Performance Testing of Wall Mount Siphon Jet Toilets at the University of Washington

by

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Abstract
As part of a comprehensive effort to reduce water consumption and associated costs, the University of Washington (UW) has planned to implement a campus-wide program to replace approximately 2000 high consumption toilets. The majority of these are wall mount flush valve siphon-jet toilets, for which there are eight manufacturers who offer 1.6 gpf replacement models in the US market. In addition, there are four manufacturers who offer a number of different models of manual flush valves appropriate for these toilets. In order to ensure optimum performance while not exceeding the mandated 1.6 gpf average flush volume, UW Facilities personnel were interested in performance testing all eight available siphon-jet models at one location along with a variety of appropriate manual flush valves. A total of (28) toilets consisting of (8) models, and (34) manual flush valves consisting (6) models were tested. Consultant time for development and implementation of the testing protocol was funded through Seattle Public Utilities.

Toilets were performance tested using calibrated piston style flush valves. For any given test, the same test valve was moved from bowl to bowl during the testing process to rule out any performance differences being caused by use of different valves. Test valves were drilled and tapped to accept a pressure gauge on the inlet side of the valve, allowing measurement of both static and flowing pressure at this location. Flush volume for all valves was ascertained by diversion of water from the valve tailpiece into a graduated bucket.

A battery of four tests was run on one each of (8) toilet models using: (1) increasing lengths of loosely wadded toilet tissue, (2) paper seat protectors placed on the seat cover, (3) tofu cut into carefully measured blocks, and (4) concentrated brine solution. Test results were tabulated, showing substantial performance variation among the different models.

Using these results, the top three performing models were selected for further evaluation. The remaining (20) high flush toilets in this same building were then changed out using a larger sample of toilets of each of these three models, along with a variety of flush valves. Each of these (20) replacement toilets was tested with increasing lengths of toilet tissue at 1.5 gpf, and volume testing was conducted on the various flush valves as installed. As a final check, one representative fixture of each of the three models was then similarly flush tested at 1.3 gpf before a final recommendation was made.

Introduction
In an effort to reduce water consumption and associated costs, the University of Washington expressed interest in implementing a comprehensive program, with help from Seattle Public Utilities and the Saving Water Partnership, to replace toilets using 3.5 gallons per flush (gpf) or more with low consumption 1.6 gpf toilets. Previously conducted facilities restroom surveys have documented that the campus contains over 2000 toilets, of which at least 1750 are believed to be wall mount flush valve toilets using 3.5 gallons per flush (gpf) or greater.

Some of these wall mount toilets are blow-out (3 bolt) and some are siphon-jet (4-bolt). For blow-out toilets there is only one manufacturer (Crane) who offers a vitreous china 1.6 gpf replacement model. However, for the siphon-jet toilets, there are eight manufacturers who offer 1.6 gpf replacement models in the US market. In order to ensure optimum performance, UW Facilities personnel were interested in evaluating all eight available siphon-jet models along with a variety of manual flush valves.

Past Studies
After conducting research into past performance studies on this type of toilet fixture, one previous independent performance study was found. This was the 1996 study entitled "A Performance Evaluation of 1.6 GPF Flush Valve Water Closets in Commercial Settings," by W.L. Corpening and Associates and commissioned by the Seattle Water Department. In this study, (41) flush valve toilets of (5) different models, using (2) different models of flush valves, were tested at (20) facilities which had recently installed low flush fixtures.

The primary test protocol used in the 1996 Performance Evaluation was called Bulk Test #1. Bulk Test #1 was conducted on all (41) toilets and consisted of placing one seat cover on the seat with the tongue to the rear of the bowl, along with two semi-tight balls of toilet tissue each consisting of (10) sheets (equivalent to a total of 7-1/2 feet) placed in the bowl. A specially designed bypass was designed and used which allowed recording of the actual flush volume, maximum flow in gpm, and static and flowing pressure. The number of flushes required to completely evacuate this material was then noted as was any observed splashing onto the seat.

This study showed a surprisingly wide variation in actual flush volume for both models of nominally 1.6 gpf valves, ranging from 1.2 gpf – 5.1 gpf with an average of 2.0 gpf. Given this wide variation in flush volumes, limited sample size, and wide variation in building pressures (ranging from 32 psi static to 105 psi static), differences between toilets of different manufacturers could not be clearly shown. Additionally, these fixtures, installed between 1995 and 1996, may or may not be equivalent to fixtures currently being manufactured by these three manufacturers.

In conclusion, the Corpening study stated, "The most unequivocal, decisive, incontestable conclusion that was reached as a result of the Seattle flush valve toilet evaluation was that good performance (or lack thereof) of these low consumption fixtures is arbitrary, inconsistent, and erratic. The actual factor or combination of factors that cause one toilet

to perform extremely well and another to perform poorly, in a given set of circumstances, is still unclear." (Corpening, p. 22)

UW Test Plan

In order to provide UW with a rational basis for selection of toilet fixtures and flush valves for it was decided that a new testing program using a more refined testing protocol would be used. Accordingly, it was decided to initially test one sample each from the (8) different manufacturers. This initial round of testing would be done on the same floor from the same plumbing riser, and with the same flush valve moves from fixture to fixture.

A set of testing protocols would also be developed to separately measure a variety of functions, rather than attempting to lump multiple functions (such as both flushing toilet tissue and pulling down seat covers) in the same test. Following the initial round of testing, additional samples of the top three performing models would then be installed and tested in a follow-up round.

Balmer Hall, a classroom facility built in 1962, was chosen as the test location. This facility contains (28) 4-bolt wall mount toilets spread out over four floors. The plan was to first replace only the (8) toilets located in the back to back men's and women's restrooms located on the fourth floor, with one sample of each of the (8) available models of 4-bolt wall mount toilets. Initial testing would then be conducted on all (8) of these samples, and the top (3) would be selected for further evaluation. The remaining (20) toilets in the building would then be replaced using a number of each of these top (3) preliminarily selected models, for follow up testing with a larger sample size. As part of the follow up effort, (6) different models of flush valve models from (4) different manufacturers were also tested, primarily for volume of water per flush.

Local manufacturers' representatives were contacted, informed of the purpose of the study, and asked if they would be willing to provide a sample of their product. Representatives for all eight manufacturers agreed to provide free samples, which were then delivered to UW facilities for installation. Installation was completed by UW plumbers.

Models Tested

The (8) toilet models requested for this study were:
American Standard "Afwall" #2257
Briggs "Sultan" #7780
Crane "Placidus" #3446
Eljer "Signature" #111-2105
Gerber "Ultra Flush" #25-030
Kohler "Kingston" #K-4330
Mansfield "Model 1300"
Toto "CT 708"

Initial Phase - Testing Protocol
All toilets were tested during the initial phase using the same Sloan Gem II 1.6 gpf piston style flush valve. This single valve was moved from bowl to bowl during the testing process to rule out any performance differences being caused by use of different valves. The test valve had been drilled and tapped to accept a pressure gauge on the inlet side of the valve, allowing measurement of both static and flowing pressure at this location.

Static pressure was first measured at approximately 40 psi, with a minimum flowing pressure, as measured at the inlet port of the flush valve, around 15 psi. It was then determined that the building pressure reducing valve (prv) was malfunctioning, resulting in inadequate building pressure. After the prv was repaired, testing was conducted over, with static pressure of approx. 70 psi with a minimum flowing pressure of around 25 psi. Gallons per flush (gpf) at this pressure for the test valve was measured by diverting water from the outlet of the test flush valve into a graduated bucket for three successive flushes. Measured flush volume for this valve ranged between 1.55 and 1.65 gpf.

Four tests were conducted for each bowl. Since the installation was in an existing building rather than a test stand, no artificial test materials were introduced which could conceivably cause problems downstream. These tests were as follows:

Test #1 – Toilet Paper
Five foot lengths of MD brand 2-ply toilet tissue were measured off. Increasingly greater numbers of these lengths were loosely wadded and placed in the bowl of the test toilet to determine the maximum number of feet, in five foot increments, that the test toilet could flush, a minimum 3 times in a row, without leaving observable traces of toilet paper in the bowl. A paddle was used if necessary to ensure all toilet paper was within the water spot and saturated before flushing. Between each flush with toilet paper, the toilet was flushed without any paper in the bowl to ensure there was no residual paper left in the trapway.

Test #2 – Seat Covers
Paper seat protectors available in each stall were placed on the seat cover, with the seat protector tongue hanging from the rear of the seat into the water spot of the bowl. The toilet was then flushed to see if the paper seat protector would be pulled down into the bowl and completely disappear from view in one flush. Care was taken to ensure the seat cover was completely dry before putting the seat protector in place. This test was performed (3) times for each toilet.

Test #3 – Tofu Blocks
Tofu was chosen to test for the size of an object that could be disposed. Sunluc brand Chinese style firm tofu was cut into blocks measuring 2-¼ ” wide x 1-5/8” thick x 4” long (only the width was changed from the original block dimensions). One block was placed into the bowl of the test toilet aligned to easily enter the trapway. The toilet was then flushed to determine if the block could be completely disposed of with one flush. The toilet was flushed again to check if a block which had passed from view may have

become stuck in the trapway. If a toilet failed this test, successively narrower blocks were used to determine the maximum that would pass. No blocks wider that 2 ¼" were used.

Test #4 – Brine

A concentrated brine solution was made up ahead of time at the ratio of 1 lb of table salt to 1 gallon of tap water. One half cup of this brine was then poured into the bowl of the test toilet, the toilet was flushed, and the conductivity (in ppm) was measured for the water in the water spot following complete refilling, using a hand held conductivity meter. From this number the ppm of initial building tap water was subtracted in order to calculate the ppm of brine remaining.

Initial Phase - Test Results

The following results were obtained at 30 - 40 psi static/15 psi min. flowing, and 1.6 gpf. As the tissue test was conducted on more than one occasion, a range is given.

Bowl Mfg.	**Tissue (feet)**	**Seat Cover**	**Tofu * (2 1/8")**	**Brine (ppm)**
Am. Std.	20'-30'	2/3	1/2	10
Briggs	5'-30'	1/3	1/2	51
Crane	25'-30'	2/3	1/2	2
Eljer	5'-15'	1/3	2/2	2
Gerber	10'-15'	3/3	0/2	2
Kohler	20'-30'	1/3	1/2	1
Mansfield	0'	1/3	0/2	15
Toto	30'-35'	1/3	1/2	1

* Two trials of 2 1/8"wide tofu only were run at this pressure.

The following results were obtained at approx. 70 psi static/25 psi min. flowing, and 1.6 gpf:

Bowl Mfg.	**Tissue (feet)**	**Seat Cover**	**Tofu * (width)**	**Brine (ppm)**
Am. Std.	20'	3/3	2 ¼"	32
Briggs	25'	3/3	2 ¼"	31
Crane	35'	3/3	2 ¼"	1
Eljer	15'	3/3	2 ¼"	2
Gerber	25'	3/3	1 7/8"	2
Kohler	35'	0/3	2 ¼"	2
Mansfield	10'	2/3	2 ¼"	39
Toto	40'	1/3	2 ¼"	1

* 2 ¼" was the maximum width of tofu used.

The minimum recommended flowing pressure recommended by the various bowl manufacturers (when specified) ranged from 15 psi to 30 psi. Since the flowing pressure of 15 psi was substantially below the minimum specified by a number of the manufacturers, and since this was also felt to be below what would normally be

encountered across the UW campus, the results at this pressure were disregarded for scoring purposes.

A scoring matrix was prepared using only the results from 70 psi static. The matrix was weighted 40% to the toilet tissue test, 10% to the seat cover test, 25% to the tofu test, and 25% to the brine test. Points for the tissue test equal the feet of tissue flushed, points for the seat cover equal the fraction of successful trials times 10, the tofu points equal 25 if 2-1/4" passed or 0 if not, and the brine points equal 25 minus half the ppm remaining.

Points **Toilet**	Max 40 **Toilet Tissue**	Max 10 **Seat Covers**	Max 25 **2-1/4" Tofu**	Max 25 **Delta ppm**	Max 100 **Final Score**
Crane	35	10	25	25	**95**
Toto	40	3	25	25	**93**
Kohler	35	0	25	24	**84**
Eljer	15	10	25	24	74
Briggs	25	10	25	10	70
Am. Std.	20	10	25	9	64
Gerber	25	10	0	24	59
Mansfield	10	7	25	6	48

Follow-up Testing

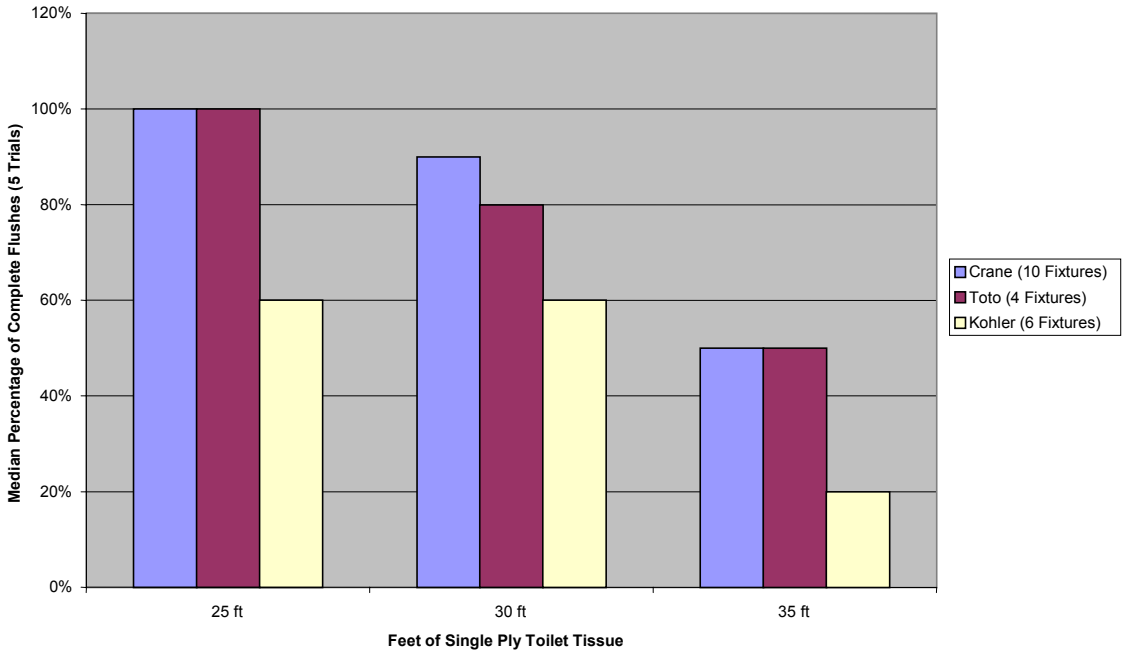
Following completion of the Initial Phase of testing, additional samples of the three top performing models were purchased and installed by UW Facilities personnel to replace the remaining (20) high consumption toilets in the same building. This included an additional (10) Crane "Placidus", (6) Kohler "Kingston", and (4) Toto "CT 708" toilets.

In order to streamline the follow-up testing procedure, only the tissue test was performed, and this was performed using the single ply tissue provided by UW (as opposed to the 2-ply MD brand tissue used in the initial phase). The only noticeable difference in results due to using the UW single ply tissue was that it was less prone to shredding, which seemed to lead to somewhat better results for toilets with poorer water exchange (high ppm).

In light of the variation in performance which may be observed from flush to flush for the same toilet, it was also decided to perform (5) trials each using 25 ft., 30 ft., and 35 ft. of toilet tissue for each toilet (15 trials total per toilet). Trials for each toilet were begun with the greater lengths and in the event that 100% at a given length passed, it was assumed that 100% would pass for that toilet at each successively lower length. For these tests, a second Gem II flush valve was used which had been calibrated at 1.5 gpf at 70 psi static and a minimum of 30 psi flowing.

The median success rates for all three models at 25', 30', and 35' is shown below:

Median Flushing Performance of (20) Fixtures with 1.5 gpf Gem II Flush Valve
75-85 psi Static / 30-40 psi Flowing

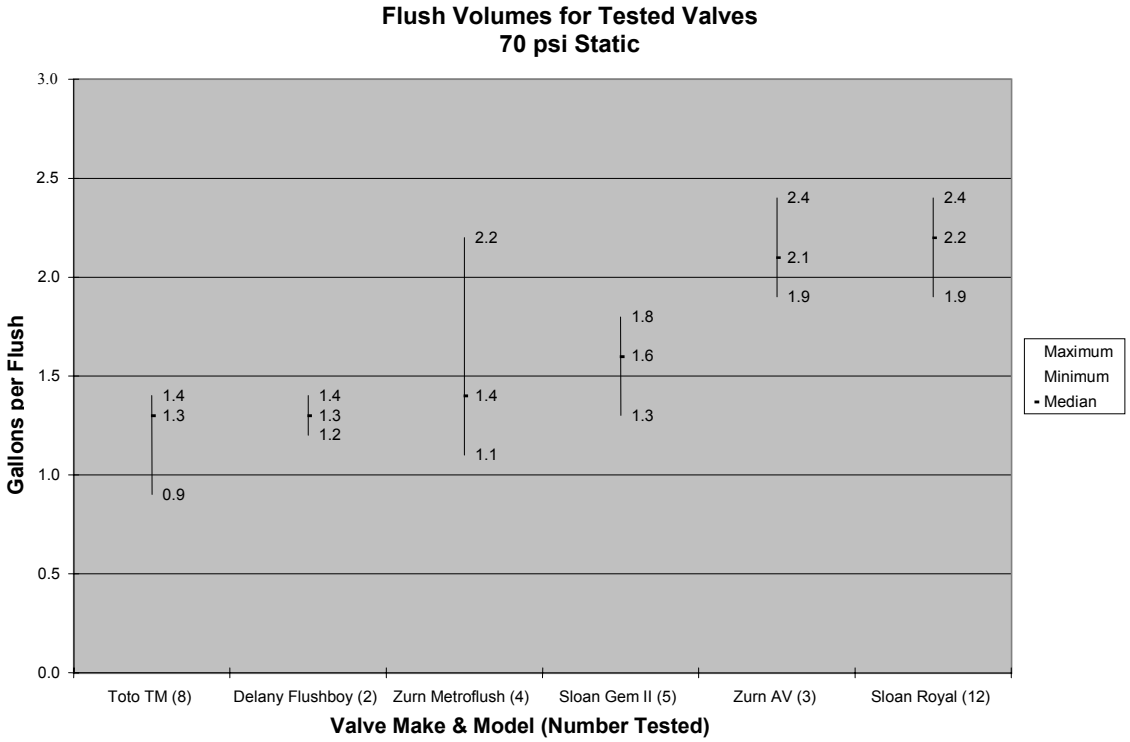


Flush Valve Testing

As part of the toilet performance testing, a variety of manual flush valves were tested as well, including both diaphragm type and piston type valves. The primary concern was to test for out-of-the-box average flush volume, check for adjustability, and to note any obvious performance differences. The Sloan "Gem II" (5 units), Sloan "Royal" (12 units), Delaney "Flushboy" (2 units), Toto "TM" (8 units), Zurn "AV" (3 units), and the Zurn "Metroflush (4 units)" were all tested for flush volume. The Toto "TM", Sloan "Gem II" and the Zurn "Metroflush" are piston valves while the rest are diaphragm type. All except the Toto "TM" are non-adjustable except by removal or replacement of internal parts. Flush volumes recorded for all units are out-of-the-box or as installed by the plumber.

Of the flush valves tested, the Sloan Gem II comes closest to the federally mandated 1.6 gpf average flush volume when tested right out of the box. The Zurn Metroflush also averaged near 1.6 gpf but exhibited a much wider range. The Delaney Flushboy averaged low at 1.4 gpf. After reading installation instructions it was discovered that there was an internal flow ring in the Delaney that could be removed to increase flow in necessary. With removal of this ring average flush volume increased to 1.8 gpf. An additional Flushboy was tested at Bellevue Community College and it tested at 1.2 gpf as installed, increasing to 1.6 gpf following ring removal. The Toto can be adjusted to flush at 1.6 gpf (or up to a maximum of 2.4 gpf), but this could be a time consuming effort if a large number of valves is involved. The Sloan Royal and Zurn AV both averaged substantially higher in water use (around 33%) than the 1.6 gpf requirement.

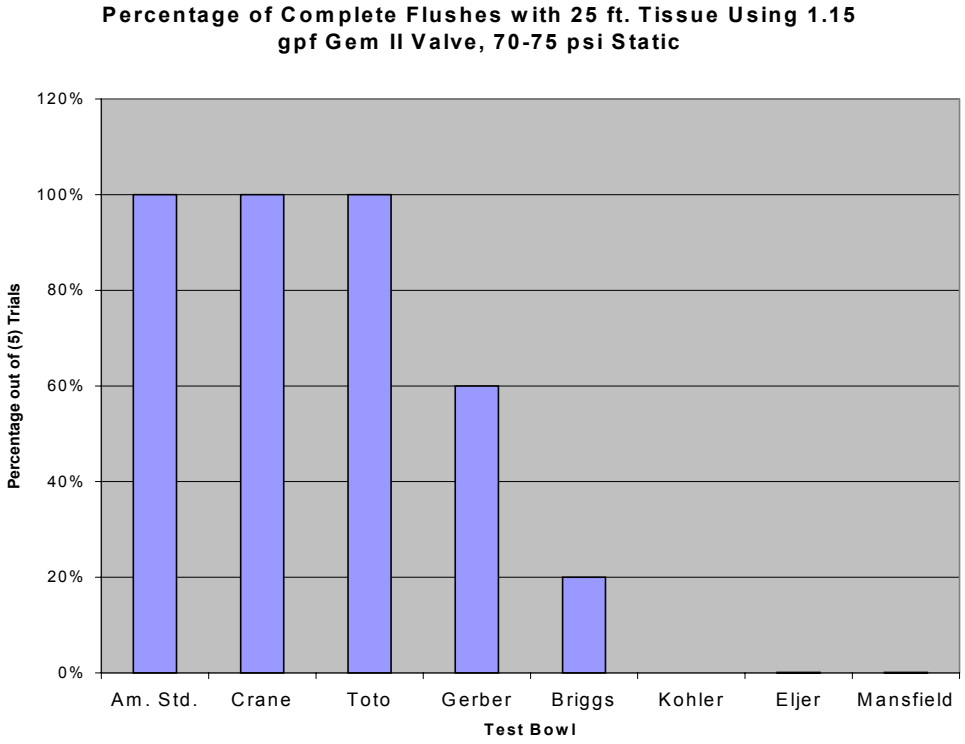
The results of this testing are shown below with minimum, maximum, and average flush volumes:



The next building which the UW chose to retrofit with low consumption toilets, after completion of Balmer Hall, was Padelford Hall, a faculty office building constructed in 1967, containing 45 toilets. These were replaced using the Kohler "Kingston" wall hung toilets along with the Sloan "Gem II" 1.6 gpf flush valves. Following installation, during a walk through of the building, it was discovered that while most of the new toilets were performing well, several of the toilets were not. Flush volumes were subsequently measured for the valves installed with the poorly performing toilets, using a graduated bucket and diversion hose. Out of (6) poorly performing fixtures identified, (1) was flushing at 1.4 gpf, (1) at 1.3 gpf, (3) at 1.2-1.25 gpf, and (1) at 1.15 gpf. After each of these flush valves was replaced with a valve flushing at 1.5 gpf or greater, the fixture performed adequately (reliably flushing at least 25 ft. of tissue).

Originally it had not been considered that receiving and installing flush valves using less than 1.5 gpf would be a significant problem, and if so that the plumbers installing the toilets could test the valves as they were installed. However, it now became apparent that if a model of valve averaging 1.6 gpf were chosen, that a significant number should be expected to flush using substantially lower volumes. It also became apparent that it would be difficult and time consuming for the plumbers to test each and every valve. It was therefore determined that the most effective solution would be to re-test each of the toilet models at the lower end of the expected range of flush volume, in order to be able to specify the toilet model(s) least affected by low flush volume. This would greatly reduce the need to identify and correct insufficiently flushing valves.

The original fixtures located on the 4th floor, representing the (8) different manufacturers, were then re-tested with tissue, using a Gem II flush valve flushing at 1.15 gpf at 70-75 psi static. The only (3) models which were able to completely pass 25 ft of tissue in (5) out of (5) trials were the Crane, Toto, and American Standard. The results for all models are as follows:



Findings

- This research at UW confirmed one of the surprising findings of the 1996 Corpening study, which was the great variation encountered in the actual gallons per flush used by the various flush valves. This study showed flush volumes for (35) "1.6 gpf" valves of (6) different models ranging from a minimum of 0.9 gpf to a maximum of 2.4 gpf. This included a surprisingly large variation between different valves of the same model (typically $\pm$ 20%), as well as significant variation between the averages for different models. This finding is all the more significant given that in this study all of these valves were tested in the same building under fairly similar conditions.

- An additional finding which again confirmed the findings of the 1996 Corpening study, was that two of the most widely installed flush valves in the area, the Sloan "Royal" and the Zurn "Aquavantage," appear to average significantly higher than the 1.6 gpf mandated maximum. Of all valves tested, the Sloan "Gem II" tested closest to the 1.6 gpf target without alterations or adjustments.

- When building pressure and flush valve performance are held constant, it appears that meaningful comparison of toilet bowl models can be made.

- Given a target average flush volume of 1.6 gpf, a substantial number of toilets may be expected to receive significantly less than 1.6 gpf. Some toilets which perform well at 1.6 gpf may not perform acceptably with less. It therefore becomes necessary to evaluate the performance of toilet bowls at flush volumes at the low end of the expected range as well. The three toilet models which ranked highest in the initial round (at 1.6 gpf) were the Crane "Placidus", the Kohler "Kingston", and the Toto "CT 708." When these three models were retested with a Gem II flush valve flushing at 1.15 gpf, which was the low end of the observed range for the Gem II, the Crane and the Toto still appeared to perform acceptably, but the Kohler did not. The American Standard "Afwall" was the only other bowl, besides the Crane and the Toto, which was able to reliably flush 25 ft. of tissue at this volume.

Recommendations

- Accordingly, the combination of the Sloan "Gem II" flush valve and the Crane "Placidus" or the Toto "CT 708" toilet bowl are recommended as having the greatest likelihood of providing reliable performance with no adjustments, while averaging no greater than 1.6 gpf.

- A third choice for the bowl would be the American Standard "Afwall." Although the Afwall did not score as well in the initial round of testing, it did perform well in the low flush volume tissue test.

This research is not meant to be a comprehensive rating of the various available models of wall mount siphon jet flush valve toilets. Any comprehensive rating would require a larger sample size and considerably more time and expense than was available for this study. It is recognized that under different circumstances and using different protocols, different results and conclusions could be obtained. However, it is felt that these results should be more than adequate for the purpose expressed by UW Facilities personnel, which was to provide a rational basis for selecting one or more toilet and flush valve models which would maximize their likelihood of achieving reliably good flushing performance while meeting the Federal 1.6 average gpf requirement. It is also hoped that insights and protocols developed as part of this study will help future researchers develop improved methods for performance evaluation of this type of fixture.

References:

Corpening, W.L., "A Performance Evaluation of 1.6 GPF Flush Valve Water Closets in Commercial Settings," for Seattle Water Department, December 1996.

A & N Technical Services, Inc. and W.L. Corpening & Associated, "Ultra-Low-Flush Toilets in Commercial Installations," for California Urban Water Agencies and California Urban Water Conservation Council, February 1994.

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Test Data (Attached)
Balmer Hall Toilet Initial Test Results
Additional Flush Valve Volume Test Results
Balmer Hall Toilet Follow-up Test Results

Photos (Attached)
Setup with Diversion Hose and Graduated Bucket for Measuring Flush Volume
Setup with Gem II Test Valve and Integral Pressure Gauge

Test Data 4/13/2002 Static pressure: 38 psi, minimum flowing pressure: 16 psi
All tests performed with same Gem II flush valve calibrated at 1.6 gpf
Tissue tests conducted with MD brand two ply tissue

Floor	M/W	Stall (L to R)	Toilet	Test Valve	Test GPF	Toilet Tissue (ft)	Seat Covers	2-1/8" Tofu (P/F)	Brine Delta ppm
4	M	1	Briggs	Gem II	1.6	5	33%	1/2	60
4	M	2	Gerber	Gem II	1.6	10	100%	0/2	2
4	M	3	Kohler	Gem II	1.6	30	33%	1/2	2
4	M	4	Eljer	Gem II	1.6	15	100%	2/2	2
4	M	5	Crane	Gem II	1.6	30	67%	1/2	2
4	W	1	Toto	Gem II	1.6	30	67%	2/2	2
4	W	2	Am. Std.	Gem II	1.6	25	67%	1/2	19
4	W	3	Mansfield	Gem II	1.6	0	33%	0/2	40

Test Data 6/7/2002 Static pressure: 70 psi, minimum flowing pressure: 24 psi
All tests performed with same Gem II flush valve calibrated at 1.6 gpf
Tissue tests conducted with MD brand two ply tissue

Floor	M/W	Stall (L to R)	Toilet	Valve	Test GPF	Toilet Tissue (ft)	Seat Covers	2-1/4" Tofu	Brine Delta ppm
4	M	1	Briggs	Gem II	1.6	25	100%	1/1	31
4	M	2	Gerber	Gem II	1.6	25	100%	0/1	2
4	M	3	Kohler	Gem II	1.6	35	0%	1/1	2
4	M	4	Eljer	Gem II	1.6	15	100%	1/1	2
4	M	5	Crane	Gem II	1.6	35	100%	1/1	1
4	W	1	Toto	Gem II	1.6	40	33%	1/1	1
4	W	2	Am. Std.	Gem II	1.6	20	100%	1/1	32
4	W	3	Mansfield	Gem II	1.6	10	67%	1/1	39

Additional Flush Valve Volume Test Results
All tests at 70 psi Static
Test Data

Make	Model	Valve Number	Trial 1 GPF	Trial 2 GPF	Trial 3 GPF	Avg. GPF
Delany	Flushboy	1	1.4	1.3	1.4	1.4
Sloan	Gem II	1	1.7	1.7	1.7	1.7
Sloan	Gem II	2	1.3	1.3	1.3	1.3
Sloan	Gem II	3	1.8	1.8	1.8	1.8
Sloan	Gem II	4	1.5	1.5	1.5	1.5
Sloan	Gem II	5	1.6	1.6	1.6	1.6
Zurn	AV	1	1.9	1.9	1.9	1.9
Zurn	AV	2	2.1	2.2	2.2	2.2
Zurn	AV	3	2.4	2.4	2.5	2.4
Zurn	Metroflush	1	1.1	1.2	1.1	1.1
Zurn	Metroflush	2	1.5	1.5	1.5	1.5
Zurn	Metroflush	3	1.3	1.3	1.4	1.3
Zurn	Metroflush	4	2.2	2.2	2.2	2.2

Balmer Hall Toilet Follow-up Test Results

All tests performed with same Gem II flush valve calibrated at 1.5 gpf at 95 psi
Tissue tests performed with UW supplied single ply tissue
Percentages (out of 5 trials each length) resulting in complete flush

Floor	M/W	Stall (L to R)	Toilet	Original Valve	Original GPF	Test Valve	Test GPF	35 ft	30 ft	25 ft
0	M	1	Kohler	Royal	2.2	Gem II	1.5	40%	100%	100%
0	M	2	Kohler	Royal	2.1	Gem II	1.5	40%	60%	60%
0	M	3	Kohler	Royal	2.2	Gem II	1.5	20%	60%	80%
0	M	4	Kohler	Royal	2.2	Gem II	1.5	20%	60%	60%
0	W	1	Crane	Royal	2.25	Gem II	1.5	100%	100%	100%
0	W	2	Crane	Royal	2.25	Gem II	1.5	60%	80%	100%
2	M	1	Crane	Toto	1.2	Gem II	1.5	0%	100%	100%
2	M	2	Crane	Toto	1.2	Gem II	1.5	100%	100%	100%
2	M	3	Toto	Toto	1.25	Gem II	1.5	20%	20%	40%
2	M	4	Crane	Toto	0.9	Gem II	1.5	80%	100%	100%
2	M	5	Crane	Toto	1.3	Gem II	1.5	60%	100%	100%
2	W	1	Toto	Toto	1.4	Gem II	1.5	0%	80%	100%
2	W	2	Toto	Toto	1.3	Gem II	1.5	80%	80%	100%
2	W	3	Toto	Toto	1.3	Gem II	1.5	100%	100%	100%
3	M	1	Crane	Royal	2.3	Gem II	1.5	0%	40%	100%
3	M	2	Kohler	Royal	2	Gem II	1.5	0%	40%	40%
3	M	3	Kohler	Royal	2.3	Gem II	1.5	0%	20%	20%
3	M	4	Crane	Royal	2.4	Gem II	1.5	0%	60%	100%
3	W	1	Crane	Royal	2.25	Gem II	1.5	40%	60%	80%
3	W	2	Crane	Royal	1.9	Gem II	1.5	20%	80%	100%

Pressures:

Basement (0): 85-95 psi Static/40-45 psi Minimum flowing
Floor 2: 75-85 psi Static/35-40 psi Minimum flowing
Floor 3: 70-80 psi Static/30-35 psi Minimum flowing

Test Data 6/16/2003 Static pressure: 70 psi, minimum flowing pressure: 25 psi
All tests performed with same Gem II flush valve calibrated at 1.15 gpf
Tissue tests conducted with UW issue single ply tissue

Floor	M/W	Stall (L to R)	Toilet	Test Valve	GPF	Percent Passsing (out of 5) 25 ft.
4	W	2	Am. Std.	Gem II	1.15	100%
4	M	5	Crane	Gem II	1.15	100%
4	W	1	Toto	Gem II	1.15	100%
4	M	2	Gerber	Gem II	1.15	60%
4	M	1	Briggs	Gem II	1.15	20%
4	M	3	Kohler	Gem II	1.15	0%
4	M	4	Eljer	Gem II	1.15	0%
4	W	3	Mansfield	Gem II	1.15	0%

Flush Diversion Hose and Graduated Bucket

Crane “Placidus” Toilet with “Gem II” Test Gauge