



Test Procedure to Evaluate Fluids in Open Loop Axial Piston Pumps

Technical Data V-PUPI-TS022-E

Pump Model
PVH57C-RF-2S-11-C25V-31

This test procedure is to evaluate fluids for use in open loop axial piston pumps. It consists of 250 hours of actual test time (not including break-in or performance running). The operation temperature is dependent upon the capability of the test fluid as specified by the fluid manufacturer or the rated temperature specified for the pump, whichever is lower. Inlet fluid temperature must be maintained per fluid/pump rating throughout the complete test.

The pump to be used is a PVH57 with a pressure compensator and load sensing control, model code PVH57C-RF-2S-11-C25V-31.

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Fluid Ratings

For standard anti-wear petroleum base fluids, the PVH57 pump has the following ratings:

- Rated Speed: 2400 rpm
- Rated Pressure: 250 bar (3625 psig)
- Rated Temperature: 95°C (203°F)
- Inlet Pressure: Atmospheric Pressure 1 bar absolute (0 psig)

For performance testing, the PVH57 is to be tested at the ratings listed in Table 1.

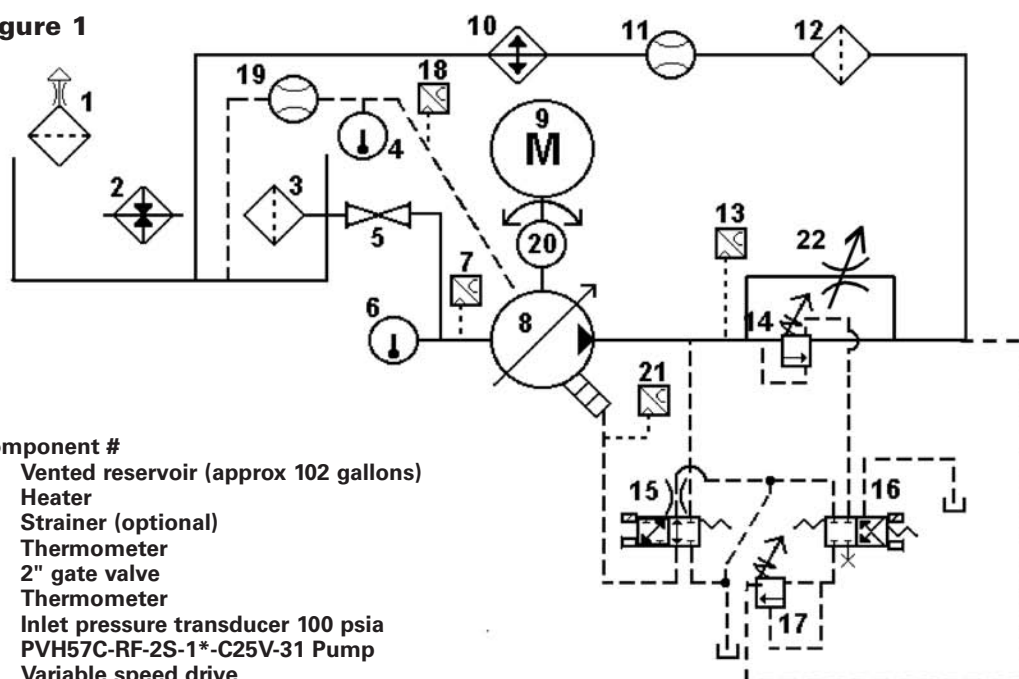
Table 1 – Performance Testing Ratings

FLUID	RATED SPEED MAX RPM	RATED PRESSURE MAX BAR (PSIG)	RATED TEMP MAX °C (°F)
Water Glycol	1800	170 (2465)	50 (122)
Invert Emulsion	1500	155 (2247)	50 (122)
90-10 HWBF	1500	155 (2247)	50 (122)
Polyolester	1800	230 (3335)	65 (149)
Phosphate Ester	1800	230 (3335)	65 (149)
Environmentally Friendly Vegetable Base	1800	250 (3625)	65 (149)
Environmentally Friendly Synthetic Base	2400	250 (3625)	95 (203)

Installation

Install pump into test circuit per Figure 1. Fill the pump case with pre-filtered anti-wear petroleum-based hydraulic fluid.

Figure 1

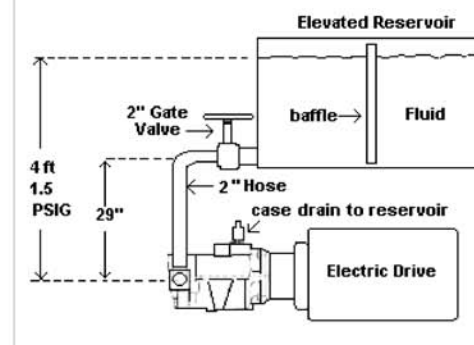


Component

- 1 Vented reservoir (approx 102 gallons)
- 2 Heater
- 3 Strainer (optional)
- 4 Thermometer
- 5 2" gate valve
- 6 Thermometer
- 7 Inlet pressure transducer 100 psia
- 8 PVH57C-RF-2S-1*-C25V-31 Pump
- 9 Variable speed drive
- 10 Cooler
- 11 Flow meter
- 12 Return filter - 3 micron absolute full flow.
Typical model: filter #OFR60SM11, element
#V4051B3C05 (use 10 μ m absolute for invert
emulsion)
- 13 Outlet pressure transducer 5000 psig
- 14 Pilot operated relief valve
- 15 Typical model: DG4V-3S-22A-M-FW-B5-60 (02-
109636)
- 16 Typical model: DG4V-3S-2B-M-FW-B5-60 (02-
109572)
- 17 Remote relief valve
- 18 Case pressure transducer 500 psig
- 19 Flow meter
- 20 Torque transducer
- 21 Load sensing line transducer 5000 psig
- 22 Variable orifice throttle valve (in parallel with
relief valve 14)

Note: Case line should be a separate line with the shortest route to the return side of the reservoir and return below the oil level.

Typical Test Set Up



Orifice (preferably in DG Valve 15 Body) to limit L.S. decay rate of 6.9 to 10.3 kbar/sec (100,000 to 150,000 psi/sec)

Pump Break-In

Pump Break-In

Break in the pump using anti-wear petroleum base hydraulic fluid that complies with Vickers Oil Recommendation Data Sheet M-2950-S. Run the break-in procedure step-by-step as listed in Table 2. Inlet is to be at atmospheric. No external leakage is allowed during the entire test.

Overall Efficiency Percentage

Continue running the pump at full stroke displacement using the parameters in Table 2, Step 7 to determine its overall efficiency.

The outlet flow must be between 121 lpm (32 gpm) and 140 lpm (37 gpm).

If not, STOP THE TEST AND CONTACT YOUR EATON REPRESENTATIVE.

Table 2 – Pump Break-In Procedure

STEP	DURATION MIN	SPEED RPM ± 20	OUTLET PRESS BAR (PSIG) ± 5 (72.5)	INLET OIL TEMP $^{\circ}\text{C} \pm 5$ ($^{\circ}\text{F} \pm 9$)
1	5	600	50 (725)	Ambient increase
2	5	1200	50 (725)	to
3	10	1200	100 (1450)	
4	10	1200	150 (2175)	
5	10	1800	150 (2175)	
6	10	1800	200 (2900)	
7	10	2400	220 (3190)	95 (203)

Record the output flow, input torque, and case flow. Compute the overall efficiency using the formulas in Appendix A.

If the overall efficiency is less than 85%, continue running the pump (20 hours maximum) using the parameters in Table 2, Step 7 and re-check overall efficiency using the formulas in Appendix A.

If the overall efficiency is not 85% or greater, DISCONTINUE

TESTING AND NOTIFY YOUR EATON REPRESENTATIVE.

Performance Baseline Test

Continue using petroleum-based fluid, but at the conditions listed in Table 1 for the test fluid. Set the compensator at rated pressure; adjust speed and temperature per the ratings for the test fluid.

Perform the pump performance check procedure.

Pump Performance Check

Sequence of Operations

- 1 Energize 15 while 16 is de-energized. The pump is now at full flow with pump outlet pressure controlled by relief valve 14.
- 2 Vary pump outlet pressure by adjusting relief valve 14.

Performance Check Procedure

The pump performance check must be at 14 bar (203 psi) below the rated pressure specified in Table 1.

Record the following parameters on the blank Pump Performance Check Record (page 11).

- Input torque
- Output pressure
- Output flow

- Case flow
- Case temperature
- Case pressure
- Inlet temperature
- Inlet pressure

Use the results to compute the overall efficiency per the formulas in Appendix A.

Figure 2 shows an example of test data obtained from the pump performance check.

Figure 2

Company: <u>Petro Oil Company</u>	Date: <u>19 January 1999</u>
Technician: <u>Joe Technical</u>	Pump Assembly: <u>690825</u>
Test: <u>Performance</u>	Pump Model: <u>PVH57C-RF-2S-10-C25V-31</u>
Pump Serial No. <u>SC00002</u>	Pump Inlet Fluid Temperature: <u>120° F</u>

Baseline Performance Check with Petroleum-Based Fluid

Fluid: Western AW Hydraulic Fluid

Pressure: _____ Speed (rpm): 1750

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY
1365 lb.in	2294 psig	25 gpm	.5 gpm	149 F	7 psig	120 F	88%

Disassembly and Inspection

Disassemble the pump per Vickers Overhaul Manual M-2210-S, Figure 3. Identify the pistons and respective bores in

the cylinder barrel per Figure 4 for re-assembly into the same location.

Figure 3

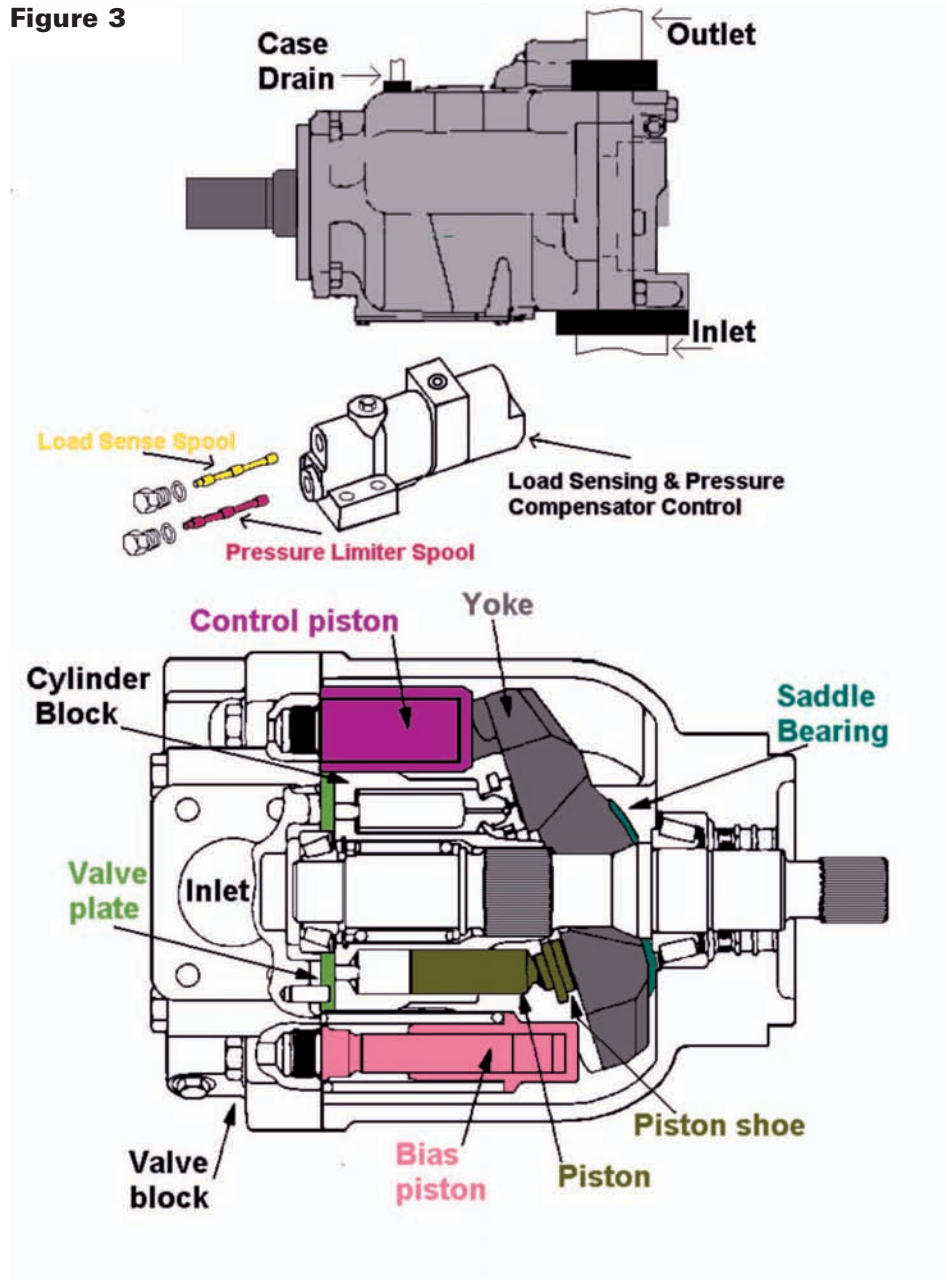
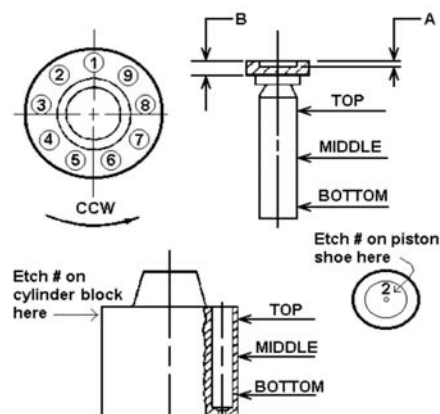


Figure 4



NOTE: In millimeters, measure cylinder barrel bores and piston OD to three decimal places (four decimal places if measuring in inches), and dimensions 'A' and 'B' to two decimal places (three decimal places if measuring in inches).

Record information on a blank Piston/Bore Record (pages 14 and 15).

Disassembly and Inspection (continued)

Inspect its components as follows:

- 1 Valve plate running-face – inspect surface finish visually and take a photograph. (Figure 5)
- 2 Cylinder barrel running face – inspect surface finish visually. (Figure 5)
- 3 Swashplate (yoke) running face – inspect surface finish visually. (Figure 5)
- 4 Swashplate (yoke) bearing journals – inspect visually. (Figure 5)

- 5 Cradle (saddle) bearings – inspect visually. (Figure 5)
- 6 Bias and control piston/rod – inspect visually. (Figure 6)
- 7 Hold-down arms and shoe face – inspect visually.
- 8 Shaft and shaft bearings – inspect visually. (Figure 6)
- 9 Measure metering lands' diameters and widths on both control spools (compensator). (Figure 6)
- 10 Measure shoe thickness (B), pocket depth (A), piston/shoe endplay (maximum

allowable end play 0.13mm [0.005"]], piston diameter at top, middle, and bottom of piston and cylinder barrel bores at top, middle, and bottom. Record results on the blank Piston/Bore Record (page 14).

- 11 Shoe cage – inspect visually.
- 12 Shaft seal and mating shaft surface – inspect visually.
- 13 Photograph visually worn parts.

Figure 5

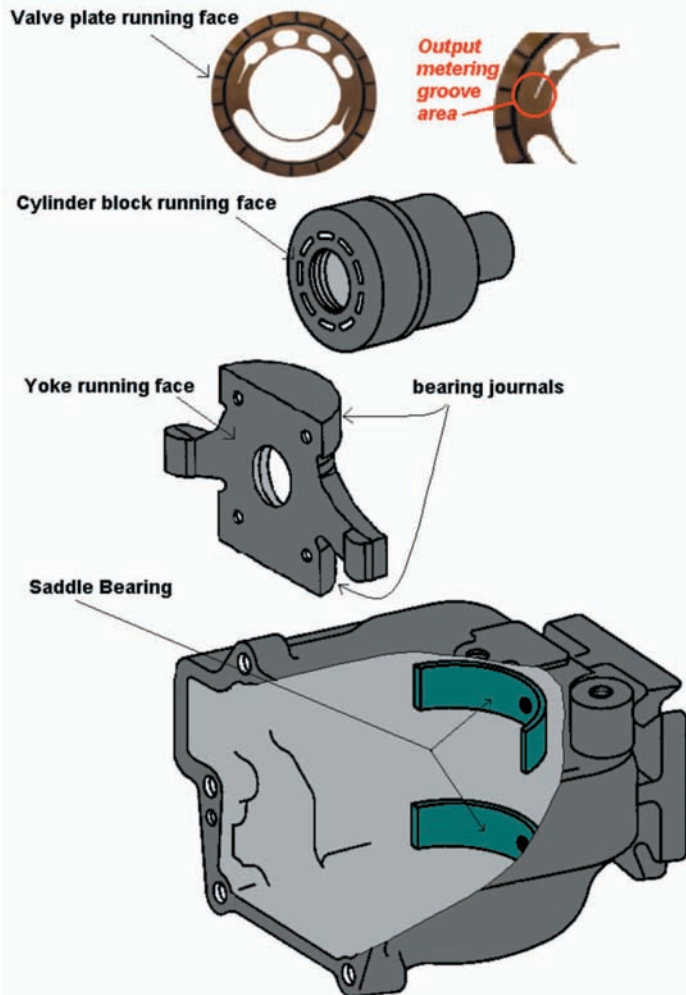
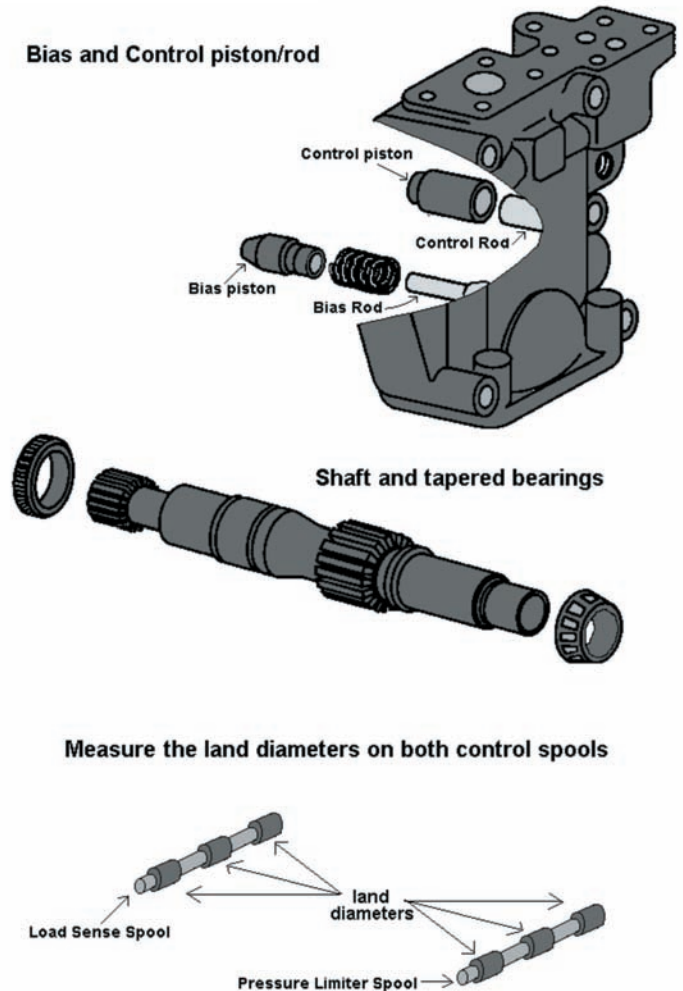


Figure 6



Test Fluid

Re-Assembly

Re-assemble the pump per Vickers Overhaul Manual M-2210-S while lubricating all parts with the fluid to be tested.

Test Pump Re-Installation

Install the test pump back into the test circuit per Figure 1 and fill the pump case with pre-filtered test fluid.

Follow NFPA T2.13.1 R3 - 1998 procedure when changing from one hydraulic fluid to another in the test stand, or consult the fluid supplier for any other specific recommendations.

Test Fluid Filling

Measure the following on the test fluid as received from the drum. Record the results on the Test Fluid Record (page 13).

- Viscosity cSt @ 40°C
- Water content wt % (0.03% max. – only for non-water containing hydraulic fluids)
- Cleanliness level ISO Code
- Spectrographic analysis for at least the following elements (ppm): P, Zn, Ca, K, Ba, B, Si, Fe, Cu, Pb, Sn
- Total Acid Number (TAN) mg/KOH (Report only for vegetable and synthetic environmentally acceptable hydraulic fluids, and poly-

olester fire resistant hydraulic fluids.)

After transferring the test fluid from the drum to the reservoir using a filter cart to assure fluid cleanliness, report the following:

- Water content wt %
- Cleanliness level ISO Code (maintain 18/16/14 or cleaner.)

Baseline Performance Check

The type of fluid being tested will determine pressure, speed, and temperature. See Table 1. Repeat the pump performance check and record the results on the Pump Performance Check Record (page 11).

Fifty-Hour Pressure Cutoff Test

The type of fluid being tested will determine pressure, speed, and temperature. See Table 1. Run for 50 to 55 hours at rated pressure (pressure compensator cut-off), rated speed, and rated temperature.

Repeat the pump performance check and record the results on

the Pump Performance Check Record (page 11).

After completion of the 50-hour cut-off test, inspect valve plate and photograph the running surface.

Fail criteria is material transfer, or cavitation and/or erosion

damage. Slight cavitation/erosion may be observed at the output metering groove area of the valve plate (Figure 5).

Re-assemble the pump and repeat the pump performance check. Record the results on the Pump Performance Check Record (page 11).

Two Hundred-Hour Cyclic Test

Sequence of Operations

- 1 Energize 16 and 15 – puts pump at full displacement and some pressure set by 17. Time: 0.75 sec.
- 2 De-energize 16 – puts pump into P.C. cut-off. Relief valve 14 is used to limit peak pressure. Time: 0.5 sec.
- 3 De-energize 15 – puts pump at L.S. standby. Time: 0.5 sec.
- 4 Repeat above sequence.

Cyclic Test Procedure

Continue running the cyclic test for at least 200 hours. The pump must run for a minimum of 200 hours (411,400 cycles) to a maximum of 210 hours (431,970 cycles).

Perform the pump performance check once per day throughout the test. Record results on the Pump Performance Check Record (pages 11 and 12).

Cycle/Pressure Parameters:

- 0.75 sec full flow at 90% rated pressure.
- 0.5 sec @ cut-off (rated pressure).
- 0.5 sec @ load sense standby.
- Load sense pressure decay rate of 6.9 to 10.3 kbar/sec (100,000 to 150,000 psi/sec)

Total cycle time of 1.75 seconds (2057 cycles/hr).

Figure 7 represents a typical cycle plot.

Control Pressure Hysteresis Check

Perform a control pressure hysteresis check (Appendix B) before running the two hundred-hour cyclic test, at 100 hours and after completion of the 200 hours.

Pay special attention to the inlet condition. Inlet pressure must be maintained at 1 bar absolute (0 psig) at full flow.

Record actual hydraulic testing cycle plot.

If a 5% or greater flow loss is found at rated conditions during the test, stop the test and disassemble the pump for inspection.

Inspect valve plate and photograph the running surface. Fail criteria is material transfer, or cavitation and/or erosion damage. Slight cavitation/erosion may be observed at the output metering groove area (Figure 5).

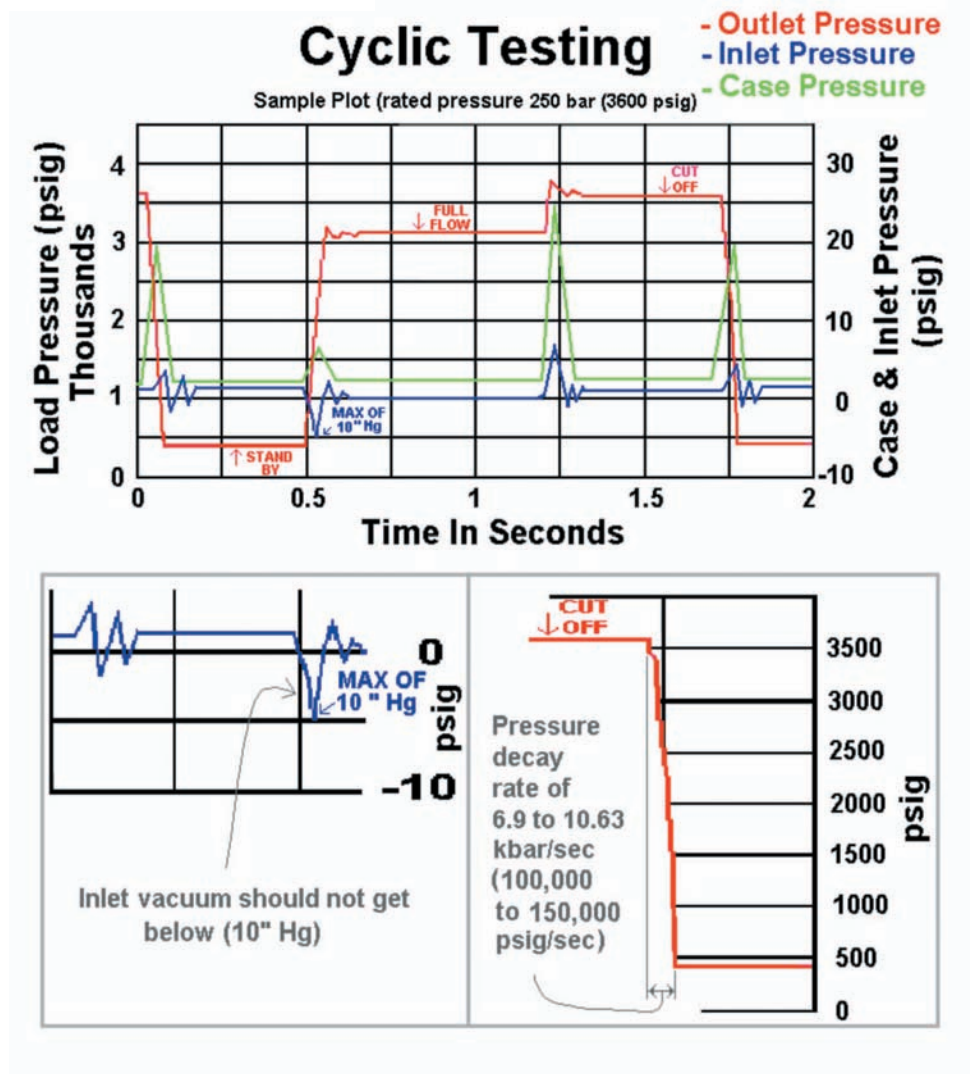
Re-assemble the pump if parts appear acceptable.

Pump Inspection

After completion of the 200-hour cyclic test, disassemble test pump and inspect as follows:

- Valve plate running face – inspect surface finish visually and photograph. (Figure 5)
- Cylinder barrel running face – inspect surface finish visually. (Figure 5)
- Swashplate running face – inspect surface finish visually. (Figure 5)
- Swashplate (yoke) bearing journals – inspect visually.
- Cradle (saddle) bearings – inspect visually. (Figure 5)
- Bias and control piston/rod – inspect visually. (Figure 6)
- Hold-down arms and shoe face – inspect visually.
- Shaft seal and mating shaft surface – inspect visually.
- Measure land diameters and width on both control spools of the compensator. (Figure 6)
- Measure piston/shoe endplay and piston diameter and cylinder barrel bores at top, middle and bottom of piston. Record results on the blank Piston/Bore Record (page 15).
- Shoe cage – inspect visually.
- Shaft and shaft bearings – inspect visually.
- Photograph any worn parts.

Figure 7



Final Fluid Testing

Measure the following on the test fluid after completion of testing. Record the results on the Test Fluid Record (page 13).

- Viscosity cSt @ 40°C
- Water content wt % (0.03% max. non-water based fluid)
- Cleanliness level ISO Code 18/16/14 or better
- Spectrographic analysis for at least the following elements

(ppm): P, Zn, Ca, K, Ba, B, Si, Fe, Cu, Pb, Sn

- Total Acid Number (TAN) mg/KOH (Report only for vegetable and synthetic environmentally acceptable hydraulic fluids, and poly-olester fire resistant hydraulic fluids.)

Fluid Pass/Fail Criteria

The following are the criteria by which the fluid is judged to have passed or failed the test:

- The overall efficiency of the pump is equal to or greater than 85%.
- The volumetric efficiency of the pump is not degraded by

more than 5% at the end of the 200-hour cyclic test.

- The control pressure hysteresis is less than or equal to 45 bar (652.5 psi) at the end of the 200-hour cyclic test.

Pressure Compensator**Cut-off:**

The pump is at maximum pressure without any outlet flow. The control has de-stroked the pump giving it the minimum displacement to maintain the outlet pressure.

Load Sense Stand-by:

The pump is at minimum pressure without any outlet flow. The control has de-stroked the pump giving it the minimum displacement to maintain the de-stroked position. The load sense signal line is at zero pressure.

Valve Plate:

The plate between the cylinder barrel and end cover on which the cylinder barrel surface runs.

Cylinder Barrel (block):

The body in which the pistons reciprocate producing flow.

Swashplate (yoke):

The surface on which the shoes of the piston/shoe assemblies run. The swashplate also determines the displacement of the pump. The control piston and bias piston provide the forces to position the swashplate.

Cradle (saddle) Bearings:

The surface on which the swashplate rotates to determine the displacement.

Appendix A

Efficiency

Formulas

Inch

$$\text{Output Power} = \frac{\text{Output Flow (gpm)} \times \text{Output Pressure (psig)}}{1714} \text{ HP}$$

$$\text{Input Power} = \frac{\text{Input Torque (in-lb)} \times \text{Speed (rpm)}}{63025} \text{ HP}$$

$$\text{Overall Efficiency (\%)} = \frac{\text{Output HP}}{\text{Input HP}} \times 100$$

Metric

$$\text{Output Power} = \frac{\text{Output Flow (lpm)} \times \text{Output Pressure (bar)}}{600} \text{ kW}$$

$$\text{Input Power} = \frac{\text{Input Torque (Nm)} \times \text{Speed (rpm)}}{9550} \text{ kW}$$

$$\text{Overall Efficiency (\%)} = \frac{\text{Output Power kW}}{\text{Input Power kW}} \times 100$$

Appendix B

Control Pressure Hysteresis Test

Sequence of Operations

- 1 Energize 15 while 16 is de-energized. Pump is now at cut-off (pressure compensation mode, high pressure, no flow).
- 2 Open variable orifice valve 22 to vary the pump outlet pressure to run a control pressure hysteresis check per Appendix B.
- 3 Once the control pressure hysteresis check has been completed, close the variable orifice valve 22 and resume test.

Control Pressure Hysteresis Check Procedure

Control pressure hysteresis is calculated using a plot of outlet flow versus control pressure. To check control pressure hysteresis, plot outlet flow (on the y-axis) versus control piston

pressure while varying outlet pressure from 500 psi (at full flow) to the compensator setting (high-pressure, no-flow condition) and back to 500 psi (at full flow).

An adapter block needs to be assembled between the control and the end cover (valve block) to pick up control piston pressure. Use a variable orifice valve to vary the pump's outlet pressure (refer to page 3 for preparatory steps). It may take 1.5 to 2.0 minutes to run a sweep from full flow to pressure compensation and back again. The majority of the sweep time should be while the pump is going into and out of the compensator mode.

After generating a plot of outlet flow vs. control piston pressure:

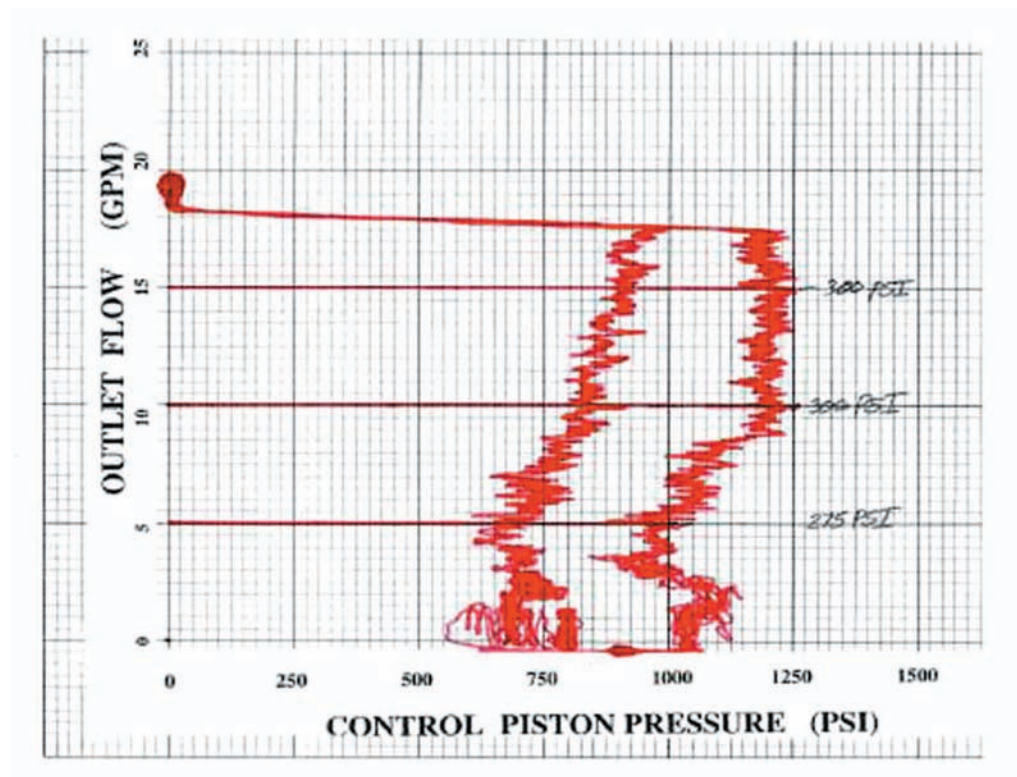
- Determine the full flow value.

- Draw horizontal lines on the plot at 75%, 50% and 25% of full flow.
- Determine the pressure values at which these lines intersect the vertical sections of the plot. (Note: There will be two intersection points for each horizontal line.)
- Calculate the difference between each pair of pressure values (one Δp for 75% flow, one Δp for 50% flow, and one Δp for 25% flow).
- Take the average of these three Δp values.

This is considered the average control pressure hysteresis. This value should not exceed 45 bar (652.5 psi).

A sample curve is shown in Figure 8.

Figure 8



Pump Performance Check Record

Company: _____ Date: _____

Technician: _____ Pump Assembly: _____

Test: _____ Pump Model: _____

Pump Serial No. _____ Pump Inlet Fluid Temperature: _____

Baseline Performance Check with Petroleum-Based Fluid

Fluid: _____

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Baseline Performance Check with Test Fluid

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check After 50-Hour Test

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check After Re-Assembly

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (24 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (48 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (72 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (96 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (120 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (144 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (168 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Performance Check During 200 Hour Test (200 hours)

Pressure: _____ Speed (rpm): _____

INPUT TORQUE	OUTPUT PRESSURE	OUTPUT FLOW	CASE FLOW	CASE TEMP	CASE PRESSURE	INLET TEMP	EFFICIENCY

Test Fluid Record

At Test Fluid Filling

Viscosity cSt @ 40°C _____

Water content wt %
(0.03% max. non-water
based fluid)

Cleanliness level
ISO Code 18/16/14 or better

Spectrographic analysis
(ppm):

P _____
Zn _____
Ca _____
K _____
Ba _____
B _____
Si _____
Fe _____
Cu _____
Pb _____
Sn _____

Total Acid Number
(TAN) mg/KOH
(Only for vegetable and syn-
thetic environmentally accept-
able hydraulic fluids, and poly-
olester fire resistant hydraulic
fluids)

At Completion of 200-Hour Cyclic Test

Viscosity cSt @ 40°C _____

Water content wt %
(0.03% max. non-water
based fluid)

Cleanliness level
ISO Code 18/16/14 or better

Spectrographic analysis
(ppm):

P _____
Zn _____
Ca _____
K _____
Ba _____
B _____
Si _____
Fe _____
Cu _____
Pb _____
Sn _____

Total Acid Number
(TAN) mg/KOH
(Only for vegetable and syn-
thetic environmentally accept-
able hydraulic fluids, and poly-
olester fire resistant hydraulic
fluids)

Piston/Bore Record

At Test Fluid Filling

Cylinder Block Bores

NO.	TOP	MIDDLE	BOTTOM
1			
2			
3			
4			
5			
6			
7			
8			
9			

Piston OD Dimensions

NO.	TOP	MIDDLE	BOTTOM
1			
2			
3			
4			
5			
6			
7			
8			
9			

NO.	MAX & MIN. PISTON TO BORE CLEARANCE	PISTON TO SHOE END PLAY	DIMENSION "A"	DIMENSION "B"
1				
2				
3				
4				
5				
6				
7				
8				
9				

Piston/Bore Record

At Completion of 200- Hour Cyclic Test

Cylinder Block Bores

NO.	TOP	MIDDLE	BOTTOM
1			
2			
3			
4			
5			
6			
7			
8			
9			

Piston OD Dimensions

NO.	TOP	MIDDLE	BOTTOM
1			
2			
3			
4			
5			
6			
7			
8			
9			

NO.	MAX & MIN. PISTON TO BORE CLEARANCE	PISTON TO SHOE END PLAY	DIMENSION "A"	DIMENSION "B"
1				
2				
3				
4				
5				
6				
7				
8				
9				

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