The Impacts of High-Efficiency Toilets on Plumbing Drainlines and Sewers

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This article addresses key questions and concerns–as well as misperceptions–about the impacts of reduced water use and wastewater flows from water-saving measures, particularly high-efficiency maximum 1.28 gallons per flush (gpf) toilets, on plumbing sanitary drainlines in buildings and municipal sewer systems. Specifically, does installation of high-efficiency toilets ("HET") lead to insufficient wastewater flows to move solid waste down building drainlines and sewers, resulting in clogs and stoppages?

Introduction

America's finite water supplies are increasingly challenged to meet the needs of a growing population. In an increasingly water-short world, installation of high-efficiency toilets, urinals, showerheads, faucets, clothes washers, dishwashers, and other water-saving measures are not an option–they are a necessity.

Water-efficient plumbing fixtures are now saving Americans over 6 billion gallons of water daily–enough water to fill 200 million bathtubs every night–since the nation's first water efficiency standards for fixtures were adopted under the U.S. Energy Policy Act of 1992. Water-saving technologies like high-efficiency toilets offer the most energy-efficient, environmentally sustainable, and affordable strategies to ensure we have enough water to meet the needs of our homes, schools, businesses, and farms in the future.

Today's average maximum 1.28 gpf high-efficiency toilets that carry the EPA's WaterSense® label are independently tested, have superior hydraulic designs, flush better, and use less than half of the water required by most toilets previously installed. Millions of American homes and many commercial businesses have installed HETs since WaterSense launched its labeling program for HETs in 2007. Since that time, sales of 1.28 gpf HET fixtures, particularly for homes, have begun to outpace those for 1.6 gpf low-volume fixtures, the maximum flush volume set forth in the 1992 federal standards.

High-Efficiency Toilets Have *Not* Been Shown to Cause Drainline and Sewer Stoppages

Reduced water demands from conservation measures do reduce wastewater flows, but thus far there are no verified instances of high-efficiency toilets causing building drainlines or municipal sewer systems to experience blockages. Despite some anecdotal reports of solid

waste stoppages associated with water-efficient toilets–typically cited in the blogosphere and by radio talk show hosts whose ratings depend on bathroom humor–in actual fact, U.S. municipal water and sewer system managers and plumbing engineers have *not* been able to verify from credible sources that such problems are occurring. U.S. water and wastewater utility and plumbing industry research has consistently reported that low-volume (1.6 gpf) and high-efficiency (1.28 gpf) toilets are *not* causing nor are they leading to an increase in drainline clogs or sewer system blockages. For example, a 2005 study of the capacity of building drainlines to flush 1.28 gpf toilets that was sponsored by several Canadian federal agencies and water and wastewater utilities determined that some toilets flushing at even only one gallon provide sufficient water volume to move wastes down drainlines. Further, EPA's WaterSense Program, which sets high standards for the performance of high-efficiency toilets and other fixtures, reports:

> "With regard to municipal sewer lines, the transport of waste has not proven to be an issue of concern in those areas with a concentration of high-efficiency toilets. Supplementary wastewater flows from other end-uses are always sufficient to move solids through the system. Furthermore, some wastewater utilities are co-funding and sponsoring the toilet replacement programs and other water efficiency initiatives of the water utilities for the very purpose of reducing sewer flows to their treatment plants."

Challenges Ahead: 21st Century Wastewater Flows in 20th Century Drainlines and Sewers

While HET and low-volume toilets have not been found to adversely affect solid waste transport in building drainlines and sewers in the United States, research in Australia and Europe indicate that in the future, the *combination* of significantly reduced wastewater flows from a wide array of high-efficiency fixtures, appliances, and equipment might result in drainline transport problems in some types of U.S. building drainlines, though less likely in sewers. The basis for this concern stems in part from research conducted in Australia since the recent major drought there that resulted in drastically reduced wastewater flows due to large-scale and in some cases severe water use restrictions. For example, some types of building drainage configurations, such as an isolated commercial restroom with very low-volume high-efficiency toilets, urinals and faucets located at the far end of a building, in some cases may not always have sufficient liquid flows to transport solid waste at a normal rate. Based on laboratory studies of such building conditions–but not yet borne out by actual experience in the United States–there is a theoretical potential for a drainline clog. This potential problem is unlikely to occur in the drainlines of single-family homes due to the presence of long duration flows from other fixtures and appliances, such as showerheads and clothes washers.

Sewer system stoppages are believed to be unlikely to occur as the result of reduced wastewater flows associated with high-efficiency fixtures and other devices, for several reasons. First, all sewer systems experience isolated stoppages and malfunctions from time-to-time, typically due to broken sewer lines, sewer design flaws, or antiquated combined sewer systems. Such conditions occurred in sewers before the introduction of water-saving devices, and they will likely continue to be inevitable features of sewer systems in the future. Second, many sewer systems experience the problem of excessive inflow and infiltration ("I&I")–too

much water in the wastewater stream. Water efficiency measures can provide beneficial flow reductions for sewers with high I&I. Third, combined sewer systems, still in use in many American cities and towns, often cause combined sewer overflows (CSO) due to excessive stormwater inflows (again, too much wastewater). Less commonly, combined sewers can also experience stoppages during periods of dry weather and other adverse conditions–but not the result of water conservation.

To be clear, plumbing research engineers and related professionals do *not* attribute water-efficient toilets alone to be the source of potential future waste transport problems in building drainlines and sewers. Problematic plumbing designs, isolated horizontal drainlines, and significantly reduced flows from multiple other fixtures and appliances would likely also have to be present for stoppages to occur. Thus, plumbing engineer researchers are mindful of the theoretical potential for such conditions and are now working to address future problems if they do occur.

In sum, the challenge ahead is how can our existing building drainlines and sewers, which were built using early 20th century design criteria for high-volume fixtures and less concentrated wastewater flows, be adapted to operate satisfactorily under the expected significantly reduced flows associated with emerging high- and ultra- high-efficiency water-efficient appliances, fixtures, and equipment of the 21st century? Building sanitary drainlines and sewers operate as part of a system that includes all varieties of water-using activities and devices. As the water inflow component of that system changes due to advances in water efficiency, drainlines and possibly sewers may one day also be affected.

To keep this future plumbing challenge in perspective, it is useful to realize that in many ways it is not unusual. Major technological advances, such as those that will continue to be achieved in water efficiency, nearly always have some unintended consequences for which solutions are subsequently developed.

Next Steps

Research is planned to better understand solid waste transport dynamics and improvements in building drainlines served by many types of high-efficiency water-using fixtures and appliances that might lead to drainline problems in the future. This work is being led by the Plumbing Efficiency Research Coalition (PERC),[1] a group of U.S.-based organizations that support water efficiency and sustainable plumbing, in collaboration with the Australia-based Australasian Scientific Review of Reduction of Flows on Plumbing and Drainage Systems (ASFlow) Committee.

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[1] PERC members include the Alliance for Water Efficiency (AWE), International Association of Plumbing & Mechanical Officials (IAPMO), International Code Council (ICC), Plumbing-Heating-Cooling Contractors National Association (PHCC), Plumbing Manufacturers International (PMI), and the American Society of Plumbing Engineers (ASPE).

Preliminary potential remediation steps for solid waste transport problems in building drainlines with very reduced flows–though not yet tested nor recommended–to be investigated by researchers include:

- Develop a better understanding of how sanitary drainline system components and variables, such as pipe slope, flow volume, and flow rate from plumbing fixtures and appliances affect solid waste transport down drainlines and into sewers;

- In existing buildings, determine the minimum wastewater flow requirements for solid waste transport in the building's drainline prior to the installation of new high-efficiency appliances, fixtures, and other-water using equipment. For example, commercial buildings with isolated high-efficiency toilets that provide most of the wastewater carrying solid wastes down isolated long horizontal drainline runs to the sewer may be potential trouble spots that will require adjustments to the plumbing system;

- Rectify problematic building drainline flows by targeted adjustments to flows and composition, possibly including:

    - Installation of one or more higher volume fixtures at the beginning of an isolated drainline (farthest from the sewer) to provide additional flows to help move solid wastes down the drainline;

    - Installation of a timer on the automatic flush valve for one or more high-efficiency toilets and/or urinals installed at the farthest end of the isolated horizontal run. These timed, extra flushes will provide periodic surges of water to facilitate solids transport down the drainline and to the sewer; and/or

    - Changing the type of toilet paper provided in restrooms. Toilet paper products vary considerably in their composition and rate of disintegration in wastewater, which in some cases affects solid waste transport.

- For new buildings, project carefully water and wastewater flow requirements when water-efficient equipment, appliances, and fixtures will be installed. Be sure to use updated flow specifications–not necessarily standard design criteria that may be outdated–when specifying pipe sizes, as approved by the code or other authority having jurisdiction.

- Develop new design criteria and sizing requirements for water and sanitary drainline pipes in buildings with multiple sources of reduced flows.

If your organization is interested in participating in the Plumbing Efficiency Research Coalition's (PERC) planned research on drainline transport in buildings, additional project partners are welcome! Please contact the Alliance for Water Efficiency for more information: http://www.allianceforwaterefficiency.org/contact-us.aspx

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