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

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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)

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

End use Equipment Testing

- Vibration Analyses
- Non-Destructive Examination
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
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Drain Water Heat Recovery Test System Schematic
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Drain Water Heat Recovery Test Unit Mounted in Lab

Cold Side Outlet/Drain Side Inlet
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Drain Water Heat Recovery Test Unit Mounted in Lab

Cold Side Inlet/Drain Side Outlet
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Drain Water Heat Recovery Test DAS
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Drain Water Heat Recovery Testing DAS Front End
### Measurement Uncertainty and Heat Balance Error

The Heat Balance Error is given by the formula:

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

#### Heat Balance Error Uncertainty

<table>
<thead>
<tr>
<th>Test Parameter</th>
<th>Measurement</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASW flow (lbm/hr)</td>
<td>6,432,815</td>
<td>128,657</td>
</tr>
<tr>
<td>CCW flow (lbm/hr)</td>
<td>7,817,038</td>
<td>402,836</td>
</tr>
<tr>
<td>ASW inlet temp (F)</td>
<td>59.32</td>
<td>0.030</td>
</tr>
<tr>
<td>ASW outlet temp (F)</td>
<td>64.39</td>
<td>0.229</td>
</tr>
<tr>
<td>CCW inlet temp (F)</td>
<td>69.17</td>
<td>0.028</td>
</tr>
<tr>
<td>CCW outlet temp (F)</td>
<td>64.94</td>
<td>0.026</td>
</tr>
<tr>
<td>ASW side heat transfer (Btu/hr)</td>
<td>31,182,747</td>
<td></td>
</tr>
<tr>
<td>CCW side heat transfer (Btu/hr)</td>
<td>33,019,710</td>
<td></td>
</tr>
</tbody>
</table>

| 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
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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

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

Hot Water Supply

- Chiller
- Water Heater
- Tempering Tank
- Tempered City Water Loop Pump
- (Future) Residential/Other Units
- Commercial Units

Tempering System

City Water Tempering System

Hot Water Demand – Simulation of End Uses

Insulated PEX lines w/ thermal isolation at draw point from distribution system

Hot Water Supply

- Hot Water Distribution System

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Conditioning City Water - Tempering System

- Hot Water Tank
- 1.5 Ton Chiller
- Mixing Tank

![Tempering System Diagram](image)
Conditioning City Water - Tempering System

Lots of pumps, which are not shown

Tempering Tank

Chiller

Water Heater

To City Water Header

From City Water Header
Distribution System – Piping Rack
Fisher-Nickel conducted field monitoring at a quick service restaurant to gather a high resolution 24-hour “real world” hot water use profile.
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)

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Flow Meters

Constant Volumetric Flow Control

2-Way Modulating Valve

8 Simulated End Uses

1

Coriolis Mass Flow Meter (Collects all Flow For Comparison)

3-Way Diverter Valve (Throttling vs. Constant Volume)

Solenoid Isolation Valve

*ATS Likely to add additional end uses
Hot Water Draw Simulation – Flow Measurement and Control (Constant Volume Draws)

Single Draw From Distribution System

2-Way Modulating Valve (Open)

Flow Meter

Constant Volumetric Flow Control

3-Way Diverting Valve

Isolation Valve

To Drain

“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)
• 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?

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