HSP46 Layover Pump Pressure Test Report

General Overview:

The HSP46 locomotive has a HOTSTART layover heating system designed to heat and circulate coolant and lubricating oil throughout the main engine when the main engine is shut down and the locomotive is connected to 480 VAC external power. The layover oil pump pressure is set at 50 PSIG by the maintenance shop at the internal relief valve, which routes high pressure oil from the pump outlet back to its inlet. After most of the fleet had pump seals replaced and pressures set to 50 PSIG, the pump seals continued to leak. The Diesel Shop installed test gauges into the rear pump inlet and outlet test ports and observed pressures a lot higher than 50 PSIG were present when the main engine was running.

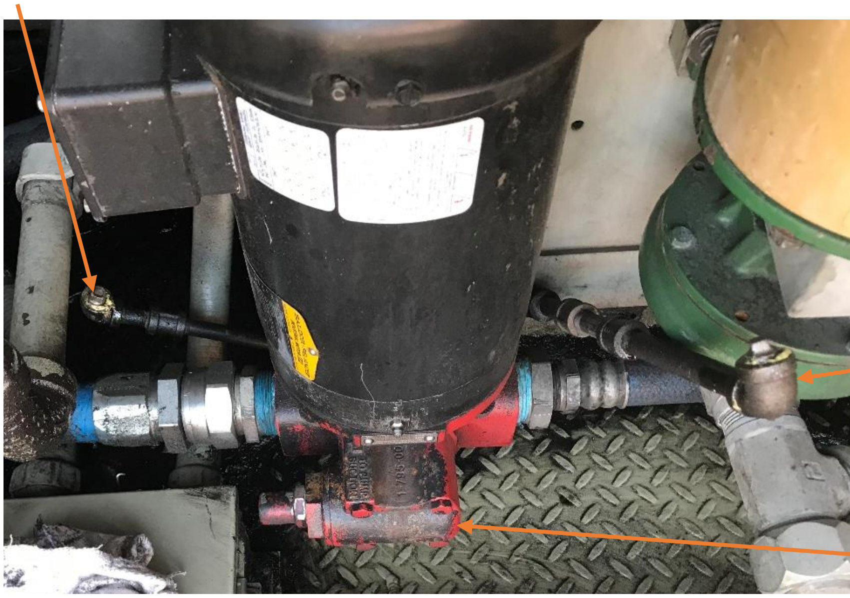


Fig. 1

The rear of the layover pump has an inlet pressure test port and outlet pressure test port, which can be fitted with piping for oil pressure gauges. As seen in Fig. 1, piping has been installed to allow for the easy installation of pressure gauges (¼” MNPT center back connection, 0-160 PSIG).

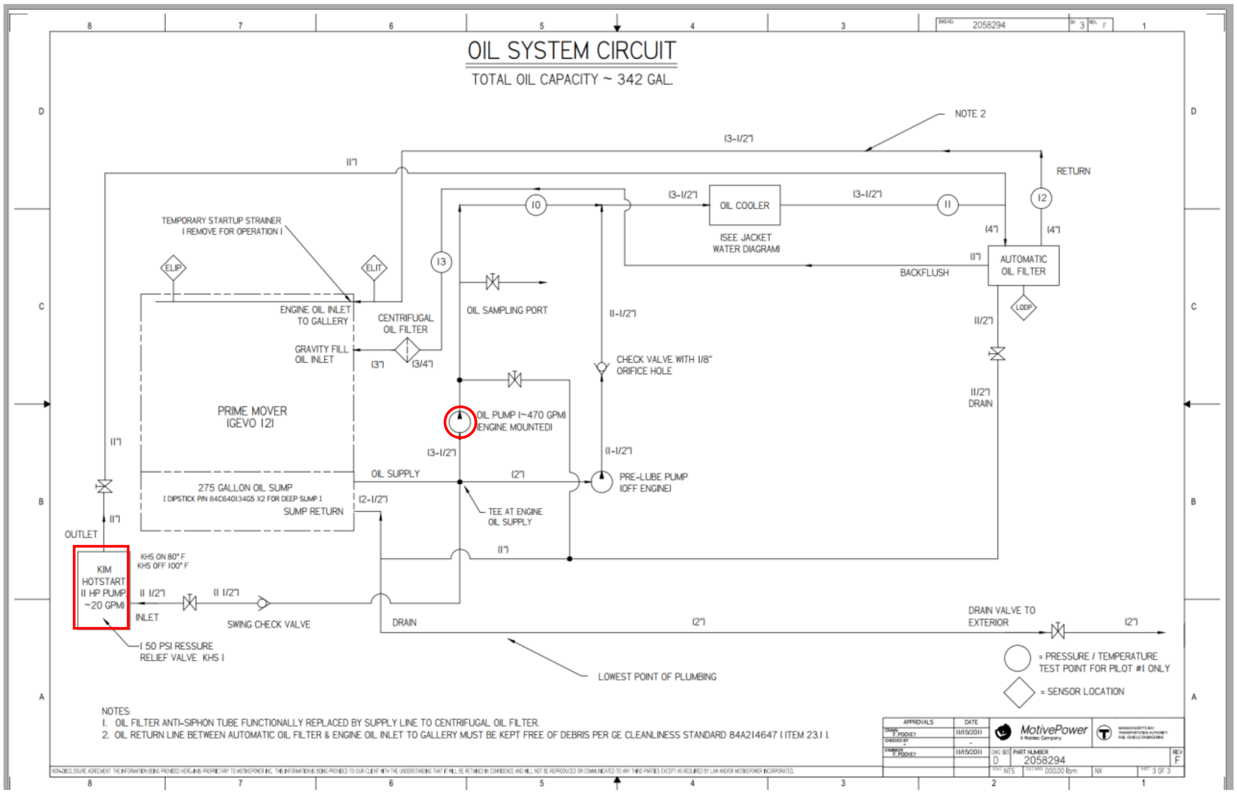


Fig. 2

Oil Heater

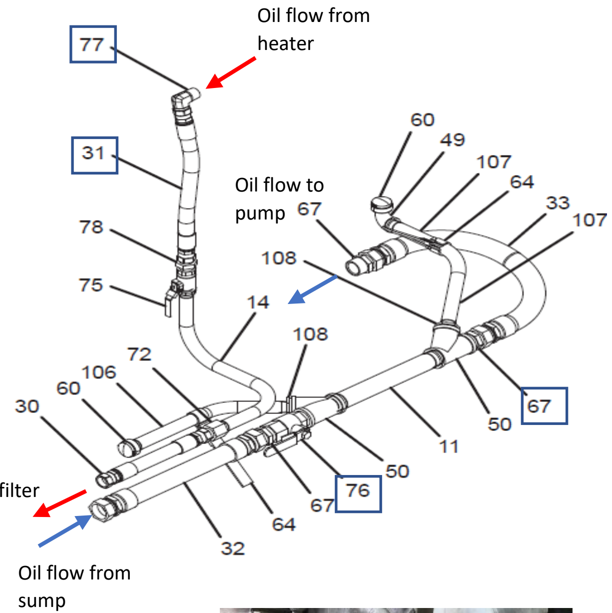
Fig. 3

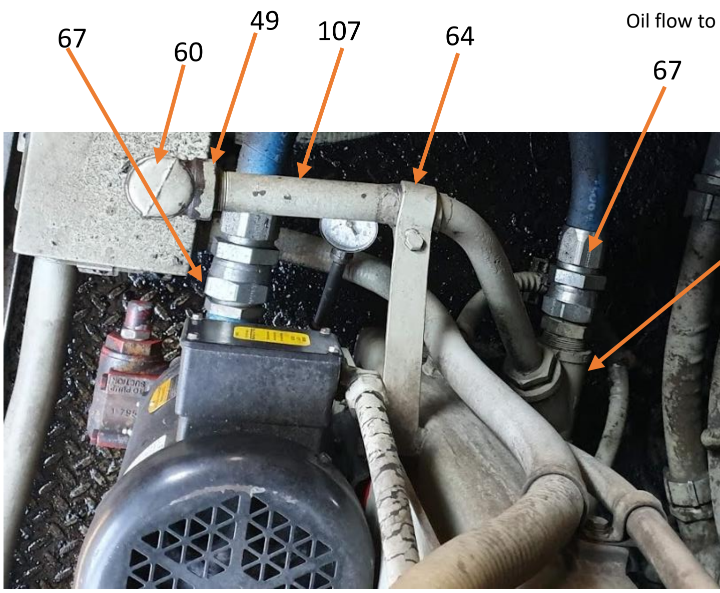
Layover pump outlet

The oil exiting the layover pump is connected to a heater before being fed into the engines. (Fig. 3)

Oil flows from the inlet ball valve (#76) through a 1 ½" NPT x 1 ½" JIC adapter (#67) which connects to the inlet of the layover pump.

The exit of the oil heater leads onto a 1.00 MNPT X 1.00 MJIC X 90 Degree (#77) before being fed into the rest of the system through a connecting hose (#31). This system is illustrated in Fig.4 .





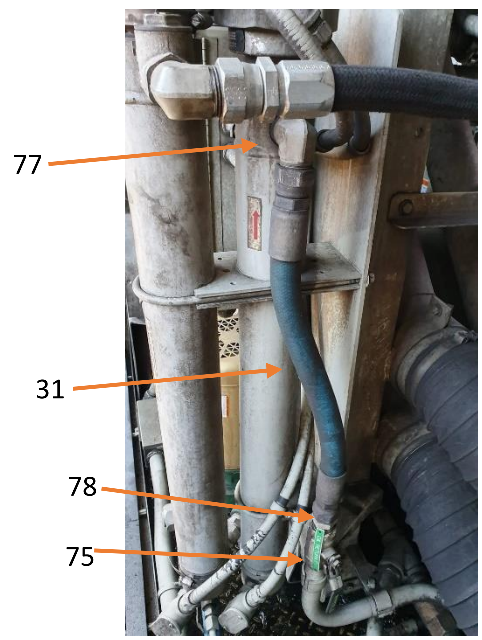


Fig. 4

Purpose of Test:

The HOTSTART layover system uses the Viking H475 oil pump in the HSP46 locomotive fleet, which is rated for 50 PSIG, and experiences pressures over 90 PSIG when the main engine is running. These kind of pressures compromises the layover pump seal causing oil to leak out of the pump.

Initial Test:

Test Plan:

There are two tests conducted; Test A and Test B.

To test the direction of flow for the high-pressure oil, the inlet ball valve (#76) and the outlet ball valve (#75) are closed shut while the engine isn't running. Ensure that the pressure gauges read 0 PSIG. We then start the engine up:

A. Open the outlet ball valve and record the pressures on the inlet and outlet gauges

Stop the engine and close the outlet ball valve once the pressures read on the gauges read 0 PSIG. Restart the engine:

B. Open the inlet ball valve and record the pressures on the inlet and outlet gauges

Fig. 5

Test Conditions	Participants
• Date: 7/25/19 2:00PM • Location: West end of Diesel Shop at BET • Locomotive: 2006 (HSP46) • Pressure gauge piping installed into the test inlet and outlet ports of the layover oil pump • 0-160 PSIG gauges installed • Engine lube temp: 160 Fahrenheit • Weather: 74 Fahrenheit, sunny • Engine had been running for about 3 hours • Blue flag protection was set up	• Jason Manes – SMW • Pat McGee – Electrical Tech • Rich Crowell – Standards Manager • Nisal Ovitigala – Mechanical Intern

Test Data:

Test A: Main engine running with both ball valves initially closed

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Closed	Open	90 PSIG	90 PSIG

Test B: Main engine running with both ball valves initially closed

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Open	Closed	0 PSIG	0 PSIG

Conclusion:

In Test B there was no pressure rise when we opened the inlet ball valve. Therefore, we can conclude that no fluid going from the inlet to the outlet was present. However, since a pressure rise was recorded in test A only when only the outlet valve was opened, we can conclude that this is due to the presence of a fluid flowing from the outlet of the layover pump to the inlet, also known as a back pressure.

The origin of this back pressure can be traced to the main engines oil pump which is shown in Fig. 6 in the highlighted region. We can be sure that the origin of this high pressure is from the engines oil pump since previous tests have shown oil pressures to linearly rise as the engine RPM's increase.

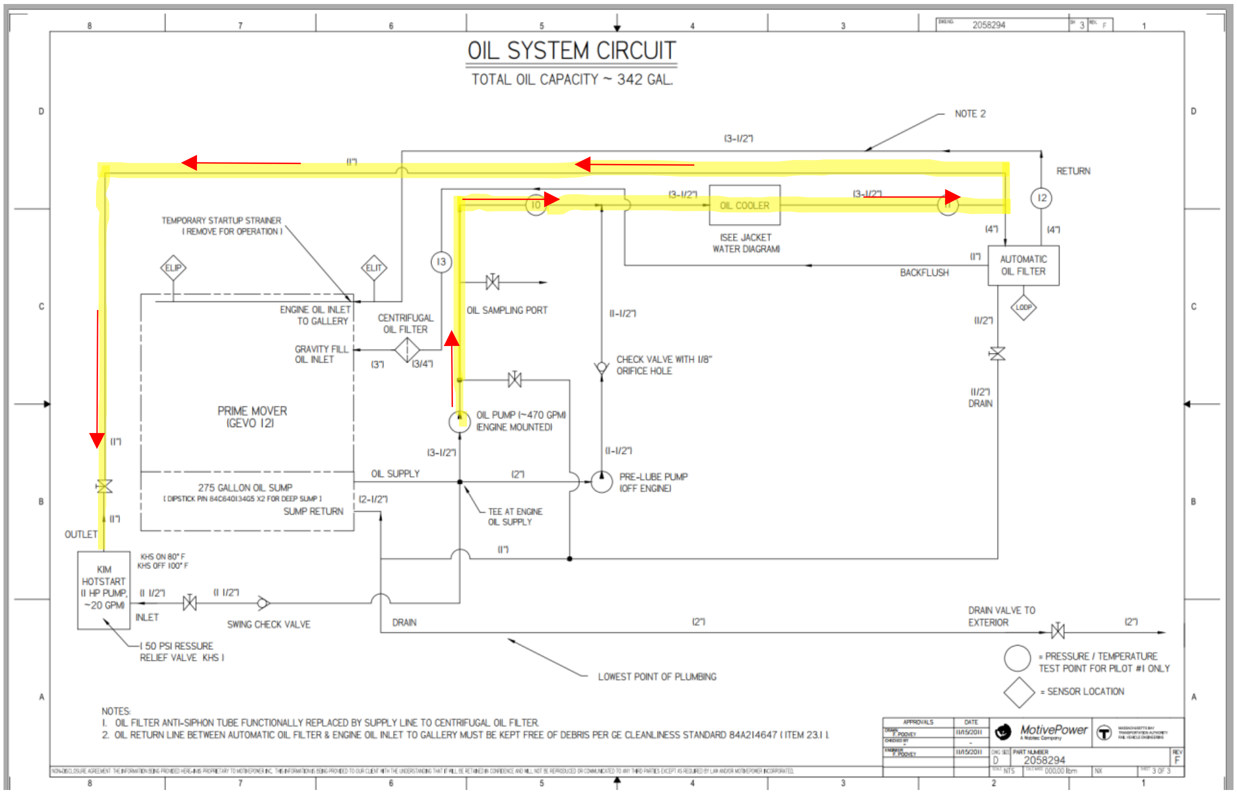


Fig. 6

Recommendation:

Since we're dealing with a back pressure, the next step would be to install a check valve and conduct the above test again.

The check valve would be installed at the outlet of the layover heater and record pressures at the layover oil pump during main engine operation and layover oil pump operation.

For test purposes, the check valve chosen was:

Apollo bronze body spring check valve w/ PTFE seal, 61-205

- 1" MNPT Input
- 1" FNPT Output
- $56.85
- https://www.mcmaster.com/47715k45

Installation:

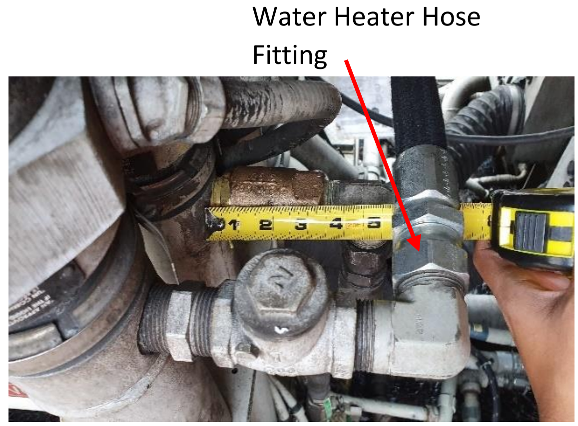


Fig. 7

CAUTION: layover pumps heating element, the surrounding pipes and the oil inside exceeds temperatures of 140 Fahrenheit. Ensure engine has been shut off and oil has time to cool down before installation:

- Ensure oil pressure reads 0 PSIG
- Cut out oil inlet and outlet ball valves at layover system
- Place rags on floor to catch residual oil leakage
- Remove top hose (#31) connection
- Remove the elbow (#77) from heater element
- Install the 1” Male end of the check valve into the female end of the oil heater
- Cut out coolant inlet and outlet ball valves at layover system
- Remove the water heater hose at the heater outlet’s JIC connector (see Fig. 7)
- Install the male end of the elbow joint (#77) into the female end of the check valve
- Reinstall top of oil hose (#31) connection to elbow (#77)
- Reinstall water heater hose fitting
- Cut in coolant inlet and outlet ball valves at layover system
- Cut in oil inlet and outlet ball valves at layover system

The hose (#31) is 20” in length, 14” of those being flexible. Once the valve is installed, there will be 2 inches of horizontal offset, resulting in an addition of 0.14” of hose length. This length change should be negligible but will be confirmed upon hose fitting.

Fig. 8

Check Valve Functional Test:

Test Plan:

Multiple tests will be conducted. Each test starts with both pressure gauges reading 0 PSIG and the engine turned off. The purpose for this test is to see if we still have a substantial back pressure after the installation of the check valve.

Test C

Ensure inlet and outlet ball valves are closed and start the engine:

1. Record pressures once engine reaches idle
2. Open the outlet ball valve and record pressures
3. Open the inlet ball valve and record pressures

Test D

Ensure inlet and outlet ball valves are closed and start the engine:

1. Record pressures once engine reaches idle
2. Open the inlet ball valve and record pressures
3. Open the outlet ball valve and record pressures

Test E

Keep inlet and outlet ball valves open and start the engine:

1. Leave engine running for 10 minutes

Test F

Keep inlet and outlet ball valves open and start the engine:

1. Record pressures during startup
2. 15 seconds after startup, closed the outlet ball valve and record the pressures
3. Open the ball valve and record pressures once they stabilize

Hypothesis:

We expect to see no back pressure after the installation since it would be serving its function as a one-way valve.

Test Conditions	Participants
• Date: 7/30/19 12:00PM • Location: Layover yard • Locomotive: 2006 (HSP46) • Pressure gauge piping installed into the test inlet and outlet ports of the layover oil pump • Check valve installed • 0-160 PSIG gauges have been installed • Engine lube temp: 160 Fahrenheit • Weather: 85 Fahrenheit, sunny • Engine had been running for over a day • Blue flag protection was set up	• Chad Capra – Piper • Rich Crowell – Standards Manager • Nisal Ovitigala – Mechanical Intern

Test Data:

Test C: Main engine running

Step	Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure	Time taken to reach pressure
1	Closed	Closed	0 PSIG	0 PSIG	No change
2	Closed	Open	70 PSIG	65 PSIG	32 seconds
3	Open	Open	70 PSIG	65 PSIG	No change

Test D: Main engine running

Step	Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure	Time taken to reach pressure
1	Closed	Closed	0 PSIG	0 PSIG	No change
2	Open	Closed	0 PSIG	0 PSIG	No change
3	Open	Open	40 PSIG	45 PSIG	38 seconds

Test E: Main engine running for 10 minutes (to determine if any difference in pressure from Test D)

Step	Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure	Time taken to reach pressure
1	Open	Open	40 PSIG	35 PSIG	No change

Test F: Main engine just started

Step	Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure	Time taken to reach pressure
1	Open	Open	0 PSIG	0 PSIG	0 seconds
2	Open	Closed	20 PSIG	15 PSIG	15 seconds
3	Open	Open	45 PSIG	40 PSIG	20 seconds

Conclusion:

The installation of a check valve has reduced pressures from 90 PSIG down to 40 PSIG and the pressures rises over the span of 35 seconds.

This suggests that the back pressure is reduced, however there seems to be leakage through the check valve which allows for oil to slowly flow backwards at a lower rate as shown by the observation of 40 PSIG pressures during tests D, E and F. This backpressure never exceeds the relief valve pressure setting of 50 PSIG.

Recommendations:

Since excess backpressure has been eliminated in the above tests, we can now conduct the following tests to identify the pump pressures with and without a check valve in both normal main engine operation, and during layover operation.

Comparison Test of System Without Check Valve vs With Check Valve:

Test Plan:

Each of the following tests must be conducted four different times with the following configurations:

- Once with the inlet and outlet ball valve closed
- Once with the inlet ball valve open and the outlet ball valve closed
- Once with the outlet ball valve open and the inlet ball valve closed
- Once with the inlet and outlet ball valve open

Test G: Main engine running without check valve installed

1. Read gauges once pressures have stabilized
2. Ensure engine is off and gauges read 0 PSIG before changing configurations

Test H: Main engine running with check valve installed

1. Read gauges once pressures have stabilized
2. Ensure engine is off and gauges read 0 PSIG before changing configurations

Test I: Main engine shut off and layover system running without check valve installed

1. Can only test with both valves open to not damage layover system

Test J: Main engine shut off and layover system running with check valve installed

1. Can only test with both valves open to not damage layover system

Test Conditions	Participants
• Date: 7/31/19 9:20 AM • Location: Service and Inspection track 3, BET • Locomotive: 2006 (HSP46) • Pressure gauge piping installed into the test inlet and outlet ports of the layover oil pump • Check valve installed • 0-160 PSIG gauges have been installed • Engine lube temp: 140 Fahrenheit • Weather: 82 Fahrenheit, sunny • Engine had been running for over a day	• Chad Capra – Piper • Yup Jung – Electrician • Nisal Ovitigala – Mechanical Intern

Test Data:

Test G: Main engine running without check valve installed

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Closed	Closed	0 PSIG	0 PSIG
Open	Closed	0 PSIG	0 PSIG
Closed	Open	90 PSIG	90 PSIG
Open	Open	90 PSIG	90 PSIG

Test H: Main engine running with check valve installed

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Closed	Closed	0 PSIG	0 PSIG
Open	Closed	0 PSIG	0 PSIG
Closed	Open	40 PSIG	40 PSIG
Open	Open	40 PSIG	35 PSIG

Test I: Layover system running with main engine shut off without check valve installed

NOTE: Only last configuration is tested to ensure layover pump doesn't get damaged by running dry

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Closed	Closed	N/A	N/A
Open	Closed	N/A	N/A
Closed	Open	N/A	N/A
Open	Open	0 PSIG	20 PSIG

Test J: Layover system running with main engine shut off with check valve installed

NOTE: Only last configuration is tested to ensure layover pump doesn't get damaged by running dry

Inlet Ball Valve Position	Outlet Ball Valve Position	Inlet Pressure	Outlet Pressure
Closed	Closed	N/A	N/A
Open	Closed	N/A	N/A
Closed	Open	N/A	N/A
Open	Open	0 PSIG	20 PSIG

Conclusion:

Layover system is working to specification. This is confirmed by visual inspection since there is no leakage seen around the check valve (see Fig. 9) or the sound of the oil backflow into the motor.

We can also confirm that there is no abnormal flow restriction because the pumps inlet and outlet pressures are found to be the same with and without the check valve.

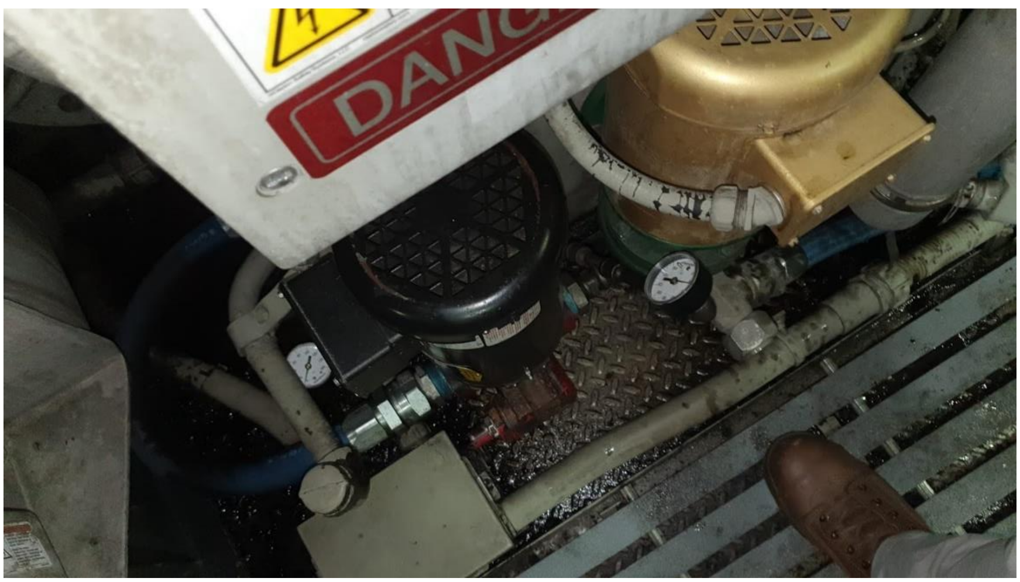


Fig. 9

Recommendation:

1. Install piping at the inlet and outlet pressure test ports on all layover oil pumps
2. Install 0 – 100 PSIG pressure gauges to the test port piping. Calibrated gauges could be installed if precise values were deemed critical
3. Install a check valve at the outlet of the oil heater (Item #77 in Fig. 4) with the following properties:
    a. 1" NPT inlet and outlet
    b. A spring backflow prevention mechanism
4. Recommended to install valve used for testing, Apollo Valves 61-205 check valve, since they are a service proven and well recognized manufacturer
    a. Lowest cost at McMaster-Carr for $56.85 ($2274 for whole fleet)

Benefits:

- The ability to set the internal relief valve pressure without the removal of hoses
- Real time monitoring of pressures through the layover pump
- Reduced pressures at the layover pump which prevents the compromising of the pump seal

Concerns:

- Added piping creates more connections and potential for oil leaks
- More parts add complexity to the layover system
- Added material cost, should be offset by the cost of the layover pump seal repairs
- Periodic replacement of new components unlikely, but to be determined with service use.

Attached below are the submittal sheets and installation sheet

"Apollo"® Valves
SUBMITTAL SHEET

61-100/200
In-Line Check Valve

61-100
FEMALE x FEMALE THREADED
1/4" THROUGH 3"

61-200
MALE x FEMALE THREADED
1/4" THROUGH 2"

Job Name:	
Job Location:	
Engineer:	
Contractor:	
Tag:	
PO#:	
Rep:	
Wholesale Dist.:	

DESCRIPTION
Apollo® CVB Ball Cone® Check Valves offer reliable protection against reverse flow and exceptional resistance to chemicals and corrosion using proven ASTM quality materials. Well-suited for a broad range of applications, including saturated steam and chemical service. May be installed in both horizontal and vertical flow with upward flow. Made in the USA.

FEATURES
- Female (Inlet) x Female Threaded (1/4" -3")
- Male (Inlet) x Female Threaded (1/4" -2")
- Spring Actuated
- Tight Shut-off with Liquid Media
- Flow Straight-Through Design Efficiency
- RPTFE Ball Cone® for Chemical Resistance
- 100% Factory Tested
- **Made in the USA - ARRA Compliant**

PERFORMANCE RATING
- Max Pressure:
  400 psi (2758 kPa) @ 100°F
  125 psi (862 kPa) Steam @ 350°F
- Max Temp: 406°F (176.6°C)

APPROVALS
- CRN: 0C11218.5C

OPTIONS & SIZES
- Lead Free (61LF-100)
- Soft Seat (61-500)
- Lead Free Soft Seat (61LF-500)
- Solder x Solder Soft Seat (61-600)
- (-A1) 0 psig Cracking Pressure (No Spring)
- (-E05) 5 psig Cracking Pressure (1/4"-1" Only)
- (-E10) 10 psig Cracking Pressure (1/4"-1" Only)
- (-57) Oxygen Cleaned
- (-17) Satin Chrome Plate Finish
- BSPP Threads (1/2" - 1" only)

Note: Not all combinations available. Call customer service for more details.

STANDARD MATERIALS LIST

BODY	Bronze, ASTM B584, UNS C84400
RETAINER	(1/4" - 1-1/4") ASTM B16 Brass (1-1/2" - 3") ASTM B584 Bronze
SPRING	Stainless Steel
BALL CONE CHECK	RPTFE, 15% Glass Filled
STEM	Brass, ASTM B16

NOTE: Not recommended for use with reciprocating pumps and similar applications. Low flows may result in undesirable noise and premature wear.

PART NO. MATRIX

61	- X	X	X	- XX
TYPE	CHECK	SPRING TYPE	SIZE (IN.)	OPTIONS
BRONZE	1 - BALL CONE (FNPT X FNPT)	0 - .5 PSIG CRACKING PRESSURE	1 - 1/4"	01 - STANDARD
	2 - BALL CONE (MNPT X FNPT)	2 - .2 PSIG CRACKING PRESSURE	2 - 3/8"	P01 - BSPP THREAD**
	0 - BALL CONE REPAIR KIT		3 - 1/2"	T01 - BSPT THREAD**
			4 - 3/4"	17 - SATIN CHROME PLATED
			5 - 1"	57 - OXYGEN CLEANED
			6 - 1-1/4"	A1 - LESS SPRING
			7 - 1-1/2"	E05 - 5 PSIG OPENING PRESSURE*
			8 - 2"	E10 - 10 PSIG OPENING PRESSURE*
			9 - 2-1/2"***	
			0 - 3"***	

**Available in 1/4" through 1" only. | **Minimums apply | ***Available on 61-100 only*
(Note: Not all combinations are available. Contact Customer Service for verification.)

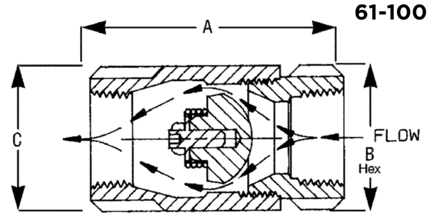
61-100/200

In-Line Check Valve

DIMENSIONS

PART NO.	SIZE (IN.)	DIMENSIONS (IN AND MM)						WT. (LB.)	WT. (KG.)
		A	A (MM)	B	B (MM)	C	C (MM)		
61-100 (FNPT X FNPT)									
61-101-01	1/4"	2.06	52.32	1.12	28.45	1.12	28.45	.38	.17
61-102-01	3/8"	2.12	53.85	1.12	28.45	1.12	28.45	.38	.17
61-103-01	1/2"	2.31	58.67	1.12	28.45	1.12	28.45	.38	.17
61-104-01	3/4"	2.87	72.90	2.37	60.20	1.50	38.10	.75	.34
61-105-01	1"	3.50	88.90	1.75	44.45	1.93	49.02	1.45	.66
61-106-01	1-1/4"	4.19	106.17	2.12	53.85	2.37	60.20	2.75	1.25
61-107-01	1-1/2"	4.94	125.48	2.50	63.50	2.81	71.37	3.94	1.79
61-108-01	2"	6.00	152.40	3.00	76.20	3.68	93.47	6.30	2.85
61-109-01	2-1/2"	7.12	177.8	3.87	98.29	4.50	114.30	14.0	6.35
61-100-01	3"	8.13	206.25	5.31	134.87	4.63	117.60	16.6	7.52

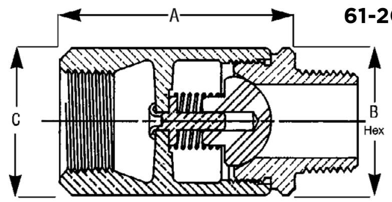
61-100



DIMENSIONS

PART NO.	SIZE (IN.)	DIMENSIONS (IN AND MM)					WT. (LB.)	WT. (KG.)
		A	B	B (MM)	C	C (MM)		
61-200 (MNPT X FNPT)								
61-201-01	1/4"	2.38	1.12	28.45	1.12	28.45	.38	.17
61-202-01	3/8"	2.38	1.12	28.45	1.12	28.45	.38	.17
61-203-01	1/2"	2.57	1.12	28.45	1.12	28.45	.38	.17
61-204-01	3/4"	3.09	2.37	60.20	1.50	38.10	.75	.34
61-205-01	1"	3.85	1.75	44.45	1.93	49.02	1.45	.66
61-206-01	1-1/4"	4.44	2.12	53.85	2.37	60.20	2.75	1.25
61-207-01	1-1/2"	5.16	2.50	63.50	2.81	71.37	3.94	1.79
61-208-01	2"	6.47	3.00	76.20	3.68	93.47	6.30	2.85

61-200



FLOW RATE

SIZE	GPM	
	CV	KV
1/4"	.85	.85
3/8"	1.21	1.21
1/2"	1.40	1.40
3/4"	3.53	3.53
1"	6.00	6.00
1-1/4"	44	44
1-1/2"	65	65
2"	81	81
2-1/2"	175	175
3"	265	265

GPM - gallons per minute at 1 psi pressure differential

Cv - expresses the flow capacity in gallons per minute (GPM) of 60°F water with a pressure drop of 1 psi (lb/in^2).

Kv - the flow of water with temperature ranging 5 - 30°C through a valve in cubic meters per hour (m^3/h) with a pressure drop of 1 bar

61 & 62 SERIES (Model: CVBE & CVS)
IN-LINE CHECK VALVE INSTALLATION, OPERATION AND MAINTENANCE MANUAL

INSTALLATION

Overall Cautions

1. It is the installers and/or system designer's responsibility to ensure that these valves and adjoining piping are installed and supported in accordance with applicable ASME B31 standards.
2. These check valves are not recommended for use with reciprocating pumps and similar applications which may induce repetitive vibrations.
3. Low flow rates which do not fully open the valve may result in undesirable noise and premature valve failure.
4. Upstream flow disturbances which create turbulence may also result in rapid wear. It is recommended that a minimum of 10 pipe diameters of straight pipe be provided between the check valve and any upstream devices such as control valves or elbows etc.

Threaded Valves

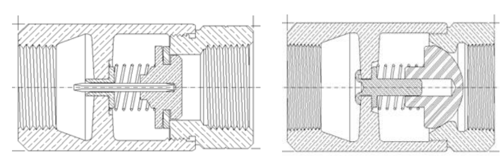
1. The 61 and 62 series Apollo check valves are designed to be installed horizontally or vertically with upward flow.
2. Make sure all pipe end connections are clean, burr free and free of any debris.
3. Apply pipe sealant (pipe dope, Teflon® tape, Loctite® compound, etc.) to the make end pipe prior to installing the valve.
4. Make sure the valve is installed in the piping system so that the intended flow direction corresponds with the flow arrow on the side of the valve body.
5. When tightening the valve onto adjoining pipe, apply the wrench to the valve at the hex closest to the joint being completed. Do not over-tighten the pipe joint. No more than 1 ½ turns should be necessary beyond finger tight to create a leak free joint. ***Caution: Do no apply installation torque through the valve as it may damage the valve body or body joint seal.***
6. Check the valve and joints for leaks prior to putting the system into service.

Solder End Valves

1. The 61 and 62 series Apollo check valves are designed to be installed horizontally or vertically with upward flow.
2. Make sure all pipe end connections are clean, burr free and free of any debris.
3. Make sure the valve is installed in the piping system so that the intended flow direction corresponds with the flow arrow on the side of the valve body.
4. 61-600 Series solder end check valves are designed to be soft soldered using solder with a melting point less than 500F.
5. Apply heat with the flame directed away from the center of the valve body and distribute evenly around the joint. Do not concentrate heat on any one point (i.e. the bottom of the joint). Make one joint at a time and allow it to cool to the touch before starting the second joint. ***Caution: Excessive heat can damage the valve's soft components.***
6. Check the valve and joints for leaks prior to putting the system into service.

MAINTENANCE

1. The 61 and 62 series Apollo check valves are designed to be virtually maintenance free.
2. Should a problem develop, do not disassemble the valve while the under pressure.
3. Repair kits are available from the factory should the seat, check or spring need replacing.
4. When reassembling the valve, use Loctite Compound 569 on the 61 Series and Loctite Compound AA with Loctite Primer N on the 62 Series.



FREEZING

Provide means to protect the valve from freezing and bursting when used on liquids.

FLUID COMPATIBILITY

Consider the corrosive, erosive and adhesive effects of fluids on the valves and piping components. It is the user's responsibility to ensure that the valve is compatible with the media in the system.

OPERATION

No manual operation is required, nor is it possible once the check valve has been installed in the piping system.

⚠ **CALIFORNIA PROP 65:** WARNING: Cancer and Reproductive Harm - www.P65Warnings.ca.gov.

FOR NON-LEAD FREE VALVES: It is illegal to use this product in the United States for potable water services (water intended for human consumption).
FOR LEAD FREE VALVES: This product complies with U.S. Safe Drinking Water Act (SDWA). Suitable for potable water applications intended for human consumption.

Conbraco Industries, Inc. 701 Matthews Mint Hill Rd. Matthews NC 28106 USA; www.apollovalves.com ; 704-841-6000