PRE-RINSE SPRAY VALVE PROGRAMS:
HOW ARE THEY REALLY DOING?

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1 Abstract

Water conservation programs continually seek simple, cost-effective technologies that can be implemented quickly. Efficient, low-flow dishwashing pre-rinse spray valves (PSRVs), which are also known as spray heads, are such a technology. Replacing the standard valves found in most places where food is served with efficient valves can reduce this use by half or more, resulting in substantial savings in water, sewer, and energy costs. Although efficient spray valves have been available for many years, only in recent years have direct-install utility programs developed to replace existing valves and capture the savings on a large scale. This paper answers the question of how much water and energy such programs actually save. Much key information comes from research performed for the California Urban Water Conservation Council (CUWCC) and Puget Sound Energy (PSE) programs, whose combined installation goals approach 50,000 valves. They have collected and analyzed extensive flow, temperature, and usage data from field observations and direct metering. We will report on these results, as well as other savings verification efforts performed to date, to provide robust estimates of actual savings by customer sector that participants and program managers can expect. Program evaluations have also shed light on customer recruitment rates with the direct installation approach, as well as retention rates and customer satisfaction levels with efficient spray heads. This paper will share early results of an evaluation of freeridership[1] (naturally-occurring market penetration for efficient valves) and how spray head programs are beginning to transform the market.

[1] Freeriders are defined as program participants who, without the replacement program, would still have replaced their PRSVs. Therefore, water authorities do not get the conservation benefits from serving freeriders because the conservation would have occurred irrespective of the program.

2 Background

Pre-rinse spray valves are used to wash and/or pre-rinse dishes, pots, and pans in food service establishments (FSEs), such as those at restaurants, hotels, schools, groceries, and churches (see Figure 1). They can account for a significant amount of water use in these facilities. For many years, such facilities nearly exclusively installed standard valves, in which water flows at low velocity in a circular pattern from multiple holes, similar to old-style showerheads. Nonetheless, low-flow valves, which rely on an engineered nozzle to create a high-velocity, fan-shaped spray pattern from a single orifice, have been available from at least one manufacturer for a number of years. The most common two types of standard and efficient spray valves are shown in Figure 2.

Figure 1: Low-flow pre-rinse spray valve in use

The Food Service Technology Center (FSTC) in San Ramon, California first identified the significant resource savings potential of a program centered on low-flow valves. They developed a test method that specifies how to reliably establish valve water consumption and cleaning performance (ASTM Standard F2324-03).

Currently, at least three firms manufacture low-flow spray valves that conform to the CUWCC's specification, which incorporates the ASTM test method. Most of these are rated nominally at 1.6 gpm (gallons per minute), although one manufacturer now offers 2.2 and 2.6 gpm valves that use a fan-shaped spray. Valves nominally rated at less than 1.6 gpm are beginning to appear in the marketplace.

3 Recent Program Activity

Since 2003, there have been numerous programs geared towards encouraging food service establishments to install efficient spray valves. The most extensive and effective of these have been direct-install programs. Current programs that have or will be actively replacing valves are shown in Table 1.

Figure 2: Standard and efficient pre-rinse spray valves

[Efficient valves are on the left in each picture]

Concurrent with this program activity has been a spate of regulatory activity. In the last year or so, a number of states adopted standards mandating a maximum flowrate for spray valves sold. In August 2005, the Federal Energy Policy Act of 2005 was signed into law. One of the new minimum-efficiency standards for products stipulated within the law addresses pre-rinse spray valves, which must have a maximum flow of 1.6 gallons per minute. Because of this, the U.S. Environmental Protection Agency has suspended its efforts to draft Energy Star® requirements for spray valves, which would establish even higher efficiency standards.

4 Performance Research

The FSTC performed the earliest rigorous assessments of spray head performance and usage. They established average flowrates using lab testing, and estimated daily hours of use from interviews with FSEs. In 2003-4, SBW Consulting, Inc. performed an evaluation, measurement, and verification (EM&V) study[2] of the CUWCC Phase 1 program, as required by the State of California. This study complied with international protocols for such work (IPMVP). We selected 19 sites selected randomly out of sites where nearly 17,000 spray valves were installed, and metered post hot water usage for at least one month, plus took pressure, cold/mixed/hot water temperatures, and flow rate measurements on site. The metered hot water usage provided a basis for estimating actual mixed water usage per valve per day at each site. FSTC measured flow rates for over 100 randomly selected original valves at standard water pressures of 60 psig. In addition, CUWCC hired field technicians to collected mixed water temperatures for about 150 sites.

The EM&V study for Phase 2 of the CUWCC program is ongoing as of this writing. In 2005 so far, we have metered valves at 16 sites, with at least another three pending. The research design for this study is enhanced from the Phase 1 effort. It features pre- and post-installation onsite metering of mixed water flow for at least a month in each period, thus capturing changes in hours

Table 1: Recent direct-install spray head programs

Program Sponsor	Geographic coverage	Valves to be installed
California Urban Water Conservation Council	State of California	41,000 through Phase 2 (ends in 2005)
Puget Sound Energy (Washington State)	Counties of King, Snohomish, Thurston, & Pierce	7,750
City of Austin (Texas)	Austin	900
Pinellas County Utilities (Florida)	Pinellas County	3,000 (through 2010)
City of St. Petersburg (Florida)	St. Petersburg	1,350
Hillsborough County (Florida)	Hillsborough County	1,000

[2] SBW Consulting, Inc. *Evaluation, Measurement, & Verification Report for the CUWCC Pre-Rinse Spray Head Distribution Program.* May 3, 2004.

of use with the new valves. In addition, we are measuring onsite flowrates, temperatures, retention, and satisfaction for an additional 173 randomly-selected valves.

Figure 3: Metering setup for determining hours of use

In late 2003, Seattle Public Utilities (SPU), prior to deciding to participate in a Puget Sound Energy-sponsored direct-install program, commissioned a small study at five restaurants in downtown Seattle. A consultant metered water use for a week before and after installation of 2.2-gpm low-flow spray valves. Results from this pre-test were encouraging enough to convince SPU to participate.

In January 2005, Veritec performed a pilot study of savings for the Region of Waterloo in eastern Canada[3]. They metered 10 sites (eight restaurants and two groceries) using paddle-type flow sensors and data loggers that recorded when the valves were in use. Veritec combined these data with water pressure readings and flow curves developed in a lab to estimate usage.

As part of the ongoing direct install program begun by Puget Sound Energy in 2003, SBW Consulting, as the implementation contractor, has collected data on pre- and post-installation flowrates, water temperatures, and business and energy system characteristics for nearly every site visited. The database currently contains data for nearly 7,000 installations. In summer of 2005, at Starbucks's request, we measured spray head savings for five of their coffee shops. For this effort, we metered mixed water use for several weeks before and after installation of efficient spray heads.

For much of the CUWCC and PSE research, SBW Consulting installed in-line turbine-type flowmeters (SaMeCo Model WFU20) to measure water use. At first, we installed meters in hot water lines below the sink, but because many chain restaurants had soldered copper piping, we switched to installing the meters in the gooseneck above the sink. Figure 3 depicts such a metering setup). We verified the accuracy of the meters by comparing the metered water volume to the actual volume in a calibrated container for a variety of operating scenarios (continuous flow, and pulses of 5-, 15-, and 25-second duration). Metered results fell within ±1.5% of actual, except in the 5-second pulse case, where the accuracy was within 5.5%. To determine average hours per day of use, we divided the difference between the meter readings by the valve flowrate

[3] Veritec Consulting, Inc. *Region of Waterloo Pre-Rinse Spray Valve Pilot Study – Final Report*. January 2005.

and the number of metered days. To measure flowrates, we used a calibrated bucket and stopwatch, and took at least two measurements to confirm accurate readings.

Information on customer satisfaction came from telephone and in-person interviews with facility staff. As part of the CUWCC Phase 2 research, expert interviewers spoke with manufacturers, distributors, spray head program managers, and installers to assess the level of naturally-occurring spray head activity.

5 Results

5.1 Facility types

Table 2 breaks out the types of sites and number of valves per site among participants in the PSE program. Because this program sought to reach all sites with spray valves, these percentages can be considered representative of the population of potential program participants. About 70% of the sites are food service establishments, with another 15% representing institutional sites, such as schools and hospitals. An additional 9% of the sites were groceries, although it is important to note that these sites accounted for 22% of the installed valves, since a typical grocery had nearly four valves. A significant portion of the "Other" category consisted of churches and other religious organizations.

Table 2: Numbers of valves and sites by business type for PSE program

Business type	# of sites	% of sites	Valves	% of valves	Average valves per site
Restaurant	3,255	70%	3,725	55%	1.14
Institutional	688	15%	1,182	17%	1.72
Grocery	415	9%	1,504	22%	3.62
Other*	299	6%	398	6%	1.33
Total	**4,657**	**100%**	**6,809**	**100%**	**1.46**

* Includes religious organization, civic and social organizations, and hotels/motels.

5.2 Acceptance rates

Table 3 provides acceptance rates for the PSE program from its inception in October 2003 through April 2005. Program installers approached nearly 4,800 sites, and found that fewer than 4% refused to participate in the program. Nearly a quarter of sites did not have eligible heads. Of the sites that had eligible heads, 95% successfully participated. A small percentage of sites were "requested" installs, meaning that customers asked the utility to install the heads.

5.3 Flowrates

Table 4 summarizes measured pre-installation flowrates in Washington, California, and eastern Canada. For the most part, these values represent actual flows measured onsite. Flowrates vary

Table 4: Customer acceptance rates for PSE program

	# of sites	% of all sites approached	% of sites w/eligible heads
Total sites approached	**4,787**	**100.0%**	--
Rejected - no eligible heads	1,173	24.5%	--
Rejected - customer refusal	179	3.7%	5.0%
Efficient head(s) successfully installed	3,435	71.8%	95.0%
Old head(s) re-installed	69	1.4%	1.9%
Net sites w/efficient heads installed	**3,366**	**70.3%**	**93.1%**

significantly depending on the type of standard valve in place. Results across programs are fairly consistent, considering the variation in the sampled populations. Standard non-efficient Fisher valves, for instance, averaged slightly more than 2.2 gpm, while T&S Brass standard non-efficient valves, the most commonly found type, used over 3.4 gpm. Aggregating all data for all types of valve, the average standard flowrate is 2.92 gpm, with a standard coefficient of variation of about 34%

Table 5 shows average flowrates with low-flow valves in place, as measured at sites in Washington, California, and Canada. Most of the valves are manufactured by Fisher, and consist of three nominal flowrates—1.6, 2.2, and 2.6 gpm. Niagara also makes a 1.6 gpm valve, which became the valve of choice for the PSE program at the beginning of 2005. The average actual flowrates for the Fisher 1.6, 2.2, and 2.6 valves are 1.23, 1.71, and 2.34 gpm, respectively—values that are 10-16% lower than the nominal values. Interestingly, the average actual flowrate for the Niagara 1.6 valve is about 9% higher than the Fisher 1.6.

Table 3: Measured flowrates for standard non-efficient valves

Location / Program	Valve mfr.	Count	Average (gpm)	Coefficient of variation**
Washington (Puget Sound Energy)	**Fisher**	2,324	2.21	15%
California (CUWCC Phase 1)*		128	2.64	
Washington (Seattle Public Utilities pretest)		1	3.00	
SUBTOTAL		**2,453**	**2.24**	
Washington (Puget Sound Energy)	**T&S**	3,517	3.41	28%
California (CUWCC Phase 1)*		35	5.01	
Washington (Seattle Public Utilities pretest)		3	3.50	
SUBTOTAL		**3,555**	**3.42**	
Washington (Puget Sound Energy)	**Other**	968	2.87	26%
California (CUWCC Phase 1)*		8	4.37	
SUBTOTAL		**976**	**2.88**	
Washington (Puget Sound Energy)	**All (combined)**	6,809	2.92	34%
California (CUWCC Phase 1)*		171	3.21	
California (CUWCC Phase 2)		119	2.26	
Region of Waterloo, Canada		10	2.75	
Washington (Starbucks)		5	3.59	
Washington (Seattle Public Utilities pretest)		4	3.38	
TOTAL		**7,118**	**2.92**	

* Based on lab testing at 60 psig water pressure.
** For PSE heads only.

Table 5: Measured flowrates for low-flow efficient valves

Location / Program	Valve mfr.	Count	Average (gpm)	Actual as % of nominal	Coefficient of variation*
Washington (Puget Sound Energy)	**Niagara 1.6 gpm**	**2,186**	**1.34**	**84%**	2%
Washington (Puget Sound Energy)	**Fisher 1.6 gpm**	262	1.23		4%
California (CUWCC Phase 1)		19	1.11		
Washington (Starbucks)		5	1.07		
Region of Waterloo, Canada		10	1.22		
California (CUWCC Phase 2)		104	1.08		
SUBTOTAL		**400**	**1.18**	**74%**	
Washington (Puget Sound Energy)	**Fisher 2.2 gpm**	4,311	1.71		5%
Washington (Seattle Public Utilities pretest)		4	1.62		
SUBTOTAL		**4,315**	**1.71**	**78%**	
Washington (Puget Sound Energy)	**Fisher 2.6 gpm**	**68**	**2.34**	**90%**	12%

* For PSE heads only.

5.4 Water Temperatures and Water Heater Types

Water temperatures and water heater types are critical for determining energy savings, and are mentioned here since energy and water savings are often intertwined in spray valve programs. The CUWCC and PSE programs had different screening criteria, which affect the averages shown. The CUWCC program rejected valve installations where cold water was used, while the PSE program did not. Table 6 shows that as a result, the average mixed water temperatures for CUWCC installations are about 113°F, compared to 93°F for PSE. Mixed water temperatures for groceries were considerably lower than for other business sectors, probably because some of the spray valves are used in cold-water applications, such as rinsing produce. Mixed water temperatures for Phase 2 of the CUWCC program most likely are lower than the Phase 1 temperatures for this reason, since Phase 2 has included more groceries.

Cold water temperatures vary seasonally, particularly in areas with surface water sources. We

Table 6: Measured water temperatures and observed water heater types

Location / Program / Facility Type	Count	Mixed water temperature (deg F)	Hot water temperature (deg F)*
Washington (Puget Sound Energy)			
Restaurant	3,672	97.6	119.6
Groceries	1,494	86.1	118.5
Institutional	1,090	91.4	109.1
Other	385	89.5	114.7
Washington (Starbucks)	5	94.1	120.1
SUBTOTAL	**6,646**	**93.5**	**117.3**
California (CUWCC Phase 1), all	140	119.3	134.4
California (CUWCC Phase 2), all	105	107.1	126.2
SUBTOTAL	**245**	**114.1**	**130.9**

*** Observed water heater types for PSE program:**

Electric	18.9%
Gas	80.7%
Other	0.4%

found that reliable measurements of these temperatures in the field were difficult.

About 81% of spray valves installed for the PSE program were at sites with natural-gas-fired water heaters. Another 19% were at sites with electric waters, and a small fraction was at sites with alternative water heating sources, such as propane.

5.5 Hours of Use

One of the most critical—and difficult to determine—variables affecting spray valve savings is the daily hours of spray valve use. Early estimates, based mostly on anecdotal evidence, established a range from 2-6 hours per day, depending on the size (number of employees) of the FSE. Subsequent metering efforts have found that actual use is considerably less, and that the usage did not correlate with establishment size. From all of the studies performed to date, 52 sites have been metered. The summary of results, shown in Table 7, shows fairly consistent results. First, spray valve usage at groceries is minimal. Secondly, hours of use with efficient valves tended to be higher than hours of use with standard valves by roughly 25%. At restaurants, before and after hours were 0.79 and 1.02 hours/day, respectively. At groceries, before and after hours were 0.11 and 0.14 hours/day, respectively. Since customers mostly reported being satisfied with efficient valve performance, it may be that the pauses between spray pulses are shorter, rather than the valves requiring 25% more time to clean. No metering has been done for certain sectors, particularly schools, churches, and institutional settings, so their usage relative to restaurants and groceries is unknown.

Table 7: Measured average daily hours of use

	Count	Daily hours w/standard valve	Daily hours w/low-flow valve*	% increase(+) or decrease(-) in hours
Location / Program				
California (CUWCC Phase 1)	18	n/a	1.27	--
California (CUWCC Phase 2)	15	0.67	0.59	-11%
Washington (Seattle Public Utilities pretest)	4	1.11	1.35	22%
Washington (Starbucks)	5	0.29	0.52	81%
Region of Waterloo, Canada	10	0.65	0.77	19%
TOTAL	**52**	**0.66**	**0.91**	--
Facility type				
Grocery*	8	0.11	0.14	23%
Restaurant**	44	0.79	1.02	28%

* Low-flow hours per day for all groceries were less than 0.5.

**** Low-flow hours per day by bin for Restaurant type:**

Less than 0.5	30%
0.5 to 1.0	30%
1.0 to 1.5	18%
1.5 to 2.0	11%
More than 2.0	11%

5.6 Utility Savings

For the 36 metered food service establishments with Fisher 1.6-gpm valves, the average annual water/sewer savings are 50 CCF/year (more than 37,000 gallons annually). Corresponding natural gas savings are 194 therms/year. Savings for the seven metered grocery installations were quite small, at 1.3 CCF/year (968 gallons) and 5.8 therms/year. Savings per site vary significantly, with cases of water savings as high as 220 CCF/year and as low as –12 CCF/year.

Assuming "mid-range" gas and water/sewer rates of $0.80/therm and $5.00/CCF, annual customer cost savings might average about $400 per valve. With more extreme utility rates, cost savings might range from $220 to $630 per valve. More details are shown in Table 8.

Table 9 shows average project water savings per valve, using the "best available" data for base and efficient flowrates and daily usage, to develop generalized estimates by efficient valve type. Consistent with the results in Table 7, installing an efficient Fisher 1.6-gpm valve may save about 51 CCF/year on average. Savings are somewhat less with a Niagara 1.6, and considerably less with a Fisher 2.2. A Fisher 2.6 valve may actually result in negative savings.

5.7 Retention

Onsite inspections have revealed minimal evidence of tampering. Out of hundreds of inspected sites, in only a handful of cases have customers have drilled out the low-flow valve nozzle to attempt to get a more forceful flow. Retention studies for both phases of the CUWCC program have shown that about only about 5% of valves are out of service after roughly a year of service. In some cases, dissatisfied customers replace them; in others, facilities go out of business.

5.8 Satisfaction

Numerous phone and onsite interviews, as enumerated in Table 10, have shown that, generally, customers are satisfied with the performance of low-flow spray valves Across the CUWCC and PSE programs, only 7% of customers expressed some dissatisfaction. Reasons for dissatisfaction most often mentioned are misting/overspray (usually because of high water pressure), and poor cleaning performance. Over half of customers said they were very satisfied with the valves. In the PSE program, we noticed no increase in the number of dissatisfied customers (at least expressed as reinstallation requests) when the program switched from 2.2 to 1.6 gpm valves.

One of the biggest program strengths is also considered one of the primary hurdles to convincing potential participants to allow the installation—the program is free to participants. Often potential participants are skeptical of the program, because there is no cost to participate. This fuels both mistrust—folks wondering "what's the catch?"—and poor performance perceptions.

Table 8: Utility savings per valve

Facility Type / Location / Program	Count	Water/ sewer (CCF)	Water/ sewer (gallons)	Natural gas (therms)	Cost savings ($ at medium utility rates)*	Cost savings range ($)*
		ANNUAL SAVINGS PER VALVE				
Food Service						
California (CUWCC Phase 1)	18	69.7	52,157	252	550	291 - 860
California (CUWCC Phase 2)	8	38.5	28,778	167	326	177 - 508
Washington (Starbucks)	5	12.0	8,986	43	94	50 - 147
Region of Waterloo, Canada	5	35.7	26,669	178	320	178 - 498
Washington (SPU pretest)**	4	40.2	30,069	116	293	150 - 460
SUBTOTAL**	**36**	**50.0**	**37,425**	**194**	**405**	**216 - 633**
Grocery						
California (CUWCC Phase 2)	6	1.2	917	5.4	10	6 - 16
Region of Waterloo, Canada	1	1.7	1,277	8.5	15	9 - 24
SUBTOTAL	**7**	**1.3**	**968**	**5.8**	**11**	**6 - 17**

* Utility rate assumptions:	Water/sewer ($/CCF)	Gas ($/therm)
Medium	5.00	0.80
High	8.00	1.20
Low	2.00	0.60

** The SPU pretest used 2.2-gpm valves, and thus is not included in the subtotal.

Table 9: Average projected savings per valve

Valve type	Flow rate (gpm)	Water usage (CCF/year)	Water savings (CCF/year)	Water savings (gallons/year)
Standard*				
All	2.92	115	n/a	n/a
Efficient**				
Fisher 2.6	2.34	128	-13	-9,700
Fisher 2.2	1.71	94	22	16,200
Niagara 1.6	1.34	74	42	31,200
Fisher 1.6	1.18	65	51	37,800

*Average daily usage for standard valves = 0.66 hours/day
**Average daily usage for efficient valves = 0.91 hours/day

Table 10: Reported satisfaction rates

Location / Program	Count	Very satisfied	Somewhat satisfied	Neutral	Somewhat dissatisfied	Very dissatisfied
California (CUWCC Phase 1)	199	65%	22%	8%	4%	2%
California (CUWCC Phase 2)	105	36%	24%	31%	6%	3%
Washington (Puget Sound Energy)	9	44%	33%	11%	11%	0%
TOTAL	**313**	**55%**	**23%**	**16%**	**5%**	**2%**
		Percent satisfied =		**93%**	**Percent not satisfied =**	**7%**

5.9 Baseline market activity

As part of the CPUC evaluation of the CUWCC Phase 2 program, evaluators are determining the base level of low-flow spray valve installation that would have occurred had the program not existed (what is known as *natural replacement*). Although the analysis is still incomplete, some early findings have emerged. Installers and program managers report low percentages (in the neighborhood of 6%) of installed low-flow spray valves prior to program intervention. Manufacturers in the state report that in recent years, about 5%-7% of their California sales consisted of low-flow models (excluding bulk sales associated with spray head programs). Some distributors report higher percentages of their sales (30-40%) are low-flow models. Because of the dramatic market penetration that has occurred because of spray valve programs, as well as recent regulatory changes, we expect that the low-flow valves' sales percentage will climb significantly in the near future.

6 Conclusions

Spray valve direct-install programs in California and Washington State have been very successful to date. Third-party evaluation and research efforts have revealed that participants in these programs are generally quite satisfied, and that the vast majority of the low-flow valves remain in place for at least a year. Five separate metering studies of actual usage have included over 50 facilities, and the results show some consistency, so that average savings derived from these data can be considered fairly robust.

It is clear that low-flow spray valves installed at food service establishments yield significant water and energy savings, although less than initially estimated at the onset of direct-install programs. Valves in grocery stores, however, generally yield little savings. Further study is needed to assess actual usage and savings in other significant sectors, such as schools. Also unknown at this point is the long-term retention rate for the valves—the five-year life currently being assumed has not been confirmed. Anecdotal evidence from program installers suggests that while some valves that receive especially heavy use may need to be replaced within a matter of months, others may remain in place for many years.

Early research has shown that in recent years, the number of facilities that would have been installed low-flow valves in the absence of programs is quite small. We fully expect that a combination of factors, including increasing publicity, code changes, and adoption by national chains, will hasten this process significantly. Nonetheless, we expect a near-term opportunity exist for programs to replace standard valves that otherwise would remain in use for years, regardless of legislative requirements. Overall, the current rapid rate at which manufacturers are introducing new low-flow pre-rinse spray valves is a successful example of a situation where aggressive public programs, combined with quick legislative action, promises to transform a market and thereby yielding significant long-lasting resource savings.