# TOILET FLAPPERS: The Weak Link of Water Conservation

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## Water Conservation and Efficient Toilets

Over the past 10 years, the replacement of water-wasting residential toilets with efficient (1.6 gallons-per-flush -- gpf) toilet fixtures has been a key strategy of a number of U.S. and Canadian water utilities for achieving their water conservation goals. The economics of these replacement programs are usually based upon a 20-year (or more) functional life for a water-efficient toilet fixture. Therefore, for the projected water savings to be achieved, these toilet fixtures must perform as designed for that entire period. This, in turn, demands that flush valve flapper seals and their readily available replacements continue to function at 1.6-gpf throughout the 20-year lifetime of the fixture.

## Problem No. 1 - Flapper Durability in Bowl Cleaners

*Toilet fixtures and flapper failure….*

A typical tank-type porcelain toilet is counted on by the water conservation community to possess a useful life of at least 20 years. However the flush valve closure mechanism (usually a flapper) within the tank of these new toilets may fail within five years, due either to normal "wear and tear" or to other factors introduced by the consumer. Failure leads to water leaks that could, unless corrected, substantially erode the water savings anticipated over the 20-year life.

*1993 - Consumers and manufacturers begin to experience flapper failures in the field….*

In October 1993, fixture manufacturers were beginning to experience severe problems with the degradation of original-equipment flush valve flappers installed in their new product. Anecdotal information was gathered by the manufacturers indicating that new toilets were sometimes leaking within months of installation. In some cases, warranty demands were being made upon the fixture manufacturers by the residential customers for repairs and/or replacements of the new toilet or its internal trim. Although many of these problems surfaced in Florida and Texas at that time, they were not exclusive to that region of the country.

The toilet manufacturers attributed the flapper leaks to the use of certain chemically-based in-tank bowl cleaners by the consumer[1]. Flapper deterioration led to failure of the flush valve seal and a continuing flow of water through the flush valve into the bowl, and through the bowl

[1] In the early 1990s, a change in the dominant consumer method of "bowl cleaning" or "sanitizing" occurred. Whereas previously, consumers had been using in-bowl cleaners that hung on the side of the bowl and dispensed chemical(s) directly into the bowl as the toilet was flushed, in the early 1990s, the chemical manufacturers began to successfully market a more "convenient" product to achieve the same goal. This product was the in-tank drop-in tablet that slowly dissolved in the tank water. Consumers dropped the tablet in the tank water and were no longer required to touch the bowl. This type of product is now manufactured by several firms and now dominates the market for bowl cleaners.

trapway into the drain[2].

*1994 - 1997 - Metropolitan Water District begins testing flapper materials….*

Because the toilet leaks could be very significant when this occurred, the Metropolitan Water District of Southern California (MWD) became concerned and undertook a major study of flapper materials in 1994 to identify the cause and magnitude of the failures, specifically those failures related to chemical attack resulting from in-tank bowl cleaners. Working in consultation with the flapper manufacturers, MWD completed its first round of independent testing by 1997. The results of that 1994-1997 study[3] indicated that certain in-tank bowl cleaners could cause severe warping, swelling, blistering, and cracking of the typical flapper, leading to a leaking flush valve.

*1994- 1997 - Flapper manufacturers respond with improved product….*

While that study of 1994 flapper materials was underway during the 1994-1997 period, most manufacturers aggressively addressed the failure issue by investigating, developing and testing new, more chemical-resistant elastomeric compounds and materials for their flapper products. Many of these new materials found their way into the product marketplace. Manufacturers claimed by 1998 that the best of these flappers would now readily withstand the attacks of bowl cleaning chemicals.

*1999 - Metropolitan Water District performs a second round of testing…*

As a result, MWD determined that a second round of independent testing was required to verify the manufacturers' latest claims. Thus, a new series materials tests was undertaken in early 1999 and concluded in October 1999[4]. Manufacturers were requested to submit their very best, state-of-the-art flappers for testing by MWD. Nine manufacturers responded by providing 16 different flapper models.

Accelerated testing was performed by immersing the sample flappers in various concentrations of 2000 Flushes® and Clorox®, the two most popular bowl cleaners at the time of the testing, for a period of 28 days at 40° C. A significant number of the new flappers successfully withstood the chemicals and maintained a "no leak" seal after the 28 days in this accelerated environment, confirming the claims by the manufacturers that their products were durable. This was viewed by the water conservation community as a very significant step forward by the industry.

*2000 - A new consumer product defeats the durable flappers….*

In 2000, a new formulation for the consumer product Vanish® appeared on retail shelves. Recognizing that the composition of the new Vanish® was significantly different than either the 2000 Flushes® or Clorox® included in the 1999 series of tests, MWD immediately undertook a

[2] In most cases, flapper failure occurred when a toilet remained unflushed for an extended period of time (vacation, etc.) and the resident had dropped a fresh tablet into the tank before leaving.
[3] *Toilet Flapper Materials Integrity Tests*, The Metropolitan Water District of Southern California, May 1998.
[4] *Toilet Flappers Materials Integrity Tests*, The Metropolitan Water District of Southern California, January 2000.

third round of testing in 2000. This round tested the same 1999 flappers in concentrations of this new product. Results showed that all of the test flappers failed to hold a seal after 28 days in the accelerated environment of Vanish®[5]. This setback was significant and sent the flapper manufacturers back to their development laboratories. At this time (2002), no commercially available toilet flapper is known to stand up to the chemicals released by the Vanish® bowl cleaner.

*2000 - ASME A112.19.5 Project Team formed and meets to address durability….*

Consensus was reached among the flapper manufacturing industry and the water utility industry that the durability of flush valve seals was of paramount importance to both industries and that development of a standard for durability should be sought. The ASME A112.19.5 Project Team, under the leadership of Burt Preston (then of Mansfield Plumbing Products), was assigned the task. On August 16, 2000, the Project Team met in Washington D.C. and organized a sub-committee for the specific purpose of addressing the durability issue; members of the Project Team agreed that participation by the manufacturers of the bowl cleaning products was essential to successfully deal with the problem. The first meeting of the Chemicals/Material Durability Sub-Committee was held on September 19, 2000, in Chicago. In addition to the members from the 19.5 Project Team, it was attended by three individuals representing the consumer products from the bowl cleaner manufacturers.

*2000 - 2003 - Durability Sub-Committee undertakes to develop a standard….*

Over the ensuing three years, the members of the Sub-Committee developed a test protocol[6] as a foundation for creating a viable durability standard. Industry members of the Sub-Committee applied the protocol within their own laboratories, analyzed the results, and developed recommendations for the Sub-Committee at large. As work proceeded, the Sub-Committee (1) identified the chemical differences between the various bowl cleaners in order to isolate the causes of the flapper failures in Vanish®, (2) refined the protocol, and (3) attempted to set an "envelope of boundaries" on the composition of the bowl cleaning products and the durability of the flappers.

*2003 – 2004 – ASME A112.19.5 Project Team decides to expedite the standard….*

In 2003, it became apparent to members of the Project Team that the process involving the bowl cleaning product manufacturers was moving too slow and might not yield a durability standard. Therefore, the Team determined to move ahead with a durability standard proposal based largely upon the earlier work of MWD and the Los Angeles Department of Water and Power, which had incorporated the MWD work into its very successful Supplementary Purchase Specification (SPS). As such, the SPS formed the textual basis for a proposed durability standard for flush valve seals. This proposal has been approved by the Project Team and awaits further standards work on flapper identification and marking (see page 6).

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[5] *Toilet Flapper Materials Integrity Tests, Supplement to Report dated January 2000*, The Metropolitan Water District of Southern California, May 2001.

[6] The protocol being developed and validated in the laboratories of Sub-Committee members was based largely upon the test protocol used previously in the MWD studies (1994-2000).

## Problem No. 2 - After-Market Replacement Flappers

*Flapper replacement by the consumer….*

Most consumers, upon discovering a leak in their toilet (whether resulting from normal "wear and tear" or from the use of an in-tank bowl cleaner), will attempt to locate a replacement flapper that stops the leak. When consumers look for such a replacement, they will generally visit the most convenient retail hardware store or home center for that product. In most cases, they will not contact the original equipment manufacturer (OEM) to obtain the exact replacement part that is designed for their toilet fixture[7].

When visiting the retail store, customers will find it extremely difficult to: (1) locate a flapper that is physically compatible with the flush valve (it fits the valve and does not leak, even though it may be the incorrect flapper for that toilet); and (2) determine that the replacement flapper maintains the 1.6-gpf characteristic of the original flapper in the ULF toilet. Whereas a consumer may easily locate a flapper that is physically compatible, they may not be able to discern whether the flapper meets the second requirement (a 1.6 gallon flush). Furthermore, once having satisfied the first requirement, many consumers may not be aware of the 1.6 gallon criteria or may even prefer a flapper that exceeds 1.6-gpf. Therefore, fixtures that are designed to function at 1.6-gpf are being fitted with after-market replacement flappers that cause the fixture to flush at volumes in excess of that figure.

*1998 - MWD studies the effect of after-market replacement flappers on 1.6-gpf toilets….*

To determine the flush volume effects of replacing OEM flappers with available after-market flappers, MWD undertook to test replacement (after-market) flappers available to consumers at major retail chains in Southern California. A total of 50 different after-market replacement flappers or flush valve sealing mechanisms were purchased from Home Depot, HomeBase (no longer in business), Orchard Supply Hardware (OSH), Ace Hardware Stores, and True Value Hardware Stores. A consumer visiting one of these major retailers will usually find an array of flappers that is confusing and, in some cases, misleading[8].

A total of 24 different water-efficient 1.6-gpf toilet fixtures were obtained for the tests, all of which were round-front commodity units at the lower end of each fixture manufacturer's price range. Of the 24 complete fixtures, seven were manufactured and sold in 1994 and 1995 and 17 were manufactured in 1997 and 1998. One of the 17 was a prototype unit not then available to the consumer. All of the other 16 are or were available in the general stream of commerce in Southern California.

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[7] The reason for this is the (usually) immediate need for the part, the very low cost of the part, and the perception by the homeowner that the part can be readily obtained at their local hardware store or home center. It should be noted, however, that the proposed new A112.19.2 standard for water closets contains a requirement that manufacturers provide information to the customer (either on or in the fixture OR in separate printed material) that enables the customer to contact the manufacturer for replacement parts. Whether or not the availability of this information (such as a toll-free telephone number) will cause customers to change their habits is yet undetermined.

[8] Flapper packaging labeled as "universal" seldom contains a flapper universally fitting an array of toilets

Of the 50 after-market flappers, 30 were physically compatible with the 17 new 1997-1998 ULF toilets. Those 30 flappers were subjected to tests designed to answer the following study questions:

1. Which flappers are functionally and physically compatible with *each* of the water-efficient toilet fixtures?
2. What is the leakage rate (if any) for each flapper when installed on each of the fixtures?
3. For each after-market flapper that is compatible with the flush valve of the toilet, what is the water consumption per flush when installed on the toilet?

*1998 - Test results when installing after-market flappers….*

The MWD tests showed that installation of the wrong flapper on a water-efficient fixture could result in water consumption amounts as high as 4.4 gallons for non-adjustable flappers and 3.4 gallons for adjustable flappers. Consequently, the water savings previously attributed to programs involving the retrofit of residential toilets could be substantially overstated. Only a few toilet fixtures maintained a flush volume near 1.6-gpf when fitted with most after-market flappers[9].

Specifically, study results revealed the following:

- For most ULF toilets, after-market replacement flappers that maintain the flush characteristics of the OEM toilets are rarely available at retail stores frequented by consumers. Each of the major chain hardware and building supply stores offers a wide choice of after-market replacement flappers. The available product, however, is not necessarily functionally nor physically compatible with the entire array of installed ULF toilet models.

  This can be attributed to (1) the vast number of flappers that would be required to fit every ULF toilet model and (2) the limited available shelf space at the retail point-of-purchase.

- Each after-market flapper performed differently in the different ULF toilet models tested. Therefore, each flapper may be uniquely suited to only a few ULF toilet models and cannot necessarily be classified as "universal."

- The packaging (or labeling) of after-market replacement flappers does not necessarily lead the consumer to the correct choice for their own ULF toilet. Labeling after-market replacement flappers as "universal" or "fits 1.6 gpf toilets" can lead the consumer to believe that purchasing and installing that product will restore their ULF toilet to its original performance at 1.6 gpf. Rather, the study results show that rarely does the replacement flapper, when correctly installed, perform at 1.6-gpf[10].

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[9] *After-Market Toilet Flappers: A Study of Compatibility and Flush Volumes,* Metropolitan Water District of Southern California, November 1998.

[10] Consumers have reported that they frequently must return to the retail outlet several times to exchange their previous flapper purchase for another flapper before they have found the one that fits the flush valve and provides a

- Adjustable flappers sold as after-market replacements for OEM flappers can generally deliver 1.6 gpf if adjusted (or set) to the correct orifice opening. Most adjustable flappers, however, are pre-set within their packaging to the opening that would cause the ULF toilet to flush with the most water (i.e., the "high" setting)[11].

*2002 - ASME A112 Standards Committee asked to address the issue….*

In the interest of bringing order out of this flapper "chaos," the California Urban Water Conservation Council formally requested on March 12, 2002, that the ASME A112 Plumbing Standards committee initiate a project within the A112 committee framework to develop a parts identification system for flush valve seals (flappers) on toilets. This request was considered at the August 2002, meeting of the committee, at which time it was assigned for action to the A112.19.5 Project Team that was then addressing flapper durability.

*2004 – ASME A112.19.5 Project Team develops a draft proposal…*

With the completion of a draft standard for flapper durability (see page 3), the ASME A112.19.5 Project Team next considered and then approved a first draft of a proposed identification standard at its meeting in Seattle on July 14, 2004.. Included within that draft are additional requirements related to marking part numbers and manufacturer contact information in or on the toilet tank.

*NEXT STEPS…*

Once the identification and marking draft is finalized, it will be coupled with the draft of the proposed durability standard and incorporated into a revised A112.19.5 standard, which will be balloted. ASME and ANSI approval of a revised standard is expected in 2005.

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complete flush. The study results indicate that although the consumer may finally install a compatible flapper that results in a satisfactory flush, the likelihood of achieving a 1.6-gallon flush is slim.

[11] The consumer could be expected to remove the replacement flapper from the packaging, install it on the flush valve, and flush the toilet (possibly without reading the instructions and adjusting the flapper setting). If, upon installation, the toilet proved to flush satisfactorily, the consumer would make no adjustments to the flapper, thus leaving it to flush at the "high" setting, usually in excess of 1.6 gallons.