Long Term Field Evaluation of High Efficiency Urinals at University of Washington

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INTRODUCTION

Urinals that use less water than current national code (1 gallons per flush) offer significant water conservation opportunities and financial savings. Unfortunately, few field observations have documented the long term performance of urinals using less than 1.0 gallons per flush (gpf). As part of an ongoing effort to reduce water consumption, the University of Washington (UW) began installation of no-flush urinals in December of 2001. At the time it was estimated the UW had around 700 high flush urinals (using between 1.5 and 3.5 gallons per flush) at various locations across their Seattle campus Motivated to reduce campus water use, the UW had, by mid 2002, replaced over 100 high flush urinals with no-flush types from several different manufacturers.

As installations of no-flush urinals continued, and with additional models becoming available from a variety of manufacturers, the UW staff were interested in evaluating the long term performance of different models currently available (preferably vitreous china). Facility staff wanted to look a wide range of urinal options, including no-flush urinals, flushing urinals using 0.5 gallons or less per flush, and comparing those with their existing 1.0 and greater flushing urinals. Of particular interest to facility staff was the comparison between different urinal models for their long term maintenance costs, performance, and cost-benefit Given the potential large number of urinals at UW which could over time be replaced with more water efficient models, it appeared prudent for the UW facility staff to set up a test site where various models being considered could be field tested under very similar usage and conditions over the long term, serving their typical population (students) and as maintained by UW Custodial personnel. Seattle Public Utilities, through the Saving Water Partnership, agreed to provide technical assistance as appropriate. This included independent review of testing installations, metering and monitoring, and compiling of data collected by UW staff. All of the decisions related to purchase, installation and/or removal of fixtures and monitoring equipment (including usage counters and sections of test pipe), along with any other costs related to plumbing, mechanical, or custodial work were the responsibility of UW staff. This was a UW urinal study, not an SPU study.

FACILITY DESCRIPTION

Lander Hall, was chosen as an ideal location for the test installations. Lander is an 8 story building, with student residences on seven floors, all having similar

restrooms. All residence floors are nearly identical in layout, house approximately 50 male residents each, with one men's restroom per floor with 3 urinals each. In addition, and perhaps most important, each of these floors (except the 4th floor), had an easily accessible walk in plumbing chase directly behind the urinals, making installation of a variety of fixtures relatively easy (with most requiring a change in the height of the waste outlet through the wall), plus providing the opportunity to remotely install and read usage counters, and to periodically monitor waste pipe conditions including for both vertical and horizontal sections.

Six floors of Lander Hall were used at the "living laboratory". Since each of the six floors had 3 urinals each, this provided 18 urinals urinal locations. The pre-existing urinals were all older blowout fixtures averaging over 3 gallons per flush making them good candidates for replacement. Over time, models of no-flush urinals from five different manufacturers (Falcon, Duravit, Uridan, Waterless Co., and Kohler) were tested here, plus three different models of flushing urinals using 0.5 gpf or less (one Zurn model using 0.125 gpf and two different Kohler models each using slightly under 0.5 gpf). In each case all three urinals in a given restroom were replaced with the identical make and model of urinal. Urinals on the 4th floor of Lander Hall remained as-is with original high flush urinals during this same time period.

INITIAL CONDITIONS

To determine baseline water usage, from April 1, 2004 to April 8, 2004, an ultrasonic water meter was installed in the plumbing chase on the water pipe providing water to the three existing urinals located on the 5th floor of Lander. Over this seven day period, the meter recorded usage of 2394 gallons (342 GPD), logging usage once per minute. Testing of urinal flush volumes on this floor, using a diverter hose and graduated bucket indicated 3.2 gpf for the left most urinal, 4.15 gpf for the middle urinal, and 2.7 gpf for the right most urinal. Assuming 70% of usage for the left most, 10% for the middle, and 20% for the right most urinal ,(as was determined later once usage counters were installed), this yields a weighted average flush volume of 3.2 gpf. Using this figure, and eliminating three outlying spikes from the usage log (one for 24 gallons, one 38 gallons, and one 33 gallons over one minute, likely indicating malfunctioning flush valves) it was computed that the total for all three urinals together was approximately 103 flushes per day, or an average of 34 flushes per day per urinal. With approximately 50 male students residing on the floor, this equated to approximately 2 urinal flushes at the dorm per male resident per day (actual urinal uses may have been somewhat more because not everyone flushes every time).

RETROFIT TIMELINE AT LANDER HALL

Installations and monitoring activities conducted as part of this study can be divided into phases.

Initial Condition Monitoring (April 1-8, 2004)
Metering and flow monitoring of three urinals on the 5th Floor

Phase 1 (6/02 – 7/07):
Initial Installation and Monitoring of three Non-Flush Urinals each from three different manufacturers (Falcon, Uridan, and Duravit).

Phase 2 (8/07 – 1/08):
Installation of Clean Pipe Sections and Waste Line Monitoring after 6 Months for Non-Flush Using Urinals from three manufacturers (Falcon, Waterless Co., and Kohler "Steward"), One Half Gallon Flushing Urinal (Kohler "Bardon"), and a One Pint Flushing Urinal (Zurn)

Phase 3 (2/08 – 1/11):
Follow-Up Pipe Inspections after 3.5 Years for the Pint Urinal (Zurn) and two models of Urinals flushing with slightly under one half gallon (Kohler "Bardon" and Kohler "Dexter")

A brief summary of the floor-by-floor installations and monitoring which was done at Lander Hall is given below, including the approximate dates (some installations and/or removals were done over a period of months).

2nd Floor:

- 6/02 – (3) Falcon no-flush urinals installed
- 4/04 – Counters installed
- 8/07 New horizontal and vertical pipe sections installed on left most fixture
- 1/08 Photos taken of horizontal and vertical pipe sections from left most fixture
- 3/08 Falcons removed and replaced with flushing urinals

3rd Floor:

- 4/03 – (3) Duravit "McDry" no-flush urinals installed
- 4/04 – Counters installed
- 3/08 Duravits removed and replaced with flushing urinals

4th Floor (no installations due to difficulty accessing plumbing chase – 3.5 gpf urinals remain)

5th Floor:

- 4/04 – Ultrasonic logging of existing 3.5 gpf urinals
- 6/04 - (3) Uridan no flush urinals installed, plus counters
- 2/06 – Uridan no-flush removed and replaced with Waterless Co. no-flush ceramic urinals

8/07 New horizontal and vertical pipe sections installed on left most fixture
1/08 Photos taken of horizontal and vertical pipe sections from left most fixture
1/08 – Waterless Co. urinals removed and replaced with flushing urinals

6th Floor:

3/06 – (3) Kohler Bardon flush urinals installed with 0.5 gpf Gem II valves, plus counters
8/07 New horizontal and vertical pipe sections installed on left most fixture
1/08 Photos taken of horizontal and vertical pipe sections from left most fixture
1/11 Photos taken of horizontal and vertical pipe sections from left most fixture

7th Floor:

8/06 (3) Kohler "Steward" no flush urinals installed, plus counters
8/07 New horizontal and vertical pipe sections installed on left most fixture
1/08 Photos taken of horizontal and vertical pipe sections from left most fixture
3/08 Stewards removed, pipes cleared, and Kohler "Dexter" flush urinals with Gem II 0.5 gpf valves installed
1/11 Photos taken of horizontal and vertical pipe sections from left most fixture

8th Floor:

1/07 (3) Zurn "The Pint" flush urinals installed, plus counters
8/07 New horizontal and vertical pipe sections installed on left most fixture
1/08 Photos taken of horizontal and vertical pipe sections from left most fixture
1/11 Photos taken of horizontal and vertical pipe sections from left most fixture

PHASE 1:
Initial Installation and Monitoring of 3 Models of Non-Flush Using Urinals (Falcon, Uridan, and Duravit)

This phase involved installation and monitoring of three models of no flush urinals on three different floors. The non-flush urinals installed during this time frame were manufactured by Falcon, Duravit, and Uridan. Infrared sensors were installed above each urinal, connected to remote totalizers located in the plumbing chase.

During March '04, infrared usage counters were installed above the no-flush urinals located on the 2nd and 3rd floors. The sensors were obtained as replacement sensors for Zurn automatic urinal flush valves and wired to digital

counters located in the plumbing chase. Flush valve sensors were used because of the delay function they come with, requiring someone to stand there several seconds before being counted, minimizing incidence of multiple counts for one user who might be shifting around, and also disallowing counting of passers by. For the Falcon units on the 2nd floor, the sensors were set into a steel channel located above the urinals. For the 3rd floor, sensors were left in their original housing, which was then attached to the remaining water stub out on the wall above each urinal. Based on counter data, all three floors show similar usage patterns, with between 100 and 160 uses/day for all three urinals on one floor. Over time, similar infrared counters were installed on the 5th, 6th, 7th, and 8th floors.

Over an approximate 4 month period of time (Jan 4 2006 – May 3 2006), each restroom on floors 2, 3, and 5 were visited approximately once every 5 days (23 visits over 17 weeks), generally every Monday and Friday, for a visual inspection for evidence of plugging or cartridge replacement. For the Falcon urinals, cartridge replacement was tracked by making a dot on the top of the cartridge, using a permanent marker pen, each time a new cartridge (with no dot) was observed, and the date recorded. For the Duravits and the Uridans, there was no replaceable cartridge that could be marked, so only observed instances of plugged urinals could be recorded.

Log sheets were also provided to custodians in an attempt to have them record frequency of cartridge and/or fluid changes as well as problems encountered such as drain plugging. However, it proved difficult to ensure all custodians made regular entries. The log sheets for the 2nd floor (Falcons) appeared to be the only ones regularly filled out.

Falcon:
Over a two year period, from 5/20/04 through 5/3/06, a total of 81,040 uses were recorded for all three Falcon urinals located on the 2nd floor. Of these, 60% of these uses were of the left most urinal (closest to the door), 17% for the middle urinal, and 23% for the far right urinal. This equates to an average of 114 urinal uses per day for the restroom (including summer and holidays, or an annual average of 68 per day for the left most, 19 per day for the middle, and 27 per day for the right most.

Since the Falcon urinals use their own proprietary cartridge, it was possible to calculate uses/cartridge by two different methods: 1) marking the cartridge with an indelible pen and recording the date and counter reading whenever a new cartridge was noticed in one of the urinals, and 2) comparing custodian waterless urinal maintenance log entries with record of counter readings.

Over a four month period of time, from 1/4/06 – 5/3/06, the Falcon urinals were visited every 3 to 5 days and dots were made on the top surface of the cartridges using an indelible felt pen, in an attempt to determine average uses per cartridge.

Over this 119 day period of time, 18,918 uses were recorded (a total of 159 uses per day for all 3). Over the same period of time, 14 cartridge changes were observed, for an average cartridge life of 1351 uses, significantly less than the 7,000 uses suggested by the manufacturer. By fixture location, the left most fixture had 11,807 uses over this period (99 uses per day or 62%) and 6 cartridge changes, for an average of 1968 uses/cartridge. The middle fixture had 3450 uses (29 uses/day or 18%) and 4 cartridge changes, for an average of 862 uses/cartridge. The right most fixture had 3661 uses (31 uses/day or 19%), for an average of 915 uses/cartridge. Cartridges in the left most fixture remained in place an average of 20 days, and cartridges in the middle and right positions remained in place an average of 30 days each.

Log sheets filled out by the custodians for the 2nd floor urinals (Falcons) between 12/2/05 and 1/21/08 indicated at least one of the three urinals in the restroom would generally clog every week. Over a four month period (120 days), from 1/5/06 through 5/5/06, 27 instances of clogging of the 2nd floor urinals were recorded on the maintenance log, for an average of one clogged urinal every 4 and ½ days in this restroom.

Duravit:
The Duravit "McDry" no flush urinals differed from the Falcons in that they do not have a cartridge but instead rely solely on the proprietary fluid being poured regularly into the integral trap built into the urinal. From the custodian's point of view this was an improvement because it meant they did not have to perform the unpleasant task of replacing cartridges. The down side was that when they did plug, there was no easy way to clean out the trapway, as there was no cartridge to replace, and no way even to use a plumbers snake, as the three cast in place drain holes in the ceramic at the bottom of the urinal bowl were too small to accept a snake. This meant that it was often necessary for the plumbers to pull these urinals off the wall to clear the trap, an even more time consuming task. In the meantime, whenever these urinals plugged, the custodians taped garbage bags over them to keep students from continuing to use them until the plumbers arrived. Custodians reported clogging incidents and/or the necessity to pour cleaning chemicals down the drain around twice a week per restroom, or approximately every 600 uses per urinal.

Over the same four month period that the Falcons were monitored on the 2nd floor, the Duravits on the 3rd floor were also monitored. It was not possible to track frequency of fluid addition by simple observation. However during this time period, (1/4/06 – 5/3/06), three instances of bagged urinals were observed (two of the left most and one of the right most). The left most fixture registered 10,995 uses over this time period (92 uses/day), and was bagged off after an average of approximately 5500 uses (once every 60 days). The right most urinal registered 3682 uses (31 uses per day), and was observed bagged off on 1/23/06. It had previously been observed as plugged on 5/2/05, with 5817 registered uses between then and the 1/23/06 plugging event, for a similar number of uses

between plugging as for the left most fixture.

Urinal Maintenance Logs for the 3rd floor urinals were provided to the custodians but were not filled out.

Although the Duravit no-flushr urinals located on the 3rd floor were not included in the latter part of the testing, experience elsewhere on the campus where they had been installed showed that most of these fixtures eventually suffered from permanent blockage of the internal trapway. One of these was sawn open by UW staff and observed to be blocked by a matrix consisting of a significant quantity of hair and other material. Most of these fixtures have also now been removed.

Uridan:
The Uridans were somewhere between the Falcon units and the Duravits in terms of design. The had a built in non-removable "cartridge" area under the drain at the bottom of the bowl. The stainless steel drain formed the top of the "cartridge" area, and there was a removable overflow pipe inside the "cartridge" area that kept in the proprietary fluid and over which the urine eventually drained. The idea, which sounded like a good one, was to be able to have the perceived benefits of a cartridge, including the ability to keep undesirable material out of the waste pipes and the ability to easily clean out the trapway it formed, without having to continually purchase and throw away replaceable cartridges. Unfortunately, these units ended up plugging frequently and were quite unpleasant to take apart and clean when plugged.

Over the period from 10/14/05 – 2/9/06 (118 days), 7463 uses were registered (63 uses per day) six instances of plugged urinals were observed, for an average of once every 1244 uses. It is unclear why these urinals recorded a significantly lower usage per day than those on the 2nd or 3rd floor. It may be that there were fewer male students on the floor, that students were avoiding this restroom because of perceived unpleasantness due to plugged urinals (or using the toilets instead), or another reason. Over the one month period after the Uridans were replaced with Waterless Co. urinals, recorded usage increased to 73 uses/day.

Maintenance logs for the Uridans on the 5rd floor were also not kept regularly, but those kept indicated a frequency of clogging of one or more times per week.

As with the Duravits, custodians reported clogging incidents and/or the necessity to pour cleaning chemicals down the drain around twice a week per restroom, or approximately every 600 uses per urinal. Several additional problems were encountered with the Uridan units. The acrylic yellowed over time, resulting in a less appealing appearance. In addition, the stainless steel drain assemblies for the Uridans became encrusted with deposits, adding to the unsightliness. There were also occasions where students lifted the Uridans off the wall

In Feb. '06 the (3) Uridans, which were no longer offered for sale in the US, were

removed and replaced with (3) ceramic Waterless Co. urinals. During the replacement process, the horizontal and vertical sections of pvc waste pipe leading from each Uridan was removed and replaced with new galvanized pipe before installing the Waterless Co. urinals. There was substantial buildup in the lines, especially for the urinal with the highest use, and especially in the vertical section of pipe below the vent connection. In the most used urinal, this vertical section was completely clogged with a matrix of inorganic solids and hair, except for an approximate ½" passageway which bore striated marks which appeared to have been left by use of a snake. It was interesting to note that for all three Uridans, the nearly horizontal section leading directly from the back of the urinals was relatively clear of deposit, while the vertical section just below the tee where the vent took off upwards and the drain went vertically down, was where the majority of the deposit was located.

Waterless Urinal Maintenance Logs were kept by the custodian on the 5th floor, for the Uridan units, over only one 18 day time period. As recorded by the custodian on the Waterless Urinal Maintenance Log, over the 18 days between 11/30/05 and 12/17/05, the three Uridan fixtures on the 5th floor experienced 5 clogging events (an average of one every 3 and ½ days). Over this time period the counters recorded a total of 2300 uses (1241 on the left, 39 for the middle, and 1020 on the right), for a average of 460 uses per clogging event. Three of the recorded clogs were on the left, and one each in the middle and on the right.

These fixtures were removed early due to excessive clogging so were not part of the subsequent regular observation schedule as were the Falcons and Duravits. At this time there were replaced with the Waterless Co. ceramic non-flush urinals.

PHASE 2:
Initial Waste Line Monitoring after 6 Months for 3 Models of No-flush Urinal (Falcon, Waterless Co., and Kohler "Steward"), One Model of Half Gallon Flushing Urinal (Kohler "Bardon"), and One Model of Pint Flushing Urinals (Zurn "The Pint")

In August '06, (3) Kohler "Steward" non-flush urinals were installed on the 7th floor.

In March '06 (3) Kohler "Bardon" flush urinals (specified by the manufacturer as 0.5 - 1.0 gpf) were installed on the 6th floor, with Sloan Gem II 0.5 gpf manual flush valves. In order to avoid any splashing against the metal strainer when the urinal is flushed, the stop valves for all three Bardons were turned down so that the flush volume was around 0.45 gpf for all three urinals, to avoid splashing against the "bee hive" strainer over the drain.

In January of '07, (3) Zurn "Pint" flushing urinals were installed on the 8th floor

with matching Zurn auto flush 0.125 flush valves.

During August 2007 (before fall classes began) new sections of 2" galvanized steel horizontal (through the wall) and 3" cast iron vertical (immediately below the vent pipe) were installed on the most used (left most) urinal on the 2nd, 5th, 6th, 7th , and 8th floors. The Duravit urinals located on the 3rd floor were not included as part of this phase because this floor had been converted to an all women's floor for the year, and the previous men's restroom had been converted to a women's restroom. The five restrooms involved had Falcon (no-water), Waterless Co. (no-water), Kohler "Bardon" (0.45 gpf), Kohler "Steward" (no-water), and Zurn "Pint" (0.125 gpf) urinals installed at the time respectively on the 2nd, 5th, 6th, 7th, and 8th floors respectively.

During a two week period, from 9/24/07 through 10/7/07, daily usage for the urinals on the upper three floors was recorded as:

Floor	Uses/day	Left	Middle	Right
6th Floor	158	69%	12%	19%
7th Floor	114	69%	14%	18%
8th Floor	125	72%	12%	16%

Six months following installation of the new pipe sections, in January 2008, the left most urinal on each of these floors was again removed, the back of the urinal and the wall opening for the horizontal waste pipe were photographed. In addition, the vertical section of waste pipe in the plumbing chase. All three models of no-flush urinals showed significant (estimated at 40% - 60%) blockage in the horizontal waste pipe at the wall where the pipe connected to the urinal. The 0.5 gpf and the 0.125 gpf urinals showed slight (estimated at 5% or less) in the horizontal waste pipe at the wall. The vertical sections for the no-flush urinals also showed significant blockage, while the vertical sections for both the flushing (0.5 and 0.125 gpf) urinals showed no significant buildup.

PHASE 3:
Follow-Up Pipe Inspections after approximately 3.5 Years for flushing urinals only (Zurn "The Pint" 0.125 gpf urinal, and Kohler "Dexter" and Kohler "Bardon" Urinals both flushing at slightly under 0.5 gpf)

Subsequent to reviewing the photos taken as part of Phase 2, the UW Facilities Services staff decided to immediately remove all no-flush urinals in the building and replace them with high efficiency 0.5 gpf flushing urinals. As part of the replacement, waste pipes were reportedly cleaned out. Unfortunately, no opportunity was given to observe or photograph the condition of the waste pipes either before or after they were cleaned. Replacements used were Kohler "Dexter" urinals with Sloan "Gem II" 0.5 gpf flush valves. Note: the "Dexter" is specified by the manufacturer as 1.0 gpf. However, these fixtures had been

successfully installed elsewhere at UW using 0.5 gpf flush valves with good performance. The two high efficiency flushing urinals previously installed (the Kohler “Bardon” and the Zurn “Pint” remained.

Approximately three years following the Phase 2 pipe inspection (three and a half years after installation of the test pipe sections) the left most urinals were again removed on the 6th, 7th, and 8th floors. As mentioned earlier, all no-water urinals had been removed subsequent to the release of the Phase 2 photos. Therefore, this Phase 3 inspection was only for high efficiency flushing urinals, including the Kohler “Bardon” 0.5 gpf urinals (6th floor) and the Zurn “Pint” 0.125 gpf urinals (8th floor) included in the Phase 2 monitoring, plus a Kohler “Dexter” urinal with a 0.5 gpf flush valve installed on the 7th floor where the Kohler “Steward” no-water urinal had previously been located.

Photos taken in January 2011 show both the horizontal and vertical pipe sections for the Zurn ‘Pint” 0.125 gpf urinal had become significantly blocked. The horizontal pipe for the Kohler “Bardon” had significantly less deposits and the horizontal pipe for the Kohler “Dexter” showed no significant deposit. The vertical pipes for both the Kohler “Bardon” showed some deposits, but not to the degree seen for the Zurn “Pint”. Note: It is possible that some of the deposits seen in the vertical section for the “Bardon” were in fact left over from when the no-water Kohler “Steward” was installed here. For this floor only, the vertical section had not been replaced. Instead, a removable section of the vent pipe was installed just above to allow viewing of where the horizontal waste line entered the vertical line.

Flow measurements were taken for the Kohler “Bardon” and Kohler “Dexter” using a graduated bucket and diverter hose and were measured as flushing between 0.45 gpf and 0.475 gof. The flush volume for the Zurn “Pint” urinal had been measured at the time of installation as 0.125 gpf. The plumbers reported the stop valves for these urinals had been turned down slightly to minimize splashing.

No clogging events were observed for any of the high efficiency flushing urinals. However, plumbers did report periodic blockages due to users dropping paper towels or other objects into the urinal bowl. There were reportedly easily taken care of by the custodians.

At this point it appears that UW has decided to discontinue installation of any new pint flush urinals and increase the flush volume of those already installed to one half gallon. New installations of half gallon flushing urinals will continue.

DISCUSSION

Observed Cartridge Life and/or Frequency of Blockage – No-Flush Urinals

Blockages were a regular problem with all no-flush urinals tested, typically occurring at least once per week per restroom. Although it proved difficult in this non-lab situation to reliably record every plugging event, especially with those not using replaceable cartridges, some upper bounds on number of uses between observed plugging events.

Floor	Mfg.	Average Uses Between Recorded Plugging Events/Cartridge Changes
2nd Floor	Falcon	1351
3rd Floor	Duravit	5500
5th Floor	Uridan	460

While a higher number of uses between plugging may be obtainable under optimal conditions, observed uses at this facility between blocking events and/or cartridge replacements were significantly less than hoped. Tracking was easiest for the no-flush urinals using replaceable cartridges (Falcon) due to the fact that they could easily be marked and then observed twice a week to catch any changes. For no-flush urinals without replaceable cartridges, direct observations required recording urinals with a pool of liquid and/or covered over with a garbage bag awaiting attention from a plumber. Since visits were made to the dorm only twice a week, it is likely that a significant number of blockage events may have been resolved by the plumbers without being recorded. However, a significant enough number of blockage events were observed and recorded to put upper bounds on average frequency. For most weeks one or more blockages would be observed in a single restroom, and this from visiting only twice a week.

Variation in Frequency of Use in a Given Restroom by Relative Position

Each of the restrooms in this study had three urinals. The urinal on the left (nearest the door) consistently received the most usage, and he one in the middle the least. There was some difference in percentage of usage by urinal location between the no-water urinals and flushing urinals, with the left most no-water urinal receiving closer to 60% of total usage and the left most flushing urinal receiving closer to 70%. However, given the tendency of the no-water urinals to clog much more often than the flushing urinals, with the left most clogging the most often (due to increased usage), this difference in usage patterns may be an artifact of users avoiding clogged urinals. For this reason, the percentage figures recorded for the flushing urinals is taken as more representative of any “natural” tendency for this configuration.

Variation in frequency of use can become an important factor with regard to urinal performance and cost/benefit in facilities with multiple restrooms and urinals where required maintenance is correlated with number of uses, i.e. for all the various no-flush urinals. In these facilities one of three choices can be made.

Option One: Cartridges and/or fluid additions can be made at the same time for all urinals in one restroom and/or for all restrooms, governed by the frequency

required by the most used urinal. This would result in the highest cost for supplies, especially when cartridges are involved, and the lowest averages uses per servicing. If the interval between required changes is long, perhaps several months or longer, this might not be a problem. However, if the required interval is significantly shorter, as was observed, the cost for this option can rapidly escalate. For example, if the maximum uses per cartridge were 2200, and to be safe, one scheduled a change out at an expected usage of 2000 uses, this would mean that the middle cartridge would be changed after around 350 uses and the one on the right after only 500, for an average of every 950 or so uses. If the cost of a cartridge (not including installation labor) is $40, this comes to around $0.04 per use.

Option Two: Cartridges are only changed out after they plug. This would minimize cost of supplies (to $0.02 per use assuming the same cost and usage figures as above), but would maximize the frequency of unpleasant situations for both users and custodial staff. This was the option that appeared to be in effect at the dorm being studied.

Option Three: Set up a scheduling program to optimize uses for each urinal between servicing. While this option would appear to be the most cost effective, the degree of complexity required (especially in facilities with multiple restrooms with differing frequencies of use combined with different numbers of urinals per restroom), coupled with unforeseen events (various things people may put down urinals), could make this option difficult to carry out in a way that reliably avoids all plugging events. The cost for supplies would likely be somewhere between that for the other two options, perhaps $0.03 per use.

This dilemma regarding frequency of service highlights one of the difficulties inherent in use of no-flush urinals. While it is true that flushing urinals may also clog or otherwise fail, they do not appear to do so with such frequency. Also, failure of flushing urinals is more often related to clogging of the screen or trapway with paper towels or other such debris, which is generally fairly easy for the custodian or plumber to resolve and does not require purchase of additional supplies. Given the complexity already inherent in maintaining a building, one would need a very compelling reason to bring into a building a technology which could frequently fail with unpleasant results for occupants, and which could also end up costing more over time to maintain than for a more conventional system.

Waste Line Deposits

Over time, deposits considered unacceptable by UW staff were observed in the waste lines leading from all no-flush and the one pint urinals. Significant buildup was observed in the no-flush urinals after only six months, and occurred in both the horizontal and vertical sections of pipe, with the vertical sections showing the greatest buildup. This indicates that it is not just a case of insufficient slope in the waste line, as has sometimes been suggested. For the pint urinal, buildup after three and a half years was similar to that seen for the no-flush urinals after only

six months. For the half gallon urinals, some deposits were observed after three and a half years, but were not deemed as significant by the plumber who assisted. The least deposits were observed in the lines from the Kohle “Dexter”.

Waste line blockages were cleared as necessary by use of a plumber’s snake. Non-caustic chemicals containing citrus extract were sometimes used as well. There did not appear to be any regular dumping of water down the drain.

CONCLUSIONS

Human urine, together with hair (that forms much of the observed matrix of the waste line deposits) and water, forms a much more complex biochemical mix than one might at first expect, and the challenges encountered in flushing it reliably down the drain in a way that minimizes deposits are likewise much greater for both no-flush and flushing urinals.

Performance of Tested No-Flush Urinals vs Tested Flushing Urinals

The primary performance questions looked at as part of this study included frequency of clogging and long term buildup of deposits in the waste lines. An additional related question touched on but not directly monitored is ongoing cost (or relative cost per use) for maintenance and custodial care. Another question often raised but not addressed here is relative smell, which is also important but difficult to quantify. Smell was especially an issue when urinals plugged.

All of the no flush urinals experienced regular clogging events, significant pipe deposits, and/or slowdowns requiring frequent servicing. Given these performance and maintenance problems, it was concluded by the UW facility staff that continued installation of no-flush using urinals was unacceptable.

Performance of Tested Pint vs Tested Half Gallon Flushing Urinals

After 3 and ½ years, the Zurn “Pint” urinals also showed unacceptably high deposits in both the horizontal and vertical sections of waste lines. Some clogging events had occurred, but these were mostly related to either placement of paper towels in the urinal, or material collecting around the strainer clamp (inside the trapway), both of which could be relatively easily remedied.

Due to the observed drainline deposits with the tested one pint urinal, one pint flushing urinals were also deemed by facility staff as unacceptable for future installations at the UW.

The two tested half gallon flushing urinal models both appeared to be performing acceptably, with minimal deposits after 3 and ½ years.

Can Urinal Flush Volume Be Reduced Below 0.5 gpf Without Unacceptable

Pipe Buildup?

Based on the limited scope of this study and models included, the question is raised as to whether urinal flush volume can reliably be reduced below 0.5 gpf without increasing the likelihood of significant waste line buildup in many facilities. The one pint flushing urinal tested appeared clearly unacceptable over the longer term. Since the deposits showed up both in the horizontal and vertical sections, it appears that this is not just a matter of pipe slope.

The half gallon flush urinals were more acceptable, but even these were not deposit free after 3 and ½ years, with the "Dexter" siphon-jet (nominally 1.0 gpf but installed with a 0.5 gpf valve) with the least build-up. Although a few models of half gallon flush urinals have been available for a relatively long time (generally marked as 1.0 – 0.5 gpf), more field testing research is needed . before reducing flush flow below current code of 1.0 gpf, particularly if flows are reduced below 0.5 gpf.

SUGGESTIONS FOR FURTHER STUDY

Urinal Design: Velocity vs Water Quantity (Wash Down vs Siphon-Jet Urinals)

One of the more intriguing observations was the difference in waste line deposits between the two urinals tested at 0.5 gpf. Of the two, the Kohler "Dexter", a siphon-jet urinal, is labeled by the manufacturer as 1.0 gpf. However, field experience has shown that this urinal can work well at 0.5 gpf as well. The other urinal tested at 0.5 gpf was the Kohler "Bardon", a washdown urinal which is labeled by the manufacturer as 1.0-0.5 gpf. Even though it is labeled only as a 1.0 gpf urinal, the "Dexter" appeared to have significantly less deposits, especially in the horizontal pipe sections, as compared with the "Bardon".

It is hypothesized here that for the "Dexter", being a siphon-jet type urinal, the water leaves the urinal at a much higher velocity over a much shorter time span, while for the "Bardon", being a washdown type, the water leaves the urinal at a much slower velocity and over a longer time span. The slower velocity, coupled with less of a wave of water, could allow more material to adhere to the sides of the pipes in both the horizontal and vertical sections. It may be worthwhile for the manufacturers to investigate design of some high performance half gallon siphon jet or blow-out urinals, of which, to the best of my knowledge, there are currently none. Additional research could be done to determine if faster acting half gallon flush valves, including piston type valves, could also help to minimize drain line deposits.

CAVEATS

The following caveats are noted which may have affected the results of this study in one way or another, and may affect the applicability of these results to other facilities.

No Special Training Given to Custodians

The UW provided minimal special training to custodians regarding maintenance of no flush urinals, other than the instructions provided with the replacement cartridges and/or containers of proprietary fluid. The intent was not to mimic a lab situation where all maintenance was performed exactly as suggested by the manufacturer, but rather a real life situation with minimal control over how maintenance was done.

Field Observations may differ from Lab Tests

A number of important factors that can't be controlled in the field could have influenced these observations. Long term performance issues with urinals in field conditions is an area needing greater research.

Small Sample Size

Only one urinal (the most used) for each model was taken off the wall each time the waste lines were inspected. It is unknown if hose urinals with less usage have experienced more, or less buildup, and to what degree all urinals of one type experienced similar buildup.

Only One Type of Facility (College Dorm)

All testing was done in one facility with one type of user (college student). Other types of facilities, such as elementary schools, may experience different results due to differences in urine chemistry, quantity of hair and other materials flushed down the urinal, and/or frequency of use.

No Variation in Water Quality (Seattle water only)

All urinals were tested uwing water provided by Seattle Public Utilities, which is relatively soft. Differing water quality in other parts of the country may contribute to differing results.

Limited Number of Models Tested

Five different models of no flush urinals, two different models flushing with one half gallon (with only one specified for one half gallon), and one model of one pint flushing urinal were tested. Any of the various urinal models not tested could provide differing results. In addition, the small sample size (3 each) of the models is not statistically significant and a larger sample size is needed to draw reliable conclusions. This report should be considered as observations only, which point to the need for further research.

PHOTOS – PHASE 2

Initial Photos
After 6 months of use

Slide 1

Lander Hall

- College Dorm
- 7 Residential Floors
- Men's Restrooms have (3) Urinals each

Slide 2

Plumbing Chases

- No-Hub Cast Iron Waste Lines
- Accessible on 6 Floors

Slide 3

Original Urinals

- 3.5 GPF "Standard"
- Approx. 30 flushes per urinal per day

Slide 4

No-Water HEUs

- (3) Falcons
- Installed 11/02

Slide 5

No-Water HEUs

- (3) Duravits
- Installed 7/04

Slide 6

No-Water HEUs

- (3) Waterless Co. ceramic urinals
- Installed 2/06

Slide 7

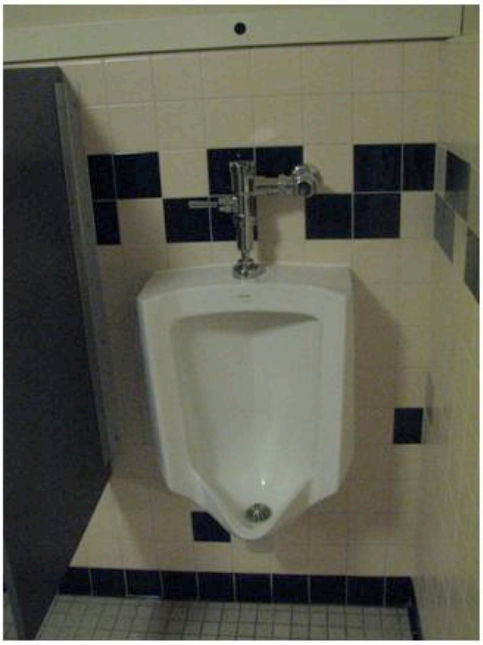
No-Water HEUs

- (3) Kohler "Steward" urinals
- Installed 8/06

Slide 8

Flushing HEUs

- (3) Kohler "Bardon" urinals
- Sloan "Gem II" 0.5 gpf flush valves
- Installed 4/06



Slide 9

Flushing HEUs

- (3) Zurn 0.125 gpf (one pint) urinals
- Installed 1/07

Slide 10

Waste Line Observations

(after 6 months of use)

Falcon "Waterfree" - Significant deposits

Wall Inlet

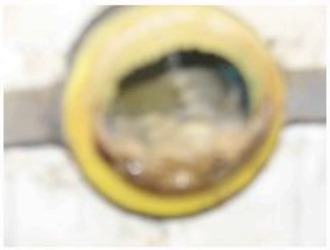
Vertical Section

Slide 11

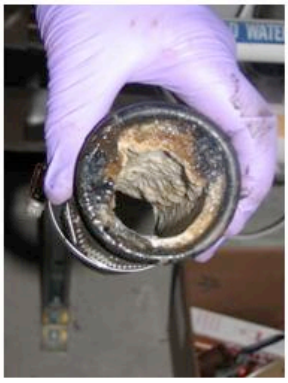
Waterless Co.

(after 6 months of use)

Significant deposits



Wall Inlet



Vertical Section

Slide 12

Kohler “Steward” no-water

(after 6 months of use)

Significant deposits

Wall Inlet

Vertical Section (at Tee)

Slide 13

Kohler “Bardon” @ 0.4 gpf

(after 6 months of use)

Minor deposits

Wall Inlet

Vertical Section

Slide 14

Zurn “One Pint”

(after 6 months of use)

Minor deposits

Wall Inlet

Vertical Section

PHOTOS – PHASE 3

Final Photos
Between 3 and 3 ½ years of use

Slide 15

Kohler "Dexter"

- 0.45 GPF
- Outlet Shows No Significant Deposits

Slide 16

Kohler "Dexter" @ 0.45 gpf

Minimal Deposits after 3 Years

Wall Inlet

Vertical Section (at Tee)

Slide 17

Kohler "Bardon"

- 0.45 GPF
- Outlet shows slight deposits

Slide 18

Kohler "Bardon" @ 0.45 gpf

Moderate Deposits after 3.5 Years

Wall Inlet

Vertical Section

Slide 19

Zurn "The Pint"

- O.125 GPF
- Outlet 50% Blocked after 3.5 Years

Slide 20

Zurn "The Pint"

Significant Deposits after 3.5 years

Wall Inlet

Vertical Section