

Proposed Change 2174

Code Reference(s):	NPC25 Div.B 2.6.3.1.(2) (first printing)
Subject:	Potable Water Systems
Title:	Use of the IAPMO Water Demand Calculator in the Design of Potable Water Systems
Description:	This proposed change adds the IAPMO Water Demand Calculator as an acceptable tool in the design of potable water systems.
Related Code Change Request(s):	CCR 2052

This change could potentially affect the following topic areas:

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| ☐ Division A | ☒ Division B |
| ☐ Division C | ☒ Design and Construction |
| ☐ Building operations | ☒ Housing |
| ☒ Small Buildings | ☒ Large Buildings |
| ☐ Fire Protection | ☐ Occupant safety in use |
| ☐ Accessibility | ☐ Structural Requirements |
| ☐ Building Envelope | ☐ Energy Efficiency |
| ☐ Heating, Ventilating and Air Conditioning | ☒ Plumbing |
| | ☐ Construction and Demolition Sites |

Problem

According to Sentence 2.6.3.1.(2) of Division B of the National Plumbing Code of Canada (NPC), potable water systems must be designed, fabricated and installed using good engineering practice, as described in the handbooks of the American Society of Heating and Air-Conditioning Engineers (ASHRAE) and the American Society of Plumbing Engineers (ASPE). While these documents are recognized as providing reliable guidance for the design of potable water systems, they may not reflect modern fixture performance or incorporate data from more recent field studies. As a result, designers may have limited options for estimating peak demand flow in a manner that is nationally recognized and aligns with the performance of modern plumbing systems while remaining consistent with Code objectives.

In the ASPE handbooks, for example, the primary method for estimating peak water demand for potable water systems is based on the conversion of fixture units (FU) into the probable peak demand flow in gallons per minute (gpm) using Hunter's Curve, a

probabilistic method developed in the 1940s to estimate peak demand flow in buildings. This method assumed higher individual flow rates for plumbing fixtures, which reflected the performance of plumbing fixtures at the time of its development.

Modern plumbing fixtures are generally designed to operate at lower flow rates as a result of advancements in technology, water-efficiency standards, and regulatory requirements. Applying the FU-to-gpm conversion to modern plumbing fixtures may lead to a higher probable peak demand flow, since the FU values originally defined in the 1940s have not been revised to consider newer, high-efficiency flow fixtures. This, in turn, may have a direct impact on how designers size piping for potable water systems, which may result in these pipes being sized larger than is necessary for actual operating conditions. Oversized potable water piping may result in lower water velocities and greater water volumes, which can increase water residence times under typical use conditions.

Larger water volumes and lower flow velocities are associated with longer water residence times in piping in potable water systems, depending on the building type, occupancy and usage frequency. Longer residence times can contribute to increased water age, greater heat loss in hot water systems, and increased material and construction costs, depending on building type and usage characteristics. Extended residence times and associated thermal losses are recognized factors that can adversely influence water quality in building water systems and as potential contributors to *Legionella* growth. In residential buildings in particular, where demand may be intermittent or lower than assumed peak conditions, oversized piping may result in a greater volume of water being retained within the system relative to actual use, which may undermine effective strategies for *Legionella* risk mitigation.

In practice, the absence of a nationally recognized methodology for estimating probable system flow demand for modern plumbing fixtures has led to variability in application among jurisdictions and design professionals. Some jurisdictions, such as the City of Vancouver, have permitted the use of alternative demand-based sizing approaches, including the International Association of Plumbing and Mechanical Officials (IAPMO) Water Demand Calculator (WDC)*, to estimate peak demand and address potential oversizing of potable water piping. However, without inclusion of such approaches within the NPC, the use of these alternative demand-based sizing methodologies remains inconsistent across Canada.

By introducing the WDC as an additional optional method for calculating the probable peak demand flow, which is supported by field studies and already adopted by jurisdictions in Canada, this proposed change would provide designers with another tool that reflects the performance of modern plumbing fixtures without impacting existing methods for calculating peak demand flow. This proposed change also would support a more consistent application of the Code and align the design of potable water systems with modern water efficiency and water quality.

Reference

[1] IAPMO WDC downloadable calculator is available at <https://iapmo.org/we-stand/water-demand-calculator>.

Justification

Analytical studies submitted in support of this proposed change, including construction cost assessments and engineering evaluations, indicate that the WDC provides a method of estimating peak demand flow that reflects the performance of modern plumbing fixtures. These studies demonstrate that, when applied within its validated scope, the WDC generally estimates lower probable peak demand flow, which in turn helps ensure that piping in potable water systems is sized considering the reduced water consumption of modern plumbing fixtures. Documented outcomes include reductions in pipe size and hot water distribution volumes, which may result in reduced water use, energy consumption, and associated labour requirements. Experience from jurisdictions that permit the use of the WDC, including the City of Vancouver, indicates that the method is practical to apply and enforce within a regulatory framework.

The WDC calculates demand estimates for potable water systems serving houses and multi-unit residential buildings and is based on probabilistic demand modeling derived from empirical residential water use data. It is intended to estimate peak demand flow under higher-use conditions within this validated scope. This proposed change would support more consistent demand-based sizing across jurisdictions and align with NPC objectives related to health and sanitation, environmental protection, and water efficiency, without mandating a change in design practice.

PROPOSED CHANGE

[2.6.3.1.] 2.6.3.1. Design, Fabrication and Installation

- [1] 2)** *Potable water systems* shall be designed, fabricated and installed in accordance with good engineering practice, such as that described in the ASHRAE Handbooks and ASPE Plumbing Engineering Design Handbooks, and that using tools such as the IAPMO Water Demand Calculator. (See Note A-2.6.3.1.(2).)

Note A-2.6.3.1.(2) Potable Water Systems.

The ~~design procedures contained in the~~ following ~~documents~~ are considered examples of documents and tools that support good engineering practice in the field of potable water systems ~~design~~:

- a. "ASHRAE Handbook – HVAC Applications", chapter on Service Water Heating,
- b. "ASHRAE Handbook – Fundamentals", chapter on Pipe Sizing,
- c. ASPE "Plumbing Engineering Design Handbook, Volume 2", chapter on Cold Water Systems, ~~and~~
- d. ASPE "Plumbing Engineering Design Handbook, Volume 2", chapter on Domestic Water Heating Systems, ~~and~~
- e. the IAPMO Water Demand Calculator.

The reference to the IAPMO Water Demand Calculator in Sentence 2.6.3.1.(2) is

intended to provide designers with an optional method for estimating peak demand flow for the potable water distribution system in houses and multi-unit residential buildings. The use of the Water Demand Calculator does not relieve designers of the responsibility to ensure that potable water systems meet the applicable pressure, flow and performance requirements stated elsewhere in this Code.

Alternatively, the following methods, which apply to both public and private water supplies, may be used in determining the size of each section of the water system using Table A-2.6.3.1.(2)-A (Small Building Method) and Table A-2.6.3.1.(2)-F (Average Pressure Loss Method). Where these methods are considered an alternative to a detailed engineering design method, the hydraulic loads shall be the sum of the total fixture units given in Tables 2.6.3.2.-A, 2.6.3.2.-B, 2.6.3.2.-C and 2.6.3.2.-D.

Impact analysis

The statistical and performance values referenced in this impact analysis are drawn from publicly available studies commissioned or developed by IAPMO, including construction cost analyses, meter-size and connection-fee research, water and energy performance modeling, sustainability reporting, and adoption and technical background materials [1] to [4]. Collectively, these sources evaluate the technical and economic implications of sizing pipes based on the probable peak demand flow calculated using the IAPMO Water Demand Calculator (WDC), as compared with traditional FU-based sizing approaches referenced in the NPC.

The current pipe sizing method in the NPC estimates probable system flow demand using a method similar to Hunter's Curve, which converts fixture units to gallons per minute or the volumetric flow rate. Since the development of the original Hunter's Curve method, plumbing fixtures and appliances have been designed to achieve substantial water efficiency improvements, which vary depending on fixture type [4]. Where flow demand assumptions do not reflect these changes, potable water piping—particularly in residential buildings—may be larger than that required for typical operating conditions.

ASHRAE Guideline 12, "Minimizing the Risk of Legionellosis Associated with Building Water Systems," which is referenced in the National Building Code of Canada, recognizes water age, temperature loss, and system complexity as factors contributing to *Legionella* risk. Larger piping system water volumes may contribute to increased water residence time, delayed hot-water delivery, and greater heat loss, resulting in conditions less favourable to effective *Legionella* control in building water systems. This proposed change does not introduce new requirements or modify existing sizing provisions. It clarifies that the WDC may be used as an optional engineering method for determining peak demand flow based on modern fixture performance.

Studies indicate that sizing pipes using the WDC may result in lower estimations of peak demand, which may result in lower construction costs through the use of smaller pipe diameters and associated fittings. A Stantec analysis [1] identified material and

labour cost reductions across multiple residential building types, ranging from modest savings in single-family dwelling units to tens of thousands of dollars in larger multifamily buildings. These savings result from cumulative reductions in pipe sizes and installation effort throughout the system.

Construction cost implications

Arup's modeling [3] indicates that reduced water volumes in pipes associated with WDC sizing may decrease water waste during hot-water draw periods, with estimated annual savings of

- 1 710 litres per year (~451 gallons) for single-family dwelling units;
- 11 280 litres per year (~2 980 gallons) for 6-unit multifamily buildings; and
- 269 700 litres per year (~71 258 gallons) for 45-unit multifamily buildings.

These reductions occur without changes to occupant behaviour and are attributable to shorter time-to-tap performance.

Energy savings implications

Arup's analysis [3] found that smaller pipe diameters reduce conductive heat loss in potable hot-water systems and may significantly reduce booster-pump energy use in high-rise residential buildings. Consistent with these findings, systems designed using reduced pipe diameters and lower internal water volumes experience improved water-heating efficiency.

Reducing nominal pipe size (NPS) from 3/4 to 1/2 may result in internal water-volume reductions of approximately 40% to 50% per unit length, depending on the specific geometry of the piping material. Reduced system water volume lowers thermal mass, decreases water residence time and reduces the volume of water requiring reheating, thereby further improving overall energy performance. The exact energy cost savings associated with the reduced water volume can be calculated by considering factors such as hot-water demand profiles, supply and return water temperatures, water-heater efficiency, distribution heat-loss characteristics, local energy utility rates and other specific operating conditions.

Embodied carbon implications

Smaller pipe sizes and reduced system component sizing are associated with lower embodied carbon. Arup's analysis [3] identified embodied carbon reductions of approximately 20% for high-rise copper piping systems, with additional reductions resulting from smaller meters, valves and backflow preventers. While embodied carbon is not directly regulated by the NPC, these outcomes support broader sustainability objectives.

The following assessment is based on the geometric structure of the piping materials. While exact cost savings from pipe downsizing depend on material type, market pricing and project scope, reducing NPS from 3/4 to 1/2 is generally associated with material reductions of approximately 35% for Type L copper and 55% for standard dimension ratio (SDR) 9 crosslinked polyethylene (PEX) piping, which are commonly used in building water systems. Although the resulting cost savings may not directly or

proportionally match these material reduction percentages, the savings associated with pipe downsizing would generally be expected to be of a similar order of magnitude and follow the same overall trend.

Water meter and utility connection fee implications

In summary, the referenced studies indicate that the WDC method for calculating the estimated probable system flow demand may contribute to lower installation costs, decrease water and energy use, reduce material-related environmental impacts, and lower long-term utility charges.

Introducing the WDC as an additional, optional method for estimating the probable system flow demand would provide designers with an evidence-informed tool that reflects modern plumbing fixture performance while maintaining the acceptability of existing calculation methods and without introducing mandatory provisions or new enforcement obligations.

References

- [1] Stantec (2021). Water Demand Calculator Construction Cost Savings Summary Report. <https://iapmo.org/research/whitepapers-and-studies/stantec-cost-report>
- [2] Alliance for Water Efficiency (2021). A Review of Connection Fees and Service Charges by Meter Size. <https://allianceforwaterefficiency.org/resource/review-connection-fees-and-service-charges-meter-size/>
- [3] Arup (2023). Energy and Carbon Savings Opportunities: Water Demand Calculator. https://iapmo.org/media/lvooslfq/iapmo_energy_savings_arup_report.pdf
- [4] IAPMO (2023). IAPMO's Water Demand Calculator™ Can Help You Save Water, Energy, and Reduce Embodied Carbon. https://iapmo.org/media/l4ehsqxq/arup_summary_report.pdf

Enforcement implications

This proposed change is not expected to require significant additional enforcement resources. Existing plan review and inspection processes would continue to apply, with appropriate guidance or training provided to plan examiners and inspectors where necessary during the initial adoption of the proposed change.

Who is affected

This proposed change may affect a broad range of stakeholders involved in the design, specification, manufacture, approval, construction and operation of potable water systems, including but not limited to designers, specifiers, manufacturers, building owners, contractors and building officials.

OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

[2.6.3.1.] 2.6.3.1. (**[1]** 2) [F72-OH2.1] [F70-OH2.2] [F71-OH2.3]