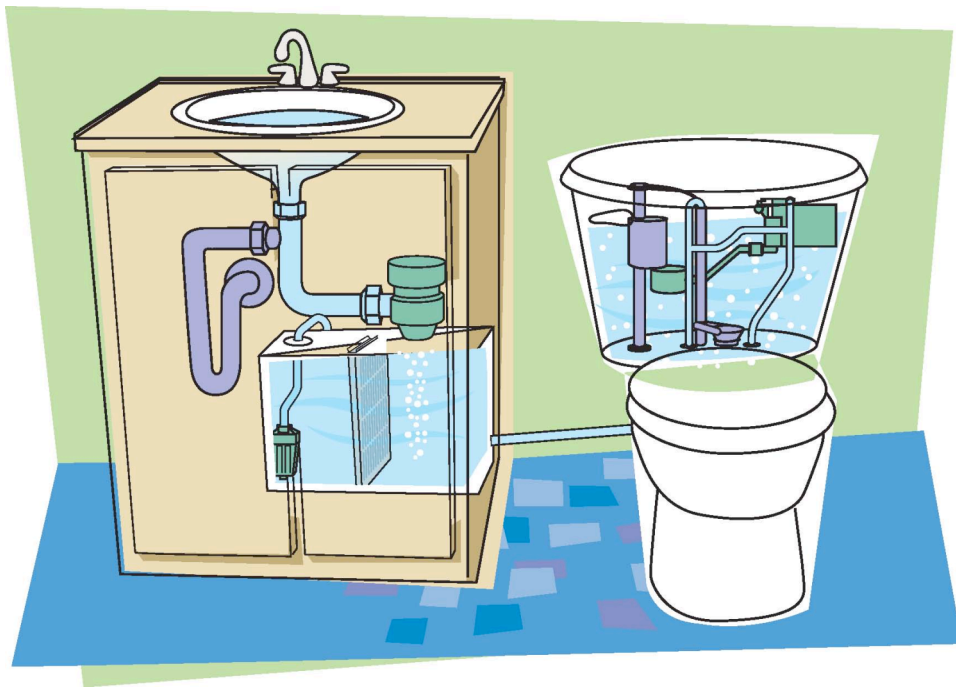


Field Study of the AQUS[®] Water Saving Device



**Report to the
Metropolitan Water District of Southern California
in support of the
Innovative Conservation Program Grant**

**Revised
January 2010**

by

**Koeller and Company
Yorba Linda, California**

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Introduction

Overview of the AQUUS® system

WaterSaver Technologies, LLC's patented water saving device, The AQUUS®, is based on the concept that using fresh water to flush the toilet is both unnecessary and wasteful. The AQUUS® system captures the untreated graywater from the bathroom lavatory sink, filters and disinfects it, and uses it to flush a tank-type gravity-fed toilet, thereby conserving the potable water normally used for flushing.

The AQUUS® system consists of two major components: (1) the fill control unit (FCU) and the (2) the vanity tank. The FCU clips onto the back of the customer's toilet tank and holds the toilet fill valve in the "off" position, allowing water from the vanity tank located under the bathroom sink to fill the toilet tank with treated graywater. Periodic (annual) maintenance of the system is required by employing chlorine tablets and by removing, rinsing and reinstalling the filter/screen.

History of AQUUS®

WaterSaver Technologies began development of the AQUUS® in 2004. Throughout this design period and prior to the product launch, a number of prototypes were built, with which beta test installations were conducted in New Mexico, Colorado, and Kentucky. Based upon the feedback from beta test users, design modifications were incorporated, new prototypes built and further beta testing was conducted.

Since the initial marketplace introduction of the AQUUS® in 2006, system modifications have been made to improve installation procedures and system performance. In 2008, WaterSaver Technologies signed a strategic partnership agreement with Sloan Valve Company to sell and distribute the AQUUS®. In the fall of 2008 and continuing through 2009, a complete product review occurred with Sloan Valve Company's involvement. The goal of this review was to investigate ways to reduce the system cost, reduce installation time and improve performance. The newly redesigned AQUUS® will be available in 2010. Additional field trials and data gathering will occur once the redesigned AQUUS® becomes available.

Function of the AQUUS® System

As individuals shave, brush their teeth, apply and remove makeup, take medications, etc. at their bathroom lavatory sink, the wastewater (graywater) from the sink flows down through the standard tubing to the vanity tank (#1 – see figure on following page) rather than to the building drain system. At the vanity tank, the untreated wastewater next passes through a plastic "T"-shaped system component containing a baffle. This baffle splashes a small amount of the wastewater into the standard p-trap to maintain its prime and control odors. The remainder of the wastewater flows through a tablet dispenser containing three chlorine/bromine tablets (#2). As the wastewater passes over the bottom tablet, chlorine is released sufficient to kill any bacteria that might be in the wastewater and leave a 1 ppm or greater chlorine residual in the treated water. The newly treated wastewater then flows into a 5.5 gallon capacity vanity tank, where it remains until needed for flushing (#4).



How it Works

- ① Water flows through standard tubing that is included with the system.
- ② Tablets in the dispenser clean water to control bacteria and other contaminants.
- ③ The screen filters out hair and other objects.
- ④ The reservoir holds up to 5½ gallons of water.
- ⑤ A 12-volt DC pump moves water through the hose to the fill control unit.
- ⑥ The fill valve remains undisturbed while the system avoids cross connection to fresh water or interference with backflow prevention.
- ⑦ The fill control unit delivers greywater to the toilet tank.

When the toilet is flushed and potable water begins to fill the toilet, a submersible, 12-volt DC pump (#5) is used to pump the treated water to the toilet tank. The treated water is pulled through a coarse screen (#3) that removes long strands of hair or large suspended amounts of undissolved material (e.g., toothpaste) from the water. The treated water is then pumped through a 3/8th inch flexible tube to the rear of the toilet at the base of the toilet tank. The water enters the toilet tank through two hollow, stainless steel bolts that connect the tank to the toilet bowl¹.

The treated water then enters the Fill Control Unit (FCU - #7) and spills into the toilet tank and down the overflow tube. As the FCU cup is filled, it acts as a counter weight and effectively lifts the normal fill valve (#6) and holds it in the “off” position. When this occurs, potable water is not able to enter the toilet tank and the AQUUS[®]-treated water is all that is being used to fill the toilet tank. The process of turning on and turning off the fresh water takes only a few seconds.

If sufficient treated water is in the vanity tank to complete the toilet tank fill cycle, then the pump automatically turns off. If there is not enough water to complete the cycle, then the treated water drains from the FCU counter-weight cup, releases the fill valve and allows potable water to complete the fill cycle.

¹ Current design limits the application of the AQUUS[®] system to two piece tank-type, gravity-fed toilet fixtures.

Study Conclusions

There are several conclusions drawn from this field study:

1. The AQUUS installations demonstrated fresh water savings, although those savings were found to be somewhat less than originally anticipated.
2. AQUUS users were satisfied and very complementary of the system and would recommend it to others.
3. The continued evolution and development of the AQUUS and associated products is planned and necessary. Such development is expected to result in an increase in water savings, more applications within the home, easier installation, and continued or expanded consumer acceptance.
4. Meter readings taken at the seven installations in the field study provided evidence of limited water savings per year (474 gallons). However, as also noted in the report, this may have been due to faulty meters as well as to some of the installation locations that were initially selected (children's or secondary baths) and, as such, may experience much lower usage. Based upon American Water Works Association data, one would have expected to find a higher savings than was reported by these meters.

WaterSaver Technologies, in partnership with the Sloan Valve Company, is continuing to improve the system through ongoing product development. A new model, available in Spring 2010, will operate within a wider array of toilet models, be easier to install, and is expected to deliver improved performance. The features and expanded applications for this second generation AQUUS are listed within the report. Once released, the new model will be deployed in additional pilot projects and the resulting data added to that shown in this report.

ICP Grant and Project Background

WaterSaver Technologies LLC (WaterSaver) applied for and received a grant from the Metropolitan Water District of Southern California (Metropolitan) Innovative Conservation Program (ICP) to demonstrate the benefits and measure water savings associated with its AQUUS[®] system. As noted earlier, the system is based upon the premise that using potable water to flush a toilet is both unnecessary and wasteful.

Under the terms of the grant, WaterSaver planned to contribute 15 AQUUS[®] systems and the associated metering and monitoring equipment for the primary purposes of: (1) evaluating system performance and customer satisfaction; (2) measuring the amount of water captured, treated, and reused for toilet flushing; and (3) measuring electricity consumption related to the operation of the system pump.

The Metropolitan grant was used to fund: (1) the proper installation of the system; (2) monitoring of the system for 30+ days; and (3) the collection of the measured data and prepare this report.

Installation, maintenance, and monitoring of each AQUUS installation was to be provided by local plumbing companies within the service areas of the selected properties.

Following is the original cost estimate for the Metropolitan grant. The grant provided 50 percent of the MWDSC funding up front, with the remainder to be paid upon conclusion of the project.

Project Budget

AQUUS [®] system	\$310 X 15 =	\$ 4,650
Flow Meters	\$250 X 15 =	3,750
Kill-a-Watt Meters	\$100 X 15 =	1,500
Installation	\$300 X 15 =	4,500
Maintenance and Support	\$300 X 4 =	1,200
Data Collection	\$200 X 15	3,000
Data Analysis & Report		6,000
Contingency Allowance		<u>2,500</u>
Total		\$ 27,100

WaterSaver committed to contribute the 15 AQUUS[®] systems and the metering equipment toward this project, a total value of \$9,900. This amount represents approximately 37% of the overall budget costs and resulted in a total grant funding request of \$17,200.

Project Start-Up – Site Selection

The ICP grant application was approved for a field trial involving the installation of 15 AQUUS[®] systems. A variety of location types were solicited. They included single family residences, offices, university dormitories, and hotels. Various individuals assisted in identifying possible installation sites in Southern California. Later, because of a rather lukewarm response to the invitations to participate in Southern California, WaterSaver was given permission to solicit installations in Northern California², so long as the majority of the installations were in the south.

² Chris Dundon, water conservation manager from the Contra Costa Water District, assisted in identifying these installation sites.

Volunteers for the system trial were sought from among property owners and managers willing to participate in a system trial of a new water saving product, including both residential and business applications. The AQUUS[®] system was offered free-of-charge to the property owner, with the additional proviso that at the end of the trial, they could have the system removed or, alternatively, keep the system for their own use without cost. All equipment and other hardware, equipment installation (including any required modifications to the property needed to accommodate the system) and monitoring costs would be borne by the installer. Participants were informed that the operation of the system would be monitored and metered for a period of no less than 30 days following installation, after which the metering devices would be removed.

Solicitation of participants and identification of all sites took several months. Prior to the actual installations, however, one participating location removed its name from the list and a second was removed from the list due to an unforeseen toilet fixture incompatibility with the AQUUS[®].

After final review of volunteer sites it was determined that installations would be performed in a total of 11 locations. This was communicated to Tim Schaadt, Metropolitan Water District, prior to beginning project installation and he agreed that we should proceed with the locations we had. Unfortunately the data collected from four of these installations was either incomplete, contaminated, or not collected.

Prior to starting the installations, WaterSaver received a second grant from New York University to install two systems in an Alumni Dormitory on campus. It was agreed that any meter reading data from NYU (while not part of the 15 AQUUS[®] units in the ICP grant) could perhaps be included in the project data and that it should be forwarded when it was received.

All interested participants were asked to submit photographs of their bathroom (including toilet and vanity) prior to commencing installation. The following is one such photo.



Installation of AQUUS

Equipment installation, maintenance, and monitoring at the participant locations was accomplished by hiring plumbing companies operating in the vicinity of the installation locations. As a result, three plumbing companies were hired for Southern California, due to the large service area involved. One plumbing company was hired to provide assistance in Northern California because that company had participated in earlier installations of AQUUS® and was familiar with the system.

WaterSaver trained members of the three (3) plumbing companies in Southern California prior to installation. The anticipated 10 southern California locations were divided among these three companies³. The northern California installer required no further training.

The following photos show components of the AQUUS system and the associated flow meter.



The time period for installation, measurement, and evaluation was initially designed to last a minimum of 30 days after each system had been installed. Several systems remained in place significantly longer, which enhanced the reliability of collected data. During the data gathering period, it was determined that two installations were equipped with faulty flow meters, causing the AQUUS® system to perform improperly. Plumbers were dispatched to these locations, the meters were removed, and the systems began to operate properly.

³ Two of the Southern California plumbing companies were successful in all but one of their assigned locations installed (one location pulled out of program). The third plumbing company was unsuccessful in their efforts and the installations were instead handled by the first company.

Project Study Results

At the end of the data collection period, the contracted plumbers made appointments and visited each installation in order to collect the readings from the flow and electrical meters and to remove those meters. At approximately the same time, a Customer Satisfaction Survey was emailed to each participant with a request to complete the survey and return it to WaterSaver.

Water Use

As noted above, each installation was equipped with a totalizing meter to record the amount of water delivered to the AQUUS[®] unit, processed (treated), and pumped to the nearby toilet tank. The water, then, was an “offset” for what would otherwise be potable water filling that tank. As such, the total amount of water delivered from the AQUUS[®] was an accurate measure of the total reduction in potable water use.

Table 1 shows the meter measurements and the water use reductions achieved with the seven remaining installations providing valid water usage data. Those seven installations yielded water use reductions averaging approximately 1.3 gallons per system per day, about 474 gallons annually for a toilet fixture used on a daily basis by an average of 2.57 persons.

Water Meters

The project used an in-line flow meter placed downstream from the pump, between the pump and the toilet tank. The meter was advertised to operate properly at low water volumes and with intermittent flows. Prior to beginning the installations, one meter was purchased and tested for accuracy and met the criteria. However, during the 30 days test period, two of the AQUUS[®] installations encountered significant meter problems. In one case, the system encountered problems because the impeller in the flow meter was jamming and severely restricted the water flow from the AQUUS[®] holding tank to the toilet tank. In the second case, a unit installed at New York University was found to have the same problem. Plumbers were dispatched to these two locations, where they removed the meters⁴, and, as a result, the systems began to function properly.

Flow meter readings generally ranged from 20 to 200 gallons over periods of about 30 to 90 days. Readings from three installations were discarded due to suspect data or independent actions by the participant that were deemed to be non-representative of a typical household⁵. Additionally, some meter readings may have been lower due to the AQUUS[®] being installed in a children's or a secondary bath. Furthermore, it should also be noted that all flow meter readings could be considered suspect and the data could be underreported due to the previously described experience with impellers inside the meters not turning properly⁶.

⁴ In the first instance, the water use data (savings) was suspected to be underreported, although it was used in the project analysis. In the second case, the data from New York University was discarded and not used in the analysis due to significant uncertainty as to its accuracy.

⁵ One participant admitted to collecting graywater from their shower in a bucket and then dumping that water into the lavatory sink to be treated by the AQUUS system. This clearly increased the throughput of the AQUUS[®] system beyond what would normally be expected in the typical household.

⁶ A new, more suitable meter will be selected for any future pilot programs.

Table 1. Flow Meter Readings and Water Savings

Name	Meter install date	Day no.	Meter remove date	Day no.	Days of Install	Meter Read (gallons)	No. persons using toilet	Avg. daily water usage (savings) per toilet (gal)	Avg daily water usage (savings) per person (gal)	Electricity consumption in kwh
TS	4/7/09	97	5/6/09	126	29	60	4	2.07	0.5172	11.71
BC	4/17/19	107	6/9/09	160	53	100	2	1.89	0.9434	12.2
ES	4/22/09	112	6/11/09	162	50	200	4	4.00	1.0000	12.47
JC	4/9/09	99	7/1/09	182	83	40	2	0.48	0.2410	6.2
MB	4/6/09	96	7/2/09	183	87	20	2	0.23	0.1149	1.17
AW	4/8/09	98	7/8/09	189	91	40	2	0.44	0.2198	
JS	5/6/09	126	7/15/09	196	70	140	2	2.00	1.0000	
Total or average					463	600	2.57	1.296	0.5766	

The figures below display the Kill-A-Watt meter and the flow meter used in the project.



Customer Satisfaction Survey

Appendix A displays an example of a completed Customer Satisfaction Survey.

The Customer Satisfaction Survey requested feedback on a number of important topics, including the appearance of the water, use of space within the vanity housing the AQUUS®

system, and overall satisfaction with performance. The following is a synopsis and discussion of each topic.

Water Appearance - The survey requested feedback on the appearance and acceptability of the treated water in the toilet bowl. All of the installations stated that the appearance of the water in the toilet bowl was acceptable (100 percent indicating “Very Clean” or “Fairly Clean”).

Odors - Respondents were asked to provide feedback on whether they noticed any odors from the AQUUS® system. Eighty percent of the installations stated that there was no noticeable odor. Two installations indicated that they experienced a slight chlorine odor at times.

Pump Noise - The AQUUS® uses a small 12-volt DC pump to deliver the treated water from the holding tank to the toilet tank. Survey respondents were asked whether they had any issues with pump noise. Sixty percent of the installations stated that the pump sound was “somewhat noticeable”, while the remaining 40 percent stated “not noticeable”.

Use of Vanity Space - The AQUUS® holding tank, located within the bathroom vanity, holds 5.5 gallons of water and can take up a significant amount of space, displacing space normally used by the homeowner for storing bathroom cleaning supplies, towels, etc. The survey asked whether this use of the vanity space was “acceptable”. Seventy-five (75) percent of the participants indicated that the use of the vanity space by the tank was “Acceptable” or “Very Acceptable”.

AQUS® Function - All but one of the respondents stated that they had “few” or “no problems” with the system. The one exception was a participant whose pump and switch mechanism had intermittent failures and had to be readjusted twice. The issue was determined to be physical limitations attributable to the style and design of the toilet tank.

Save Water and Overall Satisfaction - Almost 70 percent of the respondents believed that they saved water using the AQUUS® and over 90 percent stated that they were “somewhat satisfied” or “very satisfied” with the system.

Recommend to Others - The respondents were asked whether they would recommend the AQUUS to others. All but one of the respondents stated that “yes”, “definitely yes”, or “perhaps” they would recommend the AQUUS®.

Installation Plumber Survey

WaterSaver also solicited comments from the plumber-installers, including the amount of time required to install each component of the system and any comments that might help to improve the installation process.

Vanity Tank - The installation of the AQUUS® tank within the vanity was generally straightforward and required approximately one hour to remove existing plumbing drain lines and connect the AQUUS®. However, in two instances where the vanity cabinet floor was too high for system, a hole had to be cut to recess the tank below the kick plate. This dramatically increased the installation time.

Toilet Tank - The installation process requires that the toilet tank be disassembled from the bowl⁷. As such, the installation of AQUUS[®] components was the most time-consuming part of the process. Rusty tank bolts and adjusting the AQUUS[®] to work within the specific toilet⁸ required 2-3 hours to accomplish⁹.

Other Important Milestones

Additional pilot projects - WaterSaver, along with Sloan Valve Co., have planned several additional pilot projects beginning in 2010. Many of these projects will include more reliable flow meters and more comprehensive customer satisfaction surveys, the data from which will be incorporated in addenda to this report. The additional data and customer and installer feedback will aid product development.

Uniform Plumbing Code (UPC) and Product Listing - At the time that the ICP grant application was submitted, the AQUUS[®] had received a Classified Product Listing from IAPMO¹⁰. During the time this project was being conducted, IAPMO issued a full Product Listing for the AQUUS[®]. That Certificate of Listing is included as Appendix B.

New AQUUS Design - WaterSaver Technologies, LLC formed a strategic partnership with Sloan Valve Company¹¹ to sell and distribute the Sloan AQUUS[®] throughout the United States. A part of that agreement was to examine the existing AQUUS[®] for product improvements (e.g., broadening the compatibility of AQUUS[®] to more toilet models), reducing installation time, and reducing product costs.

The following is a comparison between the current AQUUS[®] and the new AQUUS[®] proposed for 2010.

Current System

- Toilet Tank Requirements
 - Fluidmaster type fill valve
 - Two-piece, gravity-fed toilet
 - Minimum 16" toilet tank width
- Installation
 - Requires toilet tank components (fill valve and FCU) to work together, which requires fine tuned adjustments and lengthy installation times.
 - Requires removal of toilet tank bolts
- Institutional appearance

⁷ Only two-piece gravity-fed toilet fixtures may currently be fitted with AQUUS[®] components. A listing of the toilet fixture models compatible with the current AQUUS[®] design may be found at this website: http://www.sloanvalve.com/index_AQUS_Greywater_System_ENU_HTML.htm

⁸ The physical dimensions and configurations of toilet tanks differ significantly from model to model. Therefore, physical compatibility of AQUUS[®] components with specific toilet tank designs can become an issue for installers.

⁹ This time will be dramatically reduced when the next generation of the AQUUS[®] design is introduced in 2010.

¹⁰ International Association of Plumbing and Mechanical Officials, an accredited product certifying body.

¹¹ <http://www.sloanvalve.com/> and http://www.sloanvalve.com/index_AQUS_Greywater_System_ENU_HTML.htm

2010 Design AQUUS®

- Application to more toilet models
 - Dual Flush
 - Side fill toilets (European style)
 - Multiple fill valve designs
 - Fill valves used in side fill toilets
 - Pilot type fill valve
 - Ballcock type fill valve
 - One-piece Toilets
 - No tank size limitation
- Easier Installation
 - No bolts to replace
 - No disassembly and draining of the toilet
 - No FCU to install in Toilet tank
 - Reduced installation time by approximately 50 percent
- AQUUS® appearance and customer acceptability
 - Color
 - Square Shape 15" Square – smoother edges
 - Tank holds same volume of water

AQUS Customer Satisfaction Survey

Thank you for participating in the AQUS[®] Greywater Pilot Project funded by the Metropolitan Water District. The goal of this project is to demonstrate that the AQUS[®] is a viable product and can be included in their list of products that conserve water. We would like you to complete the survey below to help us better understand customer reaction to the AQUS.

Installation Date: April 1, 2009

Installation Location & Name:



Please circle the type of bathroom in which the device was installed:

Hall Bath

How many people typically use this bathroom?

2

How many times per day do you think this toilet is flushed?

6

The water in the bowl appears:

1

2

3

4

5

Fairly Clean

Comments:

Odor from the water in the toilet bowl is:

1

2

3

Somewhat noticeable

Comments:

The sound from the AQUS[®] water pump is:

1

2

3

Not noticeable

Comments:

The AQUS[®] Tank was installed in the bathroom vanity cabinet. The use of this space is:

1

2

3

4

Acceptable

Comments:

The AQUS[®] has functioned with:

1

2

3

No Problems

If you experienced problems with the function, please list the issues in the space below:

Do you think you saved water by using the AQUS[®] in your home?

1

2

3

4

Yes

Comments: Yes, probably. We know that the system is working and with the toilet using 3- 4 gallons to flush, we are saving up to 24 gallons per day.

Overall satisfaction with the AQUS[®]

1

2

3

3

Very Satisfied

Comments:

I would recommend the AQUS[®] to others

1

2

3

Definitely Yes

CERTIFICATE OF PRODUCT LISTING BY IAPMO

IAPMO RESEARCH AND TESTING, INC.

5001 East Philadelphia Street, Ontario, California 91761-2816 • (909) 472-4100 Fax (909) 472-4244 • www.iapmo.org



CERTIFICATE OF LISTING

IAPMO Research and Testing, Inc. is a product certification body which tests and inspects samples taken from the supplier's stock or from the market or a combination of both to verify compliance to the requirements of applicable codes and standards. This activity is coupled with periodic surveillance of the supplier's factory and warehouses as well as the assessment of the supplier's Quality Assurance System. This listing is subject to the conditions set forth in the characteristics below and is not to be construed as any recommendation, assurance or guarantee by IAPMO Research and Testing, Inc. of the product acceptance by Authorities Having Jurisdiction.

Effective Date: April 2008 -Rev. 3/24/2009- Void After: April 2009

Product: Reclaimed Water Conservation System for Flushing Toilets File No. 5129

Issued To: Water Saver Technologies LLC
120 Webster Street #322
Louisville, KY 40206

IDENTIFICATION: Product should be permanently marked with the manufacturer's name or trademark and nominal size, and "CAUTION: RECLAIMED WATER, DO NOT DRINK" with a purple background and black uppercase lettering. Product shall also bear the UPC® certification mark.

CHARACTERISTICS: Graywater Conservation System for Flushing Toilet to be installed in accordance with the manufacturer's instructions, and the latest edition of the Uniform Plumbing Code.

Products comply with the applicable sections of the latest edition of the Uniform Plumbing Code®. Manufactured in compliance with IGC 207-2006b.

Products listed on this certificate have been tested by an IAPMO R&T recognized laboratory. This recognition has been granted based upon the laboratory's compliance to the applicable requirements of ISO/IEC 17025.

MODELS:

Robert R. Simeon
Chairman, Product Certification Committee

Russ Chaney
Executive Director



This listing is for the period indicated herein and is void after the date shown above. Any change in material, manufacturing process, marking or design without having first obtained the approval of the Product Certification Committee, or any evidence of non-compliance with applicable codes and standards or of inferior workmanship, may be deemed sufficient cause for revocation of this listing. Reproduction of or reference to this form for advertising purposes may be made only by specific written permission of IAPMO Research and Testing, Inc. Any alteration of this certificate could be grounds for revocation of the listing.

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