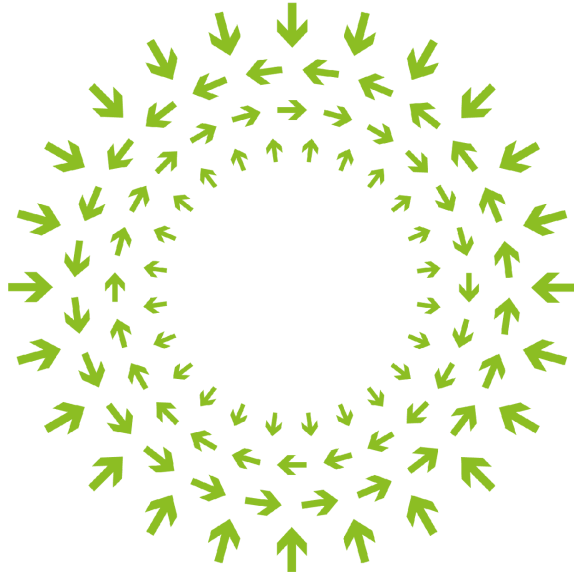




OPEN

Compute Project

Large Quick Connector Specification

Version 2.0.0

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1.2. Acknowledgements

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Parker - Tim Marquis

Safeway - Nick Goenner

2. Compliance with OCP Tenets

2.1 Openness

This specification contains necessary details for valve suppliers to recreate the design contributed to Open Compute.

2.2 Efficiency

The OCP large quick connector has been specified to enable dripless and interoperable liquid transport connections at the rack-level with high flow rates and minimal pressure drop. This results in minimal impact to pumping systems compared to other components in a liquid cooling loop.

2.3 Impact

While similar sized quick connectors are widely available in the market, these components are not interoperable across vendors/suppliers. In addition, at the size required for rack-level connections, such devices require large forces which may place a physical burden on personnel operating IT Equipment in data centers. The OCP large quick connector addresses these concerns by focusing on a dripless, interoperable and ergonomic design.

2.4 Scale

The OCP large quick connector is primarily intended for rack-level connections, primarily to technical cooling (secondary) loops. In addition, these components can be utilized for liquid transport connections across adjacent racks, such as for air-assisted liquid cooling applications. The combination of these use cases should lead to high volume deployments achieving significant scale.

2.5 Sustainability

The OCP large quick connector is designed with a focus on minimizing natural resources and costs. This is achieved through a minimum (continuous) operating life expectancy of 10 years and a focus on minimizing pumping power.

3. Version Table

Date	Version #	Author	Description
02.21.23	1.0	Meta Platforms, Inc.	Updates to comply with OCP specification template (adding compliance with OCP tenets, and version table)
03.03.26	2.0.0	Parker Hannifin, CEJN, Safeway, Meta	- Multiple updates and added criteria for performance requirements (Section 6): 6.1 Pressure Drop Test 6.2 Dry Torque Test 6.3 Wet Torque Test 6.4 O-ring, Worst Case 6.5 Fluid Loss 6.6 Air Inclusion 6.7 Operating Temperature Testing 6.8 Non-Operating Temperature 6.9 Salt Spray (Corrosion Resistance) 6.10 Hydrostatic pressure, coupled 6.11 Hydrostatic pressure, un-coupled - Working pressure increased from 35 psi to 50 psi (Section 6). - Revised upper and lower limits for flow impedance performance (Section 6). - Added and renamed mechanical form dimensions, and added notes stating all geometry features must be kept within dimensions D and E (plug) and L and M (socket) (Section 7). - Higbee cut dimensions and tolerances changed from 4.8±0.4 to 5.2 MAX on the socket and from 10.8±0.4 to 11.2 MAX on the plug (Section 7). - Added requirements for thread lubrication on the plug threaded sleeve (Section 7.3). - Added requirements for hardening of the plug threaded sleeve (Section 7.4). - Added recommendations for mounting torque (Section 7.5). - Added requirement that parts shall be clearly marked with OCP LQC PLUG or OCP LQC SOCKET (Section 9.2). - Added that parts shall have features to allow optional color coded rings (Section 9.3). - Added referenced document list (Section 11).

4. Scope

This document defines the technical specifications for large dripless interoperable quick connectors used in liquid transport for use in cooling of electronics in a data center environment. This specification was developed with industry partners to standardize the form, fit, and function of the connectors so that the connectors can operate effectively with each other and the data center plumbing systems.

5. Overview

As liquid cooling of IT gear is becoming more prevalent in the data center environment, from increasing IT gear temperatures and higher power efficiency demands, there is greater demand for a large quick connector that can interface between facility plumbing, IT gear rack manifolds, CDUs, heat exchangers, and other similar large connections.

This specification defines dimensions and performance for a large quick connector with universal interchangeability and the interfaces required for an ergonomic hand mate, dripless, and hot-pluggable connection.

5.1 Terms and Definitions

- Plug
 - Also called nipple, side of the coupling that pushes into socket, contains external sleeve with internal threads
- Socket
 - Side of the coupling with a cavity that receives the plug (external threads)
- Coupling
 - Pair of plug and socket that forms a dripless interface
- P-Q
 - Measure of pressure drop at varying flow rates, used to quantify acceptable performance range of coupling
- Termination
 - Interface at end of both plug and socket that can be used to connect or adapt to other parts of the end system
- ACME
 - A standardized trapezoidal screw thread form that is used when high load and low torque is preferred
- Higbee Cut
 - A specific cut added to screw threads to produce a blunt start, eliminates the chance of cross-threading
- BSPP
 - British Standard Parallel Pipe thread, a standardized constant diameter pipe thread that is used with an accompanying gasket to form a seal between two parts

6. Performance Requirements

General Pass/Fail Criteria

The Large Quick Connector must not bind, leak, exhibit damage to external or internal parts, have any degradation in performance beyond the requirements, meet any additional requirements listed in a particular test below and meet any requirements in any reference test specification listed in the “Reference Standard” column below for that test.

Table 1 - Test Requirements		
Test # & Description	Requirements	Reference Std.
6.1 Pressure Drop Test	● Pressure: 50 PSIG ● Ambient Temperature: 20°C ± 3°C ● Fluid Temperature: 35°C ± 3°C ● Fluid type: 25% propylene glycol-water mixture ● Requirements must be met for both flow directions	ISO 18869:2017 Section 13 Conditions

	- Flow rates: Measured at 20, 40, 60, 80, & 100 LPM - Requirements are listed in Figure 1 - Same supplier, minimum 2 samples - Interoperability testing required, minimum 3 suppliers with 1 production set per supplier	supersede any conflict with the referenced standard.
6.2 Dry Torque Test	- Pressure: 0 PSIG (no fluid) - Ambient Temperature: 20°C ± 3°C - Test Conditions: Plug and Socket installed in stationary fixture - Measuring torque on the outer surface of the rotating Plug sleeve - Velocity: Approximately 90° every second <5 Nm, connecting or disconnecting, on first 5 connections - After 100 connect and disconnect cycles, Average torque <5 Nm - Upon completion of above, plug and socket to be tested with fluid @ 50 psig to ensure no leaks or functional issues (both connected and disconnected) - Same supplier, minimum 4 samples - Interoperability testing required, minimum 3 suppliers with 3 production sets per supplier	
6.3 Wet Torque Test	- Pressure: 50 ± 1 PSIG - Pressure application to both Plug and Socket - No fluid flow required - Ambient Temperature 20°C ± 3°C - Fluid: Water or PG25 - Fluid Temperature: 25°C ± 5°C - Test Conditions: Plug and Socket installed in stationary fixture - Measuring torque on the outer surface of the rotating Plug sleeve - Velocity: Approximately 90° every second <10 Nm, connecting or disconnecting, on first 5 connections - After 100 connect and disconnect cycles, Average torque <10 Nm - Upon completion of above, plug and socket to be tested with fluid @ 50 psig to ensure no leaks or functional issues (both connected and disconnected) - Same supplier, minimum 4 samples - Interoperability testing required, minimum 3 suppliers with 3 production sets per supplier	Reference Supplemental Document - LQC Torque Testing Requirement

6.4 Elevated Flow, Mate Cycle Test, Open Loop	• Purpose explanation: This test is conducted to ensure that the seals of the valves can withstand mating/un-mating under higher pressure / flowrate conditions without washing out and creating a leak. • Although this test tests for seal durability, for guidance on use in an open loop scenario, such as during filling or draining a server – contact the valve supplier for guidance. In an open loop scenario, extreme pressure drop and fluid velocity across a valve set can induce a seal washout event. As such, fill and drain practices should follow a progressive introduction of flow and pressure within the specification of the valve. • Connection test with flow, simulating a minimally pressurized open loop connection. • Pressure: 55 PSIG (Plug Side) • Pressure: 0 PSIG (Socket Side) to open tank or drain • Ambient Temperature: 20°C ± 3°C • Fluid: Water or PG25 • Fluid Temperature: 25°C ± 5°C • Flow Rate: Set up at 83 LPM. Verify flow not to exceed 200 LPM during the test operation. • Tubing: 25.4mm [1 in] EPDM Data center Hose • Test Conditions: Plug and Socket installed in stationary fixtures. • Set-up: Assemble the plug to the socket in the test fixture rotating the sleeve approximately at 90°/second. Make 5 connections and check if the seal is still in the correct position on the socket and the plug. Repeat the test for a total of 20 times. • Upon completion of above, plug and socket to be tested with fluid @ 50 psig to ensure no leaks or functional issues (both connected and disconnected) • Same supplier, minimum 4 samples • Interoperability testing required, minimum 3 suppliers with 3 production sets per supplier	Reference Supplemental document - LQC Elevated Flow Mate Cycle Test
6.5 Fluid Loss	• Pressure: 14.5 & 50 PSIG • Ambient Temperature: 20°C ± 3°C • Fluid Temperature: 25°C ± 5°C • Fluid type: water • Spillage <0.15 mL per disconnect • Same supplier, minimum 1 sample	ISO 18869:2017, Section 12
6.6 Air Inclusion	• Pressure: Atmospheric • Ambient Temperature: 20°C ± 3°C • Fluid Temperature: 25°C ± 5°C • Fluid type: PG25 or water • Air Inclusion <2 ml/cycle	ISO 18869:2017, Section 11

	• Same supplier, minimum 1 sample	
6.7 Operating Temperature Testing	• Test Conditions: 1. Ambient: 62°C @ 15%RH: 16hrs; Fluid temp 62°C ± 2°C 2. Ambient: -5°C: 16hrs; Fluid temp -5°C ± 2°C 3. Fluid: PG25 4. Air Ramp Rates: 10°C/hr & 20%RH/hr max. (humidity control at -5°C not required) 5. Fluid Ramp rate: 10°C/hr max ramp • Post Test Functional Requirements: 1. Hydrostatic Pressure test at 150 PSI for a minimum of 3 minutes. No leakage allowed. • Same Supplier, minimum 4 samples	
6.8 Non-Operating Temperature	• Test Conditions: 1. 72°C, 15%RH: 72hrs, 20°C/hr & 20%RH/hr max 2. -42°C: 72hrs, 20°C/hr max • Pass/Fail requirements: Hydrostatic pressure test at 150 PSI for a minimum of 3 minutes. No leakage allowed. • Same supplier, minimum 4 samples	
6.9 Salt Spray (Corrosion Resistance)	• Test Conditions: 1. Follow ASTM B117 spec 2. Duration: 72 hrs • Post Test Functional Requirements: 1. Hydrostatic Pressure test at 150 PSI for a minimum of 3 minutes. No leakage allowed. • Pass/Fail requirements: • Samples continue to operate as intended. Cosmetic issues including rust or discoloration are acceptable as long as valve performance is not affected. • Same supplier, minimum 3 samples	ASTM B117
6.10 Hydrostatic Pressure, Coupled	• Pressure: 300 PSIG • Duration: 3 minutes • Ambient Temperature: 20°C ± 3°C • Fluid Temperature: 25°C ± 5°C • Fluid type: water or PG25 • Pass/fail requirements: No leakage allowed. • Same supplier and interoperability testing required, minimum 2 samples of each same supplier and interop combination	ISO 18869:2017, Section 18.3
6.11 Hydrostatic Pressure,	• Pressure: 300 PSIG • Duration: 3 minutes • Ambient Temperature: 20°C ± 3°C	ISO 18869:2017, Section 18.2

Un-coupled	• Fluid Temperature: 25°C ± 5°C • Fluid type: water or PG25 • Pass/fail requirements: No leakage allowed. • Minimum 3 samples	
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An important effort in the development of this large quick connector was to reduce mating difficulty by the end user, especially in less-than-ideal space, lighting, temperature constraints, as well as mating/de-mating under positive pressure in a live liquid loop environment. A screw-to-connect mechanism was chosen over a push-to-connect mechanism to leverage the mechanical advantage of a thread.

- Flow impedance performance
 - Requirements below are based on a coolant temperature of 35°C and with 25% propylene glycol-water mixture as the working medium
- Requirements below must be met for both flow directions (socket-to-plug and plug-to-socket)

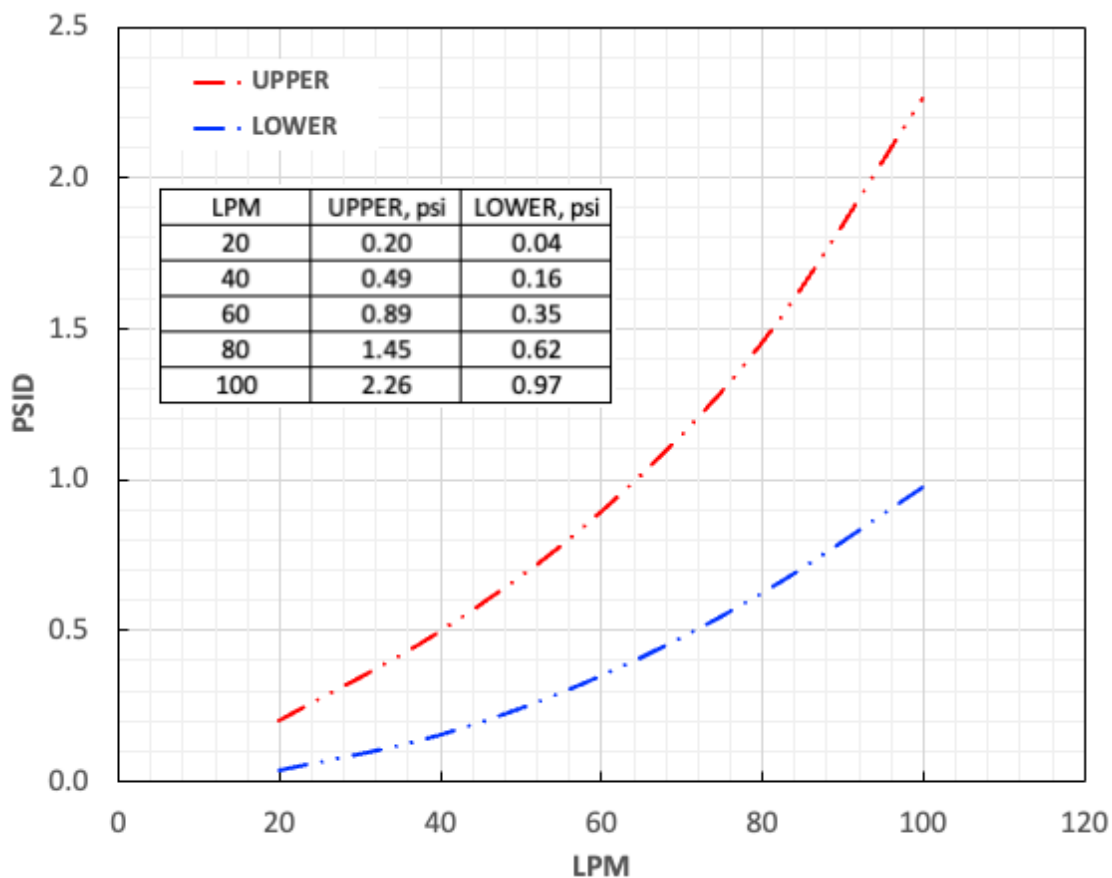


Figure 1 - Pressure Drop vs Flow Rate Performance Requirement

- Maximum Pressure during connection/disconnection: 50 psig @ 60°C
- Maximum Operating Pressure: 75 psig @ 60°C
- Temperature: -5°C to 60°C operating (tested with PG25, usage with other fluids may affect working range), -20°C to 70°C during non-operation
- Max Flow Rate: > 100 LPM
 - o Per ISO18869 defined setup and pressure/flow parameters.
 - o Testing was performed at 100 LPM but valves are capable at higher flow rates. End user to validate per their application.
- The test apparatus shall use hose or tubing appropriately sized according to the default hose diameter for a 1" (25.4 mm) hose. Connections to the LQC shall be made with minimal adapter fittings with the ID of the 1" BSPP fitting connection measuring 1" (25.4 mm) $\pm$ 5% inside diameter at the connection to the LQC. Use of a smaller diameter connection could affect test results. All hose, tubing, or fittings used for pressure drop testing shall be the same in the setup for the pressure drop test and the tare.

7. Mechanical Form

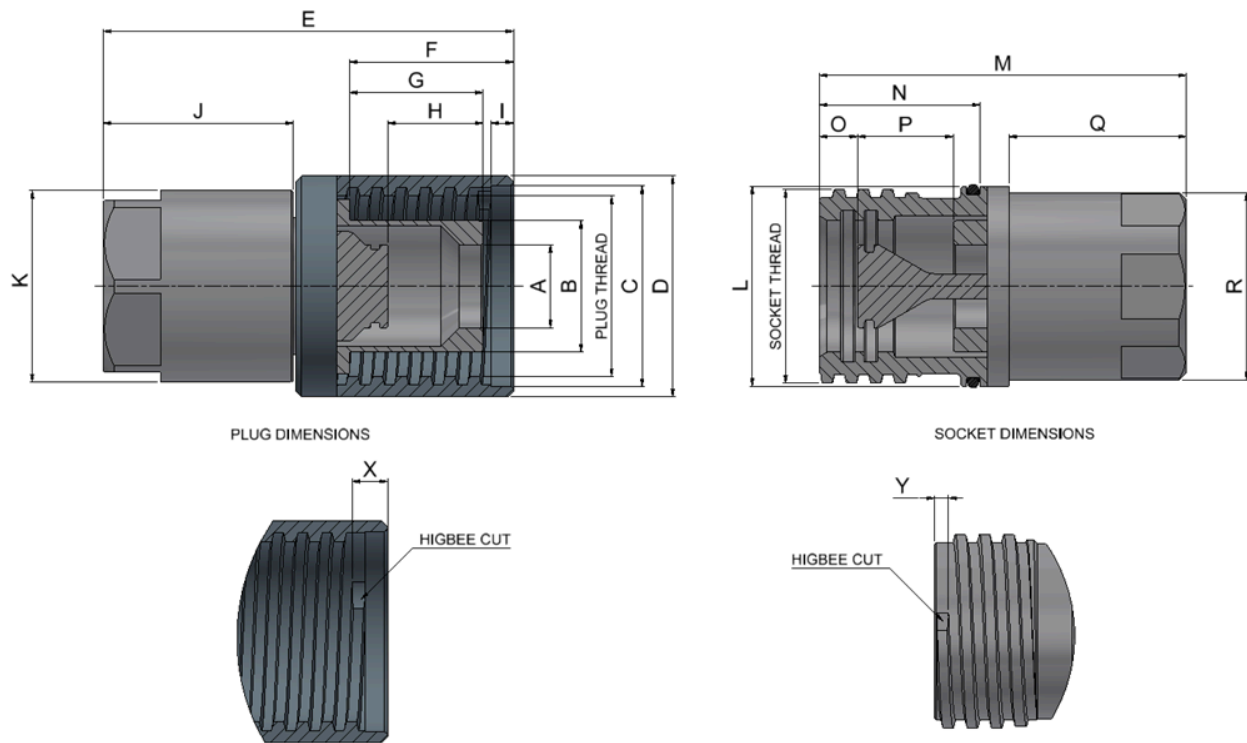


Figure 2 - Plug & Socket Dimensions

Table 2 - PLUG DIMENSIONS		
Dimension	Nominal (mm)	Tolerance (mm)
A	21.8	±0.03
A-LENGTH (TO START OF CHAMFER)	8.2	MAX
B	34.4	±0.03
C	52.4	±0.05
D	58	MAX
E	107.4	MAX
F	43	±0.30
G	35	±0.05
H (VALVE TRAVEL)	25	±0.30
I	6	±0.15
J	47	MIN
K	50	MAX
PLUG THREAD	STUB ACME 2"-4 Internal thread	2G
X (HIGBEE CUT)	11.2	MAX

Table 3 - SOCKET DIMENSIONS		
Dimension	Nominal (mm)	Tolerance (mm)
L	52.3	MAX
M	96	MAX
N	42	±0.15
O	10	±0.25

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P (VALVE TRAVEL)	25	±0.30
Q	44	MIN
R	51	MAX
SOCKET THREAD	STUB ACME 2"-4 External thread	2G
Y (HIGBEE CUT)	5.2	MAX

- Undefined geometry features are left to the manufacturer's discretion.
- All geometry features on the plug must be kept within the dimensions D and E.
- All geometry features on the socket, except the external o-ring, must be kept within the dimensions L and M.

7.1 Mating Thread

- ACME-2G 2-4 Stub External Thread (socket side)
- ACME-2G 2-4 Stub Internal Thread (plug side)
- Higbee Cut – Both internal and external threads to have a Higbee Cut (blunt start) to prevent cross-threading, as defined below
 - Add taper/debur at end of internal and external thread

7.2 End Terminations

- Both plug and socket end to terminate in G1 (BSPP 1") female thread per ISO R228
 - Other end terminations or adapters to be determined by vendor
- End termination outer diameter/hex to be determined by manufacturer

7.3 Thread Lubrication

- Apply 0.5-1.0 ml lubricant (Krytox® GPL 203 or Christo-lube® MCG 114) to the inside of the first three threads (minimum) of the plug threaded sleeve (see Figure 3).
- The lubrication will help reduce mating/unmating torque and minimize debris generated.

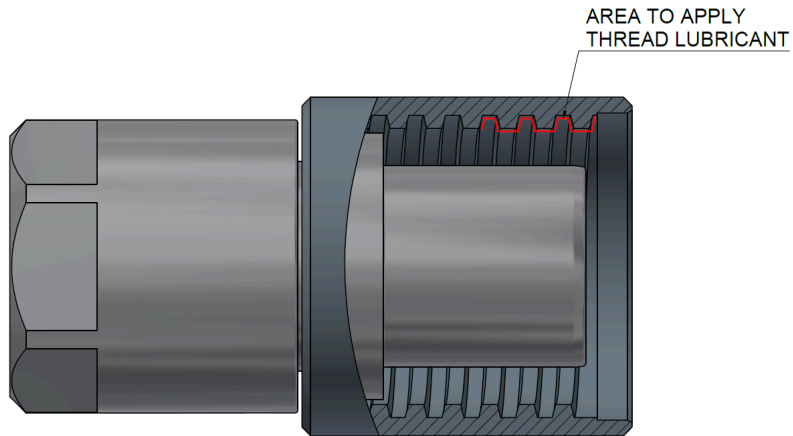


Figure 3 - Plug lubrication location

7.4 Hardening

- Plug threaded sleeve (refer to Figure 3) shall be hardened to minimize debris generation during mating
- The sleeve should be hardened to a minimum of 50 Rockwell C with .0007 in (.018 mm) minimum effective case depth. Exercise caution to mitigate the risk of hydrogen embrittlement.

7.5 Mounting torque

- Recommended minimum torque for mounting LQCs to BSPP G-1 Port Assembly (ISO 1179 / DIN 3852-2, Form A with sealing washer) is 150 N-m for stainless steel ports. Other port materials should be tested to validate.
- Threads should be lubricated prior to assembly to avoid cold welding.

8. Materials

Non-wetted:

- Threaded sleeves shall be plated or different from stainless steel for reduction of galling.

Wetted Material List:

- 300 Stainless Steel
- 17-7 Stainless Steel
- EPDM (seals)
 - Compatible with propylene glycol-water mixture (such as DOWFROST™ LC25) and treated water
 - EPDM material to meet flammability requirements as stated in UL 62368-2
 - Manufacturer to test for compatibility and other mechanical/chemical properties

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9. Part Markings

9.1 Mate Direction

- Plug sleeve to be clearly marked with “Connect” and “Disconnect” label as well as arrows to specify mate direction, as shown in Figure 4 below:

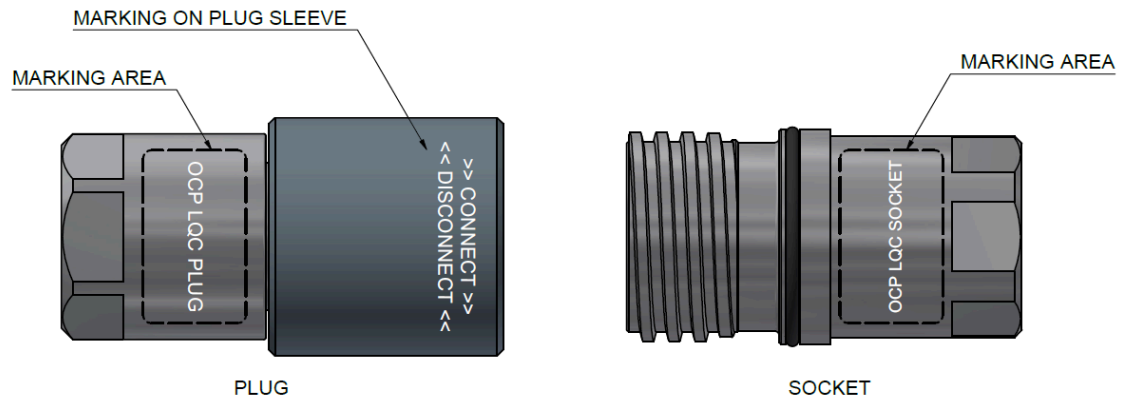


Figure 4 - Part marking

- The marking areas shown in the figure above illustrate the general location. The exact position, orientation, text size, text font or any additional marking is left to the manufacturer's discretion.

9.2 Manufacturer Markings

- Parts shall be clearly marked with “OCP LQC PLUG” or “OCP LQC SOCKET” according to each identified half, vendor name, part number and serial number on both plug and socket per Figure 4.
- Marking size, orientation, and position per manufacturer's discretion.

9.3 Color Coding

- Parts shall have features to allow optional color coded ring (red/blue). Position and implementation per manufacturer's discretion.

10. Safety and Regulatory

Test Items	Requirements	Reference	Criteria
Hydrostatic pressure (Normal operation)	Valve shall be designed to meet three times the maximum working pressure	UL62368-1	During and after tests, there shall be no rupture, no leaks

	at normal operating condition (PSI to meet: 300PSI)		and no loosening of any connection or part.
Hydrostatic pressure (Abnormal operation)	Valve shall be designed to meet two times the maximum working pressure after single fault condition is applied (PSI to meet: 150)	UL62368-1	During and after tests, there shall be no rupture, no leaks and no loosening of any connection or part.
Compatibility	See wetted materials list and OCP coolant guidance	UL62368-1	-

11. Appendix

LQC Torque Testing Guidelines

Purpose: To define the parameters and methods used for measuring the torque to connect and disconnect the OCP LQC and to provide guidance on how to complete repeated cycling for endurance testing. Detailed information is included in this document to standardize the testing procedures, methods, and measurements.

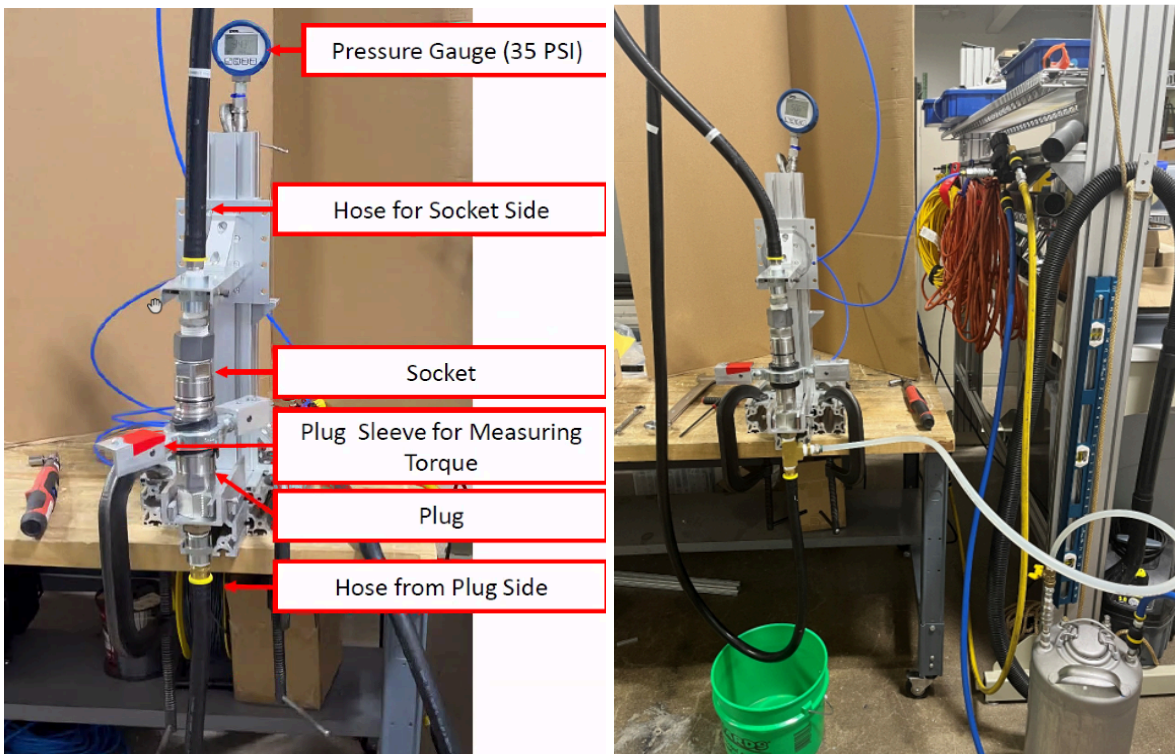
1. 100 Cycle Torque Testing
 - a. 6.2 Dry Torque Test (Average ≤ 5 N-m)
 - b. 6.3 Wet Torque Test at 50 psi (Average ≤ 10 N-m)

1. Torque Testing

1.1 Torque Test Fixture

The test fixture is to provide a means to measure the torque required to mate and de-mate an LQC assembly. This fixture is intended to accommodate both a dry condition (no pressure and no liquid in LQC) and a wetted condition with 50 Psig of water inside the coupling halves. The setup is to have an air over liquid pressure design to prevent a hydro lock in the system during mating of the LQC.

The fixture consists of the following components: Fixture Base, Fixture Upright, Floating Socket Mounting Bracket, Hoses (on socket side and on plug side), Torque Wrench to mate and de-mate LQC socket and plug.



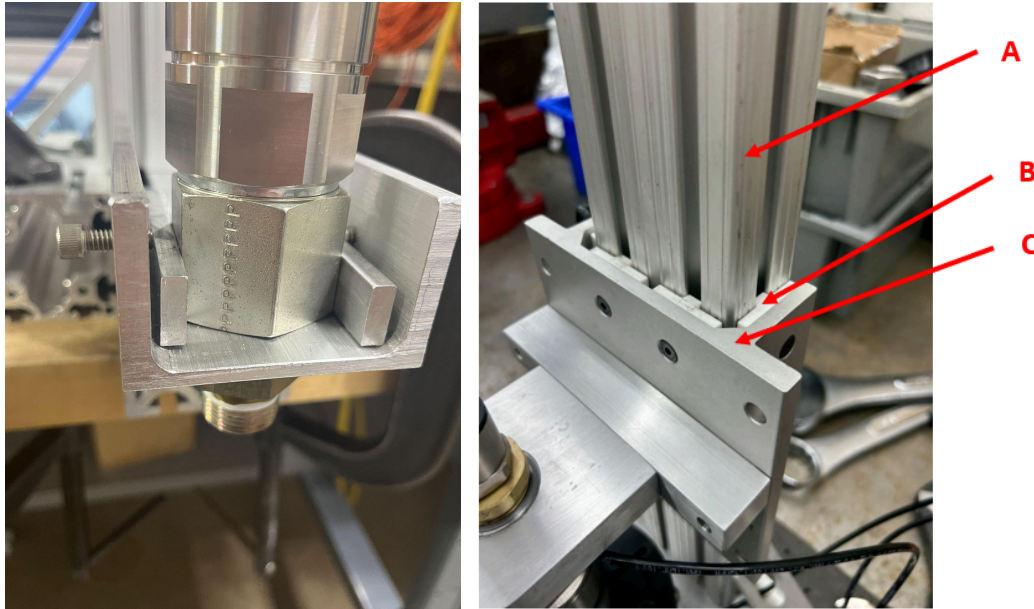
Torque Test Fixture (right: apply air pressure 50 psig to the LQC)

Fixture Base: The base of the fixture is to rigidly hold the LQC plug to prevent any movement during the test.

Fixture Upright (A): The fixture upright is to be a rigid sliding channel that provides support for the LQC socket mounting bracket. One efficient way of fabricating such a fixture is to use a double aluminum extrusion channel. Example: [extrusion sliders | McMaster-Carr](#)

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Floating Socket Mounting Bracket: As Lightweight as possible. The LQC socket is to be mounted to a sliding cantilever beam that moves in relation to the fixture upright with a minimum amount of friction and is aligned vertically with the mounted LQC plug. There are matching slide carriages available '(C)' for 80:20 double aluminum extrusion for convenience. In the picture below, (B) is a polymer linear bearing.



Hoses: As long as 50 psig is available at the bottom of the plug and the top of the socket, the size of the hose is not critical to this test fixture as there is no fluid flowing through the system. The only critical feature of hose size is the ability for the hose to accommodate up to 25ml of liquid transfer during the coupling process of the LQC assembly.

Torque Wrench Attachment: Below is a picture of the torque wrench positioned 90° from the center axis of the LQC for measuring mate and un-mate torque.



1.2 Torque Test Procedure

1.2.1 Dry Testing Procedure

1. Take pictures of valve faces, threaded areas of socket and plug of LQC, looking for debris
2. Mount plug to fixture base and torque to 150 N-m. A lower torque can be used as long as during the testing the coupling does not unthread from the fixture.
3. Mount socket to socket mounting bracket and torque down the same as step 2.
4. Install sleeve torque wrench clamp onto plug sleeve
5. Carefully start sleeve by hand just until the valve faces make contact
6. Install torque wrench into clamp with torque wrench at a 90° angle
7. Reset peak torque reading on wrench, in 1 second rotate sleeve 90°
8. Record peak torque reading
9. Repeat steps 6 through 8 to record torque at every 90° increment
10. Reversing the rotation to de-mate coupling, repeat steps 6 thru 8.
11. Mate and de-mate this LQC assembly by hand and take detailed pictures of any debris located on the valve faces, threaded areas of socket and plug on every 10th cycle
12. On the 50th and 100th cycle repeat steps 5 thru 11

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1.2.2 Wet Testing Procedure - 50 Psig:

1. Take pictures of valve faces, threaded areas of socket and plug of LQC, looking for debris
2. Mount plug to fixture base and torque to 150 N-m. A lower torque can be used as long as during the testing the coupling does not unthread from the fixture.
3. Mount socket to socket mounting bracket and torque down the same as step 2.
4. Plumb plug and socket with hose, carefully filling the system with water to a level above the couplings.
5. Apply 50 Psig of air to the system above the water level.
6. Install sleeve torque wrench clamp onto plug sleeve
7. Carefully start sleeve by hand just until the valve faces make contact
8. Install torque wrench into clamp with torque wrench at a 90° angle
9. Reset peak torque reading on wrench, in 1 second rotate sleeve 90°
10. Record peak torque reading
11. Repeat steps 8 through 10 to record torque at every 90° increment
12. Reversing the rotation to de-mate coupling, repeat steps 8 thru 10.
13. Mate and de-mate this LQC assembly by hand and take detailed pictures of any debris located on the valve faces, threaded areas of socket and plug on every 10th cycle
14. On the 50th and 100th cycle repeat steps 7 thru 13

1.3 Torque (Interoperability) Test Combination

Each plug and socket combination should be conducted at least with 2x sites.

1.4 Record Testing Result

The torque test records **peak torque (N-m)** at each quarter (90 deg) turns. Record mate at cycle 1, 50 & 100, record un-mate at 1 & 100.

1.4.1 Testing Torque Record:

Cycle	Turns	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Mate																	
1	Un-Mate																	
50	Mate																	
100	Mate																	
100	Un-Mate																	

1.4.2 Compare Average and Maximum Torque on 100th connection:

Get average peak torque from multiple sets.

Overall results show any torque above 10 N-m is considered hard to connect. The higher torque also leads to more burrs and debris on the thread after mating/demating.

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LQC Elevated Flow Mate Cycle Test Guidelines

1. Test Summary

Scenario 1: High static pressure differential (55psig) (one side pressurized with fluid)

Scenario 2: Connect/Disconnect under live flow with 50 psi, static 83 LPM, maximum 200 LPM during connect, 20 connections

<i>Scenario 1 Risk Evaluation</i>	<i>Dry</i>	<i>Op pressure</i>	<i>Pressure head on one end + dry on the other end</i>	<i>Pressure head on one end + Op pressure on the other end</i>	<i>Pressure head on both end</i>
<i>Pressure</i>	<i>0 on plug & socket</i>	<i>50 on plug & socket</i>	<i>55 on plug, 0 on socket or 55 on socket, 0 on plug -> O-ring blown out risk</i>	<i>55 on plug, 50 on socket</i>	<i>55 on plug & socket</i>

Scenario:	Fluid Flowing	Pressure hose (supply) side	Fluid Side 1	Pressure rack (return) side	Fluid Side 2	Flow rate
1 - connect dry LQC to rack with coolant - horizontal* setup	no	0	0	55**	yes	No
2 - connecting when flowing - horizontal setup	yes	55	yes	50	yes	83LPM

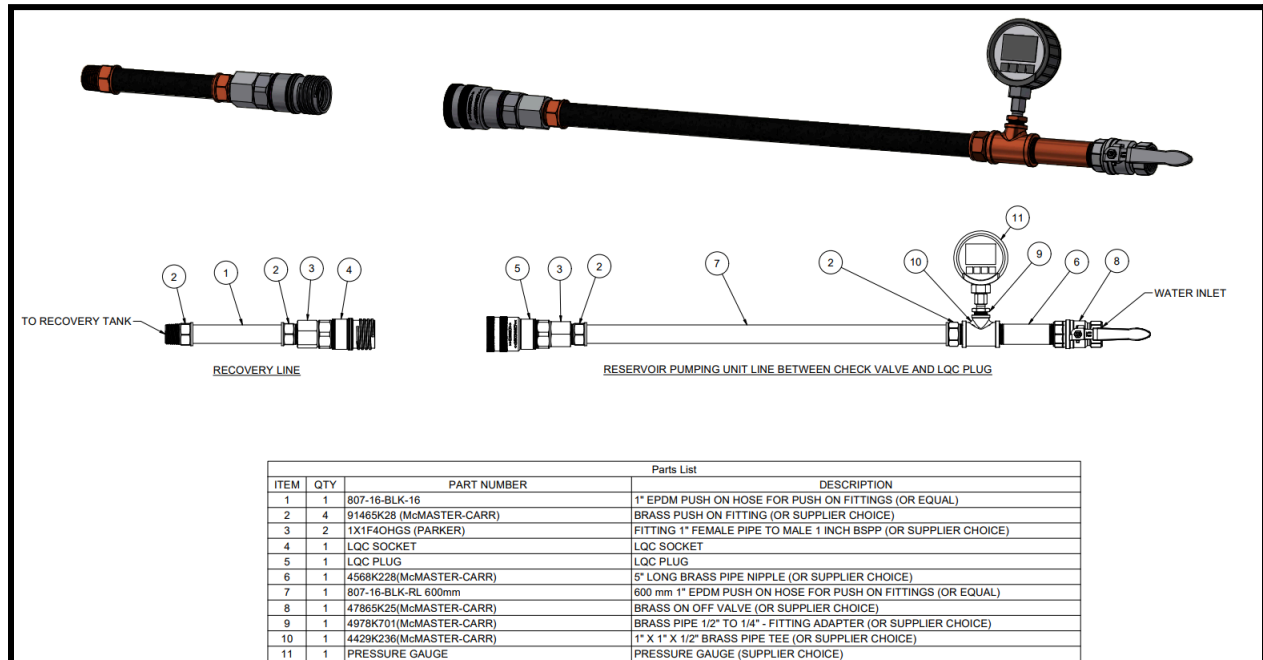
*Horizontal hose set up: Vertical hose set up can cause air in the hose to move around the connection area thus affecting the applied pressure effectiveness on impacting connection. It was proved too easy to connect with a vertical setup. Horizontal set up can eliminate air movement and aligns with actual application.

**55 PSI : Apply pressure head (static pressure from hose) on top of the 50psi (operating pressure). Max pressure head is 5 PSI (rounded from actual based on $P = \rho gh$ from 10ft hose static pressure). Measure LQC mate/demate torque and see if the o-ring is blown out.

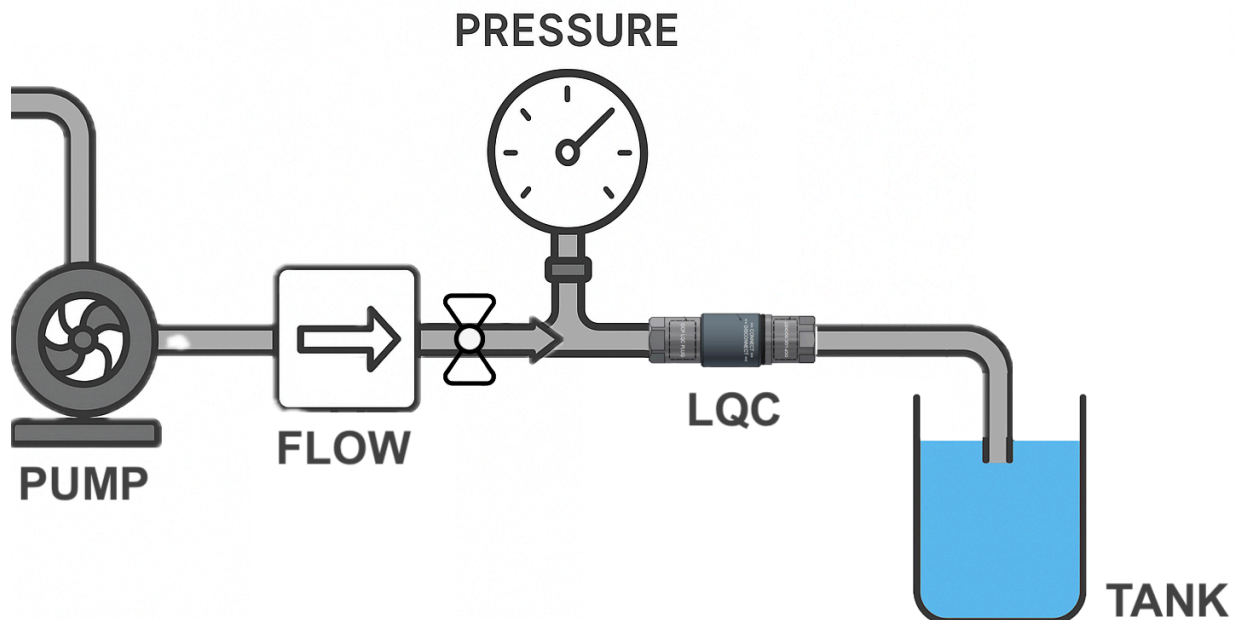
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2. O-ring Worst Test Set up

Scenario 1 - High static pressure difference (pressured side with fluid)



Bill of Material to simulate Scenario 1A



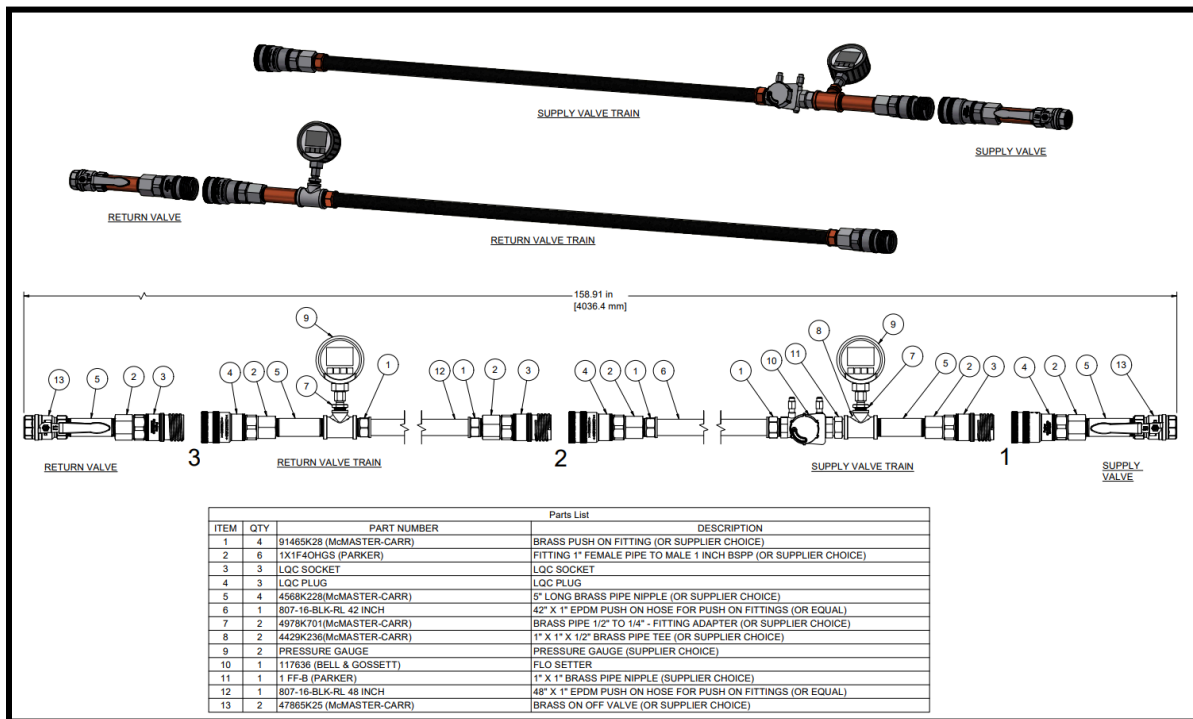
1. Left Supply Line: Fluid flow starts here.
2. Ball Valve: Controls water inlet and pressure.

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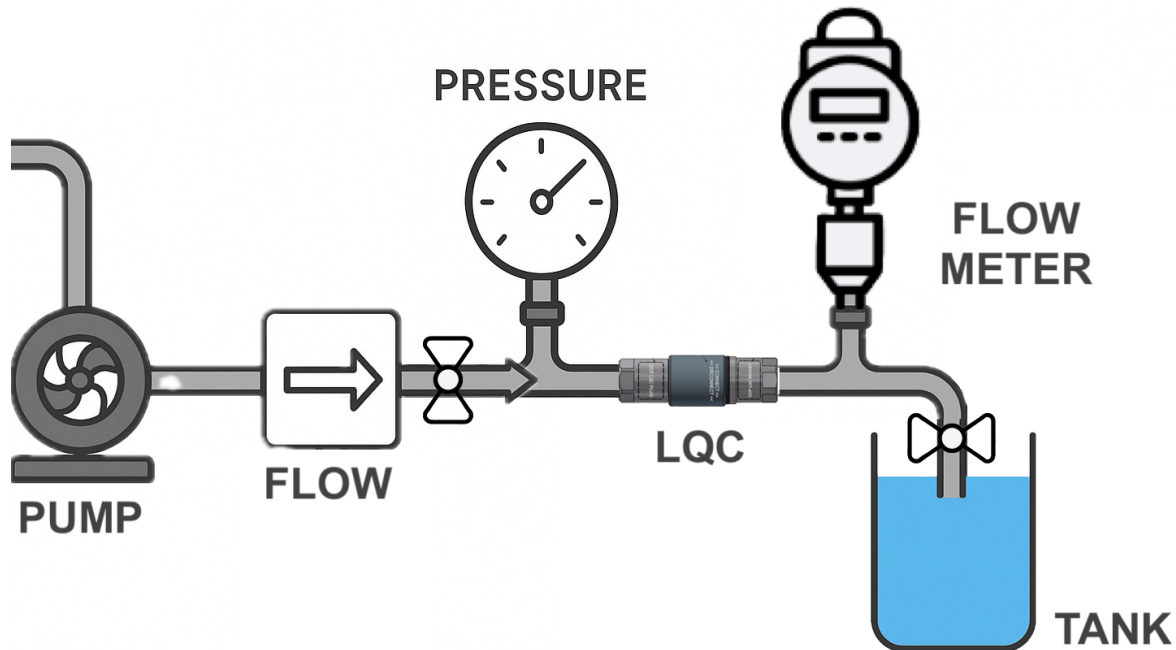
3. Diagnostic Receptacle with Pressure: Ensure pressured side reaches static 55psig before connecting LQC.
4. Liquid Cooling Component (LQC): Connect under pressure difference. Ensure no air is in the LQC or the LQC Lines.
5. Right Recovery Line: Flow exit submerged, tank open to the atmosphere.

The test set up requires one Ball Valve on supply side and a Pressure Gauge to measure peak pressure during connection, Hose attached to source end (inlet fluid RPU line) and another Hose attached to tank end (outlet fluid recovery line). Fluid direction is from plug to socket in this setup.

Scenario 2 - Connection during normal operation with active flow



Bill of Material to simulate Scenario 2



1. Left Supply Line: Fluid flow starts here.
2. Flow Setter: Set the inlet flow rate.
3. Diagnostic Receptacle with Pressure Gauge: Measures peak pressure.
4. Liquid Cooling Component (LQC): Coolant passes through here.
5. Flow Meter: Detects max coolant flow rate during test.
6. Right Recovery Line: Flow exits here, open to the atmosphere.

The test set up requires one Ball Valve on supply side and another one Ball Valve on return side, Flow Setter to control inlet fluid max flow rate at 83LPM, Flow Meter to measure max flow rate on the return side, Pressure Gauge to measure peak pressure during connection, Hose attached to source end (inlet fluid RPU line) and another Hose attached to tank end (outlet fluid recovery line). Fluid direction is from plug to socket in this setup.

3. O-ring Worst Case Test Procedure

Scenario 1 - High static pressure difference (pressured side with fluid)

1. Connect LQC Couplings together.
2. Flow coolant from the inlet to the recovery tank until air is purged. Keep the outlet submerged in the recovery tank to prevent air from re-entering the coupling before disconnecting.
3. Disconnect the LQC while the entire assembly is still filled with fluid so there is no air trapped in the RPU line.
4. Increase the fluid pressure in the RPU line to 55 ± 1 psig and turn off the on-off valve so the pressure is held in the RPU line.
5. Connect the LQC.

6. Record the maximum pressure reached at the pressure gauge.
7. Disconnect the LQC and inspect for o-ring blowout or damage on both the plug and the socket. Take pictures if there is anything to observe.
8. Repeat 5 times.
9. Repeat the entire procedure with the socket on the RPU line and the plug on the recovery line - opposite fluid direction (flow from socket to plug).

RPU Line(Supply)	Recovery line(Return)	Cycle #	Pressure trapped in the RPU line before connection (PSI)	Maximum pressure peak during connection * (PSI)	O-ring inspection	Other observations
Plug	Socket	1				
Plug	Socket	2				
Plug	Socket	3				
Plug	Socket	4				
Plug	Socket	5				
Socket	Plug	1				
Socket	Plug	2				
Socket	Plug	3				
Socket	Plug	4				
Socket	Plug	5				

Scenarios 2 - Connected under live flow

Note: Step 1-5 below should only be performed each time a new combination has been set up in position 2 for this Scenario.

1. Set supply and return valves to closed position.
2. Adjust flow setter to MAX (83 LPM).
3. Connect LQC on Position 2
4. Close return valve, then open supply valve.
5. Open return valve and flow coolant from the inlet to the recovery tank until air is purged. Keep the outlet submerged in the recovery tank to prevent air from re-entering the valve train.
6. Turn off supply valve and disconnect LQC on Position (*). Leave the return valve open. Open the supply valve after disconnecting (**).
7. Connect and Disconnect the LQC on position 2 with both the supply and return valves open (***).
8. Take photos and add comments if there is anything observed.
9. Repeat from Step 7 until a total number of 20 cycles has been performed.

* Turn off supply valve and leave return valve open before disconnecting LQC:

One step 6, turning off the supply pressure first improves the ability to disconnect and re-connect supply and return drop lines as the return line pressure is 0. In comparison, turning

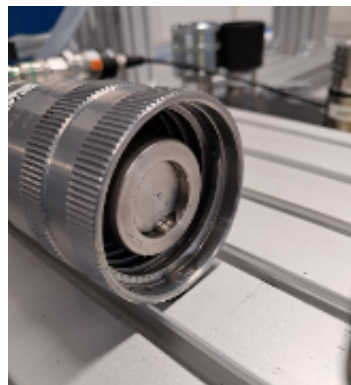
off the return valve and disconnecting and re-connect will be harder even though the fluid is not moving.

**** Seal stuck open:**

One step 6, disconnect LQC with the supply valve and return valve closed, the piston may be half closed because the engaged piston in the plug area moves back to the socket without pressure balanced. Vacuum was observed when closing the ball valve after the loop is flowing. Vacuum also leads to stuck open status on socket and plug (plug is more obvious). The half closed piston will not cause any leak issue and is still functional. When this occurs, continue using the LQC.



Socket seal stuck



Plug seal stuck under vacuum

***** Hydrolock:**

On step 7, connect LQC with the supply valve closed, hydrolock issue will be seen because of fluid movement (piston pushes some fluid from socket to plug during mating) when the loop is already full of fluid, the connection will be hard. When hydrolock occurs, can either

1. drain some fluid out from plug to allow fluid movement, or
2. turn the ball valve on and then back off as that eliminates the hydrolock and allows the LQC to be connected easier.

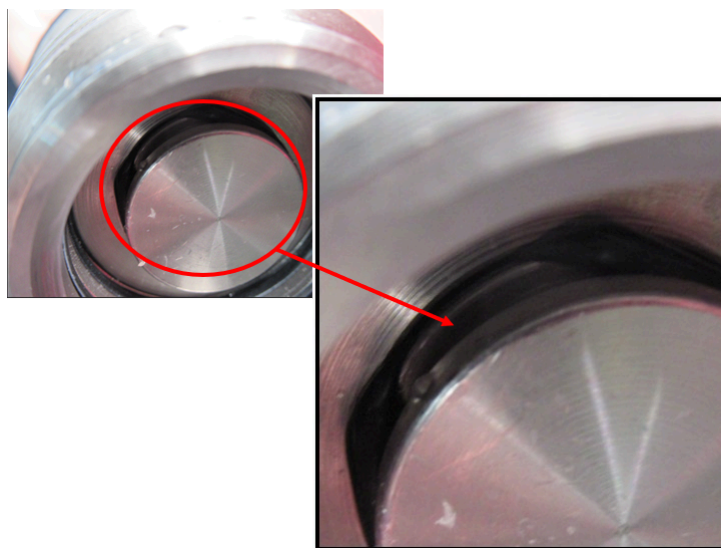
4. Record Testing Result

Scenario 1 - Recording maximum pressure peak during connection:

Combo #	Site	RPU Line (Supply)	Recovery line (Return)	Cycle #	Pressure trapped in the RPU line before connection (PSI)	Maximum pressure peak during connection * (PSI)	O-ring inspection	Other observations
1		Plug	Socket	1			NOK	O-Ring Washout on Socket
		Plug	Socket	2			OK	
		Plug	Socket	3				
		Plug	Socket	4				
		Plug	Socket	5				

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		Socket	Plug	1				
		Socket	Plug	2				
		Socket	Plug	3				
		Socket	Plug	4				
		Socket	Plug	5				



Socket o-ring was blown out during the test

Maximum pressure can go up to around 150PSI during connection. Low concern since 150PSI is still under 3x operating pressure.

Scenario 2 - Recording peak pressure and maximum flow rate:

	Cycle 1		Cycle 2		Cycle 3		Cycle 4		Cycle 5		
Combo	Peak Press ure (PSI)	Max Flow Rate (LPM)	Peak Press ure (PSI)	Max Flow Rate (LPM)	Peak Press ure (PSI)	Max Flow Rate (LPM)	Peak Press ure (PSI)	Max Flow Rate (LPM)	Peak Press ure (PSI)	Max Flow Rate (LPM)	Result
											PASS

Max flow rate can go up from original setting 83 LPM (static) to 146 LPM (transient) during connection. Vibrations/water hammer effect was felt before seal washout. Stop the test if it fail. Eventually the test should pass under live flow with 50 psi, 200 LPM, 20 connections.

Combo	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 20
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	Peak Pressur e (PSI)	Max Flow Rate (LPM)	Peak Pressur e (PSI)	Max Flow Rate (LPM)	Peak Pressur e (PSI)	Max Flow Rate (LPM)	Peak Pressur e (PSI)	Max Flow Rate (LPM)	Peak Pressur e (PSI)	Max Flow Rate (LPM)	Peak Pressur e (PSI)	Max Flow Rate (LPM)

Pressure is ensured to set above 50 psi before connection and max flow rate during connection will reach 200 LPM. When it's fully mated, flow rate will drop back to original.