

## VARIABLE-VOLUME FLUSHING (V-VF) DEVICE FOR WATER CONSERVATION IN TOILETS

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### ABSTRACT

Thirty five percent of residential indoor water used is flushed down the toilet. Five out of six flushes are for liquid waste only, which requires only a fraction of the water needed for solid waste. Designers of current low-flush toilets (3.5-gal. flush) and ultra-low-flush toilets (1.5-gal. flush) did not consider the vastly reduced amount of water needed to flush liquid waste versus solid waste. Consequently, these toilets are less practical than desired and can be improved upon for water conservation. This paper describes a variable-volume flushing (V-VF) device that is more reliable than the currently used flushing devices (it will not leak), is simple, more economical, and more water conserving (allowing one to choose the amount of water to use for flushing solid and liquid waste).

### INTRODUCTION

"Water is our most precious natural resource, but it is often taken for granted. We enjoy it, we waste it, we pollute it, assuming our need for water will be met in the future, as it has in the past, by merely turning on the faucet. Indeed it seems no thought is given to how water reaches the faucet and to whether or not the water will always be available when we want it. It's just there whenever and wherever we need it." The preceding quotation is from the *Water Conservation Book of the American Water Works Association* (AWWA) [1]. It sets the theme of this paper, which is water conservation by use of a more water-efficient toilet flushing device. Water shortages of varying degrees, due to droughts and/or inadequate development of water supplies, have occurred in almost all areas of the country. Moreover, it has been estimated that by the year 2000 more than 20 percent of the country will occasionally have serious water shortages [1]. It is obvious that increasing water-use efficiency is now mandatory in the United States because of population and industrial growth, along with increased demand for agricultural irrigation. The benefits of water-use efficiency are many, including energy savings, protection of the environment, wastewater flow reduction, and reduced cost.

This paper addresses residential indoor water use, and water conservation in the bathroom, specifically related to toilets. Decreasing toilet wastewater flow saves energy, protects the environment, and saves money. Inside the home, most water is used in bathrooms. Figure 1 shows the average inside water use for nonconserving homes [1]. Toilets use 28 percent of the water inside the home, or 22 gallons per capita per day. Toilets and toilet leakage account for over one-third of the inside water use for nonconserving homes. The V-VF device could significantly reduce the percentage of toilet water use.

The United States Environmental Protection Agency has a fact sheet entitled "21 Water Conservation Measures For Everybody." Three of the twenty-one conservation measures described in this fact sheet are related to the toilet. Conservation facts 10, 11, and 12 are as follows [2]:

- (10) Repair leaky toilets to save more than 50 gallons of water per day. Add 12 drops of food coloring into the tank. If the color appears in the bowl one hour later, the unit is leaking.
- (11) Install a toilet displacement device to save thousands of gallons of water per year, or 5 to 7 gallons per flush. Place 1 to 3 weighted plastic jugs into the tank, making sure the jugs don't interfere with the flushing mechanism or a suitable flow. Or instead of jugs, use toilet dams that hold back a reservoir of water during each flush, saving 1 to 2 gallons. Don't use bricks because they can chip and foul the flushing mechanism.
- (12) When buying a new toilet, select a low-flush model that uses less than 1.5 gallons of water to flush, saving over 7,000 gallons per year per person.

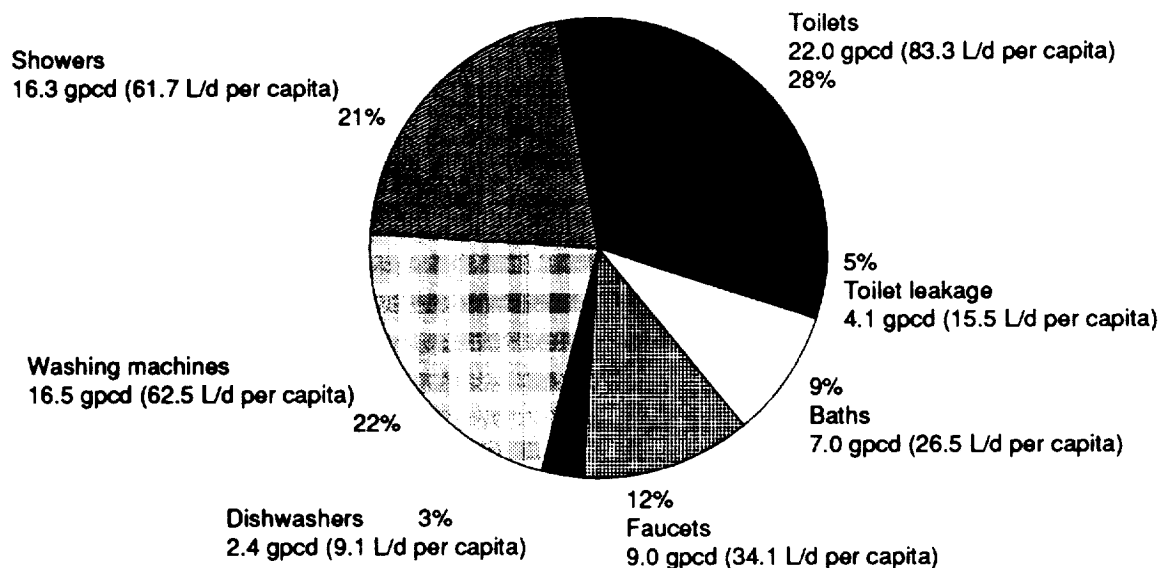


Figure 1. Average inside water use for nonconserving home.

I am in complete agreement with conservation fact 10. I am also in partial agreement with conservation facts 11 and 12. A toilet displacement device and a low-flush toilet can save thousands of gallons of water per year. However, this paper describes a V-VF device which I believe is a better approach to the toilet wastewater problem. It will conserve thousands of gallons more water per year per household than the low-flush toilets, ultra-low-flush toilets, and water displacement devices. The main reason for this belief is that the V-VF device allows the user to control the amount of water expelled from the toilet tank. Five out of six toilet flushes are for liquid waste, which needs only a fraction of the water volume per flush as compared to the amount of water required to flush solid waste. Table 1 shows 7-, 5-, 3.5-, and 1.5-gallon flush toilets compared with a 5-gallon flush toilet that has installed a V-VF device. The V-VF device is described in the next section of this paper. The comparison is made with six toilet flushes, five of which are for liquid waste and one which is for solid waste. It is assumed in this comparison that the user of the V-VF device uses 5 gallons of water to flush solid waste and 0.5 gallon to flush liquid waste. The above-mentioned numbers are based on the full tank capacity being used for flushing solid waste and a minimal amount of water used to replace the amount of water in the toilet bowl for liquid waste.

The data in table 1 show that the low-flush, ultra-low-flush, and V-VF toilets are far more water conservative than the conventional flush toilets, with the V-VF toilet the most water conservative. Several additional benefits can be realized by using the V-VF device in the toilet tank. Low-flush toilets are defined as toilets that use no more than 3.5 gallons per flush and meet performance standard A112.19.2M-1982 of the American National Standard Institute (ANSI). When low-flush toilets were first sold, reports indicated a need for double flushing; however, some claim this problem has now been solved. Experience indicates that frequent double flushing is still required for flushing solid waste with a low-flush toilet. This creates water waste. Ultra-low-flush toilets (1.5 gal. per flush) also have several less than desirable features. They use a supply of compressed air to assist the flushing action. Residential models cost about 50 dollars more per toilet than low-flush models. Concerns still exist for double flushing and

Table 1. Comparison of conventional, low-, and ultra-low-flush toilets with a V-VF device installed in a 5-gallon conventional toilet

Group toilets	Water used for 6 flushes (gal.)	% water savings normalized to 7-gal. tank
Conventional, 7-gal.	42	
Conventional, 5-gal.	30	29
Low-flush, 3.5-gal.	21	50
Ultra-low-flush, 1.5 gal.	9	79
Conventional 5-gal. with V-VF device	7.5	82

sewer-lateral clogging. The Housing and Urban Development (HUD) conducted a water conservation study [3] in which it surveyed leaking toilets. Of 188 toilets tested, 20% leaked. Low-flush toilets leaked considerably more than older conventional toilets. From an extremely small sample size, 60 percent of the low-flush toilets were found to leak. Although the small sample size reduces the accuracy of the statistics, it is my opinion that a significant number of low-flush toilets may still have this problem, especially as they age. Water savings that may be realized by repairing leaking toilets are significant and may average 24 gallons per day per toilet [1]. When the low-flush toilets are made more reliable (less leakage and no double flushing), then the V-VF device can be installed in these toilets to realize additional wastewater savings.

From the facts and statistics given above, one can understand that for water conservation it is important to have a toilet-flushing device that is reliable (will not leak), simple, efficient, and economical. The author offers the V-VF device as an option for reducing the water required to flush toilets.

### DESCRIPTION OF THE V-VF DEVICE (PATENT PENDING)

There are three main objectives of the V-VF device:

- to allow the user of a toilet to control the amount of water expelled from the toilet flush tank according to the type of waste to be flushed.
- to achieve water conservation with a mechanism that is simpler than that used in conventional toilets or in other water conservative devices intended for use in conventional toilets.
- to provide a flushing mechanism that is more reliable (does not leak) and less expensive to manufacture than conventional flushing mechanisms.

These objectives are met by replacing the overflow tube and the flapper outlet valve assembly of the conventional toilet with a low-density polyethylene bellowed tube that is compressible to any chosen amount in order to allow water to flow through the tube into the bowl, thereby flushing the toilet. By the elastic resilience of low-density polyethylene, the compressed bellowed tube becomes restored to its original height after flushing and when pressure on the tube is discontinued.

Two versions of the V-VF device are described. One version (fig. 2) uses a handle protruding through the tank cover for compressing the bellowed tube in a plunger-like motion. Although this version of the device is simpler, a hole is required in the tank cover for installation. For this reason, it may be the least attractive of the two. The second version of the V-VF device (fig. 3), uses a handle on the front or side wall of the tank to cause rotation of a shaft which extends into the tank. By means of a cantilever beam, a vertical rod depresses the bellowed tube for flushing. This version may be sold as a replacement kit and, therefore, may be more readily introduced to the public in a cost-effective manner.

Figure 2 is a view of the V-VF device employing a flush handle that rests on top of the toilet tank cover. It shows a conventional design of a toilet flush tank. Note that the water inlet mechanisms and water level controls are not shown. The collapsible bellowed tube, which is made of a low-density polyethylene-type material in the form of a bellows, provides complete elastic recovery when an applied stress is released. One end of the tube opens into the water outlet. It is affixed to the bottom of the tank to form a water-tight seal. When the handle is pressed downward, the bellowed tube is compressed to a point below the water level in the tank. A controllable amount of water enters the bellowed tube, flows through the water outlet, and thereby flushes the toilet. The handle lies flat on the tank cover when not in use. The pivot joint on the handle allows the handle to be rotated into a vertical position for flushing. The handle is provided with markings to indicate the volume of water flushed. After flushing, the handle is released, the collapsible bellowed tube returns to its original uncompressed state, and water enters the tank up to the level controlled by the water inlet mechanisms (not shown in fig. 2) but no higher than the top of the bellowed tube. Therefore, the bellowed tube also is an overflow tube which prevents excess water from entering the tank in case the water inlet mechanisms fail. The cap on top of the bellowed tube has openings to allow water to flow into the tube. The sleeve, with slits surrounding the bellowed tube, forms a cavity which allows water to enter into the cavity through the slits so that water surrounds the bellowed tube for flushing. The sleeve also prevents transverse motion of the bellowed tube when it is compressed. This simple design minimizes friction between the bellowed tube and

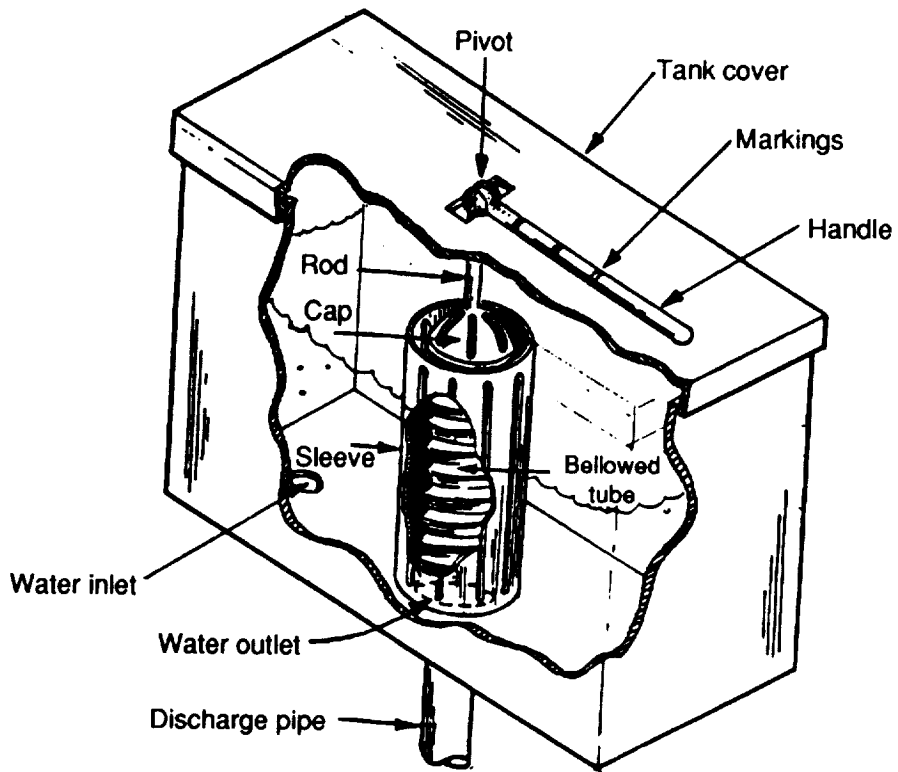


Figure 2. V-VF device inside tank having handle on top of tank cover.

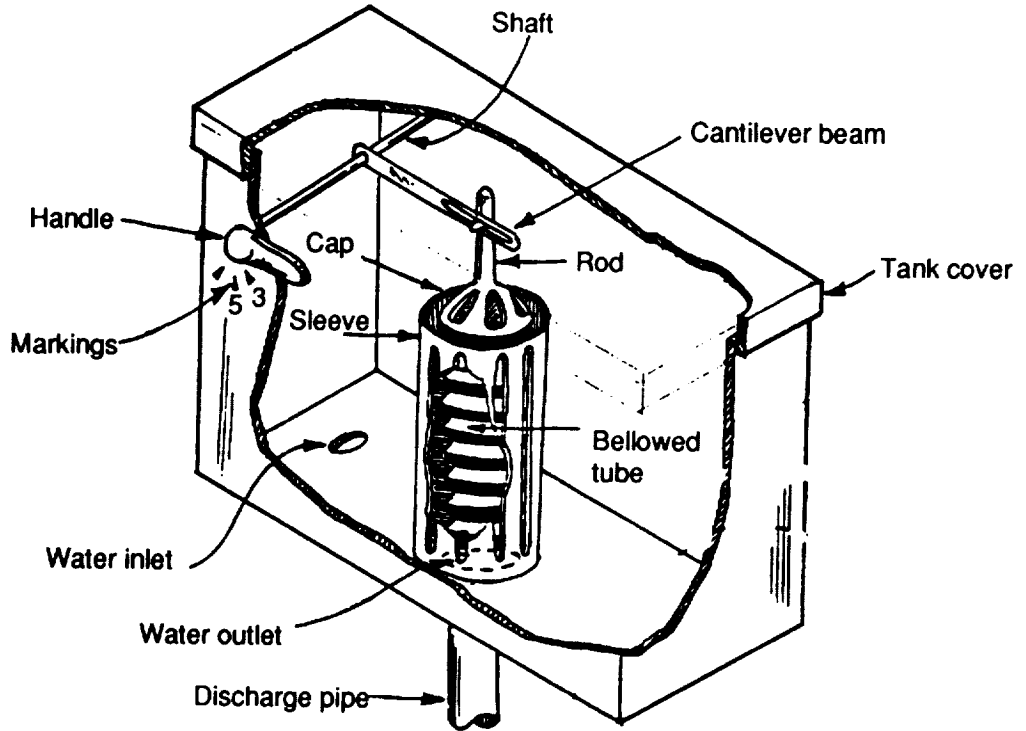


Figure 3. V-VF device inside tank having handle on front wall of tank.

sleeve so that the tube has complete elastic recovery when the applied stress is removed from the tube. Also, minimal components are used in the design to produce a highly reliable, low-cost flushing mechanism.

The second version of the V-VF device is shown in fig. 3. The flushing mechanism is actuated by the lever (on the front wall of the tank) and its attached shaft. The lever is rotated clockwise a chosen number of degrees to cause the cantilever beam to rotate in a similar fashion (move in an arc) and in turn causes the rod attached to the bellowed tube to move downward a given amount. Note that the arc-like motion created by rotation of the lever is converted into a vertical displacement of the bellowed tube. The user controls the volume of water flushed simply by rotating the handle a given amount. The rotation amount is shown by markings arranged in a circular pattern around the lever to indicate the volume of water flushed for a given rotation of the lever.

### CONCLUSIONS

Two versions of the V-VF device were described: one version uses a handle that lies on the tank cover and another uses a handle on the front wall of the tank. Because it can be sold as a replacement kit for most conventional toilets, the latter version of the V-VF device is the most attractive for introduction to the public.

It was shown that the V-VF device has a minimal number of parts, serves both as overflow and flushing tube, and is designed and constructed to be low-cost, reliable, and readily adaptable to conventional and low-flush toilets. The V-VF device is more reliable than the conventional chain-flapper valve because it does not require a seal-tight contact between a movable flapper valve and the water outlet opening in the tank bottom. Also, most importantly, the V-VF device allows efficient control of toilet wastewater by enabling the user to choose the amounts of water for flushing both liquid and solid waste. Unlike the low- and ultra-low-flush toilets, double flushing is eliminated, and a more sanitary flush is accomplished with a reduced possibility of sewer-lateral clogging. Presently, it may be more advantageous to use the V-VF device in conventional 5-gallon-capacity toilets instead of low-flush models because of the double flushing, leakage, and sewer-lateral clogging problems that might exist with these models. As an example, if double flushing of the 3.5-gallon-capacity toilet is required 50 percent of the time for flushing solid waste, then in actuality the 3.5-gallon tank becomes a 5.25-gallon tank when flushing solid waste.

The variable water flushing feature, the elimination of double flushing, and reduced water leakage can save thousands of gallons of water per household per year. The average residence uses 107,000 gallons of water during a year, and an individual uses, on the average, about 123 gallons daily. One inch of rain on an acre of land generates 27,000 gallons of water. This means that 4 inches of rainfall is required per acre to satisfy the average yearly residential water requirement. The quotation from the AWWA book that was given in the introduction of this paper should be taken very seriously, with the aim of achieving efficient water use and wastewater flow reduction. The V-VF device accomplishes both aims.

### REFERENCES

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