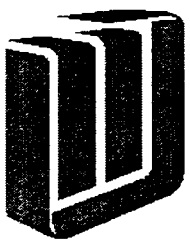
TOILET FIXTURES

Long-Term Durability Test



The Metropolitan Water District
of Southern California

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Preface

As in the past, the complete support of MWD's Corrosion Engineering group was crucial to the completion this study. The contributions of Mr. Bill Sleeper and Mr. Harvey Webster of that group were again significant. Their expertise, advice, and work on this project were exceptionally valuable in carrying out the laboratory protocol, which they did in a very professional and thorough manner. We also thank Corrosion Engineering for again making their comprehensive laboratory facilities and excellent staff available for this study.

Since 1994, the Corrosion Engineering group has applied their resources to the investigation of toilet fixtures and toilet flappers on behalf of the water conservation community-at-large. This study, together with the three studies that preceded it, provides valuable information for both the water conservation community and the manufacturers of the products tested. We anticipate that studies such as these will continue to stimulate improvements in product design by the industry and will be an important tool for those conservation professionals involved in developing purchase specifications.

Finally, we thank the following organizations and individuals for their contributions of toilet fixtures for this test program:

- Niagara Conservation Corporation, Mr. William Cutler
- Water Management Services, Inc., Mr. Brian Brittsan
- Western Pottery Division of WP Industries, Inc., Mr. Jeffrey Goldberg
- Caroma U.S.A., Mr. Darrell Rasell
- Legend North America L.L.C., Mr. Spiros Cheng

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INTRODUCTION

Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (Metropolitan) is a consortium of 26 cities and water districts that provides drinking water to more than 17 million people in parts of Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties. Metropolitan provides an average of 60 percent of the potable water used in its 5,200 square mile service area.

Metropolitan was created pursuant to an Act of the California State Legislature in 1928 to build the 242-mile-long Colorado River Aqueduct, a facility it still owns and operates. In addition, Metropolitan imports water from Northern California through the State Water Project. Metropolitan facilities also include five pumping plants, a distribution system having seven reservoirs, five water filtration plants, 43 pressure control structures, 15 power plants, and approximately 775 miles of large diameter pipelines. Recently completed by Metropolitan is the $2 billion Diamond Valley Lake project in southwestern Riverside County, which has a capacity of approximately 800,000 acre-feet of water, doubling Southern California's surface reservoir capacity.

Non-Conserving Toilet Replacement Programs and New Toilet Requirements

In the early 1990s, one of the longest droughts in California history (7 years) caused a great strain on Metropolitan's water supplies. As a result, Metropolitan implemented a number of water conservation programs designed for residential consumers, the most significant of which were the various residential toilet retrofit programs. In these programs, customers were encouraged to replace their high volume, water-wasting toilets (flush volumes of 3.5 gallons, 5 gallons, and higher) with new ultra-low-flush (ULF) toilets (1.6 gallons or less). Metropolitan and its participating member agencies used rebates, free distributions, vouchers, other toilet subsidies, and state and national legislation as the principal means of encouraging customers to retrofit their water-wasting toilets.

Toilet retrofit programs began with the onset of the drought and accelerated significantly in 1993, reaching their peak retrofit levels in 1995 (over 20,000 toilets per month). As of 2000, over 1.7 million residential toilets in Metropolitan's service have been replaced with new ULF toilets through water agency programs. In addition, the State of California mandated that, as of January 1, 1992, toilets installed in all new residential construction must be ULF toilets. As a further step, some communities also require that existing residences be retrofitted with ULF toilets upon their transfer of ownership (known as "retrofit on resale" ordinances).

In growing recognition of the urgent need to conserve the state's water supplies, the California Urban Water Conservation Council (CUWCC) defined and developed a series of water conservation measures defined as Best Management Practices (BMPs). Member water agencies throughout California (including Metropolitan) then agreed through a joint memorandum-of-

understanding to pursue the implementation of those BMPs. BMP No. 14, covering residential ULF toilets, calls for aggressive toilet replacement programs. It provides an objective method against which these programs are evaluated, the measurement being in units of toilet replaced (with the underlying assumption being that the units replaced result in associated water savings over the useful life of the ULF toilet).

STUDY BACKGROUND

Prior Studies

Studies conducted by The Metropolitan Water District of Southern California (Metropolitan) over the past six years concluded that:

a) Consumers' use of in-tank toilet bowl cleaners is causing flush valve seals (flappers) to degrade when the toilet is not flushed regularly, potentially leading to flush valve leaks[1].

a) Consumers desiring to purchase a replacement flapper for their leaking toilet may have difficulty in finding a flapper that (a) correctly fits their particular flush valve and (b) maintains the toilet at its original specification of 1.6 gallons-per-flush (gpf)[2].

Recommendations growing out of those studies included possible toilet design approaches that would: (a) result in toilets without flappers (i.e., "flapperless" toilets) and (b) store and deliver the bowl-cleaning chemicals in a manner that would isolate those chemicals from the vulnerable tank trim materials[3]. Other recommendations dealt with new materials formulations for improved flapper durability and after-market parts compatibility and identification.

Plumbing Industry Response

Concerns by water utilities over the vulnerability of typical residential toilets to flapper degradation and failure became widely known. Manufacturers, developers and entrepreneurs are responding with an array of ideas, concepts, prototypes and, in some cases, marketable products that address this issue. One of the approaches to solving the flapper problem was to entirely eliminate it from the toilet design.

Water Utility Concerns

Water conservation professionals favorably view the aggressive and innovative solutions to the flapper vulnerability problem being offered by the plumbing industry. At the same time, however, some believe that the water industry is occasionally used as an experimental platform for products and ideas that have not been previously subjected to the normal rigors of the marketplace. That is, new consumer products (in this case, toilet fixtures) make it to the

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[1] Two studies of flappers and in-tank bowl cleaners were conducted:
(a) Metropolitan Water District, May 1998; Toilet Flapper Materials Integrity Tests
(b) Metropolitan Water District, January 2000; Toilet Flappers, Materials Integrity Tests
The second of these studies included flappers made from re-formulated materials that resulted partly from the findings of the first study.

[2] Metropolitan Water District, November 1998; After-Market Toilet Flappers: A Study of Compatibility and Flush Volumes

[3] Tank trim is defined in ASME A112.19.2M-1998 as parts other than china regularly supplied with a toilet fixture, e.g., fill valves and flush valves, including flappers and other flush valve seals.

marketplace through the water conservation community before they become available to the "public-at-large" and, thus, customers of a few water utilities are being used as "field testers" for the manufacturer.

Second, some new toilets incorporating new design technology are being manufactured and distributed by entities yet unknown in the U.S. marketplace. Although these products must first comply with local codes and U.S. standards before being sold in this country, there is no assurance of their physical durability.

These two factors, when combined, caused some to pose the question: "Will this 'new' toilet continue to function over a 20-30 year period without failure of its mechanical parts?" This is particularly important to the water utilities because of their presumption that replacing an old (non-conserving) toilet with a ULF toilet will provide consistent water savings for the lifetime of the fixture's installation (usually assumed at 20 years).

TEST APPROACH

Because of the concerns expressed by water utilities over the physical durability of the toilets, Metropolitan undertook a special testing procedure designed to simulate a physical lifetime of use of the mechanical trim parts within the toilet tank. The test was designed to reveal any weaknesses in the design or manufacture of the tanks that would, under normal conditions, be experienced by a residential consumer. Depending upon the ultimate installation location of these residential toilets, a physical "lifetime" for such a product could be estimated at anywhere from 150,000 to 250,000 flush cycles. The latter was chosen as the target for this study.

The test apparatus used for the procedure is located entirely within the laboratory facilities of the Corrosion Engineering group of Metropolitan.

Corrosion Laboratory

Metropolitan's Corrosion Laboratory performs ongoing tests of the materials used in various phases of water treatment and distribution. It is one of the few laboratories dedicated to long-term testing, and results from these tests are widely distributed and valued by the water utility industry. In support of Metropolitan's water conservation programs, the Corrosion Laboratory has conducted numerous and varied individual tests of toilets and tank trim (in particular, flappers and other flush valve seals) over the years since 1994.

Test Apparatus

In 1994, Metropolitan developed and equipped a special test apparatus within the Corrosion Laboratory specifically for the long-term, continuous testing of flappers *(Toilet Flapper Materials Integrity Tests, 1998).* This apparatus includes two identical test banks each capable of sequentially and continuously flushing nine ULF toilet tanks, for a total capacity of 18 tanks. The 18 tank positions on the apparatus are plumbed and equipped with a computer-controlled automatic flushing system that can be regulated to any desired flush frequency (refer to Figure 1).

It should be noted that in order to closely replicate typical installation conditions in a residence, fresh tap water is used during the test process. Water is not recycled and re-used in the test, since to do so may introduce into that flush water substances and materials released from the interior surface of the toilet tanks or from the tank trim components. Those substances could then accumulate in the recycled water over time, clog the tank trim components, and defeat the integrity of the test procedure.

Tanks Subjected to Testing

Using this testing apparatus for a continuous flushing program, lab personnel installed eight toilet tanks of four different design technologies on the apparatus. The tanks selected for the test were either those models that utilized a new flush mechanism (Niagara and Western) or were from manufacturers new to the U.S. water conservation market (Caroma and Legend). All were available in the water conservation marketplace at the time of testing. The eight specific toilet tanks were as follows:

Table 1. ULF Toilet Tanks Subjected to Testing

ULFT Make/Model	*Start Date for Testing*	*Special Notes*
Niagara Model 2216 (#1)	Feb. 17, 2000	These 2 flapperless ULF toilets assembled in San Pedro, CA (note 1)
Niagara Model 2216 (#2)	March 24, 2000	
Niagara Model 2216 (#3)	May 19, 2000	These 2 flapperless ULF toilets assembled in Santa Fe Springs, CA (note 1)
Niagara Model 2216 (#4)	May 19, 2000	
Western Pottery Flapperless Siphonic	Feb. 17, 2000	Contains siphonic flush valve imported from United Kingdom
Caroma Caravelle 305	March 24, 2000	Dual flush wash-down toilet imported from Australia; tested only at full 1.6 gpf setting
Legend Velocity 2000 (#1)	May 19, 2000	Piston-type flush valve; WDI fill valve in 90013 tank
Legend Velocity 2000 (#2)	May 19, 2000	Piston-type flush valve; Fluidmaster fill valve in 90013 tank

Notes: (1) The first two toilets tested in the program were reported by Niagara Conservation Corporation to have been assembled in San Pedro, CA. Assembly was subsequently relocated to Santa Fe Springs, CA.

All of the above fixtures were obtained directly from the manufacturers or their representatives without charge, for which Metropolitan is appreciative.

Test Program

Over a period of approximately eight months, each of the tanks in the test was individually flushed a minimum of 250,000 cycles (once per minute, approximately 1,440 flushes per day). The test apparatus was set to depress the flush lever on the eight tanks for a period of two seconds.

At the end of each group of 25,000 flush cycles, lab personnel shut down the test process, and observed and recorded any functional or physical anomalies. These included such items as:

- Failure of a physical component
- An out-of-adjustment condition
- Obvious changes to flush characteristics
- Leaks

Where evident, the causes of any anomalies were recorded. Out-of-adjustment tanks would, to the extent possible, be brought back into adjustment and the test process re-started for the next 25,000 cycles.

If a failure occurred during a 25,000 flush cycle run, lab personnel would immediately shut down the problem tank, repair the tank and place it back "on-line." At that time, broken parts were replaced where necessary. Flush counting for the problem tank would be adjusted to assure that a full 250,000 cycles would be achieved for that tank.

SUMMARY OF FINDINGS

Note: The selection of only one or two tanks for this series of life cycle tests does not provide a statistically valid representation of all tanks of each type. Therefore, the results shown in this report should be viewed only as a possible indication of the "real world" characteristics of these products. To obtain statistically reliable results, a larger sample of tanks would be required for the tests conducted.

All of the ULF toilet tanks subjected to the cycle testing process were new to the U. S. water conservation market. As such, manufacturers were consulted as to the correct installation procedures and adjustments, and were invited to the laboratory to view the set-up and test process. During the course of the testing, manufacturers were invited to visit the laboratory in order to evaluate problems, if any, and recommend solutions where appropriate.

A detailed laboratory activity log for the completed test process is included as Appendix A. In summary, the specific toilets experienced the following:

Niagara Model 2216 (flapperless) – (Figure 2)

All four units of this model periodically experienced problems with the water containment vessels (WCV) within the tank being stuck in a dumping position (tipped at an angle from their normal resting position). This resulted in the fill valve remaining open while the toilets ran continuously. It appeared to lab personnel that this was caused when the edge of the tipped WCV was in slight contact with the side of the tank or its lid, thereby "sticking" and preventing it from returning to its at-rest position. In addition, it appeared that this occurred only when the flush handle was depressed for the period of two seconds. When this occurred, merely touching the flush handle caused the bucket to "break loose" and return to its at-rest position.

Lab personnel were not able to adjust the early units (#1 and #2) of this toilet model to the 1.6-gpf setting. Representatives of Niagara were called into the lab to investigate and concurred that these two units were experiencing problems caused by factors external to the lab tests. They arranged for two additional units (#3 and #4) to be tested; Metropolitan personnel selected units #3 and #4 at random from the Niagara warehouse in Santa Fe Springs. According to Niagara representatives, these subsequent units had been assembled at that new Santa Fe Springs location under more strict quality control procedures. Both of the new units were easily adjusted to the correct 1.6-gpf setting.

The Niagara #1 unit leaked through the flush handle opening in the tank for about the first 125,000 flush cycles. The leak volume was such that it was sufficient to result in a puddle on the floor of a residential bathroom. By 150,000 flush cycles, this problem had disappeared. Lab personnel attributed this "self-sealing" to the build-up of a mineral formation at the leak location.

Western Pottery Flapperless Siphonic ("Turbo-Siphon") – (Figures 3 and 4)

Only one of this model was tested. This unit was taken out of service at 103,387 flush cycles because of a broken return spring. A representative of the Turbo-Siphon flush valve (manufactured by Thomas Dudley Ltd., Dudley, England) provided a replacement spring, lab personnel re-assembled the siphonic unit, and the toilet was put back into service on the test apparatus at the next 25,000 cycle shut-down. The toilet was out-of-service for approximately two weeks. Turbo-Siphon flush valves or replacement parts are not available at retail plumbing supply houses.

In addition, at the 128, 387 flush cycle point, lab personnel observed that the yellow retainer pin began to work its way out of the assembly. It was pushed back in to its original position by those personnel. Later (at 137,000 flush cycles), however, the pin had worked its way completely out of the assembly and the siphonic flush valve was inoperable. The pin was re-inserted by lab personnel and for the remainder of the test, it continued to work its way out; lab personnel then periodically pushed it back into position so that the toilet could finish the entire test process.

Legend Velocity – (Figures 5 and 6)

Two of this toilet model were tested. Except for different fill valves (refer to Table 1), the units were identical. The toilet uses a piston-type flush valve.

Difficulty was experienced by lab personnel at initial set-up in adjusting the units to flush at 1.6 gpf. Later, at about 100,000 flush cycles, adjustments were required to both units to re-set the water level. After 250,000 flush cycles, some minor wear to the lift bar on the piston (plunger) was observed (see Figure 2). This wear did not affect the performance of the toilet. No other significant problems or anomalies were experienced with the Legend toilets during the test.

Caroma Caravelle 305 Dual Flush – (Figure 7)

Only one of this model was tested. The Caroma dual-flush toilet is manufactured and widely used throughout Australia. The unit provides the user with two flush volumes: 0.8 gpf for liquid only and 1.6 gpf for a full flush. The flush is activated by pressing either one of two buttons located on top of the tank. The flush option used for the test was the 1.6 gpf setting. No problems or anomalies were experienced with this toilet and it maintained full integrity during the entire 250,000 flush cycle program.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Where new designs and technologies are conceived, developed, and ultimately offered to end-use customers (including water utilities for their water conservation programs), some assurance should exist that the resulting products have already been subjected, at a minimum, to complete life cycle testing. Furthermore, that testing should result in corrective design and manufacturing changes in the event that the testing reveals product flaws.

The fact that two of the four toilet models tested experienced problems early in the test program indicates that some of the toilet fixtures being sold on the market may not have undergone the design, testing, and manufacturing engineering necessary to ensure long-term functional reliability. The repeated problems with the Niagara units during this nine-month long test occurred as these very same models of toilets were being sold in quantity to water utilities, who provide them to their residential customers.

NOTE: Subsequent to the completion of the entire 250,000-cycle testing program on November 26, 2000, Niagara representatives informed Metropolitan that certain changes had been made to the tank to prevent the problems identified in the study. Specifically, the redesign of the WCV and the fill tube to avoid contact between the WCV and the fill tube and the tank has, according to Niagara, solved the problem with the WCV hanging up in a tipped position. At the request of the Niagara representatives, Metropolitan agreed to install a new (redesigned) tank onto the test apparatus and operate the unit through 25,000 flush cycles in order to observe its operation, particularly the functioning of the WCV mechanism. That limited testing did, in fact, indicate that the problem had been largely eliminated. Niagara representatives also indicted that the problem encountered in the laboratory with the WCV hanging in a tipped position had not, to their knowledge, occurred in units already installed in customers' homes.

Recommendations

With the expected appearance of other new toilet fixture design concepts, technologies, and products, it is important that water utilities exercise serious caution when considering the purchase, promotion, distribution, or funding of these products. It is recommended that:

1. Without prejudicially eliminating some manufacturers and/or products, water utilities should adopt policies requiring that manufacturers or their representatives provide evidence of adequate product life cycle testing of all toilet fixtures (a) of new technology and/or new design and (b) from those manufacturers that are "new" to the U.S. marketplace. This includes new design concepts, technologies, and materials that are not already common to the marketplace as well as manufacturers or marketers without a previous history of business in the U.S.

2. Water utilities engage in independent testing programs to validate the claims of manufacturers and their representatives. Groups of water utilities can jointly undertake testing programs on products that they believe require independent, objective evaluations[4].

3. When warranted, water utilities should conduct periodic, formal customer surveys to determine what field problems are being encountered (if any) by customers with toilet fixtures supplied or funded by that utility. Surveys should be stratified according to specific toilet fixture models and the findings used to govern future program and product decisions.

4. Water utilities continue to encourage manufacturers to explore new design concepts for toilet fixtures with the goal of improving the longevity of the fixtures at their design flush volume of 1.6-gallons per flush. The elimination of traditional flush valve seals (flappers) in favor of seals that are (a) less susceptible to chemicals and (b) cannot be replaced or adjusted to increase the flush volume, is a goal that the water utility industry encourages the plumbing industry to continue to pursue.

[4] In conjunction with the Stevens Institute of Technology, such a program was undertaken in 2000 by 13 water utilities in the western U.S. to test toilet fixtures against proposed national standards. This report should be available from the California Urban Water Conservation Council in the latter part of 2001.

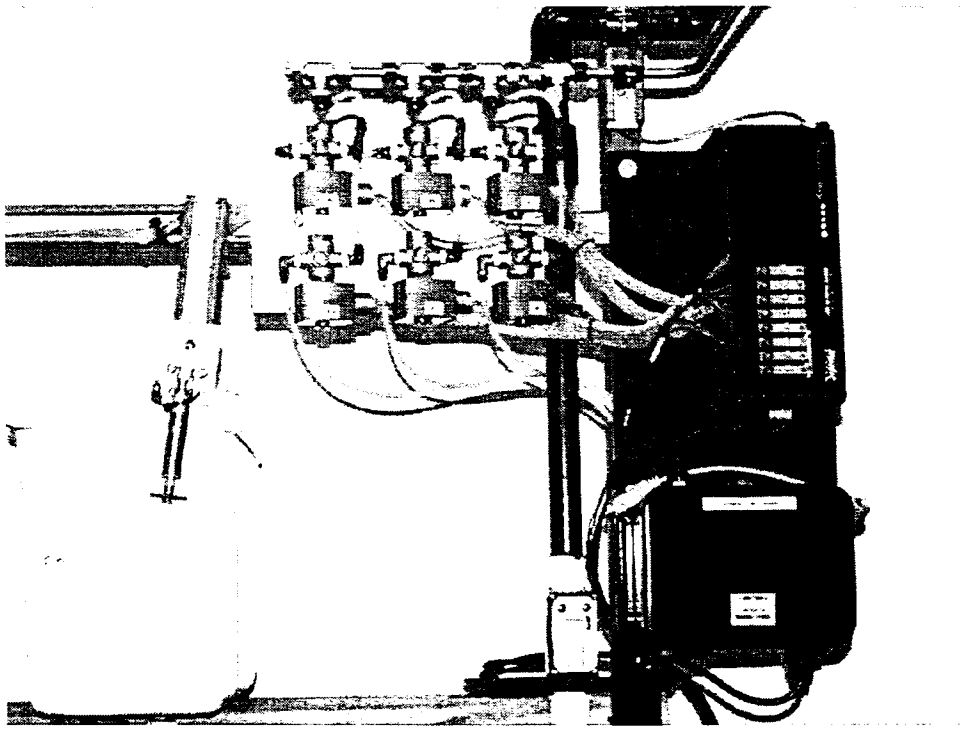

Figure 1. Controller unit showing solenoid valves actuating the air cylinder which, in turn, actuates the flush valves on the toilet fixtures

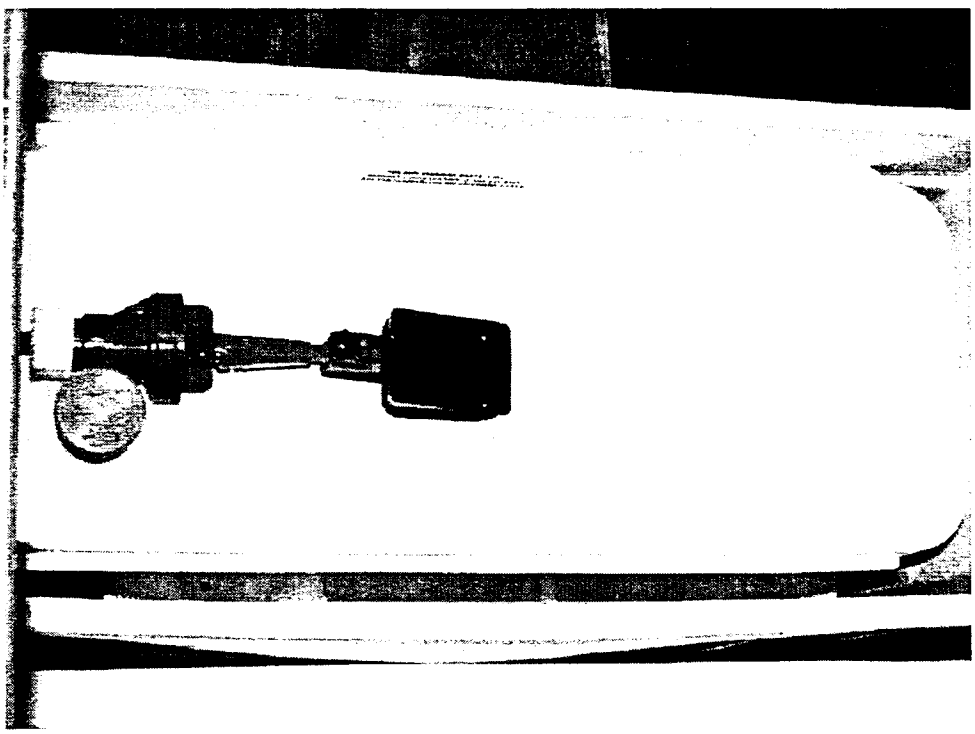

Figure 2. Top view of Niagara® showing Fluidmaster fill valve and water containment vessel

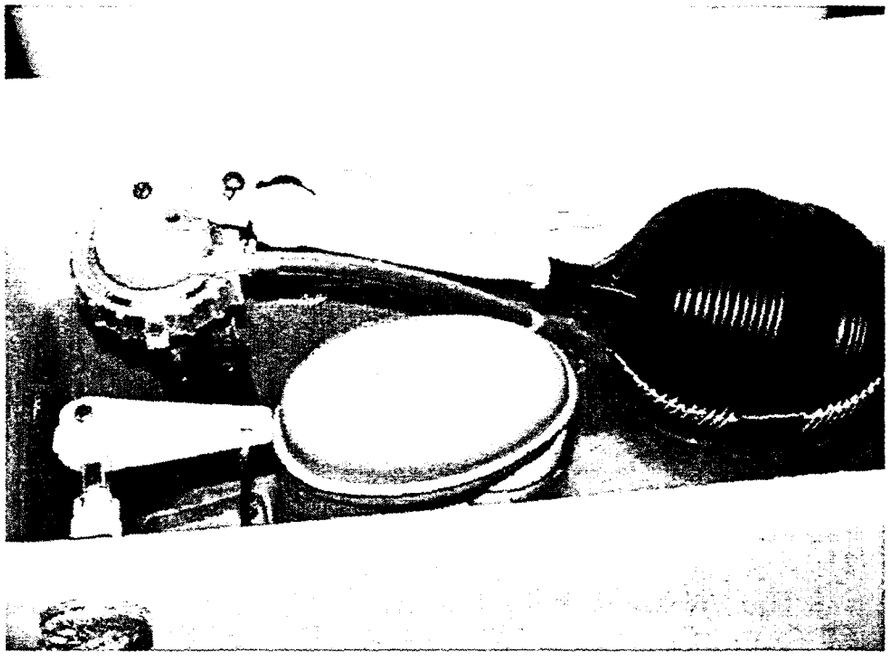

Figure 3. Turbo Siphon flush valve installed inside Western® toilet

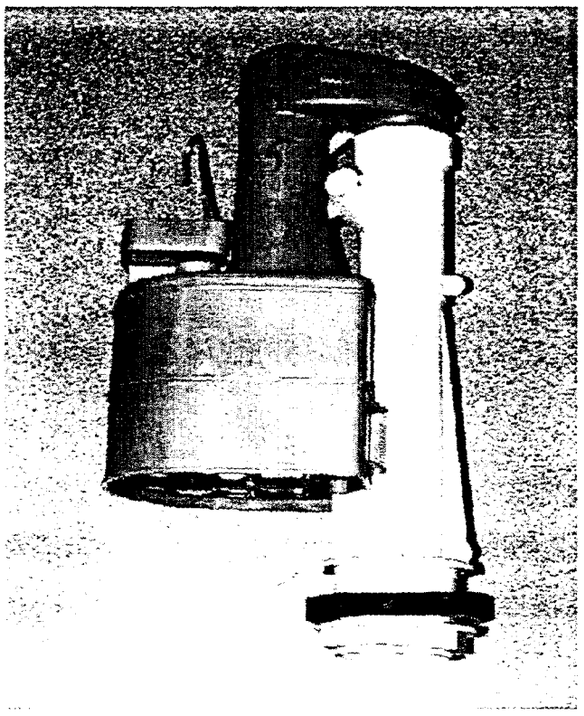

Figure 4. External view of Turbo Siphon flush valve

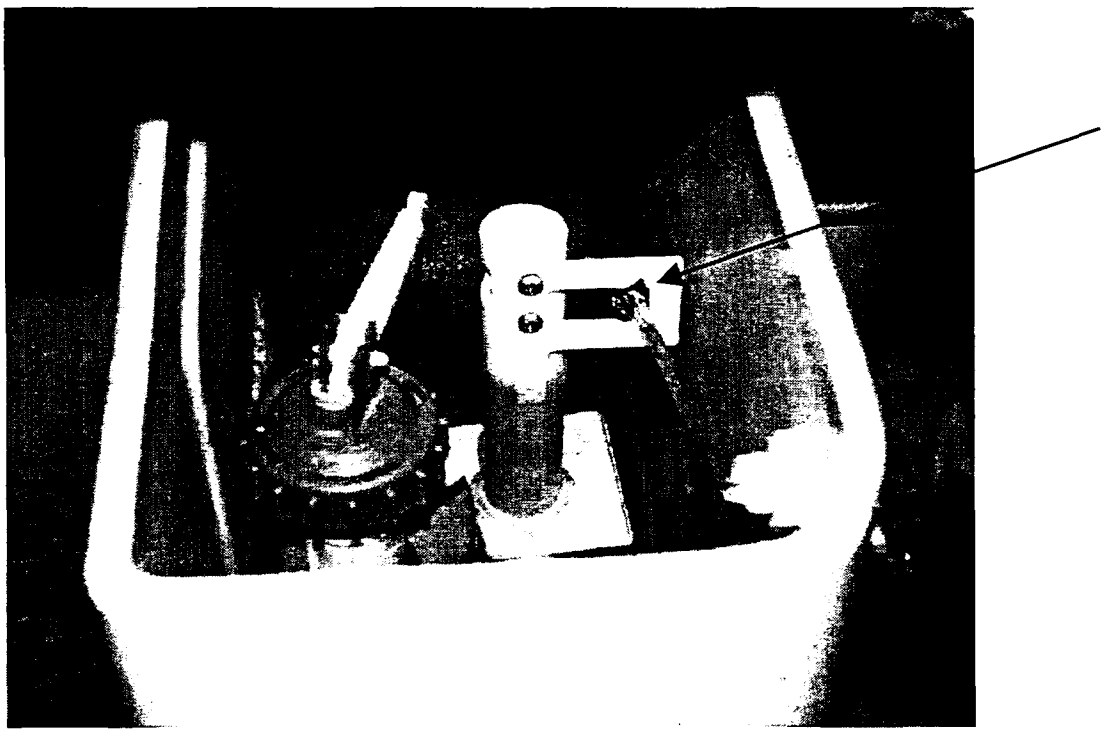

Figure 5. Legend® #1 tank, showing WDI fill valve (blue) and piston-type flush valve (note wear pattern on the lift bar)

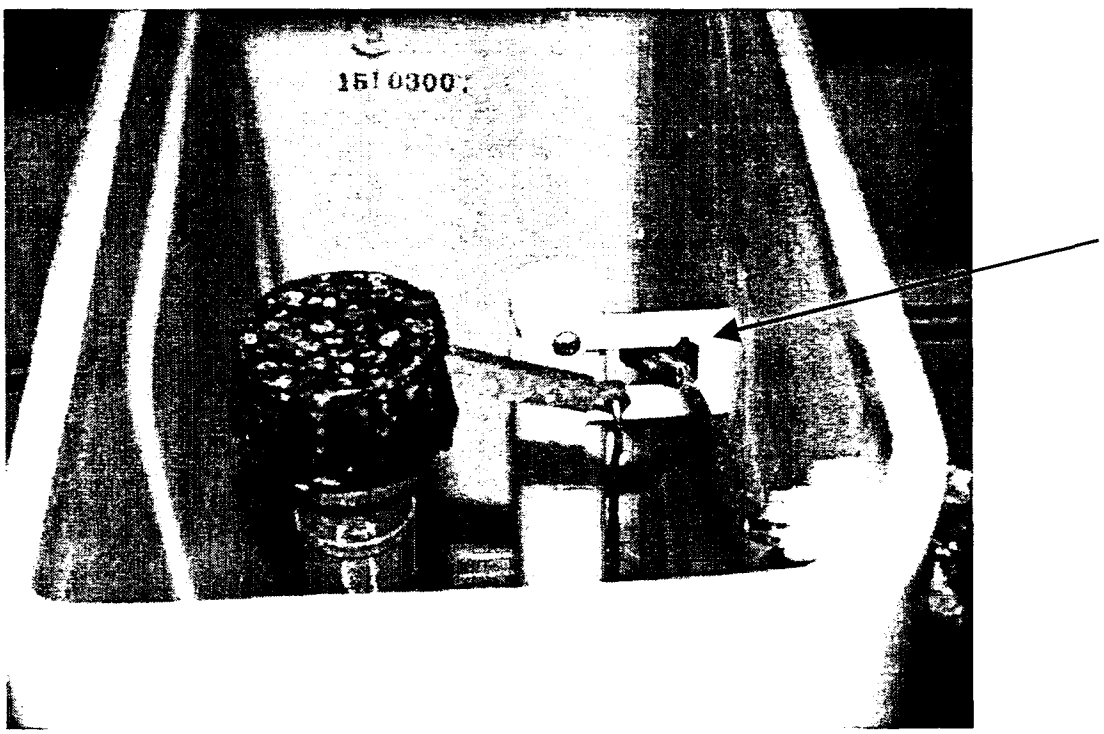

Figure 6. Legend® #2 tank, showing Fluidmaster fill valve (black) and piston-type flush valve (note wear pattern on the lift bar)

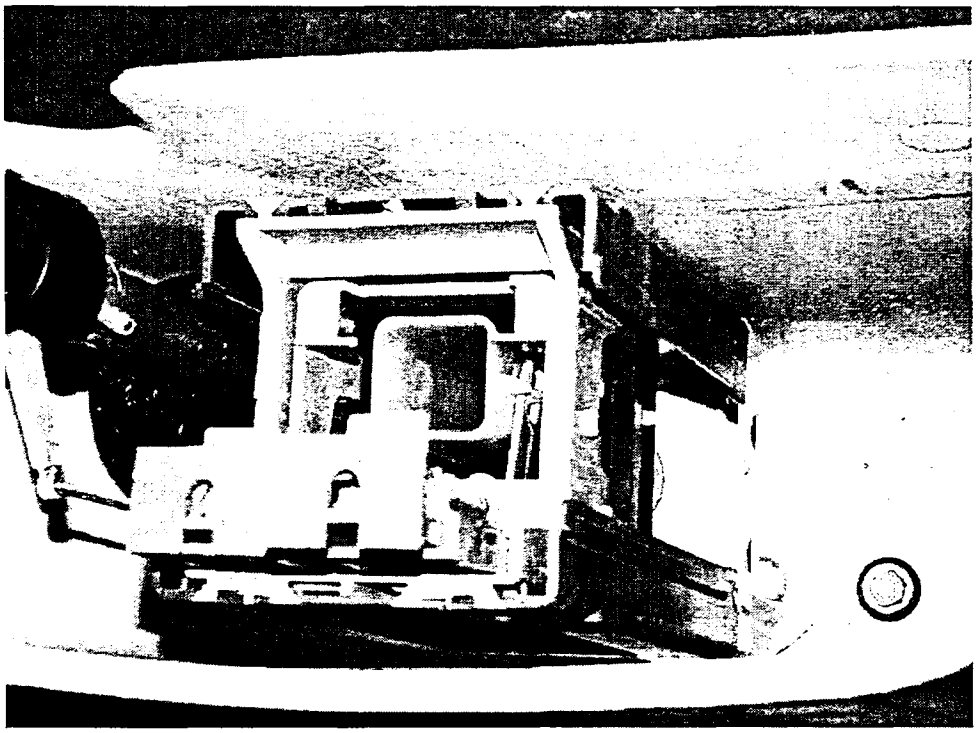

Figure 7. Fluidmaster fill valve (left) and dual-flush mechanism (right) inside Caroma Caravelle toilet

LABORATORY ACTIVITY LOG - SUMMARY

02-17-00 Mechanical testing of Niagara #1 and Western Turbo-Siphon begins.

Niagara #1 leaking through flush handle opening during flush.

03-23-00 Upon installation of Niagara #2, WCV does not return to original position after flush. This is due to the copper inlet line rubbing on the WCV.

03-24-00 A second round of 25,000 flushes was completed for Niagara #1 & Western toilets. At this time, Niagara #2 and Caroma toilet were added and another 25,000 cycle round begun.

The Niagara #1 continues to leak through the flush handle opening.

04-12-00 Current flush totals are:

Niagara #1	75,000
Western	75,000
Niagara #2	25,000
Caroma	25,000

04-25-00 Lid fitment on Niagara #2 is still causing the WCV to hang up unless the lid is positioned "just right."

04-26-00 Visit from Niagara personnel to view test and discuss problems with both units.

05-01-00 Controller reached 25,000 cycles. Visual observation performed. All units functioning well. No problems visible. Test re-started at 8:00AM.

Current flush totals are:

Niagara #1	100,000
Western	100,000
Niagara #2	50,000
Caroma	50,000

05-03-00 Western Turbo Siphon stuck in the down position. Unit had refilled and was not leaking but would not flush. Plunger rod was jiggled and unit started working again.

Western continues to stick. Unit disassembled. Return spring is bent out of shape and not working. Unit taken out of service at 103,387 flushes. Replacement for broken part requested from manufacturer.

05-18-00 Unit automatically shuts down at next 25,000 cycle increment.

Niagara units #3 and #4 installed. Niagara #3 flushing 1.78gpf as received. Adjusted to 1.6gpf. Niagara #3 is very sensitive as to how its lid is installed. If not placed precisely in one exact spot, the WCV mechanism rubs on the lid and sticks in the upset position, causing water to run continuously.
Niagara #4 flushing at 1.70 gpf as received. Adjusted to 1.6gpf.

Legend units #1 and #2 installed. Legend #1 has blue WDI fill valve. Legend #2 has Fluidmaster fill valve.
Legend #2 flushing at 2.74 gpf as received. Fill valve did not shut off until water was overflowing into overflow tube. Unit adjusted to red "WL" mark. Flushes at 1.98gpf. Unit could not be adjusted to molded "WL" mark as fill valve adjustment is "bottomed out".
Legend #1 flushing at 2.08 gpf as received. Unit filling exactly to red "WL" mark as received. No adjustment made.

05-19-00 All operating units inspected at 25,000 cycle shutdown. No problems encountered.

Spring replaced in Western Turbo-Siphon. Unit brought back on line.

Current flush totals are:

Niagara #1	125,000	Niagara #3	0
Western	103,387	Niagara #4	0
Niagara #2	75,000	Legend #1	0
Caroma	75,000	Legend #2	0

Test re-started at 8:15AM.

9-12-0 Unit automatically shutdown at 25,000 cycles. Visual inspection performed. The following observations were made:

Niagara #1 leak through the handle has apparently "healed" itself. Calcium formation seen at location of leak.
Niagara #2 - replacement of lid remains critical. If lid is not placed just right, the WCV hangs up resulting in continuous water flow.

Western - yellow pin that holds Turbo-Siphon flush valve to overflow tube had worked itself out. It was pushed back in. This has been observed before but not reported.

The current flush totals are:

Niagara #1	150,000	Niagara #3	25,000
Western	128,387	Niagara #4	25,000
Niagara #2	100,000	Legend #1	25,000
Caroma	100,000	Legend #2	25,000

Test re-started at 11:00AM.

9-12-0 Yellow pin on Western Turbo-Siphon had come completely out. Flush valve unit was free floating. Pin re-engaged. Unit resumed flushing.

9-12-0 Unit automatically shutdown at 25,000 cycles. Visual inspection performed. All toilets functioning satisfactorily.

Yellow pin on Western continues to work its way out, but if pushed back in periodically it does not pose a problem.

The current flush totals are:

Niagara #1	175,000	Niagara #3	50,000
Western	153,387	Niagara #4	50,000
Niagara #2	125,000	Legend #1	50,000
Caroma	125,000	Legend #2	50,000

Test resumed at 8:35AM.

9-12-0 Unit automatically shutdown at 25,000 cycles. Visual inspection performed. All toilets flushing satisfactorily.

The current flush totals are:

Niagara #1	200,000	Niagara #3	75,000
Western	178,387	Niagara #4	75,000
Niagara #2	150,000	Legend #1	75,000
Caroma	150,000	Legend #2	75,000

Test re-started at 1:34PM.

08-01-00 Unit automatically shutdown at 25,000 cycles. Visual inspection performed.

All four Niagara toilets found with WCV stuck in a partially cocked position (WCV tipped at 90 degrees). Water was running because fill valves could not be closed. No explanation for this. The lids were removed and the units inspected. They appear to be otherwise operating normally.

Legend #1 had to be adjusted. Unit was filling above the water line. Adjusted to the maximum and still filling 1/4-inch past indicated "WL".
Same for Legend #2.

Other units operating satisfactorily.

During the last 25,000 flush cycle period, a slug of some kind of silt must have come through the line, because every unit has a fine film of silt in the bottom of the tank. The silt did not affect the functioning of the tanks.

The current flush totals are:

Niagara #1	225,000	Niagara #3	100,000
Western	203,387	Niagara #4	100,000
Niagara #2	175,000	Legend #1	100,000
Caroma	175,000	Legend #2	100,000

Test re-started at 8:08AM.

08-03-00 Niagara #2 & #4 found in half-cocked position. Upon touching the handles they reset.

08-07-00 Niagara #2 & #4 again found in half-cocked position and was reset.

08-16-00 Niagara #4 found in half-cocked position and was reset.

9-12-0 Unit automatically shutdown at 25,000 cycles. Visual inspection performed. All units functioning satisfactorily.

The current flush totals are:

Niagara #1	250,000	Niagara #3	125,000
Western	228,387	Niagara #4	125,000
Niagara #2	200,000	Legend #1	125,000
Caroma	200,000	Legend #2	125,000

Niagara #1 completed 250,000 cycles and was removed from the test.

Test re-started at 8:05AM.

09-06-00 Niagara #2, #3 & #4 found in half-cocked position.

9-12-0 Unit automatically shutdown at 25,000 cycles. Visual inspection performed. All units operating satisfactorily. Western yellow pin was 90% of the way out but was still operating. Pin pushed back in.

The current flush totals are:

		Niagara #3	150,000
Western	253,387	Niagara #4	150,000
Niagara #2	225,000	Legend #1	150,000
Caroma	225,000	Legend #2	150,000

Western Turbo-Siphon completed over 250,000 cycles and was removed from the test.

Test re-started at 3:52PM.

09-18-00 Niagara #4 found in the half-cocked position.

09-27-00 Legend #2 lift mechanism had risen past its stop and come loose. It was re-installed.

10-02-00 Unit reached 25,000 cycles and automatically shutdown. Visual inspection performed. The following observations were made:

All units flushing satisfactorily.

Niagara # 4 - if flush handle is not fully depressed, can manually be made to hang up in the half-cocked position.
Niagara #2 and Caroma reached 250,000 flushes and were removed from test.

The current flush totals are:

Niagara #2	250,000	Caroma	250,000
Niagara #3	175,000	Legend #1	175,000
Niagara #4	175,000	Legend #2	175,000

Test re-started at 8:30AM.

10-20-00 Unit reached 25,000 cycles and automatically shutdown. Visual inspection performed. All units functioning satisfactorily.

The current flush totals are:

Niagara #3	200,000	Legend #1	200,000
Niagara #4	200,000	Legend #2	200,000

Test re-started at 3:05 PM.

11-09-00 Unit reached 25,000 cycles and automatically shutdown. Visual inspection performed. All units functioning satisfactorily.

The current flush totals are:

Niagara #3	225,000	Legend #1	225,000
Niagara #4	225,000	Legend #2	225,000

Test re-started at 10:00AM.

11-20-00 Niagara #4 WCV found in half-cocked position.

11-26-00 Unit reached 25,000 cycles and automatically shutdown. All units functioning satisfactorily. All remaining units have completed 250,000 flushes. Test is complete.