MaP | Maximum Performance

California Energy Commission
DOCKETED
12-AAER-2C
TN 71108
JUN 03 2013

June 3, 2013

California Energy Commission
Dockets Office, MS-4
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Docket No. 12-AAER-2C - Water Appliances

To Whom It May Concern:

On behalf of the Maximum Performance (MaP) testing program (www.map-testing.com), we are submitting the following comments in response to the request related to Docket No. 12-AAER-2C for Water Appliances. These comments are related solely to the topic of dual-flush toilets, their actual usage in the field and their water consumption.

Background on MaP

MaP testing was developed in 2003 through the sponsorship of 22 water utility interests in North America. It has since become one of the leading independent water closet flush performance evaluation tool for consumers, design professionals, water utilities, government and others in making specification and purchase decisions for toilets. MaP testing includes both tank-type and flushometer valve/bowl combinations, single-flush and dual-flush, and 1.6 gallons per flush (gpf) as well as high-efficiency toilets (HETs), which consume between 0.8 and 1.28 gallons per flush. MaP also tracks and lists both toilets and urinals certified to the WaterSense specifications. These lists are used by numerous California water utility fixture rebate programs as part of their rebate eligibility criteria.

MaP tests are performed by accredited, recognized laboratories, none of which is associated with a manufacturer. These independently developed test results are posted on the MaP website as noted above. Currently, MaP lists the performance test results for over 2,900 different water closet fixture models available in the North American marketplace, including 1,666 tank-type models certified to the WaterSense specification.

Our Comments on Dual-Flush

MaP has chosen to provide information on the current issues associated with dual-flush toilets, specifically:

(1) *whether the use of a formula-based composite average of the flush volumes of a dual-flush toilets is representative of the true water use of these products in the field in 'real world' applications;*
(2) *whether the specific ratio of maximum flush volumes established by WaterSense and the various 'green' codes and standards (i.e., the average of two reduced flushes and one full flush) is an appropriate measure of the representative average water use of dual-flush toilets; and*
(3) *whether the actual use of dual-flush toilets in residential applications is the same as that in non-residential (commercial, institutional, industrial) applications.*

Each of these issues has been the subject of much debate among water efficiency advocates, toilet manufacturers, and advocates for green codes, standards, and guidelines.

The current ANSI standard ASME A112.19.2-2008/CSA B 45.1-08 (and its companion ASME A112.19.14) correctly measures the two flush volumes of dual-flush water closets, but it does not define nor calculate the "effective flush volume"[1] (EFV) of those fixtures. Currently, EFV has been defined by WaterSense as well as by various green codes and green standards that exist today. However, the EFV is not referenced nor calculated in the ANSI plumbing standards noted above.

History

Dual-flush water closets were first introduced into the North American marketplace in 1967 by a major U.S. manufacturer. Therefore, the dual-flush design concept is 46 years old. *But*, the concept was not popular with consumers at that time and, as such, it had little impact on the marketplace (at least in the short term) and was withdrawn.

Re-introduced to the U.S. marketplace in January 1999, dual-flush models have gained a respectable market share. Today, according to our data (found at http://www.map-testing.com), there are 665 tank-type dual flush models offered in the North American marketplace by 72 different brands. **Attachment 1** displays the 603 dual-flush models currently certified to WaterSense. In our view, this proliferation of dual-flush models indicates strong support for the design among consumers, design professionals, efficiency advocates, and manufacturers.

Water Savings

The question always arises among the water efficiency and building design communities as to how much water is 'saved' by dual-flush fixtures when compared to the conventional 1.6 gallons per flush (gpf) single-flush toilet or the High-Efficiency Toilet (HET) rated at 1.28 gpf. Because the selection of the flush volume in a dual-flush toilet is strictly a user's behavioral choice, the few 'real world' analyses of savings have so far correctly focused upon the ratio of 'reduced' to 'full' flushes. These limited analyses have found that user behavior in residential applications is different than that found in commercial applications (albeit the behavioral data for commercial is so far very scarce).

Residential applications

The data gathered to date is confined almost entirely to residential applications. For reference, we have attached two documents and provided a link to a third document, all of which provide findings on previous studies:

(1) **Article** on dual-flush water savings by Funk, Luettgen, and Mayer as discussed in Water Efficiency magazine article (Attachment 2), posted as follows: http://www.waterefficiency.net/WE/Articles/Dual_Flush_SavingsAn_Analysis_of_Field_Data_15791.aspx

This summary covers 5 different field measurement studies in 5 entirely different locations involving something in excess of 232 installed dual-flush water closets. All of

[1] *The 'effective flush volume' is defined by WaterSense and various green codes and standards as the average water consumption of 2 reduced flushes and 1 full flush.*

the water closets were rated at 0.8 gpf on the 'reduced' flush and 1.6 gpf on the 'full flush'. The summary article is revealing in that it concludes that the 'real world' weighted average ratio of 'reduced' to 'full' flushes on a gravity-fed, dual-flush water closet installed in a residential setting was **1.4:1.0** in these 5 locations. Applying that ratio to the rated volumes yields an EFV of **1.13 gpf[2].**

(2) **Study Report** by Yarra Valley Water, 2005, "2004 Residential End Use Measurement Study" (Attachment 3), posted at: http://www.map-testing.com/assets/files/YarraValley-Residential-End-Use%20Study-2005-06.pdf

This study data logged 95 Australian households in 2004 for the purpose of quantifying residential water use. Most of the households (79 of the 95) were equipped with dual-flush toilets. Of the 79 households, a total of 63 had only dual-flush fixtures and 16 had mixed installations (both single-flush and dual-flush). Of particular interest in this study was the evaluation of several dual-flush designs, including 6/3L, 9/4.5L, 11/6L, and 4.5/3L (1.6/0.8 gpf, 2.4/1.2 gpf, 2.9/1.6 gpf, and 1.2/0.8 gpf).

As cited in the study report, the overall ratio of 'reduced' flushes to 'full' flushes in the dual-flush fixtures was 43:57 (equal to **0.75:1.0**). Interestingly, the ratio varied significantly among the various flush volume designs as follows:

Dual-flush category (Full/Reduced flush volume – rated litres/flush)	Reduced/full flush ratio	Average flush volume per flush (gallons)
4.5/3	N.A.	1.2 gal
6/3	27:73	1.5 gal
9/4.5	45:55	1.9 gal
11/6	54:46	2.1 gal
All dual flush	43:57	N.A.

N.A. – not available

As stated in the report, "The ratio is progressively more weighted to full flush as the volume of the toilet decreases." This fact should be taken into consideration when computing the EFV of a residential dual-flush toilet.

Furthermore, it should be noted that the dual-flush design has been a part of Australian installations for over 20 years and, even there, this study indicates that the ratio is substantially less than 2 to 1.

(3) **Study Report** by the Urban Water Security Research Alliance, 2011, "*South East Queensland Residential End Use Study: Final Report*, *Technical Report No. 47*" posted for download at: http://www.urbanwateralliance.org.au/publications/UWSRA-tr47.pdf

[2] *Formula: (1.4 x 0.8 + 1.0 x 1.6) ÷ 2.4 = 1.13*

This study of water use in 252 single family homes revealed that the dual flush ratio experienced was also less than the commonly accepted 2 to 1 ratio. (Refer to Tables 9, 10, 11, and 12 in the report.)

Study Reference	Geographic Area	Ratio of 'Reduced' Flushes to 'Full' Flushes (mean)
Queensland Residential End Use Study	Gold Coast	1.16:1
	Brisbane	1.16:1
	Ipswich	1.72:1
	Sunshine Coast	1.37:1

In summary, we have found no clear evidence to substantiate a 'reduced' to 'full' flush ratio of 2 to 1 for residential installations. However, in our view, the limited amount of field data is not yet sufficient to state a specific ratio for all residential dual-flush installations nationwide.

Using the data that *is* available, though, we have concluded that the water savings achieved by a dual-flush water closet installed in a residential application and designed to function at 1.6 gallons on the 'full' flush and 0.8 gallons on the 'reduced' flush is roughly equal to that of a single-flush 1.28 gallon fixture. (Both designs are classified as HETs.)

Following is a table that reflects the most commonly rated flush volumes for dual-flush water closets sold in North America along with resultant EFVs:

Design flush volume		Effective Flush Volume (gpf)	
Full Flush	Reduced Flush	2:1 Ratio	1:1 Ratio
1.6 gpf	0.8 gpf	1.07	1.20
1.28 gpf	0.8 gpf	0.96	1.04
1.6 gpf	1.0 gpf	1.20	1.30

Commercial applications

The second area of dual-flush installation is the commercial sector, where the public has access and where a significant percentage of the installed base is comprised of flushometer valve/bowl combinations. Manually operated dual-flush flushometer valves achieve a full flush when the user either pulls up or pushes down on the flush handle, with the reduced flush activated in the opposite direction.

Two field studies provide information on the use of dual-flush in the commercial sector:

(1) **Study** by Koeller and Company

A 2011 study commissioned by the U.S. General Services Administration (GSA) through Pacific Northwest National Laboratory involved a water audit of the 420,000 square foot Wynkoop Building occupied (in part) by the U.S. Environmental Protection in Denver. Reported to be certified as a LEED Platinum facility, the rest rooms were equipped with dual-flush flushometer water closets. The 'full' flush was user-activated with a downward action of the handle while the 'reduced' flush was activated by pulling up on the handle

(note that the "normal" operation of a single-flush water closet or urinal flush valve is activated by pushing down). The water demands of rest rooms on one floor of the building were data logged before and after the flush handles were replaced with units that reversed the direction of the 'full' flush activation. Prior to replacement, there was no clear evidence of the 'reduced' flush being activated by users; following replacement, a reduction in water use occurred. Because of the short period of study, however, insufficient data was obtained to draw any conclusions that could be applied universally to all commercial installations. However, the Director of the Office of Federal High-Performance Green Buildings, U.S. GSA, Mr. Kevin Kampschroer, stated in the recent IAPMO Emerging Technology Symposium that dual-flush designs were not saving water in GSA buildings. To view that presentation, go to the following link and navigate to point 30:55 minutes in the video:
http://www.youtube.com/watch?v=79ucuOO9OWE&feature=plcp

To gather more data on the Wynkoop project and evaluate the impact of the two different flush valve handle designs, contact Kimberly Fowler at the Pacific Northwest National Laboratory - Telephone 509-372-4233; email kim.fowler@pnnl.gov

(2) **Paper** by Arocha, J. and McCann, L., University of Missouri, 2012. "*Behavioral Economics and the Design of a Dual-Flush Toilet*" (Attachment 4)

For non-residential applications, the Arocha study demonstrated that the commonly installed dual-flush flushometer valve system does not result in the sizable water use reductions as claimed by proponents, due to the fact that users of these fixtures do not activate the reduced flush at a high frequency, as noted here:

Study Reference	***Type of Dual-Flush***	***Ratio of 'Reduced' Flushes to 'Full' Flushes (mean)***
Behavioral Economics and the Design of Dual-Flush Toilets (commercial)	1.6/1.1 gpf	0.63:1 (with signage)

Alternative flush valve designs wherein the 'reduced' flush is activated by a downward action rather than a lifting action could have a significant effect on the ratio, given that the natural tendency of users in public washrooms is to push down on the flush handle. In contrast to the flush valves currently being sold and installed on flushometer valve/bowl combination toilets (which require the upward lifting action to initiate a reduced flush), one California company manufacturers a flush valve with the opposite design (http://www.amtcorporation.com/adh100-16.htm).

In conclusion, we believe two factors are key to achieving water savings with dual-flush flushometer systems in commercial applications:

(1) Design of the flush valve: With uninformed or unmotivated users, the natural inclination is to activate a dual-flush flushometer water closet with a downward action which, in most cases today, results in a full flush. The reduced flush requires some degree of

extra effort to execute an upward action on the handle[3]. However, as noted above, reverse designs are available in the marketplace and were installed as flush valve replacements at the Wynkoop facility noted above. Results appeared to show that water use decreased when the 'natural' downward action initiates a reduced flush.

(2) Education of users: It is imperative that users in the commercial setting understand the purpose and function of dual-flush fixtures. Signage only is insufficient and other outreach methods are needed to make the behavioral choice the correct one.

We strongly encourage the CEC to sponsor and participate in more extensive studies of user behavior with regard to dual-flush toilets in both residential and non-residential settings, including the provision of sufficient funding to develop and execute a statistically valid field experiment.

Finally, we have been involved in the ANSI plumbing standards setting process since 1994. For many of the ensuing years, Michael Martin represented the CEC at the national standards table. Michael was always diligent to ask the right (and tough) questions and to stay abreast of industry developments, while representing the interests of CEC. Michael's passing left a large vacuum in the national standards process; California's leadership in water efficiency was no longer at that table and, as such, communications and relationships between the CEC and the ANSI standards process all but disappeared. We believe and recommend that the CEC renew their interest and participation by appointing and sending a representative to the ANSI meetings conducted through ASME. This is particularly important right now as many of the most critical national plumbing standards are undergoing revision and expansion in recognition of the need for improved water efficiency.

In summary, MaP encourages the CEC to: (1) sponsor additional research into the behavioral aspects associated with the use of dual-flush toilets in order to ascertain the appropriate dual-flush ratio and maximum water consumption and (2) be aware of and participate in the ANSI standards development process underway by appointing a representative to the ASME A112 Plumbing Standards Committee.

Thank you for this opportunity to provide the CEC with input.

[3] *Note: Anecdotal evidence suggests that, for hygienic reasons, some people prefer to initiate the flush of commercial flushometer water closets with their foot rather than their hand. It is easier to push down than to lift up with the foot and therefore the reduced flush is seldom activated in these cases.*

MaP | Maximum Performance

Sincerely,

John M. Koeller, P.E.
Koeller and Company
Principal and Partner
Maximum Performance Testing
Contact: jkoeller@map-testing.com
714-777-2744

William Gauley, P.Eng.
Gauley Associates, Ltd.
Principal and Partner
Maximum Performance Testing
Contact: bill@gauley.ca
519-853-4057

Attachments:

(1) List and MaP Score of Dual-Flush Water Closets-2013-06-01
(2) Article in Water Efficiency Magazine: "Dual-Flush Savings-An Analysis of Field Data"
(3) Report: "Yarra Valley Residential End-Use Study-2005-06"
(4) Paper: "Behavioral Economics and the Design of a Dual-Flush Toilet"