How Pre-Engineered Pump Stations Will Help Mainstream Geothermal HVAC

Commercial Track: Session 4
Learning Objectives

• Identify the difficulties of traditional pump station design and installation
• Learn how pre-engineered pump stations will streamline your projects
• Discover how a ground loop bypass can impact system efficiency
• Understand the benefits of pre-programmed controls and remote monitoring
Acknowledgements

• Steve Hamstra – Progressive AE

• George Denecke – Armstrong Fluid Technology

• Jason Shaw – Armstrong Fluid Technology

• Rich Mayhew – Armstrong Fluid Technology
Outline/Agenda

• Analysis of traditional pump station design and installation

• Introduction to pre-engineered pump stations

• Discuss system applications and benefits

• Importance of automated bypass feature
CHALLENGES

Making GSHP systems energy efficient

...and simple
CHALLENGES

Increasing the adoption of GSHP systems

...while making them cost effective
WHAT IF...

Installing a more energy efficient, pre-engineered system could help mainstream geothermal
WHY DOES IT MATTER?

Every other HVAC system uses pre-packaged products
WHY DOES IT MATTER?

26%  
Average GHX Cost

74%  
Average Interior HVAC Cost

So let’s focus on what we can control in the HVAC cost!
12%

Cost of pumps, expansion tank, air venting, equipment installation and controls on typical GSHP project
WHAT’S STOPPING YOU?

Time-intensive, inefficient, error-prone, typical pumping stations
TYPICAL PUMPING STATION

The Problems:

• Custom engineering is expensive
• Field assembly is timely and error prone
• Controls are typically installed later by a separate controls contractor
• Results in a large footprint
• Not always visually pleasing
• Results in sub-optimal performance
THE SOLUTION:
Pre-Engineered Pumping Stations

Affordable. Instinctive. Quick.
STORY BEHIND THE INSPIRATION
PRE-ENGINEERED PUMP STATIONS

- Pre-Engineered & Factory-Assembled + Tested
- Standard Package Sizes for Easy Selection (100-800 GPM)
- Compact Dimensions for Space Savings
- Plug-n-Play Electrical & Plumbing Connections
- Potential for Web-Enabled Remote Monitoring & Control
- Potential for Intelligent Variable-Speed Drives & Bypass for Optimal Savings
AUTOMATIC GHX BYPASS

• Closes valves to the ground loop when conditions are right, thereby reducing system pressure drop

• Ensures optimal energy efficiency
  • When engaged, reduces pump energy by 50-75%
  • Reclains heat from different building zones
THE DETAILS:
What goes in to a pumping station?
INTEGRATED COMPONENTS

Additional Components:

- Grooved piping connections
- 3 Flush and purge connections
  - Ground, Building, and Ground+Building
- Water makeup train connected to PLC
ASHRAE 90.1 is an energy standard for buildings. It provides the minimum requirements for the energy-efficient design of buildings. Most North American building codes have adopted ASHRAE 90.1 standards. The 2010 version was adopted by many North American building codes as of October 2013.
Traditional pumps are designed for best efficiency operation here.
ASHRAE 90.1 PUMPING REQUIREMENTS

ASHRAE 90.1 - 2013 - 6.5.4.5 Hydronic (Water Loop) Heat Pumps and Water-Cooled Unitary Air Conditioners

- 6.5.4.5.1 Each hydronic heat pump . . . Shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

- 6.5.4.5.2 Hydronic heat pumps and water-cooled unitary air conditioners having a total pump system power exceeding 5hp shall have controls and/or devices (Such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow.

PUMPS SERVING HEAT PUMP LOOPS MUST BE ABLE TO SAVE AT LEAST 70% OF THEIR ENERGY UPON 50% TURN DOWN!
How do we meet ASHRAE 90.1 requirements for pumps (30% Energy Usage at 50% Flow)?

By taking advantage of the pump affinity laws and quadratic speed control:

**AFFINITY LAWS: influence on volume, pressure and bhp.**

For variations in impeller diameter, at constant speed:

\[
\begin{align*}
D_1 &= Q_1 = H_1 \\
D_2 &= \sqrt{Q_2} H_2 \\
\text{BHP}_1 &= D_1^3 \\
\text{BHP}_2 &= D_2^3
\end{align*}
\]

For variations in speed, with constant impeller diameter:

\[
\begin{align*}
S_1 &= Q_1 = H_1 \\
S_2 &= Q_2 = H_2 \\
S_1^3 &= \text{BHP}_1 \\
S_2 &= \text{BHP}_2
\end{align*}
\]

If Speed is reduced 10% → Head is reduced by 21% → BHP is reduced 33%

Where:
- \(D\) = Impeller Diameter (Inches)
- \(H\) = Pump Head (Ft)
- \(Q\) = Pump Capacity (gpm)
- \(S\) = Speed (rpm)
- \(\text{BHP}\) = Brake Horsepower (Shaft Power - hp)
ASHRAE 90.1 PUMPING REQUIREMENTS

• Is it hard to meet ASHRAE 90.1 requirements for pumps (70% Energy Savings at 50% Flow)? **YES IT’S HARD:**

**DOES NOT MEET ASHRAE 90.1**

- 400 GPM @ 100 Ft Hd: 15.11 HP Duty Pt
- 200 GPM @ 55 Ft Hd: 5.07 HP at 50% Flow
- 66.4% Energy Savings – Falls Short!

**MEETS ASHRAE 90.1**

- 400 GPM @ 100 Ft Hd: 13.53 HP Duty Pt
- 200 GPM @ 55 Ft Hd: 3.84 HP at 50% Flow
- 71.6% Energy Savings!
Pumps and Pumping technology has changed more in the last 10 years than in the 50 years previous.

We have seen the advent of intelligent, self monitoring, internet connected variable speed pumps that automatically meet hydronic system demand without any external feedback.

Complete pre-tested and programmed variable speed pumps operate on a plug and play basis within the hydronic system.

Wireless internet connectivity for remote trending, analysis, alarms, and troubleshooting.
INTELLIGENT SENSORLESS PUMPS

• Lowest installed and lowest operating cost
• Built in parallel sensorless programming enables the most efficient pump operation on the market place
• Increased efficiency (improvement of 3-6% on hydraulic and 2-7% on iECM motor)
• Auto-commissioning for simple start-up
• Lighter and smaller footprint pumps
• No dP sensor required
• Easier to service
• Option for on-line troubleshooting during warranty with extended warranty with registration and Internet connection
• “App” to assist with pump start up and adjustments when away from the office
• On board trends for easier troubleshooting – wifi enabled!
INTELLIGENT SENSORLESS PUMPS

Mimics the performance of a sensor by pre-programming pump curve characteristics into the integrated controls.

4 Key parameters

• FLOW
• HEAD
• POWER
• SPEED
INTELLIGENT SENSORLESS PUMPS
Selections save energy and cost

<table>
<thead>
<tr>
<th>Design point</th>
<th>72%</th>
<th>68%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average load</td>
<td>68%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Often saves 7% in pump cost and 14% in energy costs
INTELLIGENT SENSORLESS PUMPS

3 parameters to adjust Sensorless control curve on site

Constant flow or pressure also can be available
INTELLIGENT SENSORLESS PUMPS

Flow meter savings and superior control

• Ability for digital flow readout and communication to BMS
• Min./max. settings for pump flow output
• Intelligent pumps can control 2 way bypass valves for critical flow equipment protection

Readout accuracy +/− 5%
Edmonton International Airport estimated $25,000 savings in re-selections during construction phase alone.
INTELLIGENT CONTROL SYSTEM

- Web-Enabled for Remote Monitoring & Control

- Monitor:
  - Loop Temperature
  - Flow Rate
  - Energy Use
  - Bypass Status
  - DP across Pump
  - Water Makeup Train
THE APPLICATIONS:
How will they perform?
WHAT TYPES OF SYSTEMS?

- Distributed Water-Source Heat Pump (WSHP) systems
  - With multistage or single stage heat-pumps
  - Must include zone valves!

- Buildings with load diversity

- Buildings with widely varying demand

- Buildings that are coming online in stages

- Clients that want to showcase GSHP energy savings
Central vs. Distributed Pumping Example – 250 Ton Geo System

Central Pumping

- 1 - 25 hp central pump
  - 50% Wire to Water efficiency
  - Equipped with VFDs

- @ 50% Load:
  - 1 pump at 3.13 hp (affinity laws)

Energy Demand = 4.66 kW

Distributed Pumping

- 100 - ¼ hp wet-rotor circulators
  - 25% Wire to Water efficiency
  - On/Off Operation

- @ 50% Load:
  - 50 pumps at ¼ hp

Energy Demand = 18.64 kW

Central pumping system uses 75% less energy!
• Easy selection and specification
  • Just select from catalogue and receive 3-part spec
  • Drag and drop from Sweets
• More adaptable and flexible solution
• Reduce installation risk
• More compact mechanical room
• Energy monitoring verifies your design performance
• Make your projects more profitable
INSTALLATION BENEFITS

- 5 Piping Connections
  - (Including water make-up train)
- 1 Electrical Connection
- Less change-orders & site revisits
- Easier project quoting
- Innovative product that differentiates you in the market
MONITORING BENEFITS

• Track long term performance of the ground loop via loop temperatures and flow rates

• Create personalized energy savings reports via energy usage and bypass status

• Alert your clients to problems before they know they exist
  • High/Low Loop Temps
  • System leaks
  • Pump Failure
MONITORING BENEFITS – CASE STUDY

- Pending Steve Hamstra
Closes valves to the ground loop when conditions are right, thereby reducing system pressure drop.

Ensures optimal energy efficiency.
BYPASS ENERGY SAVINGS

- Case Study:
  - 70 Ton Office Building
  - 35,000 Square Feet
  - Midwestern United States

<table>
<thead>
<tr>
<th></th>
<th>Warm</th>
<th>Shoulder</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bypass Engagement %</td>
<td>8.1%</td>
<td>40.6%</td>
<td>55.3%</td>
</tr>
<tr>
<td>Average Bypass Duration (hours)</td>
<td>1.06</td>
<td>1.72</td>
<td>2.04</td>
</tr>
<tr>
<td>Bypass Activations / Day</td>
<td>1.88</td>
<td>5.12</td>
<td>6.50</td>
</tr>
</tbody>
</table>
• Time Period: Winter

• Most exterior zones are heating
  • Heat is being taken from the water loop

• Most interior zones are cooling
  • Heat is being added to the water loop

• Heat from the interior zones can be reclaimed for the exterior zones
  • Water is not required to flow through ground loop

• Result: Ground Loop is bypassed and pump energy is reduced
BYPASS ENERGY SAVINGS

8AM – 5PM (Workday)

Loop Supply Temperature

Time

Loop Temperature
BYPASS ENERGY SAVINGS

8AM – 5PM (Workday)

Simultaneous Heating and Cooling

System “Recharge”

Bypass is activated 88% of the time!
• Time Period: Unoccupied hours
• Most zones may have temperature setback and will not operate for several hours
• Server room requires constant cooling
  • Requires the pump to operate at a minimum speed of 30% to ensure flow
• Ground Loop is not required during all unoccupied hours
• Result:
  • Ground Loop is bypassed for a majority of unoccupied hours and pump energy is reduced
  • Ground Loop bypass will be opened when needed
BYPASS ENERGY SAVINGS

5PM Friday – 5AM Monday
BYPASS ENERGY SAVINGS

5PM Friday – 5AM Monday

Bypass is activated 98% of the time!

Steady Cooling Load (server room)

Quick Heating Load (heat pump kicks on)
BYPASS ENERGY SAVINGS

5PM Friday – 5AM Tuesday
BYPASS ENERGY SAVINGS

Bypass is activated for 85 straight hours!

5PM Friday – 5AM Tuesday

Simultaneous Heating and Cooling

Steady Cooling Load (server room)
Conclusion

• Easily connect ground and building loop

• Eliminate custom design and installation costs

• Save energy and monitor for peace of mind
Questions?

Steve Melink
smelink@melinkcorp.com

Melink® GEO
Gen 5 – OEM Sales Presentation
Sensorless control

Mimics the performance of a sensor by pre-programming pump curve characteristics into the integrated controls.

4 Key parameters
- FLOW
- HEAD
- POWER
- SPEED
Design Envelope Pumping – Mapped into Controller
HIGH LEVEL BENEFITS: 1-10 HP

• Lowest operating cost
  • Tango with built in parallel sensorless will be the most efficient pump on the market
  • Increased efficiency (improvement of 3-6% on hydraulic and 2-7% on motor)

• Lower installed cost
  • Auto-commissioning for simple start-up
  • Lighter and smaller footprint pumps

• Easier to service
  • Option for on-line troubleshooting during warranty with extended warranty with registration and Internet connection
  • “App” to assist with pump start up and adjustments when away from the office
  • On board trends for easier troubleshooting
  • Optional diagnostic and monitoring services (Q2)
HVAC IS A PART-LOAD INDUSTRY

90% of the time
10%-60% of design load
Traditional pumps are designed for best efficiency operation here.

Pumps should be designed for BEST EFFICIENCY operation here.

BUILDING LOAD PROFILE
DESIGN ENVELOPE ADVANTAGES
Selections save energy and cost

<table>
<thead>
<tr>
<th></th>
<th>Wall-mounted VFD</th>
<th>Design Envelope Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional pump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with design point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to the left of BEP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8” pump</td>
<td>6” pump</td>
</tr>
<tr>
<td>Design point</td>
<td>72%</td>
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</tr>
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<td>Average load</td>
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</tr>
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Often saves 7% in pump cost and 14% in energy costs
Typical sensor locations

- Mechanical room
- Remote load
- Other
One method is to install the sensor at the most remote load (1).

Another option is to install it in the mechanical room (2).

Possible sensor locations:
- Most remote load
- Mechanical room
SENSOR LOCATION - MECHANICAL ROOM

- Minimum head is the same as the design head
- Doesn’t result in much energy savings at 50% load flow
- Configuration won’t meet the ASHRAE 90.1 energy standard
- Very simple to install

Diagram:

- Point A: Design Point
- Point B: Minimum Head

Graph:

- Design Speed
- 50% Load Speed
- Control Curve
- System
- 50% Load Flow
- Design Flow

Image:

- Cooling coils (Typical)
- System with DP Sensor
- Pumps
SENSOR LOCATION - REMOTE LOAD

- Configuration provides tremendous energy savings, meeting ASHRAE 90.1 standard for energy efficient operation
- Difficult to install
Differential pressure sensors issues

- Sensor acquisition, installation and controls wiring
- Incorrectly installed sensors
- Sensor installed in the wrong location
- Incorrect range for pressure or setting
- Incorrectly set
- Easily damaged during construction
- Subject to setting drift
- Subject to site shortages
Sensorless control can provide the same performance as a remote load sensor (Row E).

### Operating Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Pump</th>
<th>Power</th>
<th>Incremental Energy Savings</th>
<th>Cumulative Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>• Constant Speed Throttled</td>
<td>32.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Described in slide 15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Traditional method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>• Reduced Speed Unthrottled</td>
<td>27.11</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>• Constant Flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>• Reduced Constant Speed</td>
<td>19.36</td>
<td>29%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>• Variable Flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>• Variable Speed</td>
<td>14.35</td>
<td>26%</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>• Variable Flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mechanical Room Sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>• Integrated Control Pump</td>
<td>7.32</td>
<td>49%</td>
<td>77%</td>
</tr>
<tr>
<td></td>
<td>• Remote Load Sensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sensorless</td>
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</table>

Points A and B are at the design flow. Points C, D, and E are 50% of design flow. Note that only E is able to meet the ASHRAE 90.1 standard for 70% energy savings at 50% of design flow.
Using a quadratic pressure control (QPC) control curve can yield more than 25% energy savings at part-load over a proportional pressure control (PPC) control curve at part-load.

25%+
Energy Savings at 50% Design Flow
Edmonton International Airport estimated $25,000 savings in re-selections during construction phase alone.