



# Fluid Power Institute Summary Report

## Burst Pressure Evaluation Project #52224

**Test Completion Date:** 7/31/2014

**Test Specimen:** Zero-Leak Gold Plugs (ZLGP)

**Client:** EPCO Products, Inc.



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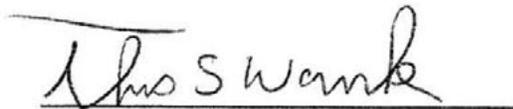
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The undersigned testify that to the best of their knowledge, the data contained in this report was collected using the instrumentation described and utilizing proper laboratory procedures and techniques.



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# Contents

Objective .....	1
Project Scope .....	1
Test Parameters.....	2
Procedure .....	2
Figure 1 – Burst Test Circuit.....	3
Figure 2 – Burst Test Setup.....	3
Figure 3 – Failure Mode: Typical ZLGP Extrusion .....	4
Figure 4 – Failure Mode: Typical ZLGP Ejection .....	4
Phase 1 Results – 70% Torque Value.....	5
Table 1 – ZLGP Burst Summary 70%.....	5
Phase 2 Results – 90% Torque Value.....	5
Table 2 – ZLGP Burst Summary 90%.....	5
Appendix A – Photographs of Components .....	6
Figure 5 – ZLGP: Before Test Top Overview.....	6
Figure 6 – ZLGP: Before Test Bottom Overview.....	6

## **EPCO Products, Inc. Notice**

This is an abbreviated version of the complete Fluid Power Institute Burst Test Report. It contains a summary of the findings from the complete FPI Burst Report. Copies of the complete report may be obtained by contacting EPCO.

This FPI Burst Test Report does not contain burst performance test data for the interchangeable SAE J514 straight thread ORB plugs, the tapered NPT plugs, nor any other type plug. Contact a supplier of that plug for its burst performance test data.

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## Objective

EPCO Products, Inc. (EPCO) contracted the Milwaukee School of Engineering (MSOE) Fluid Power Institute (FPI) to perform a burst test at two installation torque values on Zero-Leak Gold Plugs (ZLGP) per **ISO 1436-1:2001** standard for hydrostatic pressure testing to failure. Supplied specimens were installed in two different strength manifolds of Ductile Iron material [D654512 & D805506] provided by Daman Products Company (Daman) and (6 each) ZLGP of the following sizes:

- -00
- -01
- -02
- -04
- -06
- -10
- -12
- -16
- -24
- -32

The following sizes were not tested because the size was between two tested sizes which have the same rated working/burst pressure as shown in SAE J1926 Part 4.

- -03
- -05
- -08
- -14
- -20

Each test specimen was uniquely labeled and critical dimensions were recorded by EPCO before and after testing.

## Project Scope

Evaluation by the MSOE FPI determined the maximum pressure that each specimen could withstand before it would no longer contain the fluid. This defines a failure.

# Test Parameters

**Fluid Type:** Water

**Fluid Temperature:** Ambient of approximately 68° F

## Procedure

1. Before receiving ZLGPs for testing, EPCO ran a dimensional inspection test on individual ZLGPs.
2. Test specimen was torqued to (70% or 90%) of the max torque according to SAE-J1926-4 Table 5 and recorded.
3. Test specimen was plumbed into the circuit and filled with water.
4. Photograph was taken of specimen plumbed into circuit.
5. Test specimen was inspected for leaks.
6. All air was removed from circuit.
7. Pressure was increased in the specimen using an air-over-water intensifier in a deadhead configuration.
8. Each specimen was pressurized with water until it could no longer hold pressure.
9. The pressure in each specimen was measured using a GP:50 pressure transducer.
10. Burst pressure was recorded in the appropriate table shown in the Results Section.
11. Photograph was taken of the specimen and recorded.
12. Test specimen was removed using a calibrated removal torque wrench.
13. Removal torque was recorded in the appropriate table in the Results Section.
14. Test specimen was visually inspected for apparent failure.
15. Manifold threads were inspected using go-no-go thread gauge provided by Daman.
16. After testing, ZLGPs were sent back to EPCO for inspection to determine critical dimensional changes.

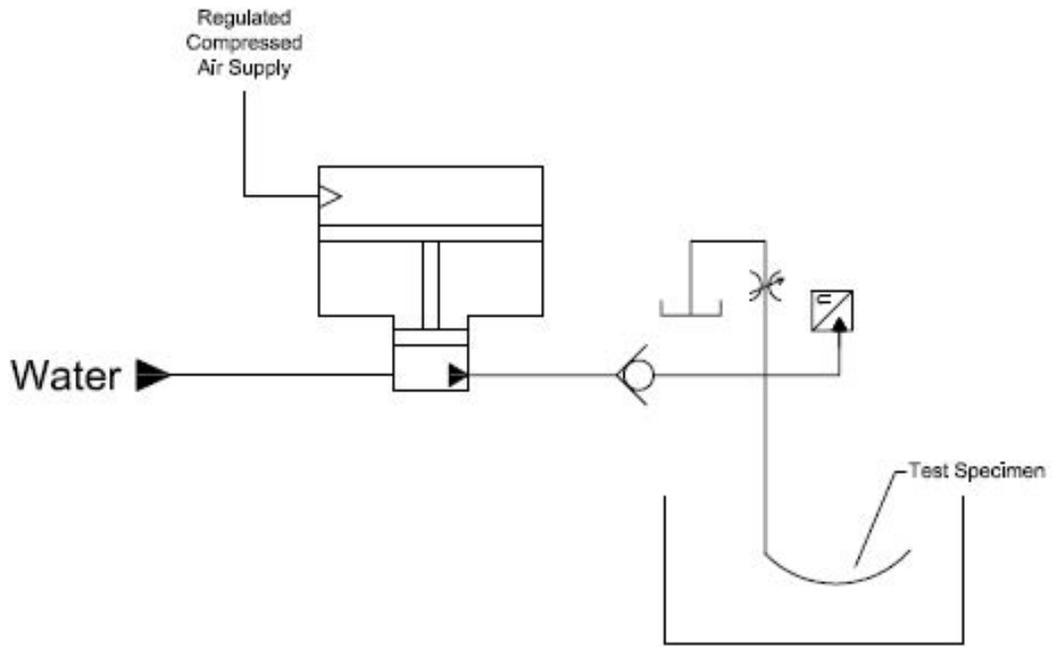


Figure 1 – Burst Test Circuit

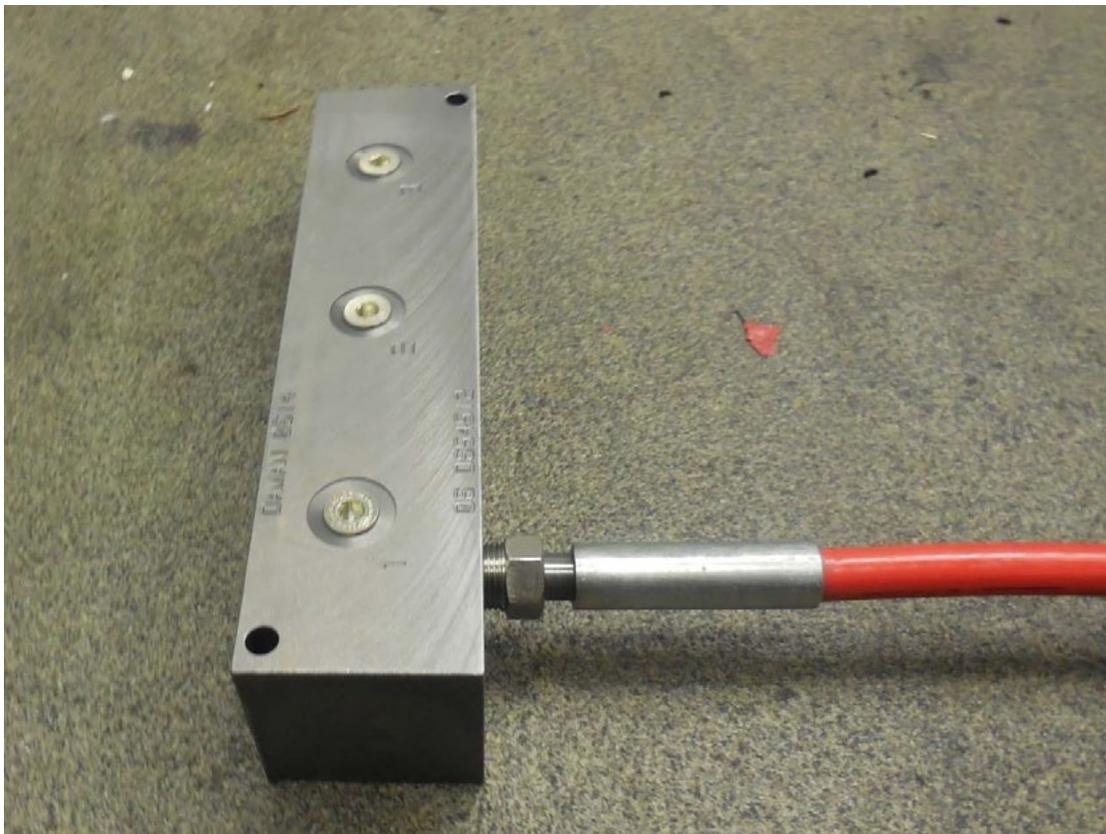


Figure 2 – Burst Test Setup

After completion of the test, each test specimen was visually inspected for apparent leaks and failures. Two failure modes were identified: Vertical ZLGP movement resulting in an O-ring extrusion "ZLGP Extrusion" and ZLGP completely leaving the manifold "ZLGP Ejection" as shown in Figures 3 and 4.

A "ZLGP Extrusion" failure was determined by the loss of the metal to metal (ZLGP contact with manifold) seal due to the water pressure either lengthening the ZLGP and/or the change in angle. The inspected result was the ZLGP seal opened enough which allowed the 70 Durometer Buna O-ring to pass through the gap as shown in Figure 3.



Figure 3 – Failure Mode: Typical ZLGP Extrusion



Figure 4 – Failure Mode: Typical ZLGP Ejection

The average burst pressure shown in Tables 1 & 2 is based on all samples of the given size which was calculated using six ZLGPs (3 from both manifolds) because the difference was minimal in burst pressure between the two.

## Phase 1 Results – 70% Torque Value

Table 1 – ZLGP Burst Summary 70%

ZLGP Size	Torque	Average Burst [psig (MPa)]	SAE Burst* [psig (MPa)]	ZLGP Working** [psig (MPa)]	SAE Working*** [psig (MPa)]
-00	5 in.-lbs.	28,359 (195.6)	~	7,090 (48.9)	~
-01	20 in.-lbs.	33,128 (228.5)	~	8,282 (57.1)	~
-02	43 in.-lbs.	44,072 (303.9)	24,360 (168.0)	11,018 (76.0)	6,090 (42.0)
-04	124 in.-lbs.	47,257 (325.9)	24,360 (168.0)	11,814 (81.5)	6,090 (42.0)
-06	23 ft.-lbs.	43,449 (299.6)	37,120 (256.0)	10,862 (74.9)	9,280 (64.0)
-10	57 ft.-lbs.	39,702 (273.8)	37,120 (256.0)	9,926 (68.5)	9,280 (64.0)
-12	90 ft.-lbs.	35,574 (245.3)	24,360 (168.0)	8,894 (61.3)	6,090 (42.0)
-16	160 ft.-lbs.	33,288 (229.6)	24,360 (168.0)	8,322 (57.4)	6,090 (42.0)
-24	215 ft.-lbs.	25,689 (177.2)	14,500 (100.0)	6,422 (44.3)	3,625 (25.0)
-32	265 ft.-lbs.	18,458 (127.3)	12,006 (82.8)	4,615 (31.8)	3,002 (20.7)

## Phase 2 Results – 90% Torque Value

Table 2 – ZLGP Burst Summary 90%

ZLGP Size	Torque	Average Burst [psig (MPa)]	SAE Burst* [psig (MPa)]	ZLGP Working** [psig (MPa)]	SAE Working*** [psig (MPa)]
-00	10 in.-lbs.	28,364 (195.6)	~	7,091 (48.9)	~
-01	25 in.-lbs.	31,208 (215.2)	~	7,802 (53.8)	~
-02	56 in.-lbs.	44,372 (306.0)	24,360 (168.0)	11,093 (76.5)	6,090 (42.0)
-04	159 in.-lbs.	48,028 (331.2)	24,360 (168.0)	12,007 (82.8)	6,090 (42.0)
-06	30 ft.-lbs.	45,642 (314.8)	37,120 (256.0)	11,411 (78.7)	9,280 (64.0)
-10	73 ft.-lbs.	39,744 (274.1)	37,120 (256.0)	9,939 (68.5)	9,280 (64.0)
-12	115 ft.-lbs.	37,392 (257.9)	24,360 (168.0)	9,348 (64.5)	6,090 (42.0)
-16	205 ft.-lbs.	32,789 (226.1)	24,360 (168.0)	8,197 (56.5)	6,090 (42.0)
-24	280 ft.-lbs.	25,120 (173.2)	14,500 (100.0)	6,280 (43.3)	3,625 (25.0)
-32	340 ft.-lbs.	18,318 (126.3)	12,006 (82.8)	4,580 (31.6)	3,002 (20.7)

**\*J1926-4 Revised AUG2010 Table 3 Internal Hex: Test Pressure-Burst**

**\*\*ZLGP Working = AVG Burst/4 (Using 4:1 Safety Factor)**

**\*\*\*J1926-4 Revised AUG2010 Table 3 Internal Hex: Working Pressure**

## Appendix A – Photographs of Components

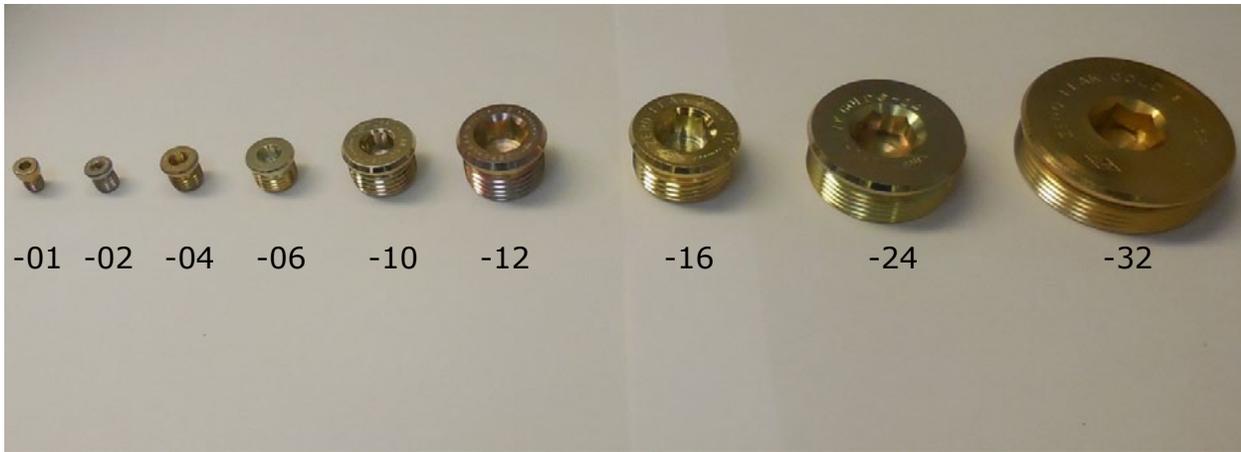


Figure 5 – ZLGP: Before Test Top Overview

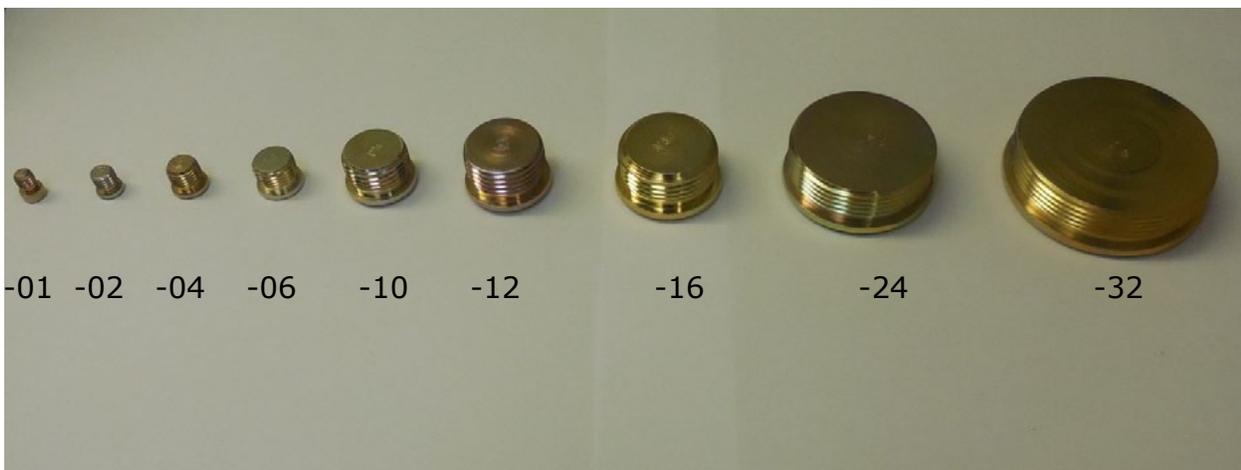


Figure 6 – ZLGP: Before Test Bottom Overview