



Guide to tuning Proportional / Differential Gain settings for Vindum Pumps

Vindum Pumps use the **Open-Valve Proportional Gain and Open-Valve Differential Gain settings** as inputs to the PID algorithm (proportional-integral-differential algorithm) that tells the pump how fast to accelerate and decelerate the active piston to reach the target pressure. Due to different system sizes and fluid compressibility, it's often necessary to "tune" the Prop. Gain and Diff. Gain values so that the pump quickly reaches the target pressure without "overshooting or cycling-around" the target pressure.

When working in "Paired Pressure" pump modes, the goal is to reach the goal line (ie, target pressure) as quickly as possible without overs-shooting the goal line. The Open Valve Proportional and Differential Gain settings on the "Pump Configure" screen are the tools to do this:

- **Open Valve Proportional Gain is like the "Accelerator Pedal" on a car** (increasing it increases piston acceleration).
- **Open Valve Differential Gain setting is like the "Brake Pedal". Increasing the Open Valve Differential Gain setting causes the piston to slow as the target pressure is approached**, so higher Diff Gain value applies more braking force and sooner, as the target pressure is approached.

The attached graph shows the influence these two values on a "system" made of a 3 ft 1/16" capillary tube. With target pressure is 1000 psi, the pump is started and pressures are measured every second. The green line shows the pressure curve associated with the default Open-valve Prop. & Diff. Gain values (3, 400, respectively). Since it was taking a relatively long time for the pump to reach the target pressure of 1000 psi, I increased both Prop & Diff Gain values by 10X (orange line). The higher Proportional Gain value (30 vs. 3 original setting) makes the pump accelerate more quickly and the it's able to reach the target pressure faster. With further experimentation I was able to reach the target pressure very quickly, about 8 seconds (see red line on graph). This was accomplished by lowering the Open Valve **Differential Gain** setting (ie, "the brake")... Lowering this value causes the piston to decelerate later/less (ie, less brake force/less and I was able to get to the 1000 psi target pressure quickly and without overshooting it. The blue line on the graph shows that an even lower Open-valve Differential Gain setting was too low... The cylinder pressure spiked over 1000 psi and took more time to settle out to 1000 psi. As you can see, using these concept and with a bit of experimentation, it's possible to adjust the Open Valve Proportional and Differential Gain values so that you can reach target pressure in an efficient manner.

The **Closed Valve Proportional & Differential Settings** work exactly the same way, except that they are used to determine how the closed cylinder is repressurized after filling with fluid. Recall that after filling with fluid, the valves on the passive piston close and the piston repressurizes the passive cylinder to match the pressure of the active cylinder (so that there is no pressure pulse at cylinder "switch-over"). Typically, you will not need to adjust the Closed Valve P&D Gain values if you allow enough time for the passive cylinder to refill and have 10-12 seconds to repressurize (ie, increase the return-rate multiplier value). However, if working with compressible fluids or gases, you may find that the passive cylinder is not able to pressurize to the same pressure as the active cylinder before cylinder switch-over. If you are not able to resolve this by increasing the return rate multiplier (to allow more time for the passive cylinder to refill and repressurize), then you can tune the Closed Valve Prop. & Diff. settings in the same manner as described above. You may also need to adjust the Closed Valve settings if working with a very small system and/or low pressure and find that the passive cylinder is over-pressuring (ie, exceeding the pressure of the active cylinder and not stabilizing before cylinder switch-over). In these cases, decreasing the Closed Valve Prop value and/or increasing the Closed Valve Diff setting will decrease the chance of the passive cylinder over-pressuring.

One last note: The Open Valve P&D gain settings are not really used for "Paired Rate" modes, since rate is the target (not pressure), but the Closed Valve P&D settings do matter because, after filling, the passive piston still pressurizes to match the pressure of the active piston, even in paired rate modes.

