

Opening the Spigot on NIST's Premise Plumbing Research Activities

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Emerging Water Technology Symposium
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History

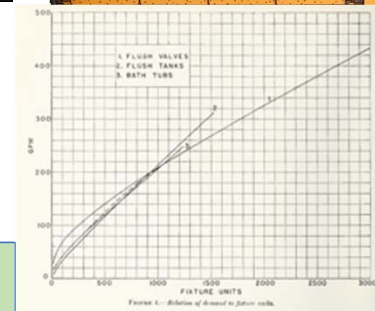
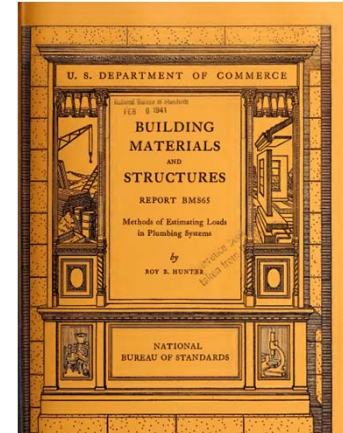
1924 Need for Minimum Plumbing Requirements

1928, 1932 Hoover Plumbing Codes

1940 Hunter sizing curves

Post World War II Advances as Europe re-built

1970s Recognition of need for Performance-based Standards and Codes



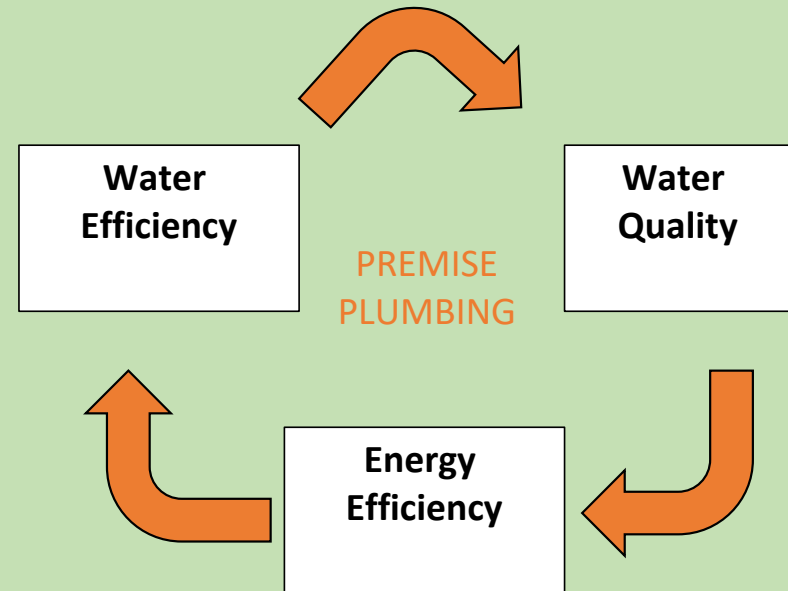
“The reliance upon traditional codes which specify allowable configurations and designs, pipe sizes and materials inhibits implementation of innovative solutions for water supply and drainage systems and for water conservation practices, and limits materials resource conservation and energy conservation opportunities. The consequences are overdesign of traditional systems and delay or difficulty in gaining acceptance of innovative approaches.” Galowin et al., 1979

NIST mission: Measurement Science, Technical Excellence, Service to Nation

Motivation

Much has changed in the world of premise plumbing

- Total Usage
- Flow Rates
- Number of Fixtures
- Types of Fixtures
- Usage Patterns
- Materials Used in Plumbing Systems
- ...



A lot of great ideas for research needs

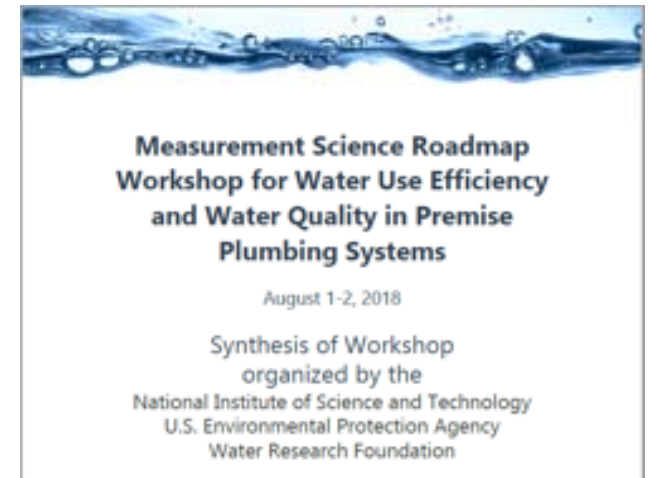
... but no compilation of those ideas

Where did NIST begin?



Documentation of Research Needs

- Workshop - 2018
- Federal Register Request for Info
- Follow-up Discussions



NIST Technical Note 2088: Measurement Science Research Needs for Premise Plumbing Systems (May 2020)

59 Research Needs:

Foundational Measurement Science e.g., metrics, test methods, data
Applied Research e.g., guidance, design approaches

<https://www.nist.gov/publications/measurement-science-research-needs-premise-plumbing-systems>

What has NIST been up to lately?

- Continue engagement with stakeholders.
- Additional, one-time NIST funding in summer of 2020
- New NIST premise plumbing research efforts
 - Pressure-flow relationships of plumbing fittings
 - Water heater temperatures and opportunistic pathogens
 - Standardized plumbing system models
 - Enhanced plumbing system simulation tools
 - Commercial building water usage survey

Pressure-flow relationships of plumbing fittings

Natascha Milesi Ferretti;
Marylia Duarte Batista,
Lingnan Lin,
John Wright (NIST/PML
Flow Calibration Lab)

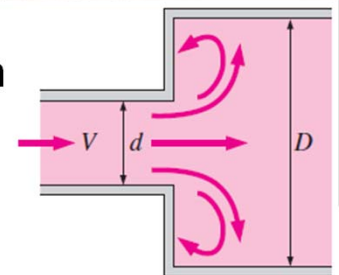
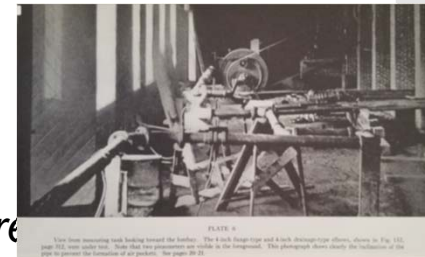
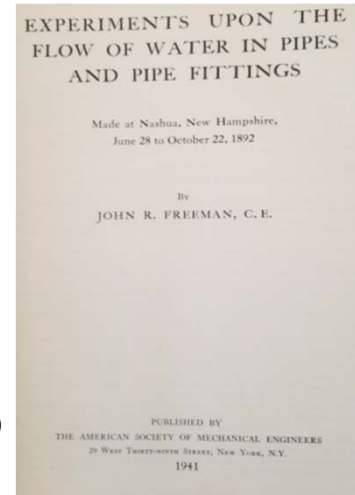
Background: Data in current codes and standards not representative of modern materials and fittings

- Most data pre-1950s
- Oversized pipes, higher costs, longer stagnation periods that facilitate pathogen growth

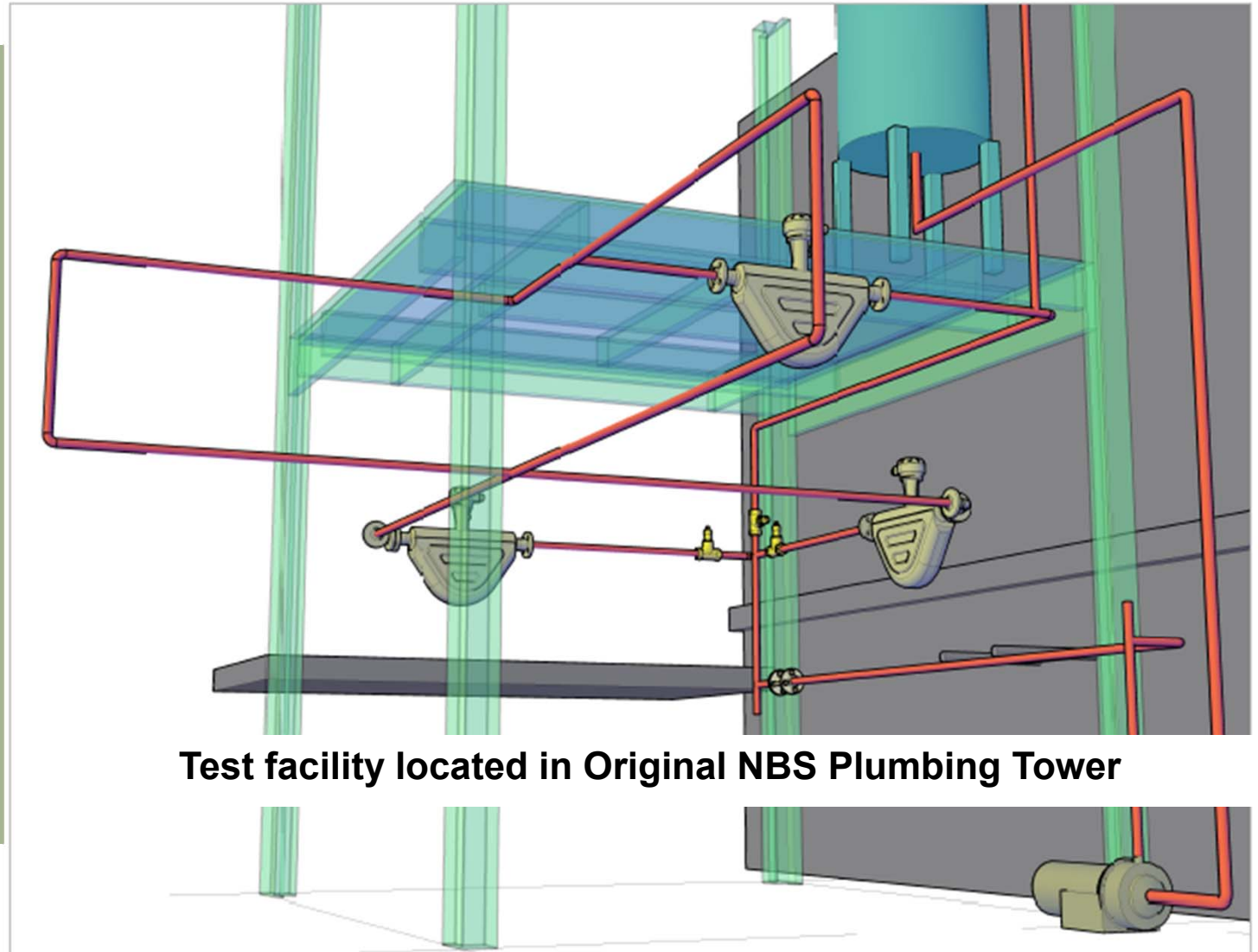
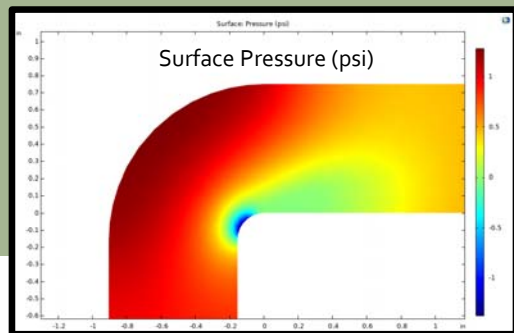
Objective: To develop measurement science needed to establish standardized and precise means of characterizing pressure loss of modern plumbing fittings as a function of various parameters (flow rate, temperature, geometry, etc.)

Technical Approach:

- *State of the art review on Measurement of Pressure Losses of Fluid Flow through Pipe Fittings*
- Expand/update database of pressure loss of common plumbing fittings (elbows, tees, etc.)



Pressure-flow relationships of plumbing fittings



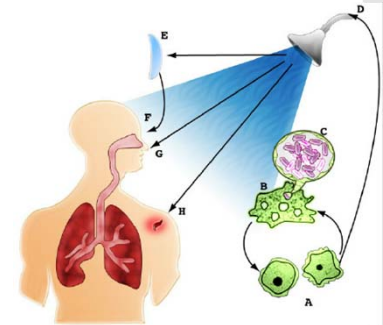
Water heater temperatures and opportunistic premise plumbing pathogens (OPPP)

Tania Ullah,
Marylia Duarte Batista,
Alshae' Logan-Jackson

Background: Inadequate understanding of relationships between water heater temperature, water usage and pathogen growth

- Low water use increases residence time and reduces disinfectant effectiveness; increased potential for pathogen growth
- Conflicting guidance on water heater setpoints

Objective: To study impact of water use pattern, temperature set point, type of water heater and water quality on OPPP growth (*Legionella*, *Pseudomonas*, *Mycobacteria*, etc.) and potential hotspots for OPPP growth in hot water distribution systems.



Residential

Water Heating
Laboratory

Innovative
Technologies

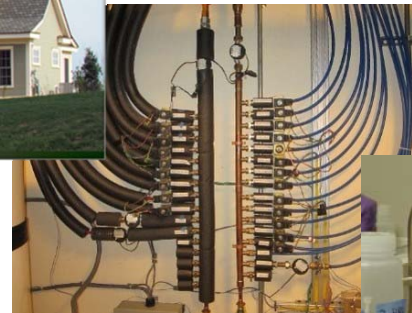
Water heater
temperatures and
opportunistic premise
plumbing pathogens –

Residential sampling

Focus: To understand effects of water heater temperature and water use patterns on occurrence and concentration of OPPPs in an existing plumbing system to identify strategies to reduce growth and public health impacts.

Technical Approach:

- Seasonal water sampling in test house, varying temperature and water usage
- Chemical and microbial analysis



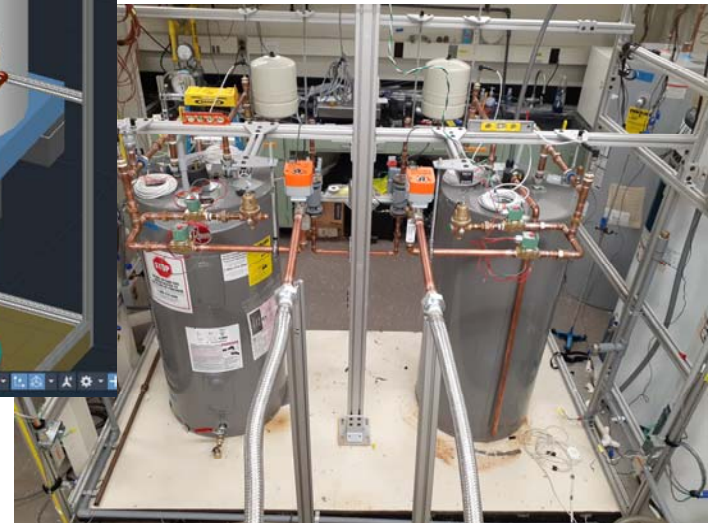
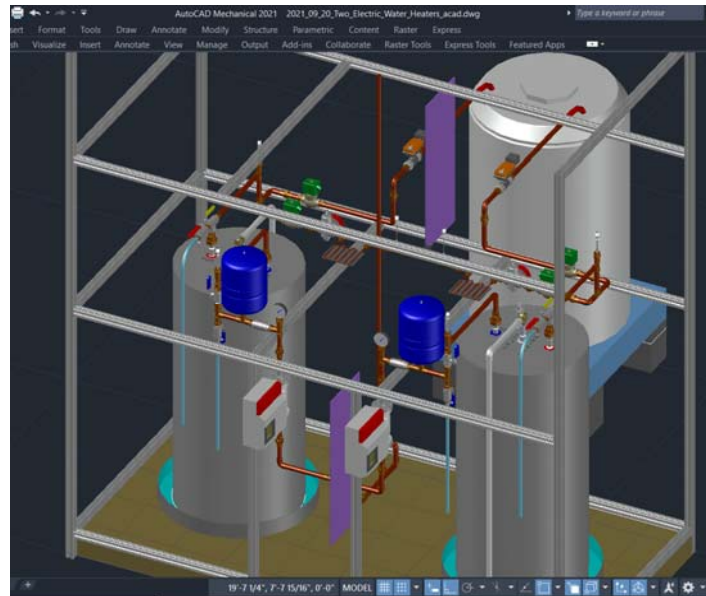
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Water Heater Laboratory

Test Facility Constructed to Evaluate OPPPs in Water Heaters

- Side-by-side water heaters to evaluate impact of different temperatures and draw profiles
- Water quality monitoring
- Microbial evaluations

Will be expanded in future to examine pipe runs and fixtures



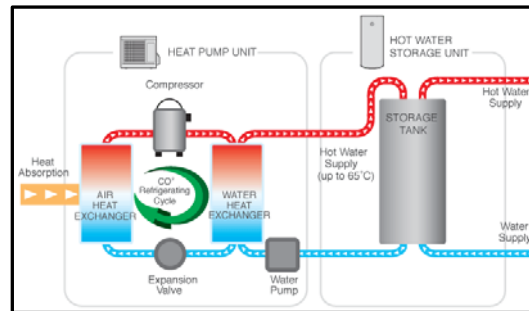
Water heater temperatures and opportunistic premise plumbing pathogens- Innovative Technologies

Water Use in High Performance Buildings

Tania Ullah PI

Objective: Develop data & tools to quantify energy and water quality performance of premise plumbing systems

- Performance testing of novel water heating systems for improved energy efficiency

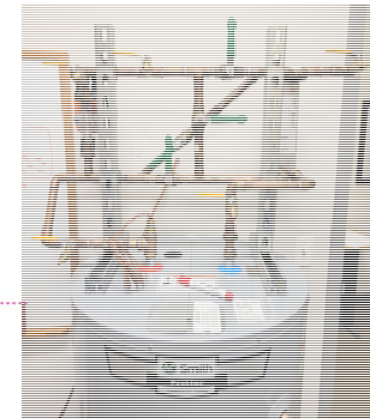
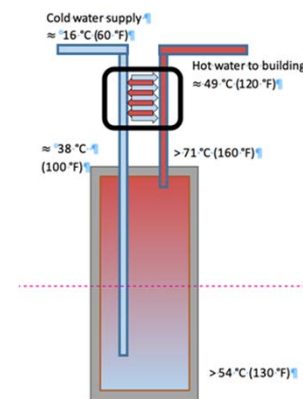


Water Heating System for *Legionella* Control

David Yashar, Tania Ullah

Objective: Design, build, modify control logic and test prototype;

- Verified system capabilities for achieving desired temperature requirements
- Measured First hour draw and Uniform Energy Factor (UEF)



Standardized plumbing system models

Stephen Zimmerman,
Andrew Persily

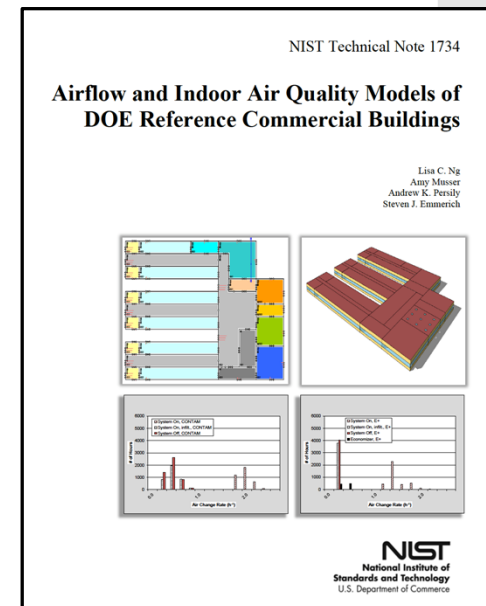
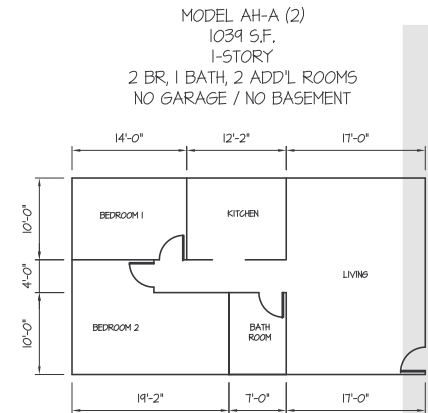
Background: Modeling studies of plumbing system performance use different buildings and systems, marking them hard to compare.

- Existing reference building models have been useful for energy and indoor air quality analyses

Objective: To develop, document and make available plumbing system designs for residential and commercial buildings for other researchers and industry to analyze system performance, new technologies, design & operation strategies

Technical Approach:

- NIST contract with A&E firm
- 3 residential and 4 commercial buildings from existing reference building collections
- Architectural and plumbing systems will be available online this summer

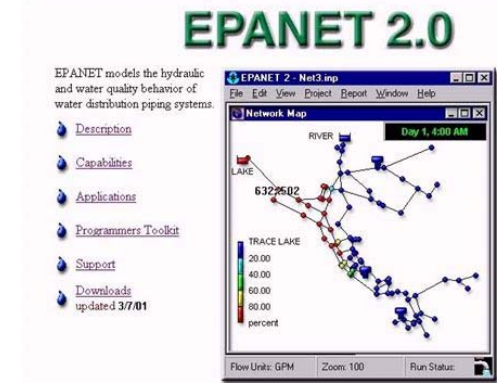


Enhanced plumbing system simulation tools

Mark Kedzierski

Background: Existing premise plumbing simulation tools based on outdoor water distribution system models (EPANET) that do not fully address all relevant phenomena

- Heat transfer not well integrated
- Dispersion only in direction of flow
- Challenges during no or low water flow



Objective: To enhance heat transfer and dispersion modeling in plumbing system simulation tools

Technical Approach:

- Speed-up TRNSYS Type604 liquid-filled pipe model for potential coupling to EPANET
- Identify strategies to better simulate dispersion in pipe networks

Non-residential water use survey (cooperative agreement with University of Cincinnati)

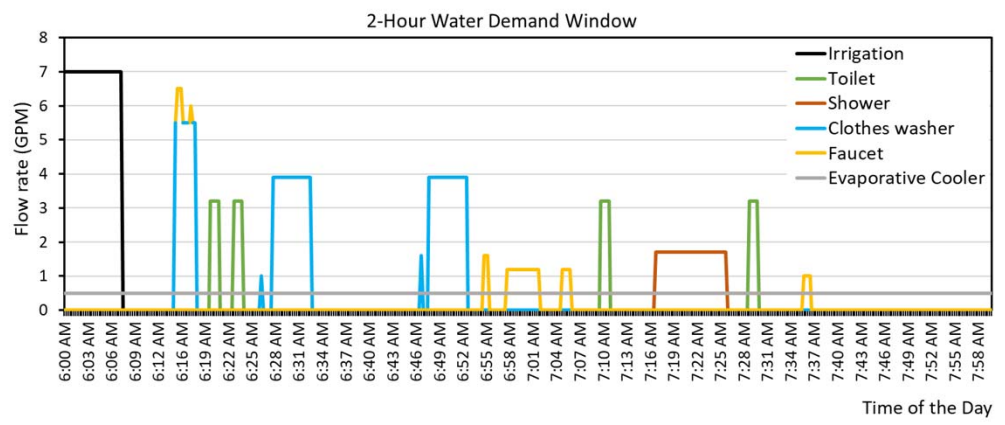
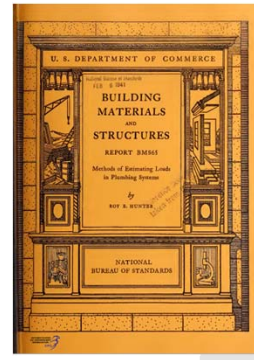
Steven Buchberger PI

Background: Outdated building codes and design procedures lead to oversized premise plumbing systems, which can trigger potential water–energy problems & public health concerns

System design, specifically pipe sizes, is based on statistical treatment of fixture use (Hunter 1940)

Technical Approach:

- Designing national survey of fixture use to improve estimates of peak water demands in commercial buildings
- Developing sensors to monitor incidence and patterns of water usage at multiple fixtures



What's Next?

- Continue both laboratory efforts: PvQ and water heating systems
- Find a more permanent home for these research efforts in our programs
- Continue interactions with stakeholders and seek out opportunities to collaborate

