



AFRL-RQ-WP-TR-2017-0147

**RESEARCH FOR THE AEROSPACE SYSTEMS
DIRECTORATE (R4RQ)**

**Task Order 0006: Airbreathing Propulsion Fuels and Energy
Exploratory Research and Development (APFEERD)**

Sub-Task: Low Lubricity Test of T700 Main Fuel Pump

B. Kent, T. McCarthy, G. Medearis, J. Sympson, and J. Walker

Woodward, Inc.

NOVEMBER 2017

Interim Report

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14. ABSTRACT
This report contains test results for the CT7/T700 Bio Fuel Low Lubricity Endurance Test. The testing was performed on Woodward Item Number 6970-034 according to Woodward test procedure DTP-2175_NEW, herein referred to as DTP-2175, using renewable R-8 HEFA fuel, at a BOCLE between 0.85 and 1.00 mm wear scar. This testing accumulated an additional 600 hours of low lubricity endurance testing on a unit, which had previously run for 400 hours of low lubricity endurance testing.

This work is a follow-on to a previous 400-hour test on the same pump (reported in AFRL-RQ-WP-TR-2014-0243) and thus achieves 1000 hours of testing.

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bio fuels low lubricity endurance test

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1.0 EXECUTIVE SUMMARY

This report contains test results for the CT7/T700 Bio Fuel Low Lubricity Endurance Test. The testing was performed on Woodward Item Number 6970-034 according to Woodward test procedure DTP-2175_NEW, herein referred to as DTP-2175, using renewable R-8 HEFA fuel (POSF 7635), at a BOCLE between 0.85 and 1.00 mm wear scar. This testing accumulated an additional 600 hours of low lubricity endurance testing on a unit, which had previously run for 400 hours of low lubricity endurance testing (as reported in AFRL-RQ-WP-TR-2014-0243).

2.0 RESULTS AND DISCUSSION

2.1 Test Article

2.1.1 Pump Configuration

The production Commercial Cartridge Pump (CCP) is Item Number 6970-034 conforming to the requirements of current Woodward production drawing 6970-034_1_C. The CCP in the tested mounting orientation is displayed in Appendix 10, Figure 2.

The Woodward produced Test Article used for the Low Lubricity Endurance Test was the following:

- 1) Item Name: CT7/T700 Commercial Cartridge Pump
- 2) Item Number: 6970-034
- 3) S/N: 19366491

2.1.2 Functional Description

The Test Article is a gear pump that includes a high pressure relief valve that limits the maximum pump pressure.

2.2 Specification Requirements

2.2.1 Fuel Lubricity

The wear scar diameter shall be 0.85-1.00 mm per the proposal.

2.2.2 Test Duration

Test running time of less than 10 minutes shall not be credited to the total test time regardless of wear scar diameter range. 50 minute cycles will be followed by 5 minute shutdown periods for a targeted total time of at least 600 hours within the wear scar diameter range. The allotted target period is split into a 100 hour cycle and then a 500 hour cycle. Start and end dates of each test milestone are provided below in Table 1.

Table 1. Test Sequence and Dates

Test Section	Start Date	End Date
Pump Run-In Procedure*	May 6, 2014	May 6, 2014
Pre-Test Inspection	June 9, 2017	June 12, 2017
Pre 100 hr. Test ATP/Characterization	June 13, 2017	June 13, 2017
100 hr. Low Lubricity Endurance Test	June 29, 2017	July 5, 2017
Post 100 hr. Test Performance Check per COM-852	July 5, 2017	July 5, 2017
Post 100 hr. Disassembly/Inspection	July 6, 2017	July 6, 2017
Assembly	July 7, 2017	July 7, 2017
Pre 500 hr. Test ATP/Characterization	July 7, 2017	July 7, 2017
500 hr. Low Lubricity Endurance Test	July 12, 2017	August 4, 2017
Post 500 hr. Test ATP/Characterization	August 10, 2017	August 10, 2017
Disassembly/Inspection	August 11, 2017	August 14, 2017

**Not required for this test sequence. Run-in was performed prior to initial 400 hour test segment.*

2.2.3 Success Criteria

The success criteria for all portions of the test are the following:

- No significant performance deviation during testing that would result in significant loss of power or ability to control the engine.
- Post-Test performance checks during the Low Lube Test shall reveal no performance degradation inconsistent with further reliable operations. Service limits pertain to overboard drain leakage only and are defined as 4 drops per minute maximum.
- Pre-test and Post-test completion of COM-852 shall reveal no degradation inconsistent with further reliable operation.
- Disassembly inspection reveals no hardware degradation inconsistent with further reliable operation as noted in Appendix A.

2.3 Test Parameters

2.3.1 Test Procedure

Bio Fuel Low Lubricity Endurance testing was performed per DTP-2175 (see Appendix 1). The test was performed at Woodward Aircraft Turbine Systems Environmental Test Facility (ETF) in Rockford, Illinois. Following the testing, the unit was post acceptance tested, then inspected in accordance with DTP-2175.

The mission cycle for the endurance testing is shown in Appendix 11. Continuous data recording was performed per DTP-2175 Section 8.6. Steady-state data recording was performed per DTP-2175 Section 8.5.

The test fluid was renewable R-8 HEFA fuel (POSF 7635) as provided by UTC. The test fluid was tested for lubricity using the Ball-On-Cylinder-Lubricity-Evaluator (BOCLE) per WI-977 to measure the wear scar diameter, with limits of 0.85-1.00 mm with 1000 gm stylus. Samples of the test fluid were taken at intervals stated in DTP-2175. Only those cycles that met the requirements of >0.85 mm WSD were accredited to the cycle count.

A test checklist was initiated and signed off throughout the test to ensure that the proper steps were taken to perform the test correctly (see Appendix 5). An equipment list and event log were generated and are provided in Appendix 5 and Appendix 6. After reassembly, the pump was tested per COM-852. The pre and post-test pump performance data is included in Appendix 3. Post inspection reports and photos are included in Appendix 8.

The Low Lube test sequence was per DTP-2175. The general sequence and dates of testing performed are shown in Table 1.

2.3.2 Test Procedure Deviations

Prior to the start of the endurance test, the 150 HP drive motor (cell hardware) was damaged and replaced.

At approx. 293 hours into the endurance test, a storm knocked out power to the building. The test was shut down while power was out and was restarted 8 hours later when power was restored.

At approx. 342 hours into the test, the test shut down due to no cell boost pressure. Investigation revealed that the boost pump in the test setup had seized. The boost pump was fixed, and test restarted two days later.

2.4 Low Lubricity Test Results

2.4.1 Fuel Lubricity

An “out-of-the-barrel” pre-test fuel sample was taken and the fuel lubricity was 0.52 mm wear scar diameter (WSD). The test fuel was subsequently conditioned using a clay filter that resulted in a pre-test fuel sample with a WSD of 0.96.

Average lubricity (WSD) during the 400 hour test was 0.969 mm with a minimum of 0.91 and a maximum of 1.01 mm. Fuel lubricity test results are shown in Appendix 7, Table 5.

2.4.2 Pre-Test ATP

Prior to testing, piece part critical inspections were completed per Appendix A of DTP-2175. The inspection record sheets are shown in Appendix 4. The Test Article was assembled per the applicable assembly procedure.

The Test Article was performance tested per COM-852 and values were all within specified limits of COM-852. The pre-performance values for the testing were all within the specified limits of COM-852. The pre-test performance data is summarized in Table 3 and copy of the data sheet is included in Appendix 3.

2.4.3 Post Test Inspections

The Test Article was performance tested per COM-852 both before and after the 600 hours of low lubricity testing. The values were all within the specified limits of COM-852. The post-test performance data is in Appendix 3. A comparison of the pretest ATP data to the posttest ATP data is shown in Table 2.

Table 2. Performance Summary (COM-852 Data)

Pre/Post eCOM-852 Data Summary										
DTP-2175 Bio Fuel Low Lubricity Endurance Test										
Pump I/N	6970-034									
Pump S/N	19366491									
Test Point	Description	Limits	Units	Post 400 hr	Pre 100 hr	Post 100 hr	Pre 500 hr	Post 500 hrs	Pre 100 hr to Post 500 hr	%
1.1	Total Flow, Intermediate Speed	3.76-6	gpm	4.18	4.21	4.21	4.22	4.16	-0.05	-1.20%
2	HPRV Max Pressure, Int. Speed	900-1070	psid	1024	1048	1052	998	995.17	-52.83	-5.16%
3.1	HPRV Reseat Flow	3.5-6.26	gpm	4.15	4.19	4.19	4.15	4.15	-0.04	-0.96%
4.1	T/O Total Flow	8.5-11	gpm	10.05	10.1	10.1	10.05	10.06	-0.04	-0.40%
5.1	Flow near HPRV Cracking Pressure	7.98-11.52	gpm	9.85	9.91	9.93	9.94	9.94	0.03	0.30%
6	HPRV Max Pressure, T/O	900-1120	psid	1022	1031	1025	1001	990.73	-40.27	-3.94%
7.1	HPRV Reseating Total Flow	8.24-11.26	gpm	9.99	10.11	10.12	10.03	10.05	-0.06	-0.60%
8.1	Start Flow	.85-1.5	gpm	0.93	0.96	0.94	0.95	0.94	-0.02	-2.15%
9.1	Max Flow Check	8.03-11	gpm	9.27	9.27	9.26	9.23	9.24	-0.03	-0.32%
10.1	External Leakage	0	drops/min	0	0	0	0	0	0.00	0.00%
10.2	OBD Leakage	0	drops/min	0	0	0	0	0	0.00	0.00%
11	Breakaway Torque	0-15	lb-in	5	7	6	6	6	-1.00	-20.00%

2.4.4 Bearings

Post-test inspections of the bearings after 600 hours showed light polishing of the bearing faces (see inspection entries in Appendix 4), which is expected in extreme low lube operating conditions. Fair polishing was observed after 100 hours of testing, which is also comparable to what has been demonstrated in past bio fuel tests. Appendix 8, Images 1-2 show the floating and stationary bearings pre/post testing.

Pre and post-test inspection results (see Appendix 4) show that all variations in measurements are within measurement repeatability, most of which have no observed variation.

Table 3. Bearing Pre and Post Test Inspections

			Inspection Data		Δ
			Pre Test	Post Test	
Floating Bearing	Drive 1401-1175	Height	0.3632	.3630	-.0002
		ID	0.6957	.6956	-.0001
	Driven 1401-1176	Height	0.3631	.3630	-.0001
		ID	0.6957	.6956	-.0001
Stationary Bearings 1401-1174	Drive	Height	0.5401	.5395	-.0006
		ID	0.6956	.6956	.0000
	Driven	Height	0.5401	.5395	-.0006
		ID	0.6956	.6956	.0000

2.4.5 Gears

The wear on the gears was typical for a 600 hour test. Table 4 shows that all variations in measurements were within measurement repeatability. The gear teeth showed polishing on the working side of the teeth (see Appendix 8, Image 3). The dimensions all remained within limits. After 600 hours, frosting was observed on several of the gear teeth.

No abnormalities were discovered during dimensional or visual inspection: all wear observed was comparable to wear seen in previous low lubricity tests.

Table 4. Gear Pre and Post Test Inspections

		Inspection Data		Δ
		Pre Test	Post Test	
Drive Gear 1445-1135	OD	1.25605	1.25590	.00015
	Width	0.37520	.37524	-.00004
	Front Journal OD	0.69381	.69402	-.00021
	Rear Journal OD	0.69391	.69390	.00001
Driven Gear 1445-1135	OD	1.25600	1.25590	.0001
	Width	0.37512	.37512	.0000
	Front Journal OD	0.69386	.69401	-.00015
	Rear Journal OD	0.69386	.69400	-.00014

2.4.6 Housing

The drive and driven bores of the pump housing's "gear wipe" remained at the same depth from the start of the bio fuel test to the end of 600 hours. The wipe on both of the bores is due to maintaining a constant inlet pressure of 30 psig throughout the test. Normally, only the inlet side of the housing bores would get wiped during the green run and normal operation; however, the high inlet pressure at low speed conditions loads the gears toward the discharge side of the housing, so wiping is observed on the discharge side as well.

2.4.7 HPRV

The HPRV had an organic deposit that originated from the previous bio fuel test. Since the HPRV had performed normally in the previous bio fuel test with this deposit, the HPRV was not replaced before the 600 hour bio fuel test. This deposit did not affect the performance of the HPRV as it cracked within limits on all ATPs. There was no additional organic deposit found during the 600 hours of testing.

3.0 CONCLUSIONS

The CT7/T700 Commercial Cartridge Pump (CCP) was tested to the agreed-to requirements between UTC and Woodward. A wear scar between 0.85 and 1.0 mm was maintained throughout the full 600 hour test, averaging 0.969 mm.

The dimensional analysis showed that all of these parts were still within tolerances.

The pre and post-test performance data indicate the pump had no significant performance deviations caused by the low lubricity fuel. Inspection results showed expected wear, particularly in the gears and bearings, which have over 1000 total hours of low lubricity endurance testing in their history. There were no signs of wear or damage that would affect the proper operation of the unit.

Post-test acceptance testing of the unit per COM-852 revealed a decrease in start flow of approximately 2.08%, which was 10.59% above the minimum ATP limit. Total Flow showed degradation of only 1.19%, which was 11.06% above minimum ATP limit.

Appendix 1

DTP-2175, Rev NEW: Low Lubricity Endurance Test Procedure

This information has been removed in order to safeguard the proprietary information contained therein.

For additional information, please contact AFRL/RQTF.

Appendix 2

COM-852, Rev. D: CCP Acceptance Test Procedure

This information has been removed in order to safeguard the proprietary information contained therein.

For additional information, please contact AFRL/RQTF.

Appendix 3
Pre and Post Test Performance Checks

Pre-Test COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
 ROCKFORD, IL
 CAGE 66503

COM-852
 ECL: D
 PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
 Date: 13-JUL-2017
 IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 9 Work Order: 2579256 Item No: 6970-034
 Current Status: A Run Status: P Test Type: AS Test Date: 26-JUN-2017

Test Point	Record	Units	Formula Tag	Min	Value	Max	Pass Fail	
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.21	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1048	1070	P
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		3.95 (Calc)	4.19	4.47 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	10.10		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.58 (Calc)	9.91	10.62 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1031	1120	P
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		9.84 (Calc)	10.11	10.36 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	0.96	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.27		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in		7		15	P

The following criteria were used to run this report:

Serial No: 19366491
 Run Number: 9
 Status:
 Run Type: AS
 Work Order Number:
 Order By: 1

 * End of IMTPC *

Post-600 hr Test COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 10-Aug-2017
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 9 Work Order: 2579256 Item No: 6970-034
Current Status: A Run Status: P Test Type: AS Test Date: 10-Aug-2017

Test Point	Record	Units	Formula Tag	Min	Value	Max	Pass Fail
1.0	Total Flow Rate Check						
1.1	Record Qtotal	gpm	QTOT_1	3.76	4.16	6.00	P
2.0	HPRV Total Flow Bypass	psid		900	995.17	1070	P
3.0	HPRV Reseating Check						
3.1	Record Qtotal	gpm		3.95 (Calc)	4.15	4.47 (Calc)	P
4.0	Total Flow Rate Check						
4.1	Record Qtotal	gpm	QTOT_2	8.50	10.06		P
5.0	HPRV Near Cracking Pressure Check						
5.1	Record Qtotal	gpm		9.58 (Calc)	9.94	10.62 (Calc)	P
6.0	HPRV Total Flow Bypass	psid		900	990.73	1120	P
7.0	HPRV Reseating Check						
7.1	Record Qtotal	gpm		9.84 (Calc)	10.05	10.36 (Calc)	P
8.0	Starting Flow Rate Check						
8.1	Record Qtotal	gpm		0.85	0.94	1.50	P
9.0	Max Flow Check						
9.1	Record Qtotal	gpm		8.03	9.24		P
10.0	Leakage Check						
10.1	Record External Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	lb_in			6	15	P

The following criteria were used to run this report:

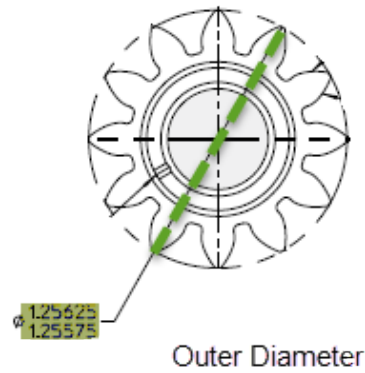
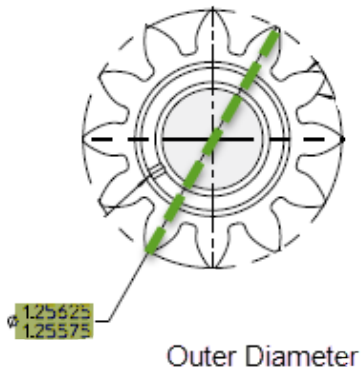
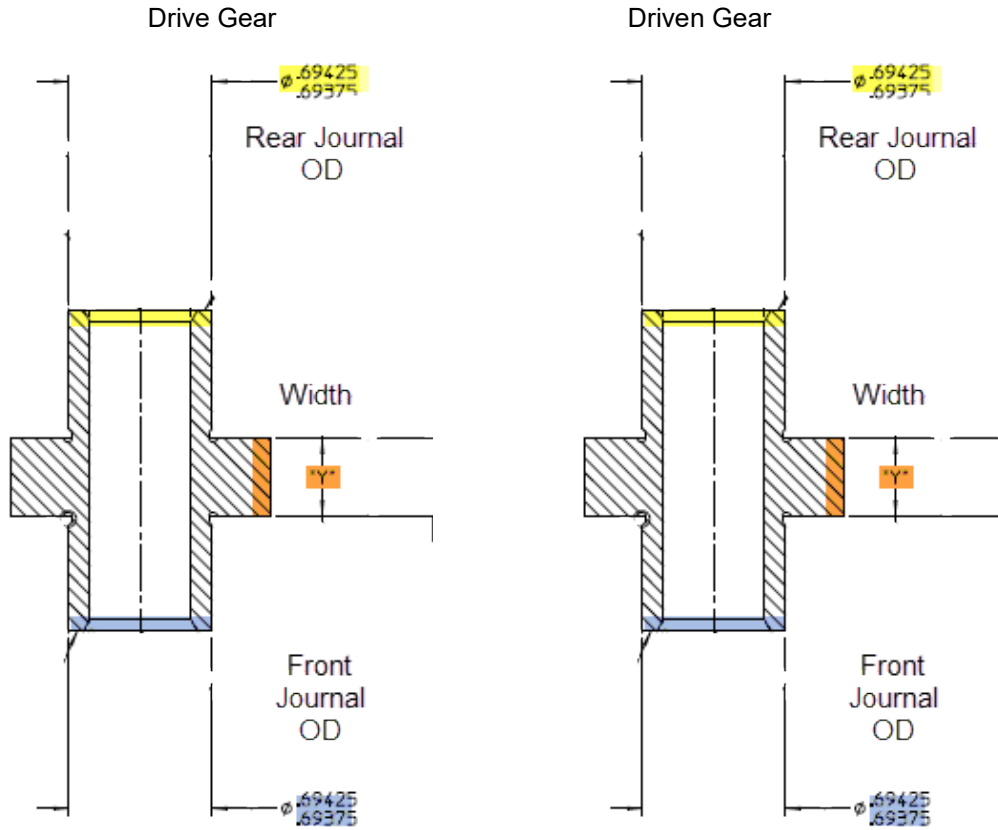
Serial No: 19366491
Run Number: 9
Status:
Run Type: AS
Work Order Number:
Order By: 1

* End of IMTPC *

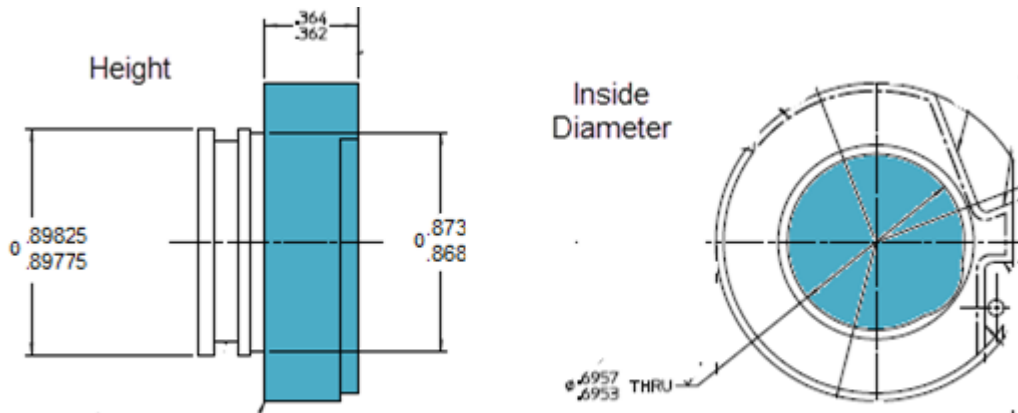
Appendix 4

DTP-2175 Appendix A Inspections

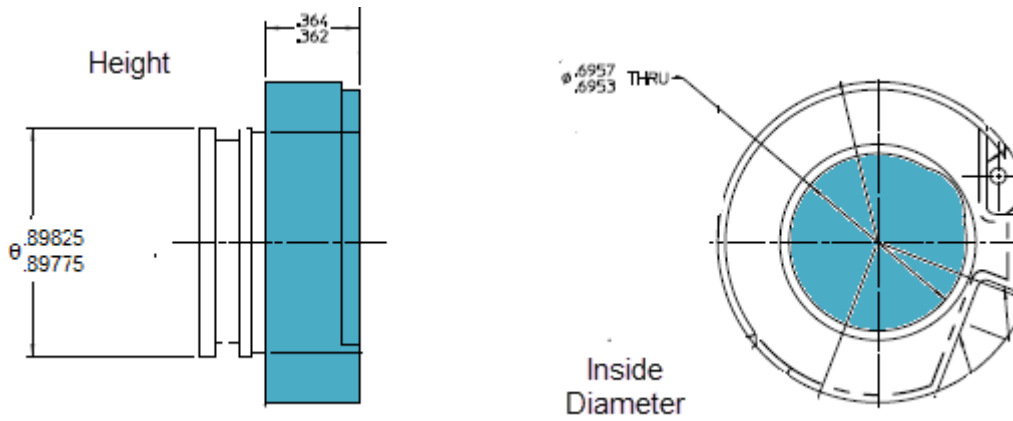
Measured Dimensions of Bearings and Gears



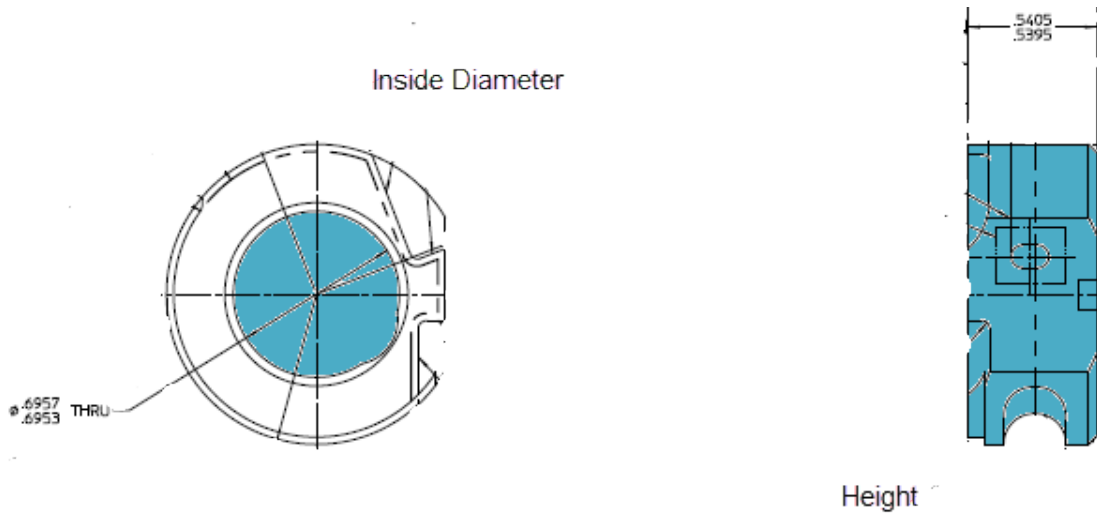
Drive Floating Bearing



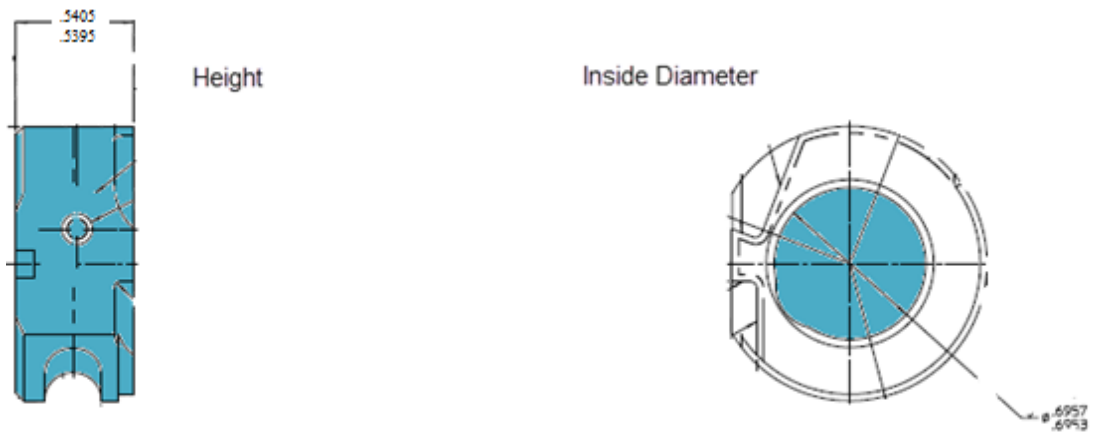
Driven Floating Bearing



Drive Stationary Bearing



Driven Stationary Bearing



Pre-Test Inspection Data

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
N/A	Breakaway Torque	7 lb-in	Tiffany Williams 06/09/17
Packing			
Ps Discharge (182748)	Visual	No discrepancies	Gavin Medearis 06/09/17
Vapor Vent (182650)	Visual	No discrepancies	Gavin Medearis 06/09/17
Overboard Drain (182650)	Visual	No discrepancies	Gavin Medearis 06/09/17
Cartridge Seal (182574)	Visual	No discrepancies	Gavin Medearis 06/09/17
Drive Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 06/09/17
Driven Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 06/09/17
HPRV (182748)	Visual	No discrepancies	Gavin Medearis 06/09/17

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	Gevin Medearis 06/09/17
HPRV Spring (1524-646)	Visual	No discrepancies	Gevin Medearis 06/09/17
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Fair polishing	Gevin Medearis 06/09/17
	Inner Diameter	0.6957	Joshua Horney 06/09/17
	Height	0.3632	Joshua Horney 06/09/17
Driven Floating Bearing (1401-1176)	Visual	Fair polishing	Gevin Medearis 06/09/17
	Inner Diameter	0.6957	Joshua Horney 06/09/17
	Height	0.3631	Joshua Horney 06/09/17
Drive Stationary Bearing (1401-1174)	Visual	Fair polishing	Gevin Medearis 06/09/17
	Inner Diameter	0.6956	Joshua Horney 06/09/17
	Height	0.5401	Joshua Horney 06/09/17
Driven Stationary	Visual	Fair polishing	Gevin Medearis 06/09/17

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Bearing (1401-1174)	Inner Diameter	0.6956	Joshua Horney 06/09/17
	Height	0.5401	Joshua Horney 06/09/17
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	Gavin Medearis 06/09/17
	Outer Diameter	1.25605	Joshua Horney 06/09/17
	Width	0.3752	Joshua Horney 06/09/17
	Front Journal OD	0.69381	Joshua Horney 06/09/17
	Rear Journal OD	0.69391	Joshua Horney 06/09/17
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals.	Gavin Medearis 06/09/17
	Outer Diameter	1.25600	Joshua Horney 06/09/17
	Width	0.37512	Joshua Horney 06/09/17
	Front Journal OD	0.69386	Joshua Horney 06/09/17
	Rear Journal OD	0.69386	Joshua Horney 06/09/17
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			
Seals			

CRITICAL INSPECTION RECORD – PRE-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Cartridge Seal (3051-5051)	Visual	No discrepancies	Gavin Medearis 06/09/17
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	Gavin Medearis 06/09/17
HPRV			
Sleeve (5225- 1254)	Visual	No discrepancies	Gavin Medearis 06/09/17
Piston (5225- 1254)	Visual	Organic deposit on several edges	Gavin Medearis 06/09/17
Spring Seat (4100-1179)	Visual	No discrepancies	Gavin Medearis 06/09/17
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	Gavin Medearis 06/09/17
Pump Housing (4034-1630)	Visual	The housing wipe extends the entire ID of each bore.	Gavin Medearis 06/09/17

Post 600 hr. Inspection Data

CRITICAL INSPECTION RECORD – POST-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
N/A	Breakaway Torque	6 lb-in	Tiffany Williams 08/10/17
Packing			
Ps Discharge (182748)	Visual	No discrepancies	Gavin Medearis 08/15/17
Vapor Vent (182650)	Visual	No discrepancies	Gavin Medearis 08/15/17
Overboard Drain (182650)	Visual	No discrepancies	Gavin Medearis 08/15/17
Cartridge Seal (182574)	Visual	No discrepancies	Gavin Medearis 08/15/17
Drive Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 08/15/17
Driven Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 08/15/17
HPRV (182748)	Visual	No discrepancies	Gavin Medearis 08/15/17

CRITICAL INSPECTION RECORD – POST-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	Gavin Medearis 08/15/17
HPRV Spring (1524-646)	Visual	No discrepancies	Gavin Medearis 08/15/17
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Light Polishing	Gavin Medearis 08/15/17
	Inner Diameter	0.6956	Joshua Horney 08/14/17
	Height	0.3630	Joshua Horney 08/14/17
Driven Floating Bearing (1401-1176)	Visual	Light Polishing	Gavin Medearis 08/15/17
	Inner Diameter	0.6956	Joshua Horney 08/14/17
	Height	0.3630	Joshua Horney 08/14/17
Drive Stationary Bearing (1401-1174)	Visual	Light Polishing	Gavin Medearis 08/15/17
	Inner Diameter	0.6956	Joshua Horney 08/14/17
	Height	.5395	Joshua Horney 08/14/17
Driven Stationary Bearing (1401-1174)	Visual	Light Polishing	Gavin Medearis 08/15/17
	Inner Diameter	0.6956	Joshua Horney 08/14/17
	Height	0.5395	Joshua Horney 08/14/17
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			

CRITICAL INSPECTION RECORD – POST-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Signs of frosting and light markings on journals	Gavin Medearis 08/15/17
	Outer Diameter	1.25590	Joshua Horney 08/14/17
	Width	0.37524	Joshua Horney 08/14/17
	Front Journal OD	0.69402	Joshua Horney 08/14/17
	Rear Journal OD	0.6939	Joshua Horney 08/14/17
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Signs of frosting and light markings on journals	Gavin Medearis 08/15/17
	Outer Diameter	1.25590	Joshua Horney 08/14/17
	Width	0.37512	Joshua Horney 08/14/17
	Front Journal OD	0.69401	Joshua Horney 08/14/17
	Rear Journal OD	0.69400	Joshua Horney 08/14/17
Both Gears	Gear Tooth Profile per Drawing (1445- 1135) Instructions	Inspect all teeth; both faces, and overlay front and back face inspection charts for each tooth. Provide inspection records to engineering.	Gavin Medearis 08/15/17
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			

CRITICAL INSPECTION RECORD – POST-TEST

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Seals			
Cartridge Seal (3051-5051)	Visual	No discrepancies	Gavin Medearis 08/15/17
Trapezoidal Seal (3051-5052)	Visual	No discrepancies	Gavin Medearis 08/15/17
HPRV			
Sleeve (5225- 1254)	Visual	No discrepancies	Gavin Medearis 08/15/17
Piston (5225- 1254)	Visual	Organic deposit remains from previous bio fuel test	Gavin Medearis 08/15/17
Spring Seat (4100-1179)	Visual	No discrepancies	Gavin Medearis 08/15/17
Housing			
Pump Cover (3550-1584)	Visual	No discrepancies	Gavin Medearis 08/15/17
Pump Housing (4034-1630)	Visual	The wipe depth has not changed	Gavin Medearis 08/15/17

Appendix 5
Test Log Sheets
Event Log

Sheet 1 of 9

Event Log

Project Number: 130876	DTP Number: DTP-2175 Rev New	Test Stand/Cell: 22
Test Article I/N: 6970-034	Test Article S/N: 19366491	

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
6/13/2017	08:30	TMM		Started mission cycle using slave pump. Took fuel sample A, WSD was 0.52.
6/13/2017	12:40	TMM		Started mission cycle using slave pump. Opened clay filter for 15 min. Took fuel sample B, WSD was 0.55.
6/14/2017	07:54	TMM		Started mission cycle using slave pump. Opened clay filter for 20 min. Took fuel sample C, WSD was 0.71.
6/15/2017	10:00	TMM		Started mission cycle using slave pump. Opened clay filter for 15 min. Took fuel sample D, WSD was 0.79.
6/16/2017	10:55	TMM		Started mission cycle using slave pump. Opened clay filter for 18 min. Took fuel sample E, WSD was 0.78.
6/16/2017		TMM		Put new clay filters in setup.
6/16/2017	13:15	TMM		Started mission cycle using slave pump. Opened clay filter for 18 min. Took fuel sample F, WSD was 0.86.
6/21/2017	08:30	TMM		Started mission cycle using slave pump. Opened clay filter for 10 min. Took fuel sample G, WSD was 0.90.
6/21/2017	13:12	TMM		Started mission cycle using slave pump. Opened clay filter for 10 min. Took fuel sample H, WSD was 0.91.
6/22/2017	09:28	TMM		Started mission cycle using slave pump. Opened clay filter for 14 min. Took fuel sample I, WSD was 0.92.
6/23/2017	08:10	TMM		Ran steady state with clay filter on for 22 min. Took fuel sample J, WSD was 0.93.
6/23/2017	12:47	QS		Ran steady state with clay filter on for 30 min. Took fuel sample K, WSD was 0.92.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
6/26/2017		TMM		150 HP drive burnt up. Needs to be replaced.
6/29/2017		TMM		150 HP drive replaced.
6/29/2017	09:40	TMM		Installed test article in cell. Ran 3 mission cycles, ran clay filter for 20 min. Took fuel sample, WSD was 0.91.
6/29/2017	14:05	TMM	00H:00M	Started test, took fuel sample #1 and a sample to be saved until the report is written. WSD was 0.96.
6/29/2017	14:35	TMM	00H:30M 3 Acc Cycles	Took fuel sample #2, WSD was 0.95.
6/29/2017	18:35	QS	04H:30M	Took fuel sample #3, WSD was 0.95.
6/29/2017	22:35	QS	8H:20M	Took fuel sample #4, WSD was 0.95.
6/30/2014	02:35	KK		Took fuel sample #5, WSD was 0.98.
6/30/2017	05:52	TMM	15H:14M 87 Acc cycles	Test running good, transferred data.
6/30/2017	06:35	TMM	16H:25M 91 Acc cycles	Took fuel sample #6, WSD was 0.96.
6/30/2017	09:05	TMM	19H:0M 105 Acc cycles	Ran clay filter for 11 minutes, WSD not checked.
6/30/2017	10:35	TMM	20H:35M 114 Acc cycles	Took fuel sample #7, WSD was 0.94.
6/30/2017	11:45	TMM	22H:30M 119 Acc cycles	Test running good, transferred data.
6/30/2017	14:35	TMM	24H:30M 135 Acc cycles	Took fuel sample #8, WSD was 0.97.
6/30/2016	18:35	QS	28H 30M 156 Acc cycles	Took fuel sample #9, WSD was 0.97.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/1/2017	06:00	TMM	39H:50M 217 Acc cycles	Test running good, transferred data.
7/1/2017	06:35	TMM	40H:25M 222 Acc cycles	Took fuel sample #10. WSD not checked.
7/1/2017	11:15	TMM	45H:00M 247 Acc cycles	Test running good, ran clay filter for 5 minutes. WSD not checked.
7/1/2017	18:43	IAH	52H:38M 288 Acc cycles	Took sample #11. WSD was 0.96.
7/2/2017	06:10	TMM	64H:05M 351 Acc cycles	Test running good, transferred data.
7/2/2017	06:35	TMM	64H:25M 353 Acc cycles	Took sample #12. WSD not checked.
7/2/2017	12:00	TMM	69H:55M 383 Acc cycles	Test running good, ran clay filter for 5 minutes. WSD not checked.
7/2/2017	18:00	IAH	75H:55M 424 Acc cycles	Took sample #13. WSD was 0.91.
7/3/2017	06:00	TMM	87H:55M 481 Acc cycles	Test running good, transferred data.
7/3/2017	06:10	TMM	88H:05M 482 Acc cycles	Ran clay filter for 10 minutes. WSD not checked.
7/3/2017	06:35	TMM	88H:25M 484 Acc cycles	Took sample #14. WSD was 0.95.
7/3/2017	11:40	TMM	93H:25M 511 Acc cycles	Checked test, running good.
7/3/2017	16:40	QS	98H 30M 539 Acc cycles	Took sample #15, WSD was 0.91.
7/3/2017	18:05	QS	100H 0M 547 Acc cycles	Ran clay filter for 10 minutes, WSD not checked.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/4/1017	06:17	TMM	112H:05M 613 Acc cycled	Test running good, transferred data.
7/4/2017	06:35	TMM	112H:15M 614 Acc cycles	Shut test down for post 100 hour inspections. Took posttest fuel sample to be saved until the report is written and sample #16. WSD was 0.96.
7/5/2017	12:30	QS		Refilled sump to full quantity and mounted slave pump.
7/5/2017	15:15	QS		Ran steady state and opened clay filter for 25 minutes. Took fuel sample M, WSD was 0.88.
7/5/2017	20:00	QS		Took fuel sample N. WSD was 0.86.
7/6/2017	17:40	QS		Ran steady state and opened clay filter for 25 minutes. Took fuel sample O, WSD was 0.82.
7/7/2017	15:30	QS		Ran steady state and opened clay filter for 30 minutes. Took fuel sample P, WSD was 0.83.
7/10/2017	07:30	TMM		Started mission cycle using slave pump. Opened clay filter for 30 min. Took fuel sample Q, WSD was 0.86.
7/10/2017	13:20	TMM		Put new clay filters in setup.
7/10/2017	13:20	TMM		Started mission cycle using slave pump. Opened clay filter for 25 min. Took fuel sample R, WSD was 1.04.
7/10/2017	15:50	QS		Topped off sump. Started mission cycle using slave pump. Opened clay filter for 20 minutes. Took fuel sample S, WSD was 1.00.
7/10/2017	16:35	QS		Installed test article in cell. Ran steady state for 3 hours.
7/12/2017	06:15	TMM	112H:15M 614 Acc cycles	Start of 500 hour portion of test, took fuel sample #17 and a sample to be saved until the report is written. WSD was 0.99.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/12/2017	06:45	TMM	113H:00M 618 Acc cycles	Took fuel sample #18. WSD was 0.99.
7/12/2017	10:45	TMM	117H:05M 640 Acc cycles	Took fuel sample #19. WSD was 0.99.
7/12/2017	14:45	TMM	120H:55M 661 Acc cycles	Took fuel sample #20. WSD was 1.01.
7/12/2017	18:45	JAS	125H:05M 683 Acc cycles	Took fuel sample #21. WSD was 0.99.
7/12/2017	22:45	KLK	129H:05M 705 Acc cycles	Took fuel sample #22. WSD was 1.00.
7/13/2017	02:44	KLK	133H:05M 727 Acc cycles	Took fuel sample #23. WSD was 1.00.
7/13/2017	06:45	TMM	137H:00M 749 Acc cycles	Test running good, transferred data. Took fuel sample #24. WSD was 0.99.
7/13/2017	18:45	TK	149H:05M	Took fuel sample #25. WSD was 0.99.
7/14/2017	05:40	TMM	159H:55M 874 Acc cycles	Test running good, transferred data.
7/14/2017	06:45	TMM	161H:05M 880 Acc cycles	Took fuel sample #26. WSD not checked.
7/14/17	18:45	JAS	173H 5M 945 Acc cycles	Took fuel sample #27. WSD was 0.99.
7/15/17	6:35	QS	184H 56M 1010 Acc cycles	Test running good, transferred data.
7/15/17	6:45	QS	184H 56M 1010 Acc cycles	Took fuel sample #28. WSD was 0.98.
7/15/17	18:45	QS	197H 1M 1076 Acc cycles	Took fuel sample #29. WSD was 0.98.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/16/2017	06:23	TMM	208H:31M 1139 Acc cycles	Test running good, transferred data.
7/16/2017	06:45	TMM	208H:50M 1141 Acc cycles	Took sample #30. WSD not checked.
7/16/2017	18:45	JJ		Took sample #31. WSD was 0.96.
7/17/2017	05:56	TMM	232H:11M 1268 Acc cycles	Test running good, transferred data.
7/17/2017	06:45	TMM	232H:56M 1272 Acc cycles	Took sample #32. WSD not checked.
7/17/2017	18:45	TK	245H:05M 1338 Acc cycles	Took sample #33. WSD was 0.99.
7/18/2017	05:53	TMM	256H:01M 1398 Acc cycles	Test running good, transferred data.
7/18/2017	06:45	TMM	256H:56M 1403 Acc cycles	Took sample #34. WSD not checked.
7/18/2017	18:45	TK	269H:02M 1469 Acc cycles	Took sample #35. WSD was 1.00.
7/19/2017	05:45	TMM	279H:51M 1528 Acc cycles	Test running good, transferred data.
7/19/2017	06:45	TMM	280H:56M 1534 Acc cycles	Took sample #36. WSD not checked.
7/19/2017	18:45	TK	293H:01M 1599 Acc cycles	Took sample #37. WSD was 0.98.
7/20/2017	20:19	TMM		Storm knocked out power to the building, test shut down.
7/20/2017	06:40	TMM		Restarted test.
7/20/2017	06:45	TMM	294H:44M 1609 Acc cycles	Took sample #38. WSD was 0.93.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/20/2017	18:45	NO	306H:38M 1674 Acc cycles	Took sample #39. WSD was 0.96.
7/21/2017	05:54	TMM	317H:36M 1734 Acc cycles	Test running good, transferred data.
7/21/2017	06:45	TMM	318H:31M 1739 Acc cycles	Took sample #40. WSD not checked.
7/21/2017	18:45	NO	330H:36M 1804 Acc cycles	Took sample #41. WSD was 0.97.
7/22/2017	06:45	TMM	342H:36M 1870 Acc cycles	Test running good, transferred data. Took sample #42, WSD not checked.
7/22/2017	09:32	TMM		Test shut down due to no cell boost pressure. Investigation revealed boost pump seized up.
7/24/2017	08:30	TMM	354H:42M 1936 Acc cycles	Restarted test.
7/24/2017	09:00	TMM	355H:02M 1938 Acc cycles	Ran 2 cycles and took fuel sample #43. WSD was 0.95.
7/24/2017	18:45	JS	364H:54M 1991 Acc cycles	Took sample #44. WSD was 0.97
7/25/2017	05:48	TMM	375H:47M 2951 Acc cycles	Test running good, transferred data.
7/25/2017	06:45	TMM	376H:42M 2056 Acc cycles	Took sample #45. WSD not checked.
7/25/2017	08:45	TK	388H:49M 2122 Acc cycles	Took sample #46, WSD was TBD.
7/26/2017	05:50	TMM	399H:47M 2182 Acc cycles	Test running good, transferred data.
7/26/2017	06:15	TMM	400H:42M 2187 Acc cycles	Took sample #47. WSD was 0.96

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
7/26/2017	18:45	TK	412H:45M 2253 Acc cycles	Took fuel sample #48. WSD was 0.96.
7/27/2017	06:45	TMM	424H:42M 2317 Acc cycles	Test running good, transferred data. Took sample #49, WSD was 0.96.
7/27/2017	18:45	TK	436H:44M 2384 Acc cycles	Took sample #50. WSD was 0.95.
7/28/2017	06:00	TMM	447H:52M 2445 Acc cycles	Test running good, transferred data.
7/28/2017	06:45	TMM	448H:42M 2449 Acc cycles	Took sample #51. WSD not checked
7/28/2017	18:45	TK	460H 48M 2514 Acc cycles	Took sample #52. WSD was 0.98.
7/29/2017	06:45	JLJ	472 H 47M 2580 Acc cycles	Took sample #53. WSD not checked.
7/29/2017	18:00	QS	484H 7M	Test running good, transferred data.
7/29/2017	18:45	QS	484H 42M 2645 Acc cycles	Took sample #54, WSD was 0.98.
7/30/2017	06:45	JAS	496H:54M	Took sample #55. WSD not checked.
7/30/2017	18:45	TR	508H:49M	Took sample #56. WSD was 0.98.
7/31/2017	06:00	TMM	520H:03M 2838 Acc cycles	Test running good, transferred data.
7/31/2017	06:45	TMM	520H:48M 2842 Acc cycles	Took sample #57. WSD not checked.
7/31/2017	18:45	TR	532H:50M 2907 Acc cycles	Took fuel sample #58. WSD was 0.99
8/01/2017	06:00	TMM	543H:53M 2968 Acc cycles	Test running good, transferred data.

Event Log

Date of Event	Time	Initials	Test Segment/ Test Article Run Time	Event/Action
8/01/2017	06:45	TMM	544H:48M 2973 Acc cycles	Took sample #59. WSD not checked.
8/01/2017	18:45	NO	556H:50M 3038 Acc cycles	Took sample #60. WSD was 0.95.
8/02/2017	06:00	TMM	568H:08M 3100 Acc cycles	Test running good, transferred data.
8/02/2017	06:45	TMM	568H:48M 3104 Acc cycles	Took sample #61. WSD was 0.92.
8/02/2017	18:45	NO	580H:53M 3169 Acc cycles	Took sample #62. WSD was 0.94
8/03/2017	05:53	TMM	591H:58M 3230 Acc cycles	Test running good, transferred data.
8/03/2017	06:20	TMM	592H:28M 3233 Acc cycles	Opened clay filter for 3 minutes
8/03/2017	06:45	TMM	592H:53M 3235 Acc cycles	Took sample #63. WSD not checked.
8/03/2017	18:45	TK	604H:49M 3300 Acc cycles	Took sample #64. WSD was 1.00
8/04/2017	05:45	TMM	615H:48M 3360 Acc cycles	Test running good, transferred data.
8/04/2017	06:00	TMM	615H:58M 3361 Acc cycles	Took sample #65 and posttest fuel sample to be saved until the report is written. WSD was 0.97.
8/04/2017	06:04	TMM	616H:08M 3362 Acc cycles	Shut test down, DTP-2175 total time requirement was 610 hours minimum. Transferred final data file.

Test Checklist

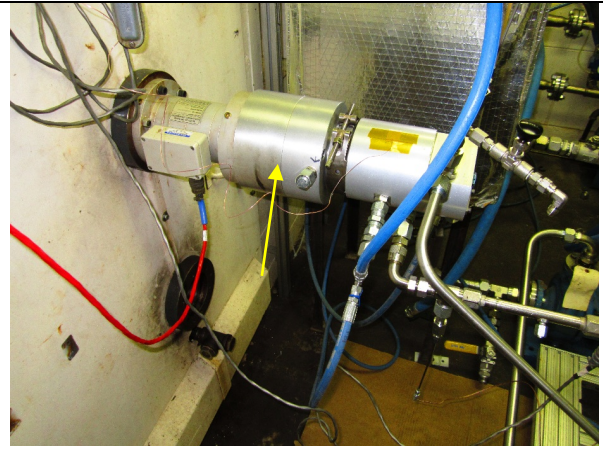
This information has been removed in order to safeguard the proprietary information contained therein.

For additional information, please contact AFRL/RQTF.

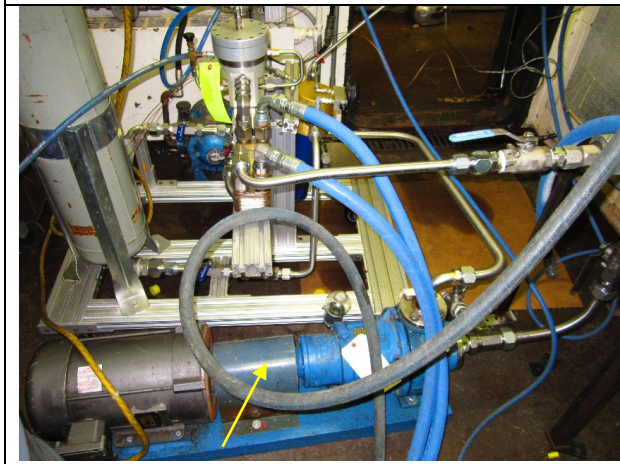
Appendix 6 Setup Photographs



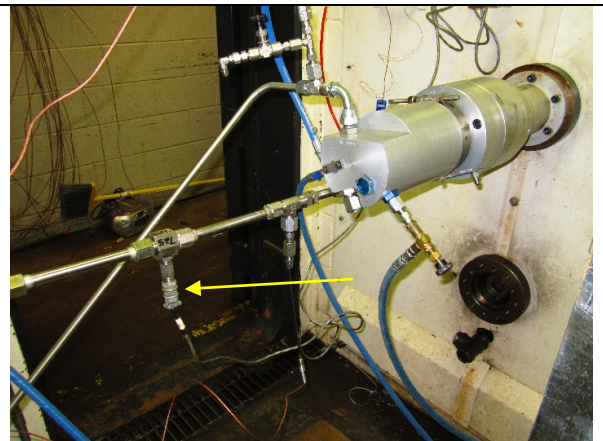
Clay Filter



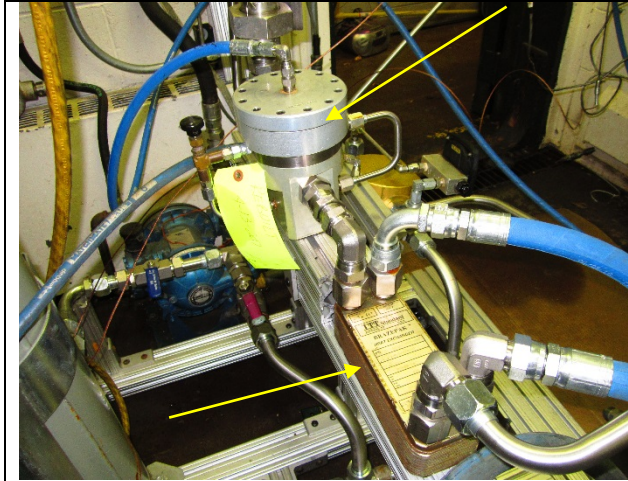
Test Unit in Test Block on Drive Pad.



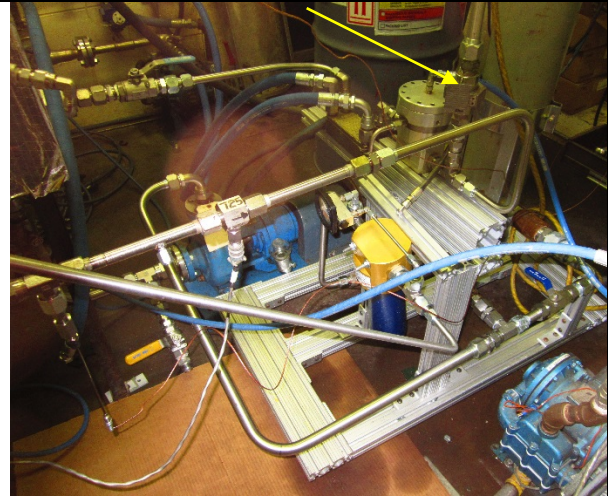
Boost Pump



Flow Meter



Pressure Control Valve and Heat Exchanger



Burst Disk

Appendix 7

Low Lubricity Data

Table 5. Lubricity Test Results

Sample	Date	Time	Accred Cycles	Accred Hours	Lubricity
1	29-Jun-17	14:05	0	0	0.96
2	29-Jun-17	14:35	3	0.5	0.95
3	29-Jun-17	18:35	-	4.5	0.95
4	29-Jun-17	22:35	-	8.33	0.95
5	30-Jun-14	2:35	-	-	0.98
6	30-Jun-17	6:35	91	16.5	0.96
7	30-Jun-17	10:35	114	20.5	0.94
8	30-Jun-17	14:35	135	24.5	0.97
9	30-Jun-17	18:35	156	28.5	0.97
10	1-Jul-17	6:35	222	40.5	-
11	1-Jul-17	18:43	288	52.6	0.96
12	2-Jul-17	6:35	353	64.5	-
13	2-Jul-17	18:00	424	75.9	0.91
14	3-Jul-17	6:35	484	88.5	0.95
15	3-Jul-17	16:40	539	98.5	0.91
16	4-Jul-17	6:35	614	112.25	0.96
17	12-Jul-17	6:15	614	112.25	0.99
18	12-Jul-17	6:45	618	113	0.99
19	12-Jul-17	10:45	640	117.1	0.99
20	12-Jul-17	14:45	661	120.9	1.01
21	12-Jul-17	18:45	683	125.1	0.99
22	12-Jul-17	22:45	705	129.1	1

Sample	Date	Time	Accred Cycles	Accred Hours	Lubricity
23	13-Jul-17	2:44	727	133.1	1
24	13-Jul-17	6:45	749	137	0.99
25	13-Jul-17	18:45	-	149.1	0.99
26	14-Jul-17	6:45	880	161.1	-
27	14-Jul-17	18:45	945	173.1	0.99
28	15-Jul-17	6:45	1010	184.95	0.98
29	15-Jul-17	18:45	1076	197	0.98
30	16-Jul-17	6:45	1141	208.9	-
31	16-Jul-17	18:45	-	-	0.96
32	17-Jul-17	6:45	1272	232.95	-
33	17-Jul-17	18:45	1338	245.1	0.99
34	18-Jul-17	6:45	1403	256.95	-
35	18-Jul-17	18:45	1469	269	1
36	19-Jul-17	6:45	1534	280.95	-
37	19-Jul-17	18:45	1599	293	0.98
38	20-Jul-17	6:45	1609	294.75	0.93
39	20-Jul-17	18:45	1674	306.7	0.96
40	21-Jul-17	6:45	1739	318.5	-
41	21-Jul-17	18:45	1804	330.6	0.97
42	22-Jul-17	6:45	1870	342.6	-
43	24-Jul-17	9:00	1938	355	0.95
44	24-Jul-17	18:45	1991	364.95	0.97
45	25-Jul-17	6:45	2056	376.7	-
46	25-Jul-17	8:45	2122	388.8	-

Sample	Date	Time	Accred Cycles	Accred Hours	Lubricity
47	26-Jul-17	6:15	2187	400.7	0.96
48	26-Jul-17	18:45	2253	412.75	0.96
49	27-Jul-17	6:45	2317	424.7	0.96
50	27-Jul-17	18:45	2384	436.75	0.95
51	28-Jul-17	6:45	2449	448.7	-
52	28-Jul-17	18:45	2514	460.8	0.98
53	29-Jul-17	6:45	2580	472.8	-
54	29-Jul-17	18:45	2645	484.8	0.98
55	30-Jul-17	6:45	-	496.9	-
56	30-Jul-17	18:45	-	508.8	0.98
57	31-Jul-17	6:45	2842	520.9	-
58	31-Jul-17	18:45	2907	532.8	0.99
59	1-Aug-17	6:45	2973	544.8	-
60	1-Aug-17	18:45	3038	556.8	0.95
61	2-Aug-17	6:45	3104	568.9	0.92
62	2-Aug-17	18:45	3169	580.9	0.94
63	3-Aug-17	6:45	3235	592.5	-
64	3-Aug-17	18:45	3300	604.8	1
65	4-Aug-17	6:00	3361	615.9	0.97

Appendix 8
Pre and Post Test Inspection Photos





Pre Test	Post Test	Notes
Image 1: Floating Bearings		
		<p>Floating bearings show light polishing after 600 hours.</p>
		<p>Floating Bearings show no significant cavitation or clipping after 600 hours.</p>

Image 2: Stationary Bearings



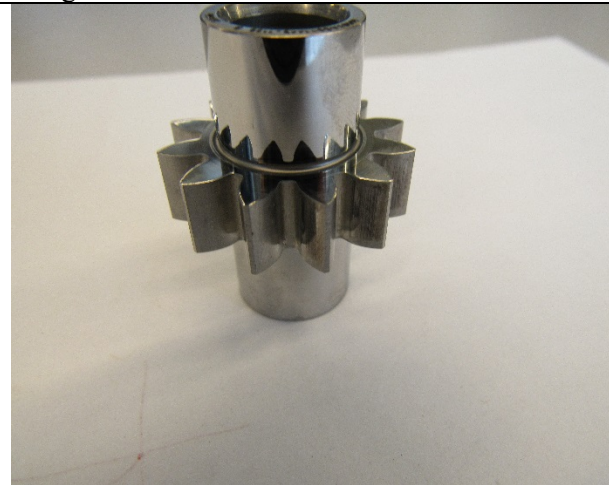
Stationary Bearings show no significant clipping after 600 hrs.



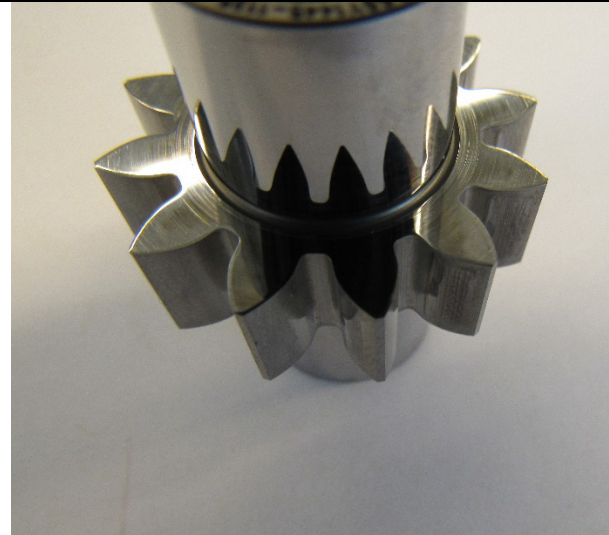
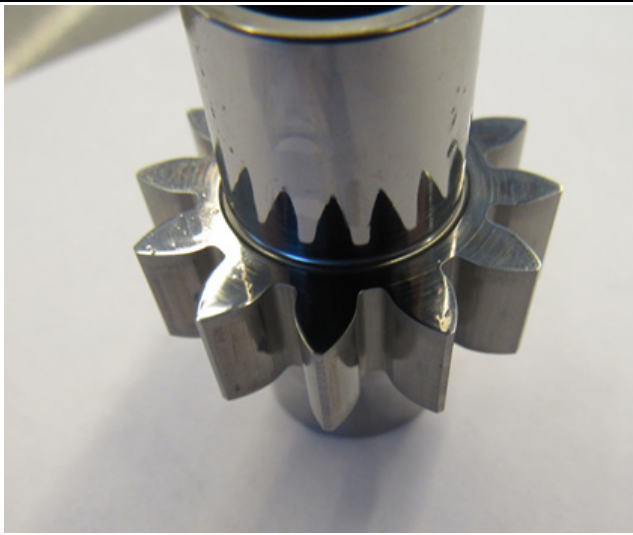
Stationary bearings show light polishing after 600 hours.



Image 3: Gear Set



Idler gear shows typical wear and cavitation with polished gear teeth on working side.



Idler gear journal shows fair polish with a few small scratches on the journal.

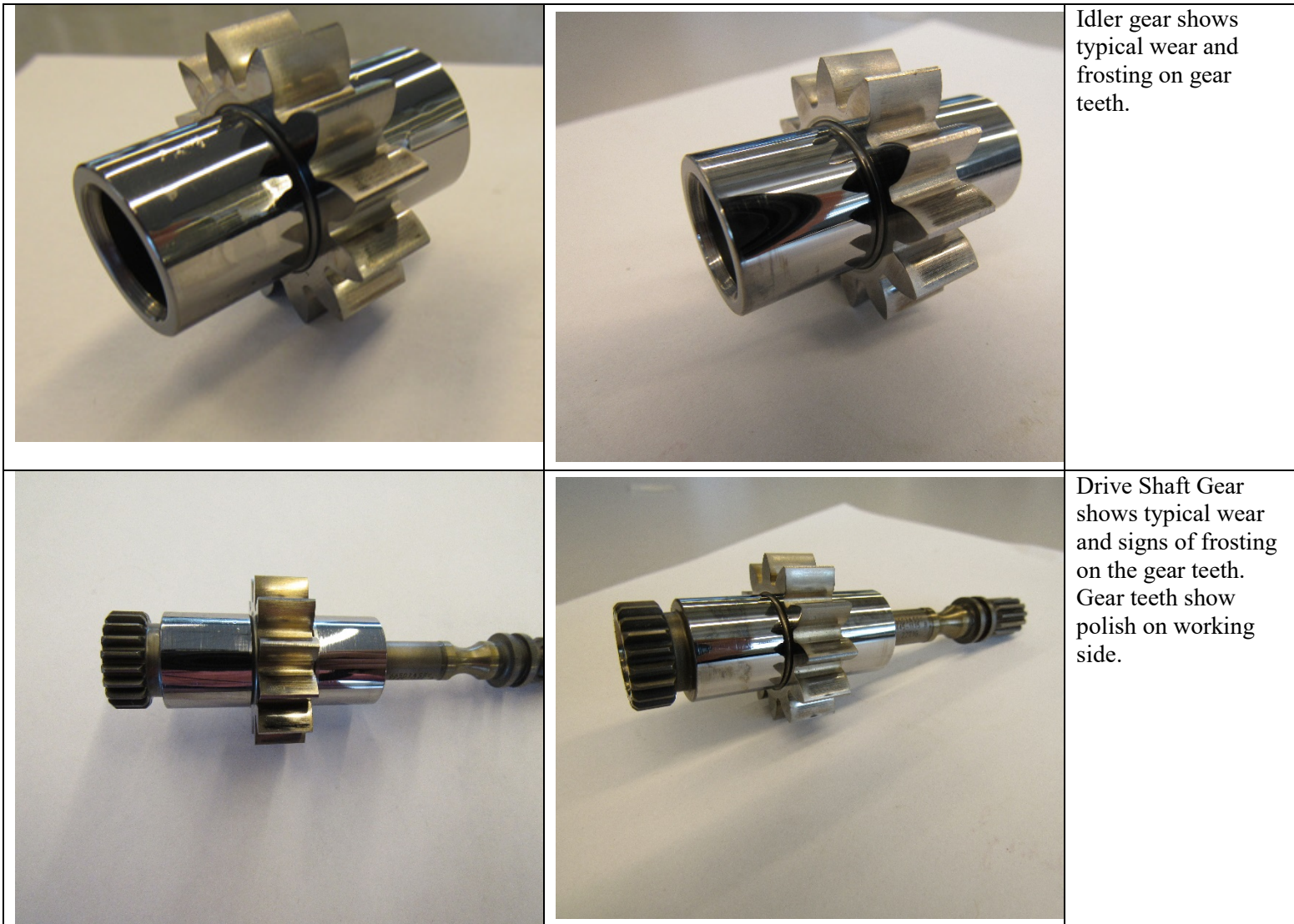
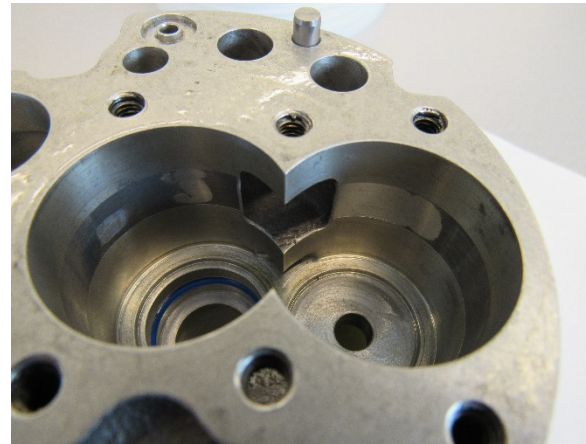
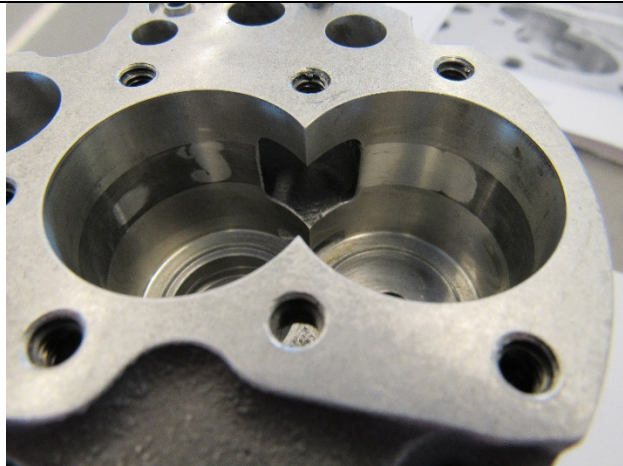
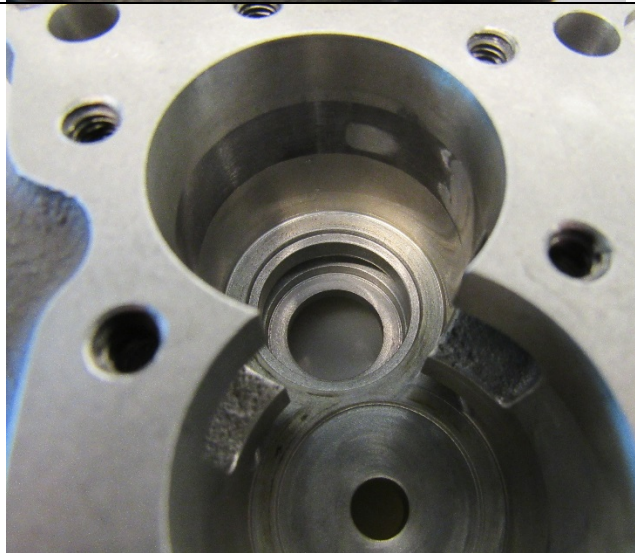


Image 4: Housing Bores



Housing inlet: bore is wiped completely around the inside diameter of both the driven and idler gear bore. The housing wipe depth has remained the same since the previous bio fuel test.



Housing discharge bore.

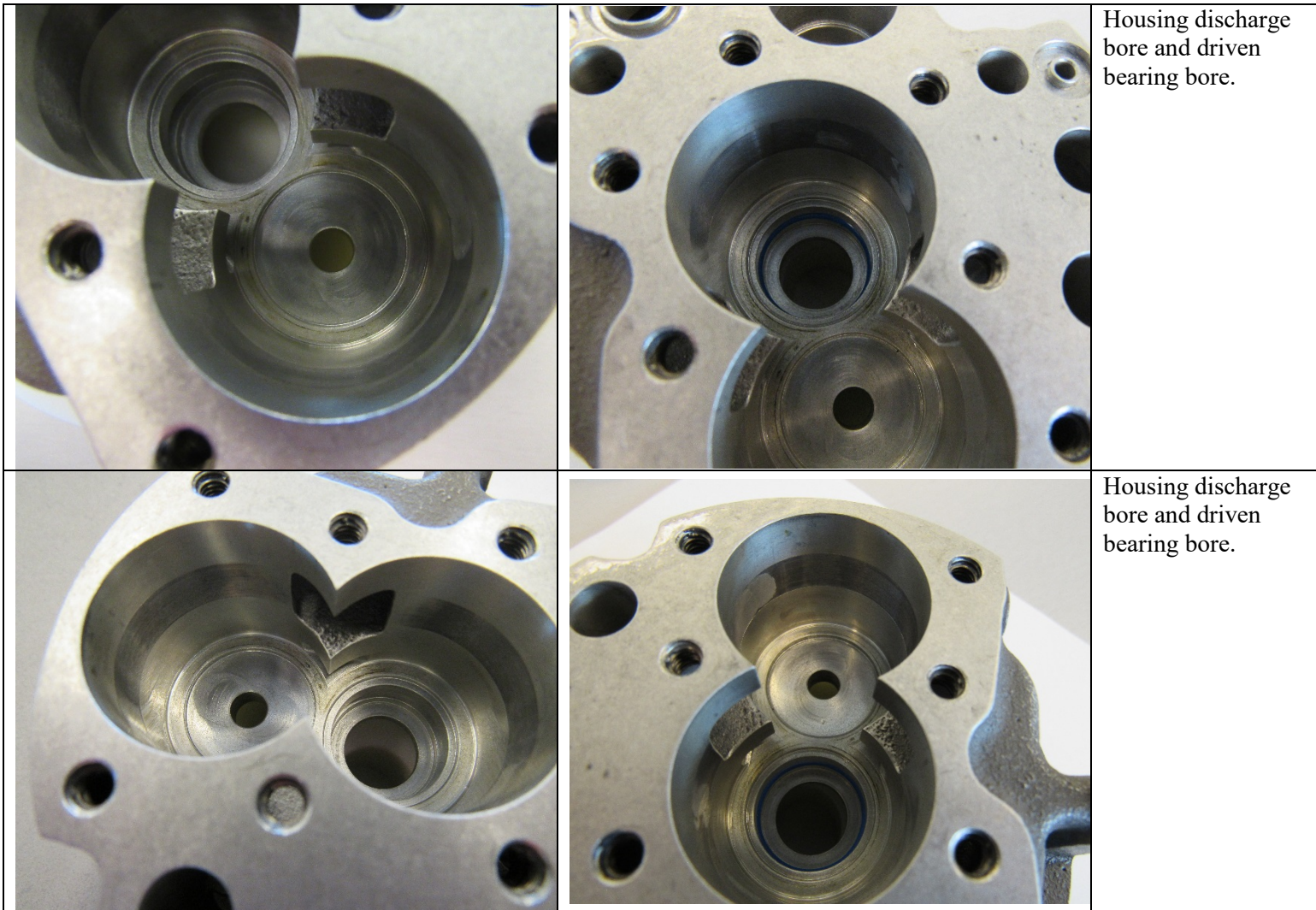
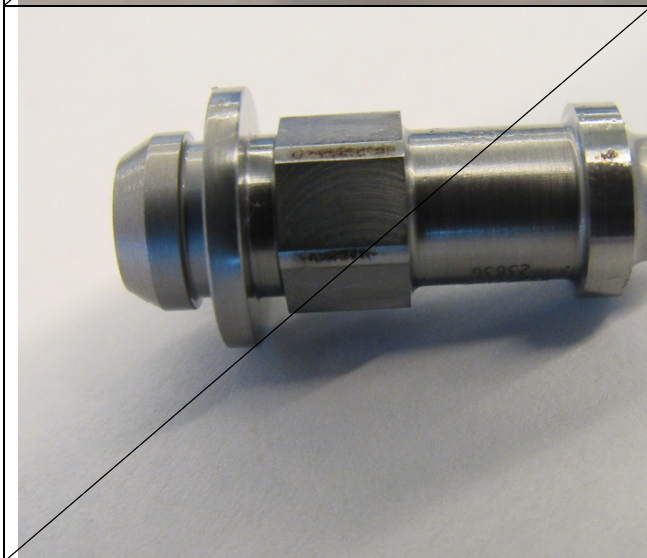


Image 5: HPRV

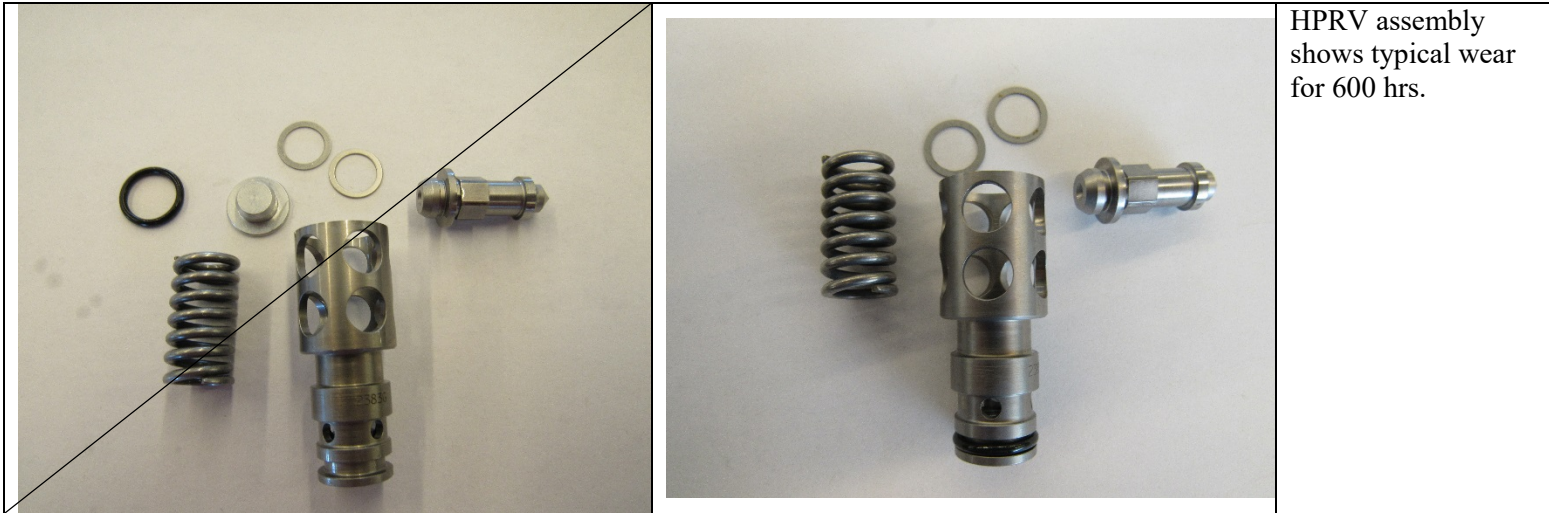


HPRV shows no signs of significant wear.



Several edges show signs of a deposited organic substance that remained from the previous bio fuel test.

Post-performance check of HPRV showed no significant issues.



Appendix 9
Intermediate Checks

Post 100-hr COM-852, CCP Acceptance Test

WOODWARD GOVERNOR COMPANY
ROCKFORD, IL
CAGE 66503

COM-852
ECL: D
PAGE : 1 OF 1

Desc: COM - CCP ACCEPTANCE TEST PROCEDURE
Date: 13-JUL-2017
IMTPC - TEST SPECIFICATION RESULTS PRINT REPORT

Serial No: 19366491 Run No: 10 Work Order: 2306635 Item No: 6970-034
Current Status: A Run Status: P Test Type: AS Test Date: 13-JUL-2017

Test Point	Record	Units	Formula Tag	Min	Value	Max	Pass Fail	
1.0	Total Flow Rate Check							
1.1	Record Qtotal	Qtotal	gpm	QTOT_1	3.76	4.21	6.00	P
2.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1052	1070	P
3.0	HPRV Reseating Check							
3.1	Record Qtotal	Qtotal	gpm		3.95 (Calc)	4.19	4.47 (Calc)	P
4.0	Total Flow Rate Check							
4.1	Record Qtotal	Qtotal	gpm	QTOT_2	8.50	10.10		P
5.0	HPRV Near Cracking Pressure Check							
5.1	Record Qtotal	Qtotal	gpm		9.58 (Calc)	9.93	10.62 (Calc)	P
6.0	HPRV Total Flow Bypass	(Ps-Pb1)	psid		900	1025	1120	P
7.0	HPRV Reseating Check							
7.1	Record Qtotal	Qtotal	gpm		9.84 (Calc)	10.12	10.36 (Calc)	P
8.0	Starting Flow Rate Check							
8.1	Record Qtotal	Qtotal	gpm		0.85	0.94	1.50	P
9.0	Max Flow Check							
9.1	Record Qtotal	Qtotal	gpm		8.03	9.26		P
10.0	Leakage Check							
10.1	Record External Leakage	Ext Leakage	drops/min		0.0	0.0	0.0	P
10.2	Record OBD Leakage	OBD Leakage	drops/min		0.0	0.0	0.0	P
11.0	Breakaway Torque Check	Tq	lb_in		6	15		P

The following criteria were used to run this report:

Serial No: 19366491
Run Number: 10
Status: A
Run Type: AS
Work Order Number:
Order By: 1

* End of IMTPC *

Post-100 hr Inspection Data

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
N/A	Breakaway Torque	6 lb-in	Tiffany Williams 2017-07-07
Packing			
Ps Discharge (182748)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Vapor Vent (182650)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Overboard Drain (182650)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Cartridge Seal (182574)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Drive Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Driven Floating Bearing (182625)	Visual	No discrepancies	Gavin Medearis 2017-07-07
HPRV (182748)	Visual	No discrepancies	Gavin Medearis 2017-07-07

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs




Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Drive Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	Gavin Medearis 2017-07-07
	Outer Diameter	1.25605	Joshua Horney 2017-07-07
	Width	0.3752	Joshua Horney 2017-07-07
	Front Journal OD	0.69381	Joshua Horney 2017-07-07
	Rear Journal OD	0.69391	Joshua Horney 2017-07-07
Driven Gear (1445-1135)	Visual (Including Journal and Face Finishes)	Minimal cavitation and light markings on journals	Gavin Medearis 2017-07-07
	Outer Diameter	1.25600	Joshua Horney 2017-07-07
	Width	0.37512	Joshua Horney 2017-07-07
	Front Journal OD	0.69386	Joshua Horney 2017-07-07
	Rear Journal OD	0.69386	Joshua Horney 2017-07-07
Both Gears	Gear Tooth Profile per Drawing (1445-1135) Instructions	Inspect all teeth; both faces, and overlay front and back face inspection charts for each tooth. Provide inspection records to engineering.	Gavin Medearis 2017-07-07
* Drawing Limits on all outer gear diameters are 1.25575" – 1.25625"			
* Drawing Limits on all gear widths are .3747" - .3753"			
* Drawing Limits on all journal outer diameters are .69375" - .69425"			

CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	Gavin Medearis 2017-07-07
HPRV Spring (1524-646)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6957	Gavin Medearis 2017-07-07
	Height	0.3632	Gavin Medearis 2017-07-07
Driven Floating Bearing (1401-1176)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6957	Gavin Medearis 2017-07-07
	Height	0.3631	Gavin Medearis 2017-07-07
Drive Stationary Bearing (1401-1174)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6956	Gavin Medearis 2017-07-07
	Height	0.5401	Gavin Medearis 2017-07-07
Driven Stationary Bearing (1401-1174)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6956	Gavin Medearis 2017-07-07
	Height	0.5401	Gavin Medearis 2017-07-07
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			

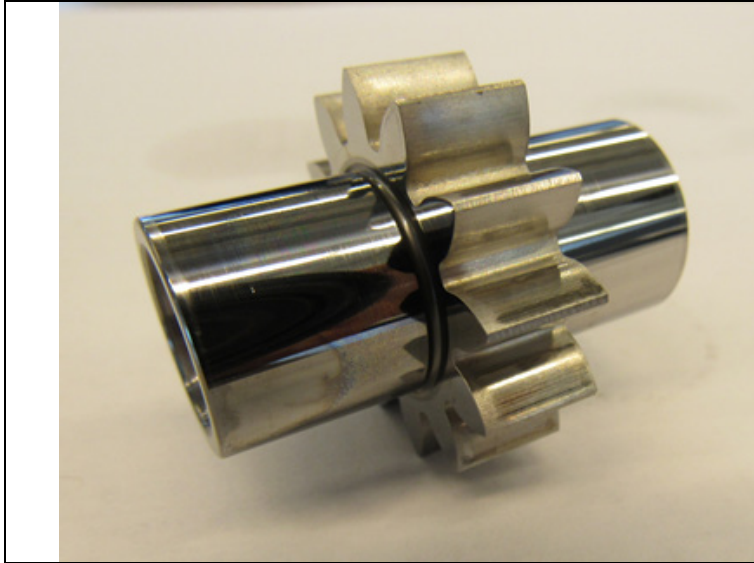
CRITICAL INSPECTION RECORD – POST-TEST 100 hrs

Test Article I/N: 6970-034		Test Article S/N: 19366491	
Item Name/ Location (I/N)	Inspection	Record	Name and Date
Springs			
Floating Bearing Springs (1520-1423)	Visual	No discrepancies	Gavin Medearis 2017-07-07
HPRV Spring (1524-646)	Visual	No discrepancies	Gavin Medearis 2017-07-07
Bearings/Gears			
Drive Floating Bearing (1401-1175)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6957	Joshua Horney 2017-07-07
	Height	0.3632	Joshua Horney 2017-07-07
Driven Floating Bearing (1401-1176)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6957	Joshua Horney 2017-07-07
	Height	0.3631	Joshua Horney 2017-07-07
Drive Stationary Bearing (1401-1174)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6956	Joshua Horney 2017-07-07
	Height	0.5401	Joshua Horney 2017-07-07
Driven Stationary Bearing (1401-1174)	Visual	Fair polishing	Gavin Medearis 2017-07-07
	Inner Diameter	0.6956	Joshua Horney 2017-07-07
	Height	0.5401	Joshua Horney 2017-07-07
* Drawing Limits on all bearing inner diameters are .6952" - .6957"			

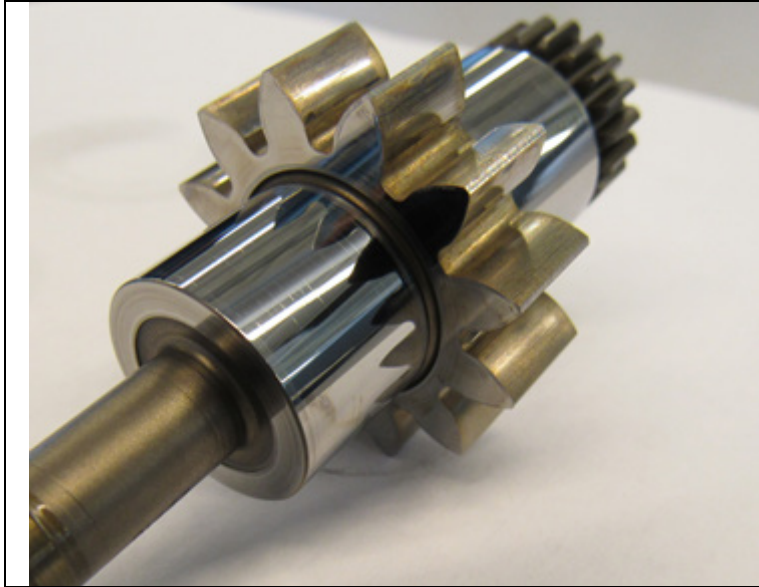
Post-100 hrs	Notes
	<p>Floating bearings show fair polishing after 100 hrs.</p>
	<p>Floating Bearings show expected wear for after 100 hrs.</p>
	<p>Stationary bearing faces show fair polishing after 100 hrs.</p>



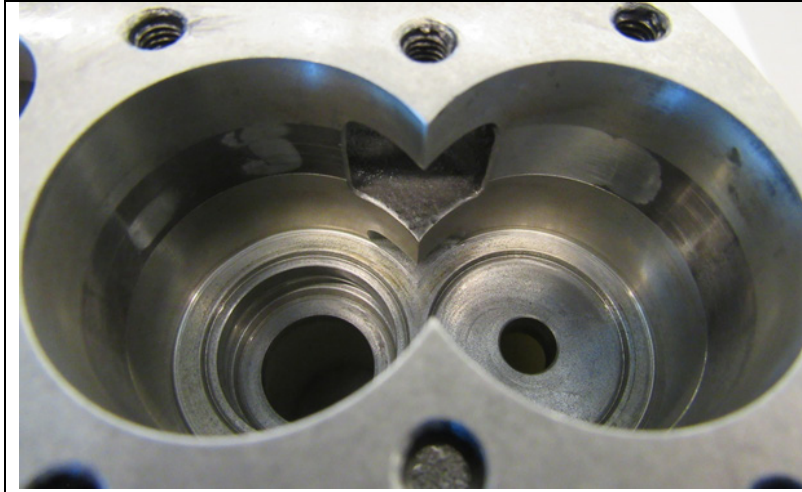
Stationary Bearings show typical wear after 100 hrs.



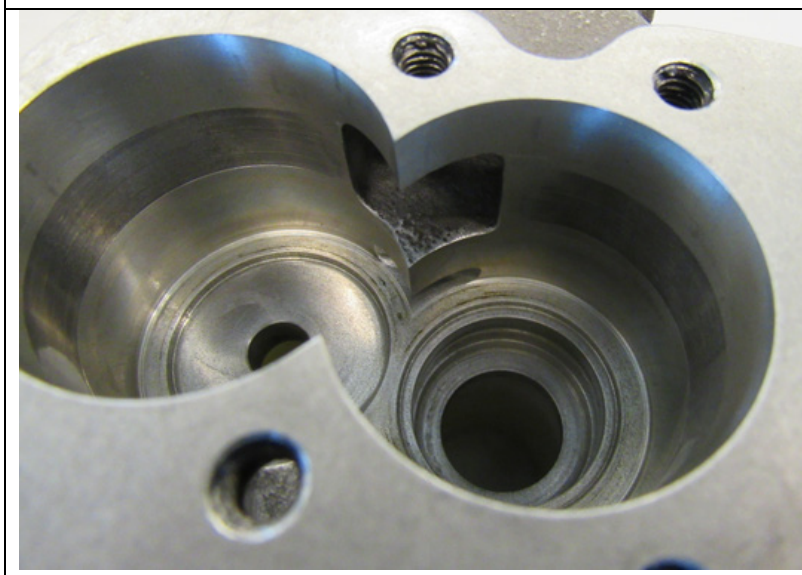
Idler gear shows typical wear and cavitation.



Drive gear shows typical wear and cavitation



Housing inlet: gear wipe extends the entire inner diameter of each bore. Housing wipe depth remains the same after 100 hrs.



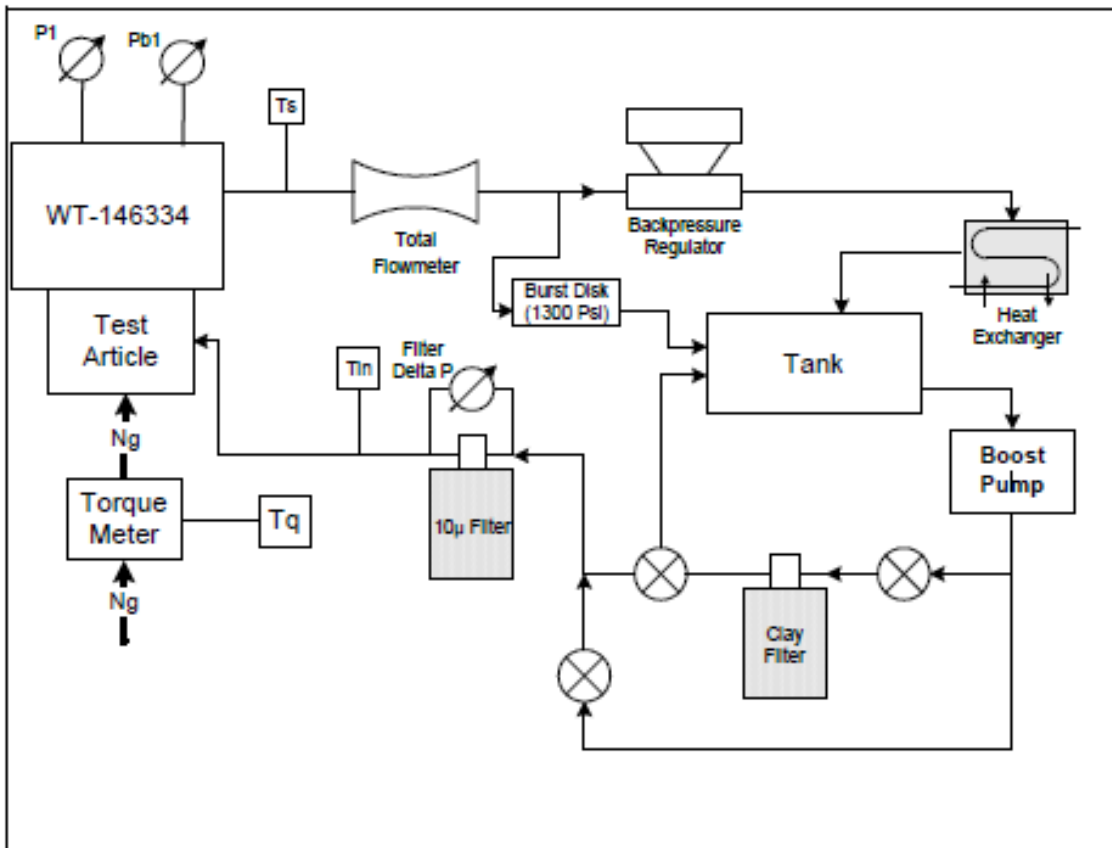
Housing discharge

Appendix 10

Figures

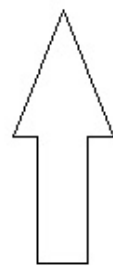
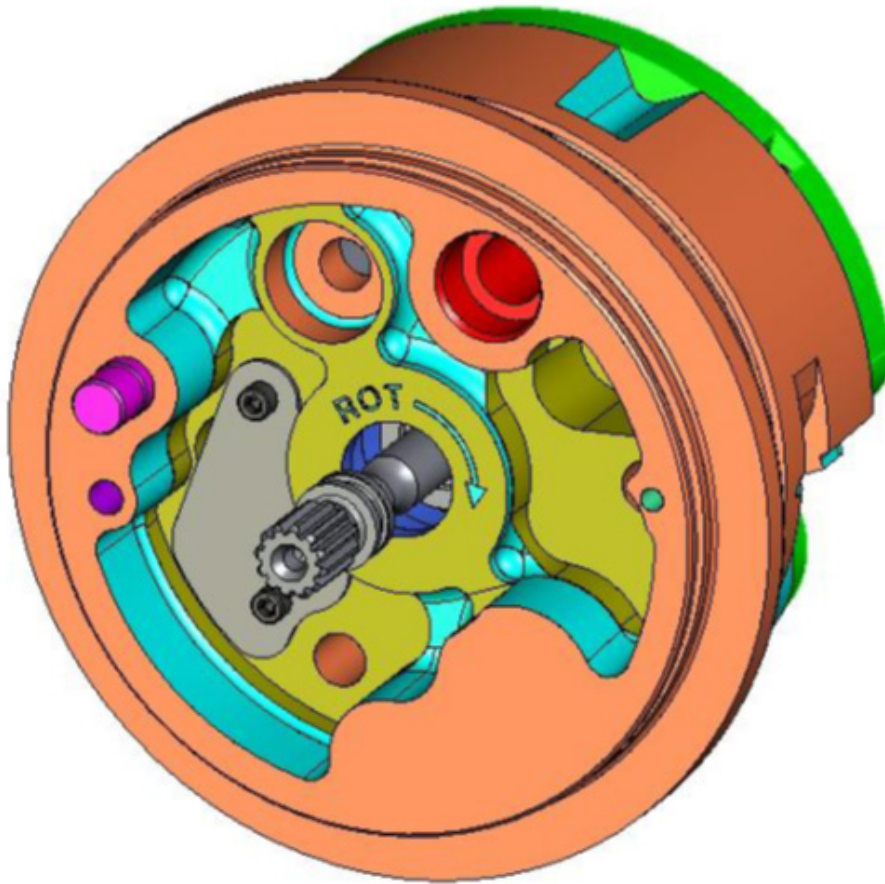
Test Schematic

Figure 1.



Test Mounting Orientation

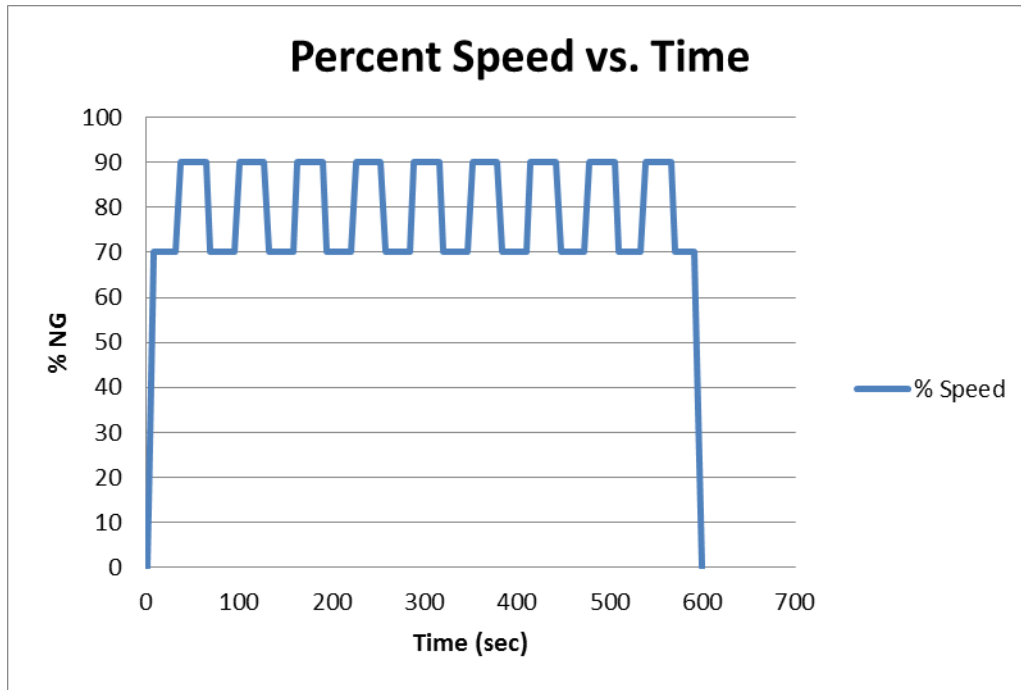
Figure 2.



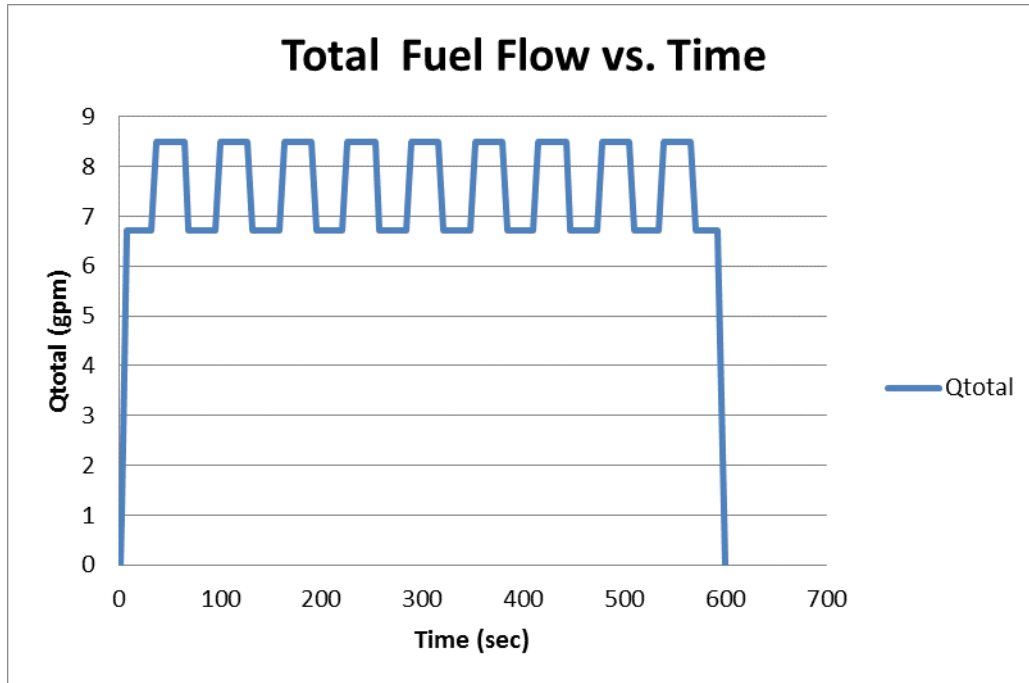
0 degrees

Appendix 11 Mission Cycle

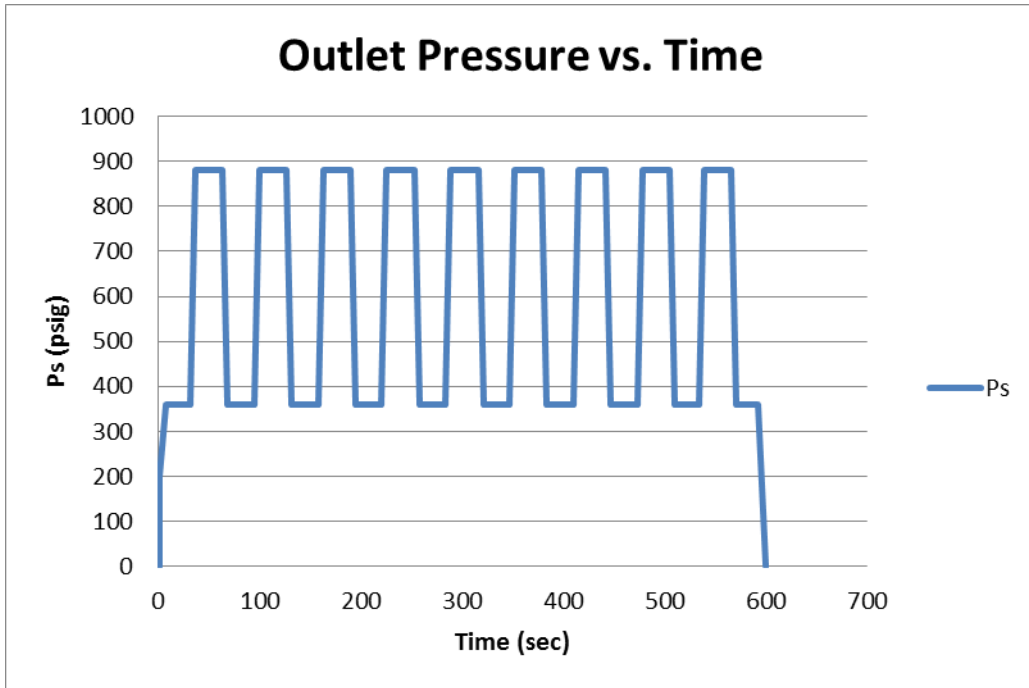
Test Cycle per Table 3; % Speed vs. Time



Test Cycle per Table 3; Fuel Flow vs. Time



Test Cycle per Table 3; Discharge Pressure vs. Time



List of Symbols, Abbreviations, and Acronyms

<u>Acronym</u>	<u>Description</u>
AFRL	Air Force Research Laboratory
APFEERD	Airbreathing Propulsion Fuels and Energy Exploratory Research and Development (APFEERD)
BOCLE	Ball-On-Cylinder-Lubricity-Evaluator
CCP	Commercial Cartridge Pump
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DTIC	Defense Technical Information Center
EAR	Export Administration Regulation
ETF	Environmental Test Facility
ITAR	International Traffic in Arms Regulation
R4RQ	Research for the Aerospace Systems Directorate
RQ	Aerospace Systems Directorate
RQT	Turbine Engine Division
RQTF	Fuels and Energy Branch
USAF	United State Air Force
UTC	Universal Technology Corporation
WPAFB	Wright-Patterson Air Force Base
WSD	Wear Scar Diameter