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REGULATORY RESOURCES

Effects of Water Conservation on Plumbing Systems

Sustainability and conservation have become part of the conscience of the North American population. Legislation and other initiatives to save energy and conserve water are necessary due to limited resources and increased consumption across the globe. The plumbing industry's attention has primarily focused on water conservation, especially in the light of recent droughts in the southwestern U.S., specifically in California.

Water conservation most notably began with the Energy Policy Act (EPAct) of 1992 that federally regulated maximum flow rates for plumbing fittings and fixtures. Further reductions in flow rates have resulted from changes in product standards, the U.S. EPA WaterSense program and state initiatives, such as those implemented by the California Energy Commission (CEC). There has been a great success as a result of all these efforts, with substantial reductions in water use (see the table below). Since the creation of the WaterSense program in 2006, the EPA published that the total water savings in the U.S. totals 1.1 trillion gallons.

Historic Maximum Allowable Water Usage

Fitting/Fixture	Pre-1992	EPAct 1992	WaterSense Post-2006	CEC Post-2016
Water closet (in gallons per flush)	5 or greater	1.6	1.28	1.28
Urinals (in gallons per flush)	3 or greater	1.0	0.5	0.125
Kitchen faucet (in gallons per minute)	3.5	2.2	N/A	1.8
Residential lavatory faucet (in gallons per minute)	3.5	2.2	1.5	1.2
Showerheads (in gallons per minute)	3.5	2.5	2.0	1.8

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While water conservation efforts have been very successful and the intentions of water conservation are good, there is a concern in the industry that not understanding the intricacies of the overall system and how individual plumbing products contribute to the function of the infrastructure may result in some unforeseen consequences.

U.S. EPA WaterSense

The U.S. EPA's voluntary WaterSense certification scheme seeks to protect the future of the U.S. water supply by offering people a simple way to use less water. WaterSense covers lavatory faucets, toilets, pre-rinse spray valves, irrigation controllers, urinals and showerheads.

Examples of maximum flow rates and flush volumes for WaterSense certified products are:

> Toilets need to comply with ASME A112.19.2/CSA B45.1 and the effective flush volume must not exceed 1.28 gallons.

> Lavatory faucets and lavatory faucet accessories must conform to applicable requirements in ASME A112.18.1/CSA B125.1 and NSF/ANSI 61, Section 9. The flow rate of the lavatory faucet or the lavatory faucet accessory must not exceed 1.5 gallons per minute (gpm) at a pressure of 60 pounds per square inch (psi) at the inlet, when water is flowing; and the minimum flow rate must not be less than 0.8 gpm at a pressure of 20 psi at the inlet, when water is flowing.

> Ceramic, stainless steel and plastic urinal fixtures must conform to the applicable ASME/CSA standard (ASME A112.19.2/CSA B45.1; ASME A112.19.3/CSA B45.4; IAPMO Z124.9) requirements. The average maximum water consumption must not exceed 0.5 gallons per flush.

> Showerheads need to comply with ASME A112.18.1/CSA B125.1. The manufacturer must specify a maximum flow rate value (rated flow) of the showerhead equal to or less than 2 gpm tested at 80 psi. There are also spray force and spray coverage requirements.

NSF International is an EPA licensed certification body for providing WaterSense certification for plumbing products.

California Energy Commission

The California Energy Commission (CEC) has also established strict water conservation requirements that result in substantial fines. Examples of CEC maximum flow rates and flush volumes are:

> Toilets need to comply with ASME A112.19.2/CSA B45.1, and the effective flush volume must not exceed 1.28 gallons.

> The flow rate of the lavatory faucet or the lavatory faucet accessory must not exceed 1.2 gallons gpm at a pressure of 80 psi.

> Non-wall-mounted urinals must not exceed 0.5 gallons per flush.

> Wall-mounted urinals must not exceed 0.125 gallons per flush.

> Showerheads must be equal to or less than 2 gpm when tested at 80 psi. This is being reduced to 1.8 gpm in 2018.

NSF International is a recognized and approved testing laboratory by the CEC.

Disinfection and Water Conservation

The key to providing safe drinking water is the ability to effectively disinfect the water being supplied for drinking, cooking, bathing, etc. Water treatment chemicals such as chlorine and chloramines are added by water utilities at the water treatment plant, and for very large distribution systems they are also dosed in water storage and subsequent points. These disinfectants are dosed in very precise concentrations calculated to balance the effective disinfection with taste,

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odor and other health impacts. These chemicals are useful disinfectants but will dissipate over time, leading to lower concentrations the longer the water goes unused. If significantly reduced demand for water results from lower flow plumbing products, there is the possibility that chlorine may dissipate before it makes its way completely through the system. As a result, some parts of the distribution system may not be effectively disinfected. Simply increasing the concentration of disinfectant is not a solution because the concentrations may then be too high at other portions of the system.

Current research is aimed at understanding the relationship between lower flow velocities and the growth of microbes and biofilm on the internal surfaces of plumbing systems. Excessive biofilm can also accelerate the depletion of disinfection chemicals by reducing free chlorine in the water and are ideal places for the growth of bacteria. In addition to expending the disinfection chemicals, the biofilm shields the bacterium from any remaining disinfection chemicals and provides nutrients to promote bacterial growth.

Safety

Reduced flow also has the potential to compromise common safety features. Many products, typically for shower use, are designed to provide scald protection and that feature may not work well at lower flow rates. A mismatch in the flow rate of the showerhead and the flow rate of the mixing valve can result in safety features of these products not performing as intended, possibly causing burns or temperature control problems (notably, thermal shock).

Waste Removal

Unforeseen consequences are not limited to the supply side of the system. Water use and flow rates are also important for the proper functioning of waste and drainage systems. Standard methods for determining pipe sizes are based on flow rates and water use requirements from the early part of the last century, resulting in systems designed with pipes that are larger than actually needed to accommodate current flow rates and water demands. Pipe size affects how well the drain line carries the solid and liquid waste away. While newer water-efficient toilets are designed to evacuate the bowl with less water, proper drain line carry was likely not taken into consideration. The lower volume of water flowing through pipes can cause solids to accumulate in the system and cause blockages in building drain lines and public sewers resulting in inconvenience, backups, more frequent servicing and added maintenance cost.

Directions for the Future

Conserving water will continue to be an important factor in the design of plumbing systems and products for the foreseeable future. While there is limited data at this point, the plumbing industry is concerned about potential adverse effects of lower flow rates and volumes. Several research studies are currently underway and much more research is needed to evaluate the impacts of lower flows on health, safety and performance. Preliminary results from some studies are indicating that we may have reached the lowest flow possible without creating negative consequences or making more broad changes to the overall system to counteract the impacts of the lower flow rate. It is important to have an integrated approach which considers all the effects that can occur and knowing what potential tradeoffs may exist.

Article by Terry Burger, Senior Engineer, Plumbing.

Testing and Certification of PEX Plumbing Products

Crosslinked polyethylene (PEX) tubing has been one of the most commonly used materials for residential housing in the USA and Canada for over 20 years, and the use of PEX is increasing in residential and commercial construction across North America for plumbing, hydronic heating and other applications.

Claims have been made in the past that PEX tubing adds chemicals, which may be harmful to human health, to drinking water. However, those claims have ignored the fact that it is mandatory for PEX tubing to be tested and certified to NSF/ANSI 61, which is a standard that helps to ensure that the product will not contribute harmful levels of contaminants to drinking water.

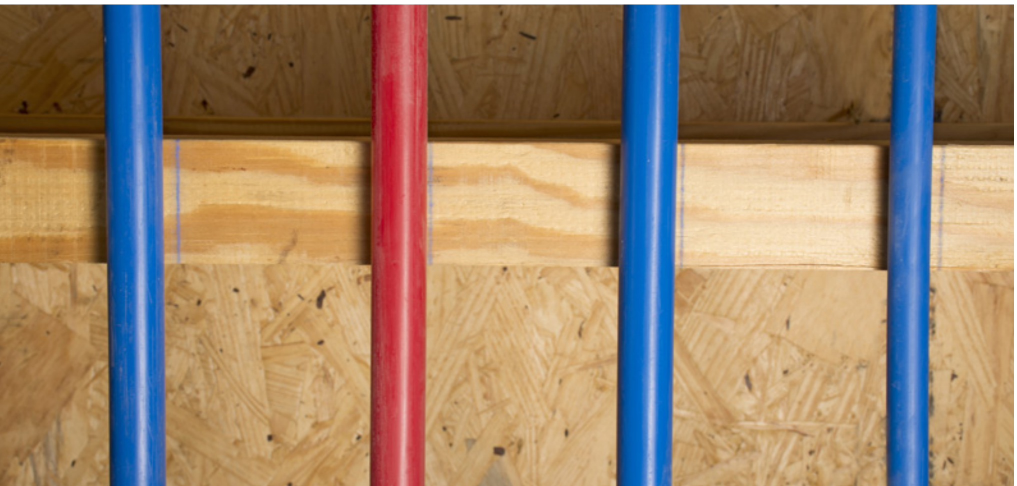
NSF/ANSI 61 contains a test procedure for evaluating the concentration of any chemical contaminant that a material may contribute to drinking water. It also requires a toxicological assessment of the daily dose of that contaminant which a person may safely consume where no adverse health effects would occur. Only products that meet this stringent standard are allowed to bear the "NSF-61" or "NSF pw" mark for potable water safety.

For example, a test that NSF conducted showed that some newly installed PEX tubing may sometimes contribute 1 part per billion (1 ppb) of xylene to drinking water. A part per billion is equivalent to one drop of water in an Olympic-size swimming pool. However, NSF/ANSI 61 defines the safe threshold for the total allowable concentration (TAC) of xylene in drinking water as 10 parts per million (ppm). That is 10,000 times higher than the 1 ppb occurrence level for xylene added by PEX tubing.

So while claims that "PEX adds xylene to drinking water" may alarm some consumers, the scientific data shows that the levels of xylene added are 10,000 times below the safety threshold.

NSF/ANSI 61

NSF/ANSI 61: *Drinking Water System Components - Health Effects* is the American National Standard for health effects of drinking water system components. It establishes the health effects requirements for the chemical contaminants and impurities that are indirectly imparted to drinking water from products, components and materials used in drinking water systems.



Plumbing codes and state and provincial drinking water agencies across the U.S. and Canada require products such as plastic pipes and fittings that contact drinking water to be certified to NSF/ANSI 61 by an accredited certification organization.

The standard is maintained by a joint committee with equal representation from regulators (such as the U.S. EPA, Health Canada and state drinking water officials), users (such as water purveyors, utilities and engineers) and product manufacturers. NSF/ANSI 61 is accredited by the American National Standards Institute (ANSI), which ensures the standard is developed and maintained using an open, consensus process and has representation by all stakeholders. The committee meets annually and any member of the public is allowed to attend the meeting or submit suggestions for improving the standard.

Product Testing

The product testing process for PEX under NSF/ANSI 61 is quite rigorous. First, a formulation review is performed on the raw material, ingredients and the manufacturing process to determine what possible contaminants could leach out into drinking water. This review determines what type of chemical extraction testing is necessary for the specific product.

PEX tubing is tested by exposing the tubing to formulated exposure waters, and then analyzing the exposure waters for contaminants. In other words, testing is designed to measure if contaminants leach from the tubing into special water

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that is formulated for this purpose. Three separate formulated waters are used during the product exposure. Both pH 5 and pH 10 test waters are separately used for exposures, as these are aggressive toward extraction of metallic contaminants. A pH 8 test water is used during the exposure for organic based contaminants. In addition to 73°F (23°C) testing, products intended for hot water use are exposed in water at 140°F (60°C) for domestic hot water systems or 180°F (82°C) for commercial hot water systems.

Tubing specimens are conditioned by exposure to the formulated waters for 17 days, with the water being changed on 12 of those days. The water collected from the final day, which encompasses a 16-hour exposure period, is then analyzed for contaminants. Any contaminants found must be below the total allowable concentration (TAC) established for the contaminants, or the product fails the test. For contaminants regulated by the U.S. EPA or Health Canada, the TAC is equal to the regulated level. For non-regulated contaminants, NSF/ANSI 61 sets health-based pass/fail levels based on review of available toxicity data using the risk assessment procedures in Annex A of the standard. Contaminants with no toxicity data, or those that lack the minimum data to determine chemical specific concentrations in accordance with the requirements of Annex A, are evaluated under the threshold of evaluation (TOE) of 3 parts per billion (ppb) for the TAC.

Water exposed to PEX tubing and associated fitting systems is tested for the following contaminants as required by NSF/ANSI 61:

> VOCs (volatile organic compounds)
> Semi-volatile compounds (base neutral acid scan by gas chromatography/mass spectroscopy)
> Phenolics
> Metals including antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium and thallium
> Methanol
> Tertiary butyl alcohol
> MTBE (methyl tertiary butyl ether)
> ETBE (ethyl tertiary butyl ether)
> Any other potential contaminant identified during the review of the tubing manufacturer's formula

These test methods are capable of detecting contaminants in water below 1 part per billion (1 ppb), and even lower for some contaminants.

Determination of Total Allowable Concentrations

The TAC values in NSF/ANSI 61 are based on risk assessments for contaminants, and they go through external peer review by the NSF Health Advisory Board (HAB). This panel consists of toxicologists from the U.S. EPA, U.S. state regulatory agencies, Health Canada, academia, consultants and chemical manufacturers. Following the external review by the HAB, the document then is submitted to the NSF Drinking Water Additives Joint Committee (consisting of equal representation by regulators, manufacturers and end users) for approval. The joint committee's recommendation then is reviewed and approved by the NSF Council of Public Health Consultants (public health officials from the U.S. and Canadian federal governments, states and provinces). The risk assessment values then are published in NSF/ANSI 61.

Finding Products That Meet the Requirements

PEX tubing that meets the health effects requirements of NSF/ANSI 61 will bear either the "NSF-61" mark or the "NSF pw" (potable water) mark on the print string, and will be listed on **www.nsf.org**. The "NSF pw" mark indicates the product meets the health requirements of NSF/ANSI 61 as well as performance, long-term strength and quality control requirements as required by NSF/ANSI 14: *Plastic Piping Components and Related Materials*. This provides assurance that drinking water coming from PEX tubing that is certified to NSF/ANSI 61 is safe for human consumption.

NSF® pw

If a product has only the "NSF rfh" mark, this indicates the product has only been evaluated for radiant floor heating applications and is not intended for transport of potable water.

As of early 2017, 140 PEX tubing products (made by 27 companies) are certified for potable water applications in NSF's certified product listings: **www.nsf.org/certified-products-systems**.

PEX tubing used in drinking water applications is required by both International and Uniform Plumbing Codes to be certified to NSF/ANSI 61 and NSF/ANSI 14.

Article by Jeremy Brown, Senior Technical Reviewer, Plastics.

Plastic Piping Products in Water Transmission and Distribution Systems: The NSF/ANSI 14 Advantage

Water utilities are currently facing the complex and costly challenge of replacing, repairing and expanding a rapidly aging water infrastructure system. The Environmental Protection Agency (EPA) estimates that by 2031, nearly $250 billion will have been invested in water transmission and distribution systems in the United States.[1] When it comes to choosing large diameter polyethylene (PE), polyvinyl chloride (PVC) and molecularly oriented polyvinyl chloride (PVC-O) pipe for water service, requiring an independent, third-party certification to NSF/ANSI 14 is the best way to ensure that these investments represent money well spent.

NSF/ANSI 14: *Plastics Piping System Components and Related Materials* was created in 1965 to establish rigorous criteria for evaluating the public health and safety requirements of plastic piping. Today, it is the most widely accepted and specified standard for plastic piping systems, raising the bar on quality for plastic piping products globally.

When water utilities specify PE, PVC and PVC-O piping products that are independently certified to NSF/ANSI 14, they can be assured that each of the following requirements has been met:

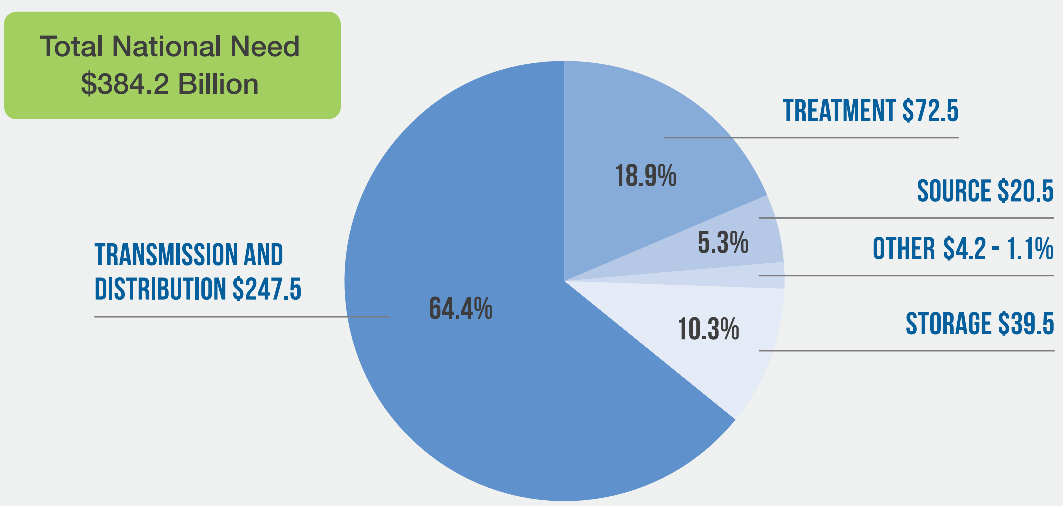
- Annual performance testing to an applicable pipe standard (see table on next page)
- Annual NSF/ANSI 61 health effects testing to ensure the pipe is suitable for drinking water
- Semi-annual residual vinyl chloride monomer (RVCM) testing (PVC pipe only)
- Verification of the pipe material's long-term strength rating and physical properties
- Regular unannounced inspections of the manufacturing location
- Verification that manufacturers are following an appropriate quality control program

Why Is All This Testing Necessary?

Producing quality plastic piping is highly dependent upon the quality of raw materials, precise monitoring of the manufacturing process and frequent quality control testing. As we know, the

1 2011 Drinking Water Infrastructure Needs Survey and Assessment, Environmental Protection Agency (EPA)

Total 20-Year Need by Project Type
(in billions of January 2011 dollars)



Note: Numbers may not total due to rounding.

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one consistent aspect of manufacturing is change. In order to stay competitive, meet production needs, reduce costs and fulfill quality goals, successful manufacturers are constantly having to implement change in their operations, suppliers, equipment, ingredients and processing parameters. Each member of their supply chain is also doing the same. Any one of these changes has the potential to affect the quality of a plastic piping product. Regular, impartial testing and auditing by a third party confirms that pipe is consistently meeting or exceeding quality requirements over time.

There is no way for municipalities to test and audit every pipe producer, but it makes sense that they ensure someone is. Protect your water infrastructure investments by specifying NSF/ANSI 14. Adding a specification such as “All plastic pipe and fittings shall be certified to NSF/ANSI 14 by an ANSI-accredited certification organization” is the best way to ensure the quality of plastic piping in a water transmission and distribution system.

Article contributions by Liz Kelley, Angela Beach, Jeremy Brown.

Annual Performance Testing to Applicable Pipe Standard		Applicable Sizes
Polyethylene (PE) Pipe Standards		
AWWA C906	Polyethylene (PE) Pressure Pipe and Fittings, 4 in. Through 65 in. for Waterworks	4" - 65"
ASTM F714	Standard Specification for Polyethylene Plastic Pipe (DR-PR) Based on Outside Diameter	3" - 48"
ASTM D3035	Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter	1/2" - 65"
CSA B137.1	Polyethylene (PE) pipe, tubing, and fittings for cold-water pressure services	1/2" - 60"
Polyvinyl Chloride (PVC) and Molecularly Oriented PVC (PVCO) Pipe Standards		
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In.	4" - 60"
ASTM D1785	Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120	1/8" - 24"
ASTM D2241	Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR) Series)	1/8" - 36"
CSA B137.3	Rigid polyvinylchloride (PVC) pipe and fittings for pressure applications	1/8" - 60"
ASTM F1483	Standard Specification for Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe	4" - 16"
AWWA C909	Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. and Larger	4" - 30"

QUESTIONS? CALL THE NSF HOTLINE

The NSF Regulatory and Consumer Information Hotline is a valuable resource for plumbing officials, inspectors, consumers and manufacturers who have questions about product certification. The hotline, which fields more than 15,000 inquiries each year, can help with your questions about NSF certification marks, the certification process and where to find certified products. If you have a question or comment, call us at **+1.800.673.8010** or email **brown@nsf.org**.

NSF STANDARDS AVAILABLE FOR REVIEW

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