.5 gpm to 1.0 gpm, will lead to either the prominence of or increased concentration of Legionella.

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