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Pressure Regulating Valve Pilot Characteristics
2-Way vs. 3-Way Pilots

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Pressure regulation valves, with 3" – 6" diameters, are commonly found at the entrance to agricultural irrigation blocks and manifolds. These valves are typical of a "hydraulic" design, in which a chamber above a flexible disc/diaphragm is filled or emptied. As the chamber is filled or emptied, the irrigation water passes through a smaller or larger orifice, and the pressure downstream of the valve is lowered, increased, or maintained at a constant target pressure. The flow in/out of the chamber is controlled by a small "pilot valve". The characteristics of these pilot valves are discussed here, in general terms. Of course, there are always variations and some pilots are sold as some type of combination 3-way/2-way design.

Knowing something about pilot valve operation is important because the pressure losses across pressure regulation valves are often different with and without a pilot valve attached. Manufacturer pressure loss curves, if developed without a pilot valve attached, may grossly under-represent the actual pressure loss across a valve in the field.

The design of a pilot valve is also very significant in determining if the valve will display hysteresis, and how well the valve will maintain a set pressure if the flow rate changes, or if the upstream pressure changes.

ITRC provides these notes based on discussions with valve representatives and upon results seen in hydraulic valve testing at ITRC laboratories.

3-Way Pilots

- A 3-way pilot allows the valve to be operated with a pressure loss equivalent to an open valve body. When fully open the pilot itself does not inherently introduce additional friction loss.
- In "auto mode" the 3-way pilot controls the flow of water (i.e., pressurizing) to the top of the valve diaphragm in **three discrete operations.** These operations are based upon a three-way spool inside the base of the pilot valve with these functions:
  - **Closing the valve**: When the downstream pressure, acting on the pilot diaphragm, can overcome the pilot spring force, the spool moves and connects the upstream pressure to the bonnet.
  - **Static:** When the downstream pressure, acting on the pilot diaphragm, matches the pilot spring force, the spool moves into a static mode.
  - **Opening the valve:** When the downstream pressure, acting on the pilot diaphragm, creates a thrust force less than the pilot spring pressure, the valve **vents/empties the bonnet to atmosphere**. If the valve continues to open, the bonnet pressure can be decreased to atmospheric pressure, which allows the valve to fully open.

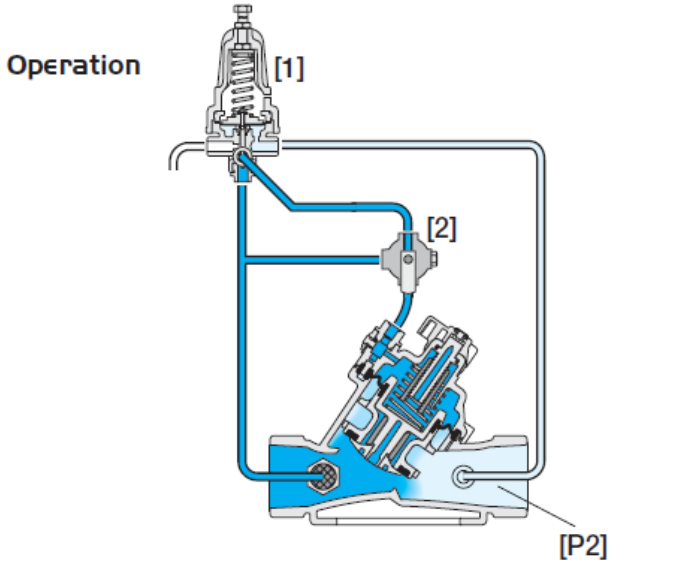

Figure 1. Bermad plumbing diagram from 100-series manual

- The problem with this design is that it is very difficult to maintain a constant downstream pressure as the inlet pressure changes. A "good" performance for these valves is an ability to hold within +/- 1 to 1.5 psi when they are turned on and off.
- For a 9 psi emitter (avg. field P), this variation can cause a drop in field (system) DU from an expected 0.93 down to as low as 0.88.
- Hypothetical control characteristics as a function of bonnet pressure in time can be seen in Figure 2.

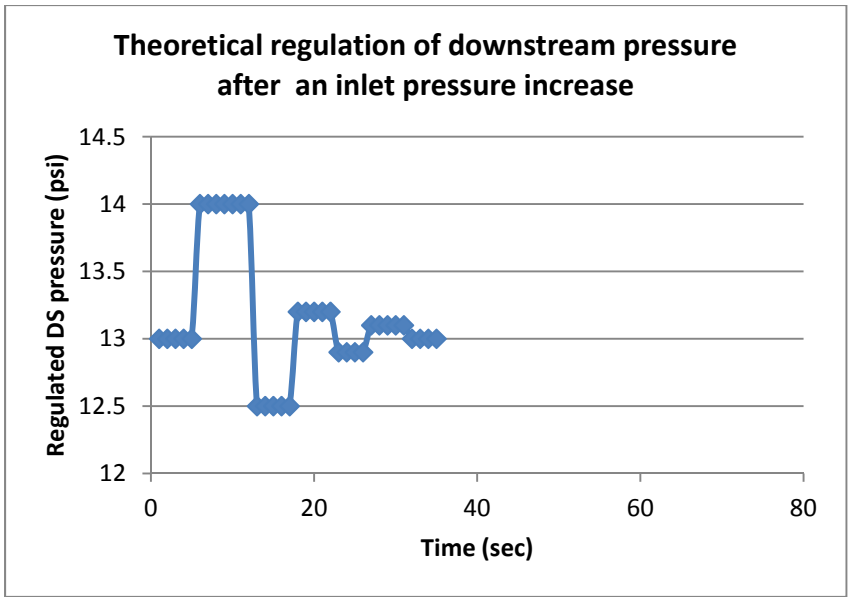

Figure 2. Theoretical regulation of downstream pressure after an inlet pressure increase

- The best way to set 3-way pilots is to first adjust the pilot valve to obtain the target downstream pressure. Then shut off the valve. Then turn the valve on again and check the pressure. If it is not yet at target, repeat the procedure until it is correct.
- For both 3-way and 2-way pilots, it is recommended to install the downstream sensing tube 1-2' downstream of the valve in conditions where velocities through the valve body are excessive. That is, remove the tubing from the typical downstream sensing location, plug that hole, and install extended tubing to the new, more downstream position. This can be seen in Figure 3, where the downstream pressure connection point is a tee downstream of the valve.

Figure 3. Example of extended tubing

2-Way Pilots

- A 2-way pilot introduces considerably more friction loss in the valve. It keeps the valve diaphragm partially closed even when it is "wide open".
- In "auto mode" the 2-way pilot controls the flow of water (i.e., pressurizing) to the top of the valve diaphragm in **two discrete operations.** These operations are based upon a two-way spool inside the base of the pilot valve with these functions:
  - **Closing the valve**: When the downstream pressure, acting on the pilot diaphragm, can overcome the pilot spring force, the spool moves and connects the upstream pressure to the bonnet.
  - **Opening the valve:** When the downstream pressure, acting on the pilot diaphragm, creates a thrust force less than the pilot spring force, the spool moves and **vents the bonnet to the downstream side of the valve**.
- Because the 2-way pilot must vent to a pressurized downstream port, the valve is not able to **fully** open, creating an inherent minimum loss across the valve.
- With 2-way pilots, the bonnet pressure is continuously being pressurized and vented, requiring a small but consistent flow through the pilot/bonnet. This creates an increased potential for plugging of the upstream tubing filter.
- The advantage of some 2-way pilots is that there is virtually no hysteresis. Additionally, if the inlet pressure changes, the discharge pressure does not change much.

As an example of available manufacturer information, Bermad publishes losses through valves with 3-way pilots without pilots (as the valves can fully open). However, for valves with 2-way pilots, Bermad publishes similar valve loss tables with a "2-way circuit ADDED HEAD LOSS" for velocities under a given threshold (see Figure 4).

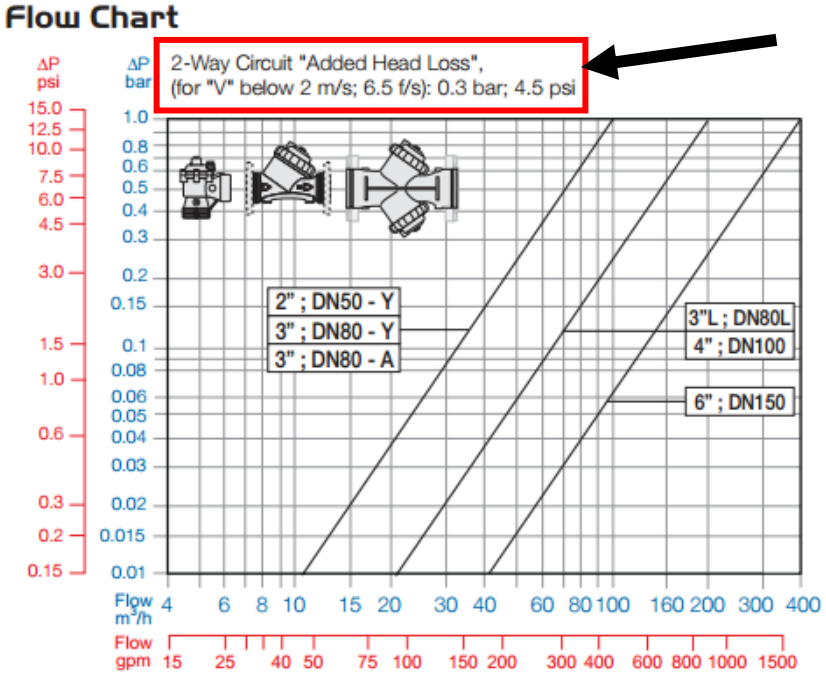

Figure 4. Flow chart for Bermad 100 series Hyflow, pressure reducing valve