Troubleshooting and Preventive Maintenance of Hydraulic Systems
Learning to Read the Signs of Future System Failures

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Hydraulic Pumps

Fixed Displacement Pumps

The GPM of the fixed displacement pump cannot be varied.
Gear Pump
Relief Valves and Fixed Displacement Pumps

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

1000 PSI

1500 PSI Setting
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
• 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.
Troubleshooting Fixed Displacement Pump Circuits
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 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

Diagram:
- Two circles with arrows pointing to "150°" and "120°".
• Check the current draw on the electric drive motor

\[ HP = \text{GPM} \times \text{PSI} \times 0.000583 \]

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
Variable Displacement Pumps

• Variable Displacement Pumps are used when the volume requirements change in the system
Pressure Compensating Piston Pump
Pressure Compensating Piston Pump
Pressure Compensating Piston Pump
Pump Compensator

Spring

Spool
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

Hand Valve Fully Open

Compensator
Set at 1000 PSI

10 GPM

800 PSI
Pressure Compensating Pump Example

- Hand Valve Partially Closed to Allow only 7 GPM to pass
- Back Pressure Builds

Compensator Set at 1000 PSI

800 PSI

1000 PSI

7 GPM
Pressure Compensating Pump Example

- 0 PSI
- Hand Valve Fully Closed
- 1000 PSI
- Back Pressure
- 0 GPM

Compensator Set at 1000 PSI
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.
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 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

- 78% Nitrogen
- 21% Oxygen
- 1% Argon and other gases
Accumulators

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

**Rule of Thumb** - Precharge to one-half of the maximum system pressure
Using the Charging Rig

- Gauge
- Gas Chuck
- Handle
- Bleeder Valve
- Nitrogen Bottle Connection
- ACCUMULATOR
Checking the Precharge Hydraulically

Dump Valve Closed

Pressure Locked in System

Pump turned off

2000 PSI

2000 PSI
Checking the Precharge Hydraulically

Pressure slowly drops to precharge, then immediately to 0 PSI
Types of Accumulators

Piston Accumulators
Example Circuit

1000 PSI

1/4” Dump Valve (Open when the power is turned off)

Isolation Valve

2000 PSI
Example Circuit

1/4" Dump Valve (Closed)

2000 PSI

Isolation Valve

2000 PSI

Power On
Example Circuit

1/4" Dump Valve (Closed)

Isolation Valve

1800 PSI

2000 PSI

Extend Cylinder
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.

1800 PSI
Checking the Piston Accumulator

Heat should be felt from here to here:

Piston Travel
Checking the Piston Accumulator

Dropping to a very LOW pressure usually indicates an accumulator problem.

1000 PSI

100
PSI
Overcharged

Heat

Piston Movement
Overcharged

Oil Bypasses Around Piston
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

Leak Paths for Nitrogen
Undercharged

Hydraulic pressure drives piston near the top

Heat
Bladder Accumulator

1000 PSI

Poppet Valve
Bladder Accumulator

1000 PSI

Poppet Valve
Bladder Accumulator

2000 PSI

Poppet Valve
Bladder Accumulator

1850 PSI

Poppet Valve
Checking The Bladder Accumulator

Heat should be felt between these two points
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
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**

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

<table>
<thead>
<tr>
<th></th>
<th>≤5m</th>
<th>≤15m</th>
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<tbody>
<tr>
<td>System 1</td>
<td>44</td>
<td>13</td>
</tr>
<tr>
<td>System 2</td>
<td>469</td>
<td>94</td>
</tr>
</tbody>
</table>
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

$\beta_3 = 2$

2 3m particles in

1 3m particle out
Beta Rating

Hydraulic systems require a beta rating of 75 to 100

$\beta_{10} = 75$

98.7% Efficient
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

Weld

PIPE

O-Ring
Hose Installation

• Proper **Crimping**

• Proper **Length**

• Protective **Sleeves**
Drain Lines

Case drain lines should be piped directly back to tank Below Fluid Level
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
Thank You For Attending!

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