

Green

The Green Stagnation Paradox: When Efficiency Breeds Pathogens

As energy codes cause water usage to go down, "Water Age" is going up. For the mechanical contractor, the unintended impact of conservation is a new battleground in the fight against building pathogens.

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Key Highlights

- **Modern low-flow fixtures** reduce water use but can increase water stagnation, creating environments conducive to biofilm growth
- **Traditional pipe sizing models are outdated**; inadequate flow velocities in green buildings lead to disinfectant decay and bacterial proliferation
- **Flushing alone is insufficient** to remove established biofilms; specialized remediation and system rebalancing are necessary for water safety
- Contractors can **expand their role** by offering water management plans, including commissioning, balancing, and strategic remediation, to mitigate biological risks

On paper, the modern LEED-certified commercial building is an engineering marvel. It uses low-flow fixtures, high-efficiency heaters, and sensor-activated valves to reduce water use by up to 40 percent in comparison to conventional structures. It is a victory for conservation and an extremely huge selling point for developers.

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However, on the inside of the piping, there is another and more dangerous story unfolding.

By pursuing efficiency so relentlessly with little to no regard to anything else, the construction industry has inadvertently opened up a conflict between the International Energy Conservation Code (IECC) and basic hydraulic hygiene. The decrease in flow rates, combined with complex plumbing architectures, has created a sharp increase in "Water Age"—the amount of time spent stagnant in premise plumbing before the water is actually used.

For the plumbing and hydronic professional, this creates an ever-important pivot point. The days of "install it and forget it" are over. As can be seen from new research from Purdue University's Center for Plumbing Safety and the EPA, the modern plumbing system is becoming a biological incubator. The solution is not only in a better installation but also in a fundamental shift in the role that the contractor plays: from pipe fitter to microbiome manager.

The Physics of Stagnation

To be able to understand the problem, contractors have to take a look at the disconnect between pipe sizing codes and the reality of modern fixtures. While the plumbing codes have changed, many of the pipe sizing methodologies still use Hunter's Curve; a model created in the 1940s at a time when the fixture flow rates were much greater and toilets consumed five to seven gallons per flush.

In a "green" building, engineers specify low-flow toilets, faucets, and showers to meet efficiency standards. However, if the supply lines—especially the risers and mains—are not made smaller in proportion, the velocity of the water traveling through the system drops precipitously.

This phenomenon has been highlighted by research as the main driver of the degradation of water quality. When water is flowing too slowly, the amount of time it spends in the pipe is increased. This allows leftover disinfectant (chlorine or chloramine provided by the municipality) to dissipate before it is ever able to reach the tap. With no such chemical barrier, the inside walls of the piping become a breeding ground for biofilm.

Biofilm is a glue-like material of bacteria that sticks to the walls of pipes. It is notoriously hard to remove and thus becomes a safe haven for pathogens. While the industry is up-to-speed on the dangers of Legionella pneumophila, the stagnancy found in green buildings fosters the growth of a broader range of Opportunistic Premise Plumbing Pathogens (OPPPs), such as Pseudomonas aeruginosa and Mycobacterium avium. According to a landmark study in Environmental Science: Water Research & Technology, the environment in which these organisms thrive in particular is the low-velocity environment that is created in modern efficiency standards by accident. The notable finding of the study was that the rate of disinfectant residuals decay in green buildings is up to 144 times higher than in conventional systems because of such stagnation.

The Thermal Conflict

The issue of flow is complicated by the issue of temperature. A lot of energy efficiency protocols actually recommend lower water heater setpoints in order to cut fuel usage. At the same time, complex mixing valves are installed so that scalding is prevented.

While these measures save energy and enhance safety, they reduce the window of thermal control. Legionella and other OPPPs thrive in temperatures that range from 77°F to 108°F. In a traditional system, hot water is stored at 140°F and circulated at a high enough temperature to inhibit growth. In high-efficiency systems, where storage temperatures may be decreased to minimize standby loss, in many cases the water enters the "Goldilocks zone" for bacterial growth.

Furthermore, the complexity of modern hydronic and domestic water systems is part of the problem. Extensive looping, dead legs that are created by future-proofing for "potential" expansion, and complicated balancing valves provide a greater surface area in which biofilm can colonize. Every linear foot of pipe with stagnant, room-temperature water in it is a potential liability.

Why 'Just Flushing' Fails

Historically, the contractor's recommendation for stagnant water remediation was a simple one: flush the lines. In the case of a modern, complex facility, this approach is increasingly insufficient.

Biofilm is resilient. Once established in a low-flow system, the sheer shear force that would be needed to scour it off the pipe walls is often greater than what

low-flow fixtures can achieve. Opening a 0.5 GPM faucet is not likely to generate sufficient turbulence to dislodge a mature biofilm matrix in the branch line. The water just flows over the layer of slime, and the pathogens are left undisturbed.

Additionally, it has been suggested that manual flushing programs tend to be executed poorly. Maintenance people in large facilities such as hospitals or hotels may flush the toilets but forget about the showers or rarely used sink faucets in the mechanical rooms. This produces "dead legs," which re-seed the rest of the system with bacteria despite a main flush.

The New Revenue Model: Water Management Plans

For the plumbing and mechanical contractor, this challenge is a major business opportunity. The liability for water quality is moving from the municipality to the building owner. Once water passes the meter, it is up to the building owner.

Contractors are in a unique position to provide solutions that go beyond emergency remediation. This includes the operationalization of ASHRAE Standard 188 that defines the requirements for Legionellosis risk management.

Instead of competing on installation bids only, forward-thinking contracting firms are providing Water Management Plans (WMP) as a service. This takes the relationship from transactional to recurring. A strong WMP for a green building consists of a number of technical interventions that can only be performed by a licensed professional:

1. Commissioning for Flow, Not Just Pressure

Standard commissioning checks are checking for leaks and pressure. A biological commissioning process involves checking for the turnover rates of water to conform to design intent. Contractors can provide flow verification services so that the "as-built" conditions match the hydraulic modeling.

2. Recirculation Loop Balancing

In many green buildings, undersized or out-of-balance recirculation pumps are used to save on energy, leaving distal loops to stagnate. Contractors can offer rebalancing services, which can ensure that return velocities are high enough to maintain temperature and turbulence throughout the system.

3. Strategic Remediation

When compromise occurs on a system, thermal shock or chemical hyper-chlorination can be used by contractors. However, unlike the general maintenance personnel, the mechanical contractor understands the compatibility issues of the materials. High levels of chlorine can corrode some valve seals or degrade PEX piping if the process is not done properly. Providing a safe and material-conscious sanitization is a high-value service.

4. Design-Assist Consulting

For firms engaged in new construction or retrofit works, there is potential for advocating for "right-sizing" plumbing. This means going against the urge to install oversized pipes "just in case." By promoting smaller diameters with maintenance levels that ensure scouring velocities, contractors can assist engineers in designing systems that are both efficient and hygienic.

The Liability Shift

The Environmental Protection Agency (EPA) and the Center for Disease Control and Prevention (CDC) are paying a lot of attention to premise plumbing as a vector for disease. With regulations becoming more stringent, building owners will seek out professionals who are aware of the nexus between biology and mechanics.

The industry cannot afford to not take notice of the data. The EPA's technical review on Legionella Control in Premise Plumbing shows that most, if not all, of the waterborne disease outbreaks are now coming from premise plumbing, not the main of the public water supply.

For the plumbing professional, the implication is obvious: the definition of a "working system" has changed. A no-leak system but with pathogen-laden water is a failed system.

Conclusion

The conflict between energy conservation and water safety is the defining technical challenge of the next decade. It is not a problem that is going to be solved by taking away low-flow fixtures, which are here to stay. It

will be solved when a higher caliber of system management is in place.

Mechanical contractors and hydronic professionals are the only people who possess the technical skillset to fill this gap. By understanding the physics of water age, as well as the biology of biofilm, contractors can protect their clients not just from mechanical failure but also from biological risk. The green building of the future needs more than a certificate of sustainability; it requires a water management strategy with plumbing considered to be a living system.

Sources

Primary Source (Green Buildings & Water Age):

- **Study:** "Survey of green building water systems reveals elevated water age and water quality concerns" by Rhoads, Pruden, and Edwards (2016).
- **Relevance:** This is the specific study that identified the "144 times faster decay" of disinfectant in green buildings.
- **Link:** https://pubs.rsc.org/en/content/articlelanding/2016/ew/c5ew00221d

Primary Source (EPA Control Technologies):

- **Document:** "Technologies for Legionella Control in Premise Plumbing Systems: Scientific Literature Review" (EPA 810-R-16-001).
- **Relevance:** Authoritative government review of biofilm, stagnation, and remediation technologies.
- **Link:** https://www.epa.gov/ground-water-and-drinking-water/technologies-legionella-control-premise-plumbing-systems

Scientific Context (Purdue University):

- **Reference:** Purdue University Center for Plumbing Safety.
- **Relevance:** Establishes the concept of "Water Age" and the link between green buildings and water quality degradation.
- **Link:** https://engineering.purdue.edu/Plumbing-Safety

Industry Standard (ASHRAE):

- **Reference:** ASHRAE Standard 188.
- **Relevance:** The industry standard for Legionellosis: Risk Management for Building Water Systems.
- **Link:** https://www.ashrae.org/technical-resources/bookstore/ansi-ashrae-standard-188-2021-legionellosis-risk-management-for-building-water-systems

Code Reference (IECC):

- **Reference:** International Energy Conservation Code.
- **Relevance:** The code body driving the efficiency standards discussed in the article.
- **Link:** https://codes.iccsafe.org/content/IECC2021P1

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