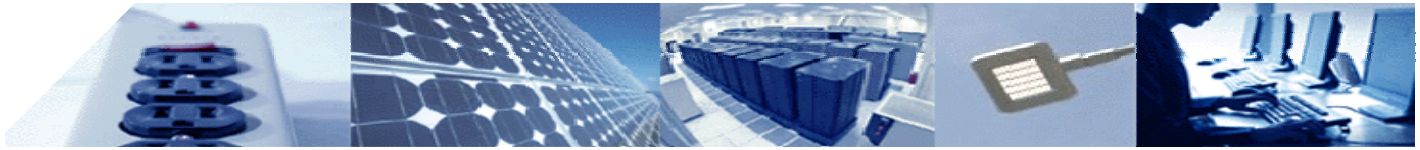


Drain Water Heat Recovery Testing at PG&E's Applied Technology Services

Edwin Huestis, P.E.

Senior Mechanical Engineer

PG&E Applied Technology Services

ACEEE Hot Water Forum

February 23, 2016

Pacific Gas and Electric Company®

Presentation Objectives

- Who is ATS?
- Identify desired DWHR device test system capability
- Review design of DWHR test system
- Discuss DWHR test uncertainty
- Describe the vision of PG&E's Upgraded Hot Water Technology Performance Laboratory
- Where is the lab at right now?

PG&E Applied Technology Services (ATS)

End use Equipment Testing

Non-Destructive Examination

Vibration Analyses

- Multidisciplinary team of Engineers, Technologists, Technicians and Scientists
- Act as an internal PG&E consultant, also perform some 3rd Party work

PG&E Applied Technology Services
DWHR Desired Test System Capabilities

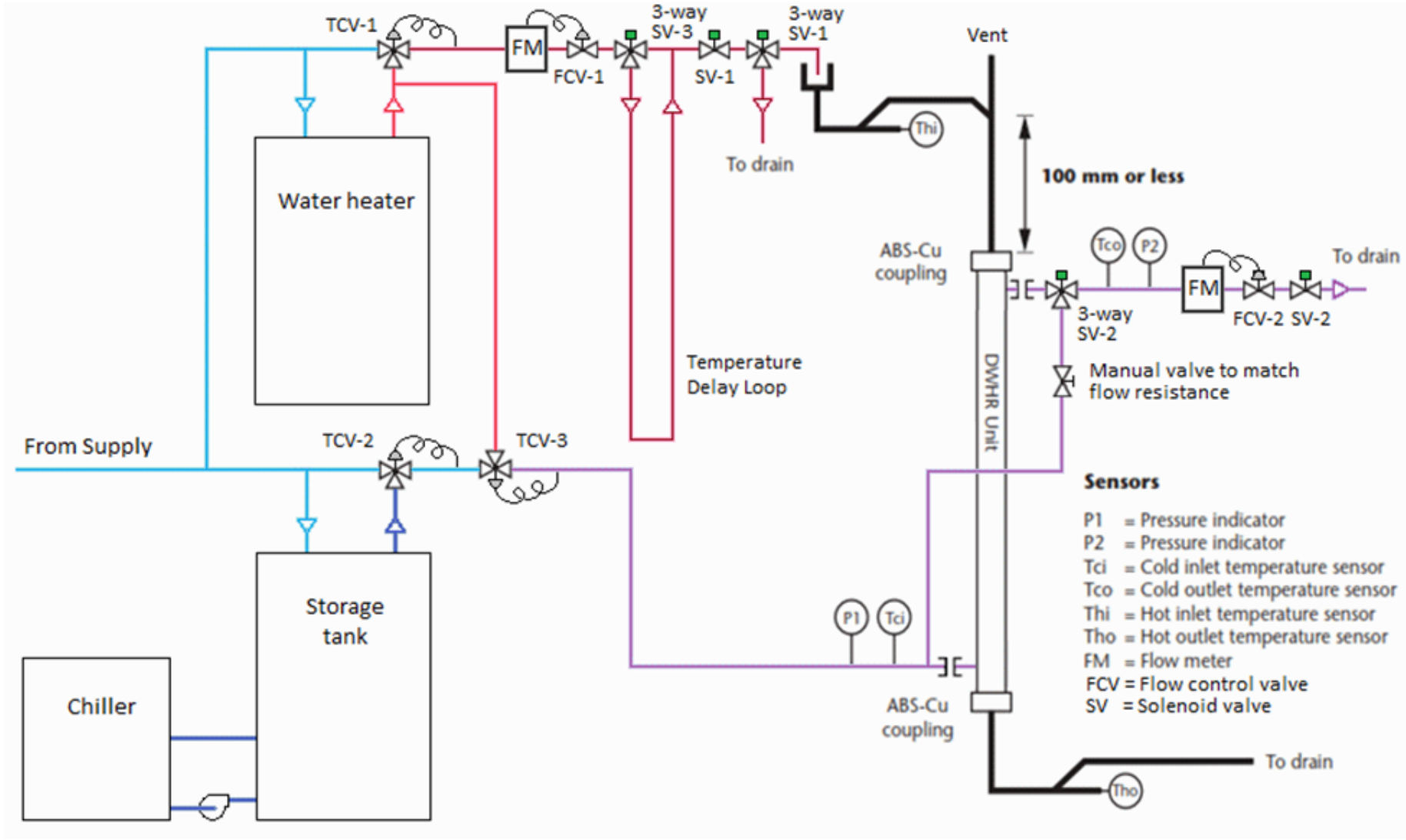
Fully automate all tests, performing the following:

1. Allow both “cold” and “drain” side flow rates and temperatures to reach desired set points in test script
   A. On the cold side – bypass flow through paralleled line and through cold side flow meter
   B. On the drain side – bypass flow to sewer, which already has passed through drain side flow meter
2. Divert flow to DWHR unit and run test for 15 minutes, maintaining steady state conditions
3. Once test is complete, flush unit with room temperature water, returning the DWHR unit roughly to equilibrium with the ambient environment

Critical data points include:

Flow: cold and drain side
Temperature: cold and drain side inlet/outlet, 8 surface mounted TC’s, ambient
Pressure: dP across cold side
Visual of flow inside drain via boroscope, and with clear drain inlet/outlet pipe

PG&E Applied Technology Services
Drain Water Heat Recovery Test System Schematic



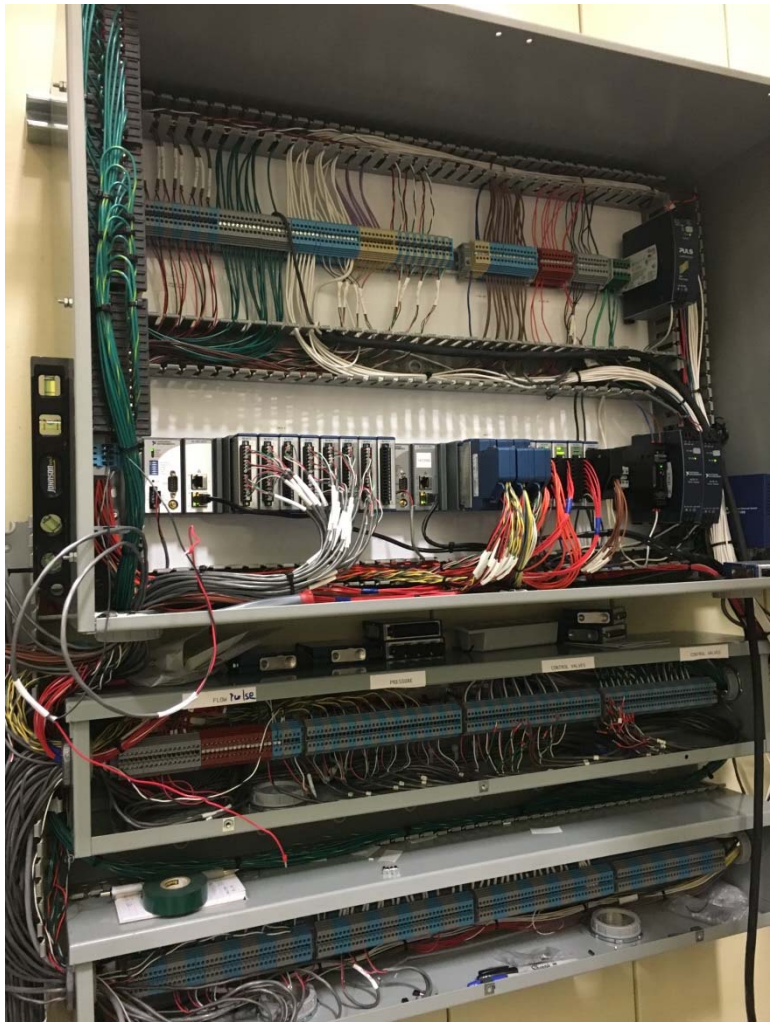
PG&E Applied Technology Services
Drain Water Heat Recovery Test Unit Mounted in Lab

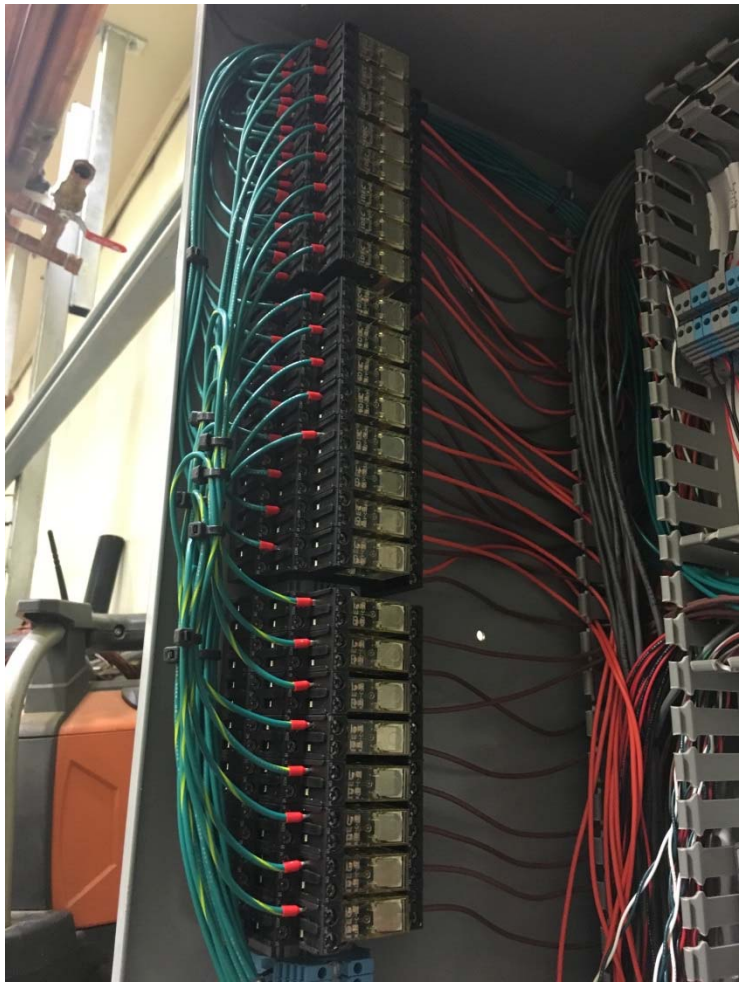
Cold Side Outlet/Drain Side Inlet

PG&E Applied Technology Services
Drain Water Heat Recovery Test Unit Mounted in Lab

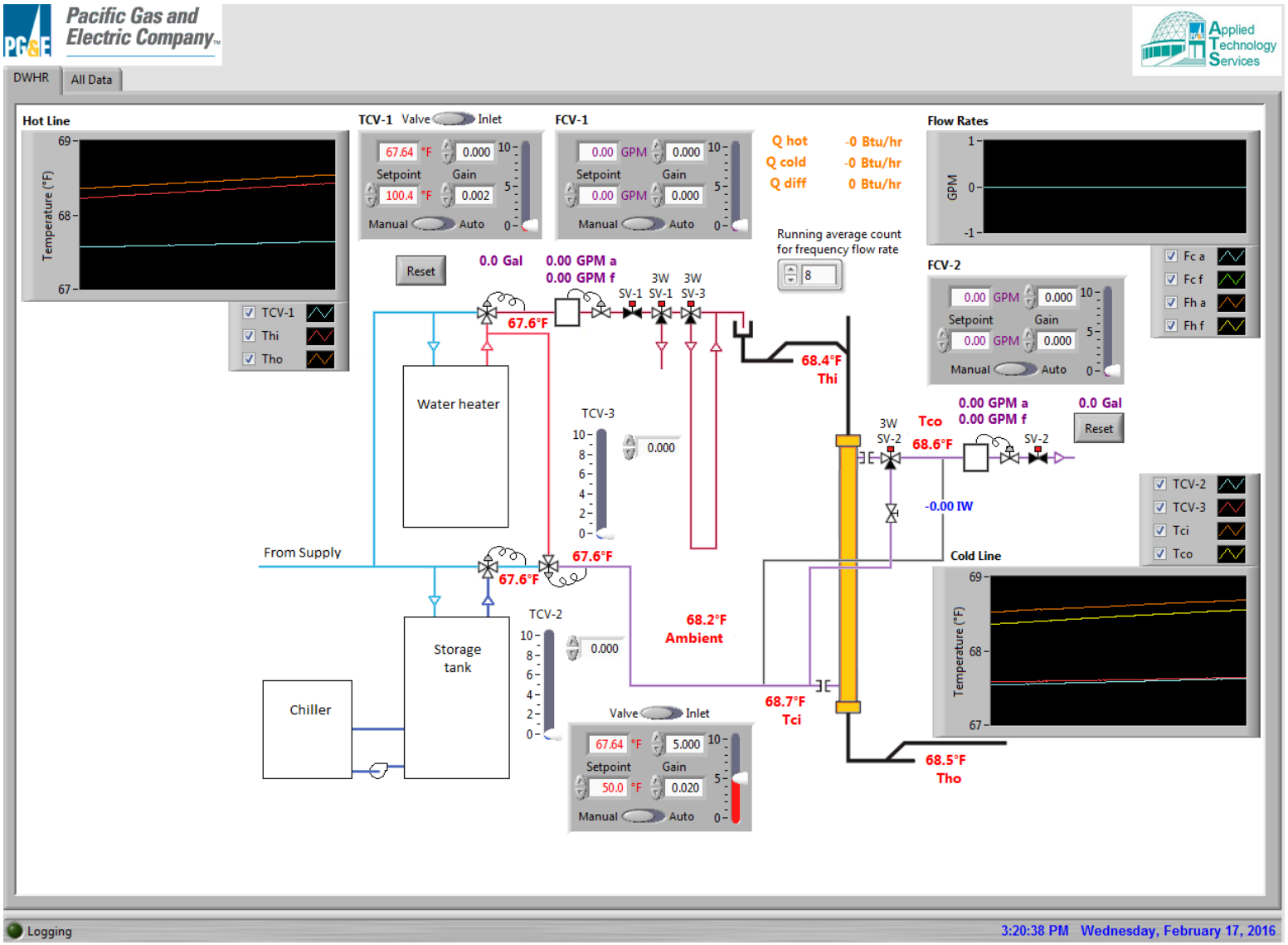
Cold Side Inlet/Drain Side Outlet

PG&E Applied Technology Services
Drain Water Heat Recovery Test DAS





PG&E Applied Technology Services
Drain Water Heat Recovery Testing DAS Front End



Measurement Uncertainty and Heat Balance Error

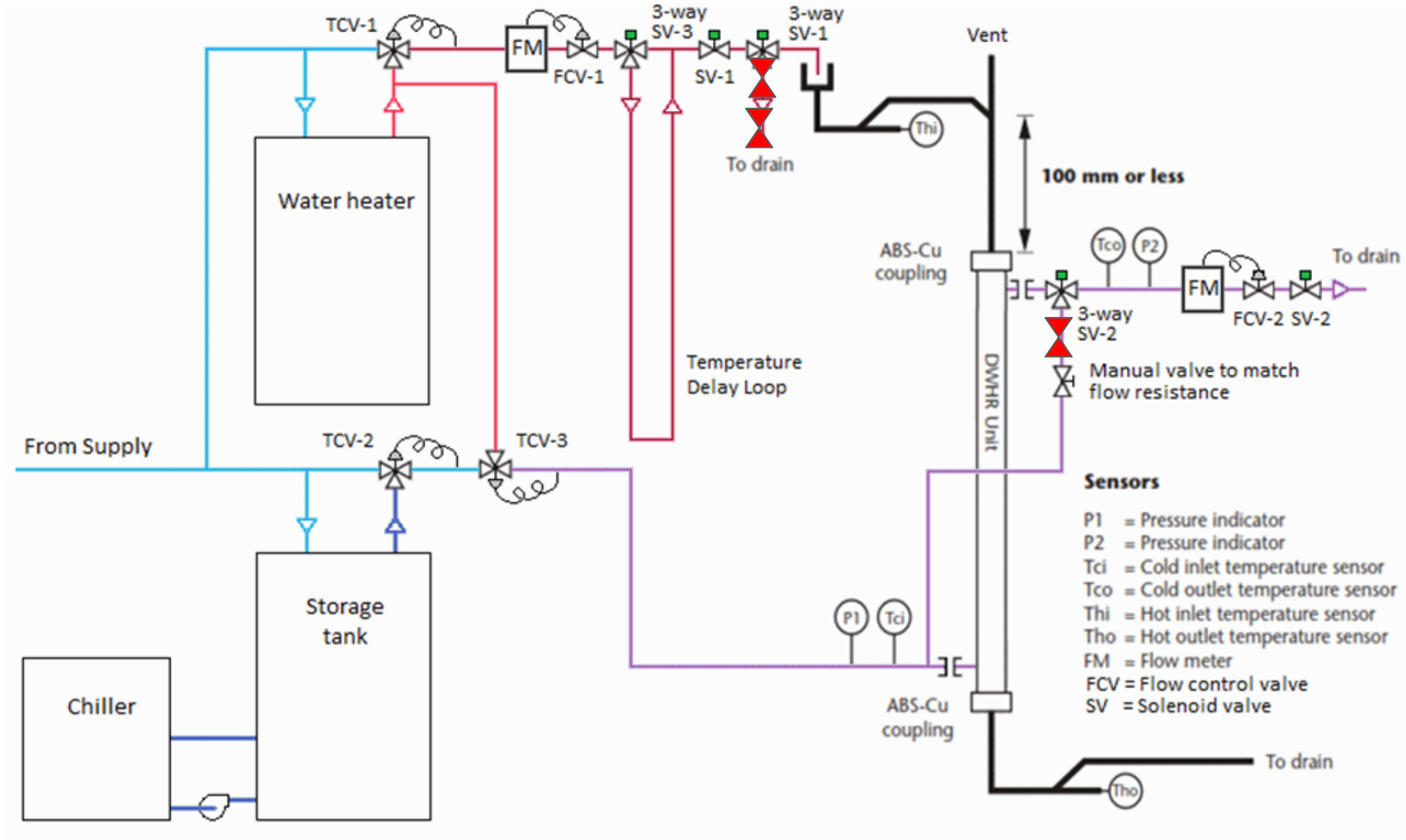
$$\text{Heat Balance Error } (\%) = \frac{100 * (Q_{DRAIN} - Q_{COLD})}{\left(\frac{Q_{DRAIN} + Q_{COLD}}{2}\right)}$$

Heat Balance Error Uncertainty		
Test Parameter	Measurement	Uncertainty
ASW flow (lbm/hr)	6,432,815	128,657
CCW flow (lbm/hr)	7,817,038	402,836
ASW inlet temp (F)	59.32	0.030
ASW outlet temp (F)	64.39	0.229
CCW inlet temp (F)	69.17	0.028
CCW outlet temp (F)	64.94	0.026
ASW side heat transfer (Btu/hr)	31,182,747	
CCW side heat transfer (Btu/hr)	33,019,710	
Heat Balance Error (%) *	5.72	7.64

- Reduce temperature/flow uncertainty, eliminate possibility for bypass
- When measuring heat transfer on both sides of the heat exchanger, Heat Balance Error allows you to check your uncertainty analyses/estimates

PG&E Applied Technology Services
Drain Water Heat Recovery Testing – Flow Bypass Concern

PG&E Applied Technology Services
Drain Water Heat Recovery – Flow Bypass Concern (cont'd)



Temperature Measurement and Calibration

4-wire RTD's Used

Isothermal Block for Temperature Calibration

Pressure Measurement and Calibration

Rosemount Pressure
Transmitters used for DWHR dP

Dead Weight Tester – Calibration Standard
*New pressure tester used as well

Flow Measurement and Calibration

Nutating Disc Hot Water Meter

Coriolis Flow Calibration Standard

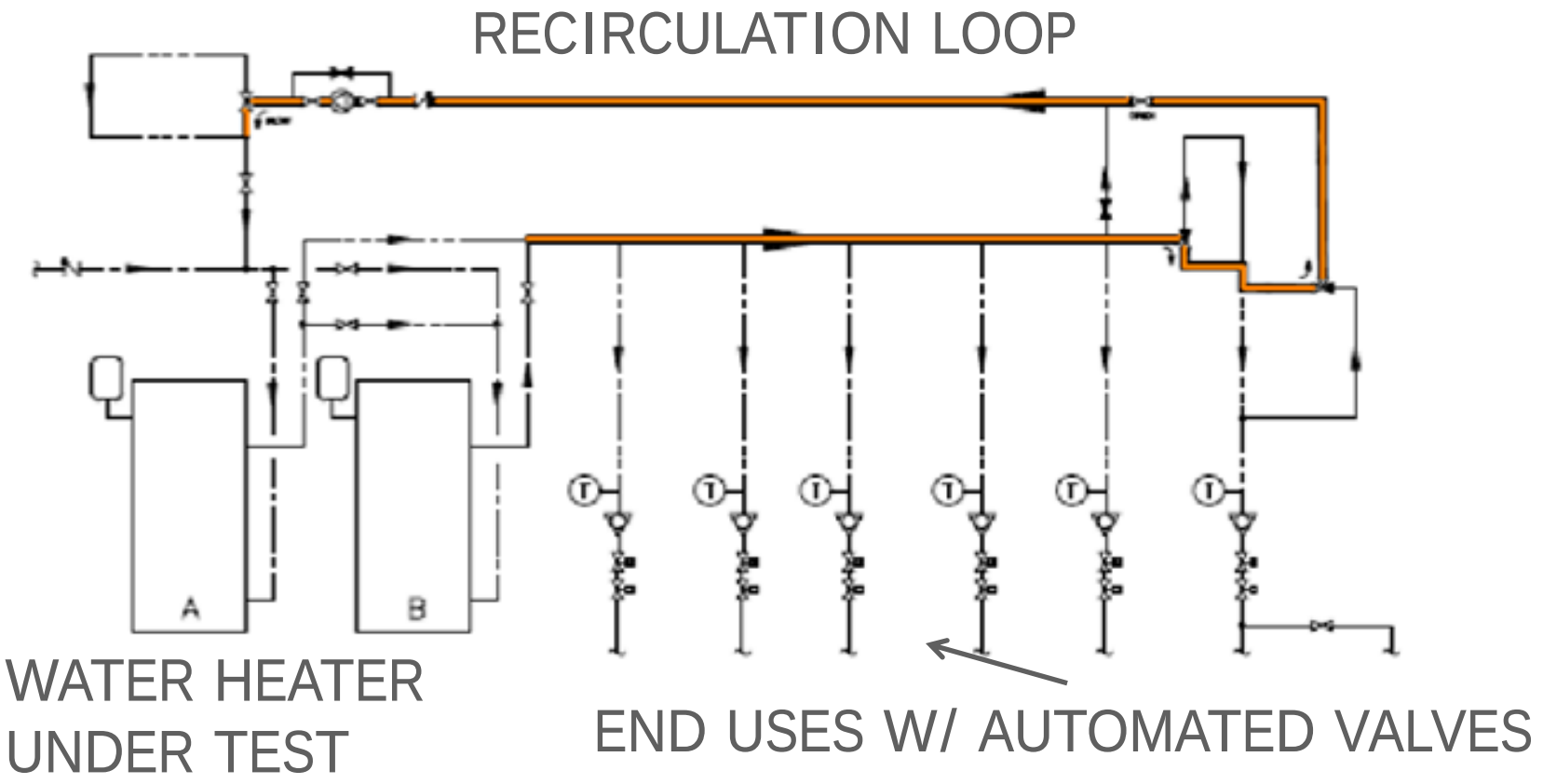
DWHR Summary

- Addressing challenges with test automation, including flow throttling and temperature mixing
- Performed multi point calibration on temperature and flow instrumentation to reduce measurement uncertainty
- Testing to commence within the next few weeks
- Results to be presented at next Hot Water Forum
- No plans to remove this feature from the lab

History of Hot Water Testing at ATS – Residential Water Heater Testing

- Started off supporting the development of ASHRAE standards
- Focus on Residential Energy Factor Testing

PG&E Applied Technology Services
Commercial Water Heater Laboratory Configuration



- Testing expanded into Commercial Systems

Pacific Gas and Electric Company®

PG&E Applied Technology Services
Commercial Water Heater Laboratory Configuration (cont'd)

- Fully instrumented and automated quick service hot water system in laboratory
- 24 hr. draw profile testing

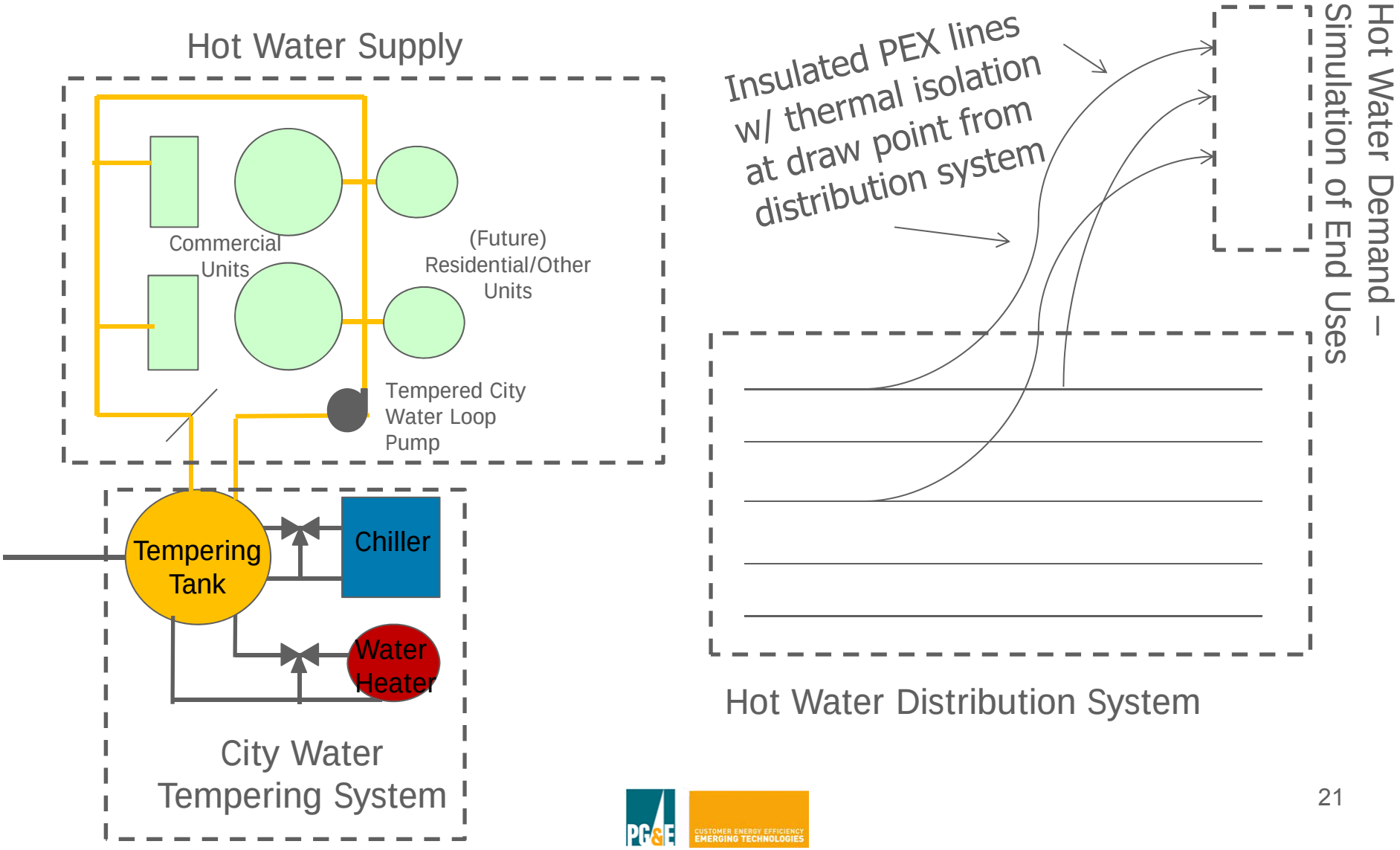
Pacific Gas and Electric Company®

PG&E Applied Technology Services
Hot Water Technology Laboratory Vision

Vision for PG&E's Upgraded Hot Water Technology Laboratory

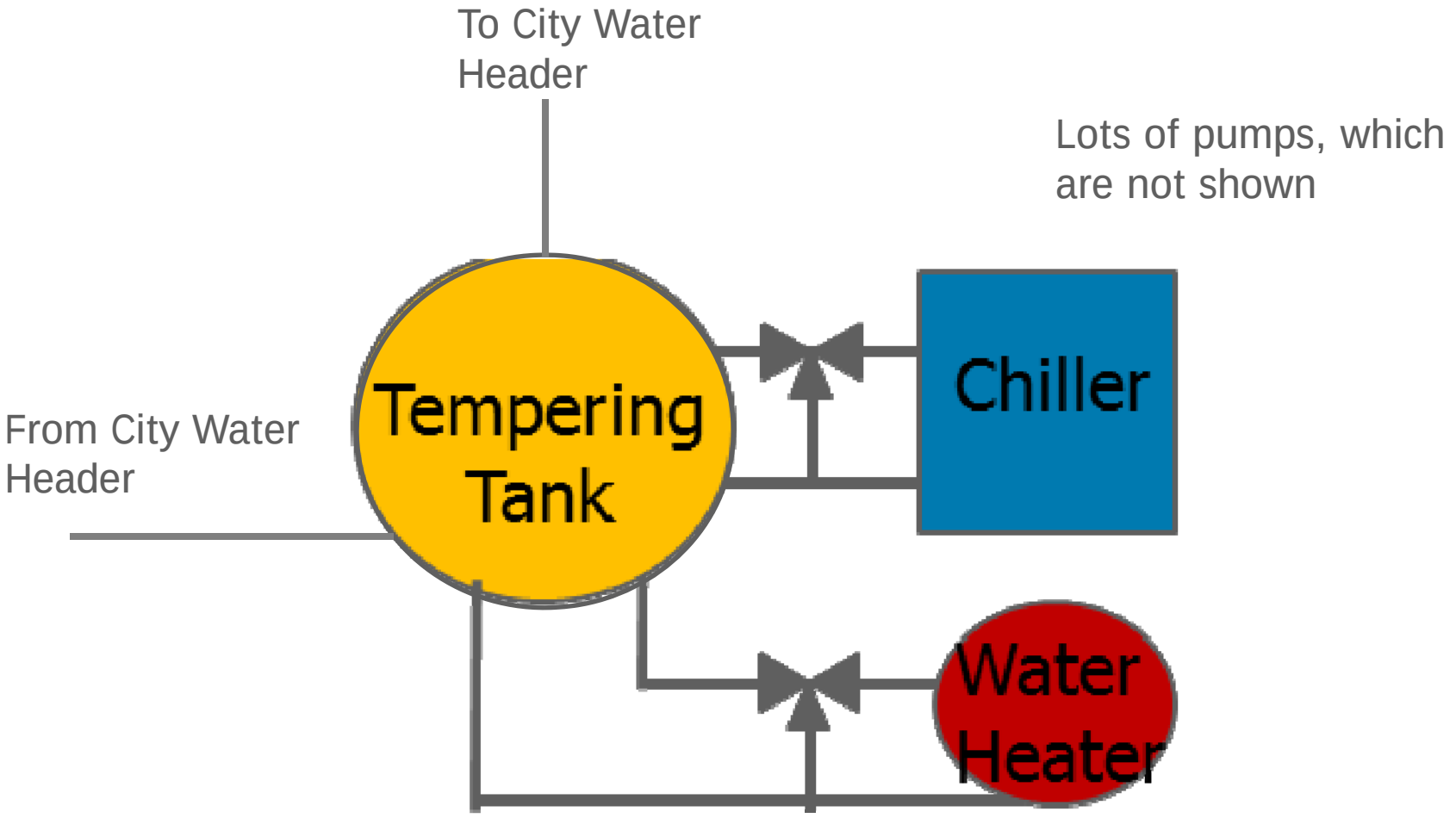
- Include capabilities of past residential and commercial test systems
- Employ modular laboratory design, easily adaptable to changing test conditions
- Design instrumentation plan and DAS system for versatility
- Automation of tests via National Instruments Labview DAS
- Continued focus maintaining high instrument accuracy and control of test variables
- Rely on industry for guidance and new ideas

PG&E Applied Technology Services
Implementing the Hot Water Technology Laboratory Vision

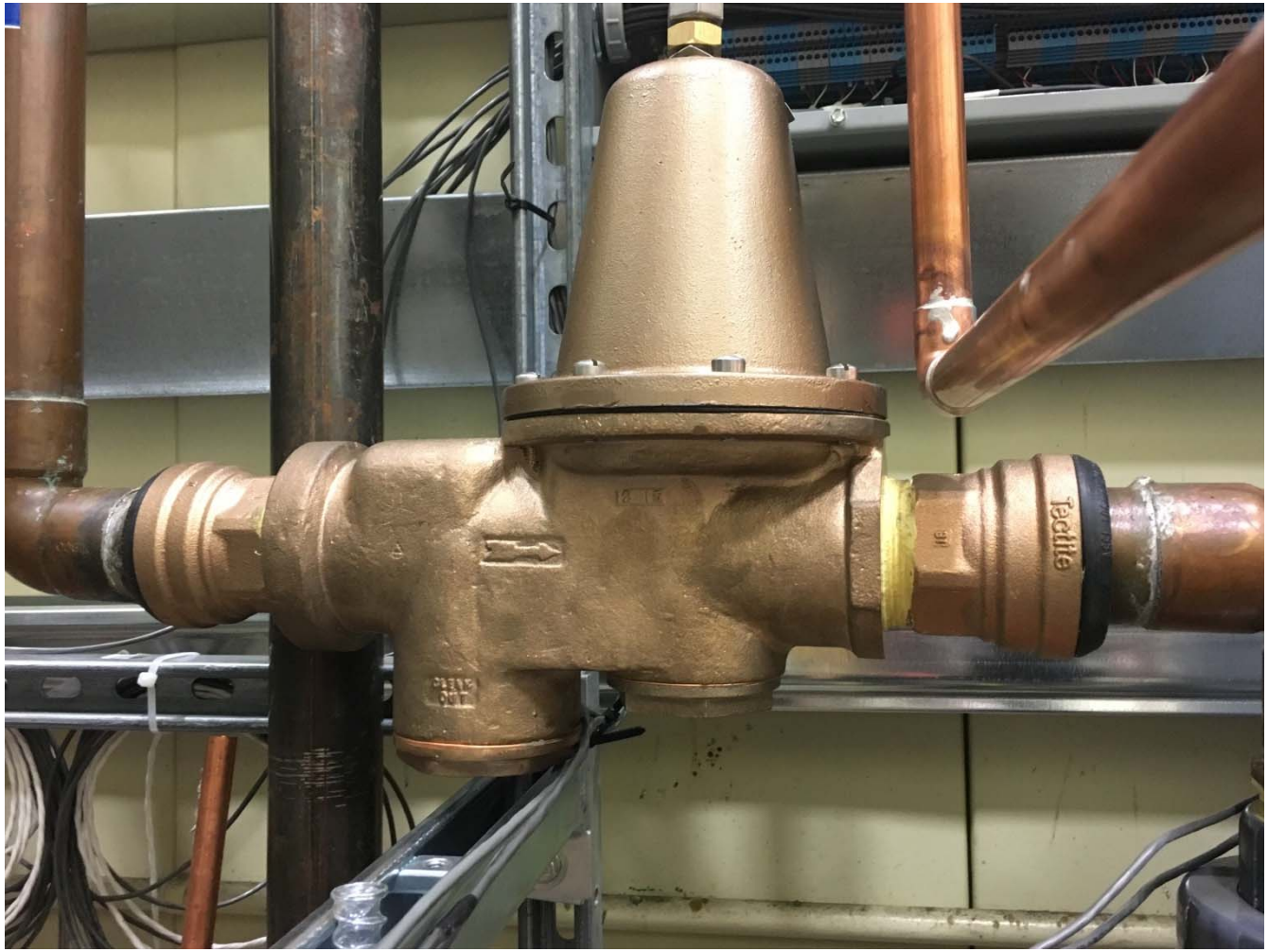


Conditioning City Water - Tempering System

Conditioning City Water - Tempering System



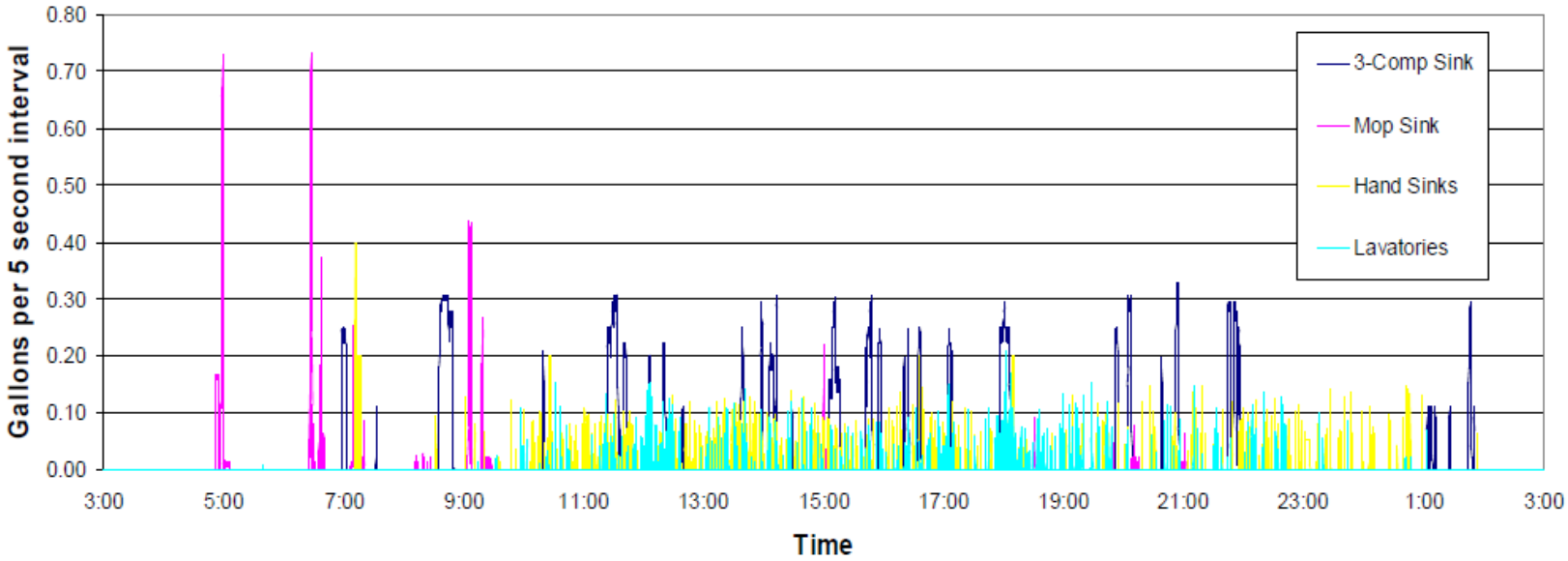
Regulating City Water Pressure



Distribution System – Piping Rack

Field Characterization Work feeds Into the Lab

Time	3-Comp Sink	Mop Sink	Hand Sinks	Lavatories	24hr Total
Gallons	322.0	60.8	62.1	55.4	500.37
# of Draws	1793	810	1258	1161	5022.00
Average GPM	2.16	0.90	0.59	0.57	

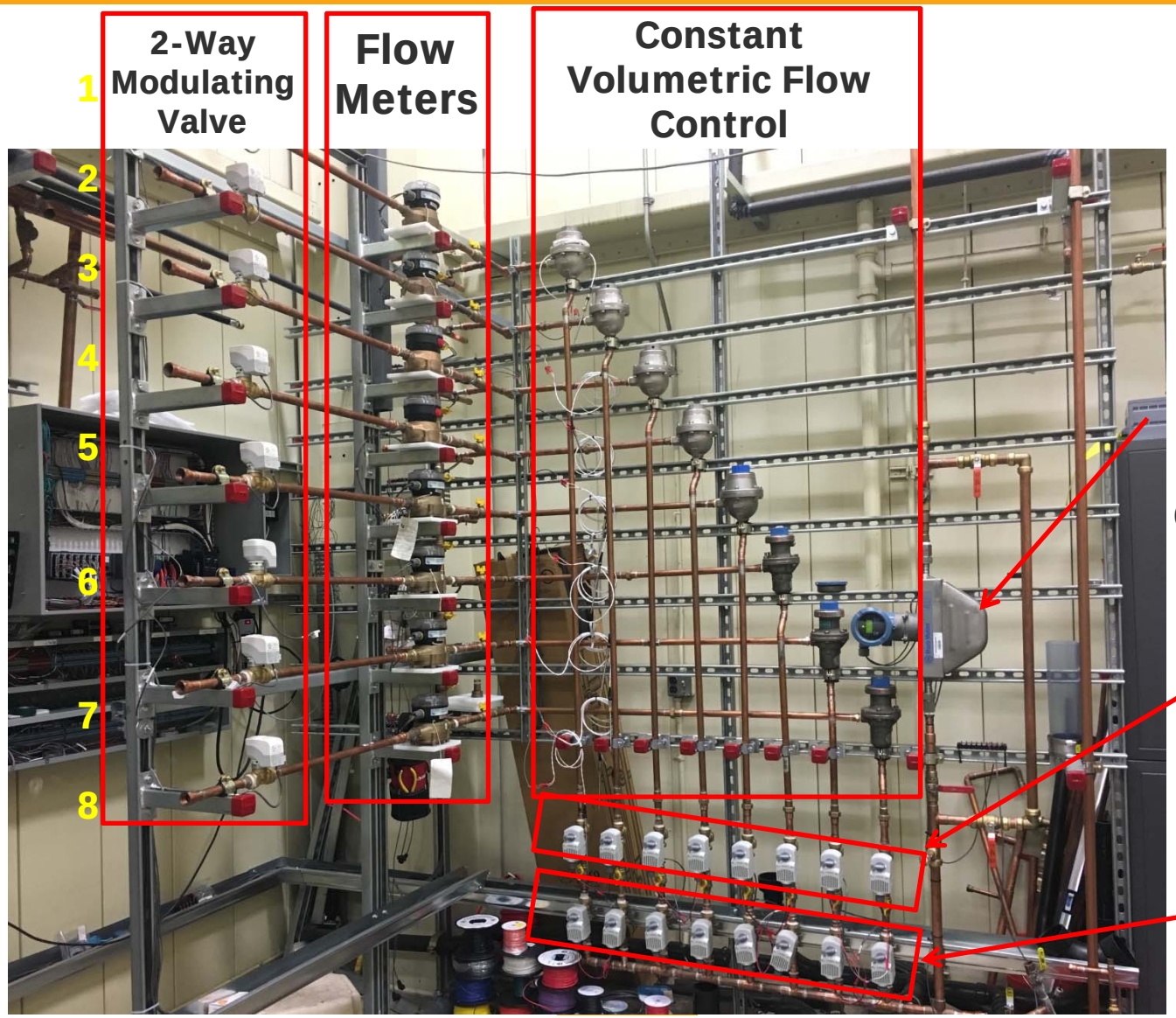


- Fisher-Nickel conducted field monitoring at a quick service restaurant to gather a high resolution 24-hour “real world” hot water use profile

Pacific Gas and Electric Company®

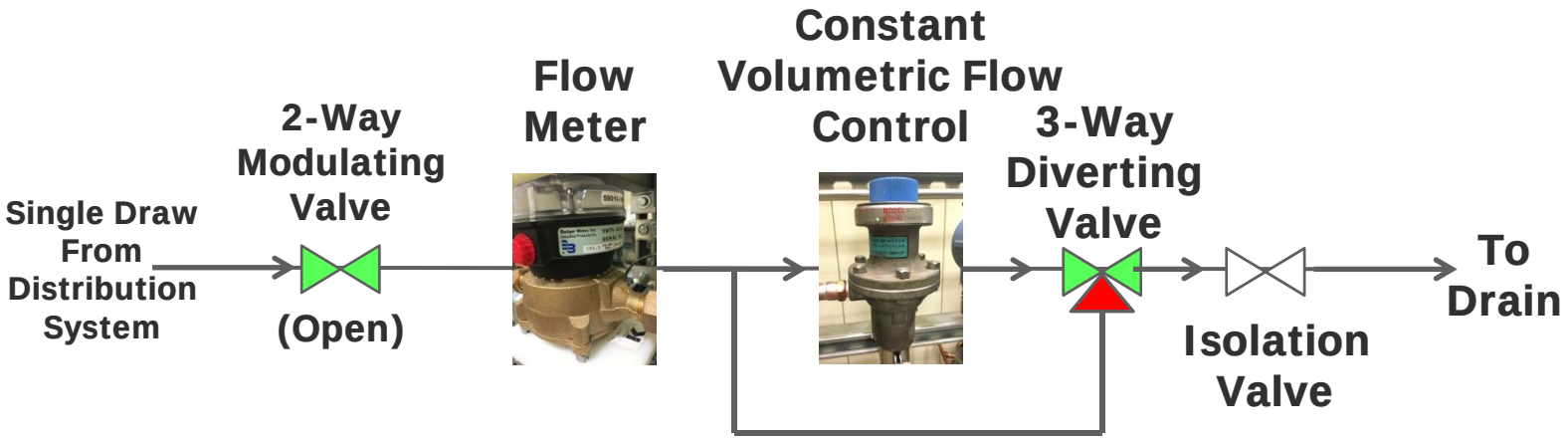
Hot Water Draw Simulation – Flow Measurement and Control (Constant, Staged and Variable Volume)

Hot Water Draw Simulation – Flow Measurement and Control (Constant, Staged and Variable Volume)



*ATS Likely to add additional end uses

Hot Water Draw Simulation – Flow Measurement and Control (Constant Volume Draws)

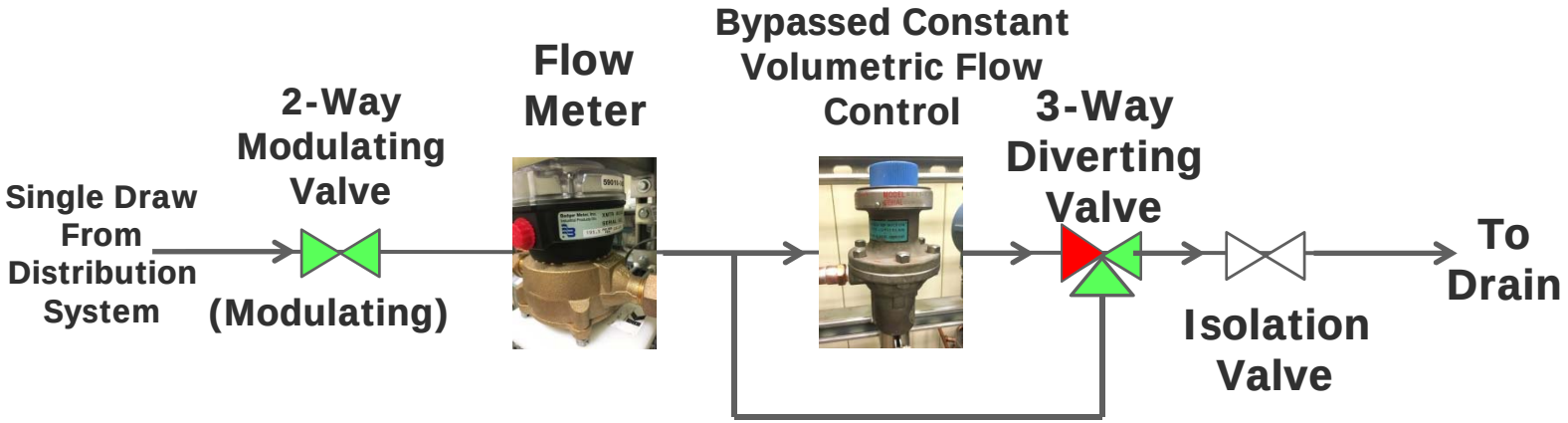


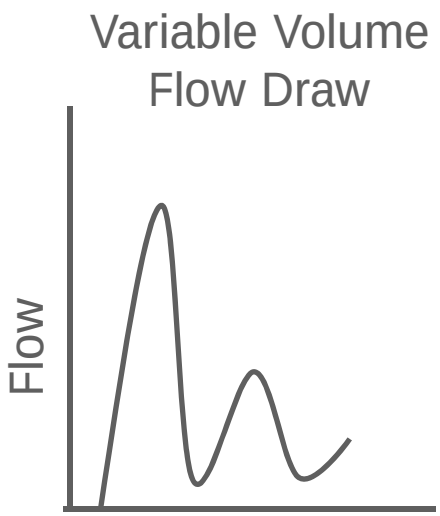
"Larger" Pressure Compensating Valve

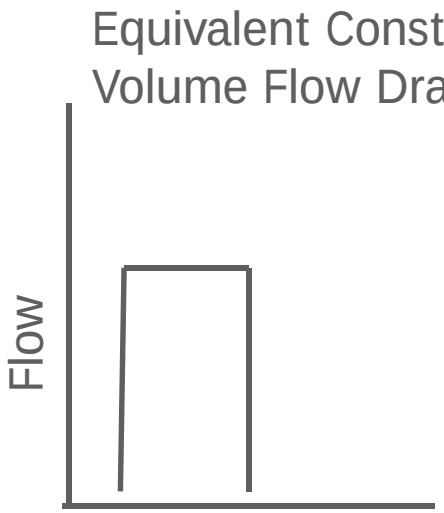
"Smaller" Pressure Compensating Valve

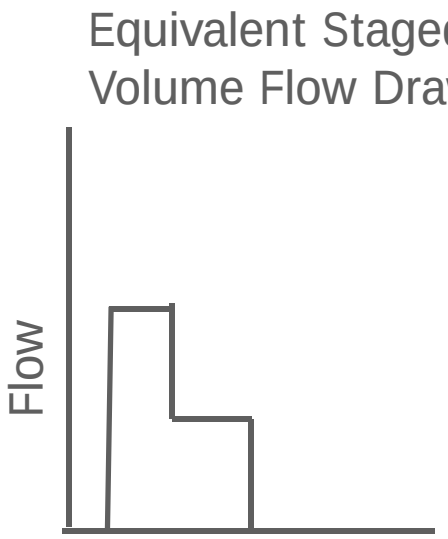
Volumetric Flow between
.2 – 3.0 gpm (smaller valves)
.7 – 20 (larger valves)

Hot Water Draw Simulation – Flow Measurement and Control (Variable Volume Draws) (Not Implemented Yet)









PG&E Applied Technology Services
Hot Water Technology Laboratory – Future Efforts

- Distribution system design and optimization
- Further drain water heat recovery testing
- Measurement of pressure drop in systems
- Central recirculation return on condensing tank-type water heaters
- What Else?

Thank You!

Questions?

EMHk@pge.com