



PBMC Test Fixture Guidelines & Procedures

Revision 1.0

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Date: 03/18/26



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Summary

This document is supporting collateral for the PBMC Design Specification and referenced in the specification. This document outlines fixture requirements, fixture design details, reference test fixture design images, test fixture set-up details and diagrams, data acquisition requirements, and test procedures for several tests.

Draft

Date: 03/18/26



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Version History

Date	Version #	Author	Description
xx JULxx	x	x	x

Date: 03/18/26



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1.0 Fixture Guidelines

1.1 Flow and Mate Related Fixture Guidelines

Table 1.1 outlines the fixture details & requirements for the PBMC test fixtures used for the various flow related tests, mate force, and mate cycle testing.

Table 1.1: Flow and Mate Related Fixture Design Requirements

Criteria	Figure	Specification/Details
Mate Distance Reference for fixture tests	Figure 1.3	Shows mating references for testing
Valve movement in fixture	Figure 1.4.1	General movement of the socket in the fixture
Valve rotational & axial movement in fixture in combined state (angle & offset)	Figure 1.4.2	Socket is angled relative to plug for adapting to misalignment for this fixture. The sliding axial axis is the same as the plug axis. The socket angle is exaggerated for effect.
Location of valves relative to each other for aligned condition socket	Figure 1.5.1	Need to add tolerance for angle and radial relative to plug for all test
Radial only condition	Figure 1.5.2	Location of socket relative to plug for radial only
Combined-S condition - socket offset	Figure 1.5.3	Layout requirements for combined radial and angular offset condition during tests for -S condition, Socket rotates and moves along the axis of plug horizontally.

Combined-P condition - plug offset	Figure 1.5.4.A Figure 1.5.4.B	Layout requirements for combined radial and angular offset condition during tests for -P condition, Socket rotates and moves as if the plug was rotated for fixture simplicity.
Which side of fixture the load cell is located	Figure 1.6.1	Load cells to be placed on socket side of fixture
Load Cell basic locating requirements	Figure 1.6.2	• Locate the 3 load cells on the same plane with each other and parallel to the socket datum A* (socket mating surface) • Load cell locations do not need to be equidistant from the socket axis Datum B* (although it is preferred)
Minimum load cell count	N/A	Minimum 3
Socket Fluid connection	Figure 1.6.3	behind socket, but should not affect load cell readings
Location of load cells relative to socket for aligned condition	Figure 1.6.4	Does not need to be defined, Can move with socket or stay in original location. The load cell plane must remain normal to the axis of movement.
Location of load cells relative to socket axis for radial only tests	Figure 1.6.5	
Location of load cell relative to socket centroid for combined (angle + radial offset	Figure 1.6.6 Figure 1.6.7	Does not need to be defined, it can move or rotate with socket or stay in the original location. Load cells may rotate along with the socket axis but must be maintained within 3° of the plug axis. Note that this allowable angular variation results in less than 0.14% error and is considered acceptable.

Attachment bore diameter the fixture to locate plug on fixture plate	Figure 1.7.1	Diameter of bore in mounting plate: 31.10mm -min., 31.20mm - max.
Attachment method for the plug:	Figure 1.71 Figure 1.7.2	(1) align plug shoulder with hole in fixture plate (2) mount to plate with 4 M3 screws
Socket Attachment	Figure 1.7.3	- thread valve into threaded port as as shown
Mate cycle speed	N/A	40 mm/s (slow) +/- 2mm/s and 330 mm/s (fast)+/- 4mm/s per test details in PBMC Design Spec.
Static mate force dwell time between Readings at different mate distances	N/A	1 second
Fixture acceleration/deceleration	N/A	Fixture velocity to be 330 mm/s from stage 1 thru stage 4 and then decelerate at a rate of 5000 mm/s ² +/-10% to min mate distance, then accelerate at the same rate on the de-mate stroke back to 330mm/s until fully unmated
Fixture maximum applied force threshold during tests involving force and motion	N/A	Applied load max: 667N, note for the 330mm/s tests, results above this are considered a failure
General Test Apparatus Requirements for Pressure Drop Testing	N/A	Refer to ISO 18869 section 13 for set-up. Flow test tubing internal diameter to be 14-16mm to

		improve consistency of results reporting.
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* see Section 4 in the PBMC Design Specification for details on Datums for the valves.

1.2 Fixture Tolerance and Data Acquisition Guidelines

Details for units, tolerances, data acquisition requirements for the test fixture is provided below

Table 1.2: Tolerances & Data Acquisition Requirements (unless otherwise specified)

Parameter	Units	Acceptable Error	Applicable Range
Axial Distance	mm	+/- 0.25 mm	General range = 70.8-150 see table 11.1 in valve spec for details for each specific test and distances
Pressure	PSIG	+/- 3%	0-75 PSIG (higher for burst and other tests)
Pressure Drop (specific to test 7.1-1 in the specification)	PSID	$\leq \pm 0.15$ psid for differential sensor $\leq \pm 0.075$ psig for independent sensors	N/A; ensure compliance with acceptable error
Flow Rate	LPM	+/- 3%	0-42 (may be higher for some tests)
Temperature	C	+/- 3 C (some tests are -0/+3C)	Varies by test and some tests are -0/+3C, see test spec for details
Force	N (lbf)	+/- 3%	-667 to +667N (-150 to +150lbf)
Sampling Rate	Hz	n/a	1kHz min for load cell @ 40 mm/s speed, 2 Hz min for all other sensors, record peak

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			force value @ 330 mm/s speed for reference (5kHz min sample rate)
Load Cell Count/Capacity	N (lbf)	n/a	3x load cells min 667N (150 lbf) min load capacity
Volume (spillage)	mL	+/- 10%	

1.3 Mating Distance and Reference Information

Datum A on the socket is the valve seating face that sits flush on the manifold spot face (coplanar with the manifold spot face surface). Datum A on the plug is the plug cup mounting surface coplanar with the inside of the sheet metal panel.

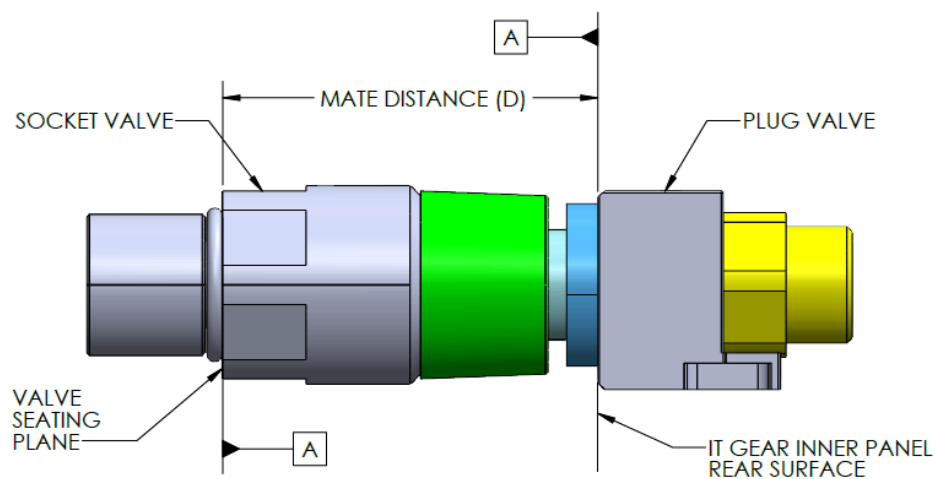


Figure 1.3.1: Mate Distance Reference for fixture tests

Datum A on the socket is the valve seating face that sits flush on the manifold spot face (coplanar with the manifold spot face surface). Datum A on the plug is the plug cup mounting surface coplanar with the inside of the sheet metal panel.

1.4 Basics Movement of Valves In Fixture

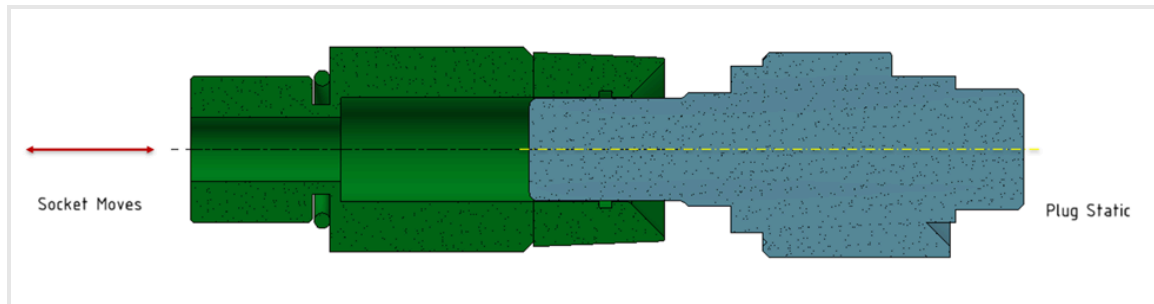


Figure 1.4.1: General motion of socket relative to plug

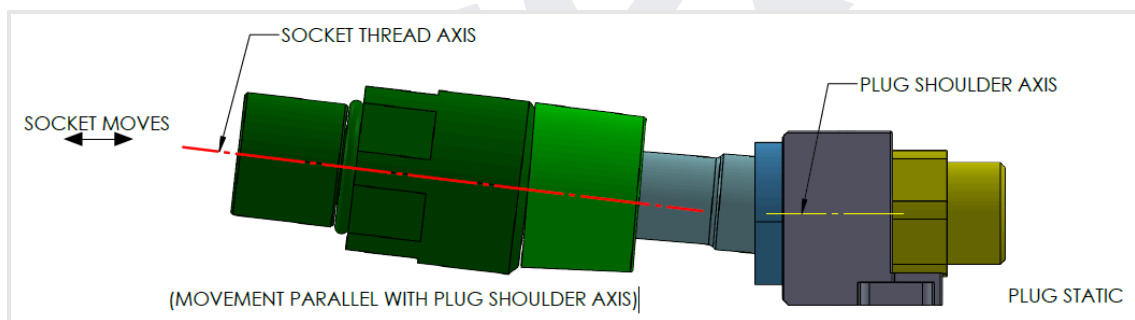


Figure 1.4.2: Socket rotation and motion relative to static plug position.

1.5 Fixture alignment requirements

PBMC is designed to accommodate connection with up to 5mm of offset and up to 2.5° between the base datums as described in the PBMC specification. Due to differences in construction and location of pivot points between the mating halves, the combined offset case where the plug is offset and rotated relative to the socket base datums results in a different misalignment condition (different pivot angle) from the case where the socket is

offset and rotated relative to the plug base datums. As a result, the team tests both conditions to ensure the design meets the offset requirements. We also test with margin on various parameters during testing to ensure we meet the requirements (velocity, offset distance, angle offset, mate distances, etc.).

Below are figures showing the offset conditions and allowable fixture tolerance for each condition. As mentioned previously, the plug is stationary and fixed while the socket is adjusted to the correct offset and it moves axially in the fixture during testing.

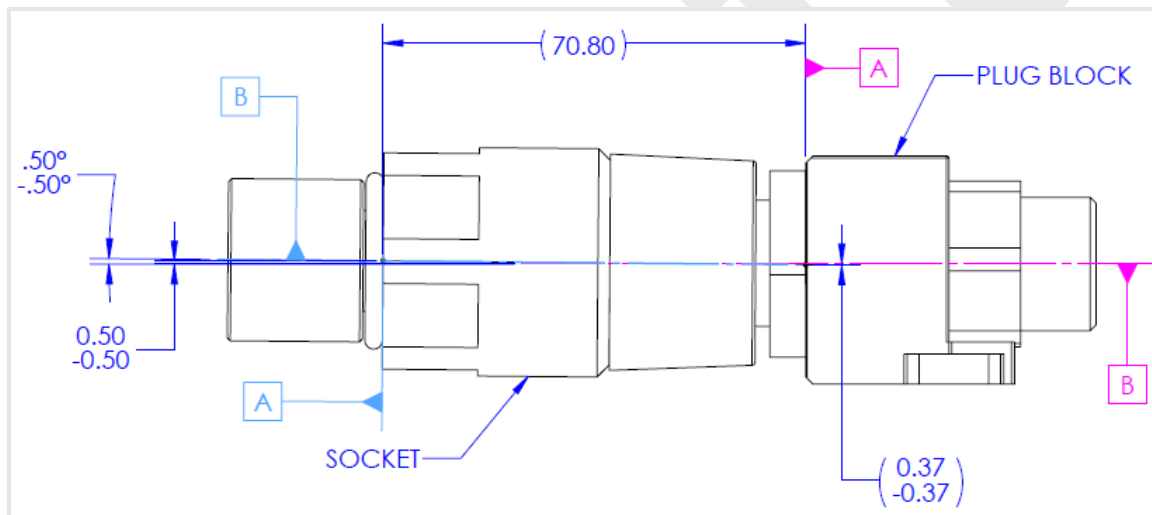


Figure 1.5.1: Permissible misalignment envelope (radial and angular) for the test fixture during cycle testing in the **Aligned condition**.

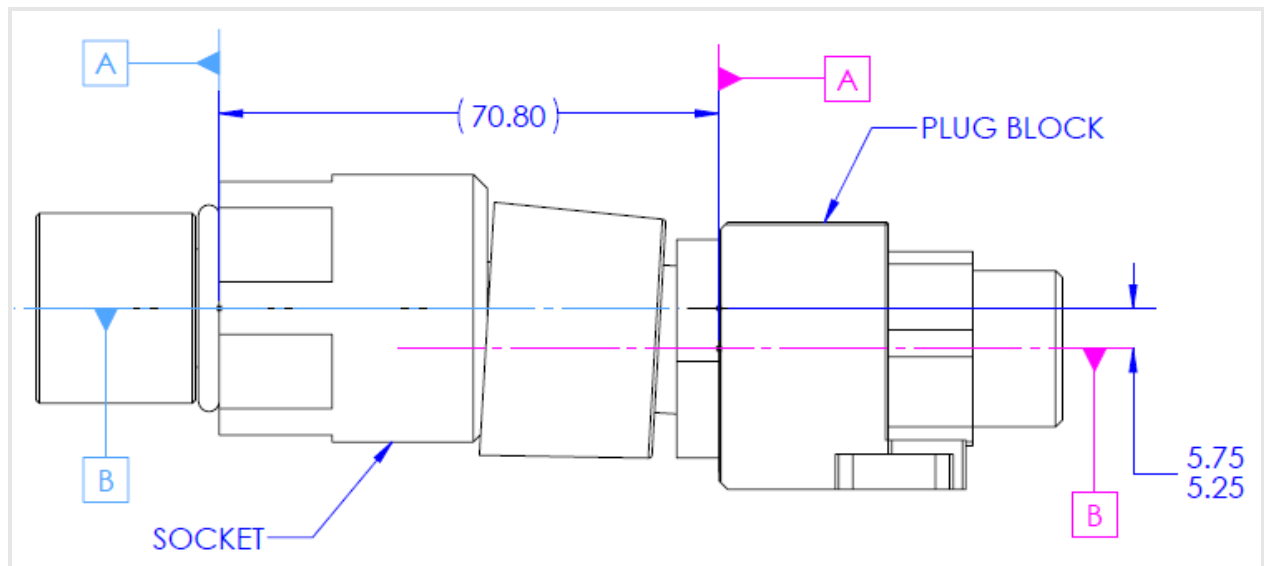


Figure 1.5.2: Permissible misalignment envelope (radial and angular) for the test fixture during cycle testing in the **Radial Offset** condition.

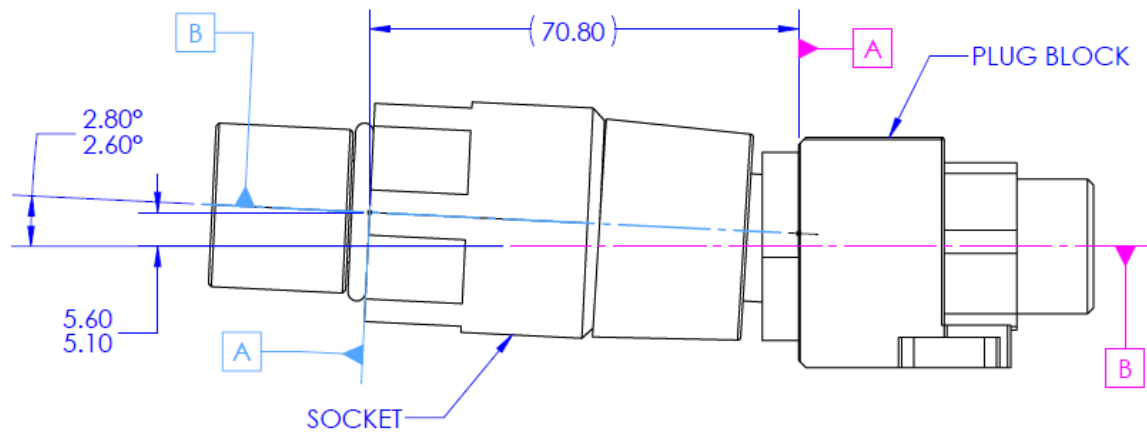


Figure 1.5.3: Permissible misalignment envelope (radial and angular) for the test fixture during cycle testing in the **Combined Offset Condition, Socket Rotated (Combined-S)** where the socket is offset and rotated relative to plug Axis B.

In this fixture set-up the plug is stationary and the socket is rotated x° and y mm while the socket moves axially

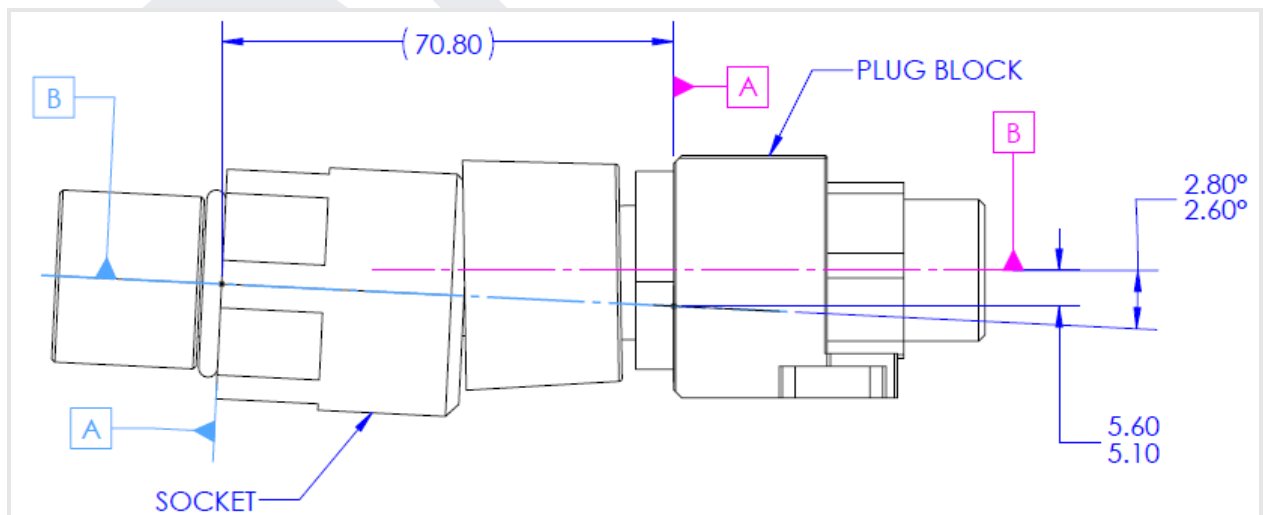


Figure 1.5.4.A: Permissible misalignment envelope (radial and angular) for the test fixture during cycle testing in the **Combined Offset Condition, Plug Rotated (Combined-P)**

Figures 1.5.4.A and 1.5.4.B show the Combined-P test valve alignment. Figure 1.5.3, Figure 1.5.4.B shows the generalized offset and rotation concept. However, for fixture simplicity, the orientation is adjusted as in Figure 1.5.4.A so that the plug position does not change between test cases, as illustrated in Figure 1.4.2.

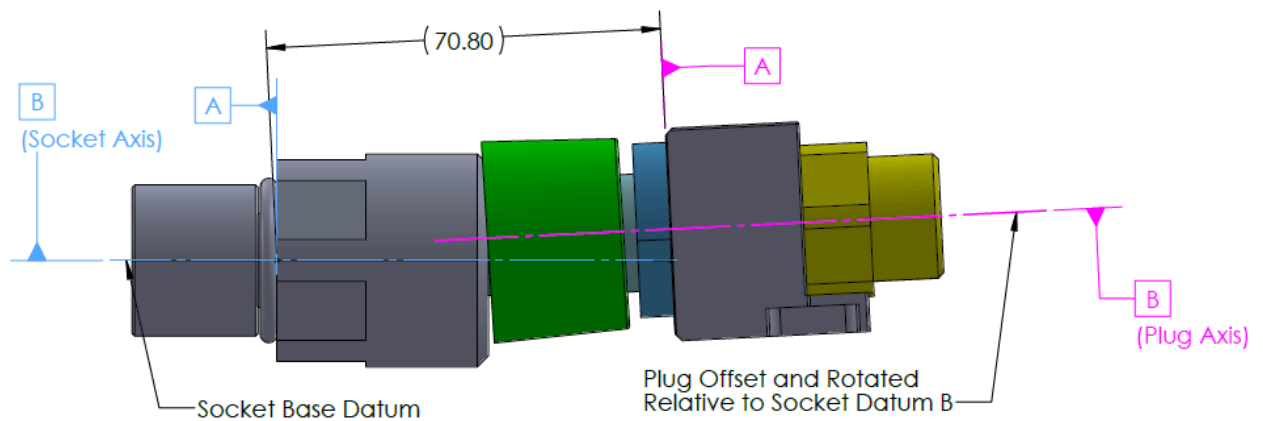


Figure 1.5.4.B: Representation of 'Combined-P' Offset condition where Plug is offset radially and rotated relative to the Socket base datums. This case is equivalent to Figure 1.5.4 except that it has not been rotated to align with the fixture direction of travel to simplify fixturing.

1.6 Load Cell Related Information

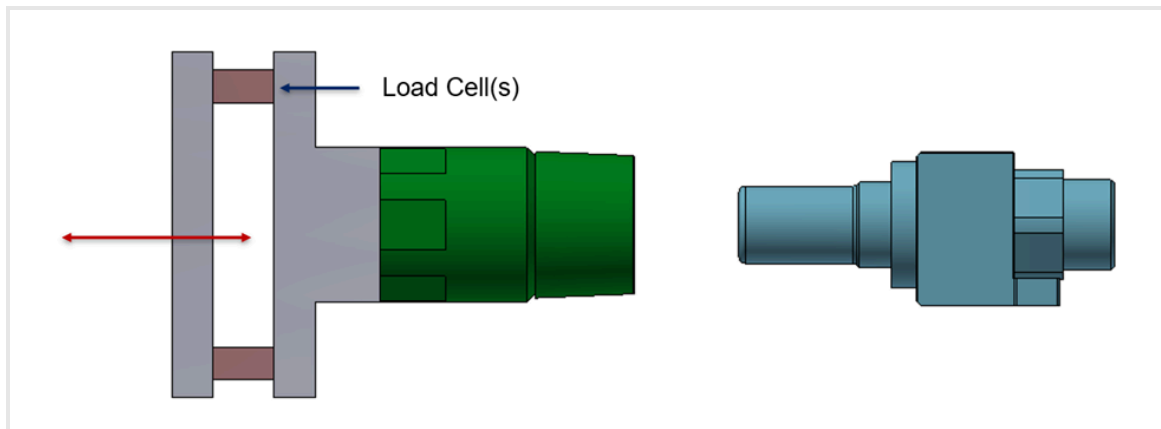


Figure 1.6.1: Load cell placement (on the socket side) and orientation

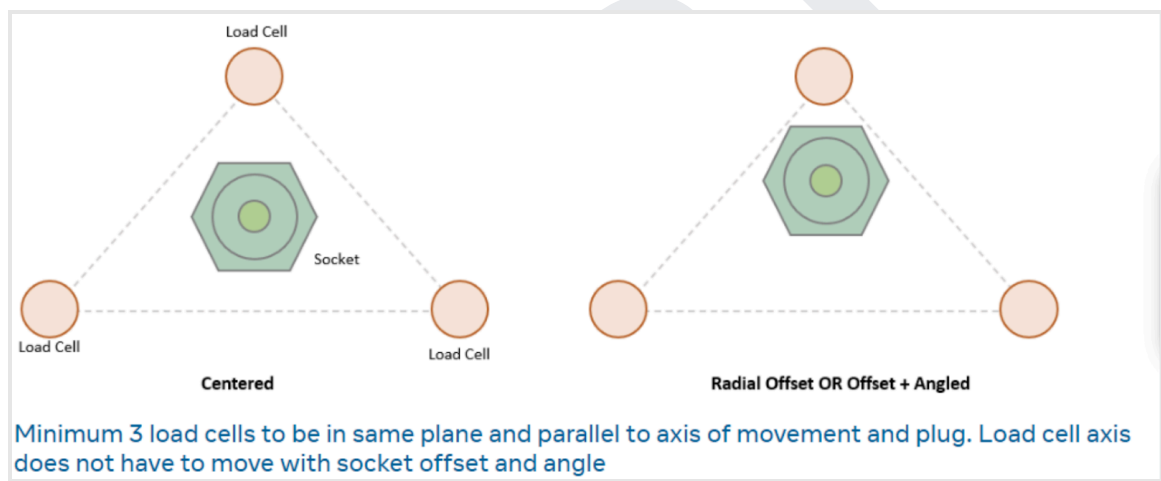


Figure 1.6.2 - Basic Load cell positioning relative to the socket valve

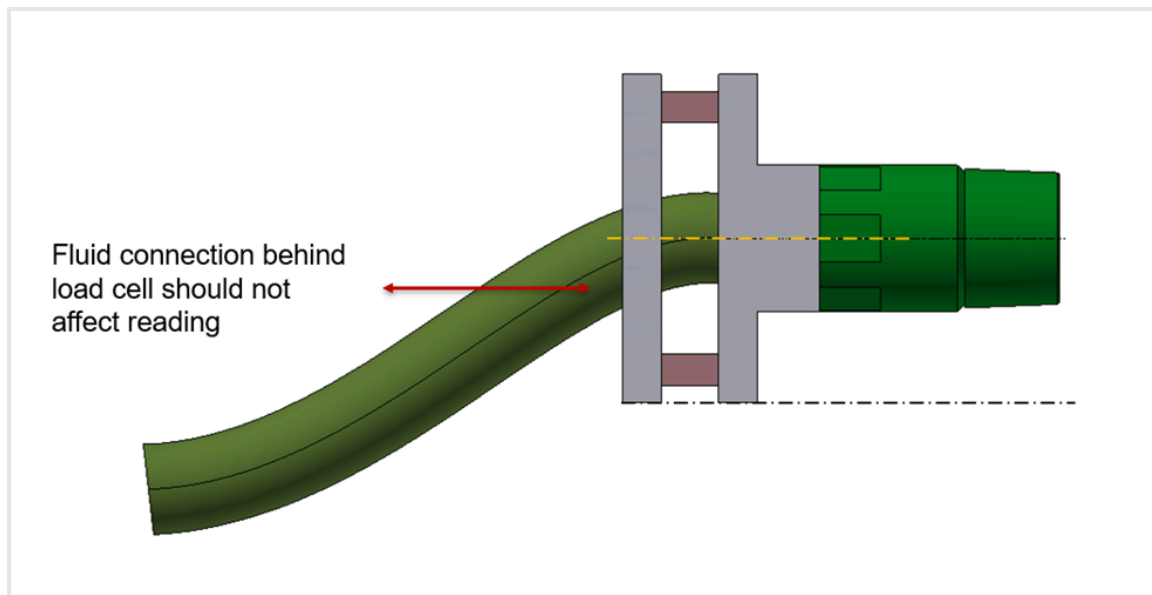


Figure 1.6.3: Socket Valve Fluid Connection Location

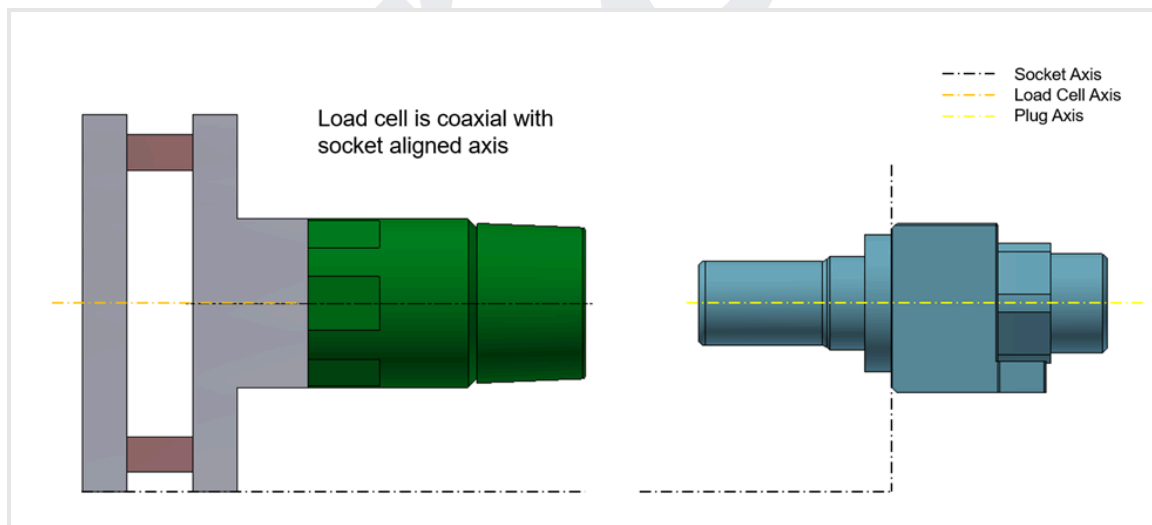


Figure 1.6.4: Location of load cells for aligned connection

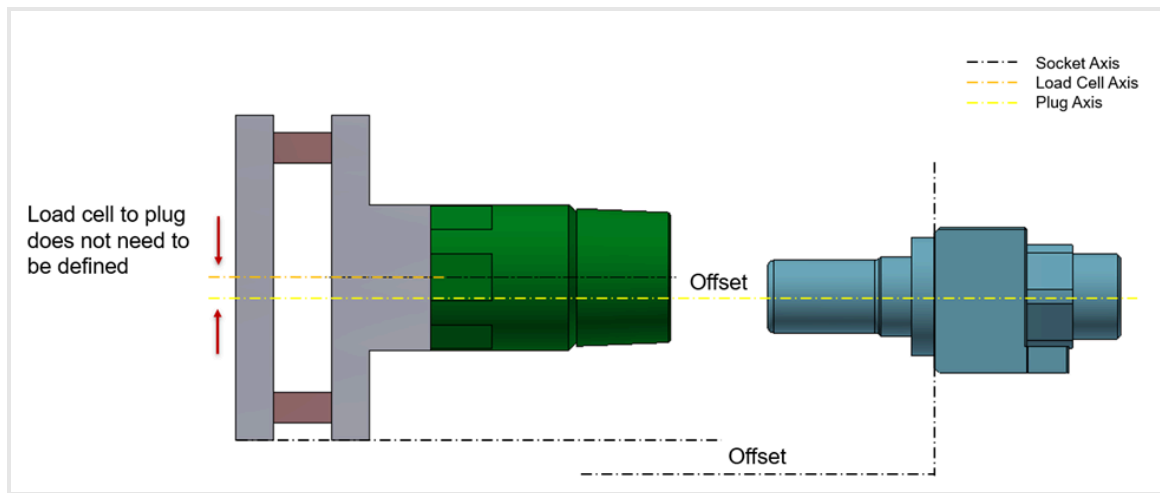


Figure 1.6.5: Location of load cells for radial-only connection

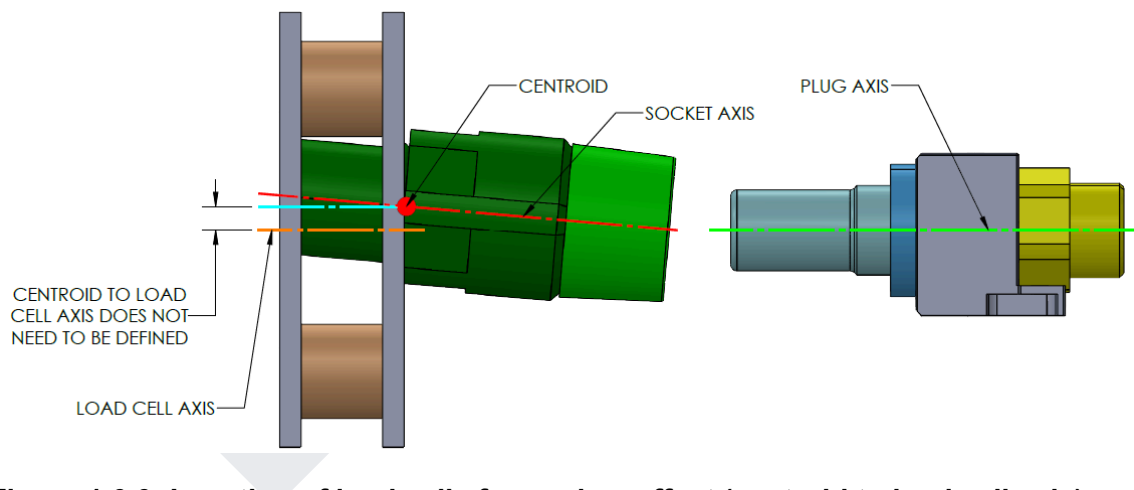


Figure 1.6.6: Location of load cells for angle + offset (centroid to load cell axis)

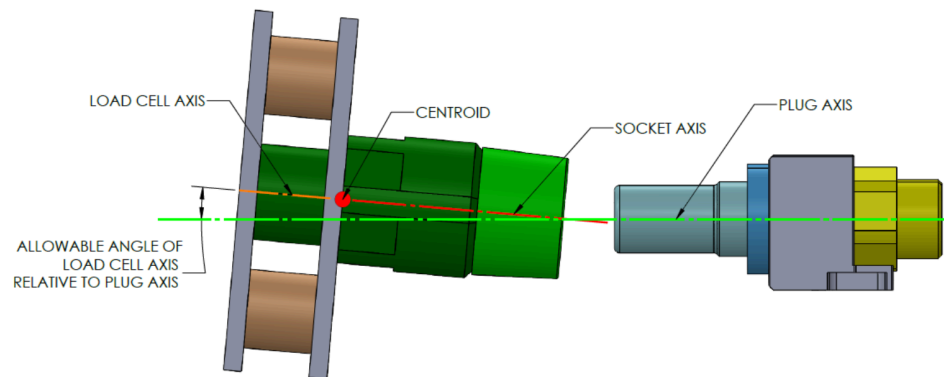


Figure 1.6.7: Allowable rotation of load cell axis relative to plug axis

1.7 Valve Attachment:

Valve attachment information for the test fixture.

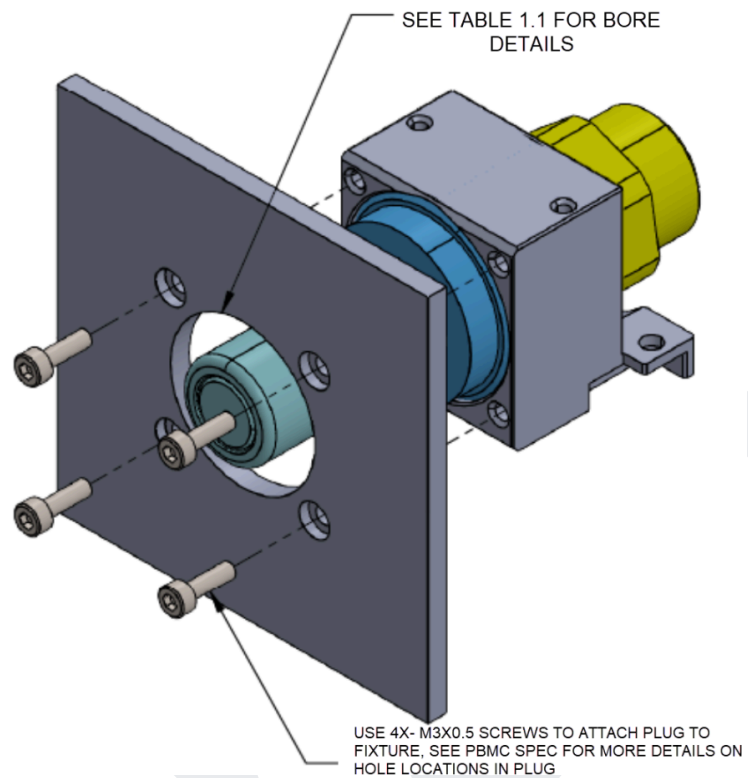


Figure 1.7.1: Plug mounting to panel

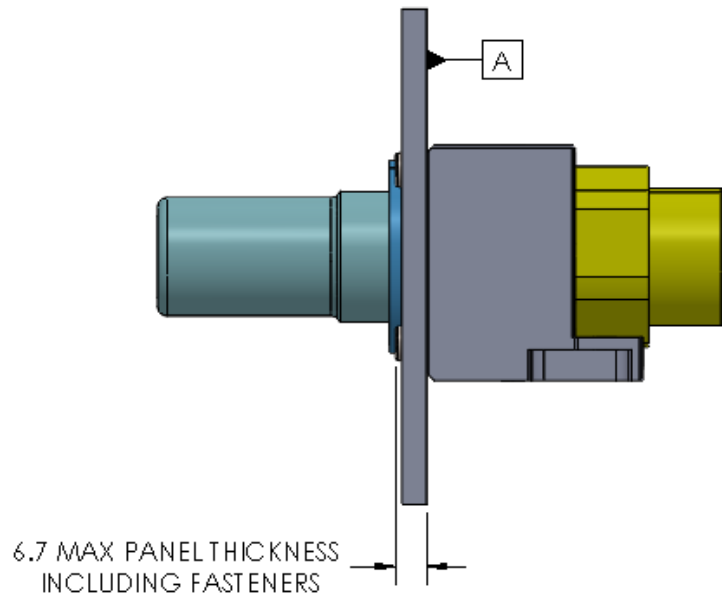


Figure 1.7.2: Maximum panel thickness and screw height from Datum A

Example manifold depicting installation of socket using Datums A and B as defined in Section 2.2.1. This represents the configuration used during fixture level testing.

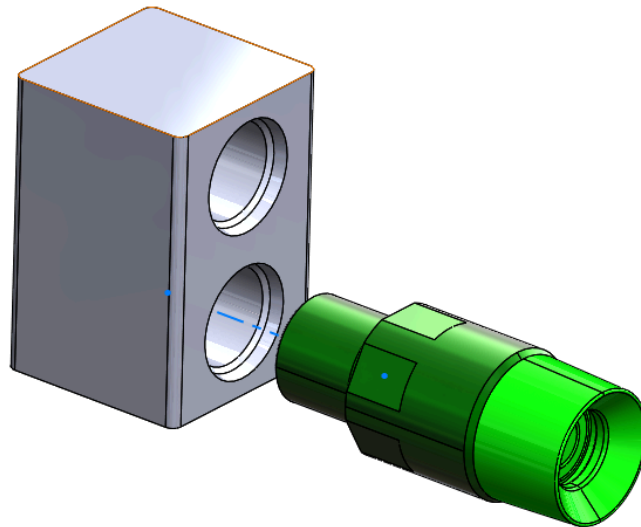


Figure 1.7.3: Socket Attachment & Mate Distance Reference for fixture tests

1.8 Pressure Drop Tare

Tare design requirements for pressure drop testing.

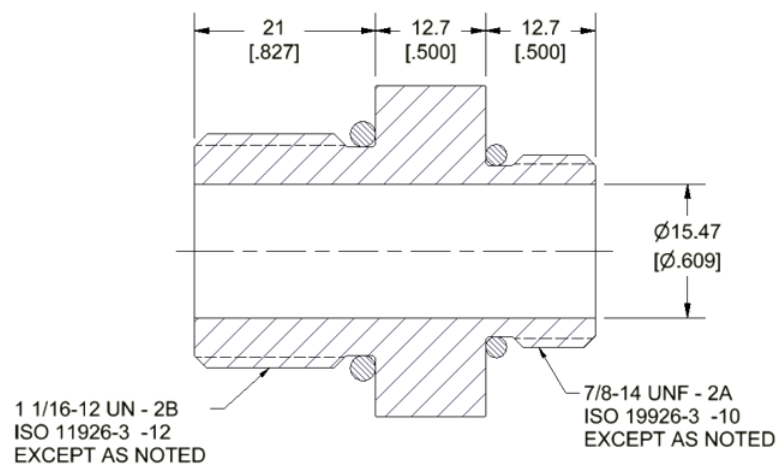


Figure 1.8 Tare Fitting for Pressure Drop Testing

Tare Fitting: The above image is the tare fitting to be used for pressure drop testing. Subtract the pressure drop values run through the tare from the values run through the connected Socket and Plug. The reported net pressure drop is the difference between the two.

Tubing: Adapt each end of the tare fitting to use -12 size tare tubes on both sides of the connected coupling during the pressure drop test. When the tare fitting is replaced with the PBMC coupling, use the same -12 tare tube and adapter that was used when running the tare fitting pressure drop.

1.9 Sample Test Fixture Images

Below are some reference pictures of test fixtures used by the suppliers for testing. Note that Datums A and B are used for fixturing each mating half, respectively, while plug Datum C and other mounting options are not used during fixture-level testing.

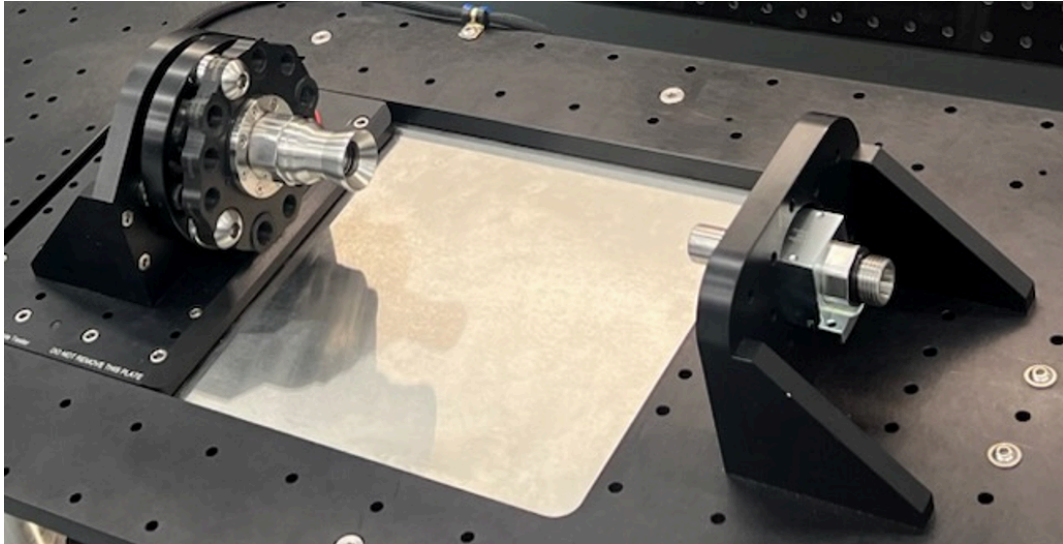


Figure 1.9.1

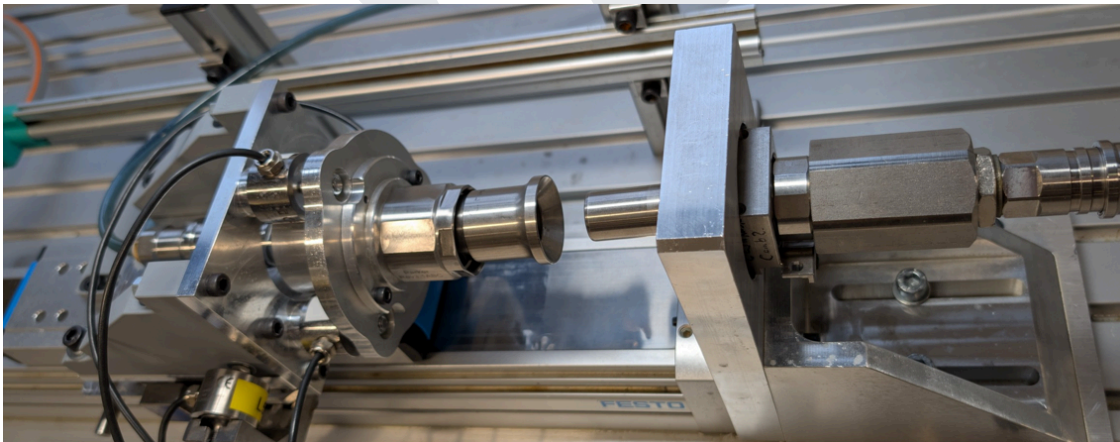


Figure 1.9.2

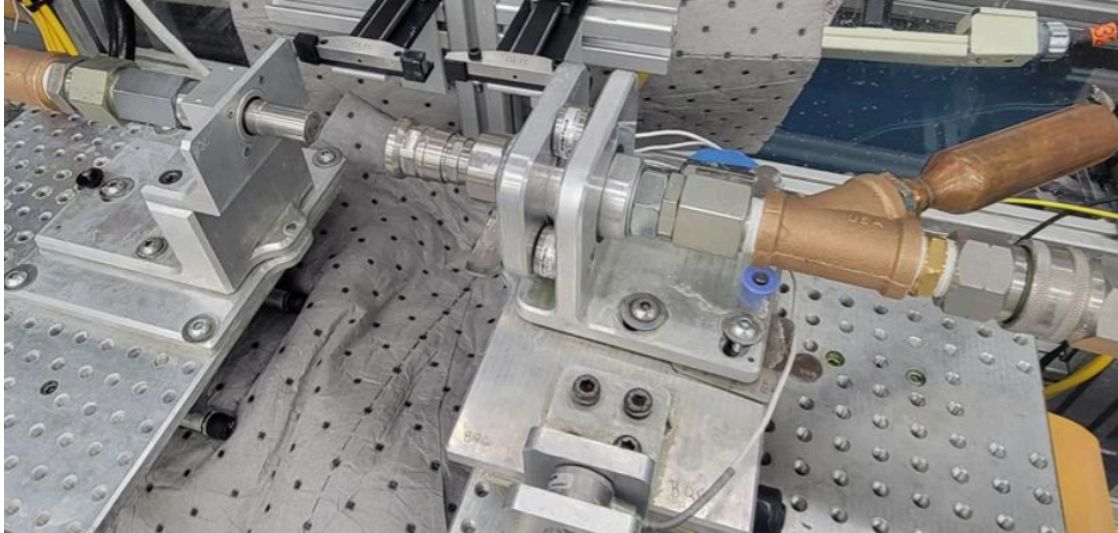


Figure 1.9.3

2.0 Test Procedures

The section below provides additional information on test procedures referenced in the PBMC Design Specification Section 7.

2.1 Test Procedure for 7.1-6 Elevated Flow Test, Connected, Closed Loop

Test Procedure 7.1-6 Elevated Flow Test, Connected

1. Set-up test per ISO 18869, with the following unique requirements.
 - a. Key Parameters:
 - i. Plug and socket to be connected at maximum mate distance (78.5 mm)
 - ii. Test to be done in both flow directions (1) plug to socket (2) socket to plug
 - iii. Fluid: PG25.
 - iv. Fluid Temperature: $50 \pm 5^{\circ}\text{C}$
2. Starting from 0 lpm flow rate, gradually increasing the flow rate, must increase within 30 seconds to 72LPM and full pressure.
3. Hold flow rate at above listed value for 2 minutes while checking the differential pressure gauge. No sudden increase or decrease of the differential pressure is allowed during the flow increase or holding period.
4. Test for 1 cycle

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5. After the test, check for any leakage in the disconnected position for both the Socket and Plug valves

2.2 Test Procedure 7.1-7 Elevated Flow, Mate Cycle Test, Open Loop

Test setup process:

1. Reference Figure 2.2.1
2. Referencing Figure 11.1. arrange a hose (E), with an inside diameter of 19.05 mm ($\frac{3}{4}$ "), connected on the downstream side of the PBMC such that there 1 PSI (0.7m water column) always present on the downstream side of the fixture prior to each mate cycle.
3. For the test, the fluid is connected on the downstream to drain fluid after each cycle.
4. Turn on the pump.
5. With the valves fully disconnected, adjust bypass valve 8 so that supply side fluid has a static pressure equal to test pressure.
6. For fixed displacement pump: With the sample fully mated, verify that test flow rate is achieved.
For centrifugal pump: For initial fixture adjustment to calibrate the fluid flow, mate the valves so that they are fully mated and set metering valve A to achieve test flow rate.
7. The fixture is now ready for test cycles.

Test Procedure:

1. Before each connection (with valves fully disconnected) verify static pressure is equal to test pressure.
2. When the valves are connected, verify the flow rate is at the desired setting.
3. Conducting the test: Connect and disconnect with at the specified mate speed. Refer to specification for the number of cycles in each flow direction. Check for leakage or seal washout during and after each cycle.

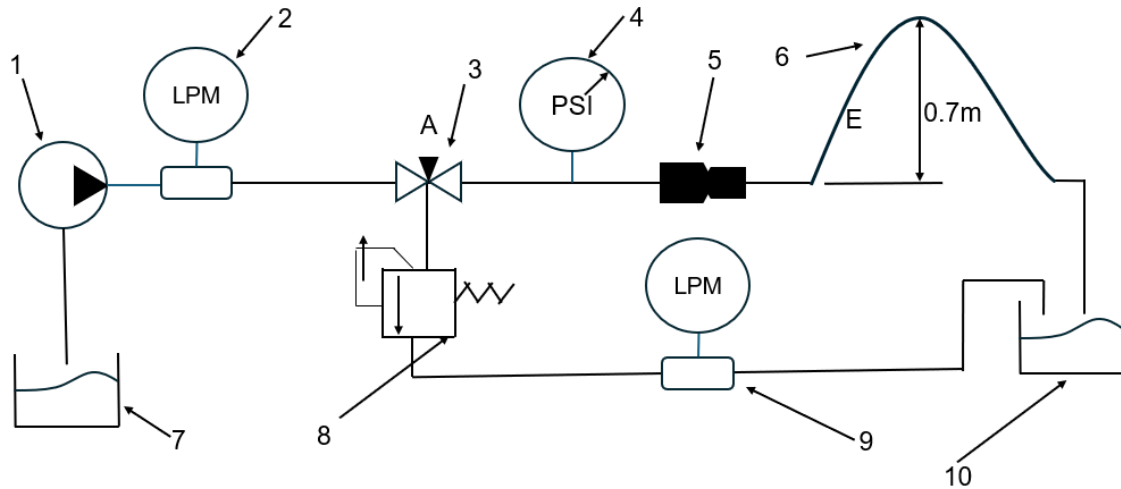


Figure 2.2 Test Set-up

Key For Figure 2.2

1. Pump
2. Flow meter
3. Valve A (optional on fixed displacement pump)
4. Pressure gauge
5. Test sample
6. Water column of 0.7m, creates 1 psi pressure at test sample
7. Tank with fluid
8. Differential pressure bypass
9. Flow meter (optional)
10. Tank with fluid

2.3 Set-Up For Test 7.1-12

Figures 2.3.1 and 2.3.2 below provide two example fixture set-ups that were used to test per 7.1-12 mate cycle testing with flow. Other test arrangements may also be valid.

When disconnected, pressure is set at 75 psi upstream and 30 psi downstream. When connecting, there is a 45 psi differential. Once connected, the flow is 36LPM and pressure is not specified. When disconnecting the inlet pressure rises to 75 psi and the outlet retains 30psi.

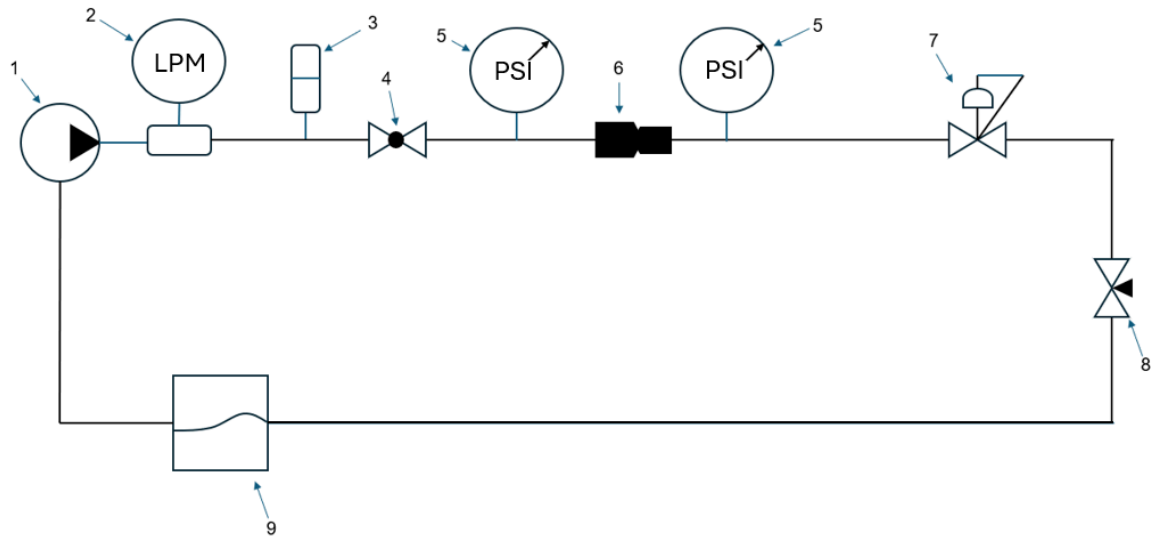


Figure 2.3.1 - Option 1 for test set-up (with centrifugal pump)

Key For Figure 2.3.1

1. Pump
2. Water flow meter
3. Expansion vessel/water hammer arrestor
4. Regulating valve
5. Pressure gauges
6. Test objects
7. Back pressure valve, to maintain 45PSI differential pressure
8. Flow regulating valve
9. Tank with fluid

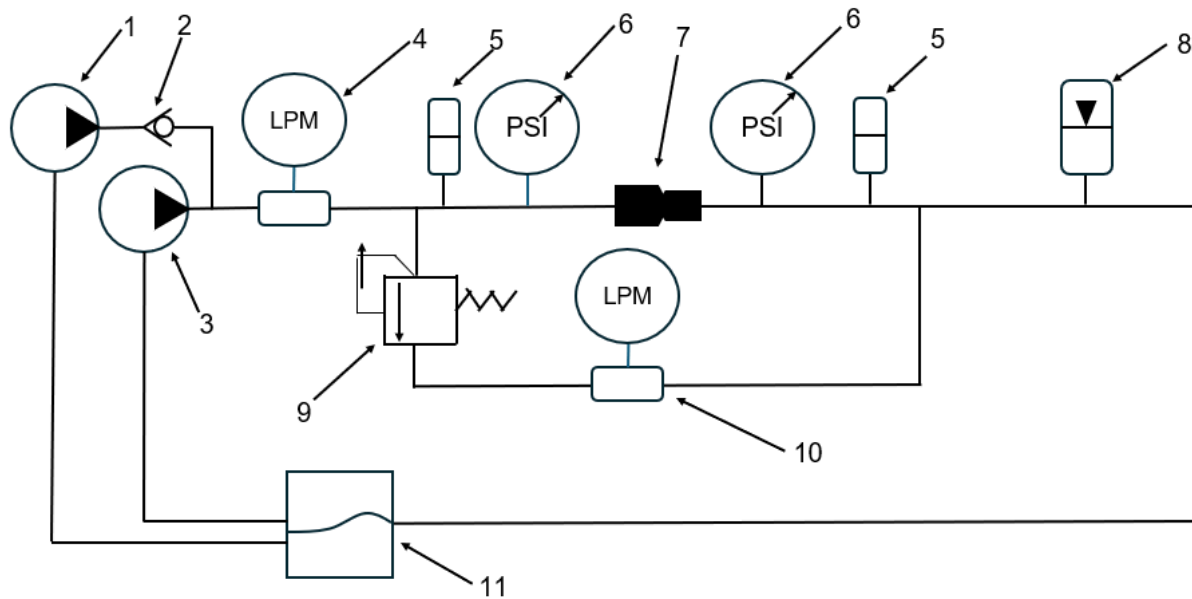


Figure 2.3.2 - Option 2 for test set-up (with fixed displacement pump)

Key For Figure 2.3.2

1. Axillary pump
2. Check valve
3. Primary pump
4. Flow meter
5. Expansion valve/water hammer arrestor
6. Pressure gauges
7. Test objects
8. Adjustable accumulator
9. Differential pressure bypass, to maintain 45PSI differential pressure
10. Flow meter
11. Tank with fluid

2.4 Radial Force Measurements and Testing. (Tests 7.1-13 thru 7.1-16)

Figures 2.4.1 & 2.4.2 below show the load cell arrangement to measure the radial forces induced between the two mating valves while pivoting during connect and disconnect when there is misalignment. The load cell could be on the socket or plug half fixturing. Frictional forces in the radial direction from the fixturing should be minimized and/or accounted for in the measurement. For example, a linear rail or guide may be used to constrain motion in the radial direction while minimizing frictional forces to reduce measurement error.

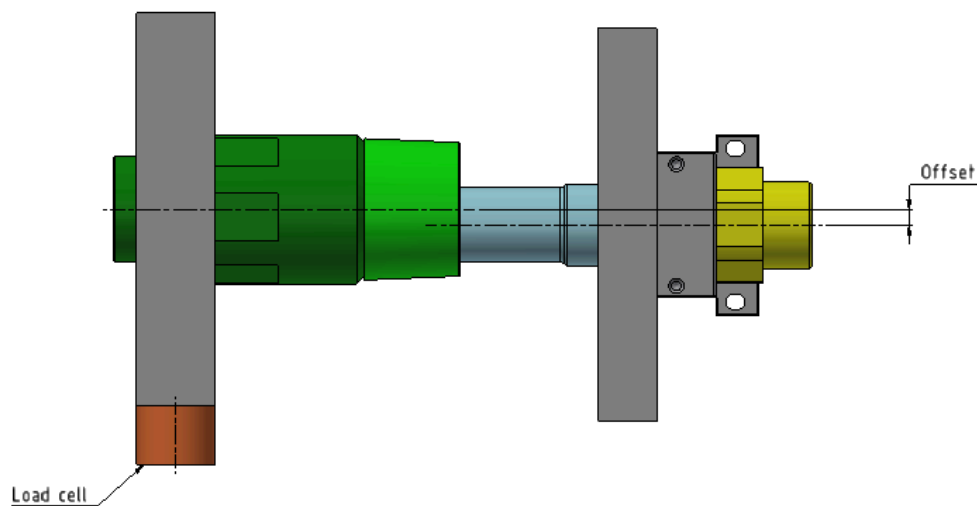


Figure 2.4.1 Load Cell on the socket side of fixture

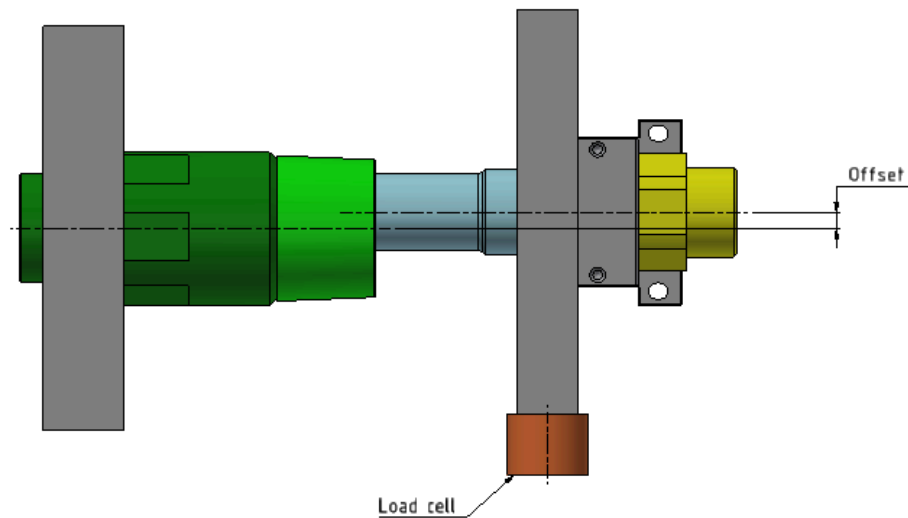


Figure 2.4.2 Load Cell on the plug side of fixture

2.5 Plug & Socket Rotation

Below is an example of a 3D printed test gauge to verify the rotation capabilities of plug and socket valves. Gauge to be assembled with tight fit on a diameter concentric with Datum B on Plug / Socket and then rotated 360 degrees to verify rotation capability in all directions. See test 7.1-18 in the PBMC Specification for angle requirements.

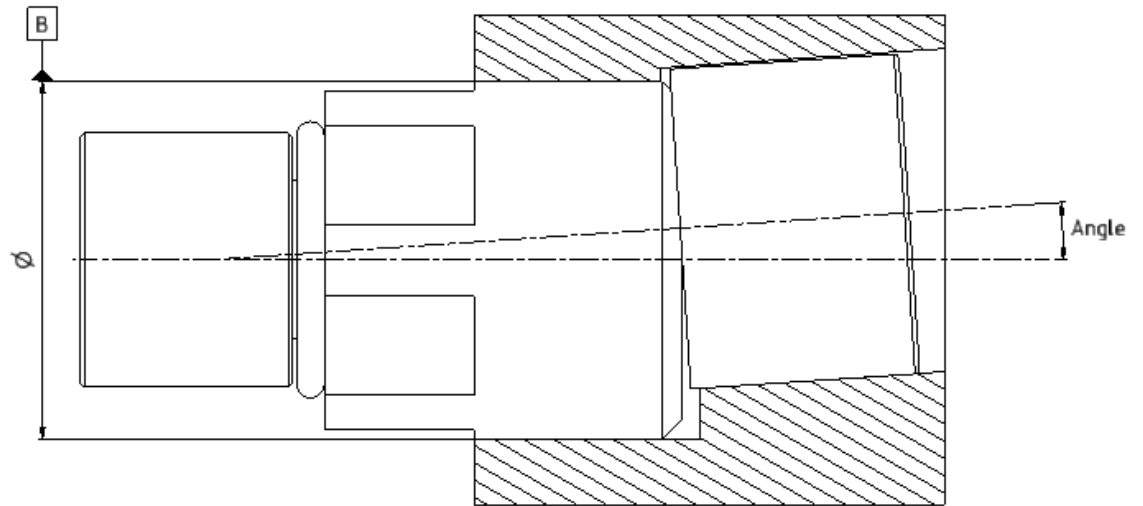


Figure 2.5.1 Socket Example

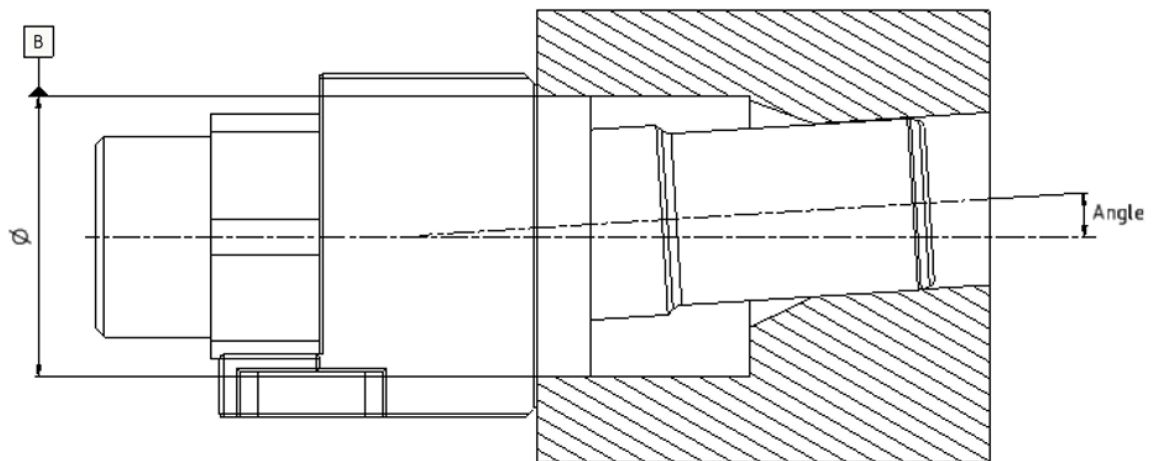


Figure 2.5.2 Plug Example

2.6 Pivot Movement & External Torque Test.

Details for the test procedure 7.1-20 in the PBMC Design Specification are provided below.

2.6.1 Plug Test

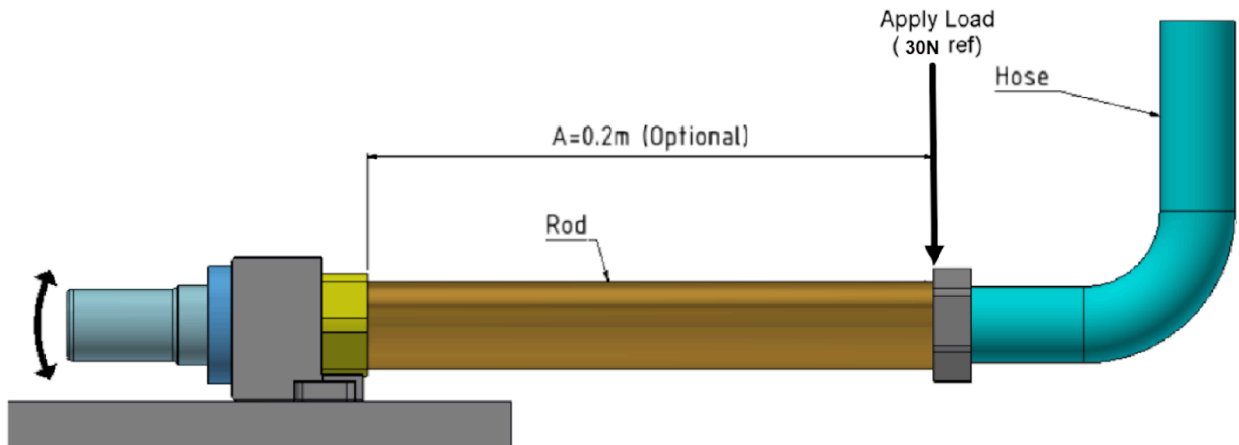


Figure 2.6.1 Reference Plug Test Set-up

1. Figure 2.6.1 shows the basic test set-up for testing the plug with a reference rod and force to meet the requirement.
2. Mark the plug tip and swivel nut to identify rotation between the parts.
3. Fix the PBMC plug to a solid base.
4. Install a min. 0.2 M (Optional length) long adaptor rod to the PBMC -10 ORB male thread. Length of rod starts at the end of the swivel shoulder. Length of rod is optional, but the applied torque must equal value in step 5 below.
5. Apply a force of 30N at a distance of 0.2 M = 6Nm to the adaptor rod.
6. Apply 1PSI water pressure to the PBMC plug.
7. Connect the plug to a socket to make sure there is no air left in parts or fixturing, then disconnect the socket and plug after removing air in line.
8. By hand move the plug end to its maximum angle in multiple directions, at least 10 movements in 4 directions. Angles of movement: 0, 90, 180 and 270 degrees (40 movements)
9. Check for any leakage.
10. Remove the load.
11. Rotate the swivel nut at 0, 90, 180 and 270 degrees vs. plug tip, applying the 6Nm load at each angle.
12. After each rotation repeat point 7-10 to check for leakage.
13. Repeat Steps 9-11 2 times.

14. Repeat Steps 4-13 and test at 75PSI.

2.6.2 Socket Test:

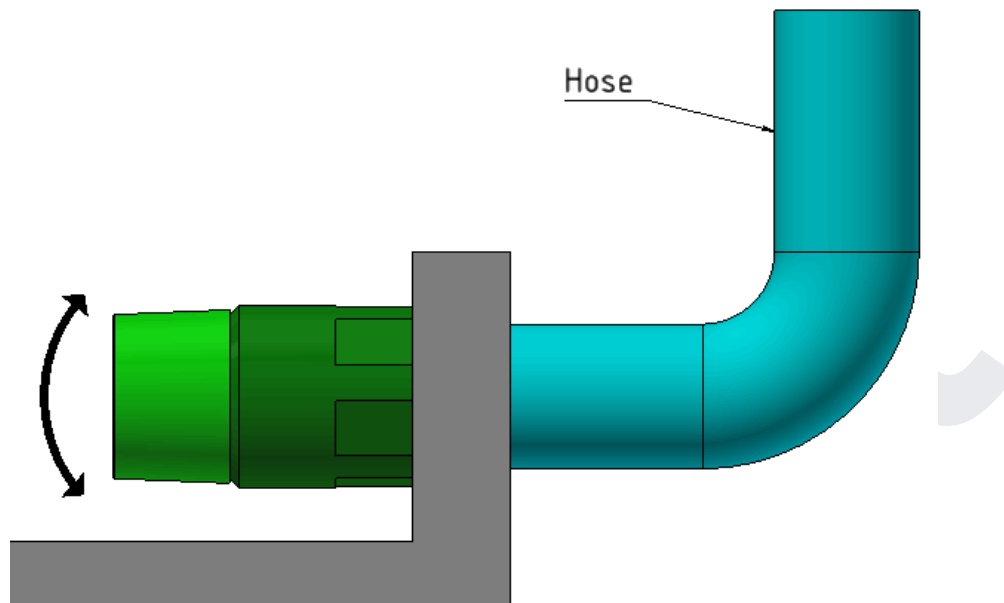


Figure 2.6.2 Reference Socket Test Set-up

1. Fix the PBMC socket by the threaded end to a solid base.
2. Apply 1PSI water pressure to the PBMC socket.
3. Connect the socket to a plug to make sure there is no air left in the parts or the fixturing.
4. Disconnect plug valve.
5. By hand move the pivoting part of the socket to its maximum angle in multiple directions (until it hits movement stops), at least 10 movements in 4 directions. Angles of movement: 0, 90, 180 and 270 degrees (40 movements)
6. Check for any leakage.
7. Repeat Steps 4-5 and test to 75PSI.