Design/Commissioning Tips for Variable Speed Pumping Systems
Differential Pressure Transmitters

The main goal of the secondary chilled water system is to distribute the correct amount of water to satisfy the load. It must first accurately monitor the system for changes in load dynamics.

Secondly, it must respond to these load changes with the “correct” amount of flow.

Typically a differential pressure sensor is the device chosen for feedback in a building management system.

### Differential Pressure Transmitter Types

<table>
<thead>
<tr>
<th>Photo</th>
<th>Mfg. Name</th>
<th>Model No.</th>
<th>Accuracy</th>
<th>Differential Pressure Range</th>
<th>Burst Pressure</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="photo1.png" alt="Image" /></td>
<td>Taco</td>
<td>DPS629</td>
<td>+/- 0.5% FS</td>
<td>0-25 psid</td>
<td>250 psi</td>
<td>4-20 mA</td>
</tr>
<tr>
<td><img src="photo2.png" alt="Image" /></td>
<td>Taco</td>
<td>DPS3100</td>
<td>+/- 0.075% FS</td>
<td>1-100 psi</td>
<td>10000 psi</td>
<td>4-20 mA</td>
</tr>
</tbody>
</table>
**NOTES:**
- Material of construction as required by application.
- DP Transmitter may be wall mounted or pipe stand mounted.
- Orientation of DP XMTR and pipes has no effect on performance.
- Gauges can be rotated for best viewing.

It is critical that the design engineer tell the installing contractor WHERE in the system they would like the sensors installed. This is most easily done with a small schedule indicating which terminal unit the engineer wants.
Differential Pressure Transmitter Quantity

Quantity:

Three sensors can provide a very accurate picture of system demand.

- One for the longest run
  (Student dorm or remote part of East Campus)

- One for the dominant load
  (New basketball arena in Central Campus)

- One for another zone
  (Administrative office located in remote part of West Campus)

For buildings with a very asymmetric layout, other sensors may be added to monitor each zone.

**TIP:** Provide three way valves or bypass at remote points of the system.
Determining Differential Pressure Setpoint

The sensor must keep enough pressure differential across the supply and return to “push” the design capacity flow through the coil and control valve.

Setpoint = Sum of coil pressure drop + control valve pressure drop at design conditions (17’)

\[ \text{Setpoint} = \text{Sum of coil pressure drop} + \text{control valve pressure drop at design conditions} \]
Sensor Placement

Whether the Dp sensor is located at the pump discharge or the end of the pipe loop with the highest head does not affect the ability of the pumps to move the design flow. However, it **dramatically affects the amount of energy consumed by the pumps**.

A ∆P sensor located near the pump discharge will save very little energy. The setpoint must be equal to the pressure drop through all the coils, control valves and connecting piping downstream of the sensor at design flow. This value is only slightly less than the pump’s design head. The shaded area represents the energy savings compared to constant speed pumps.

![Sensor Location 80' setpoint (Across Pump)](image)
A ΔP sensor located at the furthest most significant load will save the most energy. Its setpoint must be equal to the pressure drop through the single coil, control valve and connecting piping downstream of the sensor at design flow. This will be about 17’ like our example on the previous page. Again the shaded area is how much energy can be saved compared to constant speed pumps.
Minimum Allowable VFD Speed

A good rule of thumb for 1750 RPM applications is that the minimum allowable VFD speed should be no less than 15Hz (25% max speed).

The primary reasons are:

1. Protect the seal from premature failure
   A minimum speed is required to overcome the spring compression forces between the stationary and rotating elements. Additionally, it must overcome the difference in pressure between the system fluid and atmosphere. There are speeds at which the seal spring (or large differential pressure) forces the two seal faces closed and forces out all of the fluid necessary for lubricating and cooling. Operating in this condition is equivalent to running the seal dry.

A good rule of thumb for 1750 RPM applications is that the minimum allowable VFD speed should be no less than 15 Hz. Preferably 20 Hz. The equivalent rule of thumb for 1150 RPM minimum VFD speed is 25Hz.
2. **Below 15hz (25% max speed) is unlikely to move water out of the mechanical room**

According to the pump affinity laws, flow is proportional to speed and head is proportional to speed squared. When you run a pump at ¼ speed or 15hz, you can only generate 1/16 of the pump’s head.

\[ \frac{1}{4^2} = \frac{1}{16} \]

1/16th of the head is unlikely to even move the water out of the mechanical room.

*Energy reduction at 1/4 speed = 1/4^3 or 1/64 of design HP.*
*This is the realistic lower end of turn-down.*

3. **Specialty Pump Exceptions**

Some pumps such as vertical turbines require water to lubricate journals and bearings. Particularly vertical turbine pumps. The minimum speed must be set to move water up the height of the column and overcome any static head loss. There are times that this will be above the hz.
Establishing Minimum System Flow

The overall hydronic system and each of its major branches need a minimum amount of flow.

It is recommended to use a bypass with balancing valve or a three way valve at the end of each major zone for the following reasons:

• Prevents thermal stagnation.

• Increases the life of the pump by preventing dead-head or no-flow condition.

• Rule of thumb: Ensure there is at least 1/4 GPM per design HP to protect the pump at min speed.

Note: More flow will be required if you are trying to protect against dead head on a full speed situation.
Design tips for flow meters

Use a Flow Meter for:

- Accurate Staging
- End of Curve Protection
- Shut Off Protection
- Best Efficiency Control
Pump staging with flow

- Here we show 2 pump parallel operation.
- Note the pumps are selected to allow the single pump curve to intersect the system curve.
- If the system flow increases beyond the single pump intersection point (a), the system will see a drop below the system setpoint and initiate the lag pump start.
Liquid Flow Sensor Installation Detail

NOTES:

• Refer to instruction manual for mechanical installation details.

• Orientation (Horizontally preferred).

• Locate for use in full pipe (Make sure to eliminate air).

• “A” Upstream — 10 pipe dia. length of straight rin pipe with no restrictions, enlargements, valves, couplings or other intrusions.

• “B” Upstream — 5 pipe dia. length of straight rin pipe with no restrictions, enlargements, valves, couplings or other intrusions.
Common Problems

Most systems are set up with the following problems:

• Incorrect pressure sensor installation
• Incorrect pressure sensor setpoint
• Air not bled out of sensor
• Control loops detuned to handle all situations
Differential Temperature

- Delta-T lends itself to even more cost effective variable speed pumping.
- The issues associate with placement and of Delta-T sensors is replaced with ease and simplicity of thermistors.
- As the Delta-T falls below setpoint, the pumps would slow down.
- As the Delta-T rises above setpoint, the pumps speed up.
- Remember that \[ \text{BTUH} = \text{GPM} \times \Delta T \times 500 \]

Temperature Sensor

TRP1 Series Sensor is a thermistor type 10K Ohms (Type III) sensor. The TRP1 Series is a stainless steel bullet probe which is 1/4” in diameter and 1” long with a 24” wire leads. Output: 10K Ohm @ 77°F.