Pressure Regulators

Agenda

Swagelok

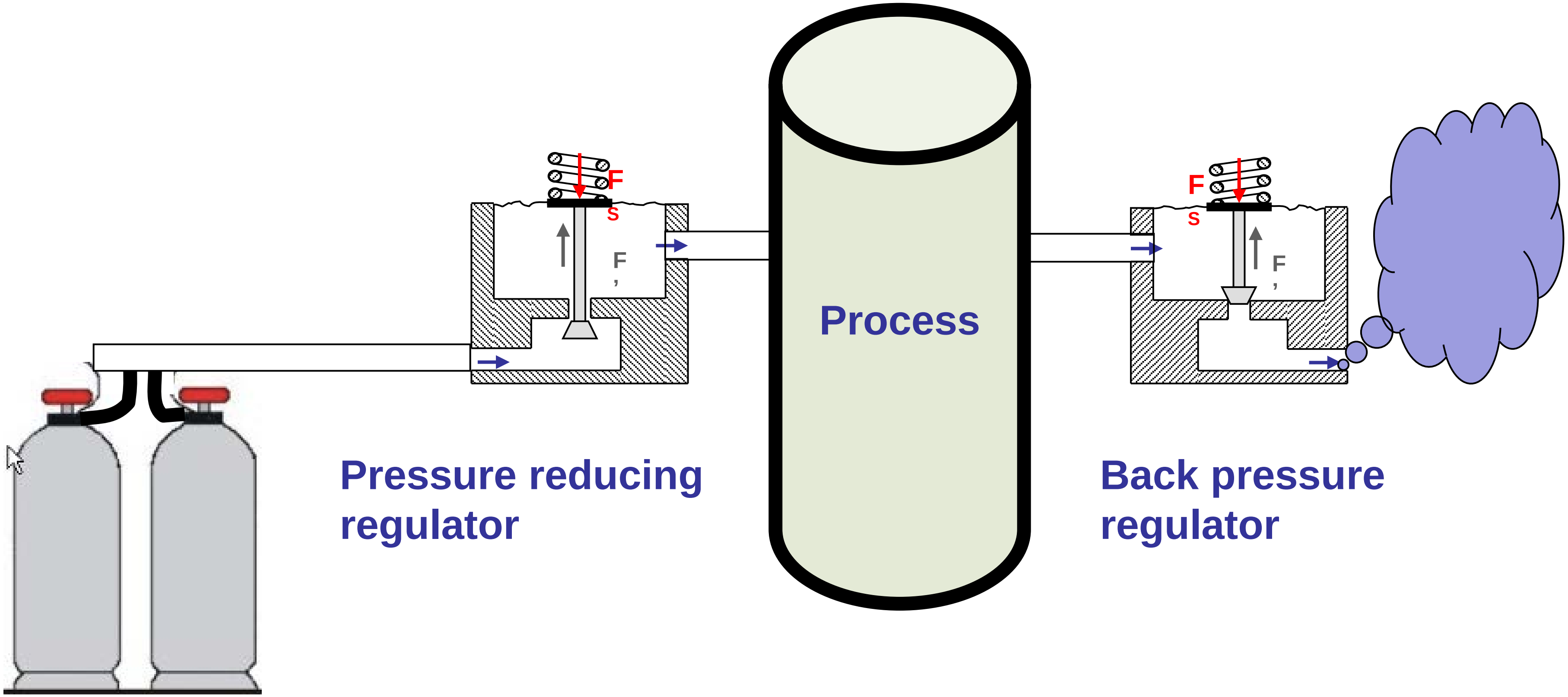
- Theory of Regulators
- Pressure Regulator Performance
  - Lock-up
  - Droop
  - Choked Flow
  - Creep
  - Supplied Pressure Effect
  - Joule Thompson

Theory of Regulators

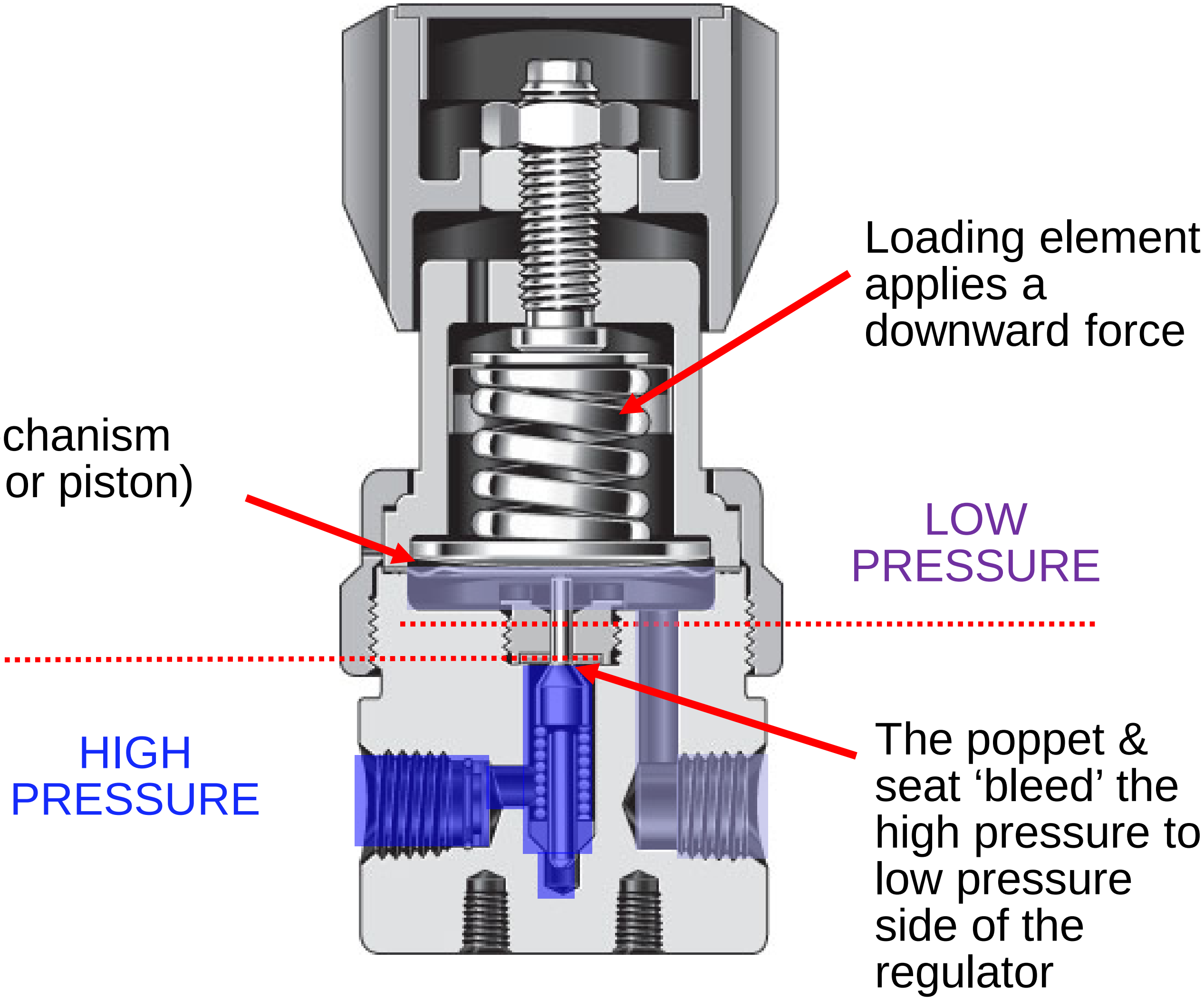
Theory of Regulators:
Types of Regulators

Pressure-reducing regulators control pressure to process by sensing outlet pressure.

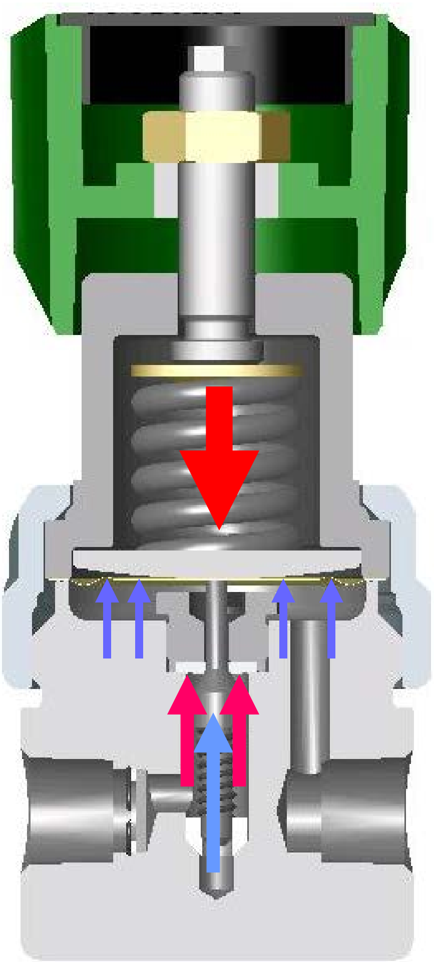
Back pressure regulators control pressure from process by sensing inlet pressure.



Theory of Regulators:
Regulator Basics



Theory of Regulators:
Balance of Forces



F_1 = Loading Force

F_2 = Inlet Spring Force

F_3 = Outlet Pressure Force

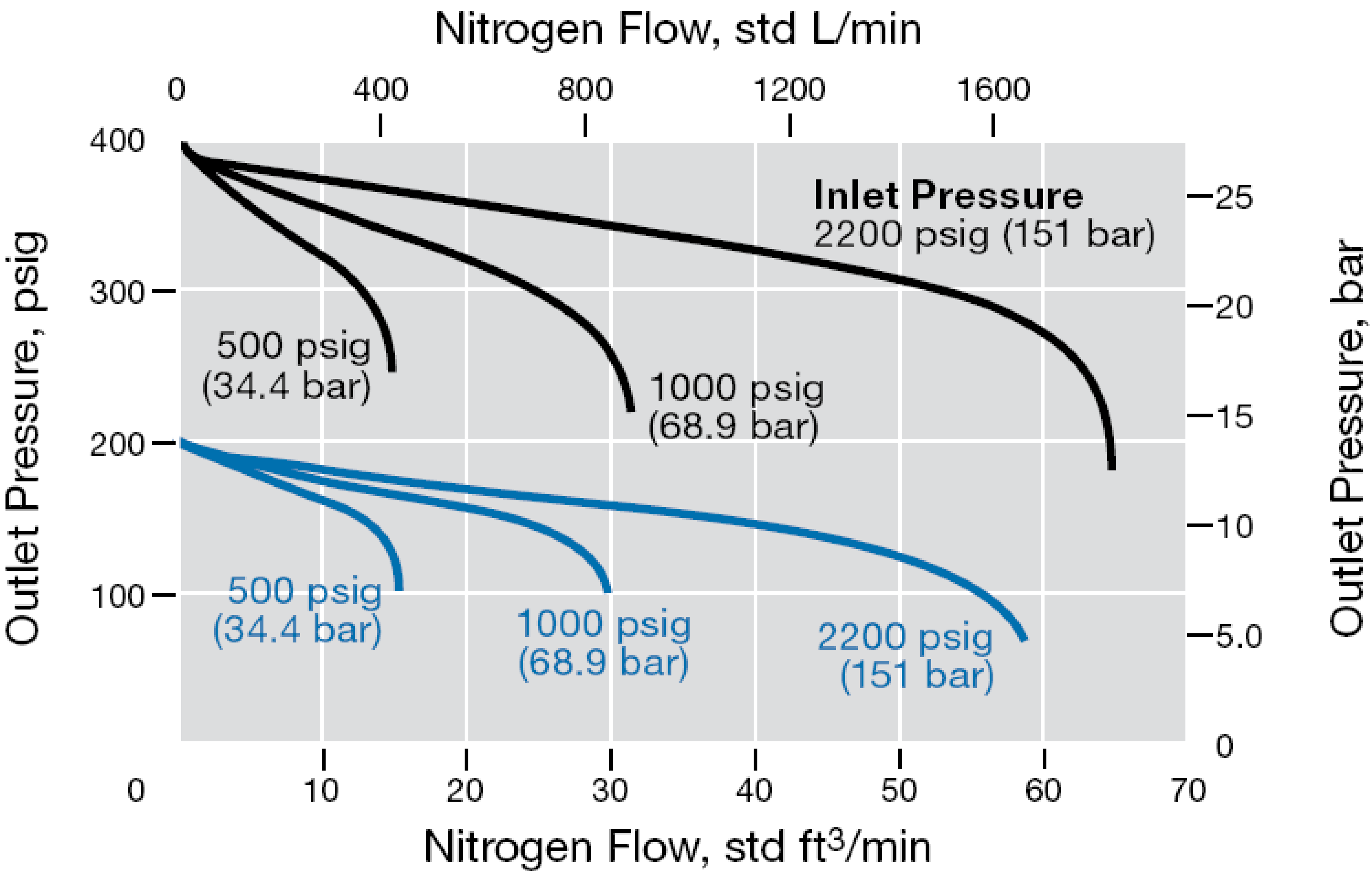
F_4 = Inlet Pressure Force

$$F1 = F2 + F3 + F4$$

Pressure Regulator Performance

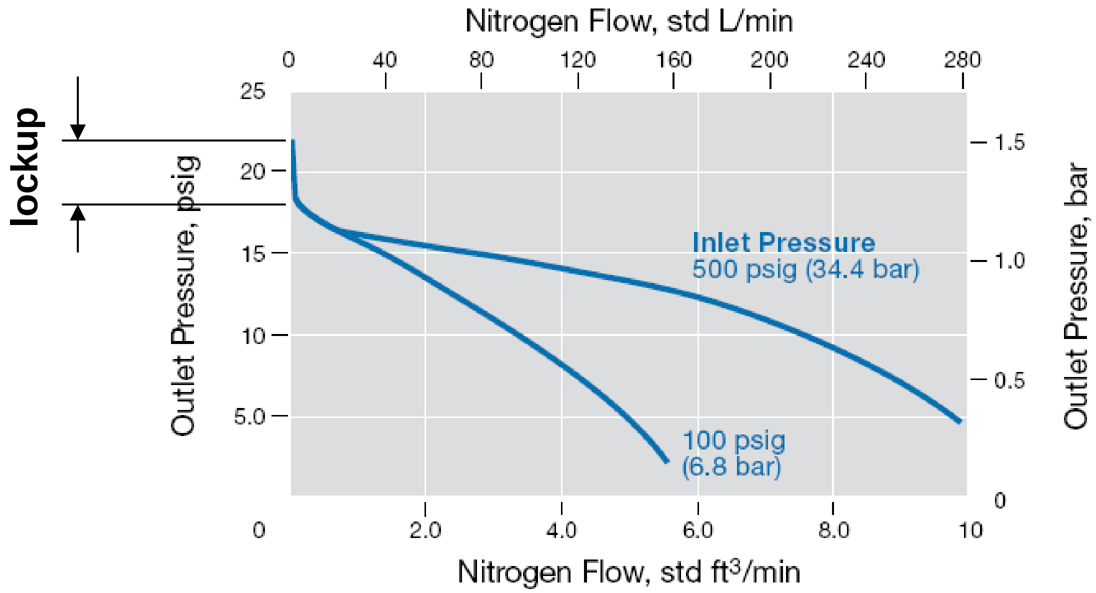
- Lock-up
- Droop
- Choked Flow

Regulator Performance: Flow Curves



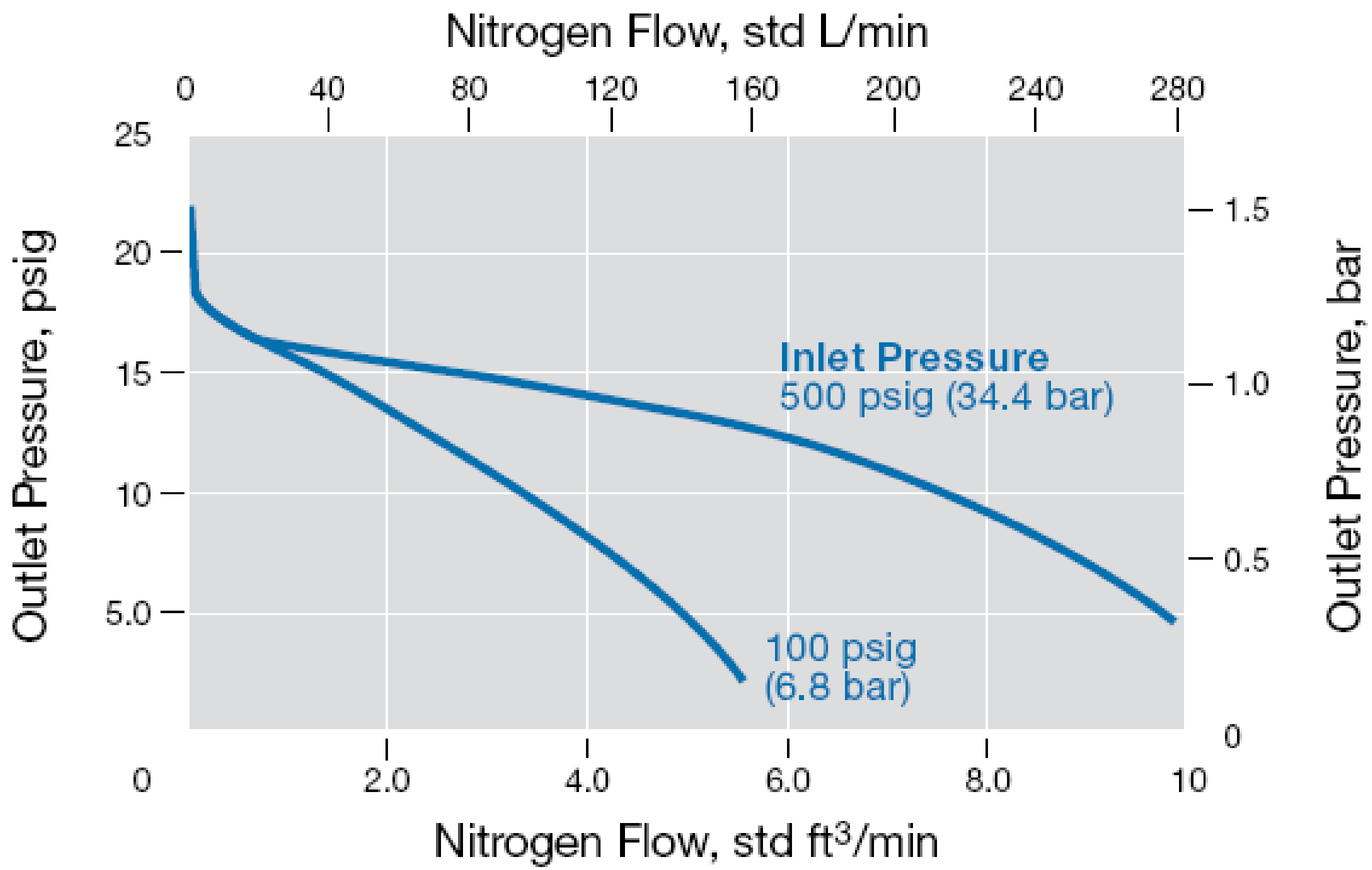
Regulator Performance: Lockup

- The difference in pressure between a flowing and non-flowing condition.
  - As flow decreases, the poppet will move closer to the seat and outlet pressure will rise.
  - The final rise in pressure is needed to fully stop flow
  - This pressure must be released before flow can start again



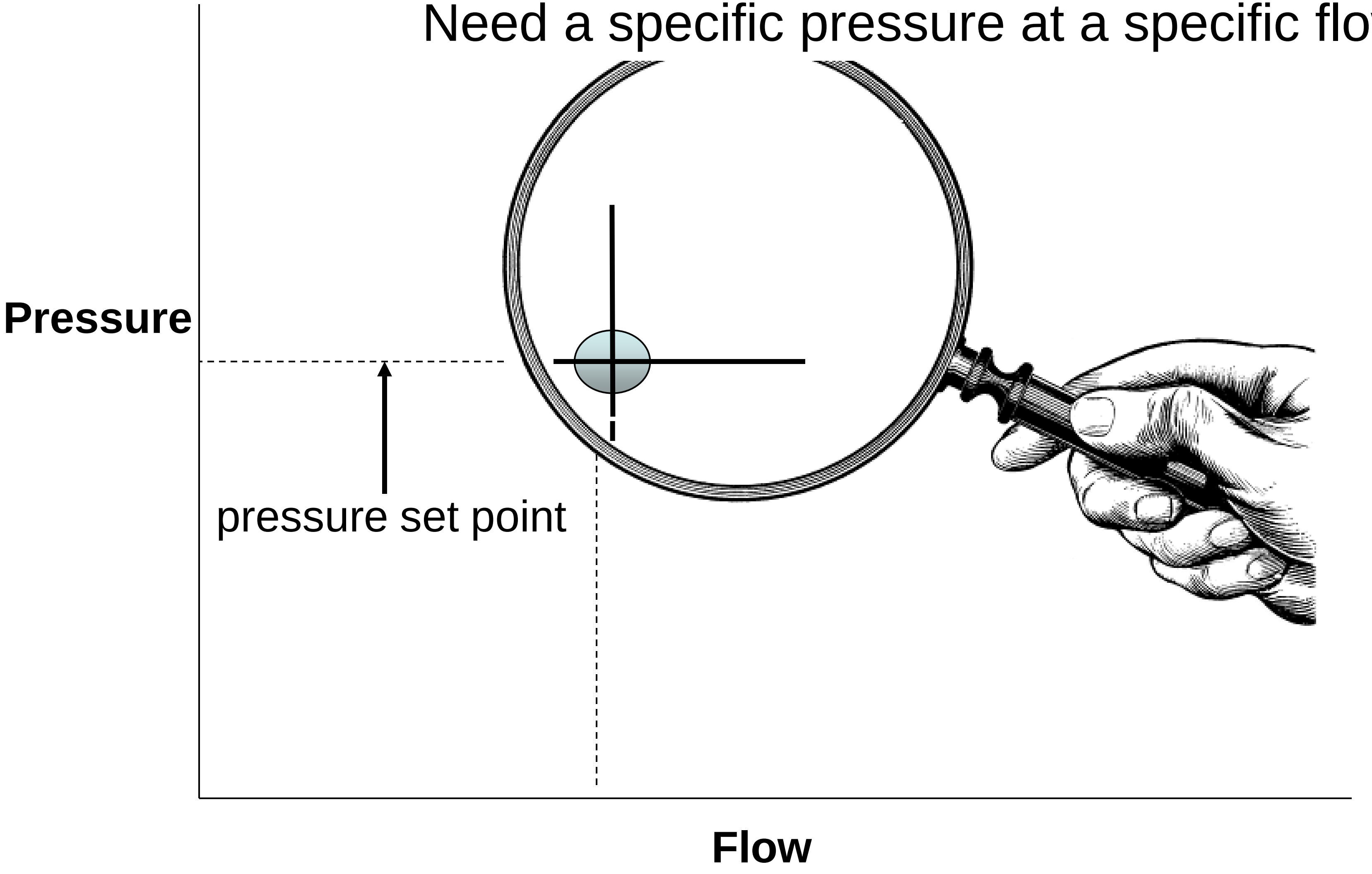
Regulator Performance: Droop

- Droop is the reduction of outlet pressure as flow increases.

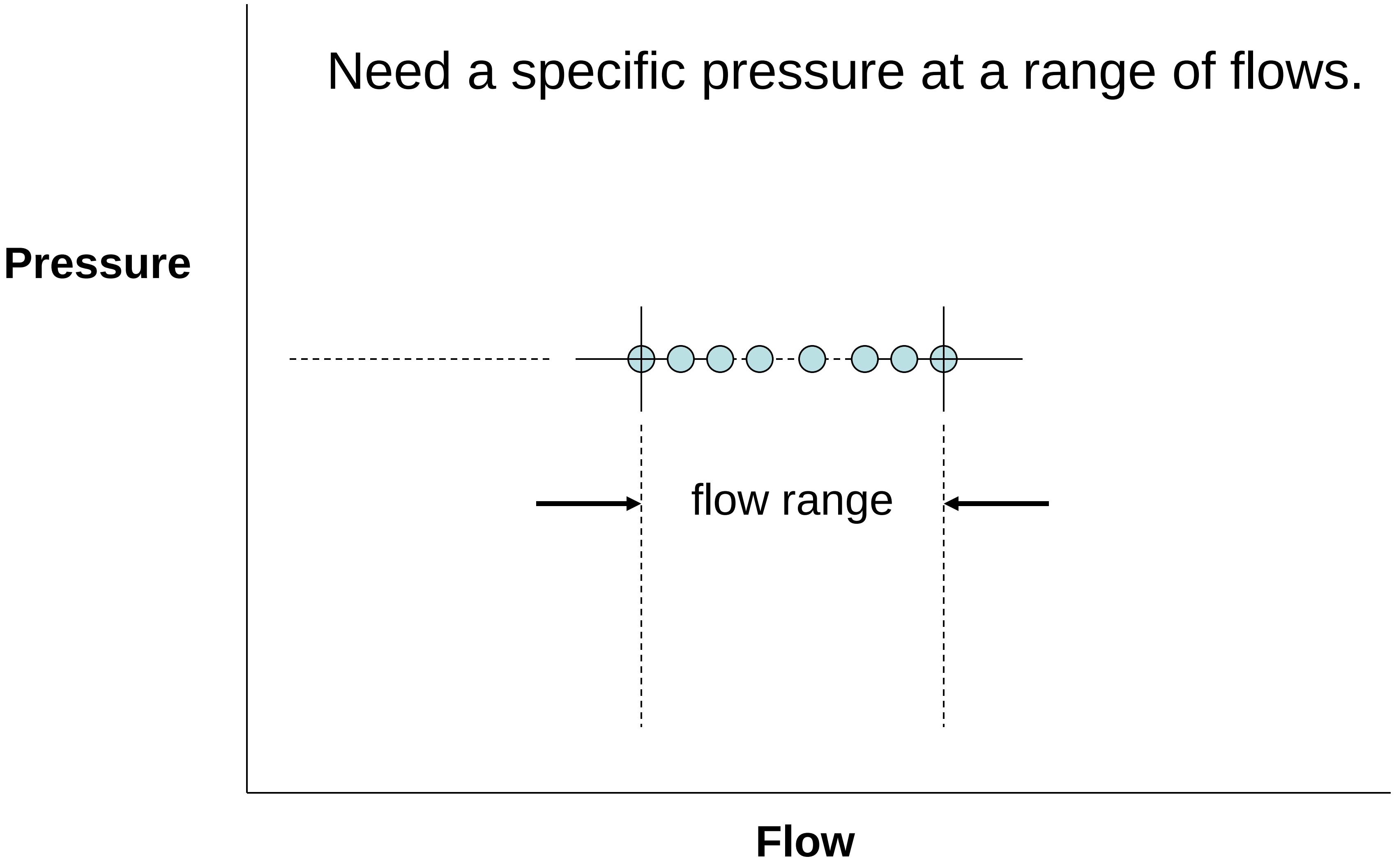


Why is droop important?:
Perceived Problem

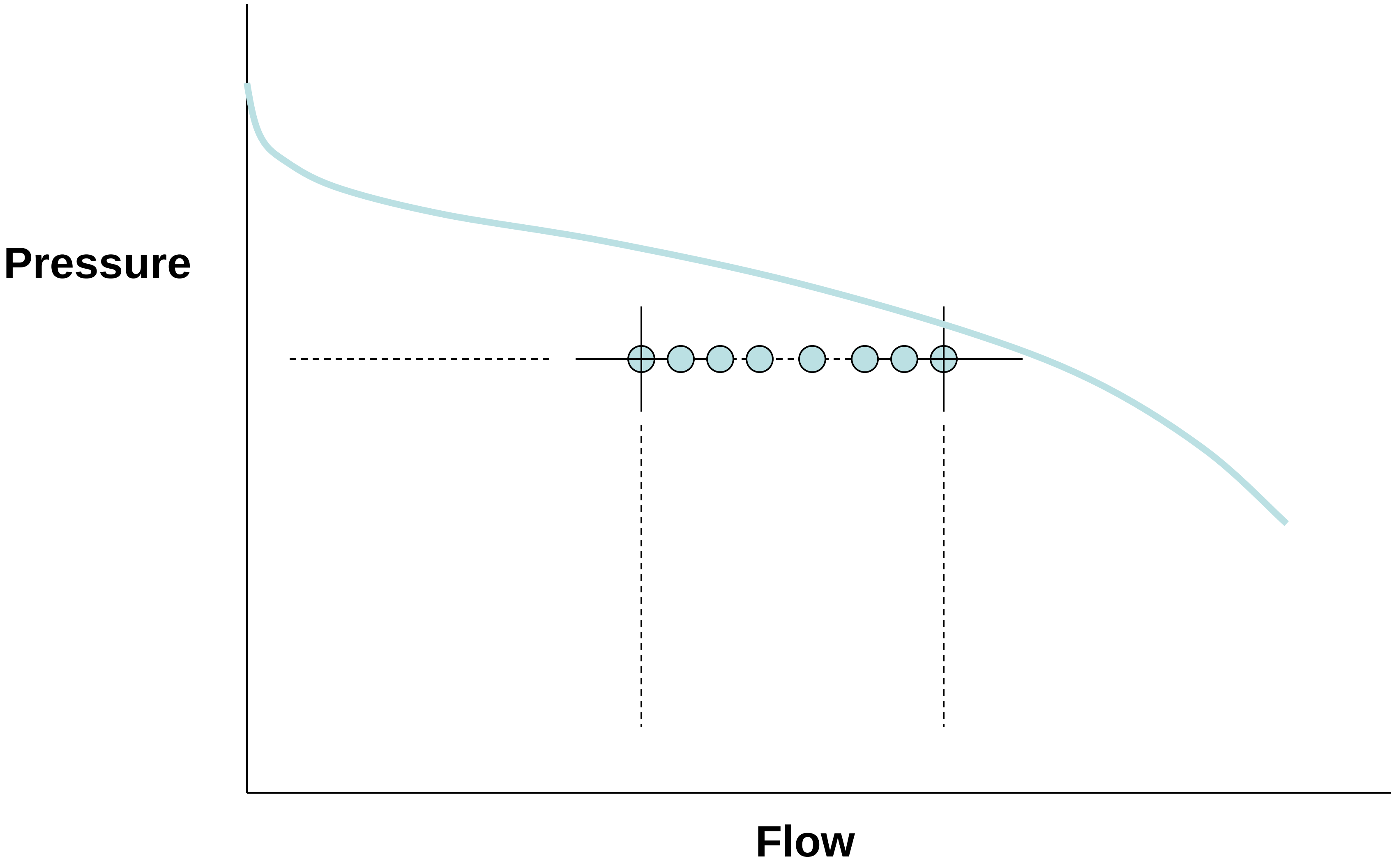
Need a specific pressure at a specific flow



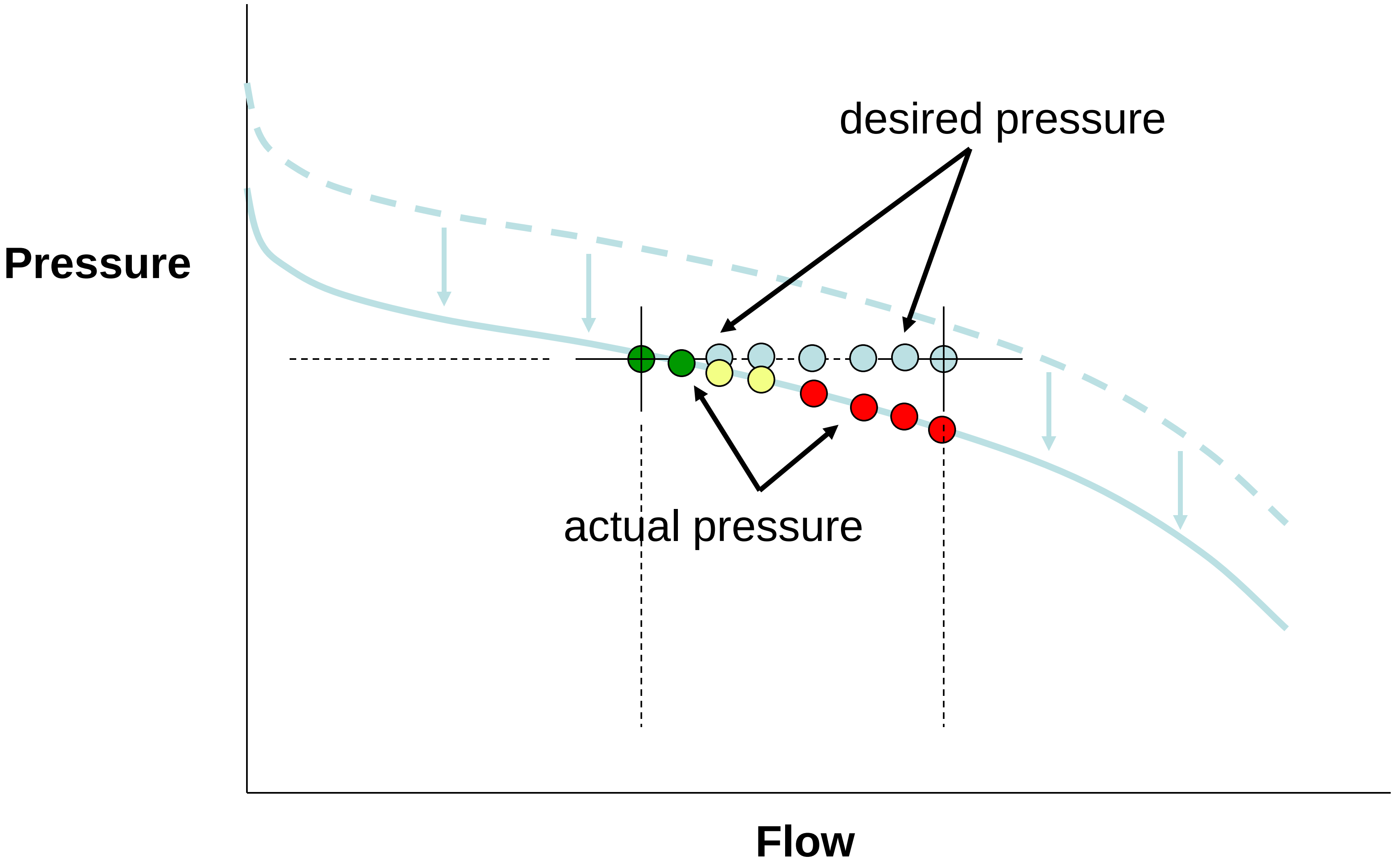
Why is droop important?:
Actual Problem



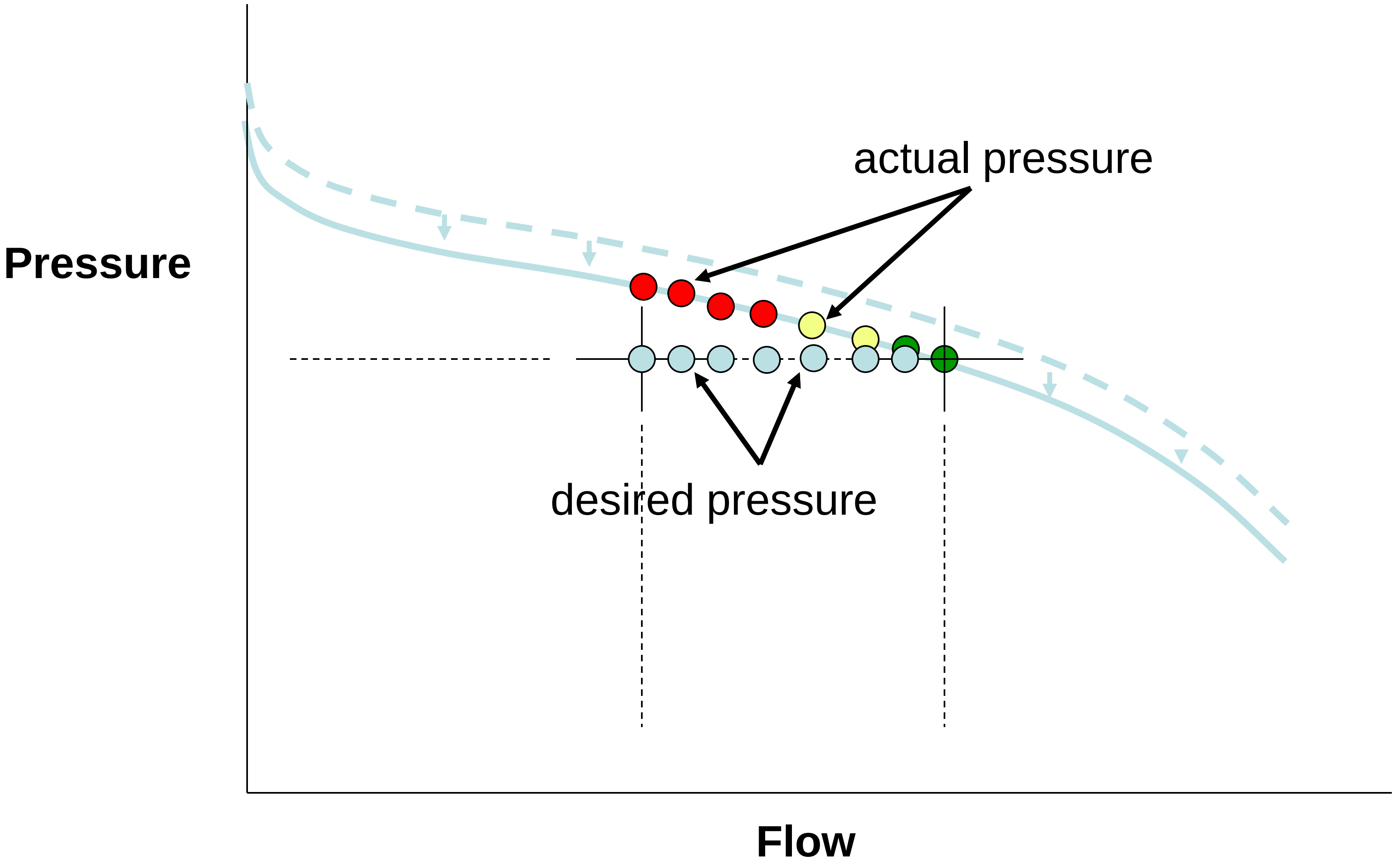
Why is droop important?:
Flow Curve vs. Need



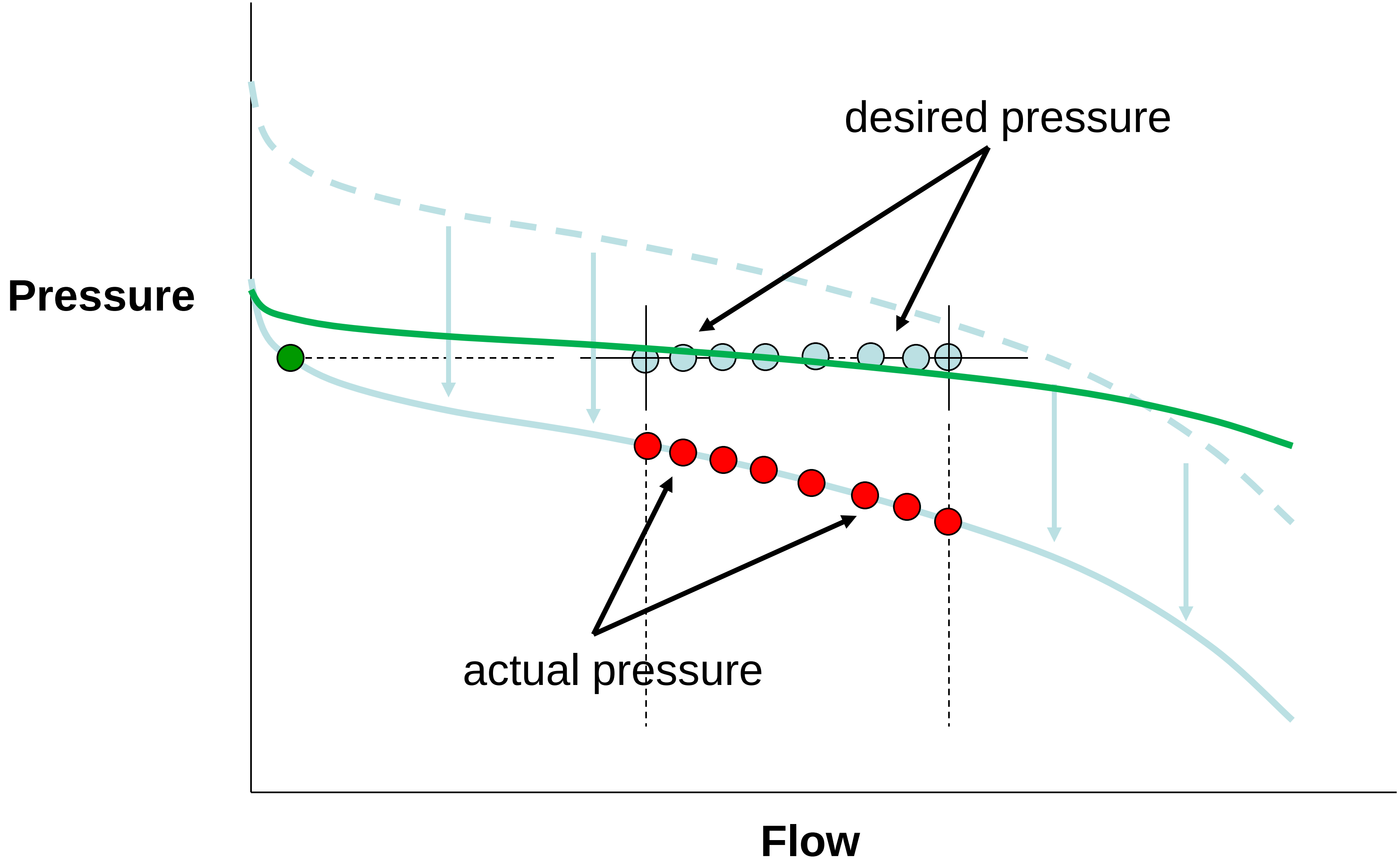
Why is droop important?:
Flow Curve with Outlet Pressure set at Lowest Flow



Why is droop important?:
Flow Curve with Outlet Pressure set at Highest Flow

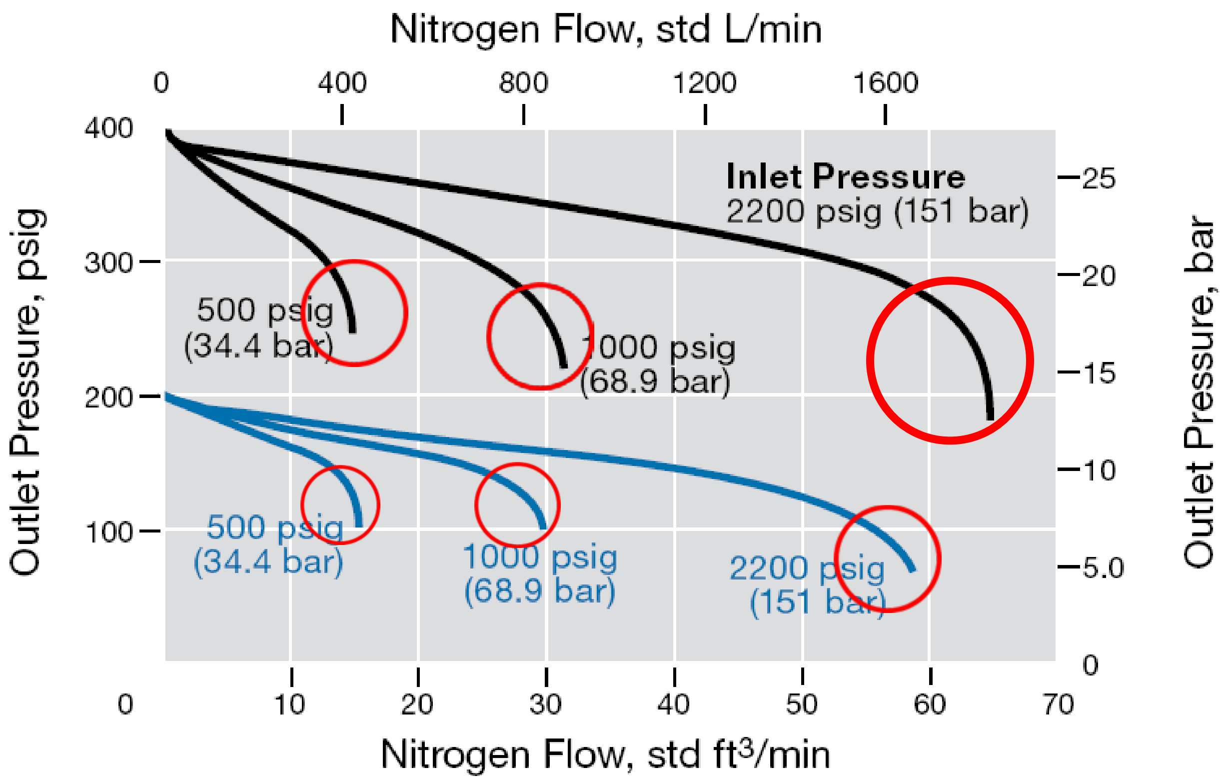


Why is droop important?:
Flow Curve with Outlet Pressure set at Nominal Flow



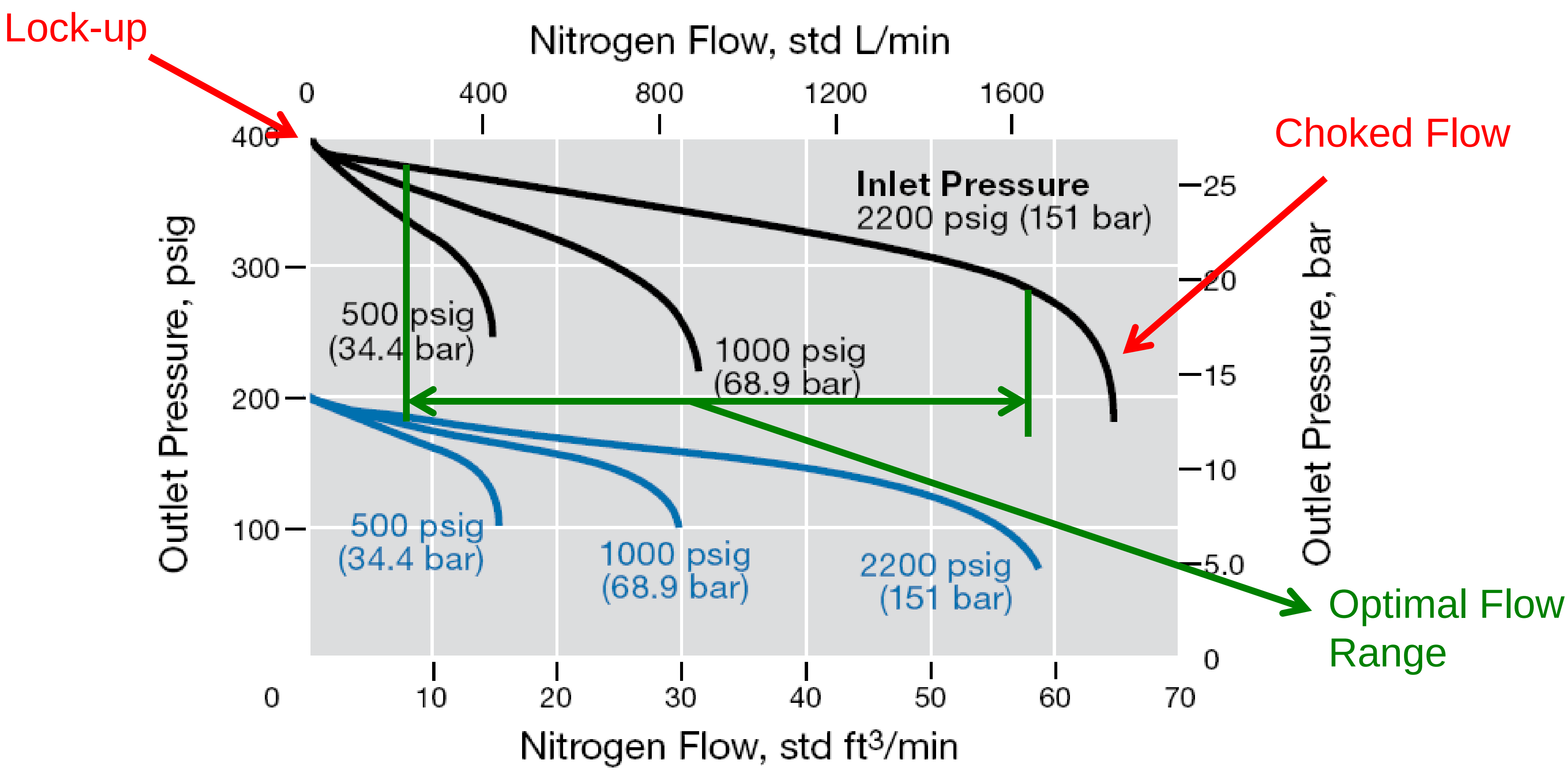
Regulator Performance: Choke Flow Range

- When a regulator is in the full open position and no longer regulating pressure.
  - Acting as a restricting orifice



Regulator Performance: Optimal Flow Range

- The portion of the flow curve in which a regulator should operate for best performance

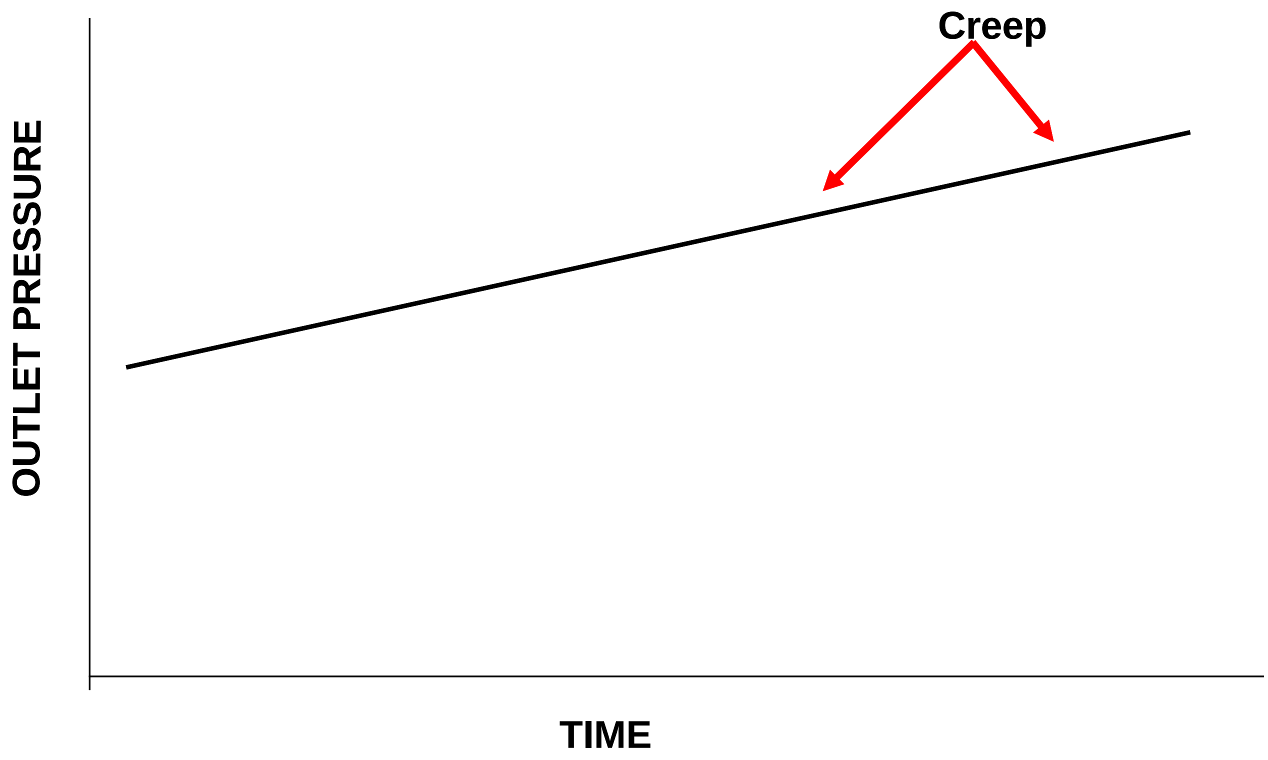


Pressure Regulator Performance

- Creep
- Supplied Pressure Effect
- Joule Thompson

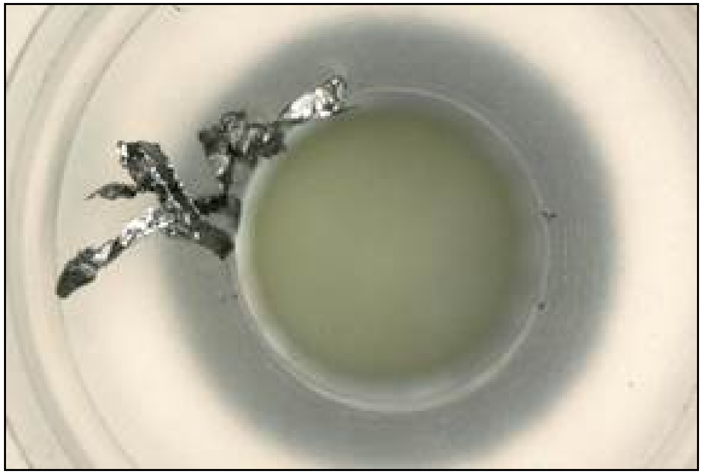
Creep

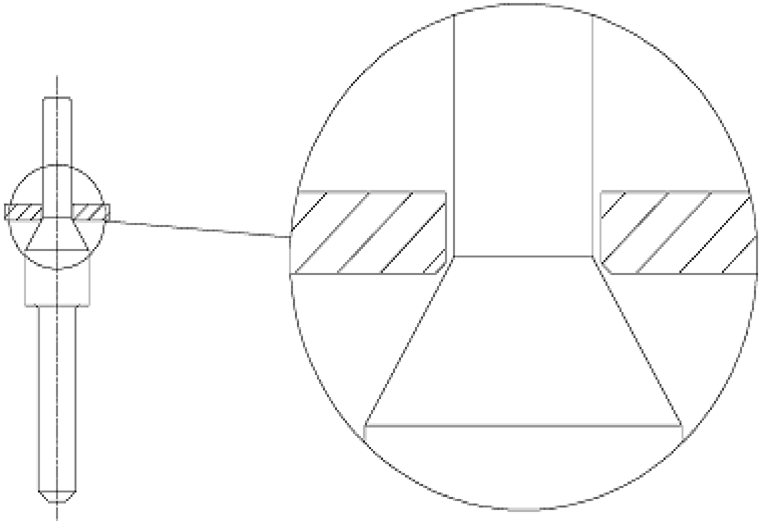
- If the poppet does not fully seat in the orifice, inlet pressure may continue to bleed through the orifice.
- Over time this leakage can increase the outlet pressure until it equals the inlet pressure

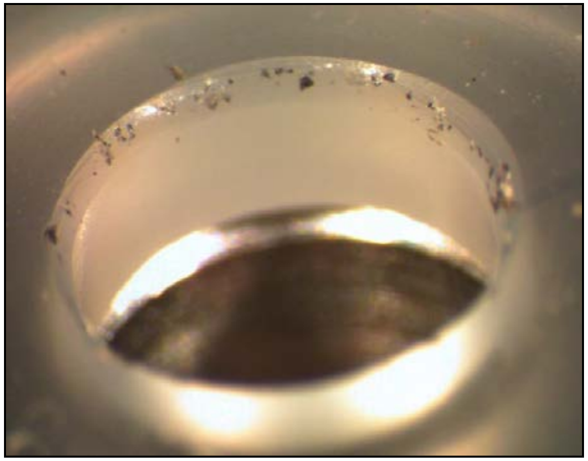


Creep

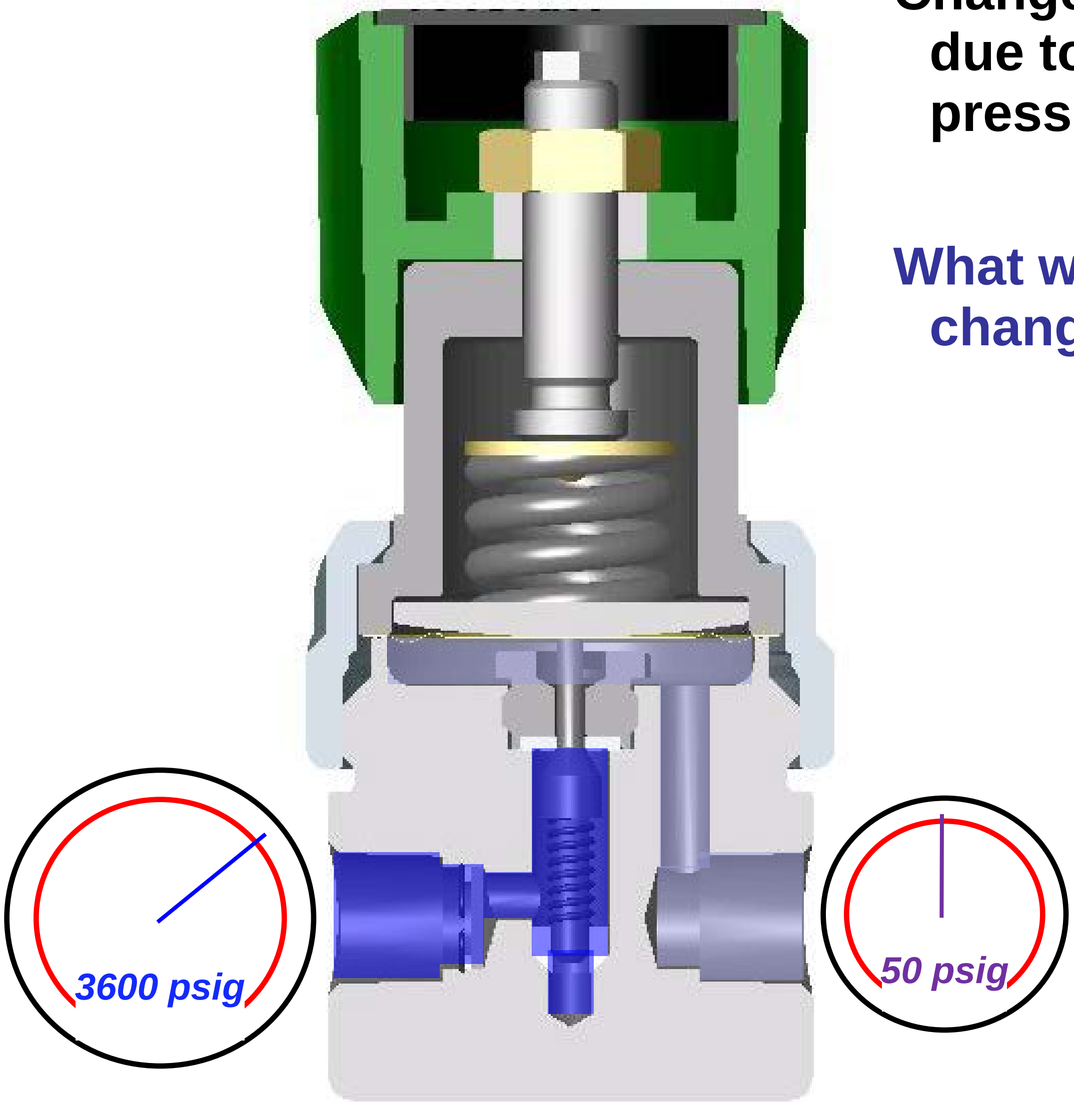
- Causes:
  - Contamination of the seat
    - Upstream filtration critical
  - Damage to the poppet or seat
  - Misalignment of the poppet to the seat
- Relief valves provide protection
- A regulator is not a shut-off device!







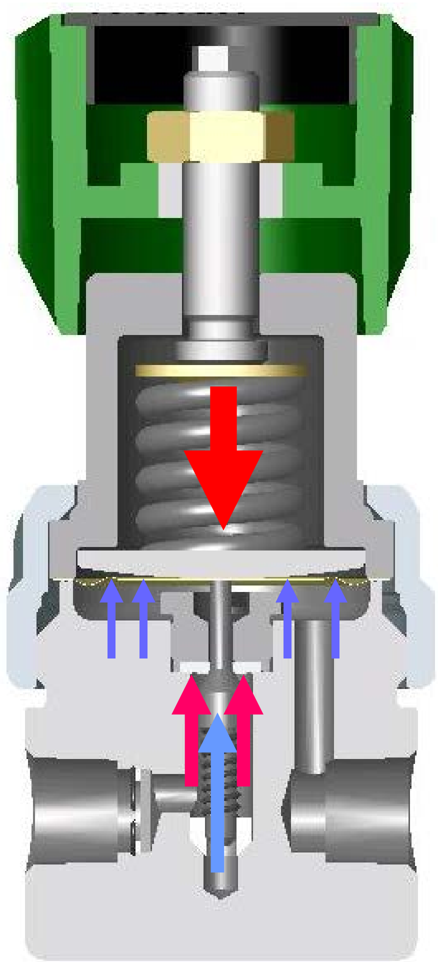
SPE- Supply Pressure Effect



Change in outlet pressure due to change in inlet pressure

What would cause a change in inlet pressure?

SPE: Operating Principle
Balance of Forces



$F1 = F2 + F3 + F4$

F_1 = Spring Force

F_2 = Inlet Spring Force

F_3 = Outlet Pressure Force

F_4 = Inlet Pressure Force

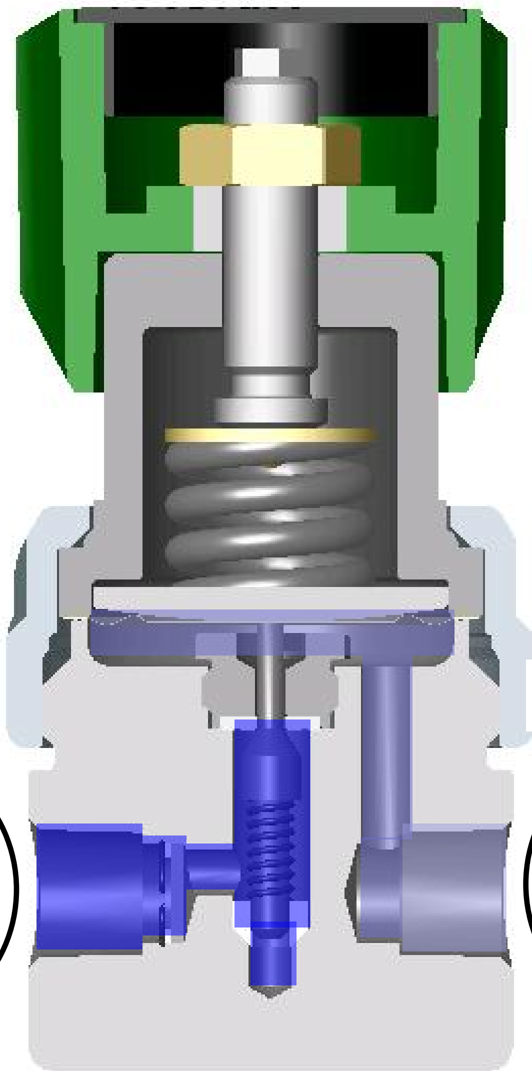
F_1 and F_2 are constant.

As inlet pressure drops, F_4 decreases

To maintain a balanced equation, F_3 will increase

SPE- Supply Pressure Effect

Swagelok

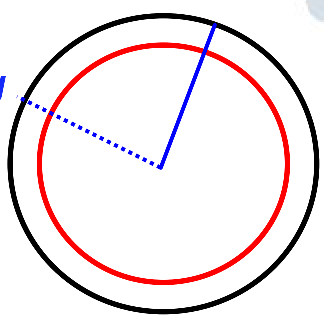


P_{inlet} decreases from 3600 to 2600 = 1000 psig

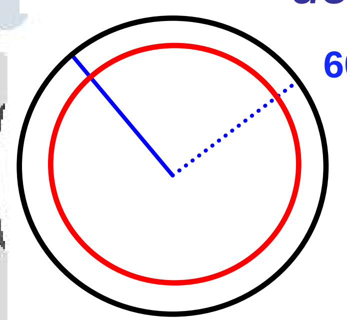
1% of 1000 psig = 10 psig

P_{outlet} *increases* 10 psig

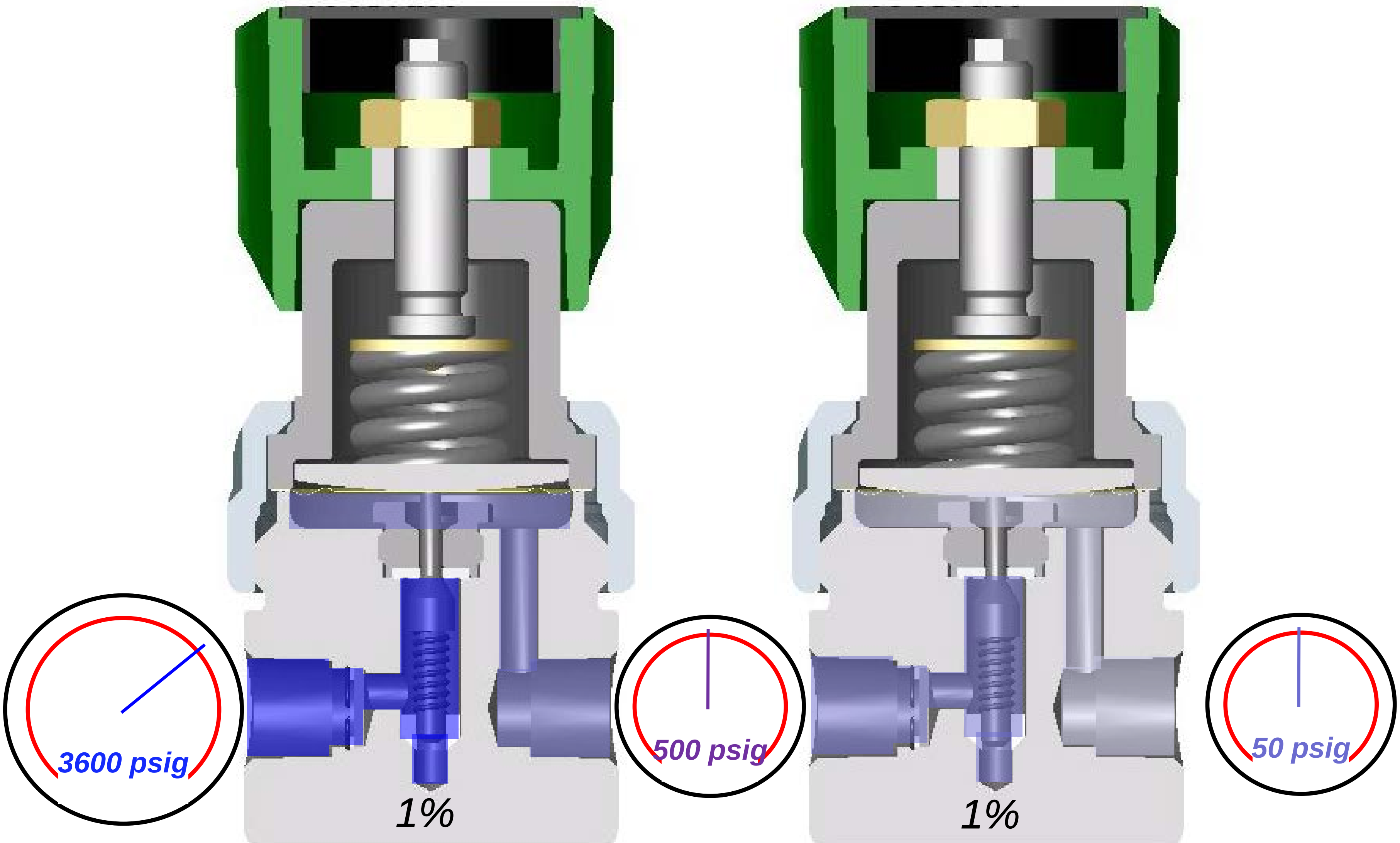
***1.** Upstream pressure decreases as cylinder is depleted*



***2.** Downstream pressure increases 1% of the inlet decrease*



SPE- Supply Pressure Effect



SPE- Supply Pressure Effect

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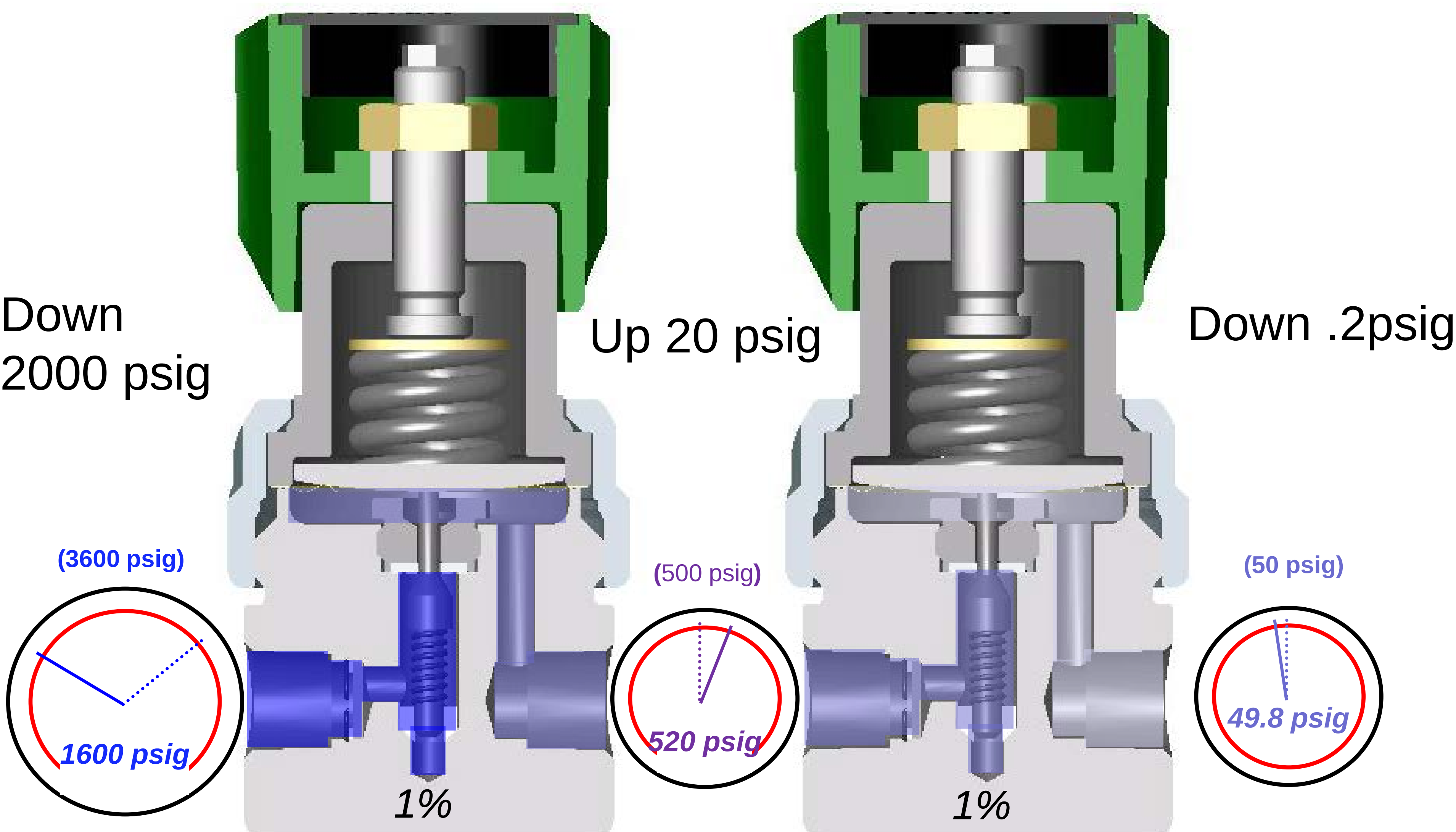

SPE- Supply Pressure Effect

Joule-Thomson Effect

The temperature of a high pressure gas can drop when there is a pressure drop where the gas expands

For example:
With natural gas, the average temperature drop will be approximately 1° Celsius for every 2 bar drop in pressure.

How can we compensate for this?

By:

- Heating the gas

or

- Using a two-stage pressure drop

Joule-Thomson Effect

- When a compressed gas is taken from high to low pressure (inlet to outlet of a pressure regulator or valve), the temperature will also decrease. This is the Joule-Thompson effect.
- At room temperature, most gases **COOL** upon expansion by the Joule-Thomson Process.
  - Hydrogen, Helium, and Neon **HEAT** up.
- Average temperature drop is 1 degree Celsius for every 2 bar pressure drop

~2 degree F for every 30 psi.

Joule-Thomson Effect

- What does J-T mean to me?
  - Cooling of your system fluid may cause constituents to drop out, changing the composition.
  - Liquid in the fluid stream may freeze, impairing or damaging the regulator.
  - Even if your fluid is a ‘pure gas’ the decrease in temperature may damage elastomeric seals.