Evaluation of Toilet Certification Test Media

A laboratory study
sponsored by Tampa Bay Water

March 6, 2007

Conducted by

Veritec Consulting Inc., Mississauga, Ontario, Canada
Koeller and Company, Yorba Linda, California, USA

TABLE OF CONTENTS

Evaluation of Toilet Certification Test Media

1.0 Background

The National Energy Policy Act of 1992 (EPAct) established water efficiency standards for the manufacture, distribution, and/or sale of toilet fixtures in the U.S. Except for flushometer valve toilets, these standards went into effect on January 1, 1994[1] and essentially banned the sale of inefficient, water-wasting toilets (i.e., toilets flushing with greater than 1.6 gallons) throughout the country. On January 1, 1996, the Ontario Building Code began requiring 1.6-gallon (6-litre) toilets to be installed in all new construction within the Province (though the sale of inefficient toilets is still allowed in all Canadian provinces). Both of these actions were initiated to help ensure that water, one of our most precious natural resources, is used more efficiently – thereby reducing the cost of water and wastewater infrastructure and benefiting both the consumer and the environment.

Unfortunately, many of the early generation 1.6-gallon toilet models sold in North America performed poorly and failed to meet consumer expectations for flushing performance. Yet virtually all of these models met all of the prevailing performance requirements to become certified[2]. Many consumers reported a need for frequent double-flushing to clear the bowl of waste and many homeowners (and toilet installers) made adjustments to their new water-efficient toilets (increasing the flush volume) in an effort to improve the fixture's poor performance. As a result, the water savings achieved via the installation of 1.6-gallon toilets was somewhat less than expected.

Throughout the late '90s and early 2000s complaints about the poor performance of water-efficient toilets were common; a Michigan Senator even tried to repeal the toilet fixture provisions of EPAct 92 because of consumer dissatisfaction with the new toilets. The question naturally arose – **"How is it possible that toilet models certified as meeting all applicable standards do not meet consumer expectations for performance?"**

Water utilities were concerned over the negative customer feedback they were receiving regarding toilet fixtures that they had encouraged (through rebates) their customers to install. In response, 22 U.S. and Canadian utilities and other water interests, recognizing that toilet certification did not guarantee a high level of performance, sponsored the development of the independent Maximum Performance (MaP) Testing Program in 2003[3]. The goal of MaP was to quantify and compare the flushing performance of a number of popular 1.6-gallon toilet models by using a more realistic and credible testing protocol.

[1] Flushometer valve toilets were required to meet the 1.6 gallon (6-litre) maximum on January 1, 1997.
[2] Those performance requirements are defined in the ASME A112.19.2 and 19.6 (subsequently combined with 19.2) and CSA B45 Series 02 national standards.
[3] The latest MaP Testing Report can be downloaded from a number of sites, including the website for the California Urban Water Conservation Council: http://www.cuwcc.org/MapTesting.lasso

MaP testing protocol varies from the existing certification testing protocol in three important areas:

1. MaP testing used a very realistic test media – a combination of extruded soybean paste and toilet paper – vs. the unrealistic sponges, kraft paper, and plastic balls and beads used as part of the certification process,
2. The minimum performance requirements established for the MaP program, i.e., that a toilet model must flush at least 250g of realistic waste from the fixture in a single flush, were based on real life data from a British medical study[4].
3. Similar to consumer expectations, MaP testing requires toilet samples to flush 100 percent of the waste from the fixture (certification requires toilets to completely flush as little as 79 percent of the test media).

In brief, the MaP testing program was intended to identify and publicize toilet models that met consumer expectations for performance, mitigating the need for double-flushing or for flush volume tampering and thus meeting the intent of the EPAct mandate.

Certification Test Media

MaP Test Media

The results of the MaP testing program are embraced by consumers and municipalities/water agencies as believable and trustworthy. Based on increasing consumer confidence and satisfaction with MaP-approved toilets, many utility-sponsored toilet replacement programs are rebating only those toilet models meeting the MaP testing requirements. Toilet manufacturers also support MaP testing. More than 300 different toilet models have been submitted by various manufacturers for MaP testing, and many manufacturers openly state they complete in-house MaP testing on their products to design more efficient and better performing toilet models. Additionally, the methodology established by the MaP testing program was adopted by the U.S. EPA's WaterSense water efficient product labeling program as part of its requirements for high-efficiency toilets.

[4] J.B. Wyman, K.W. Heaton, A.P. Manning, and A.C.B. Wicks of the University Department of Medicine, Bristol Royal Infirmary, *Variability of Colonic Function in Healthy Subjects*, 1978. The average mass of the largest single bowel movements of each male participant over the course of the study was 250g.

Even though the MaP testing program has been growing in acceptance since 2003 and is now considered the de facto methodology for toilet performance testing throughout North America, certification requirements have remained largely unchanged. Therefore, poorly performing toilets (based on customer complaints) are still being certified and sold in the marketplace.

2.0 Project Goal

To determine whether a high level of "success" in certification testing is necessarily reflected in a high level of consumer satisfaction with flushing performance.

3.0 Current North American Certification Requirements for Toilets[5]

3.1 Mixed Media Test:

- 20 floating sponges (1.1-in. x 0.8-in.) and 8 paper balls (Kraft paper) are added to the bowl. Total 28 media.
- Requirement: A minimum of 22 (79%) of the mixed media must be flushed out of the fixture on the first flush.

3.2 Granule and Ball Test:

- 2,500 floating polyethylene granules plus 100 sinking ¼ inch diameter plastic balls are added to the bowl.
- Requirement: No more than 125 granules and not more than five ¼ inch balls shall be visible after the flush.

3.3 Drainline Transport Test:

- 100 floating ¾ inch polypropylene balls are added to the bowl.
- Requirement: the average carry distance of the balls shall be a minimum of 40 feet.

Note 1: prior to the adoption of the Mixed Media test (as described above), one of the certification performance tests involved flushing at least 75 of the 100 floating ¾-inch polypropylene balls that were added to the bowl. In the current version of the standard, the ¾-inch balls are only used to evaluate drainline transport. As such, although this project included flushing performance testing with the ¾-inch polypropylene balls, the results of these tests are not included in the final performance evaluation.

Note 2: after completing some initial granule and ball tests it was observed that the 100 sinking balls offered virtually no flushing challenge to the toilet and, therefore, they were not used in subsequent tests.

[5] For a more complete description of certification requirements please refer to ASME A112.19.2-2003.

4.0 Methodology

A series of comparative flushing performance tests were completed on ten different toilet models using both the current certification test media and the soybean paste/toilet paper media used in the MaP testing program. The intent was to compare the two different flushing performance testing methodologies (MaP vs. certification) and not the flushing performance of individual toilet models. As such, names of toilet models tested in this project have purposely been omitted from the results. A brief description of the different models included in this project is provided in Table 1.

Table 1 – Description of Toilet Models Tested

Description	No. of Models Tested
3.5-gallon gravity flush	2 models tested
1.6-gallon gravity flush	5 models tested
1.1-gallon pressure-assist	2 models tested

5.0 Project Results

To stratify toilet models tested in this study, a rating system was established. Toilets clearing a greater percentage of media in a single flush were assigned a higher rating. A point score was also assigned to each model based on how well it performed in the test. The point score was used to calculate an "*Expected MaP Performance*" score, i.e., the MaP score each model would be *expected* to achieve based on how well it flushed certification media, which was compared directly to the actual MaP score achieved by each fixture.

5.1 Mixed Media

Each toilet model was rated on its ability to flush floating mixed media. To pass existing certification approval requirements a toilet model must flush a minimum 22 of the 28 media (79%) from the fixture in a single attempt. Results are provided in Table 2.

Table 2 – Rating system used for mixed media testing

No. of Media Remaining in Fixture after Flushing	Rating	Score
0, 1, or 2	Excellent	4
3 or 4	Very Good	3
5 or 6	Good	2
7 or 8	Fair	1
> 8	Poor	0

5.2 Polyethylene Granules

Each toilet model was rated on its ability to flush the floating polyethylene granules. To pass the existing certification requirements, a toilet model must leave no more than 125 granules visible in the bowl after flushing. (Note that the ¼-inch sinking plastic balls were not included as part of this test.) Results are provided in Table 3.

Table 3 – Rating system used for granule testing

No. of Media Remaining in Fixture after Flushing	Rating	Score
5 or fewer	Excellent	4
6 to 20	Very Good	3
21 to 40	Good	2
41 to 100	Fair	1
> 100	Poor	0

5.3 Three Quarter Inch (¾") Polypropylene Balls

Each toilet model was rated as to how it was able to flush the floating polypropylene balls. Although this media is no longer used within the certification process to evaluate flushing performance, it is still used to evaluate drainline transport, i.e., how well a single toilet flush can move waste through the drain pipe. When this media was used in the past to measure flushing performance, a passing score required a minimum of 75 of the total 100 balls to be removed from the fixture in a single flush. Note that these scores (see Table 4) from the ¾-inch floating balls were not included in the final assessment.

Table 4 – Rating system used for polypropylene ball testing

No. of Media Remaining in Fixture after Flushing	Rating	Score
0	Excellent	4
1 to 5	Very Good	3
6 to 10	Good	2
11 to 20	Fair	1
> 20	Poor	0

5.4 Soybean Paste and Toilet Paper

Each toilet model was rated on its ability to flush a realistic mixture of extruded soybean paste and toilet paper (MaP testing media). The score it receives equals the mass of media the toilet is able to completely remove from the fixture in a single flush (in at least four of five attempts). Toilet models must flush at least 250g of media to "pass" the MaP test, and 350g of media to meet the U.S. EPA's WaterSense requirements. Table 5 summarizes certification media test scores and lists the MaP score for each model.

Table 5 – Summary of Test Results

	Certification Media Rating[6]			Actual MaP Score (grams)
	Mixed Media	Granules	¾" Balls	
Toilet #1	1	1	4	400
Toilet #2	3	3	2	1,000
Toilet #3	3	4	3	50
Toilet #4	4	4	4	800
Toilet #5	2	1	3	400
Toilet #6	1	0	0	600
Toilet #7	4	4	4	900
Toilet #8	4	3	4	500
Toilet #9	4	3	3	350
Toilet #10	4	3	4	200

5.5 Converting Mixed Media & Granule Score to "*Expected MaP Performance*" Score

To compare the results from the use of certification media to the results achieved by using soybean paste media testing it was necessary to convert each certification media test score to an equivalent *Expected MaP Performance* score. Since the ¾-inch floating balls are no longer used to measure flushing performance, the results from these tests were excluded from the average computed in Table 6.

Since an *Excellent* rating in this study equates to a score of 4 out of 4, and an excellent MaP score would be given to any toilet model able to flush 1,000 grams of media (the highest MaP score a toilet model can achieve is 1,000g), the average certification media scores are multiplied by 250g (i.e., 1,000g ÷ 4 points) to achieve the Expected Performance Score.

Table 6 - *Expected MaP Performance* – Mixed Media & Granules

	Mixed Media	Granules	Avg. Score	*Expected MaP Performance* (g)
Toilet #1	1	1	1.0	250
Toilet #2	3	3	3.0	750
Toilet #3	3	4	3.5	875
Toilet #4	4	4	4.0	1,000
Toilet #5	2	1	1.5	375
Toilet #6	1	0	0.5	125
Toilet #7	4	4	4.0	1,000
Toilet #8	4	3	3.5	875
Toilet #9	4	3	3.5	875
Toilet #10	4	3	3.5	875

[6] Excellent = 4 points, Very Good = 3 points, Good = 2 points, Fair = 1 point, Poor = 0 points

5.6 Comparison of Performance using Different Media

To determine how well existing certification test media scores reflect a toilet model's ability to perform under real world conditions, *Expected MaP Performance* scores are compared to the actual MaP testing scores achieved by each model. Similar scores in both categories indicate a high level of confidence in the certification test media scores; widely variant scores indicate a low level of confidence in the certification test media scores.

The *Difference* column in Table 7 is calculated as the difference between the Expected Performance and MaP performance scores, divided by the MaP Performance score. The results have been sorted from the smallest to the largest difference.

Note that fully half the toilet models in this study (highlighted in yellow in Table 7) achieved significantly different scores (greater than 50 percent) when tested with certification and MaP testing media – in one case a difference of 1,650 percent! Two models excelled when tested with the certification media yet *failed to meet the minimum requirements of MaP testing*!

Table 7 – Comparison of Expected Performance vs. MaP Performance

	Expected MaP Performance (g)	**Actual MaP Performance (g)**	**Difference**
Toilet #5	375	400	6%
Toilet #7	1,000	900	11%
Toilet #2	750	1,000	25%
Toilet #4	1,000	800	25%
Toilet #1	250	400	38%
Toilet #8	**875**	**500**	**75%**
Toilet #6	**125**	**600**	**79%**
Toilet #9	**875**	**350**	**150%**
Toilet #10	**875**	**200**	**338%**
Toilet #3	**875**	**50**	**1,650%**

6.0 Conclusions

This study was initiated to answer the question posed earlier in this report, **"How is it possible that toilet models certified as meeting all applicable standards do not meet consumer expectations for performance?"**

Clearly there is a problem with the existing methodology used to certify toilets. It is intuitively obvious that the current toilet certification test media are unrealistic insofar as appearance and physical characteristics are concerned. What is not obvious, however, is how poorly suited these media are to assess toilet flushing performance.

This study indicates the existing certification test media can produce *inaccurate* results and, in certain instances, can produce completely *contrary* results. It is quite possible that many of the early generation 1.6-gallon toilets in North America were able to flush the existing certification media very well yet failed to meet consumer expectations for flushing waste. Designing a toilet to flush sponges and Kraft paper balls may be no guarantee that it will do well flushing human waste.

The methodology developed for the MaP testing program, on the other hand, has been "field validated" by satisfied consumers and is accepted not only by water utilities and the U.S. EPA, but also by specifiers, architects, retailers, wholesalers, manufacturers, and government.

The research completed in this study clearly quantified that:

- Scoring well in certification testing is no guarantee that a toilet model will meet customer flush performance expectations,
- Scoring poorly in certification testing is no guarantee that a toilet model would fail to meet those customer expectations,

Certification testing – for all products – should be representative of "real world" demands and expectations. Consumers rely on the results of these tests and expect certified products to "do the job". The poor performance of many of the early model 1.6-gallon toilets in North America may be directly related to a lack of meaningful results provided by flushing sponges, plastic granules and plastic balls. (The worst of the early model 1.6-gallon toilets still met the certification requirements.)

If the current toilet certification testing program does not produce representative and meaningful results (and in some cases it actually produces contrary results), then its value must be questioned.

While this study does not recommend the MaP testing protocol as a replacement for the existing certification protocol, it clearly illustrates a need to reevaluate the current toilet certification testing program and make appropriate changes that will ensure results are realistic and meaningful.

7.0 Recommendations

1. Further comparative media testing should be completed by an independent accredited laboratory, e.g., IAPMO. If testing results confirm this study's findings, work should be initiated and completed on new ASME and CSA toilet certification requirements that are meaningful and more accurately reflect "real world" conditions.
2. Municipalities, water agencies, and consumers should continue to rely on the results of the MaP testing program (vs. certification testing) as a true indicator of how well a toilet model would be expected to perform in the field.

Any questions concerning this study should be directed to the authors:

Bill Gauley, P.Eng., Principal
Veritec Consulting Inc.
Mississauga, Ontario, Canada L5T 1M2
P: (905) 696-9391, ext. 102
F: (905) 696-9395
Email: bill@veritec.ca

John Koeller, P.E.
Koeller and Company
Yorba Linda, California, USA 92886
P: (714) 777-2744
F: (714) 777-2267
Email: koeller@earthlink.net