Troubleshooting and Preventive Maintenance of Hydraulic Systems

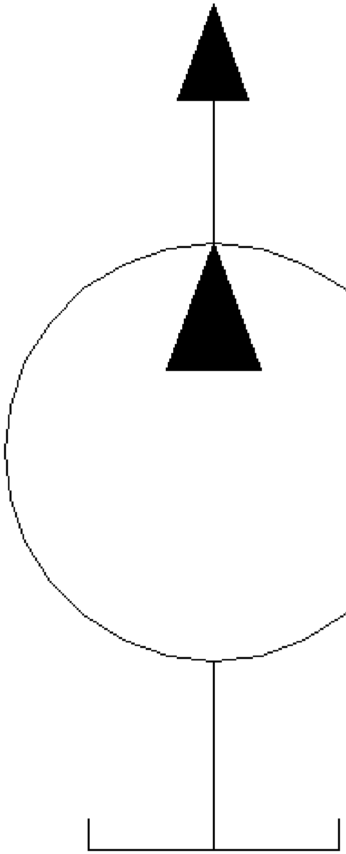
Learning to Read the Signs of Future System Failures

Instructed by:

Al Smiley & Alan Dellinger

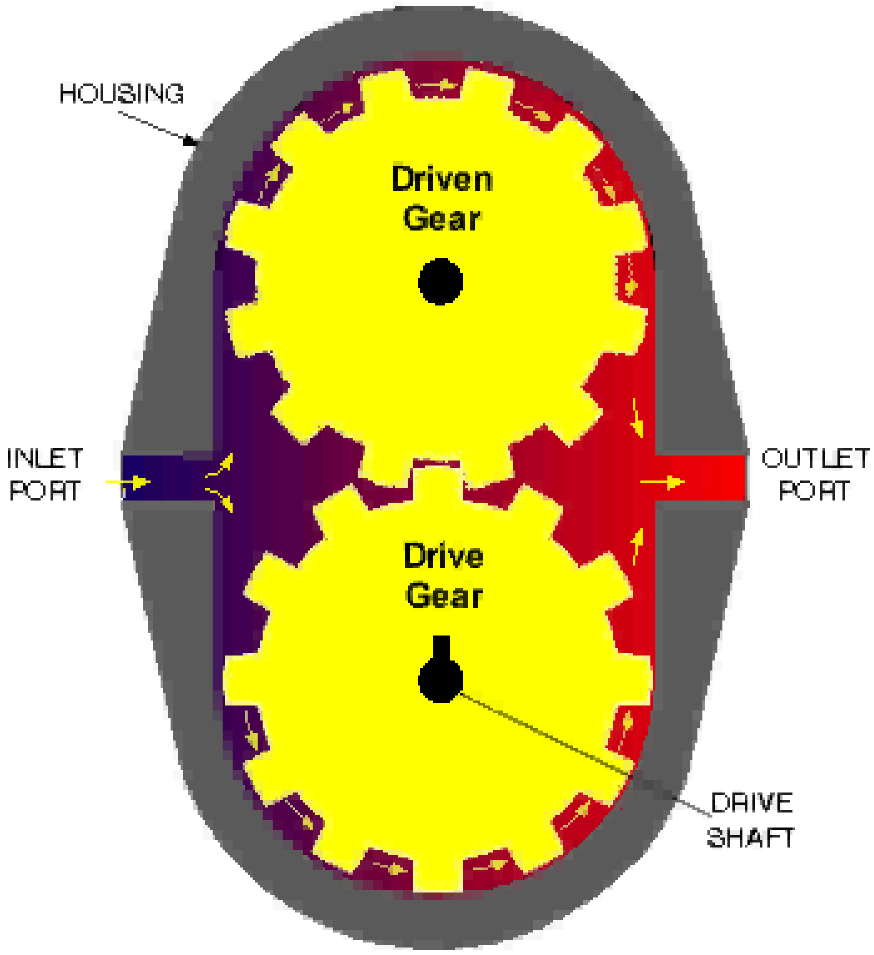
Hydraulic Pumps

Fixed Displacement Pumps

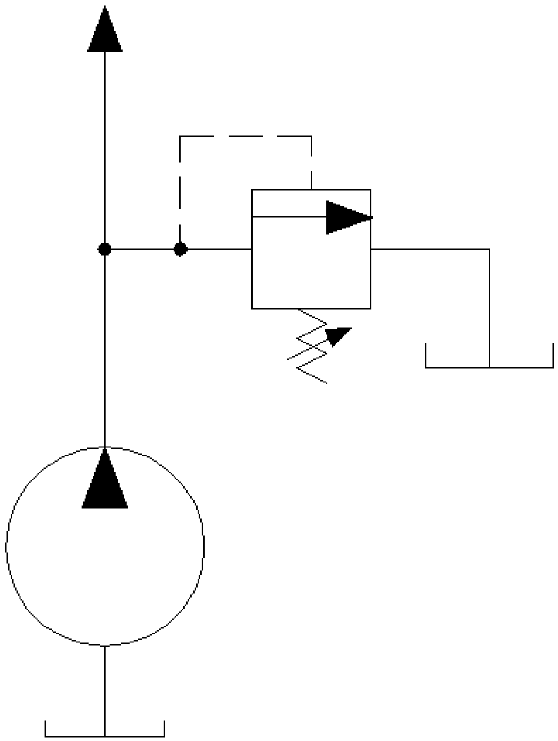


The GPM of the fixed displacement pump can not be varied.

Gear Pump

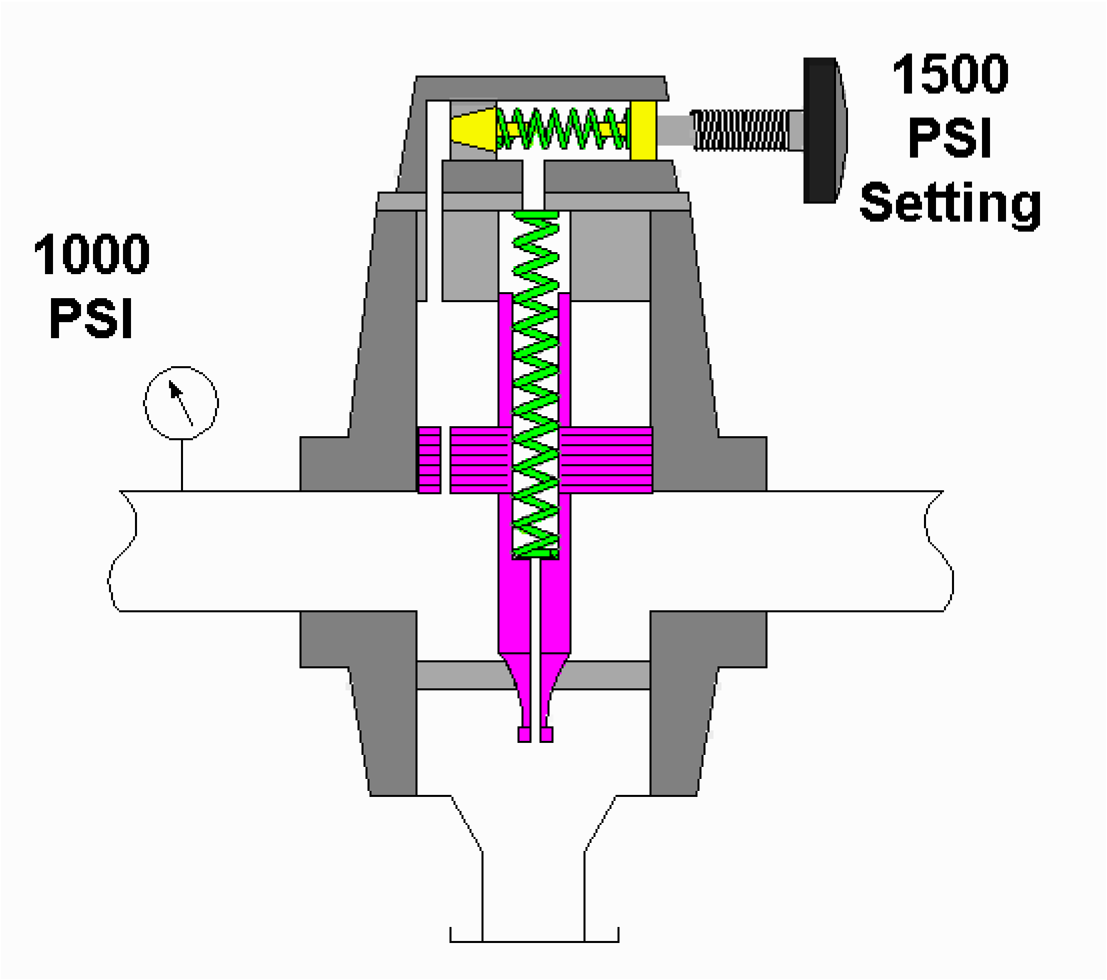

HOUSING
Driven Gear
INLET PORT
OUTLET PORT
Drive Gear
DRIVE SHAFT

Relief Valves and Fixed Displacement Pumps



- Provides a flow path for the pump volume back to tank
- Limits the maximum system pressure

Relief Valve

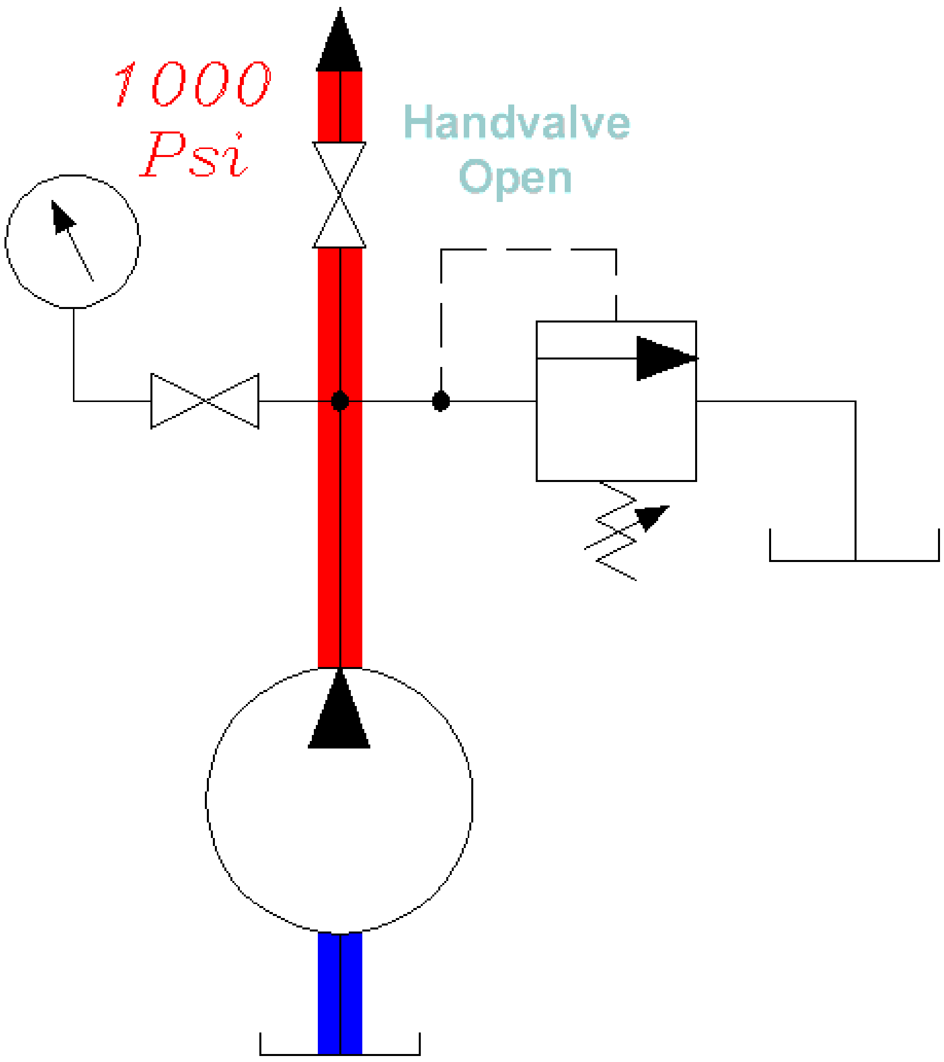


Setting the Relief Valve in a Fixed Displacement Pump Circuit

- Observe the pressure while operating.

- Open all flow controls and isolate any accumulators.

- Set the relief valve 200 PSI above the maximum operating pressure

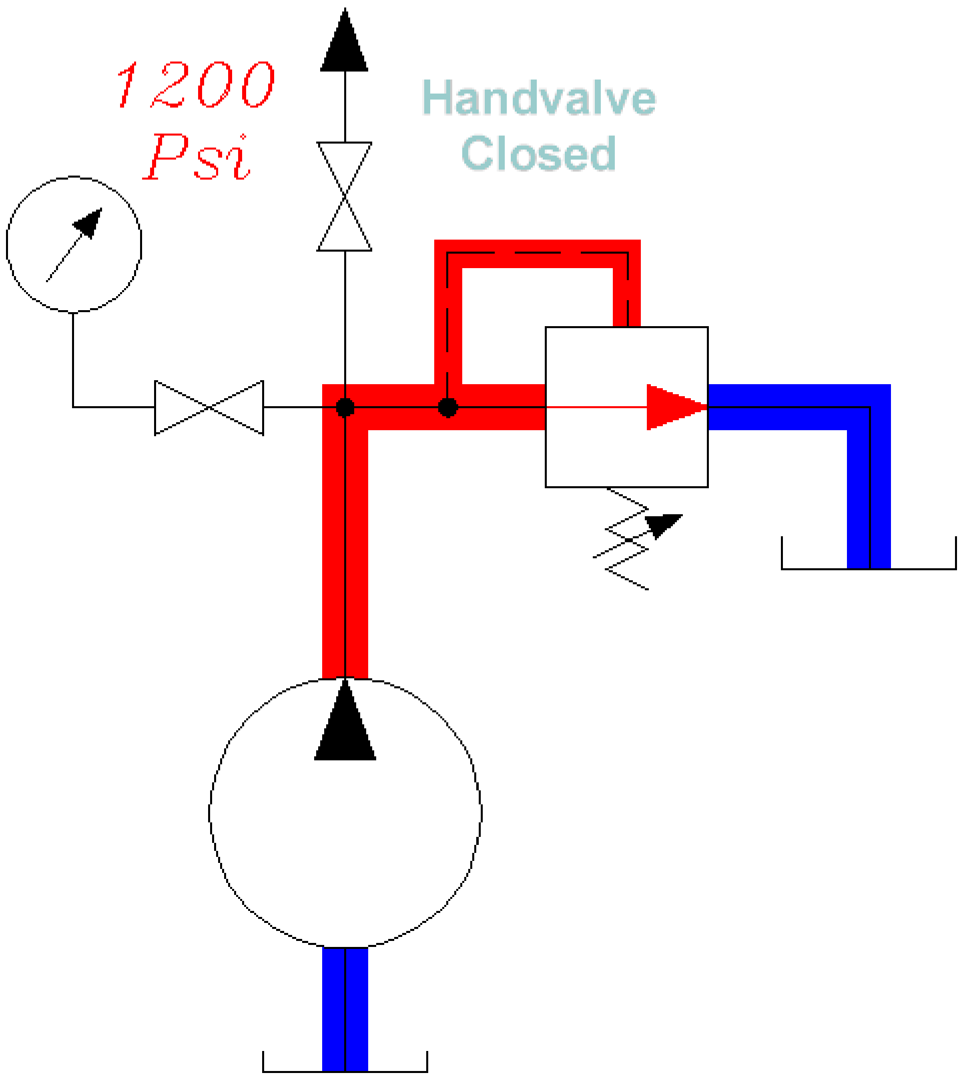


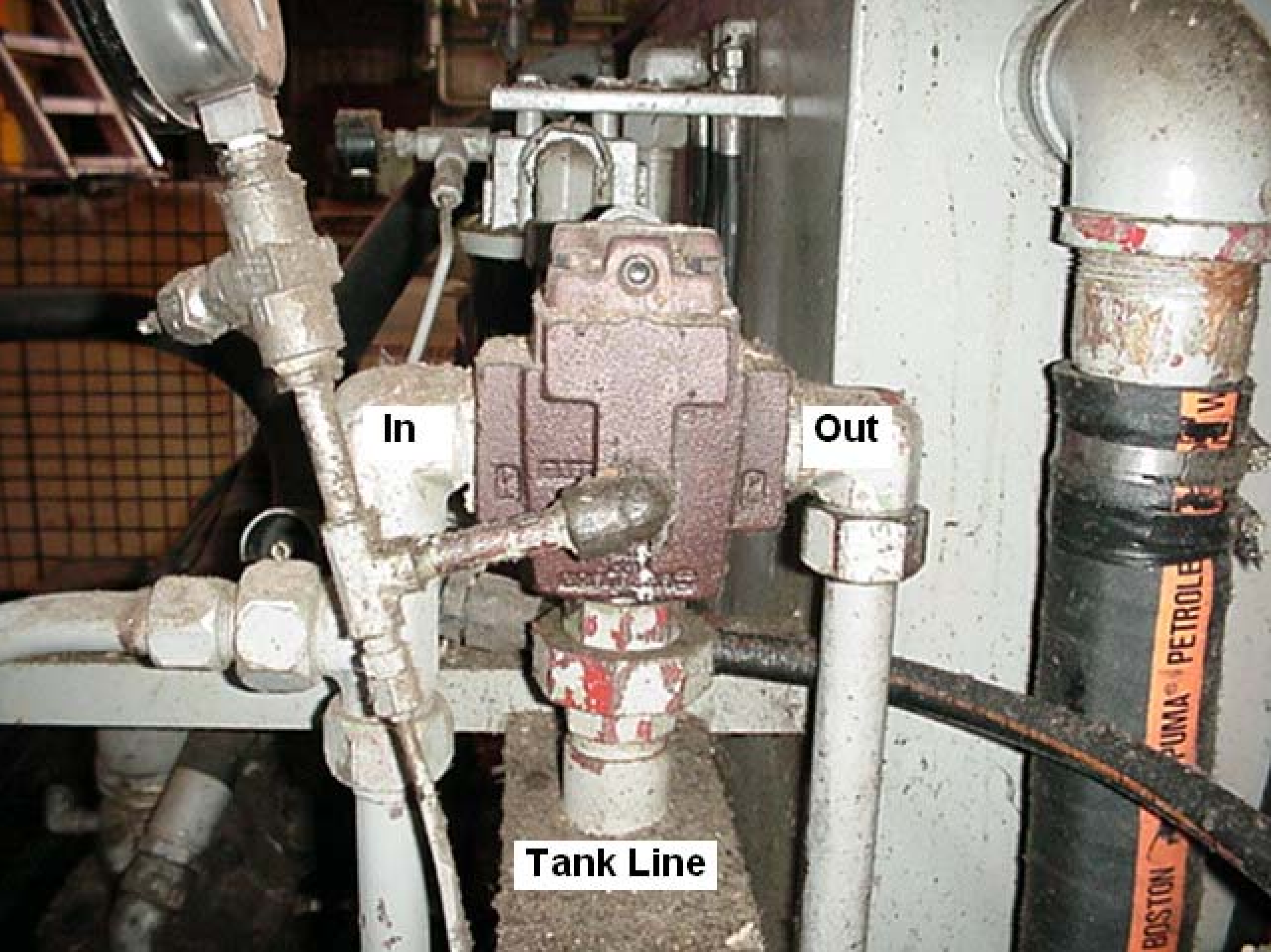
Setting the Relief Valve in a Fixed Displacement Pump Circuit

- Close the Hand Valve.

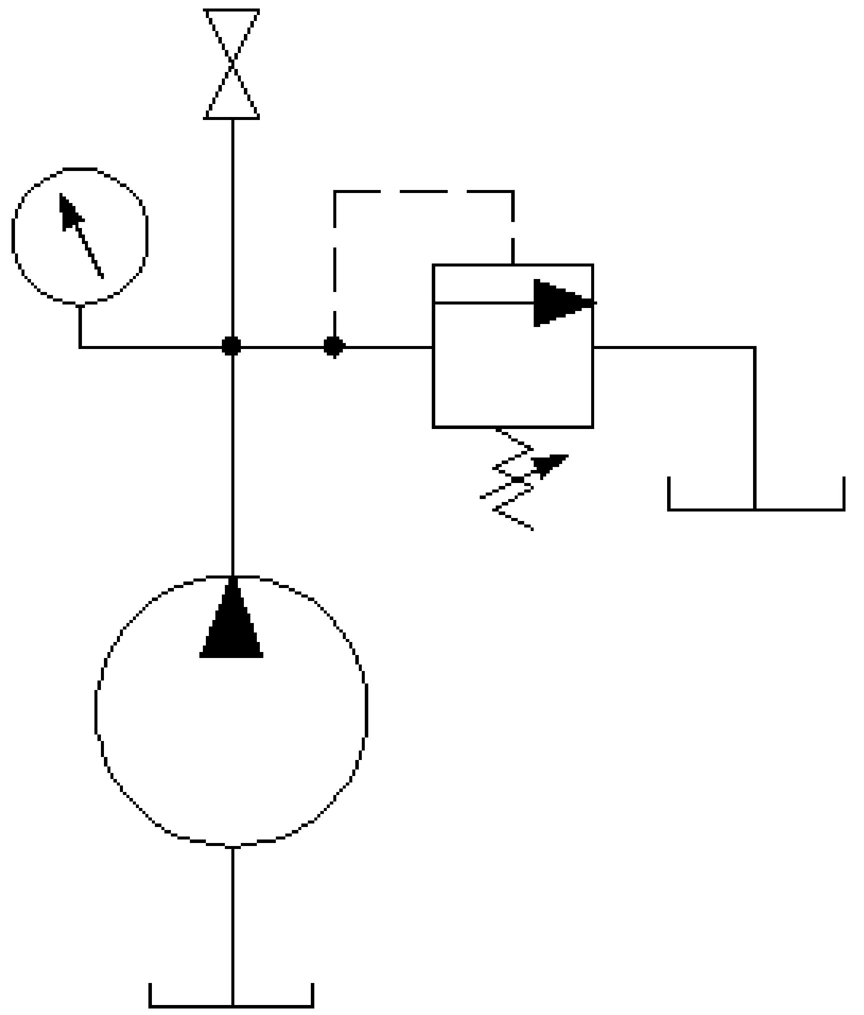
- Adjust the relief to 1200 PSI. (For this example)

- Turn the system off, open the hand valve and remove the gauge.




In
Out
Tank Line
PUMA
PETROLE
BOSTON

Troubleshooting Fixed Displacement Pump Circuits



Sound Checks

Cavitation is the formation and collapse of air cavities in the liquid.

A pump that is cavitating will put out a reduced flow until it destroys itself.

Cavitation is caused by:

- Oil viscosity too high
- Plugged suction filter
- Electric motor RPM too high

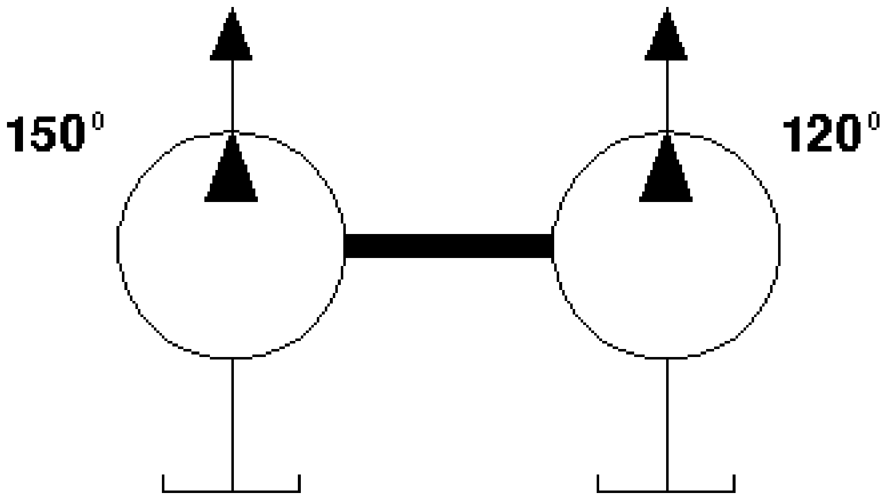
Aeration

Aeration occurs when outside air enters the suction side of the pump. Aeration is caused by:

- Air leak in the suction line
- Bad shaft seal on a fixed displacement pump
- Fluid level too low
- Improper Installation:
  - Coupling is not properly aligned
  - Wrong shaft rotation

Checking the Fixed Displacement Pump

- Check the pump housing for heat



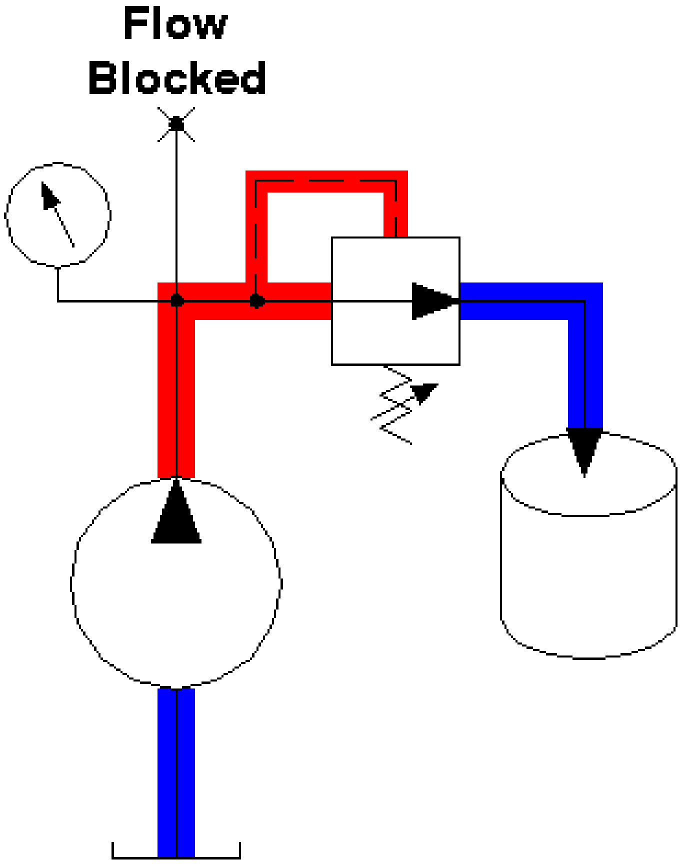
- Check the current draw on the electric drive motor

$$HP = GPM \times PSI \times .000583$$

↓ ↓

If the pump is bypassing and the GPM output is lower, then the drive motor's current draw will also be lower

Checking the Fixed Displacement Pump Through the Relief Valve

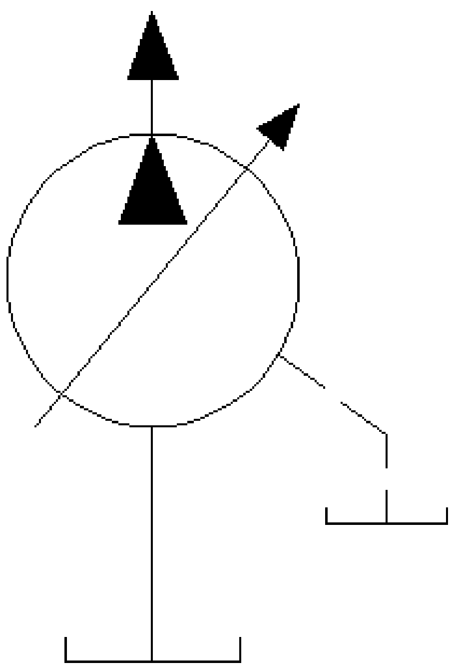


- Turn the relief valve CCW and observe the flow
- Gradually turn the relief CW and observe the flow

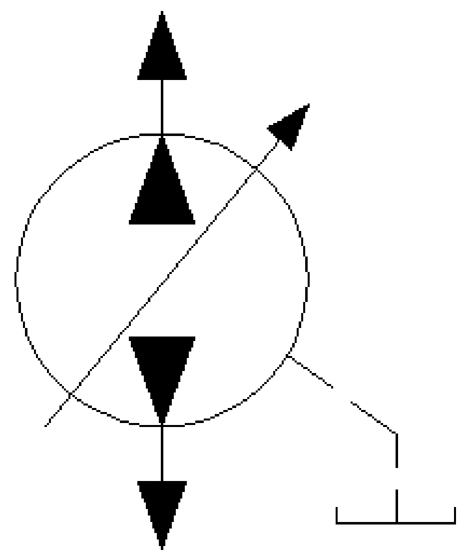
41100 50
WATTS

Variable Displacement Pumps

- Variable Displacement Pumps are used when the volume requirements change in the system

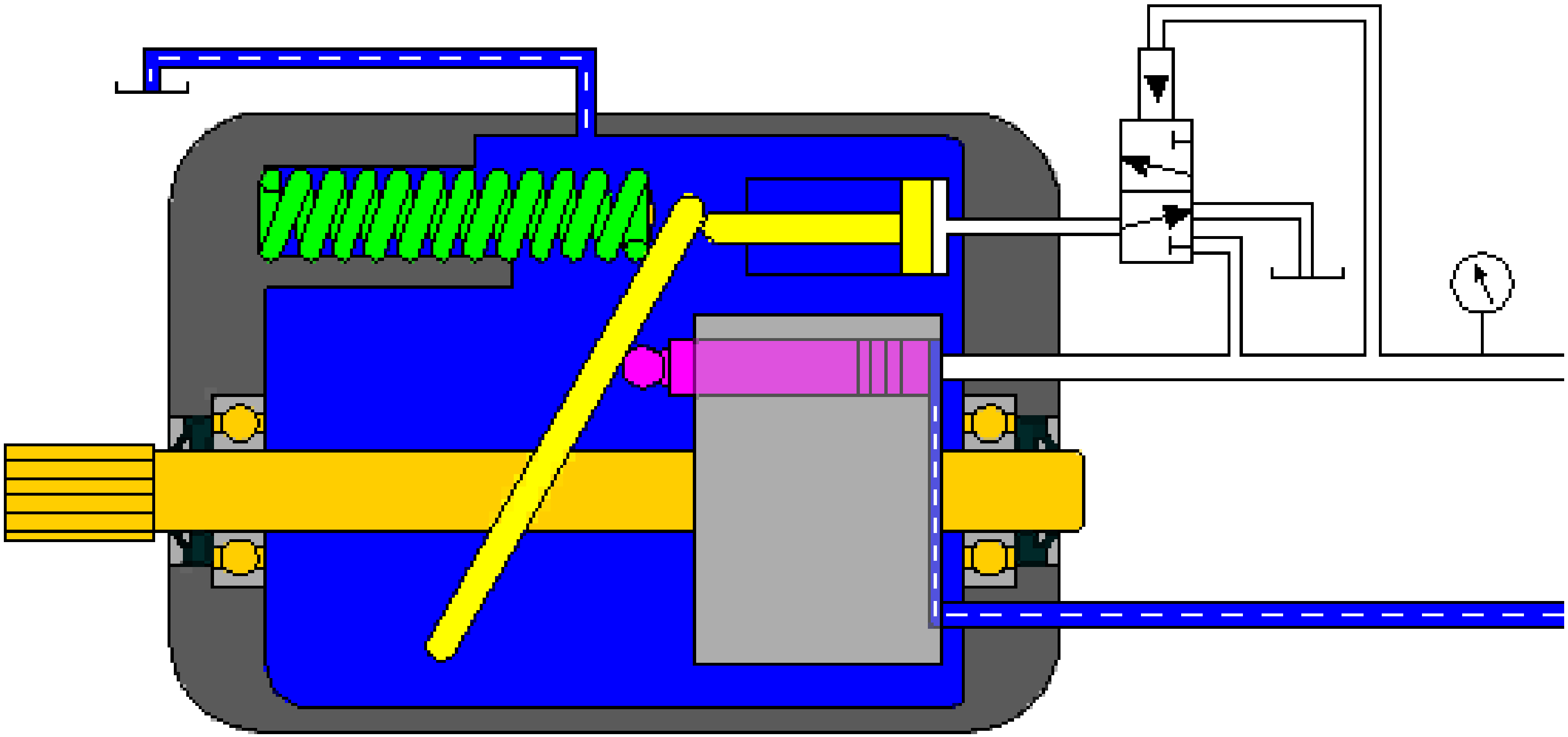


1 Directional Pump

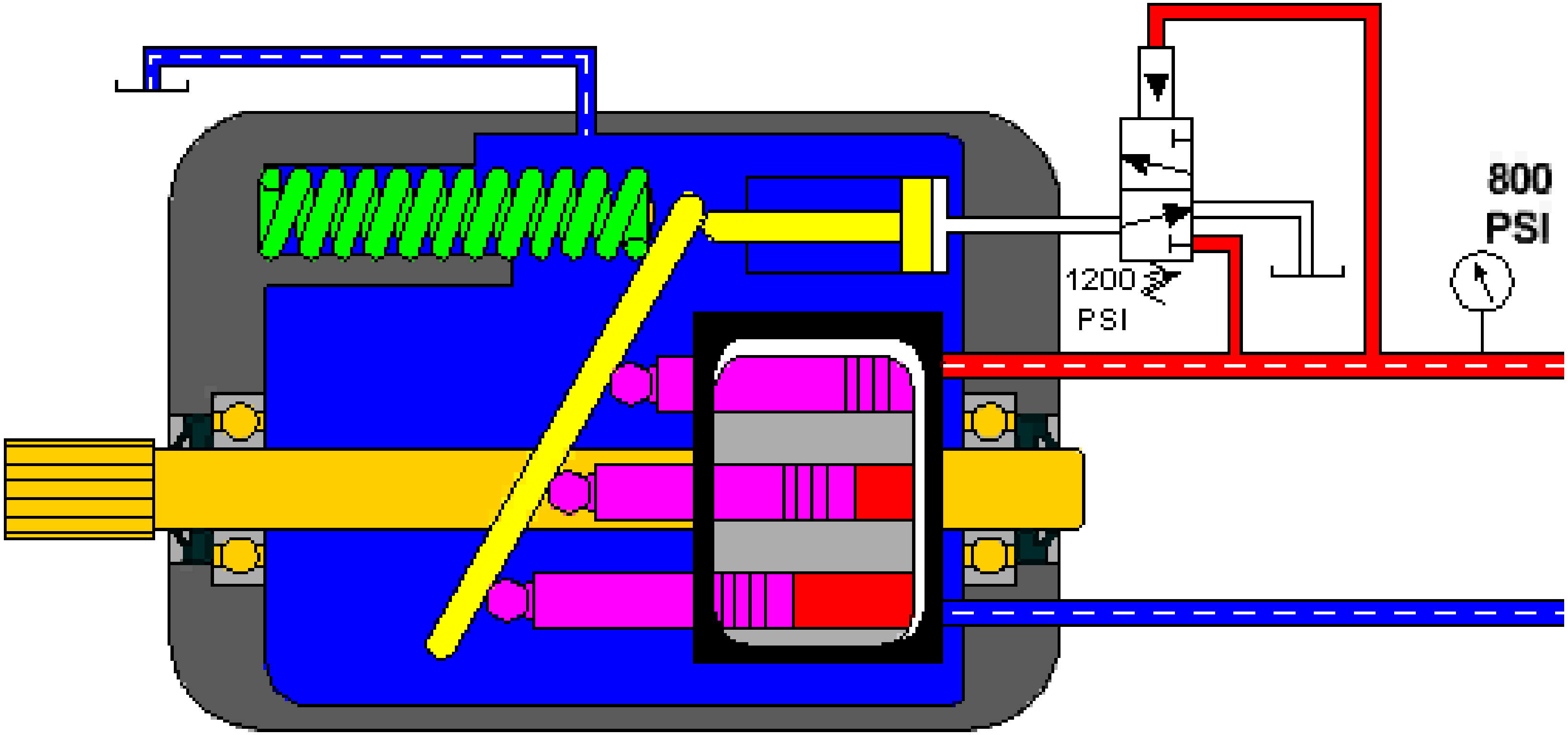


Bi-Directional Pump

Pressure Compensating Piston Pump

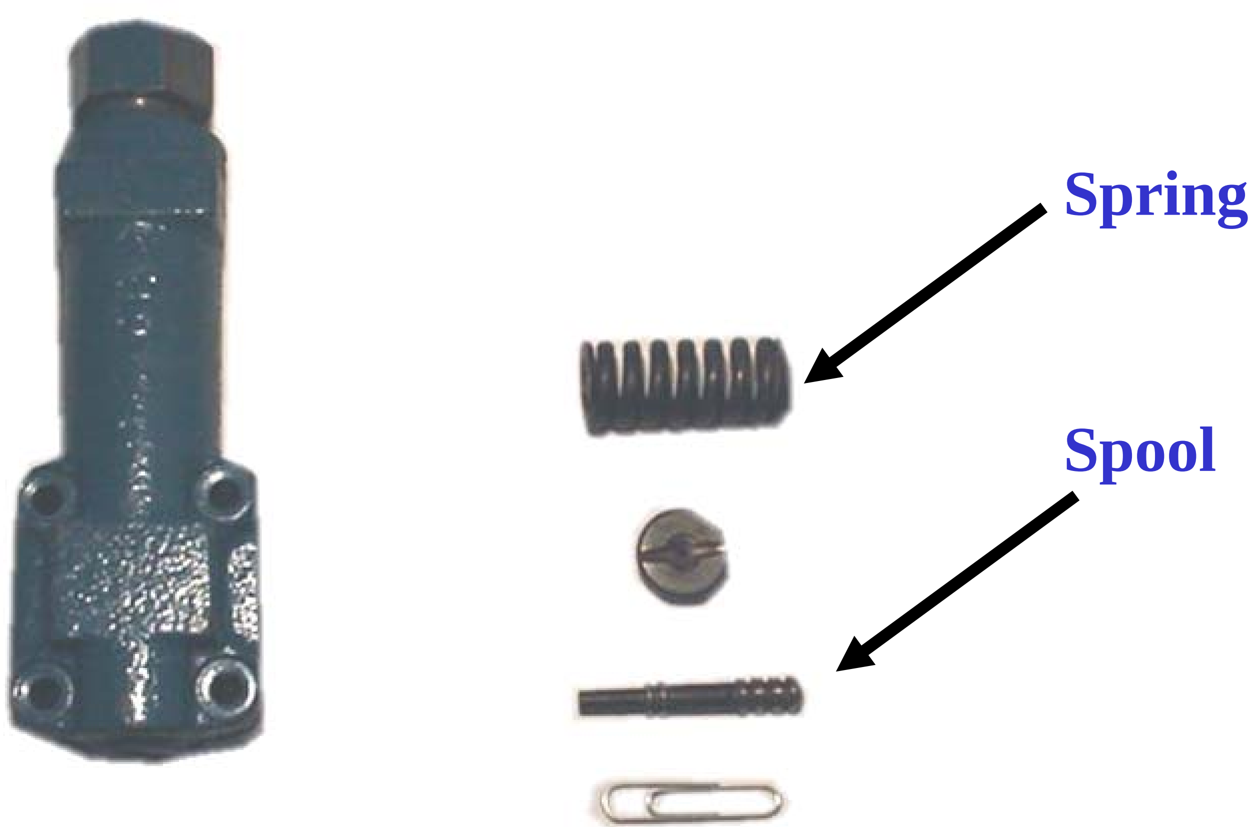


Pressure Compensating Piston Pump



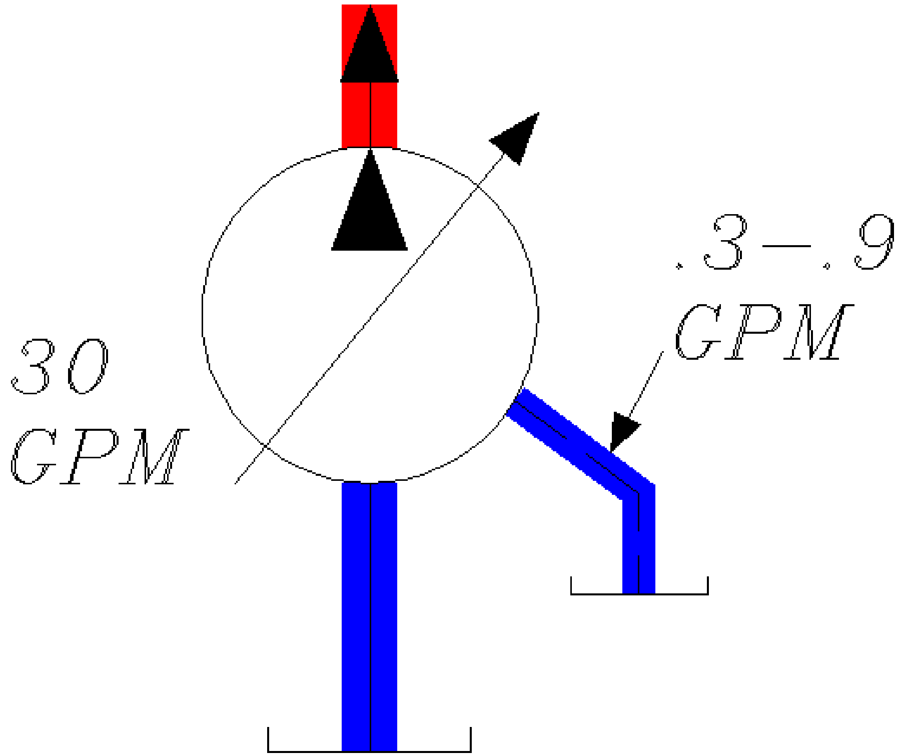
Pressure Compensating Piston Pump

Pump Compensator



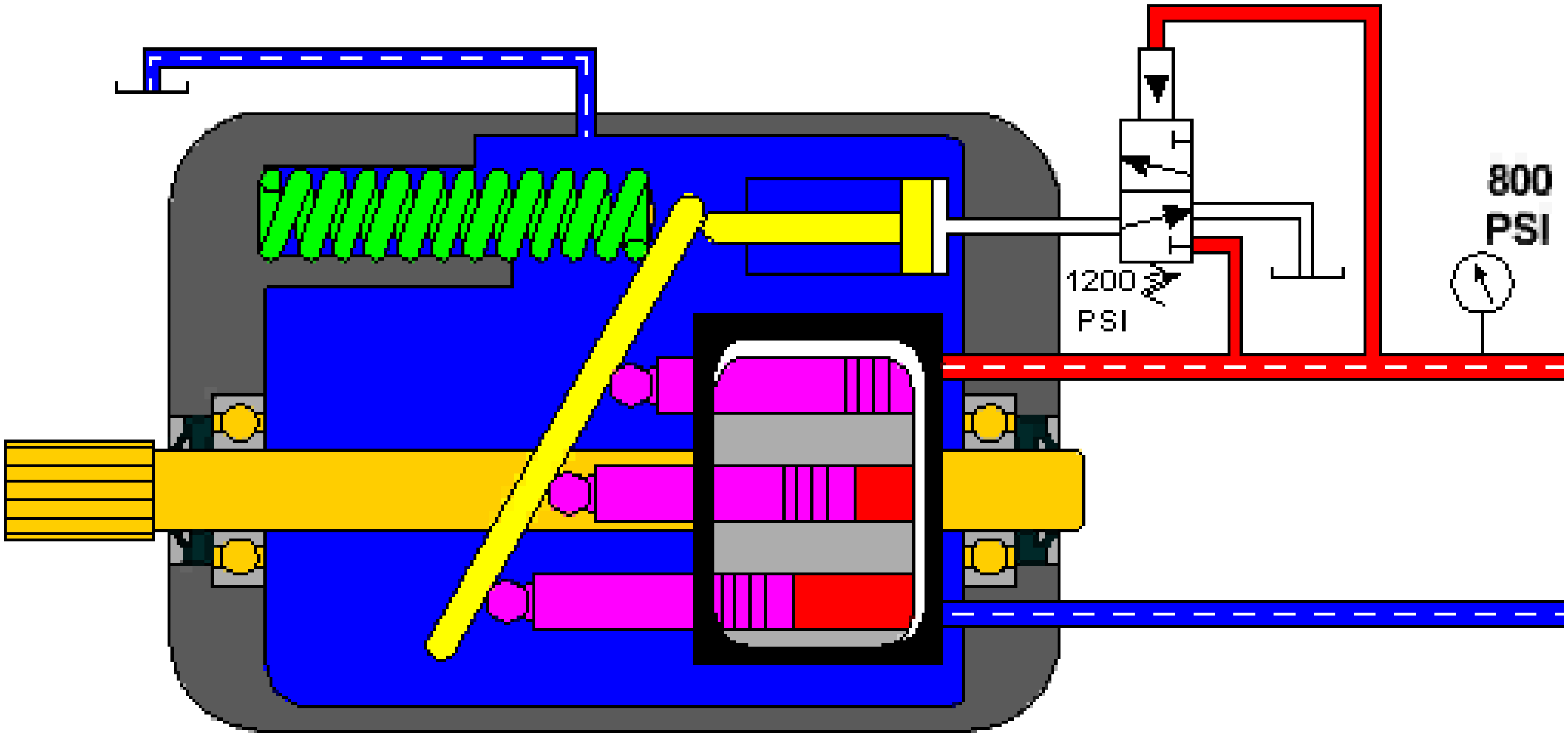
Case Drain

- Most Variable Displacement Pumps have an external case drain piped directly back to tank.



Normal bypassing is 1-3% of the total pump volume.

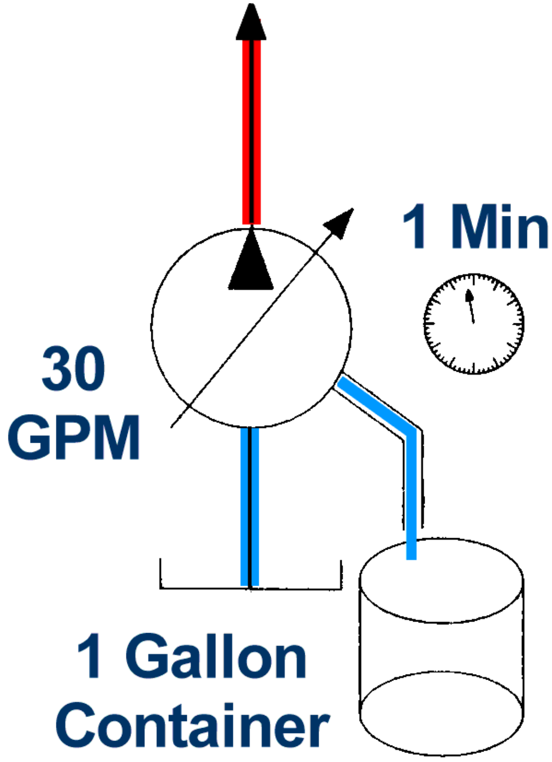
Pressure Compensating Piston Pump



Case Drain Flow Method #1

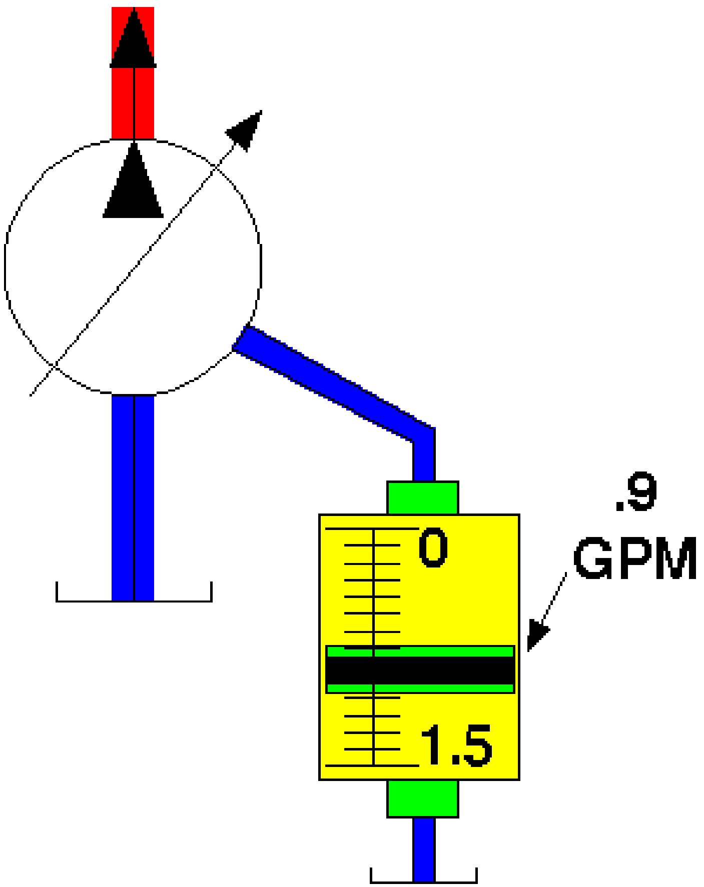
There are two methods of checking case drain flow:

- Run the case drain flow into a container of known size and time it

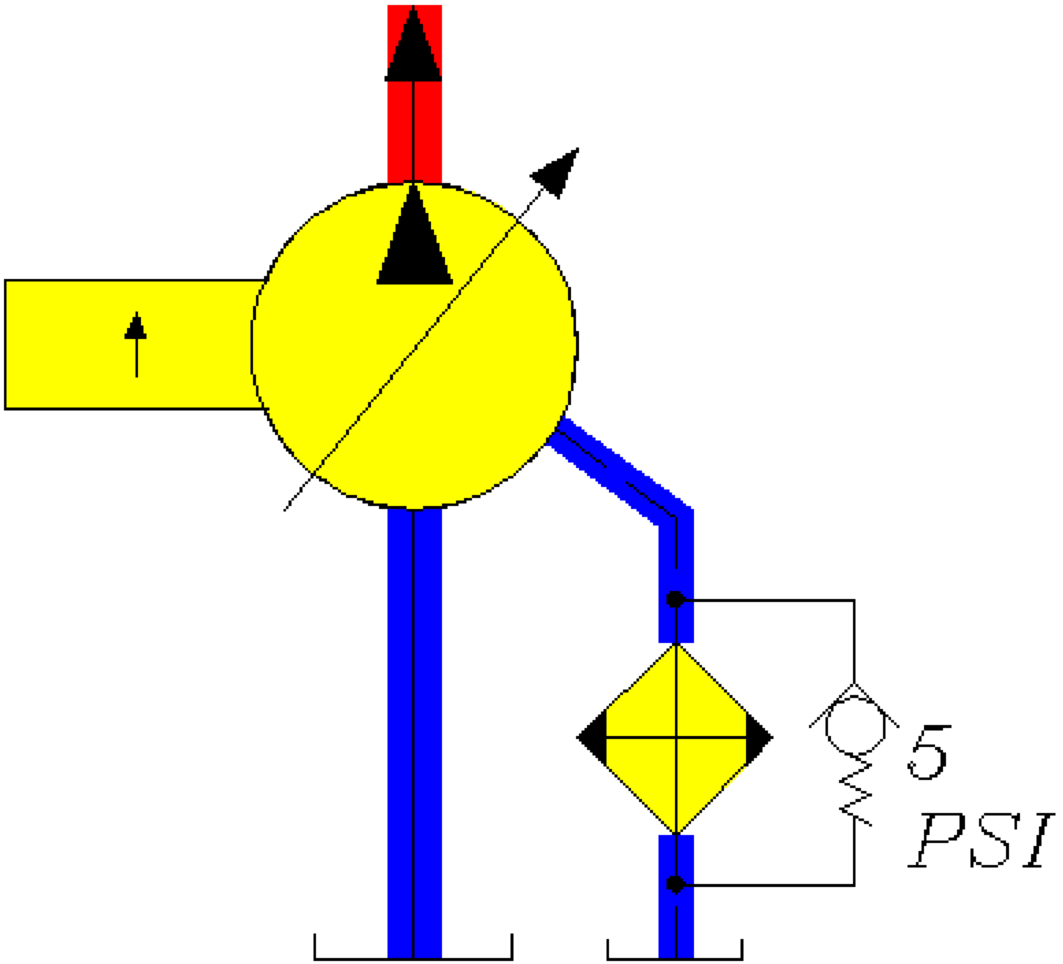


Case Drain Flow Method #2

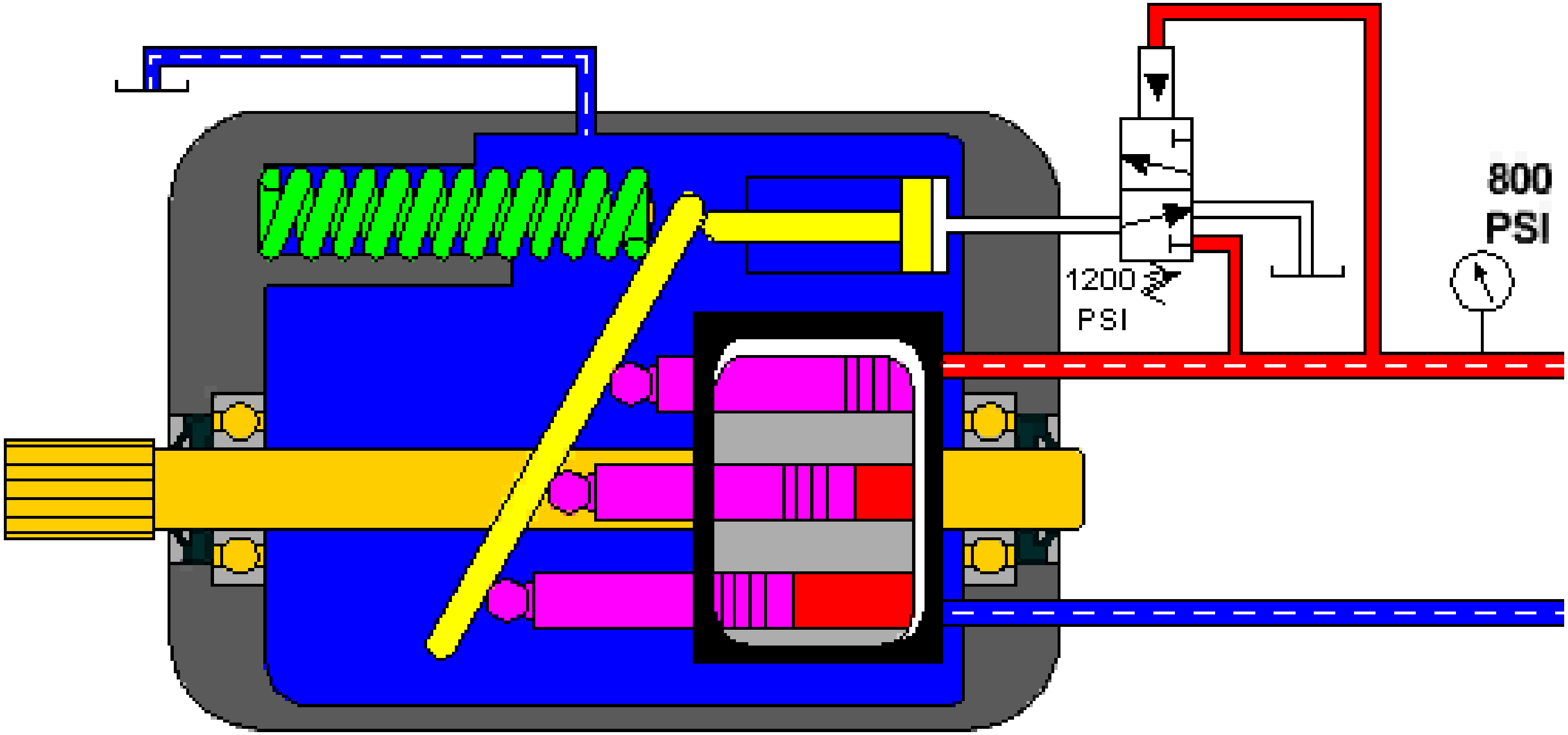
- A flow meter may be permanently installed in the case drain line.



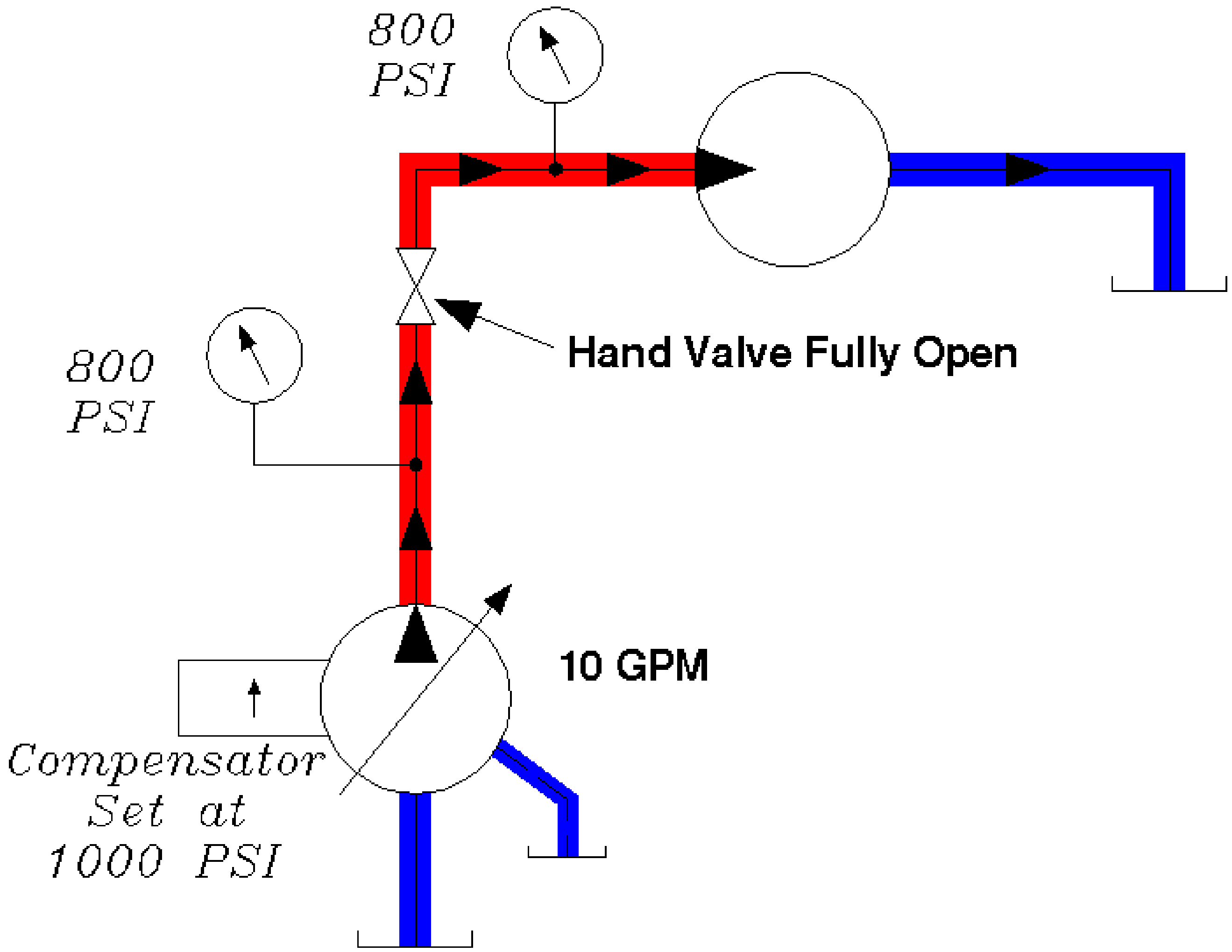
Case Drain Line Cooler



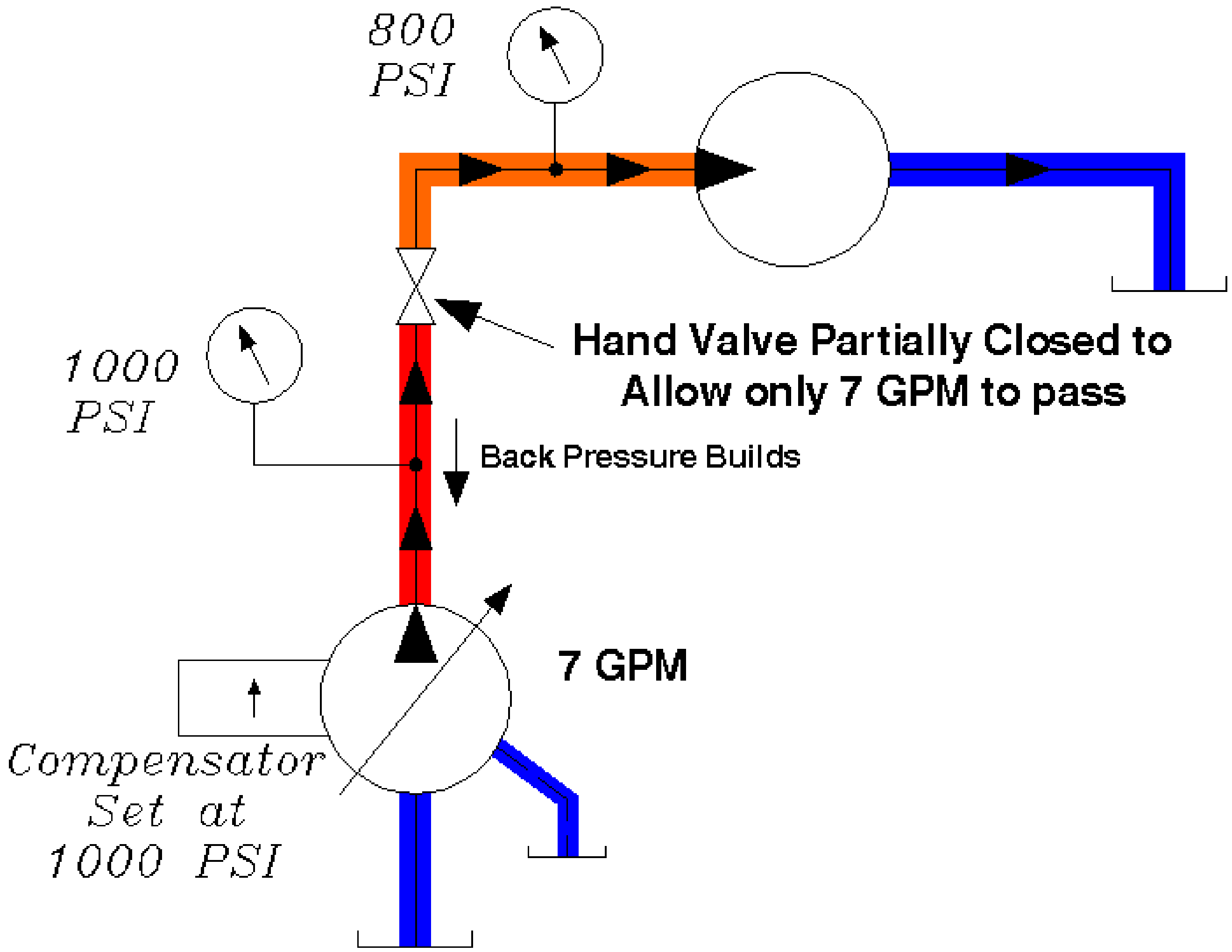
Pressure Compensating Piston Pump



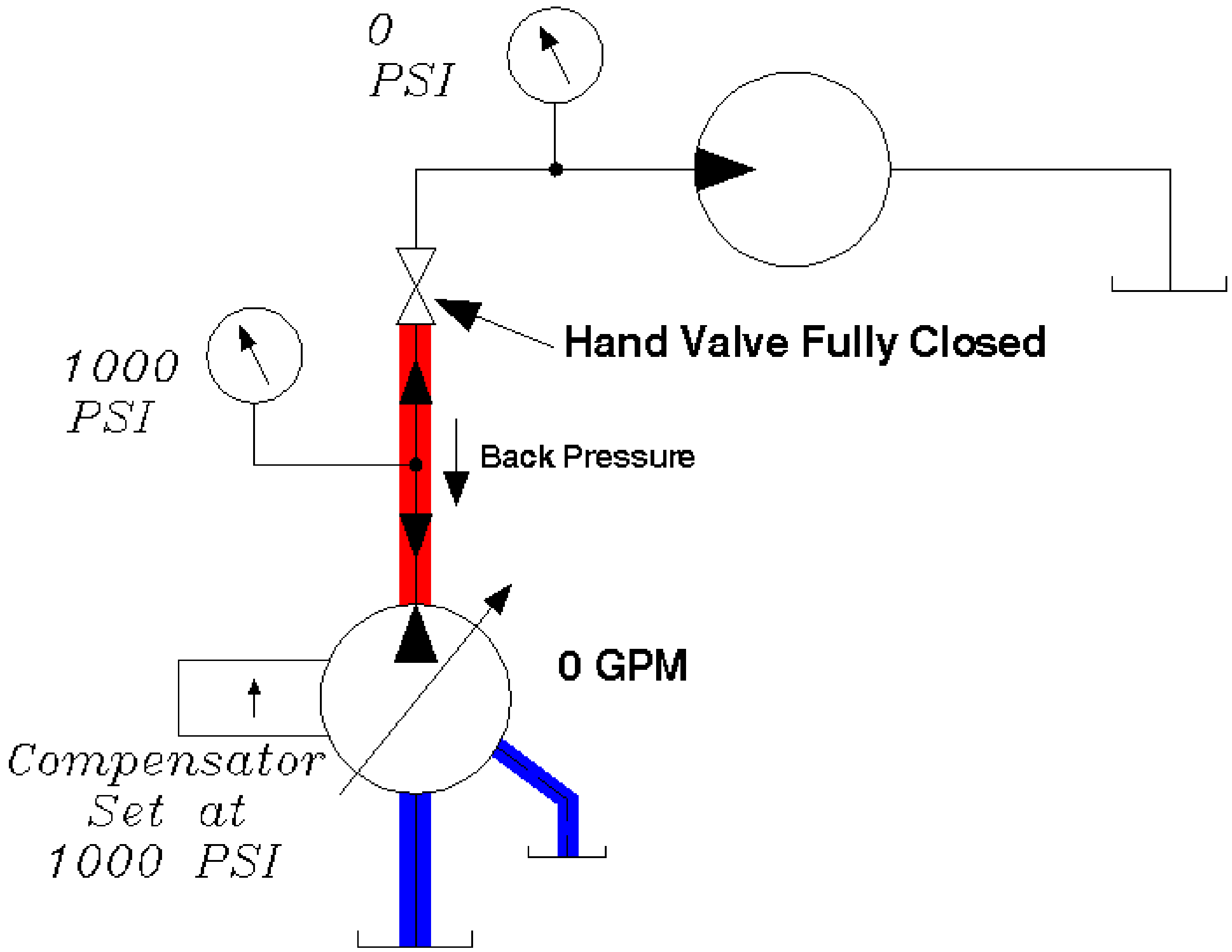
Pressure Compensating Pump Example



Pressure Compensating Pump Example



Pressure Compensating Pump Example

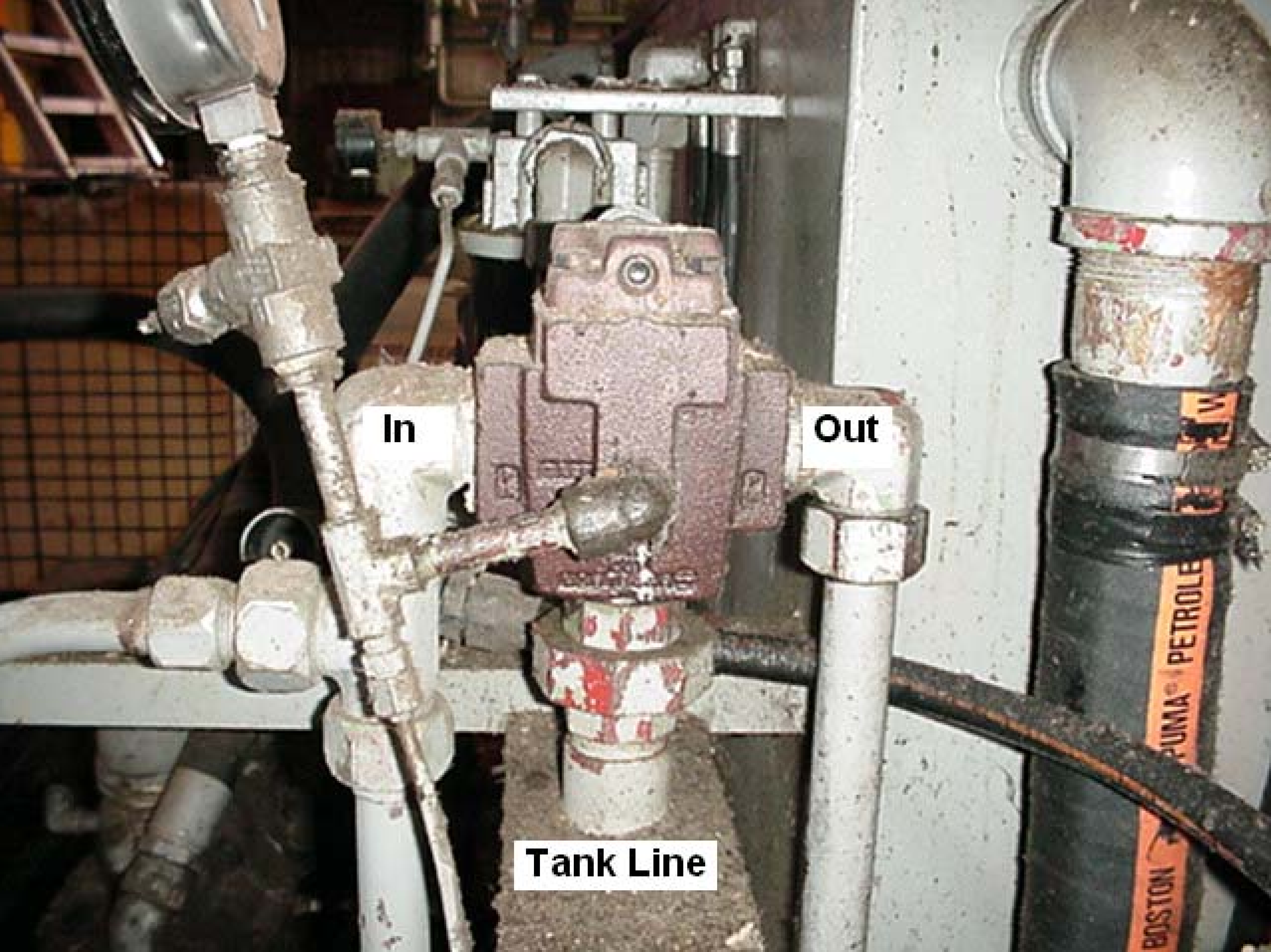


Systems With Relief Valves

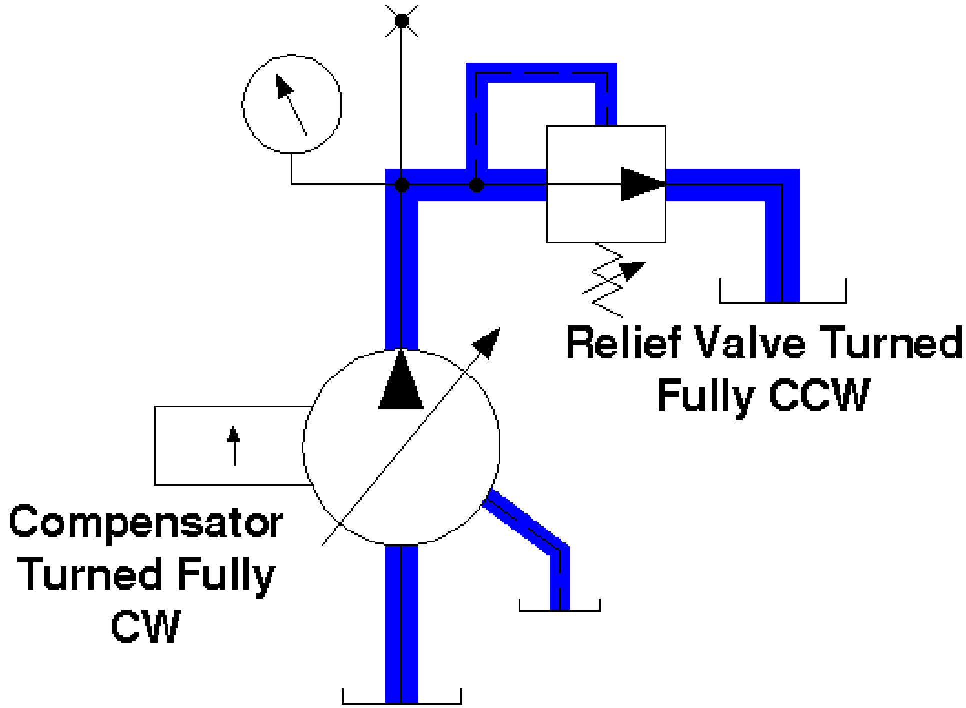
The purposes of a relief valve in a pressure compensating pump system are:

- Absorb pressure spikes
- Operate as an extreme safety device

The only time the relief valve should open is when the pressure rises above the compensator setting.

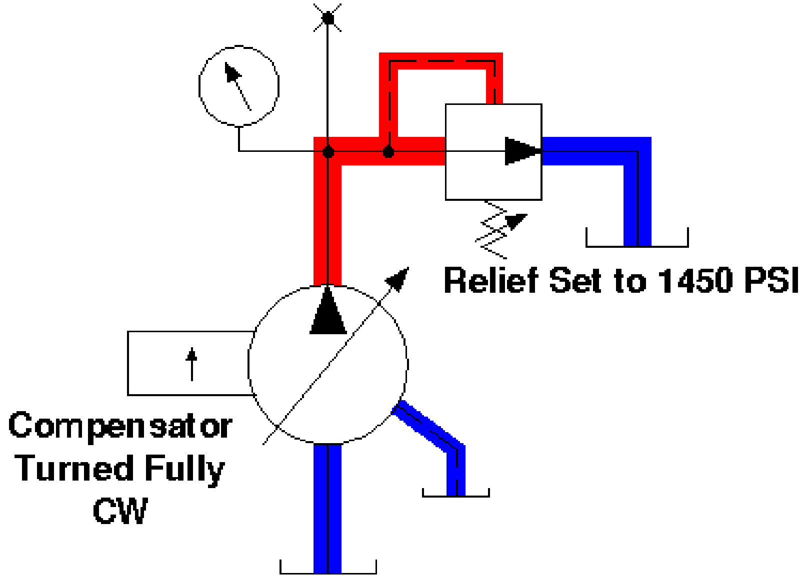

In
Out
Tank Line
PUMA
PETROLE
BOSTON

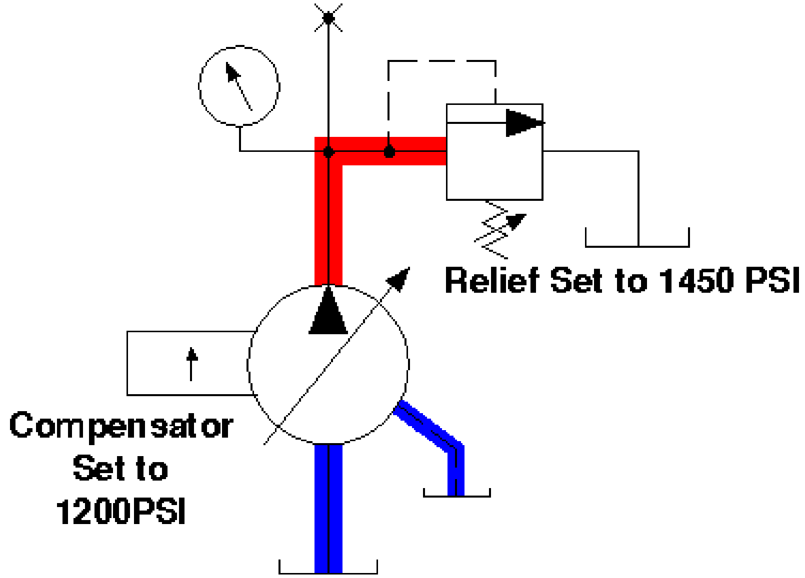
Adjustment Procedure



- Observe the system to find the maximum operating pressure
- Establish a deadhead condition
- Turn the relief valve fully CCW
- Turn the compensator fully CW

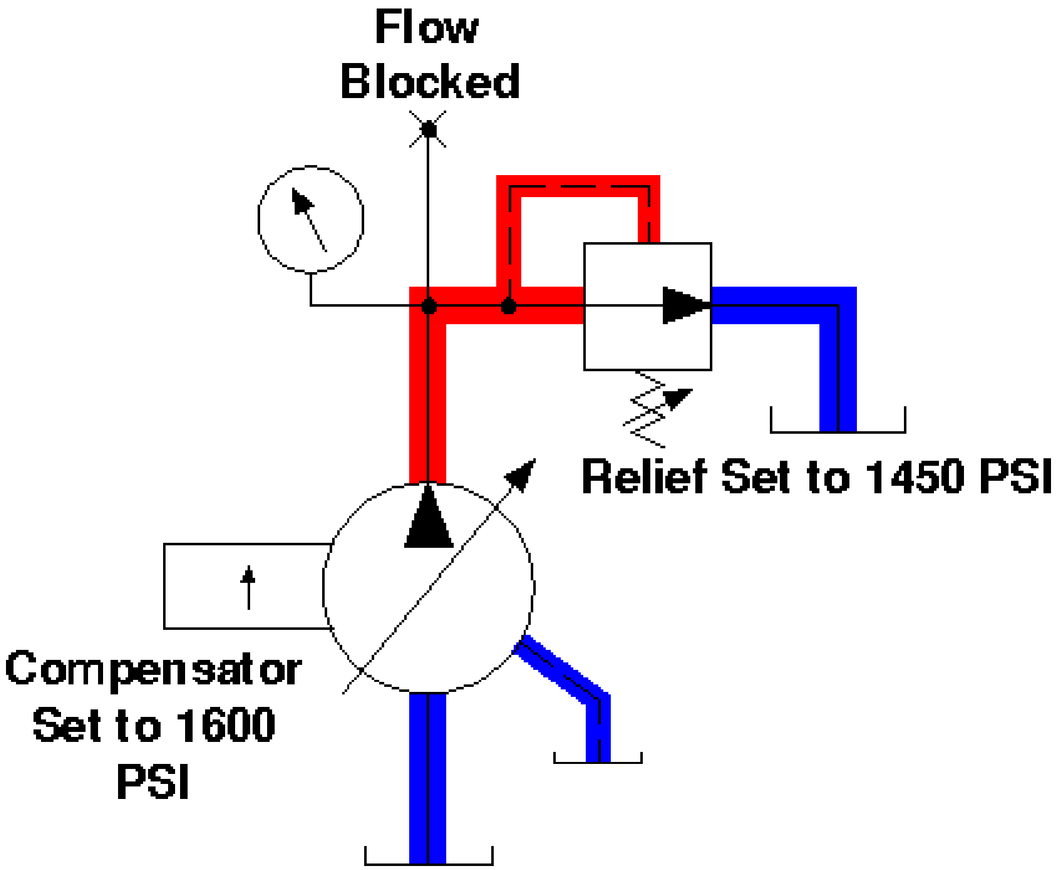
Adjustment Procedure





- Turn the relief valve CW to 1450 PSI
- Turn the compensator to 1200 PSI

Relief Set Below Compensator



- If the relief valve is set below the compensator, the pump will act as a fixed displacement pump.

Heat will be generated!

Calculating Heat & Electrical Power

- HP = GPM X PSI X .000583

  = 30 X 1450 X .000583

  = 25 HP

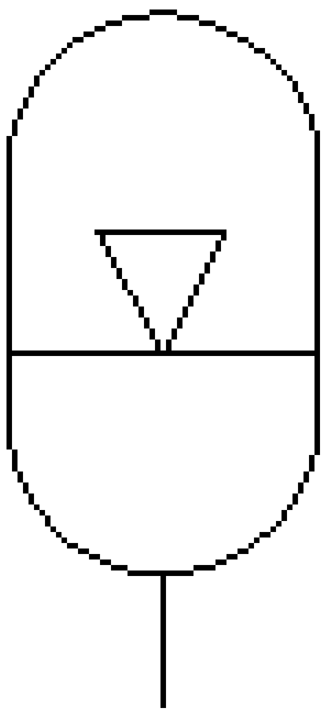
- 746 Watts = 1 Horsepower

Electrical Power = 746 X 25

= 18,650 Watts

Accumulators

Hydraulic accumulators are used to store pressurized fluid



Bladder Accumulator


Piston Accumulator

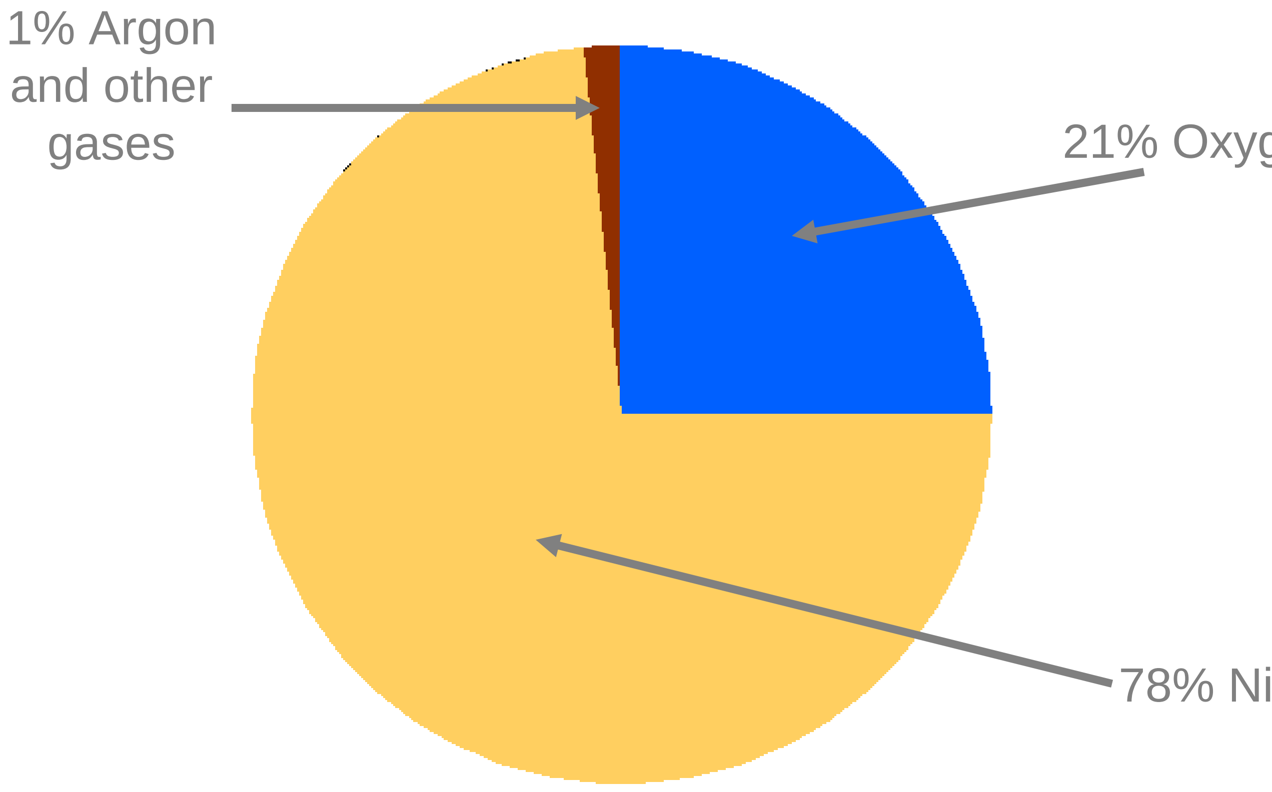
Accumulators

Accumulators are used for ONE of two purposes depending upon the PRECHARGE

- Supply additional oil flow to the system at a very fast rate
- Absorb shock

Accumulators

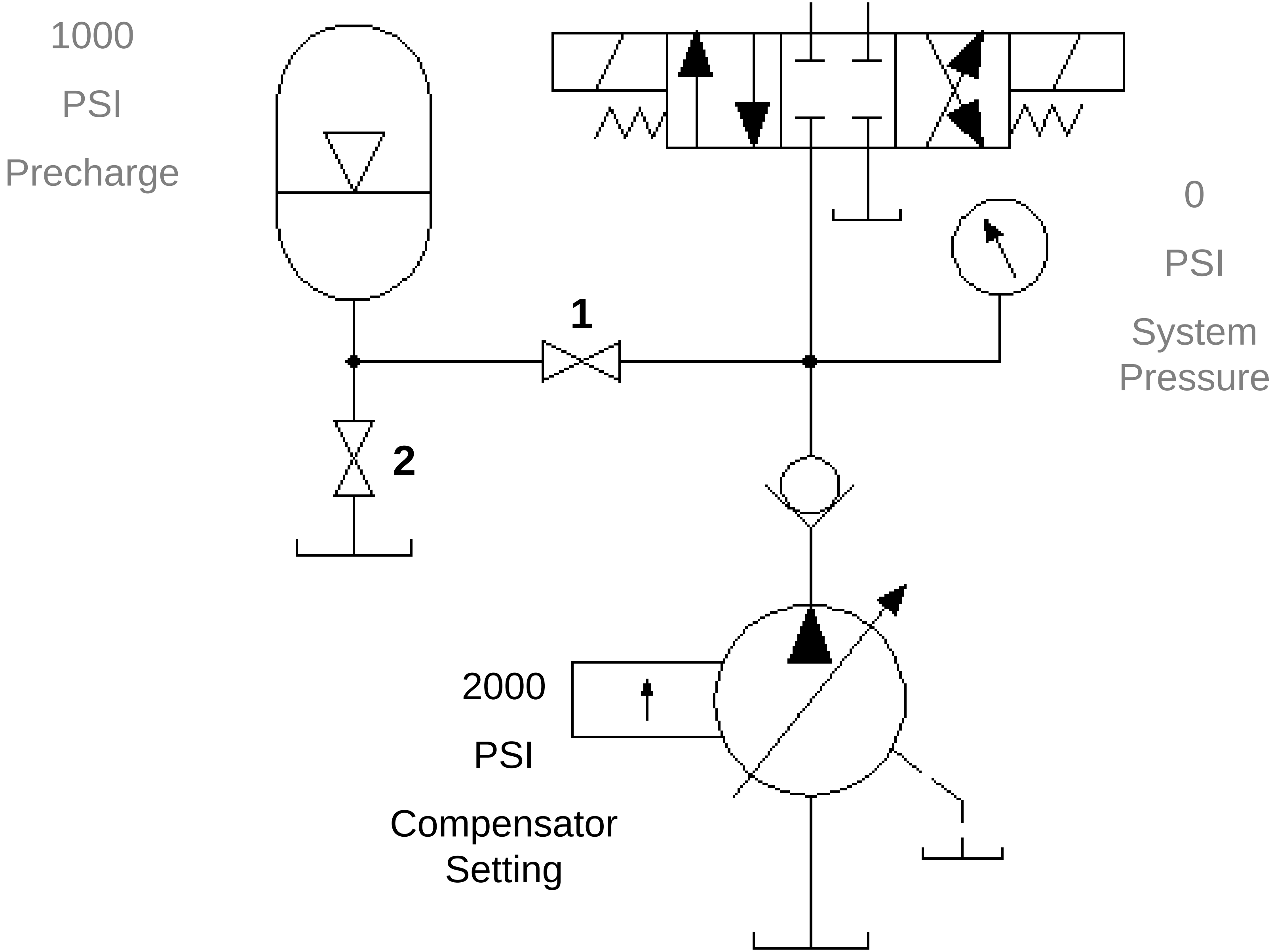
Dry Nitrogen is used to precharge the top portion of an accumulator



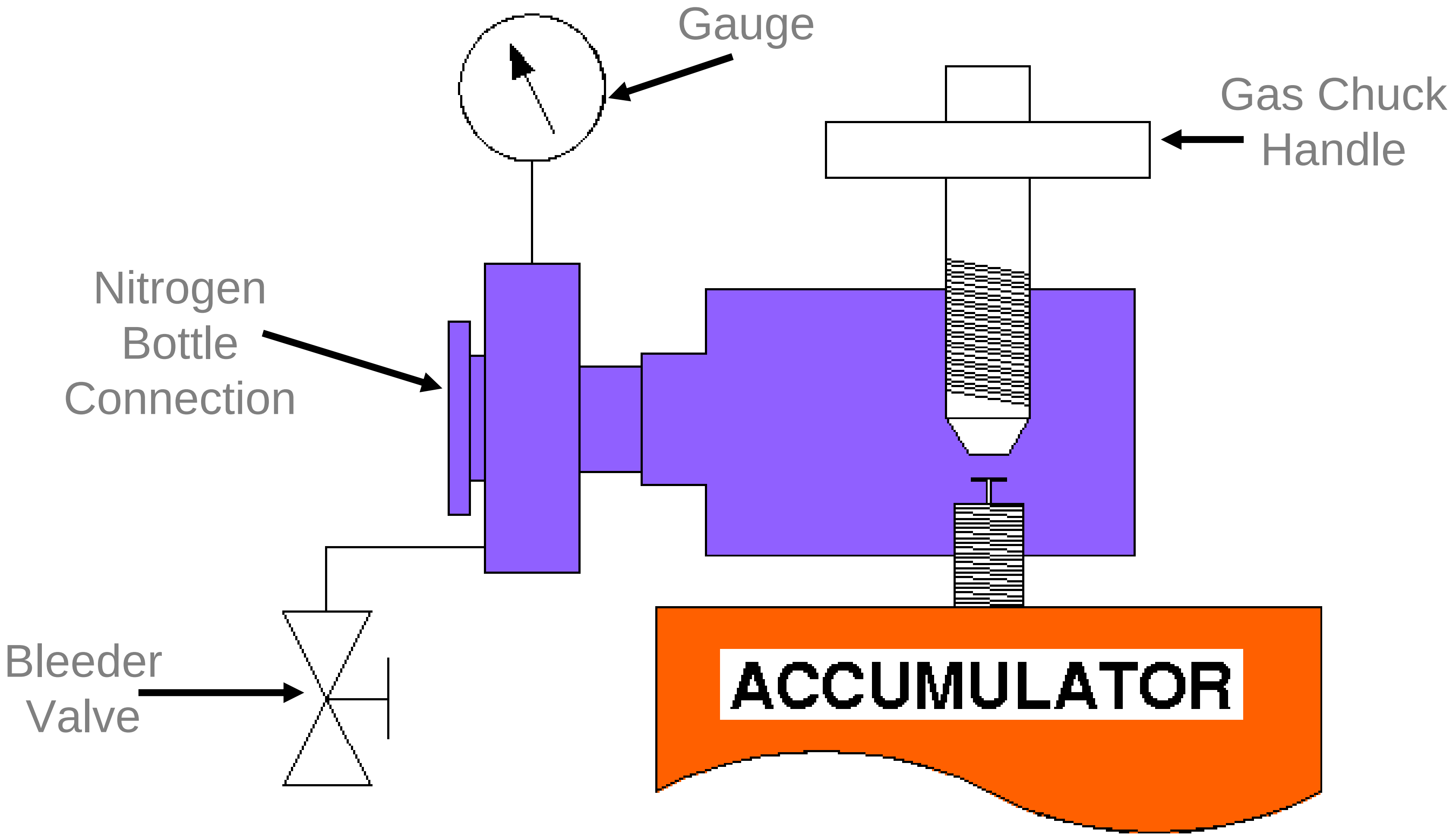
Accumulators

NEVER use *Oxygen* or *Compressed Air* to precharge an accumulator!

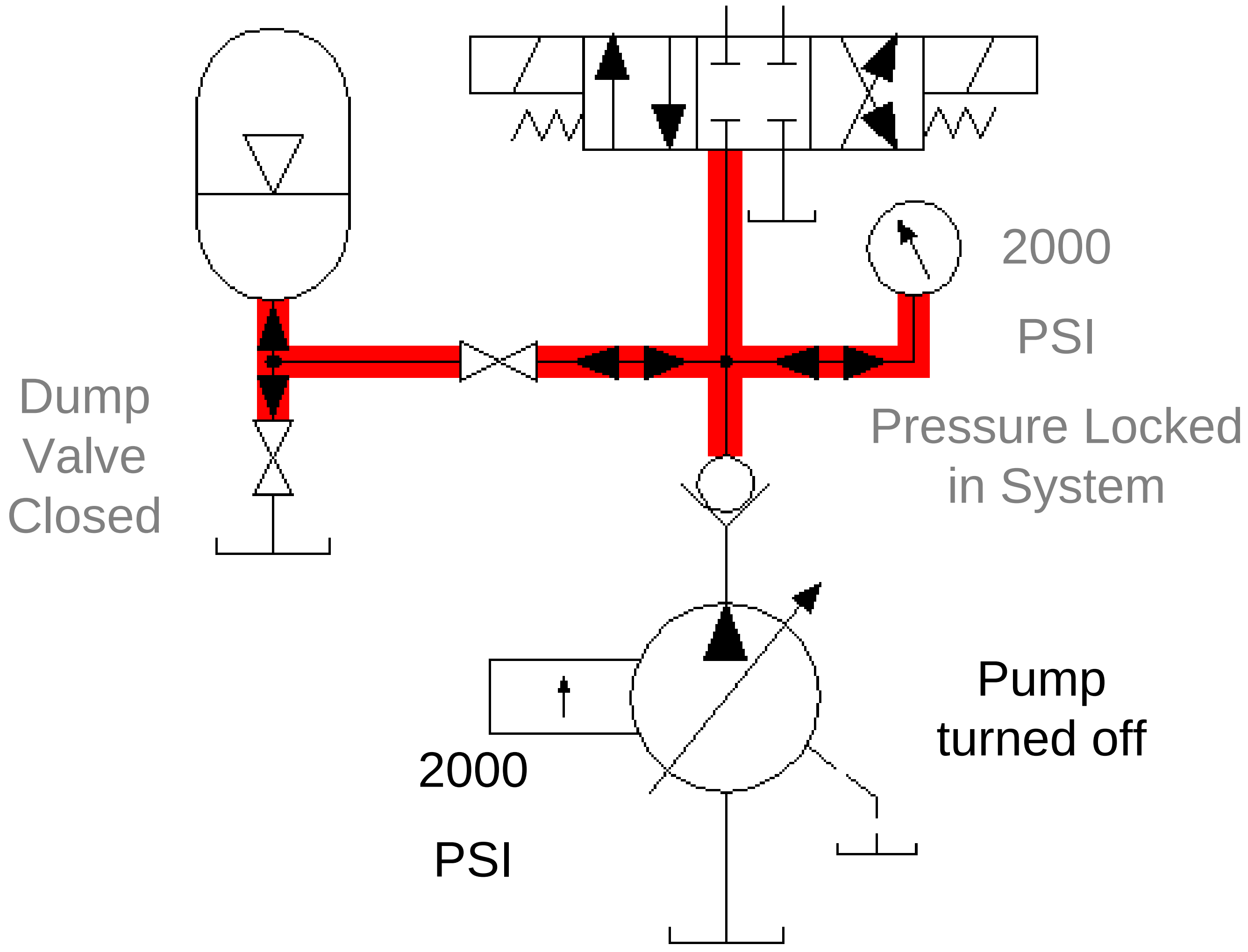
Rule of Thumb - Precharge to one-half of the maximum system pressure


1000
PSI
Precharge
0
PSI
System
Pressure
1
2
2000
PSI
Compensator
Setting

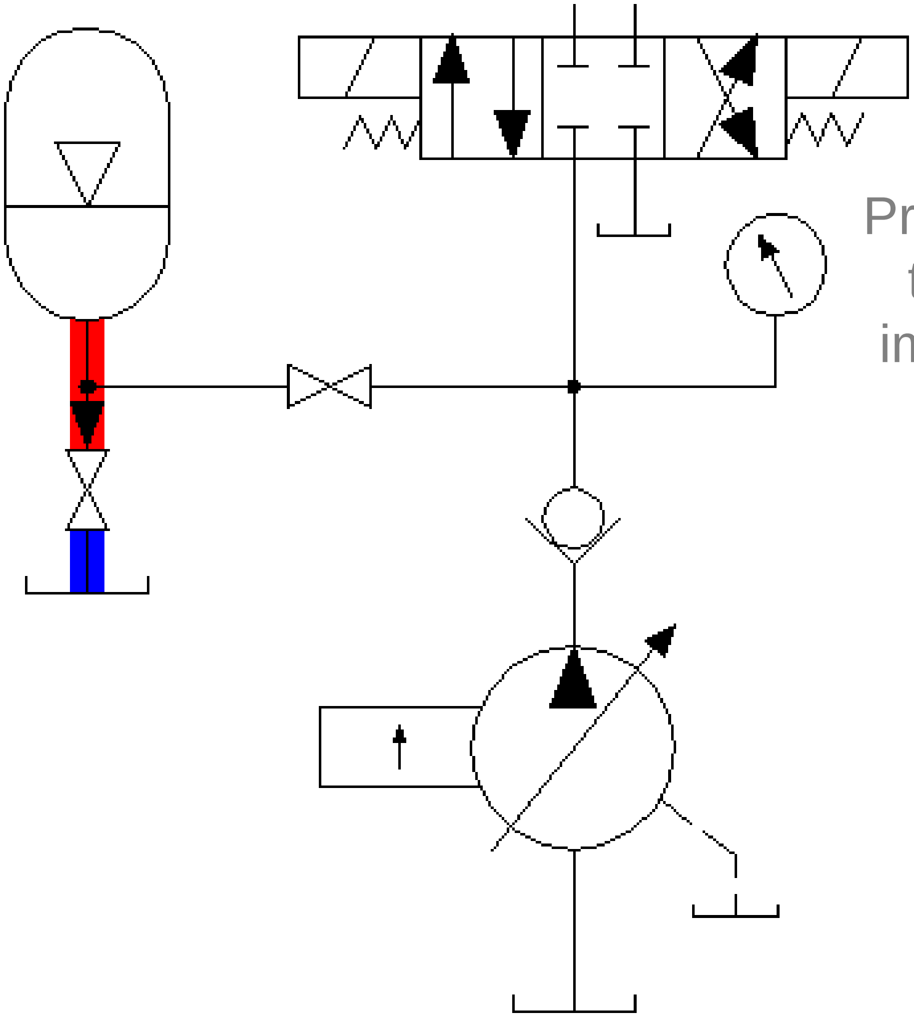
Using the Charging Rig



Checking the Precharge Hydraulically



Checking the Precharge Hydraulically

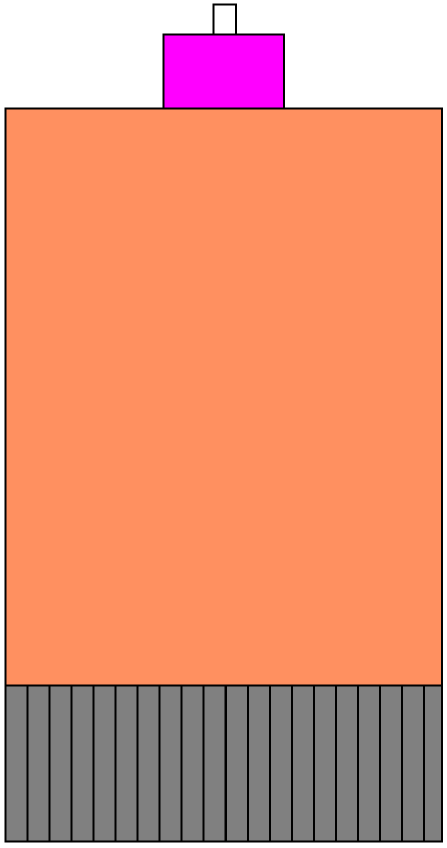


Pressure slowly drops to precharge, then immediately to 0 PSI

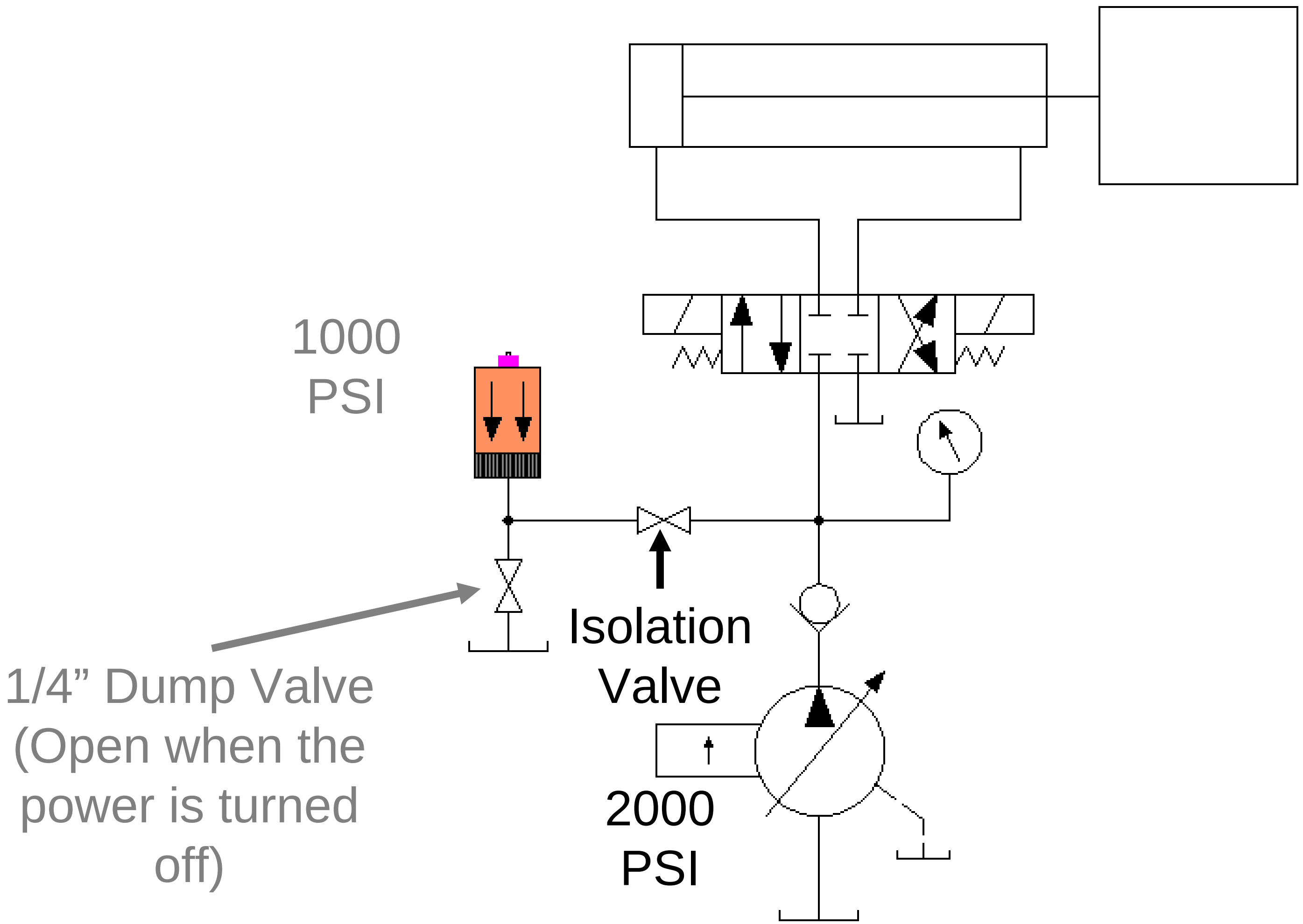
Dump Valve Open

Types of Accumulators

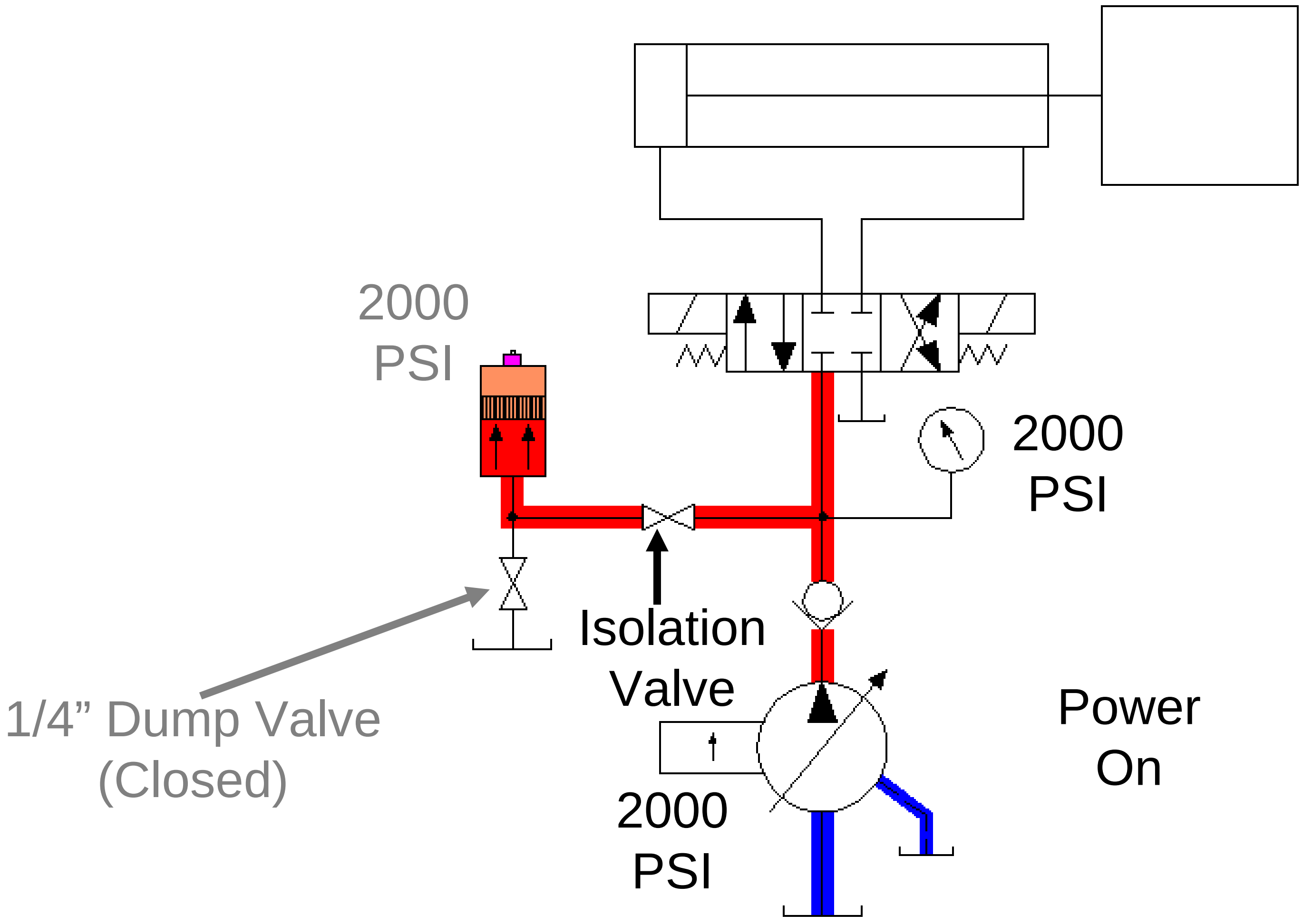
Piston Accumulators



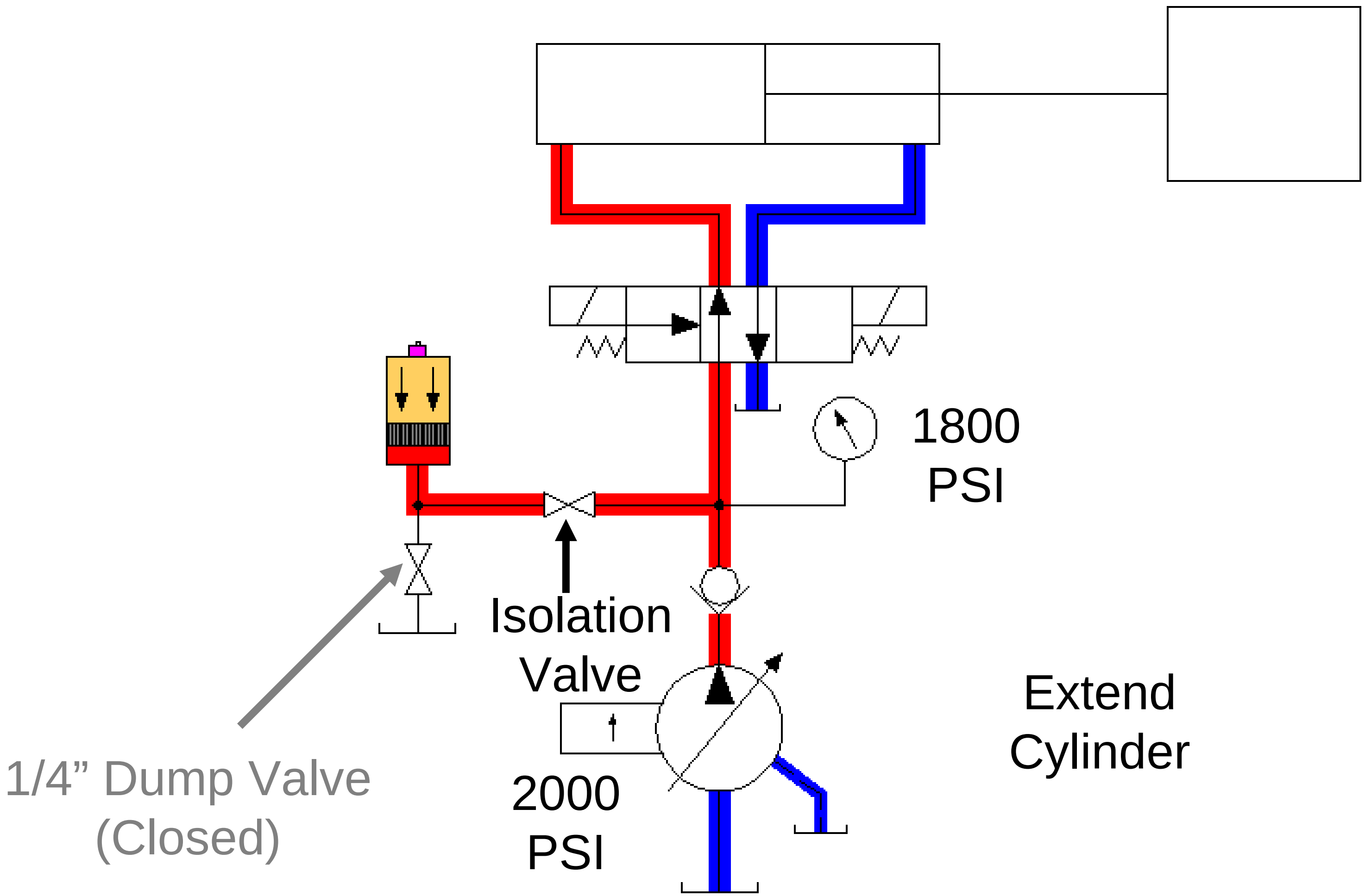
Example Circuit



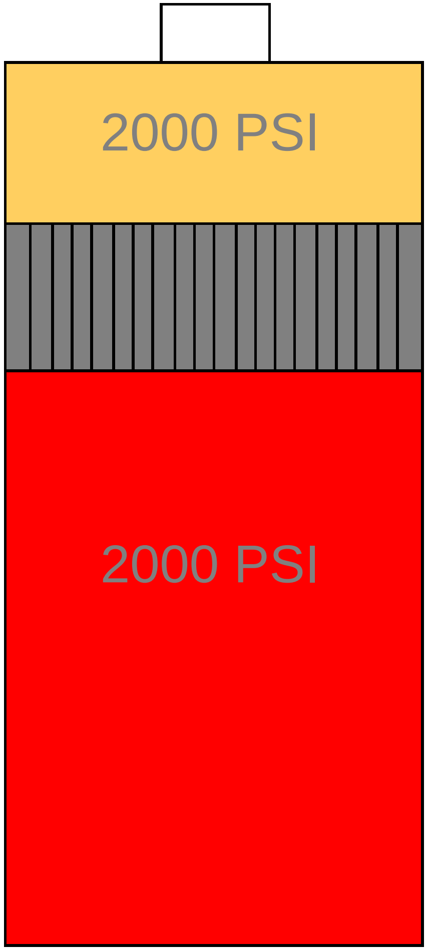
Example Circuit



Example Circuit

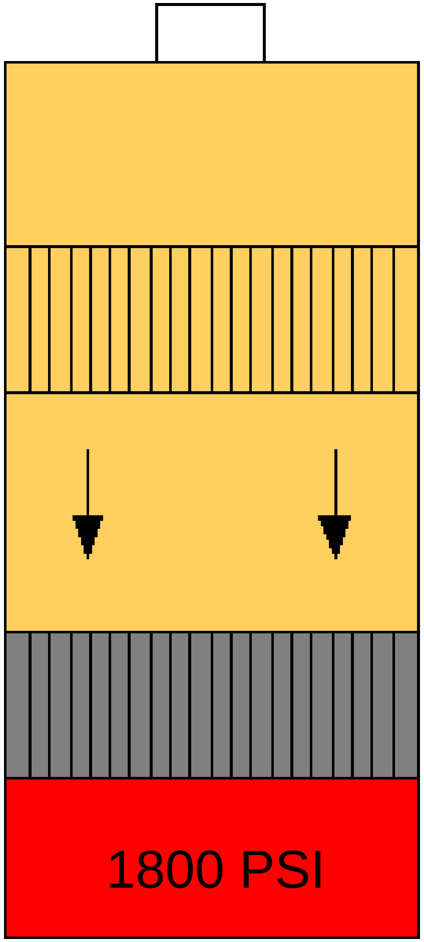


Checking the Piston Accumulator



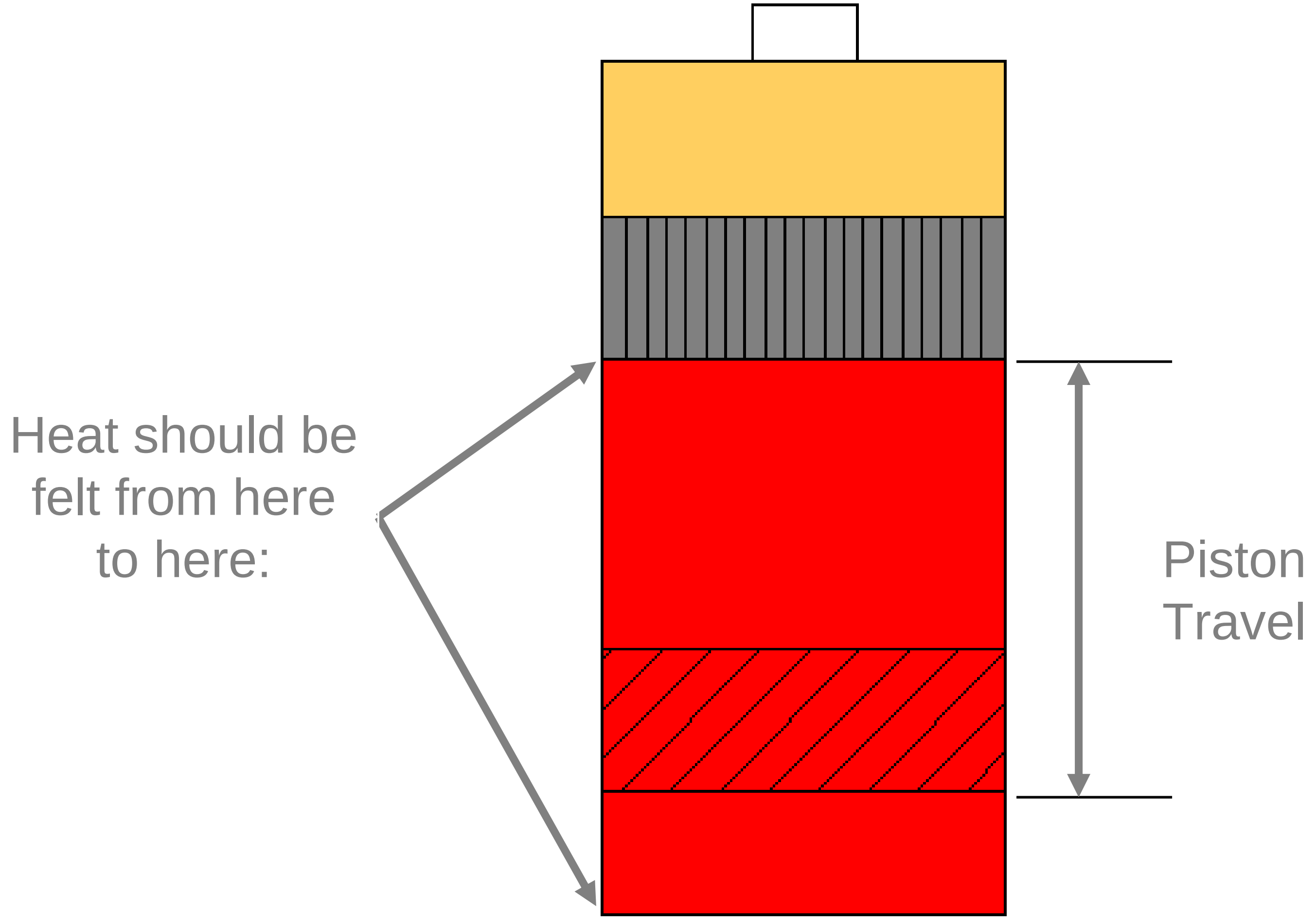
System pressure should build to the compensator setting whenever actuators are not cycling

Checking the Piston Accumulator

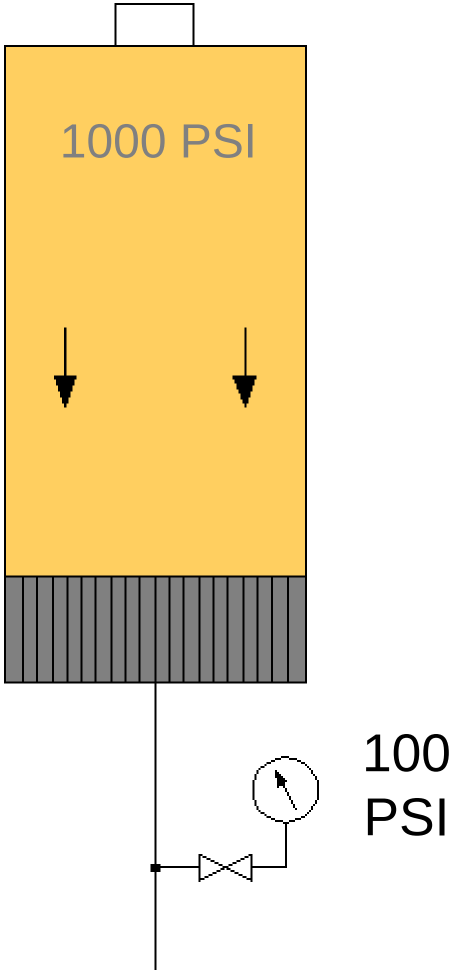


System pressure should not drop more than 100-200 PSI when the directional valve opens

Checking the Piston Accumulator

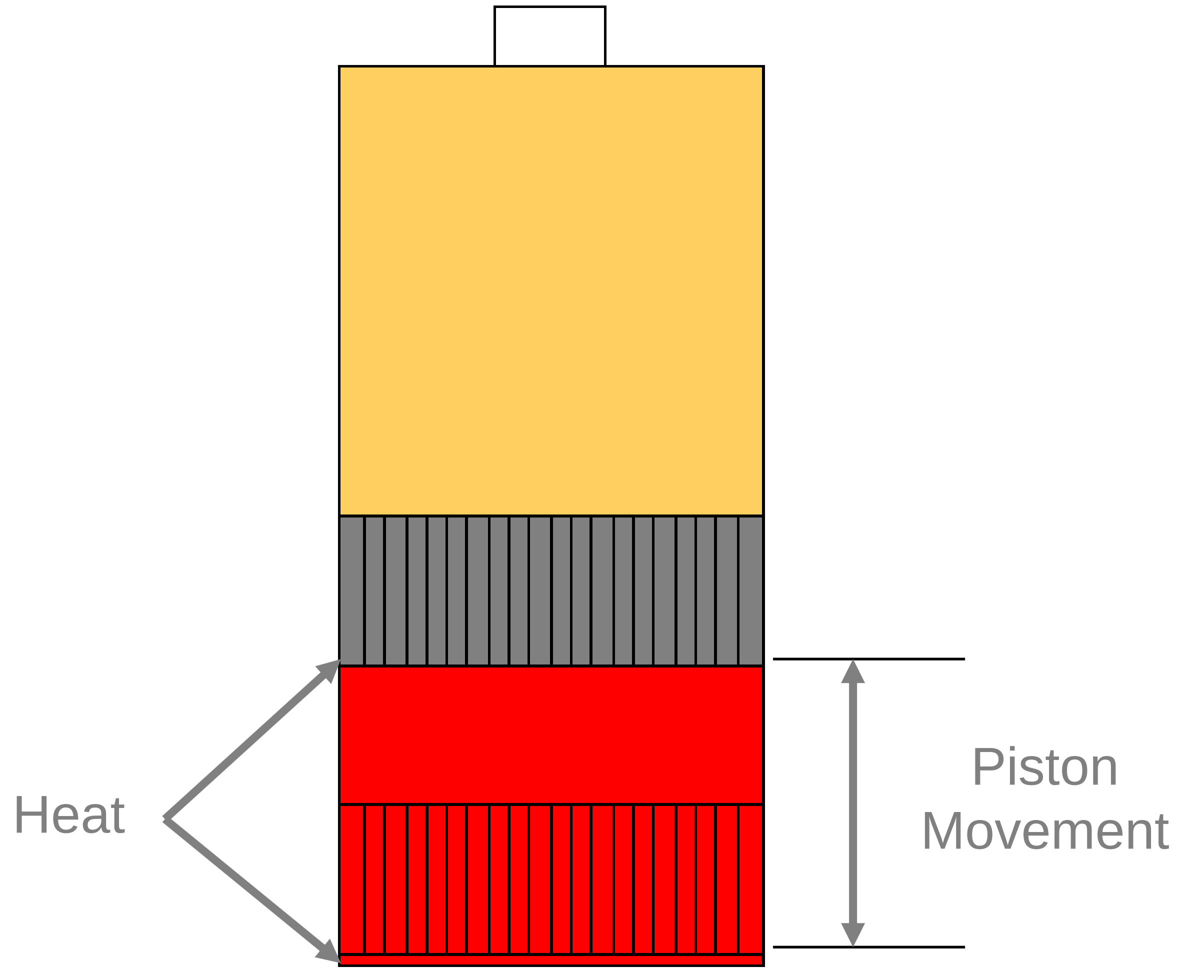


Checking the Piston Accumulator

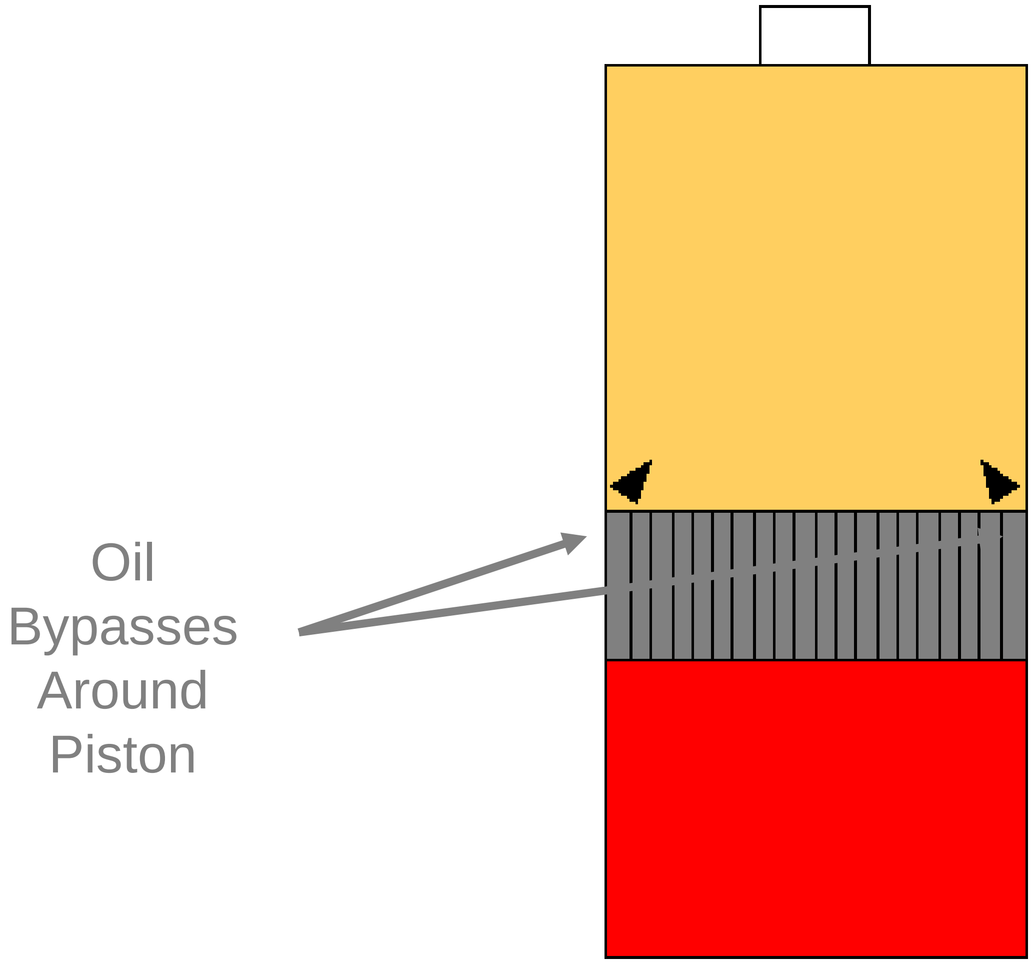


Dropping to a very LOW pressure usually indicates an accumulator problem

Overcharged

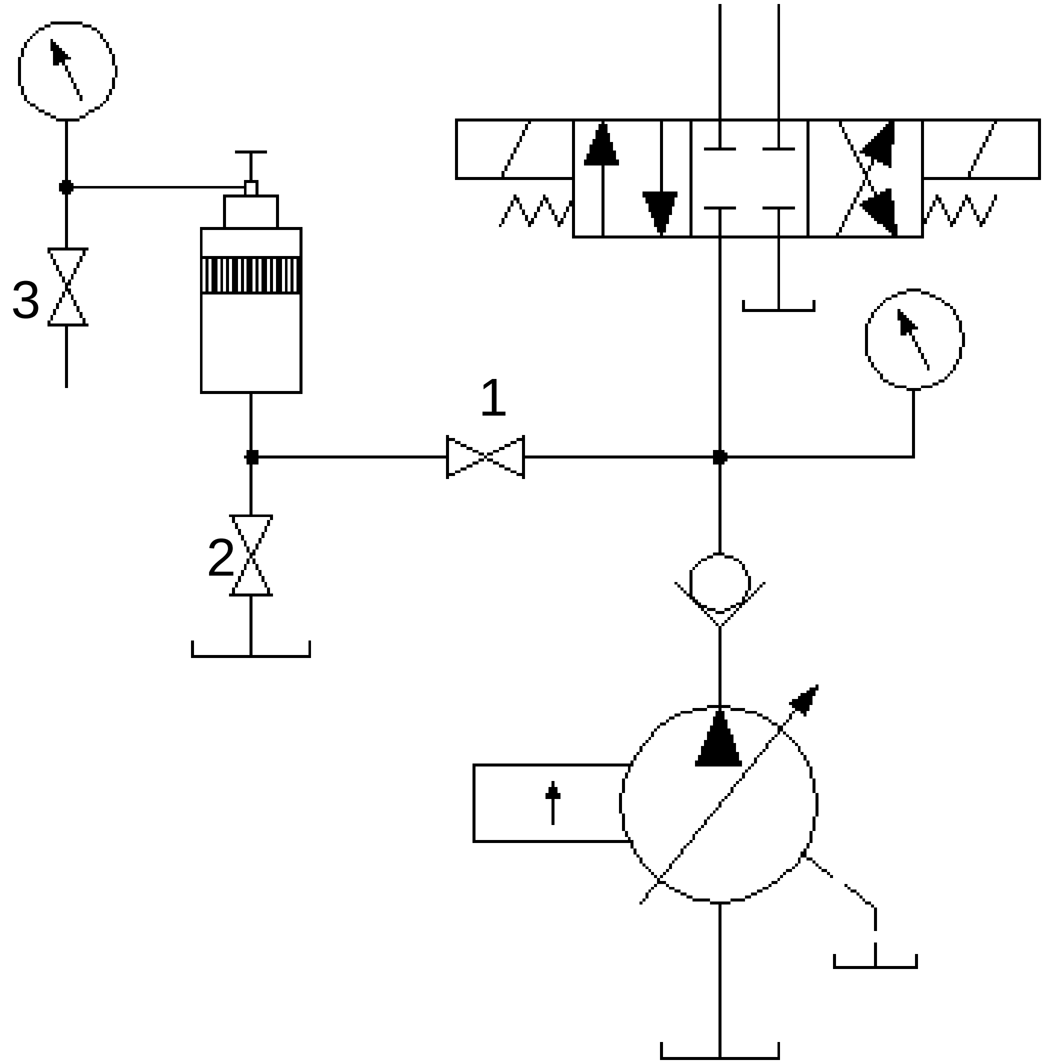


Overcharged

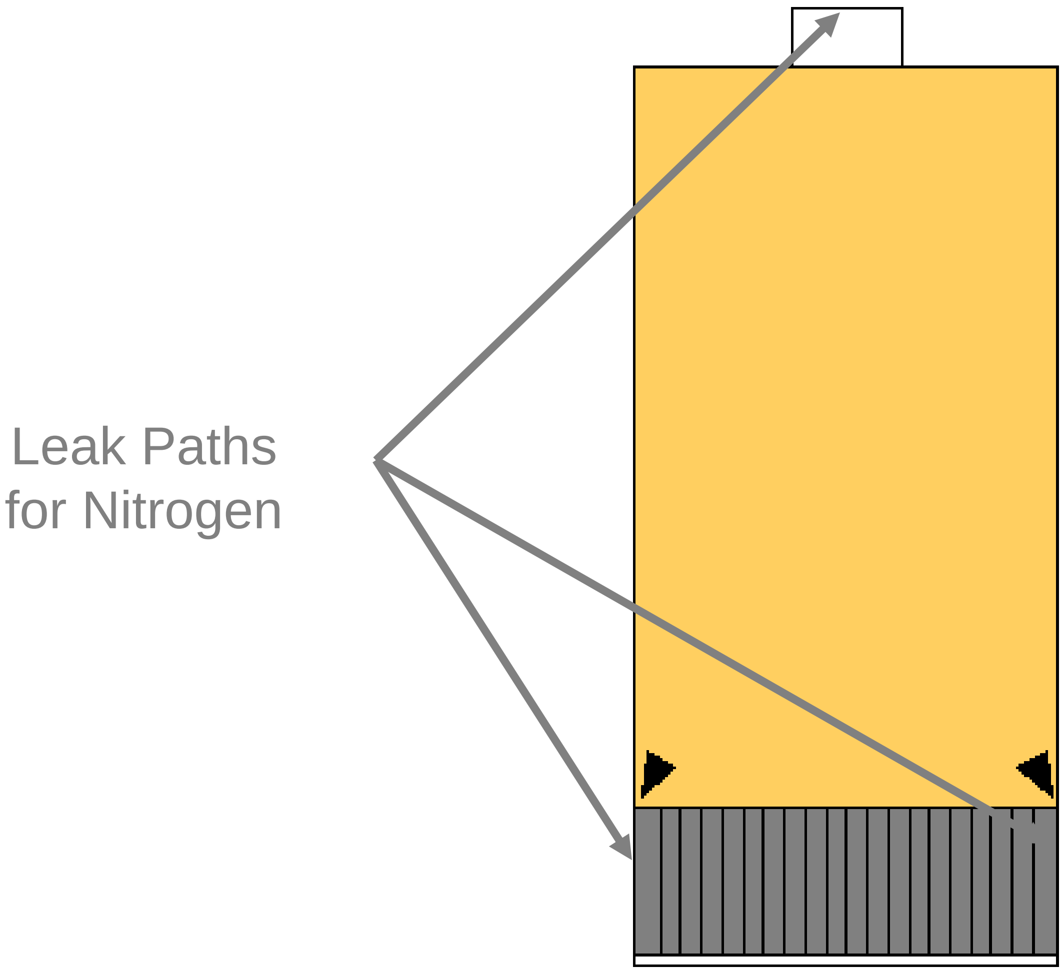


Piston Removal

- With the pump on, open the #3 bleeder valve on the charging rig
- Close the #1 isolation valve
- Open the #2 manual dump valve
- Remove the charging rig and the top of the accumulator

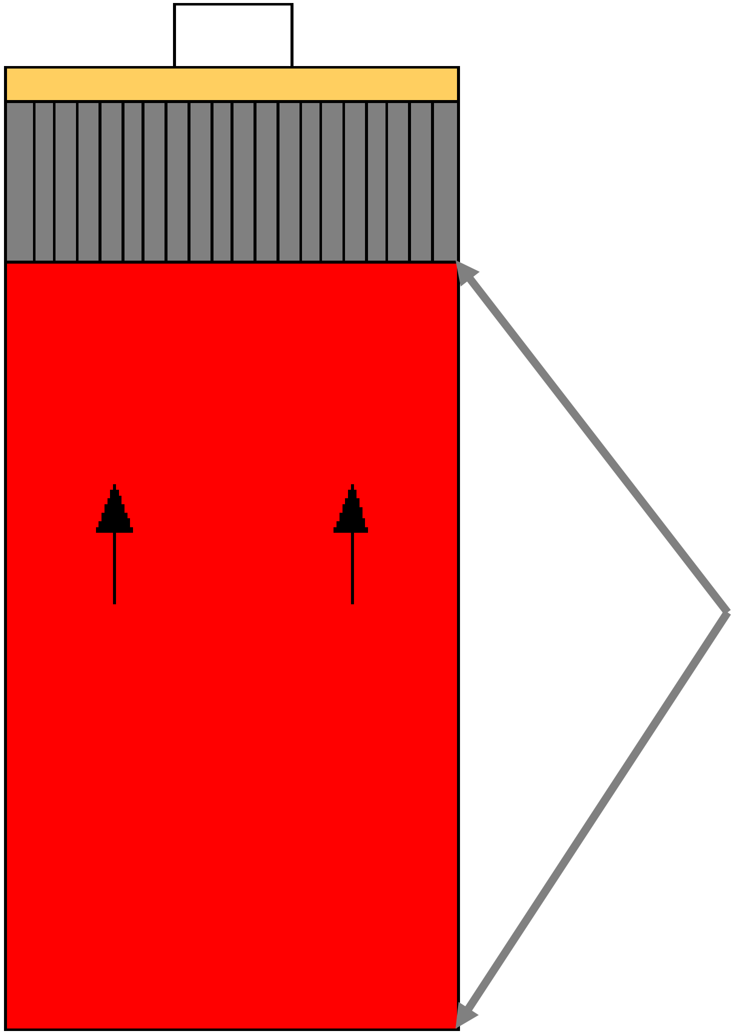


Undercharged



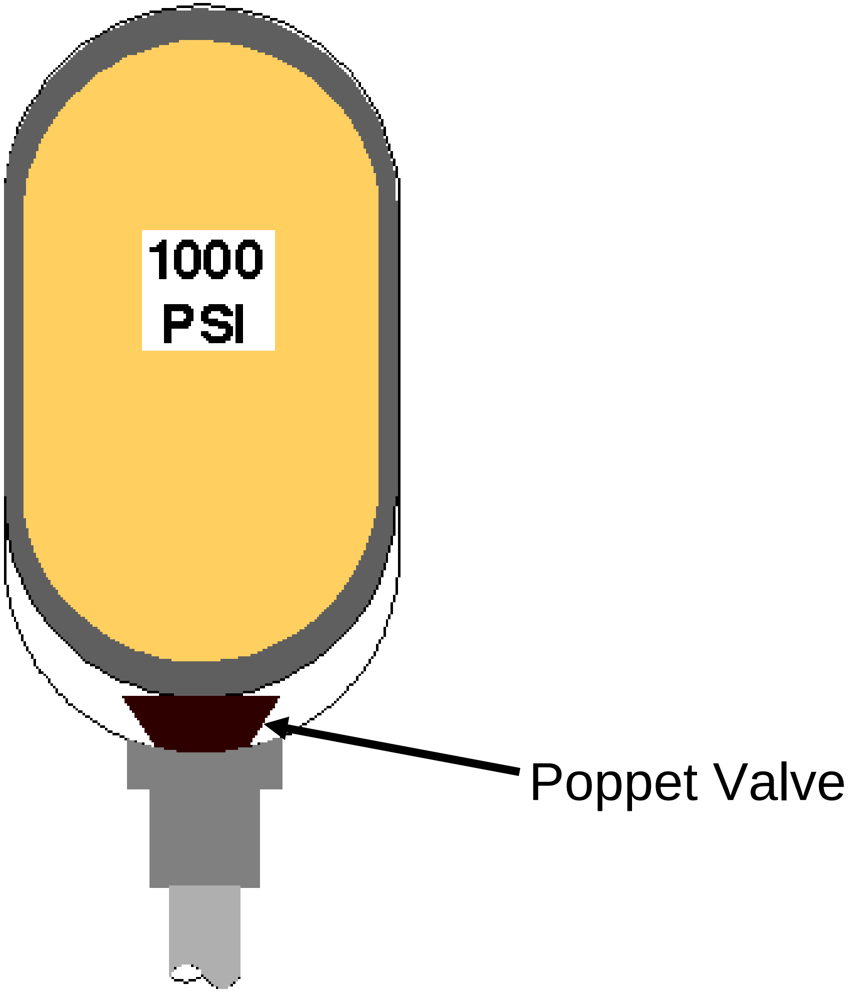
Undercharged

Hydraulic pressure drives piston near the top



Heat

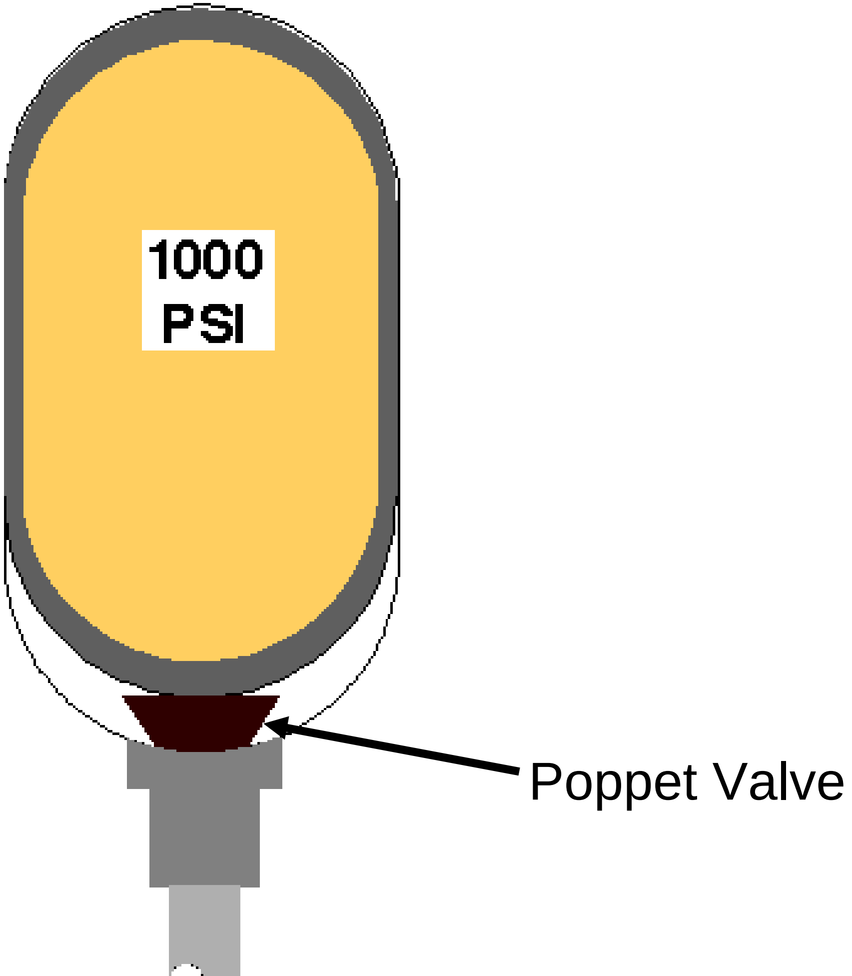
Bladder Accumulator



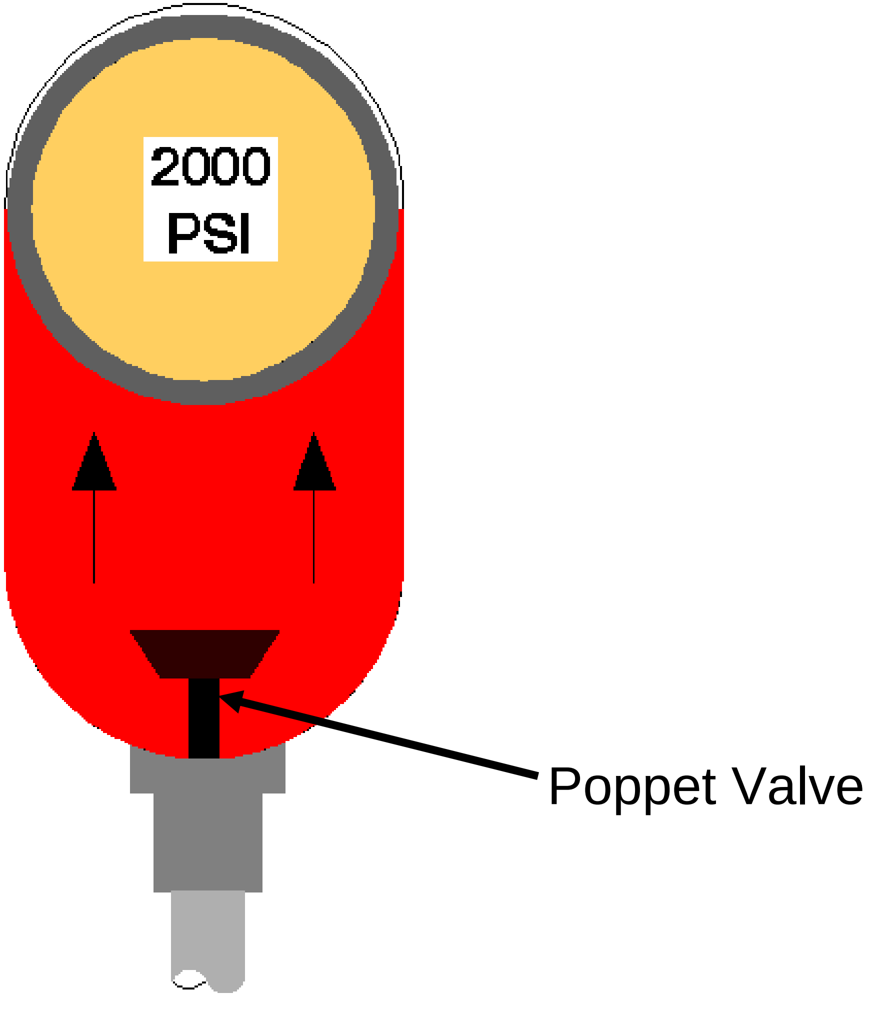

UNDER PRESSURE.
DANGER
COMPRESSED
AIR


Retainer Ring
Shell
Poppet Valve
Nut & Washer
O-Ring

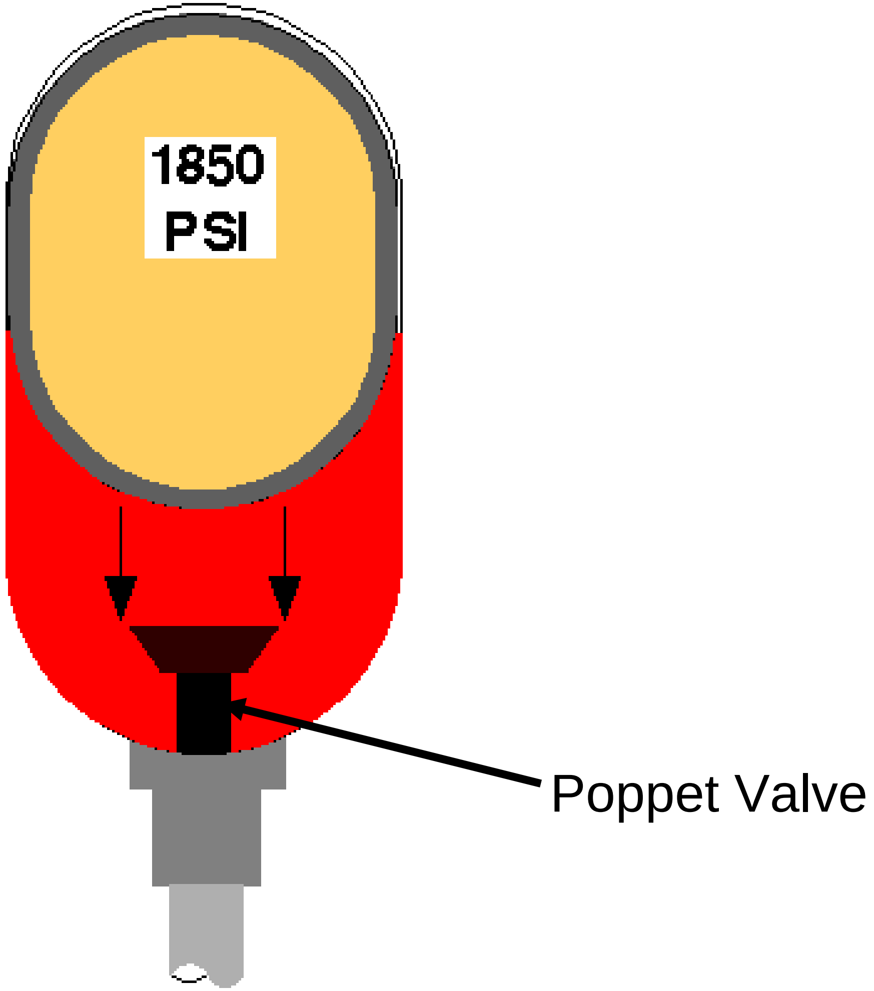
Bladder Accumulator



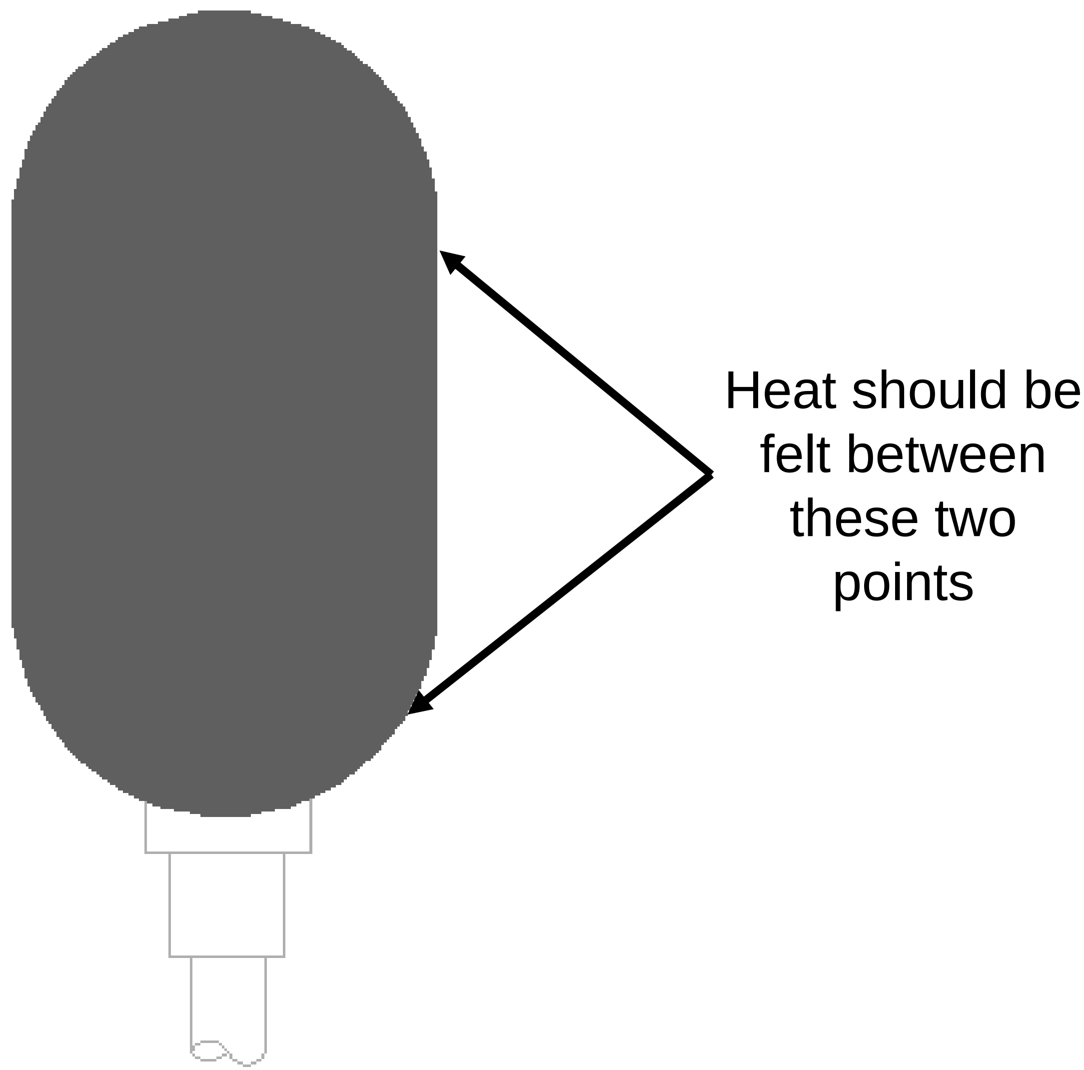
Bladder Accumulator



Bladder Accumulator



Checking The Bladder Accumulator



Checking The Bladder Accumulator

If *no* heat is felt on the bladder accumulator, then one of two things has happened:

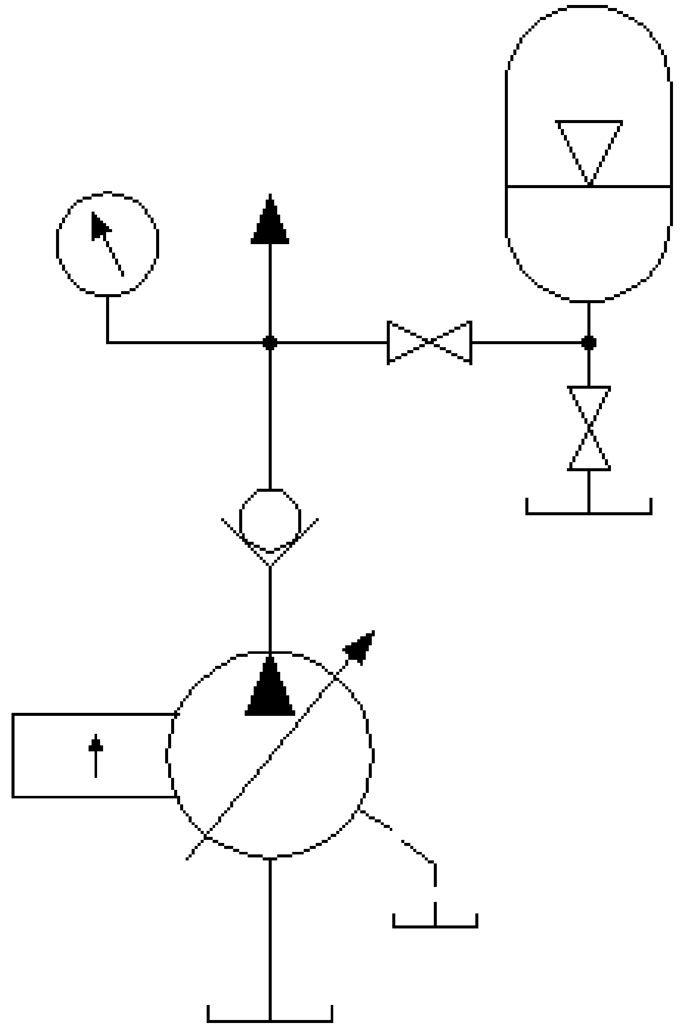
- The precharge is *above* the maximum system pressure
- The bladder is *ruptured*
- *The nitrogen has leaked out of the bladder*

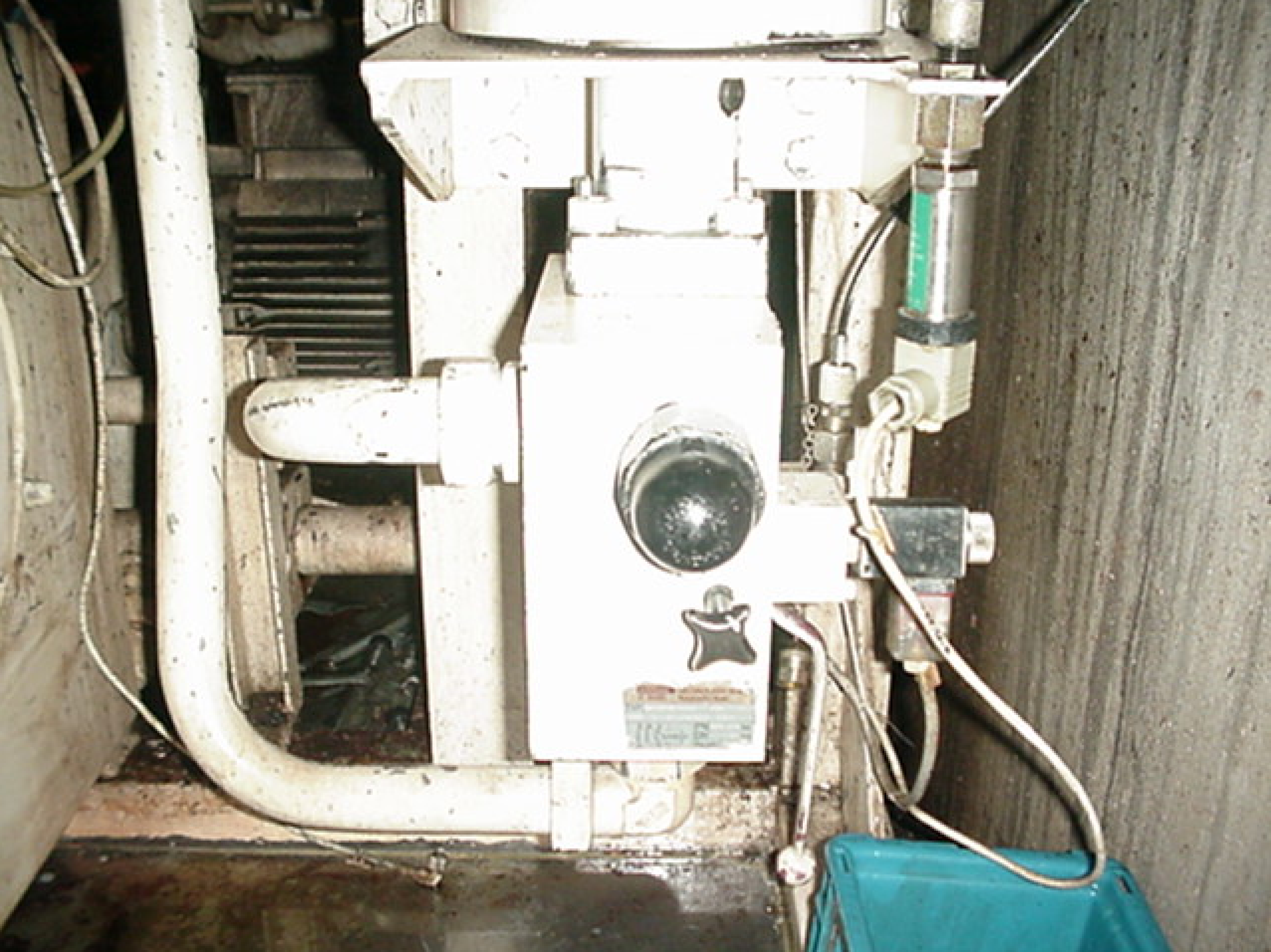
Accumulator Dump Valves

ANY circuit using an accumulator MUST have some method of bleeding the pressure down when the system is turned off

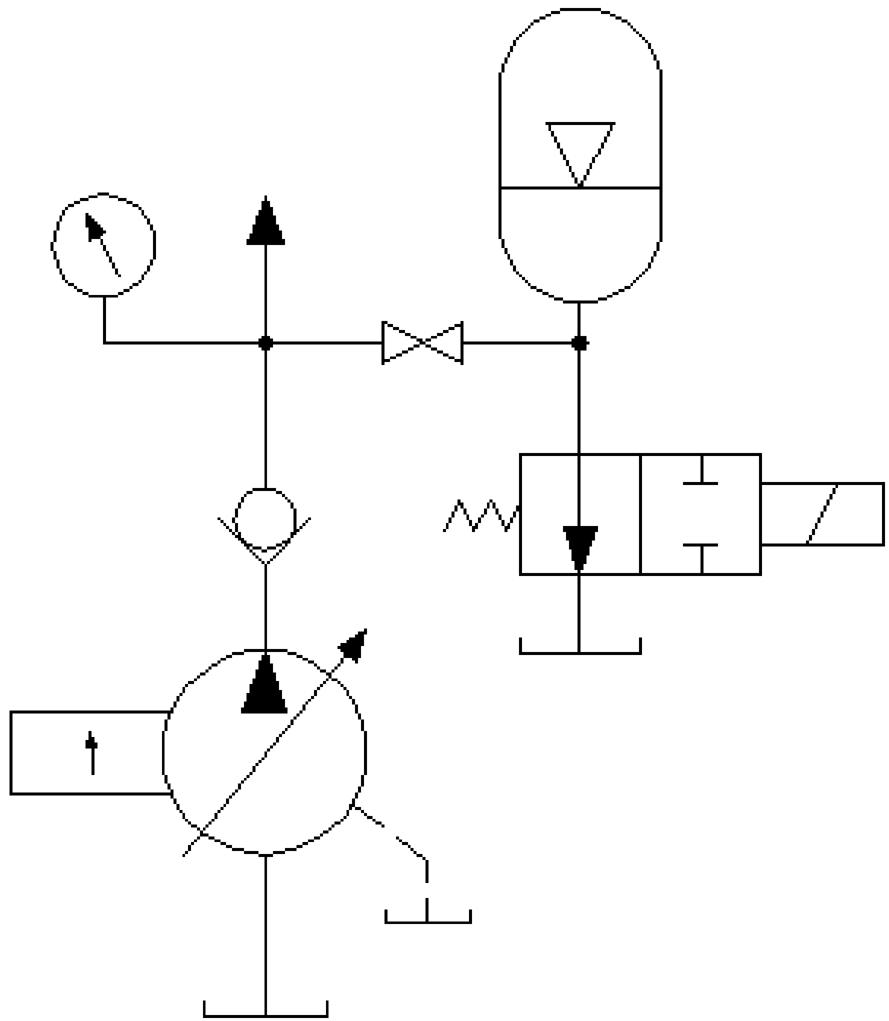
Prior to working on the system, you should VERIFY that the pressure is bled down by observing the gauge

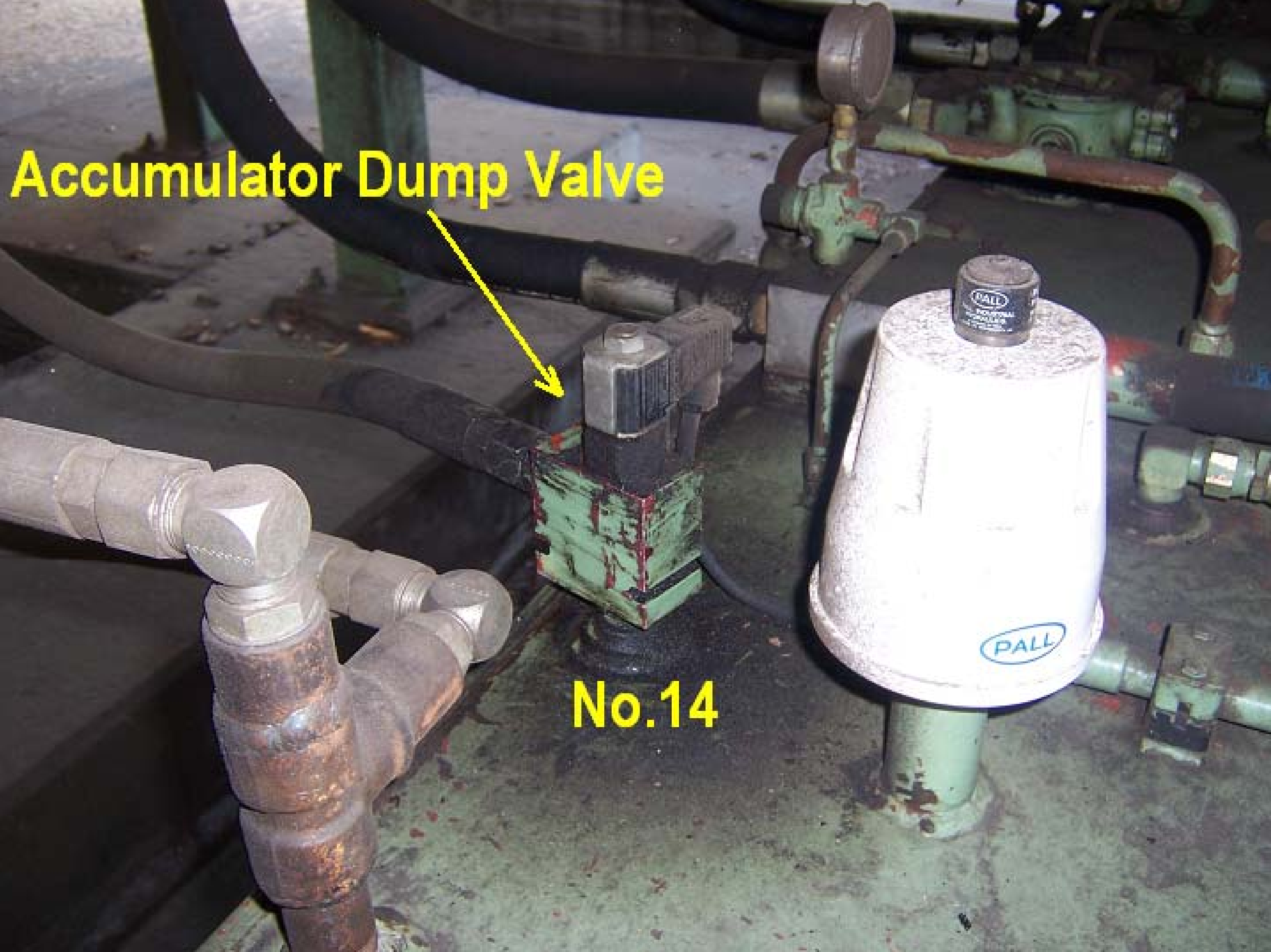
Manual Dump Valve





Solenoid Operated Dump Valve




Accumulator Dump Valve
No.14
PALL

Tolerances In Components

- Tolerances in hydraulic pumps and valves:
  5 - 8 microns (.0002 - .0003”)

- Tolerances inside servo valves:
  3 microns (.0001”)

Sources of Contamination

New oil leaving the refinery is relatively clean

By the time it reaches your mill it meets a 50 - 200 micron standard

Oil should always be filtered prior to entering the reservoir

Built In Contamination

When a system is first built and installed, contamination may be in the form of:

- Metal Chips
- Dirt
- Sand
- Pipe Sealant
- Burrs
- Dust
- Weld Splatter
- Paint

Ingressed Contamination

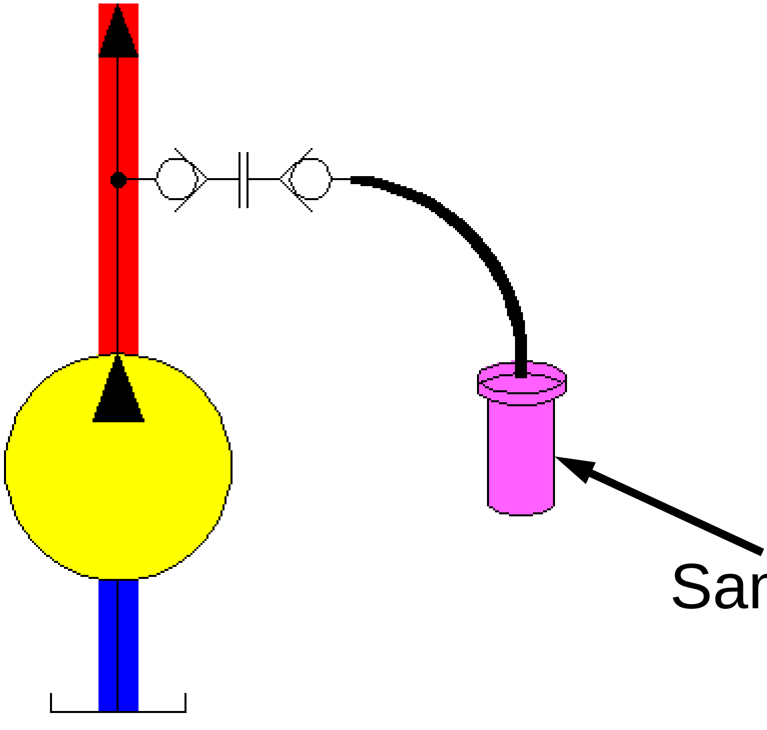
There are four ways contamination can enter the system from the outside:

- Breather Cap
- Access Plates
- Hose and Component Replacement
- Cylinder Seals

Fluid Sampling

The biggest problem in hydraulic systems is

CONTAMINATION



Sample Bottle

The key to controlling it is through an effective fluid sampling and filter maintenance program

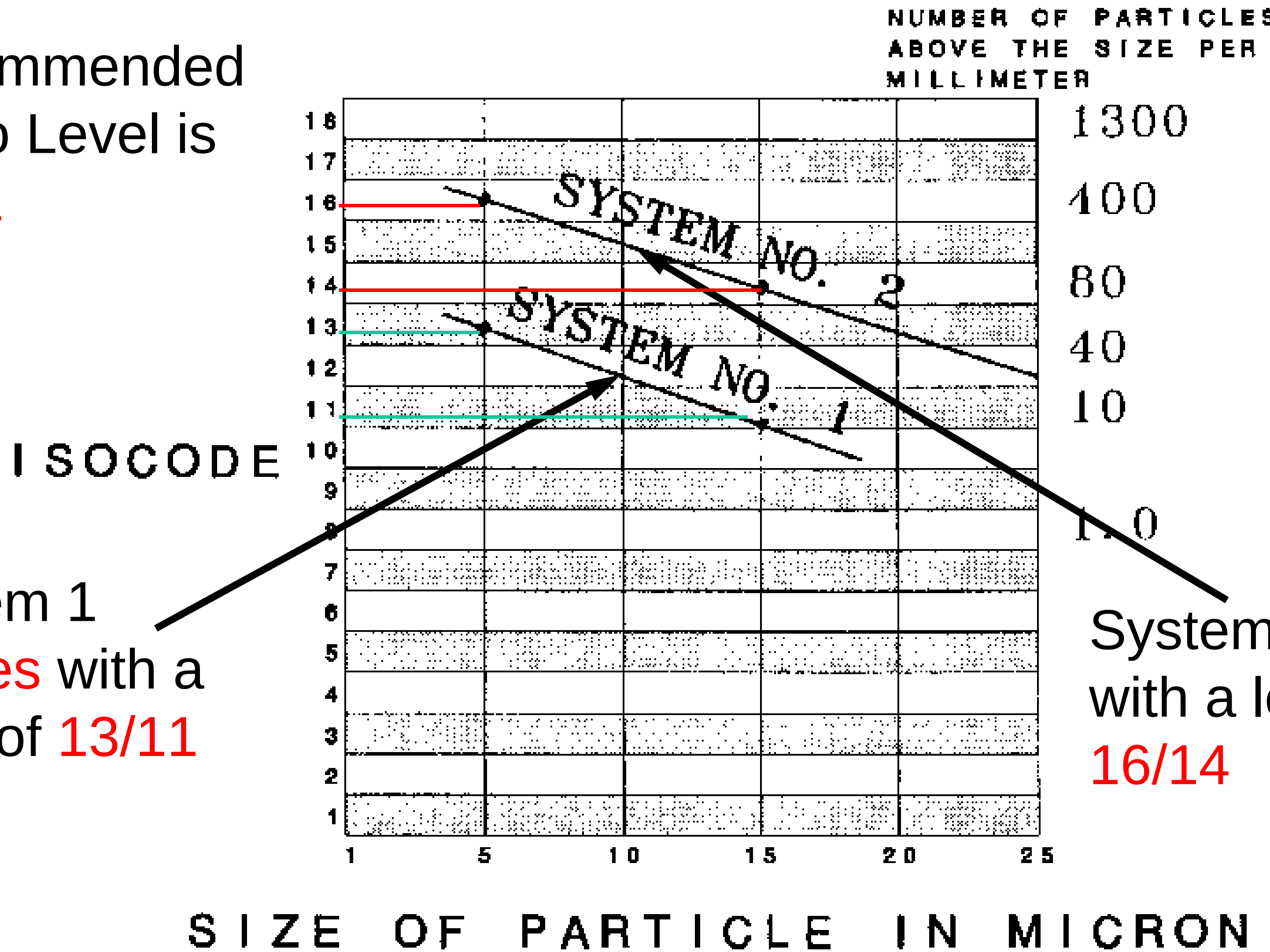
Oil Analysis

The size and number of particles taken from 1ml of the sample are measured by a particle counter

	$\leq$ **5m**	$\leq$ **15m**
System 1	44	13
System 2	469	94

ISO Cleanliness Code

Recommended Servo Level is 14/11

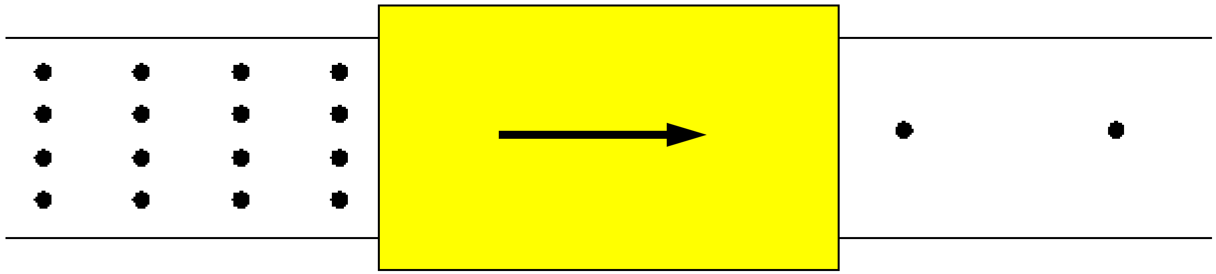


System 1 passes with a level of 13/11

System 2 fails with a level of 16/14

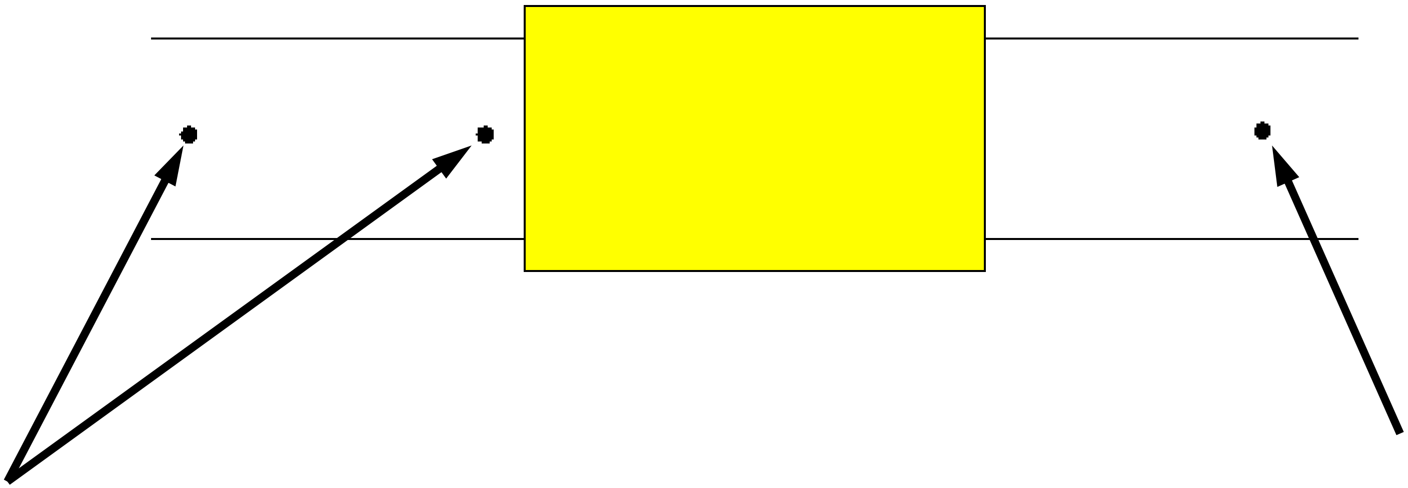
Filter Selection

Filters are selected by a Beta rating - the ratio of the number of particles upstream of the filter versus the number of particles downstream of a specific size



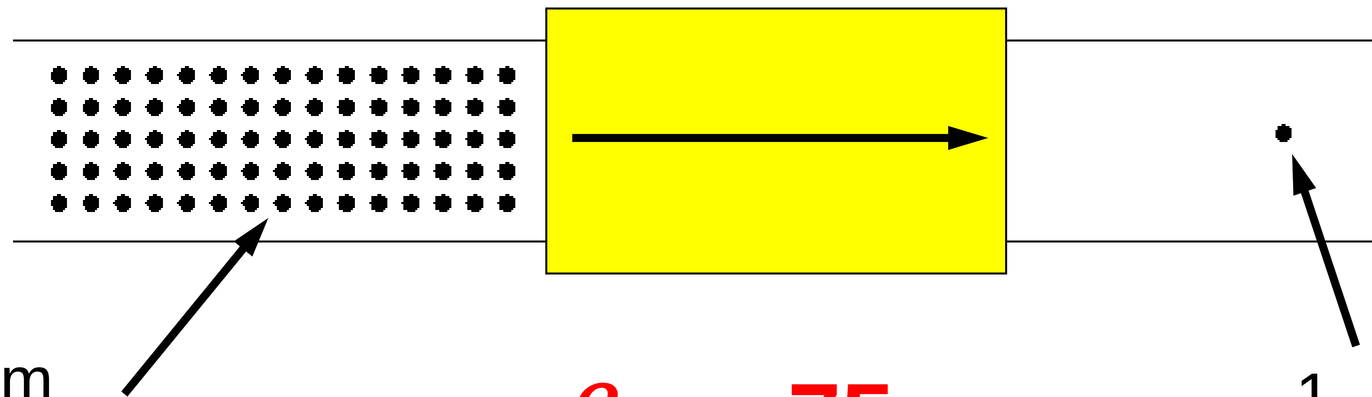
Fluid entering and fluid leaving the filter is measured with a particle counter

Beta Rating



$$\beta_3 = 2$$

Beta Rating



β_{10} **= 75**

98.7% Efficient

Hydraulic systems require a beta rating of 75 to 100

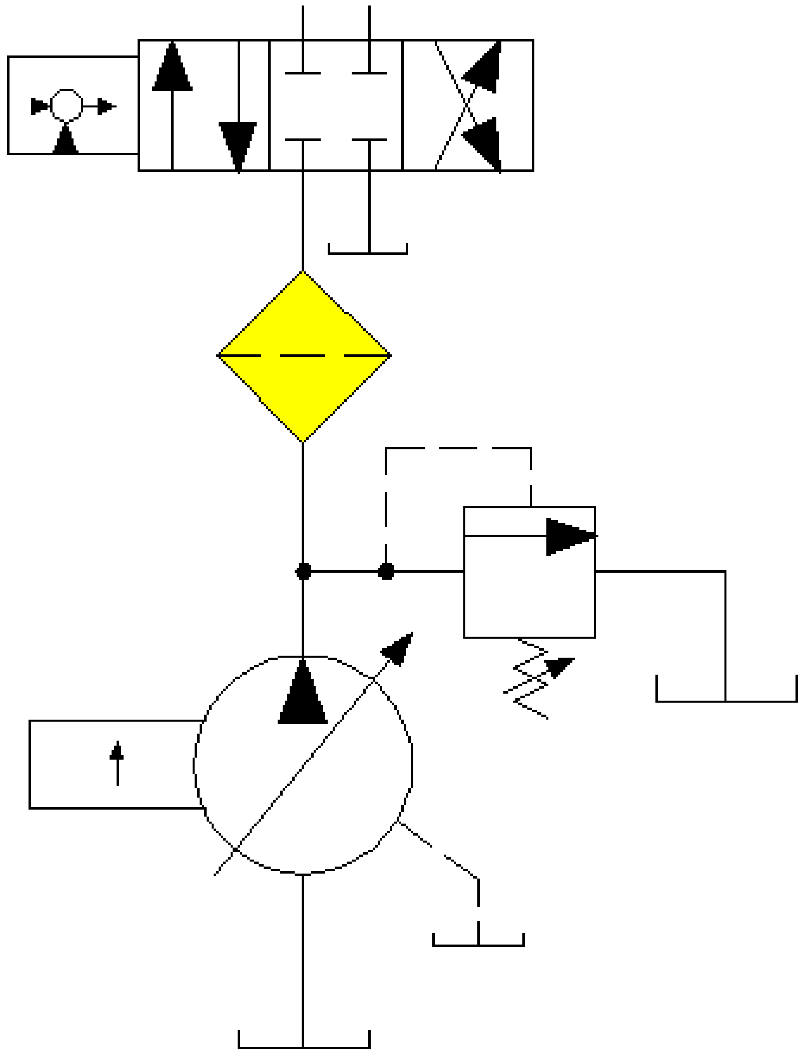
Filter Placement

There are primarily three locations for filters in the system (other than the suction strainer):

- Pressure Line
- Separate Recirculating System
- Return Line

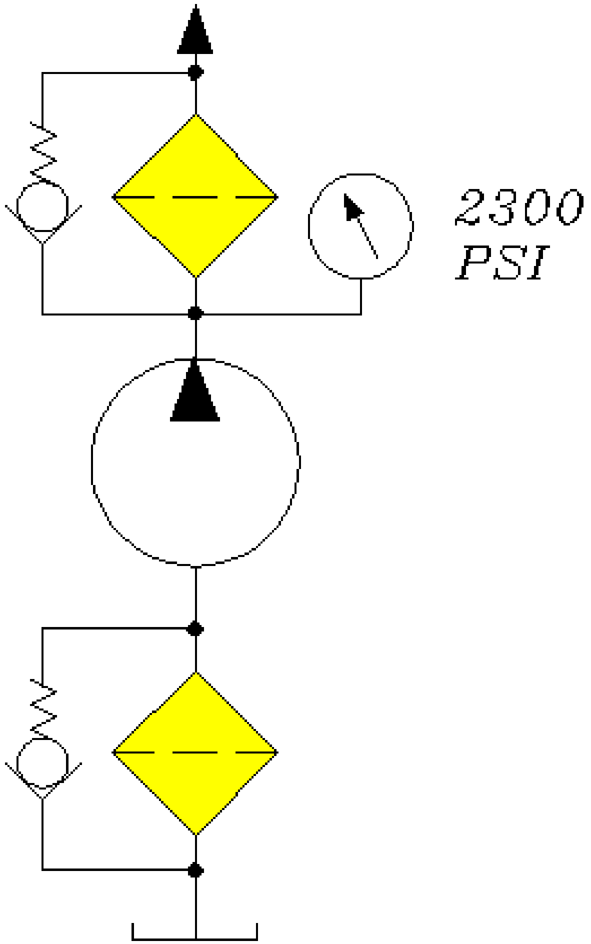
Pressure Line Filter

Upstream of ANY Servo Valve



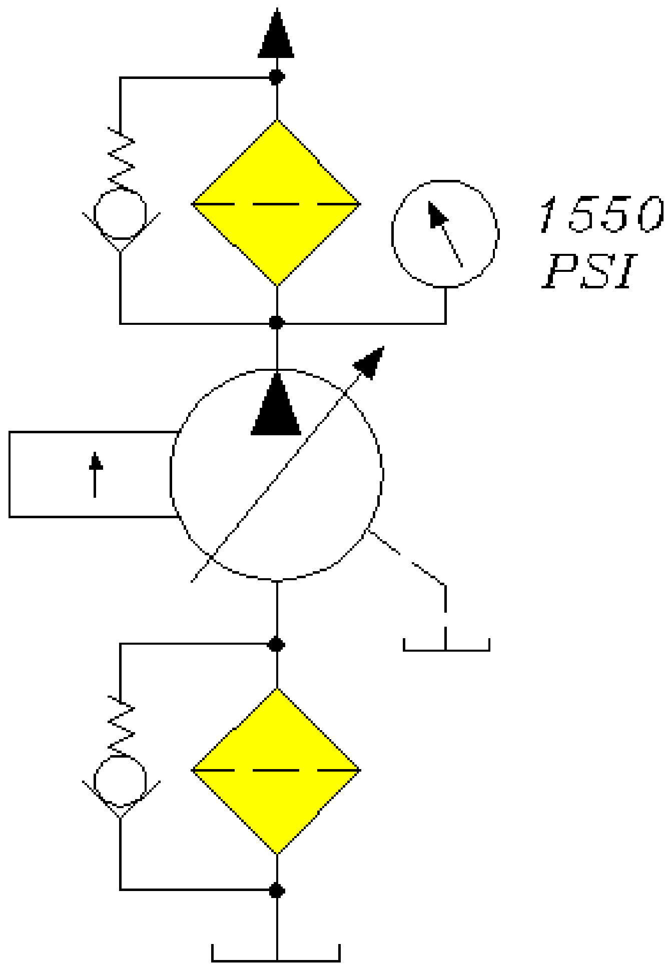
Pressure Line Filter

Downstream of a Fixed Displacement Pump operating at pressures exceeding 2250 PSI

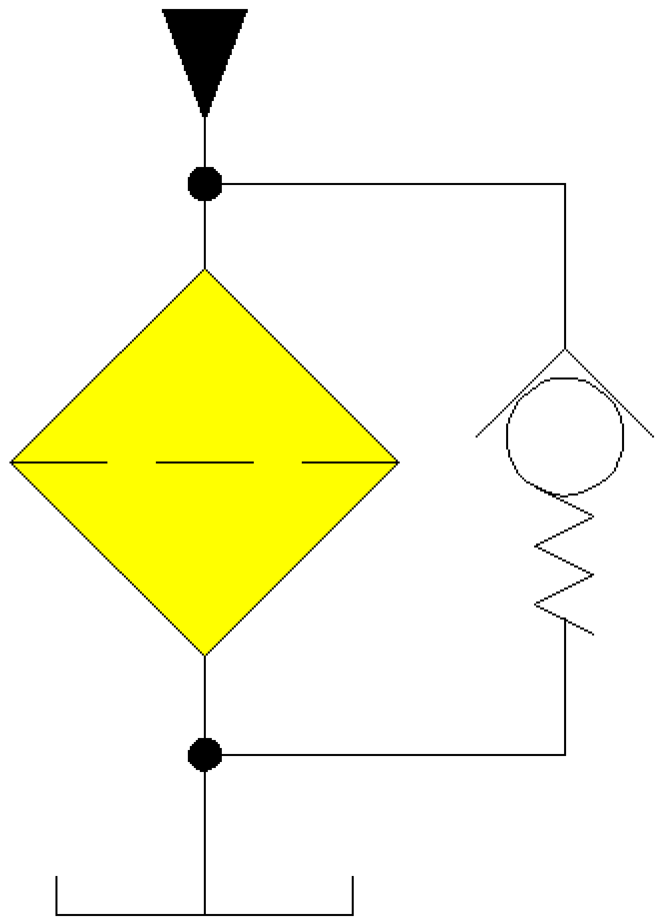


Pressure Line Filter

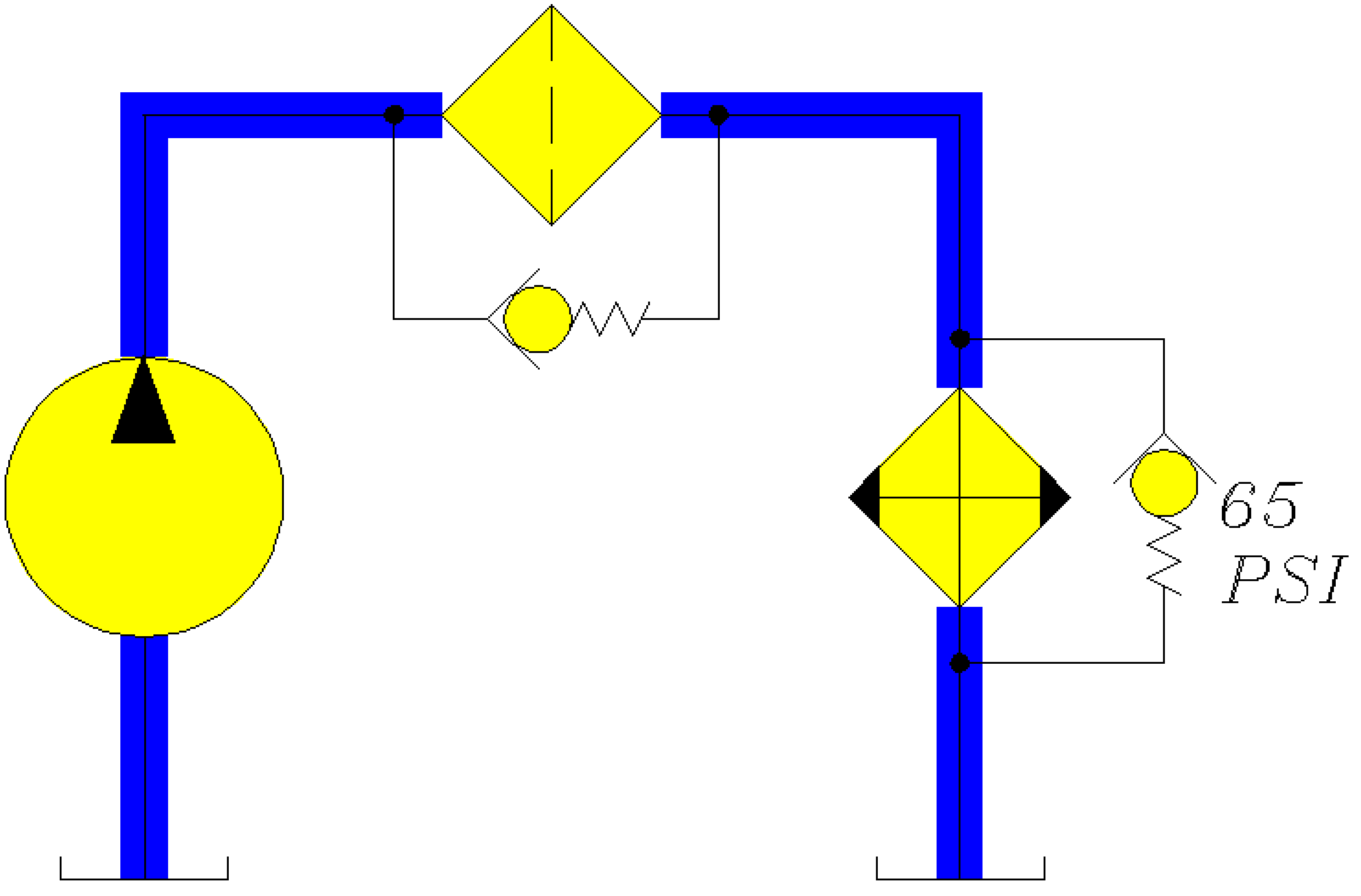
Downstream of a Variable Displacement Pump operating at pressures exceeding 1500 PSI



Return Line Filter



Separate Recirculating System



Leakage Control

Problems with leaks:

- Expensive - at $3.00 a gallon, one leak that drips one drop per second will cost:
  - $3.38 a day
  - $102 a month
  - $1225 a year
- Unsafe - dangerous conditions
- Environmentally Hazardous - EPA setting stricter standards and penalties

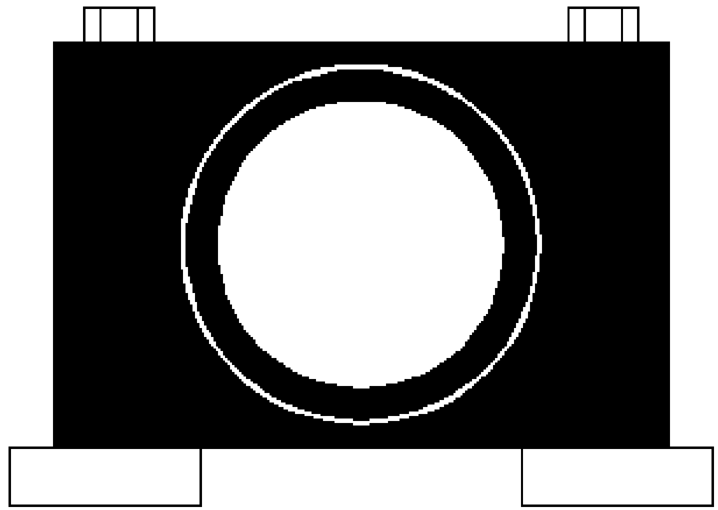
Causes of Leaks

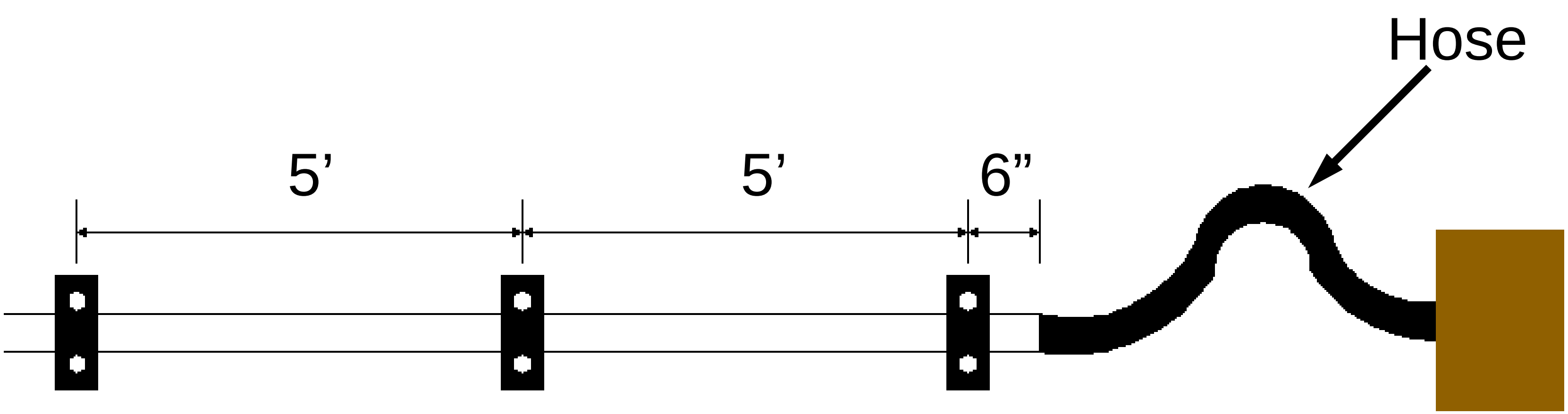
The main reason hydraulic systems leak is because of a bad installation

- Use the proper schedule of pipe
  - Schedule 40 for suction and return lines
  - Schedule 80 or 160 for pressure lines

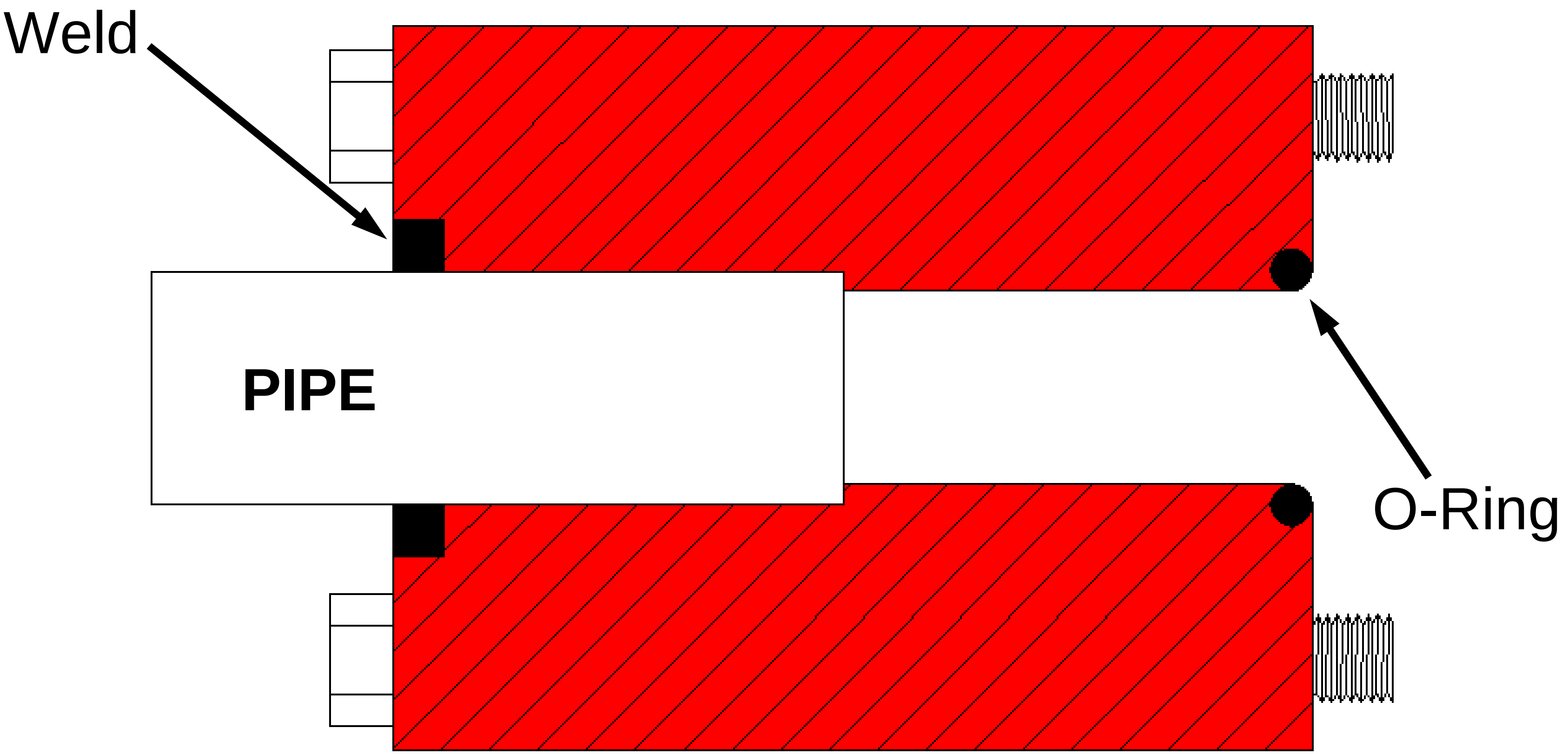
- Apply sealant properly

Proper Clamping





Socket Weld Flanges

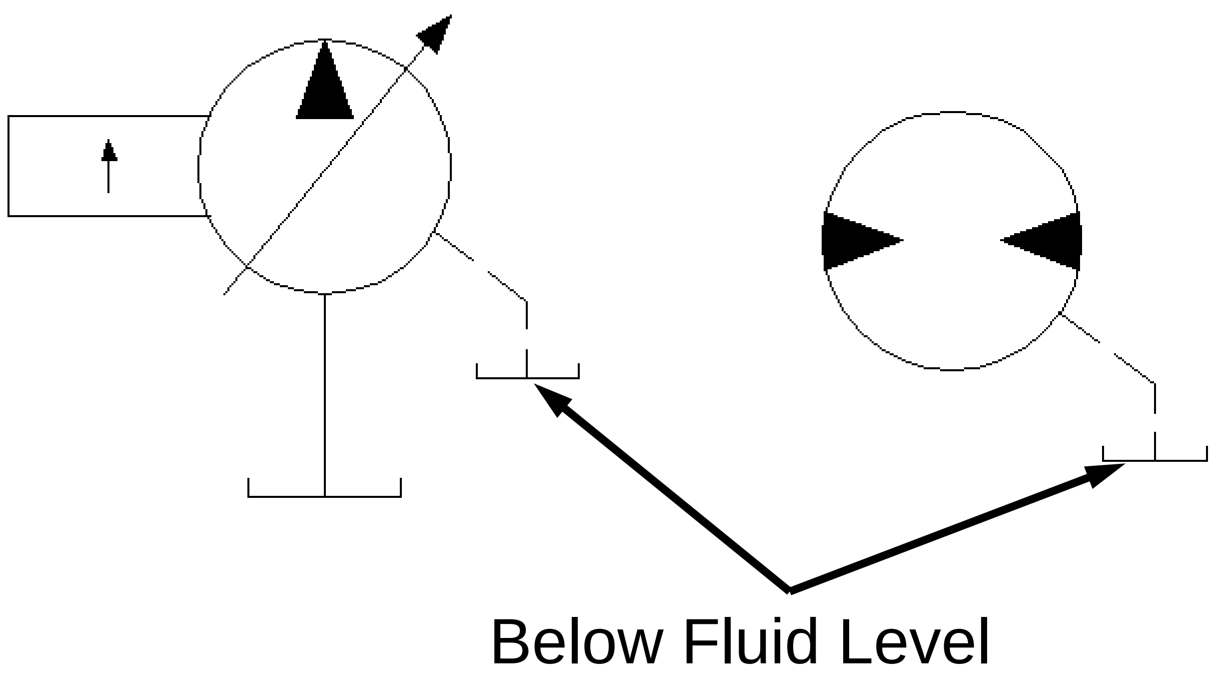


Hose Installation

- Proper Crimping
- Proper Length
- Protective Sleeves

Drain Lines

Case drain lines should be piped directly back to tank



Other Causes of Leaks

•**Pressure settings and shock** - pressures set too high result in excess force. Absorbed by the system, excess force shows up as leaks

•**Contamination** - Cylinder rod seals are not 100% efficient. In unfriendly environments, a protective cover or boot should be used

GPM Hydraulic Consulting, Inc.

Thank You For Attending!