1. WILLBROS CONCLUSIONS AND RECOMMENDATIONS

The preliminary report completed by Pipeline Petroleum Services, Inc. and issued to the Navy concluded that the both the 18-inch and 32-inch lines for Tank-5 at Red Hill passed the contract required volume correction calculations as set forth by the California State Fire Marshal's office. Pipeline Petroleum Services stated that the entire test was considered inconclusive in their opinion because each test failed the temperature – pressure evaluation and their thoughts were that there is trapped air into the system and that is why the system failed the temperature – pressure evaluation.

During Willbros review of the report prepared by Pipeline Petroleum Services, it was noted that during testing, the temperature probe in the tunnel recorded a 0.1 °F drop in temperature and the temperature probe in the tank recorded a 2.0 °F rise in temperature.

James Hagen the Project Manager for the Red Hill Tank-5 work informed us that there can easily be a 2.0 °F temperature change in the tank from the tunnel based on air movement from the ventilation system.

Based on the fact that the majority of these pipes are installed where the temperature of the tunnel would have more of an effect on the temperature – pressure evaluation than the area inside the tank, Willbros asked Pipeline Petroleum Services to re-run their calculations and re-evaluate their inconclusive opinion on the 18-inch and 32-inch lines for Tank-5 by removing the temperature recorded from the tank, in their temperature – pressure evaluation. Petroleum Pipeline Services did that and stated that their conclusions are the same as before. The 18-inch and 32-inch lines passed the volume correction calculations as set forth by the California State Fire Marshal's office but were inconclusive based on the temperature – pressure evaluation.

Willbros spoke to the management of Pipeline Petroleum Services about their conclusions and Pipeline Petroleum Services told Willbros that because of the scrutiny and liability that they would accept with passing these tests, they would not pass if there were any interpretations to be made.

Pipeline Petroleum Services recommendation was to perform a pneumatic test on the lines, to determine if their inconclusive evaluation was correct or not. Willbros was informed by the Navy that a pneumatic test would not be allowed.

Willbros then began analyzing the data supplied by Pipeline Petroleum Services, to determine if the tests were indeed inconclusive or an error was made.

Willbros performed an analysis of the data and determined the accuracy of the testing equipment to determine if the un-explained ΔP/ΔT is within the accuracy of the testing equipment.

Based on the accuracy of the equipment used during the test and applying these accuracies to the test data, we feel that any test should be deemed acceptable if the unexplained pressure loss or gain that falls within ¼ degree.

Test ID Number: 14-332-02 had an unexplained pressure loss of (-3.2 +1.73) - 1.47 psig and is within ¼ degree ΔT accuracy of 3.57 psig.

Test ID Number 14-332-01A had an unexplained pressure loss of (-3.2 +1.63) -1.57 psig and is within ¼ degree ΔT accuracy of 5.104 psig.

Test ID Number 14-332-01B had an unexplained pressure loss of - 0.10 psig and is within ¼ degree ΔT accuracy of 5.104 psig.

Based on the fact that Pipeline Petroleum Services found that all tests passed the volume correction calculations established by the California State Fire Marshal's office and Willbros determined that all three test performed by Pipeline Petroleum Services falls within ¼ degree of the accuracy of the equipment, Willbros deems that the three tests passed and no test should be considered inconclusive.

It is Willbros recommendation that no further testing of these lines need to be conducted, until the next API 653 examination of Tank-5 is due.

08/20/2014

Justin T. Johnson
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Willbros Engineers (U.S.), LLC
Oklahoma C.A. No. 144

Naval Facilities Engineering Command
ENGINEERING SERVICE CENTER

Prepared for

NAVAL FACILITIES ENGINEERING COMMAND
ENGINEERING SERVICE CENTER
Port Hueneme, California

Technical Submittal for Project:

Project Title: CLEAN, INSPECT, AND REPAIR STORAGE TANKS 5 & 17
Location: PEARL NAVAL BASE – REDHILL COMPLEX, Pearl Harbor, HI
Task Order No.: N62583-09-D-0132/0003
WGS Project Number: 54118
Date: August 19, 2014

TANK 5 HYDROSTATIC TEST RESULTS FOR 18-INCH AND 32-INCH LINES

Submitted By:
Willbros Government Services, LLC
2087 E. 71st Street
Tulsa, OK 74136

Rev	Date	Description	Reviewed	Approved
A	8/19/2014	For Approval	TDA	RGG

WILLBROS

Distribution and use is limited to US Government agencies and their contractors; administrative/operational use within the context of this project. Other request shall be referred to the Naval Facilities Engineering Service Center. All Willbros plans and procedures are Confidential and Proprietary information; and the sole property of Willbros.

1. WILLBROS CONCLUSIONS AND RECOMMENDATIONS

The preliminary report completed by Pipeline Petroleum Services, Inc. and issued to the Navy concluded that the both the 18-inch and 32-inch lines for Tank-5 at Red Hill passed the contract required volume correction calculations as set forth by the California State Fire Marshal's office. Pipeline Petroleum Services stated that the entire test was considered inconclusive in their opinion because each test failed the temperature – pressure evaluation and their thoughts were that there is trapped air into the system and that is why the system failed the temperature – pressure evaluation.

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It is Willbros recommendation that no further testing of these lines need to be conducted, until the next API 653 examination of Tank-5 is due.

14-332: PRESSURE TESTING REPORT
OF TANK 5 FUEL LINES

Red Hill Underground Fuel Storage Facility

OAHU, HI

Prepared for:

Willbros Government Services (USA), LLC
Tulsa, OK

Prepared under:

Willbros Contract Number: N62583-08-D-0132/003

Prepared by:

PIPELINE PETROLEUM SERVICES, INC.
1324 Cavalier Blvd
Chesapeake, Virginia 23323

June 23-27, 2014

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LIST OF APPENDICES

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Appendix D Raw Test Data from Dataloggers (18"Ø & 32"Ø lines)
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LIST OF ABBREVIATIONS AND ACRONYMS

- MAOP: Maximum Allowable Operating Pressure
- MAWP: Maximum Allowable Working Pressure
- PRV: Pressure Relief Valve
- MOV: Motor Operated Valve
- DBB: Double Block & Bleed Valve
- HPV: High Point Vent
- LPD: Low Point Drain
- SS: Stainless Steel
- CS: Carbon Steel
- AG: Aboveground
- UG: Underground
- NPT: National Pipe Thread
- PSI: Pounds / Square Inch
- WOG: Water or Gas
- CP: Cathodic Protection
- AST: Aboveground Storage Tank
- UST: Underground Storage Tank
- PIT: Pressure Indicating Transmitter

1.0 EXECUTIVE SUMMARY

The scope of this project is to perform point-in-time hydrostatic pressure testing of the Tank 5 fuel lines at the Red Hill Underground Fuel Farm, Oahu, HI. The testing was performed and documented in accordance with the Willbros Pressure Test Procedure NDT-3, Revision 9, Dated June 5, 2014, as well as "Pressure Testing Requirements for Hazardous Liquid Pipelines in California", Office of the State Fire Marshal, Pipeline Safety Division, May 2011 Revision (CSFM) and "Operation & Maintenance: Maintenance of Petroleum Systems" United Facilities Criteria (UFC) UFC 3-460-03F, January 2003, which is the jurisdictional Government regulation of Military Petroleum Facilities. The tested lines were tested to cross-country and process hazardous liquid pipeline testing standards since an API-653 hydrostatic test was not feasible at this time.

The Tank 5 lines are actually classified as tank nozzles from the skin valve flange to the wall of the tank and consisted of one 32"Ø F-76 line and one 18"Ø JP-8 line, each between 50-70 feet in length located directly beneath the tank. The lines were hydrostatically pressure tested between the dates of June 23, 2014 and June 27, 2014 at 1.5 times (150%) the maximum allowable operating pressure of 108 psi for four hours. The test pressure was calculated by factoring the maximum head of a full tank calculated by (.433)(SG)(Height): (.433 (psi / ft head – fresh water))(1.0 (Specific gravity of fresh water))(250'(Height of Tank 5)) = 108.25 psi x 150% = 162.375 psi.

The CSFM pass / fail criteria was chosen by the Navy to determine the success of each test base on volume gain / loss calculations based on temperature change. Strictly based on the volume loss criteria established by the CSFM both tests passed, however neither line fully stabilized and the temperature / pressure evaluation of expected pressure change vs the actual pressure change, while very close, did not achieve a passing result. Because of the conflicting calculation results, both test attempts are inconclusive pending the result of the recommended pneumatic test.

The recommendation from PPSI at this time is to perform pneumatic testing of both lines to positively confirm or deny the existence of trapped vapor preventing a successful hydrotest.

2.0 INTRODUCTION

Willbros Government Services (WGS) contracted Pipeline Petroleum Services, Inc. (PPSI) to perform temperature compensated hydrostatic pressure testing of the Tank 5 issue / receipt lines located at the Red Hill Underground Fuel Facility, Oahu, HI.
The testing under this cover was performed to determine integrity of these lines in the absence of an API-653 hydrotest.

3.0 SITE DESCRIPTION

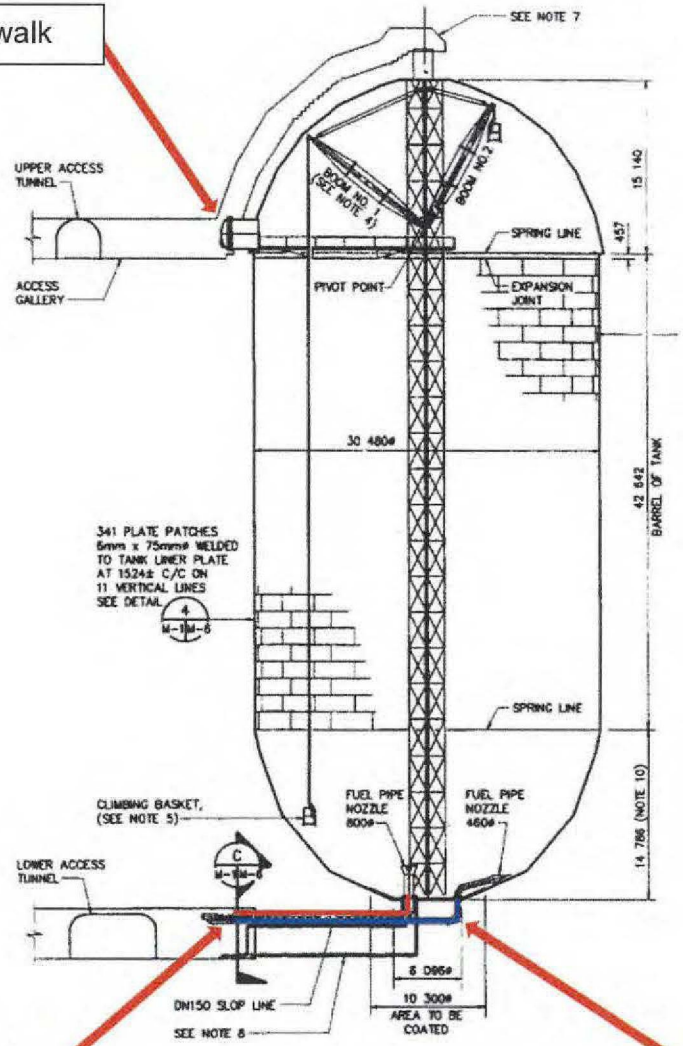
The Red Hill Underground Fuel Facility is located on the island of Oahu, HI approximately 3 miles due east of Pearl Harbor. The Red Hill fuel farm is a classified facility and consists of 20 underground tanks approximately 250' tall x 100' in diameter with an estimated capacity of 12.5 million gallons each, as well as underground pumping facilities, line networks, and multiple access points. The facility receives jet propulsion fuel (JP-8 & JP-5), as well as marine diesel fuel (DFM / F-76) from tankers as well as from a trans-island line and dispenses to trucks at the truck rack and to navy ships from

several piers. The facility issues to Pearl Harbor by gravity and pumps located in PH 59 are used to recirculate or pump back up to Red Hill.

Testing was performed on the Tank 5 dual purpose issue / receipt lines for F-76 & JP-8. Refer to Figure 3-1 on the following page: Tank 5 Layout.

Figure 3-1: Tank 5 Layout (Identical to all Red Hill Tanks)

Tank Manway & Access Catwalk



Test Sections:
Red: 32"Ø F-76 Piping
Blue: 18"Ø JP-8 Piping

Tank skin valves removed at this location and test blinds installed.

Test Section Lines

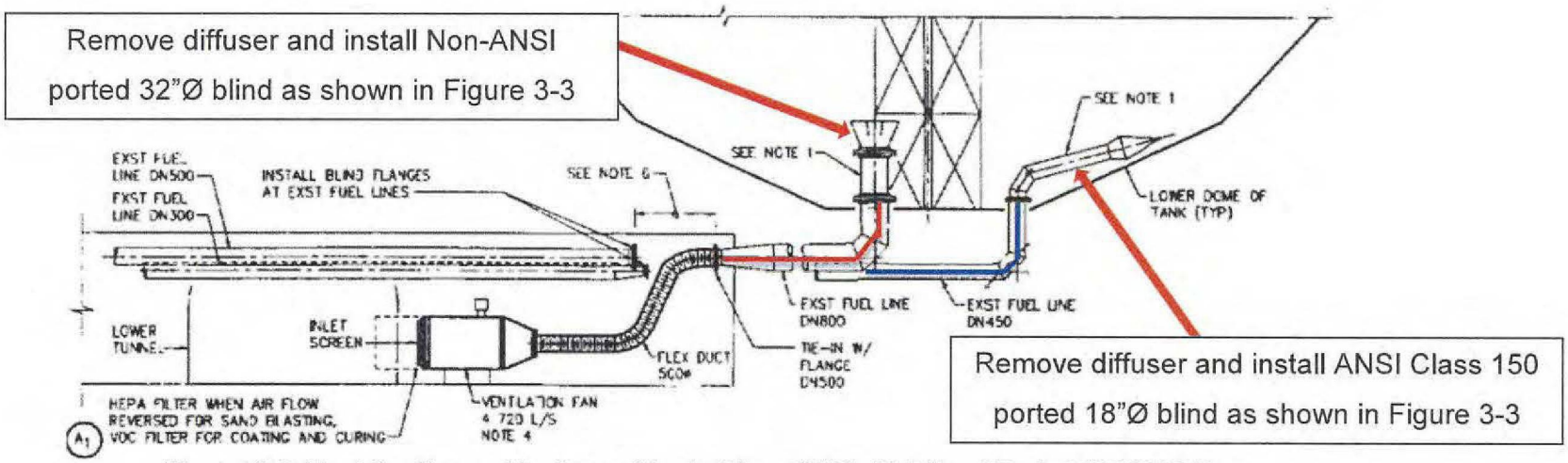


Figure 3-2: Test Sections at bottom of tank. Blue: 18"Ø JP-8 line / Red: 32"Ø F-76 line.

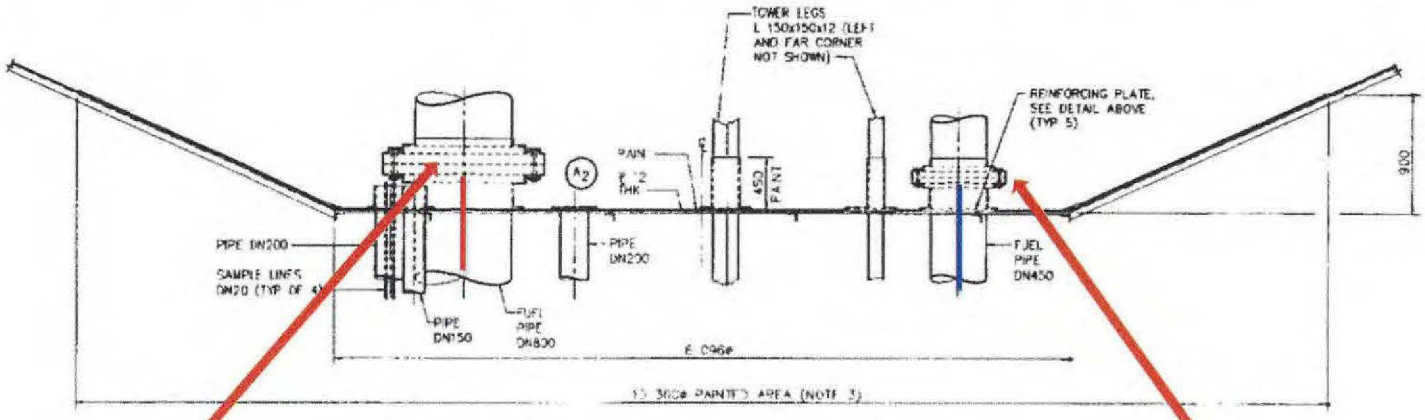


Figure 3-3: Test Sections: Inside of tank detail.

4.0 TESTING PROTOCOL

4.1 Test Procedure

Testing procedures used were performed in conformance (In part) with United Facilities Criteria (UFC) UFC 3-460-03F (Reference 7.1), California State Fire Marshal's (CSFM's) Pressure Testing Requirements for Hazardous Liquid Pipelines (Reference 7.2), American Society of Mechanical Engineers (ASME) B31.3: Process Piping (Reference 7.3) & ASME B31.4: Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids (Reference 7.4) and with Section 3.4 of American Petroleum Institute's Recommend Practice 1110 (API RP-1110): Pressure Testing of Liquid Petroleum Pipelines (Reference 7.5).

These testing procedures are not normally applied to tanks, but cross country and process pipelines. Since a normal API-653 hydrostatic test was not feasible, these procedures were chosen.

The procedure on site also satisfies the Willbros Pressure Test Procedure NDT-3, Revision 9, Dated June 5, 2014. (Reference 7.6)

4.2 Test Criteria

The acceptance criteria for this project is based on criteria established (In part) in API RP-1110, CSFM, test volume and temperature compensation calculations, no visual evidence of leaks, and accepted industry practice.

This testing satisfies the requirements of UFC 3 460 03F for a five-year hydrostatic test.

The requirements for UFC are listed below:

> *2.3.3. Pipeline Testing. Pipelines must be tested annually for leaks. The MAJCOM fuels engineer may authorize an equivalent methodology as long as state environmental requirements are met. Pressure tests are affected by weather, so it is best to do them in the spring or fall when fuel, ground, and air temperatures are similar. An overcast day or early in the morning would be preferable to lessen the solar effects on aboveground lines. Maintain all leak test records in the LFM shop for five years unless environmental requirements dictate longer. Send copies of these records to the MAJCOM fuels engineer if requested. Use the following testing approach unless state requirements are more stringent:*
>
> > *2.3.3.1. Annual Pressure Testing. Pressure-test all on-base fuel piping systems annually using existing system pumps. Pressurize unloading, loading, transfer, and hydrant dispensing piping systems by running the appropriate pumps against a closed system until deadhead pressure is reached. Close appropriate valves to trap this pressure in the system, then turn off the pumps. NOTE: Some ball valves do not provide isolation and require a differential pressure (DP) to seat, so blind flanges may be required. Take pressure gauge readings within fifteen minutes after allowing sufficient time for the fuel pressure to stabilize. Visually check all aboveground piping and piping in concrete pits for leaks. Audibly check closed valves for sound as evidence of an internal valve leak. If no visible or audible leaks occur, then take pressure gauge readings every fifteen minutes for the first hour, and once every half-hour for the next hour. Total time for the pressure test will be two hours. Document all pressure tests by recording the following:*
> >
> > > *2.3.3.1.1. Name of system test (i.e., refuel header, defuel header, lateral pipelines). Provide facility number.*
> > >
> > > *2.3.3.1.2. Date of test and weather conditions (e.g., sunny and 27 [ ]C [80 °F]; cloudy and 18° C [64 °F]). NOTE: Record any weather change during the test period.*
> > >
> > > *2.3.3.1.3. Pressure readings:*
> > >
> > > > *2.3.3.1.3.1. Start (approximate local time) pressure.*

2.3.3.1.3.2. Fifteen minutes (approximate local time) pressure.

2.3.3.1.3.3. Thirty minutes (approximate local time) pressure.

2.3.3.1.3.4. Forty-five minutes (approximate local time) pressure.

2.3.3.1.3.5. One hour (approximate local time) pressure.

2.3.3.1.3.6. One and one-half hours (approximate local time) pressure.

2.3.3.1.3.7. Two hours (approximate local time) pressure.

2.3.3.2. Five-Year Hydrostatic Test. Perform a hydrostatic pressure test every five years on all underground fuel transfer pipelines (product is typically the test media for this test). The MAJCOM fuels engineer sets the specific year. A hand-operated hydraulic pump, or equivalent with a built-in reservoir tank supplies hydrostatic pressure. This takes the place of the annual pressure test. The hydrostatic test may be conducted using a dual-pressure, temperature-compensating pressure test conducted at the same pressure specified in paragraph 2.3.3.2.2 with MAJCOM fuels engineer approval. The test vendor must have an independent third-party review of the test.

2.3.3.2.1. To test the pipe, first isolate the section being tested with blind or spectacle flanges. If OBB valves will hold the pressure, blind flanging is not required. NOTE: filter/separators (F/Ss), thermal relief valves, safety valves, and sight glasses may have to be removed or isolated by blind/skillets.

2.3.3.2.2. Using a hand-operated hydrostatic pump, perform a static pressure test to the lesser of 1.5 times the system dead head pressure or 1.896 megapascals (275 pounds per square inch gauge) maximum. Use fuel to perform all tests. Pressure may also be applied with a dead- weight tester or suitable motor-driven pump.

2.3.3.2.3. Once the pressure is stabilized, record the pressure every 15 minutes for the first hour, every 30 minutes the second hour, then every hour thereafter. If at the end of the minimum four-hour test (the longest test possible is recommended preferably overnight) no leaks are found, further testing is not required. (Use the procedure described in paragraph 2.3.3.1.) If a leak or excessive pressure change is observed, perform a flow test by repressurizing the line with the hydrostatic pump. Measure and record the amount of fluid required to maintain this pressure for four hours. If a leak is found, contact the environmental flight and take action to repair it. Also, promptly notify the command fuels engineer and DESC if additional funding is required for repairs, leak detection, and or location. A drop in pressure could be the result of a decrease in product temperature or absorption by the product of air in the line. To rule this out, you may repressurize the line and extend the test period to at least 24 hours.

The requirement and the intent of the Regulation(s) is not just to strength test the pipeline or system; it is to confirm the tightness of the system to the extent possible, which is the reason we feel the test results under this cover are inconclusive at this time. (See test results)

The procedure and criteria used under this report cover is to calculate the tightness of the system by reconciling any pressure loss / gain with pipeline temperature, compressibility of the test media, pipeline material coefficient of expansion, and by converting fluid gain / loss into equivalent pressure change to ensure that the test results actually confirm or deny that the pipeline is suspected of leaking.

The calculations used are based on the CSFM Appendix C Standard Pressure / Temperature Formulas as shown below:

Appendix C – Standard Formulas used for Pressure / Temperature Calculations:

CSFM Standardized formula for performing pressure – temperature calculations to determine volume change.

Basic Formula: $\Delta V / V = Kp\ \Delta P + Kt\ \Delta T$

Where: $Kp = [(D / t)(6 / 4 - \mu) / E] + 1 / \beta = (1.9\ D / 2\ E\ t) + 1 / \beta$

And: $Kt = 3a - g$

ΔP	=	Liquid Pressure Change
ΔT	=	Liquid Temperature Change
ΔV	=	Liquid Volume added to that inside the pipe (negative if flows out)
V	=	Nominal Pipe Volume = $\pi D^2 L / 4$
D	=	Inside Pipe Diameter
L	=	Pipe Length
t	=	Pipe wall thickness
μ	=	Poisson's ratio = 0.3
E	=	Young's Modulus = 30 * 10^6 psi
β	=	Liquid Bulk Modulus, a function of Pressure and Temperature
g	=	Liquid Volumetric expansion coefficient, a function of Pressure and Temperature
a	=	Linear coefficient of Thermal Expansion = 6.5 * 10^{-6} $1/^{\circ}F$

4.3 Tester Qualifications

The supervisor on site (Dennis Cobb) during testing has over twenty (20) years of pressure testing experience with a working knowledge of applicable regulations and test standards.

4.4 Test Section Descriptions

Testing on the Tank 5 fuel issue / receipt lines was conducted on the dates indicated. Table 4-1: Test Sections and Appendix C provide details of each test section and configuration.

Table 4-1: Test Sections

Test Section Identification	Designation	Diameter (Inches)	Length (Feet)	Volume (Gallons)	Comments
14-332-01A & B	32"Ø F-76	32" / 20"	48	1838	Length was calculated by using the total volume pumped into the line sections as well as using the head pressure to determine the vertical rise, therfore the length is estimated.
14-332-02	18"Ø JP-8	18" / 12"	65 (Estimate 61' of 18"Ø & 4' of 12"Ø)	764	Length calculated same as the 32" line.

Note: Test sections could not be physically measured during testing because they are encased in concrete.

5.0 TESTING RESULTS

Detailed test results for the 18"Ø & 32"Ø test sections are provided in Appendix C. The 32"Ø test results are from the 4 hour test period on 6/26/14 from 20:00 to 24:00 and the theoretical test using the last 45 minutes of data from the following morning. The 18"Ø test results are from a test period derived from the datalogger data that was recorded overnight from 10:37 PM on 6/25/14 to 01:37 AM on 6/26/14. The result for both tests from the CSFM volume correction calculations is a passed test, however the result from

the temperature evaluation is a failed test. We feel that based on the conflicting results of the test calculations, the margin of error with the unknown variables such as actual volume of the reducers in the line and the actual pipe specification and grade, and the inherent margin of error with hydrotesting, that the result is inconclusive at this time. The rate of decay and non-stabilization could be the result of trapped air or a leak and it is impossible to determine which at this time.

Test results are listed in Table 5-1.

Table 5-1: Test Results

Test Section Identification	Designation	Length (Feet)	Volume (Gallons)	Test Date	Result
14-332-01A	32"Ø F-75	48	1838	6/26/14	Passed CSFM Volume Correction Calculations / Failed temperature – pressure evaluation. Inconclusive – Recommend Pneumatic testing to confirm presence of trapped vapor.
14-332-01B	32"Ø F-76	48	1838	6/27/14	Passed CSFM Volume Correction Calculations. Temperature – pressure evaluation results much closer than in Test A due to apparent stabilization overnight, however the final result remains inconclusive.
14-332-02	18"Ø JP-8	65	764	6/25/14 & 6/26/14	Passed CSFM Volume Correction Calculations / Failed temperature – pressure evaluation. Inconclusive – Recommend Pneumatic testing to confirm presence of trapped vapor.

5.1 Testing Activities

We attempted to pressurize, stabilize, and test both test sections several times and exhausted all known methods to obtain a successful hydrotest. We ensured that there were no leaks on any external feature that we could control and even modified our test equipment to ensure no air was trapped at that point that would affect the tests. Excessive amounts of time were expended trying to re-pressurize and stabilize to try and compress any trapped air in both test sections.

The following is the official test charts from the dataloggers for both test periods. The charts clearly show all pressurizations, depressurizations, logger movements to replace the flange gaskets, and the relative stability of the temperature in the tunnel while the temperature inside the tank fluctuated between 2-4°F indicating it was affected by the ambient air differences in the tank. Also seen clearly is the relative stability of all lines towards the end of the logging period for the 32"Ø test.

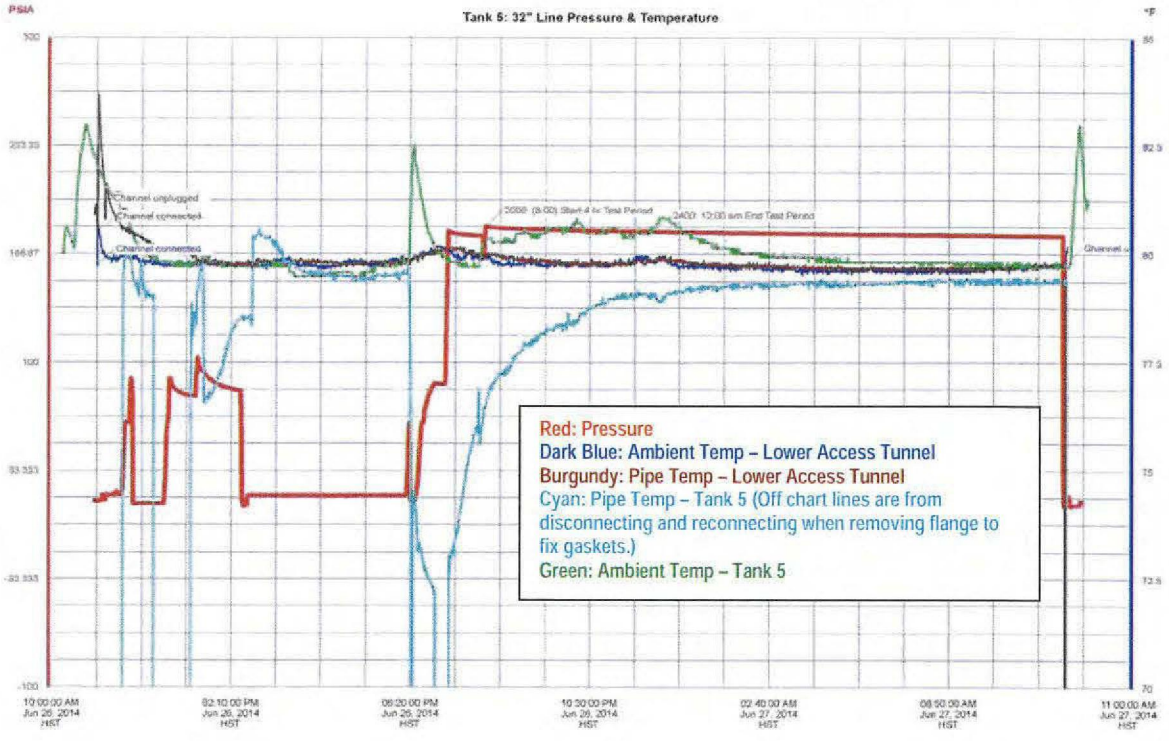


Figure 5-1: Test data chart from the 32"Ø testing attempts.

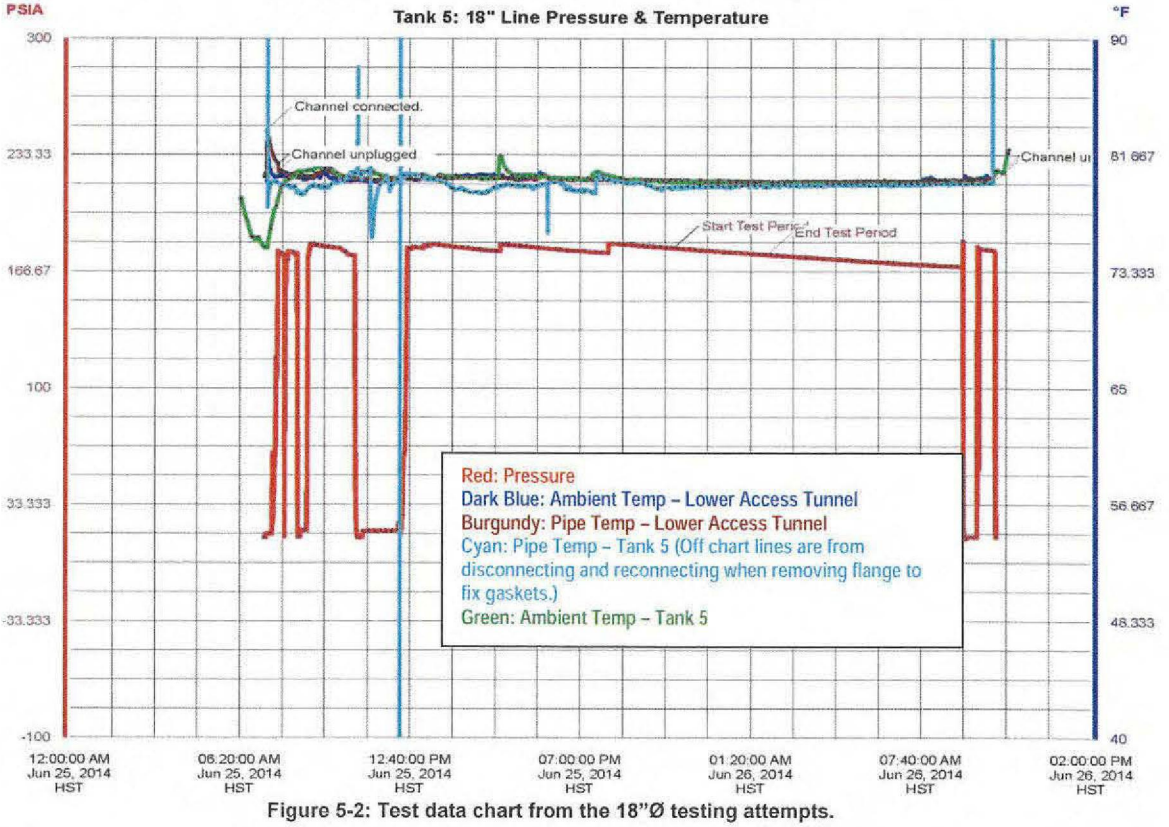


Figure 5-2: Test data chart from the 18"Ø testing attempts.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This hydrostatic pressure testing of the subject lines are not considered precision volumetric leak detection testing. The testing performed is classified as a point-in-time, pressure decay combination strength / stress / leak test of the line system against the test blinds to determine if there is a suspected leak to the extent possible.

Testing was performed per the jurisdictional regulatory requirements of United Facilities Criteria (UFC) UFC 3-460-03F (United Facilities Criteria) and the test procedures used were performed in conformance with (In part) API-RP-1110, CSFM (California State Fire Marshall – State Lands Commission Hydrotesting Procedures), and the Willbros Pressure Test Procedure: NDT-3.

The lines passed the CSFM volume correction calculations, however experienced pressure loss that could be attributed to trapped air in the test sections, which caused the pressure / temperature evaluation to fail. Because of this both tests are considered inconclusive at this time.

This determination is based on criteria established (In part) in API-RP-1110, CSFM, as well as, test volume and temperature compensation calculations, no visual evidence of leaks on exposed portions of the lines in the tunnel and inside of the tank, and accepted industry practice.

We were unable to stabilize either line due to suspected trapped vapor in the lines. We are forced to conclude at this time that trapped vapor is the cause of the pressure loss observed because of the extremely small rate of pressure loss and the rate of pressure loss decreased as time passed. It should be noted that a leak, if present, would also experience a decrease in the leak rate as the pressure decreased in the same manner as dissolution of trapped air into the test medium.

While this loss of pressure could be attributed to a small leak, a pneumatic test must be performed to rule exclude the possibility of trapped air before the line(s) can be considered a failure.

If the pneumatic test is successful then an engineering evaluation can be performed to accept the lines as a successful test using tracer testing or another method of leak detection that is not affected by trapped vapor.

If the pneumatic testing is not successful, the line(s) would then be considered a failure and must be repaired or taken out of service.

In addition, if the pneumatic testing proves successful and the determination is that the lie(s) are tight, that determination does not guarantee that the line(s) will

not leak in the future. This is important because there has been some visual evidence of pitting on the interior surface of the 32"Ø line prior to our arrival.

See the Section 6.2 titled "Recommendations" for a sample procedure used by PPSI on other projects to confirm or deny the existence of trapped air.

Figures 6-1 and 6-2 on the following two pages illustrate possible locations of trapped air in each test section for consideration. They are not meant to depict the actual configuration of the pipe sections.

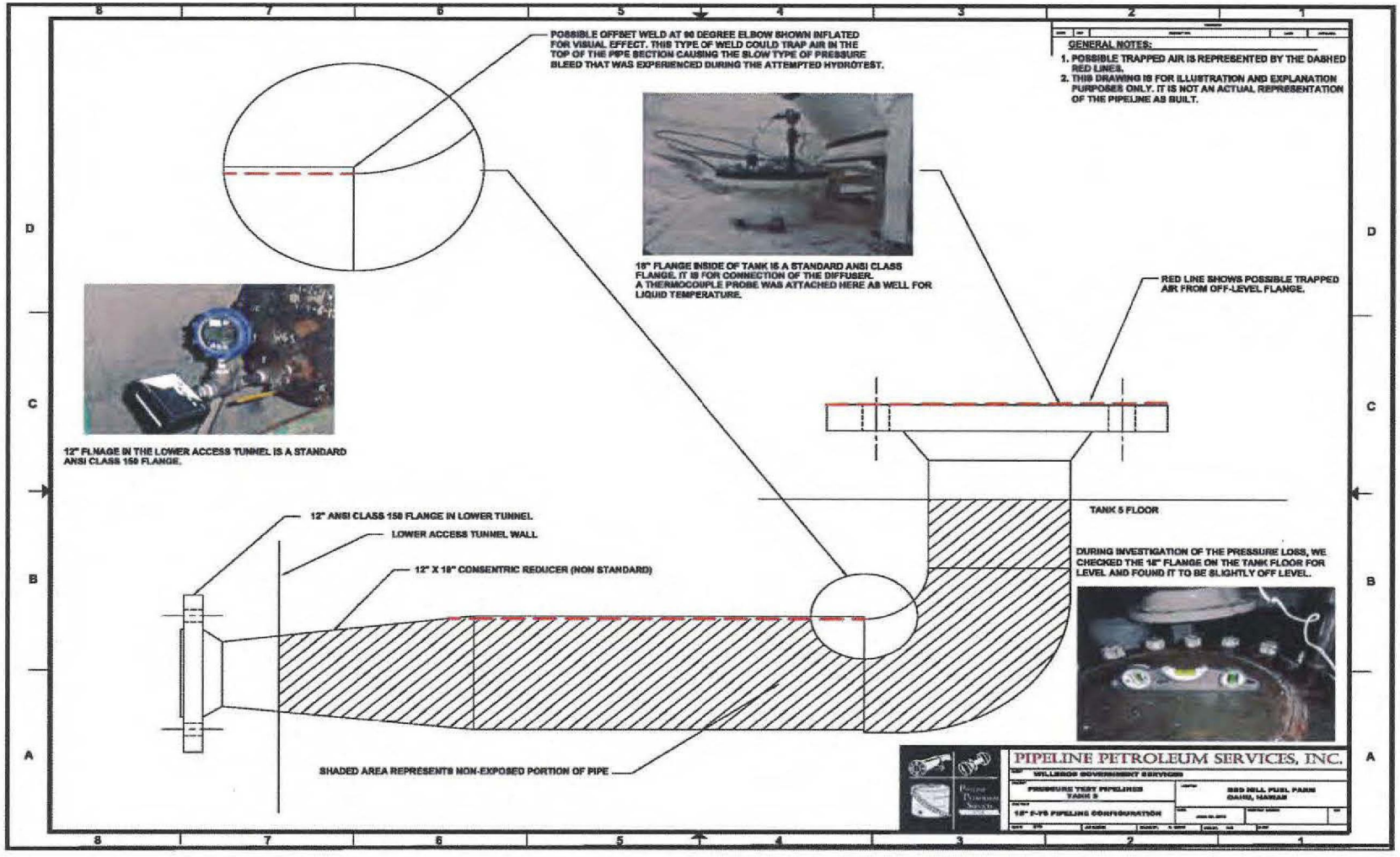


Figure 6-1: Drawing of the 18"Ø line explaining possible trapped air scenarios.

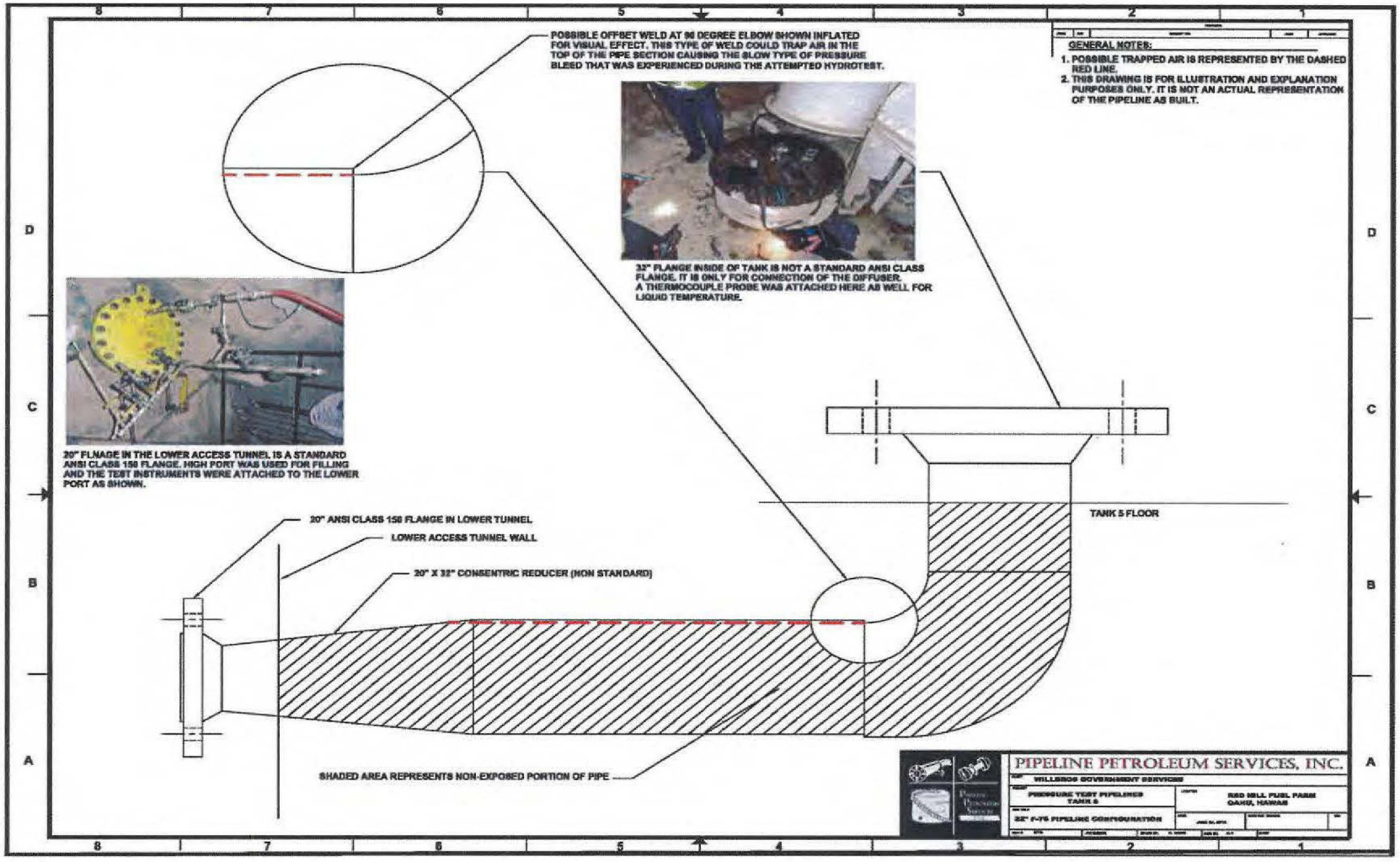


Figure 6-2: Drawing of the 32"Ø line explaining possible trapped air scenarios.

6.2 Recommendations

Due to our inability to stabilize the test sections at the Red Hill, Tank 5 site with trapped air hindering our hydro testing attempts, we recommend to use preliminary pneumatic tests to verify in the field if the lines were leaking or if the pressure loss was due to trapped air.

During the pressurization attempts and hydrostatic testing attempts, we followed an order of operations developed by PPSI using past experience to follow in case of pressure loss to determine in a logical order if the cause is a leaking valve, trapped air, or an actual leak in the line. We knew in this instance there was only two causes for the pressure loss; trapped air in the line or a leak. On each line test section we used the following order of operations in troubleshooting the loss of pressure:

1. Initial pressurization and air bleed. Allow reasonable stabilization period and repressurize if necessary.
2. Identify any suspect fittings or flanges / gaskets. Repressurize and stabilize.
3. Identify any other areas that could possibly trap air.
4. Repressurize final time.
5. **Next Recommendation:** Pump line down to extent possible and pressurize with compressed air to 25 psi and hold. If line does not experience a decrease in pressure with the compressed air, the problem is trapped air in the line and steps need to be taken to further modify the line so a successful hydro-test can be accomplished if that is the final desire.

Proposed Pneumatic Test Procedure

The following pneumatic test procedure has been developed and has been used by PPSI successfully several times at other sites.
ASME B 31.3 Section 345.5 addresses pneumatic testing as does ASME B 31.4 Section 437.4.3. Only the B 31.4 standard specifies a duration of one hour for a leak check.

I. Hydrostatic Testing Discontinue Criteria

1. Line is 100% isolated either by DBB valves (Check cavities for leaks), installation of skillets, or removal of valves and blinding. **Completed – testing up against ported test blinds.**
2. Air has been bled to extent possible and system investigated for other possible causes of pressure loss. **Completed – see notes in this report.**
3. Line has been pressurized up to 5 times in an attempt to stabilize and left overnight at least one night for stabilization. **Completed with no real success.**

II. Pneumatic Test Criteria

ASME B31.4 only allows for pneumatic testing for piping operated at a hoop stress less than 20% of the SMYS of the pipe. Since we don't know what the SMYS of this piping is, we will limit any pneumatic test pressures to 25 psi (IAW ASME B31.3). The purpose of this test is not to specifically satisfy ASME B31.4; it is to confirm the line is subjected to trapped air preventing a successful hydrotest and to confirm that the line is not actually leaking causing the loss of pressure in the initial hydrostatic test.

1. Pump as much liquid as possible from line after removal of the test blinds.
2. Test line at determined pressure for 4 hours. Soap all joints, flanges, and threaded fittings during test period. Test pressure as described in ASME documents is 110% of the design pressure or MAOP. Again, we feel a 25 psi test is more than sufficient to confirm trapped air in the hydrotest.

   Under the circumstances that we are proposing a pneumatic test and the intent that the pneumatic testing will be utilized, we feel that a 25 psi test would suffice for determining if the lines are leaking or not. Pneumatic testing is inherently dangerous and that risk factor is multiplied as the pressure increases.

3. Testing gas shall be compressed air as there is no petroleum in the line and the tank is currently out of service.
4. Pass / Fail criteria shall be no loss of pressure for duration. All visual inspection requirements remain the same.
5. All parties must concur with the test result.
6. ASME PCC-2 should be used to calculate a safe distance from the piping during testing. This area will be physically isolated for the test duration.

Should any questions about this report or the information contained herein arise, contact Mr. Dennis Cobb, Vice President / Owner at (757) 544-0831 or by email at dcobb@pipelinepsi.com.

7.0 REFERENCES

7.1 "Operation & Maintenance: Maintenance of Petroleum Systems" United Facilities Criteria (UFC) UFC 3-460-03F, January 2003

7.2 "Pressure Testing Requirements for Hazardous Liquid Pipelines in California", Office of the State Fire Marshal, Pipeline Safety Division, May 2011 Revision

7.3 American Society of Mechanical Engineers, "Standard B31.3: Process Piping", 2009

7.4 American Society of Mechanical Engineers, "Standard B31.4: Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids", 2009

7.5 American Petroleum Institute, "Recommended Practice 1110: Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, or Carbon Dioxide", Sixth Edition, February 2013

7.6 Willbros Government Services, "Pressure Test Procedure: NDT-3", Revision 9, June 5, 2014

APPENDIX A –

PROJECT PHOTOGRAPHS

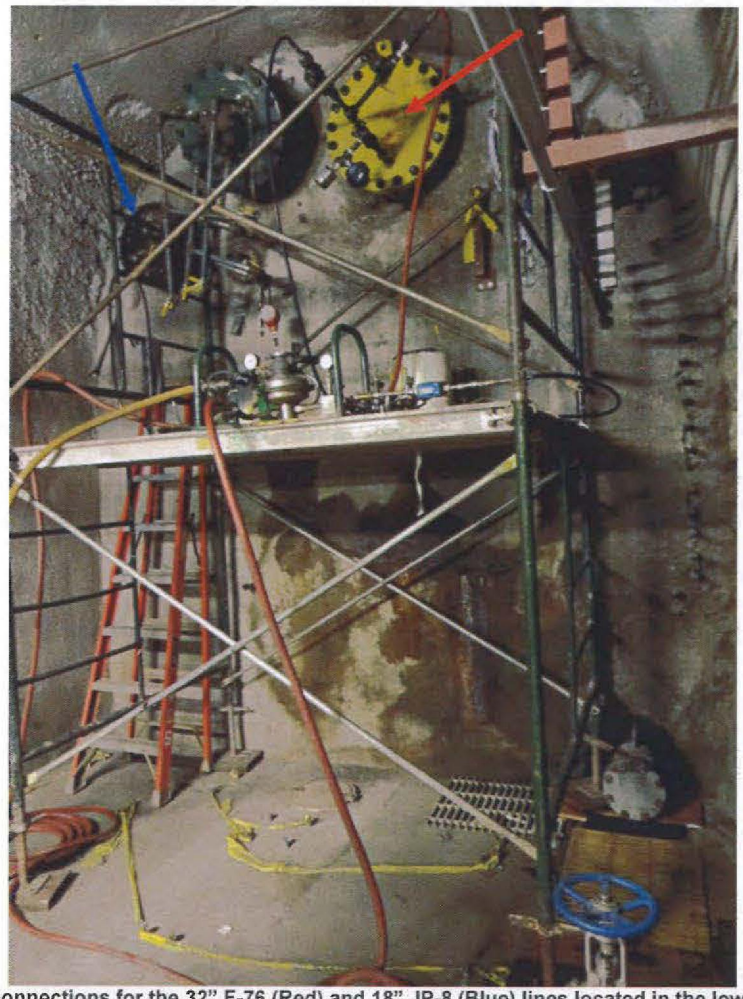


Figure 1.0: Test connections for the 32" F-76 (Red) and 18" JP-8 (Blue) lines located in the lower access tunnel.

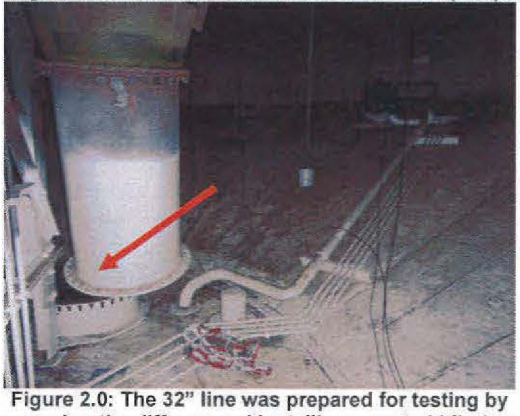


Figure 2.0: The 32" line was prepared for testing by removing the diffuser and installing a ported blind on the pipe flange as indicated. This connection was not a standard ANSI flange and required a custom ported blind to be fabricated. This flange was also not even and required several attempts to seal using different combinations of gaskets of various materials.

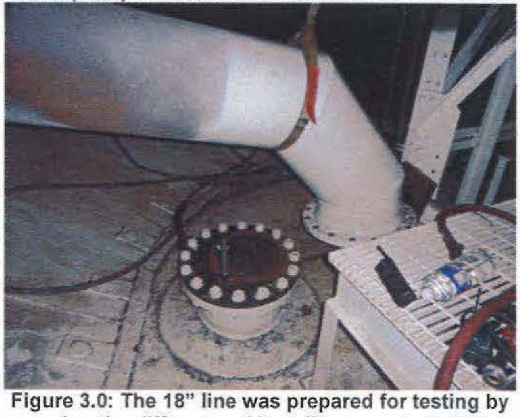


Figure 3.0: The 18" line was prepared for testing by removing the diffuser and installing a ported blind on the pipe flange as indicated. This connection was a standard ANSI Class 150 flange.

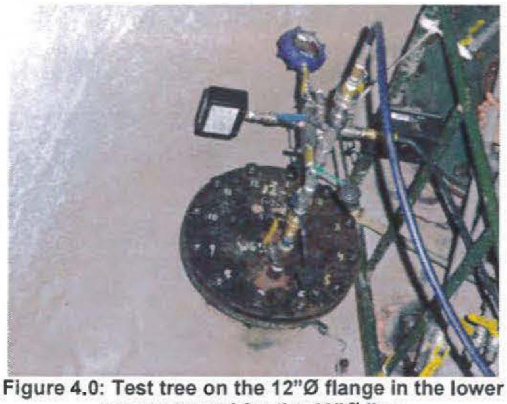


Figure 4.0: Test tree on the 12"Ø flange in the lower access tunnel for the 18"Ø line.

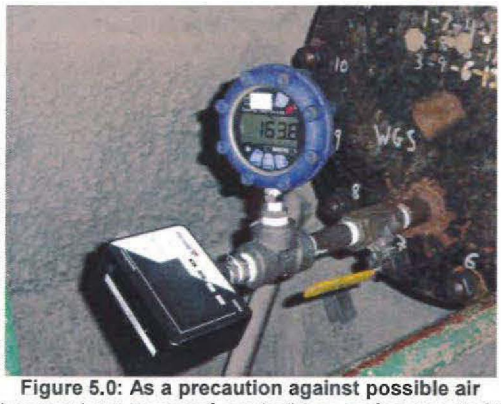


Figure 5.0: As a precaution against possible air entrapment, we removed our test tree and connected the test instruments directly to the pipe in an effort to stabilize the pipe. The efforts were not successful.

Figure 6.0: The 18"Ø line inside of Tank 5. Note temperature probe connected to the port on the blind flange.

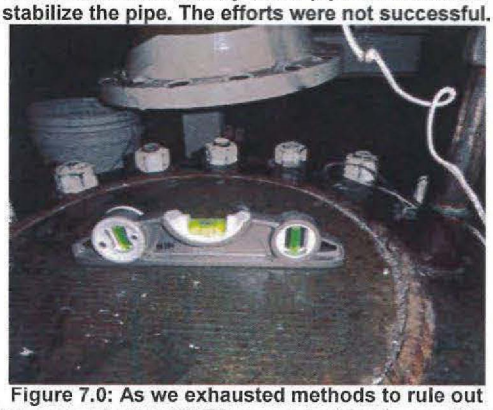


Figure 7.0: As we exhausted methods to rule out trapped air in the 18"Ø line, we decided to see if the level of the flange inside of the tank could trap a small amount of air and the conclusion is yes.
(See drawing 6-1)

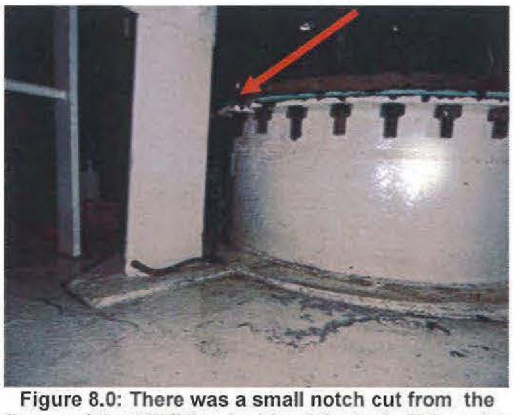


Figure 8.0: There was a small notch cut from the flange of the 32"Ø line inside of the tank. This notch was the source of some of the leaks that proved difficult to overcome on the 32"Ø flange.

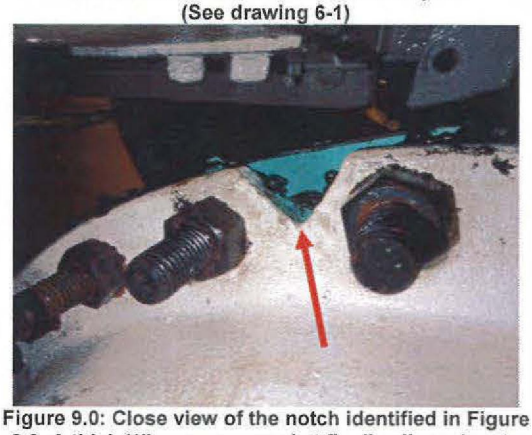


Figure 9.0: Close view of the notch identified in Figure 8.0. A thick ¼" neoprene gasket finally allowed us to seal the flange.

Figure 10.0: The 32"Ø pipe was drained just enough to remove the flange to change the gasket. We confirmed that there was little room for trapped air at this point.

Figure 11.0: The custom fabricated 32"Ø ported flange supplied by WGS is shown here.

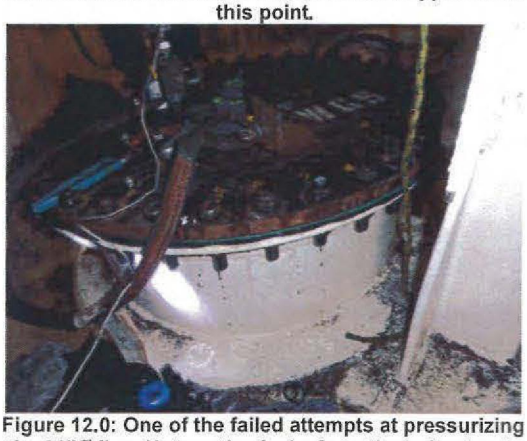


Figure 12.0: One of the failed attempts at pressurizing the 32"Ø line. Note active leaks form the bolts due to the gasket not ssealing.

Figure 13.0: 910 ml was drained from the 32" line during the DV / DP check.

APPENDIX B –

FIELD NOTES & DAILY ACTIVITIES

Willbros - Red Hill – Tank 5 Daily Notes Day 1 and 2

6/23/14 – **0600** – Onsite. We met with James Hagen (Willros). Take a tour of upper and lower tunnels and Tank 5 to familiarize ourselves with the site. **0800** – Meeting with NAVFAC, Navy, and Willbros personnel to discuss scope of work and safety. **0900** – Site walk through and evaluation with all personnel. **1200** – Connect test equipment to 20" flange (for 32" pipe) inside the lower access tunnel while connecting a temperature probe and bleeder equipment inside tank. **1323** – Start pumping water into line with 1" hose from water main inside of the lower access tunnel. **1546** – Pumped in approximately 1832.99 gals in thus far and 3.3 psi on the line. Personnel from inside the tank indicate that there are leaks coming from the bolts of the flange inside the tank. We stopped pumping water and secured. Crew decided to get a new gasket for the flange and change it tomorrow. **1700** – Left site for the day.

6/24/14 – **0600** – Onsite. Sign in and Safety briefing. **0700** – Wilbros personnel make up gasket for 32" flange from garlok material supplied by the facility (Per Scott Hedricks) and install it. There was estimated 3 gallons of water on tank floor due to leaking bolts the day before. Dry up water using buckets and rags. **0839** – Start pumping water into the line. **0842** – We have 1839.03 gals in and 48.7 psi on the line from the normal water main pressure. We bled off 2.12 gals (All Pressure – down to 0 psi) to allow crew inside of tank to put temp probe on line. Cut on water again from the main, added 2 gals and pressure went back up to 48.3 psi. **1022** – Start pressurizing line with pressure pump supplied by Willbros. Again, there were leaks inside tank from several bolts. We stopped operations. D. Cobb and James Hagen go into the tank to identify the leaks. **1111** – Bleed off pressure. It was confirmed that the gasket needed to be replaced with a different combination. **1245** – Crew went to get silicone and Willbros personnel make up 2 more gaskets. **1330** – D. Cobb, James and Willbros personnel entered tank to install new gaskets and apply silicone. Let sit overnight to fully cure. **1500** – Drain approximately 20 gallons from 32" line so flange can be removed. **1530** – Connect fittings and water hose to 12" flange (for 18" pipe). **1542** – Start pumping water into line. **1642** – Add 761.69 gallons to the line. Bleed air from the ported blind inside of tank. We disconnected the water hose and attached our pressure testing equipment / sensors to the pipe. **1700** – All personnel met upper level tunnel at Tank 5 and discuss the next day plan of work. **1745** – Left site for the day.

Willbros - Red Hill – Tank 5 Daily Notes Day 3

6/25/14 – **0600** – Onsite. Sign in and Safety briefing. **0700** – Start pressurizing 18" line from 0 psi to 47 psi with head pressure from water hose thru the pump (1.65 gals in). **0742** – Start pressuring up using pump. **0745** – Pressure at 102.2 psi (total 2.3 gals in). Bleed down 10 psi to 92.2 psi into measuring cup (340ml) for DV / DP check. Resume pressurizing line. **0747** – Pressure at 163.0 psi. (2.66 gals in) Let stabilize. **0800** – Pressure at 161.1 psi. Bleed air to 157.8 psi and re-pressurized. **0810** – Pressure at 162.8 psi (2.67 gals in total). Let Stabilize. We tightened up our pressure recorder (Madgetech Unit 1) after a minor drip was observed. Pressure is still decreasing. **0852** – Pressure at 160.2 psi, Re-pressurize again. **0857** – Pressure at 166.5 psi (2.68 gals in total). Let Stabilize. **0920** – **START TEST**.... Take first readings. **0921** – Crew inside of the tank called on radio, we have several more leaks from bolts on the flange inside the tank. Crew attempted to stop the leaks with hammer wrenches. **0935** – **STOP TEST!** D. Cobb and James Hagen went into the tank and identify leaks. They used hammer wrenches again to try to stop the leaks. **1030** – Pressure at 160.2 psi. **1035** – Pressure at 160.0 psi and still dropping. **1040** – Bleed off pressure and change gasket. **1220** – Start pressurizing line by using water thru the pump. **1235** – Pressure at 48.0 psi (3.95 gals in). Start using pump to pressure up line. **1238** – Pressure at 164.7 psi (4.29 gals in total). Let Stabilize. **1243** – Pressure at 164.2 psi, Re-pressurize to 165.3 (4.29 gals in total). Let Stabilize. **1308** – Pressure at 164.8 psi. Re-pressurize to 166.2 psi (4.29 gals in total). Let stabilize. **1325** – Pressure at 164.4 psi. Re-pressurize to 166.9 psi (4.29 gals in total). Let stabilize. **1559** – Pressure at 162.7 psi. **1600** – Re-pressurize to 166.9 psi (5.31 gals in total). Let stabilize. **1720** – Pressure at 164.9 psi. **1740** - Pressure at 164.5 psi. **1800** - Pressure at 163.9 psi. **1820** - Pressure at 163.6 psi. **1845** - Pressure at 163.1 psi. **1900** - Pressure at 162.7 psi. **1915** - Pressure at 162.5 psi. **1930** - Pressure at 162.3 psi. **1945** - Pressure at 161.9 psi. **2000** - Pressure at 161.6 psi. **2004** – Re-pressurize to 167.4 psi (5.33 gals in total). Let stabilize and left pressure on pipe overnight. **2030** – Secured for the day and left site.

Willbros - Red Hill – Tank 5 Daily Notes Day 4

6/26/14 – **0600** – Onsite. Sign in and Safety briefing. **0635** – Met with NAVFAC, Navy and Willbros personnel to discuss yesterday's actions and todays plan of work. **0725** – Descend into the lower tunnel to tank 5 and checked pressure gauges on 12" flange (for 18" line). **0735** – Ambient Temp: 79.9; Pipe Temp: 79.8 and Pressure was at 155.1 psi. **0802** – Ambient Temp: 79.9; Pipe Temp: 79.9 and Pressure was at 154.6 psi. **0830** – Inside tank Probe temp was 79.6. **0915** – Pressure at 153.5 psi. Pipe Temp: 79.9, and Ambient Temp: 79.9. We pressurized line to 170.1 psi. Closed off valve to the pipe and removed our test

equipment from the pipe. We also took the filters off our pressure recorder and digital gauge and directly installed into the pipe to make sure there was no source of air in our test tree. Bleed air and let stabilize at ***0945***. ***0950*** – Pressure at 163.9 psi. ***1005*** - Pressure at 163.5 psi. ***1020*** - Pressure at 163.3 psi. Inside tank Probe Temp: 79.7. ***1025*** – Line still losing pressure, bleed off pressure and stop all meters from running. ***1035*** - Switch out Aux temp recorder with crew inside the tank to move back to the 32" line. ***1100*** – Back in lower tunnel, activate our meters and set up our pressure recorder and digital gauge and directly installed into the 20" flange (for 32"line). ***1115*** – Crew inside of tank begin bleeding air from ported blind. ***1138*** – Start pressurizing line with water thru the pump. ***1143*** – Pressure at 48.1 psi (15.98 gals in total). ***1147*** – Start pressurizing line by using pump. ***1150*** – Pressure at 75.0 psi but decreasing. Got call from crew inside of the tank on radio. There are more leaks from 32" flange inside of tank. Bleed off pressure. ***1155*** – D. Cobb and James Hagen went to identify leaks in the tank. Attempt to tighten up bolts using knock wrenches. ***1235*** – Cut on water and pressurized the pipe thru the pump using only the main pressure. ***1241*** – Pressure at 48.0 psi (16.45 gals in total) ***1242*** – Start using the pump. ***1244*** – Pressure at 75.0 psi but decreasing. ***1320*** – Pressure at 64.0 psi. Start pressurizing. ***1322*** – Pressure at 75.0 psi (17.55 gals in total). Continue pumping. ***1323*** - Pressure at 87.6 psi (18.46 gals in total). Crew is still trying to tighten up bolts inside tank. ***1327*** - Pressure at 77.4 psi. Pressurize back up to 80.0 psi (19.16 gals in total). ***1423*** – Depressurize line – gasket is leaking from a triangle notch cut out of the flange inside of the tank. Drained out 5 gallons from line. Willbros crew went to get more material to make up thicker, more pliable gasket. ***1520*** – Drained out 5 gallons from line. ***1545*** – Crew makes up ¼ " gasket and install it on 32" flange inside tank. ***1806*** – Start filling up pipe with water thru the pump using water main pressure. ***1815*** – Pressure at 48.6 psi (10.25 gals in total). Stop the water. Bleed off pressure. ***1824*** – D. Cobb and James back in lower tunnel. Use the water to pressurize line thru the pump. ***1838*** – Pressure at 48.2 psi. (17.88 gals in total) Start pump up. ***1857*** – Pressure at 71.6 psi. (18.00 gals in total). We had to stop pumping and take the flow meter out and clean the turbine. ***1907*** – Place flow meter back in service and start pressurizing back up with pump. ***1912*** – Pressure at 165.0 psi (19.5 gals in total). Let stabilize. ***1935*** – Pressure at 163.0 psi. ***1950*** – Pressure at 162.5 psi. ***1956*** –Pressure at 162.2 psi. Bleed down to 162.2 psi for the DV / DP check. (910 ml drained out) ***1958*** – Pressure up line to 168.1 psi. (0.15 gals added in) ***2000*** – **START TEST**. Take readings every 15 mins for the 1st hr and 30 mins thereafter. (See gauge sheet). ***2400*** – **TEST COMPLETE**. Leave pressure on line over night because line never fully stabilized, even though the rate of decrease slowed.
0045 – Secure for the day and Left site.

Willbros - Red Hill – Tank 5 Daily Notes Day 5

6/27/14 – ***0900*** – Onsite. Sign in and Safety briefing. Met with Willbros personnel to discuss today's plan of work. ***0915*** – Descend into lower tunnel to tank 5 and checked pressure gauges on 20" flange (for 32" line). ***0930*** – Ambient Temp: 79.9; Pipe Temp: 79.9 and Pressure was at 162.3 psi. De-pressurize line and download data from dataloggers. Load up equipment in pelican case for shipping. 1020 – Mob to upper tunnel and secure tank. ***1120*** – Mob outside of upper tunnel. Review site actions over the past week. ***1200*** – Secure for the day. Left site.

APPENDIX C –

TEST ID 14-332-01A DETAILED TEST RESULTS
TEST ID 14-332-01B DETAILED TEST RESULTS
TEST ID 14-332-02 DETAILED TEST RESULTS

APPENDIX C –

TEST ID 14-332-01A DETAILED TEST RESULTS
TEST ID 14-332-01B DETAILED TEST RESULTS
TEST ID 14-332-02 DETAILED TEST RESULTS

PIPELINE PETROLEUM SERVICES, INC.
1324 Cavalier Blvd / PO BOX 6808
Chesapeake, VA 23323
Phone: (757) 544-0831

Pipeline Pressure Test Report - Test Summary

Form Revision Number: 6
Form Revision Date: 4-Jan-14

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

I. GENERAL TEST INFORMATION

Test ID No:	14-332-01A	Job No:	14-332	Type of Test:	Hydrostatic Pressure Decay (Hydrostatic x 150% MAWP, Hydraulic x 125% or 150% MAWP; Hydro-Pneumatic x 110% or 150% MAWP, Pneumatic x 110% MAWP; Pressure Decay, Strength Test, Leak Test, Spike Test, Ect.)
Minimum Test Duration: (Hrs)	4				
Date:	6/26/2014	Customer:	Willbros Government Services	Dwg Color Code:	None
Contract Number:	Willbros Contract # N62583-08-D-0132/003	System:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm, Oahu, HI
Test Medium:	Water				
Test Medium Source:	Water Line in Lower Access Tunnel	Tank #:	5	AST / UST:	UST
Test Medium Additives:	None	Specific Gravity: 141.5/(131.5 + Degrees API)	1	Product:	Water
		API Gravity:(141.5/SG)-131.5	10.00	Flash Point:	N/A
Included Pipe Sections or Laterals: (Test Section)	32" - F-76 service lateral to Tank 5 from the 20" flange at the wall of the Lower Access Tunnel to the 32" flange inside of the tank where the diverter was connected. (Diverter removed for the test)	Test Connection: (Location / Size / Type)	Ported test blind on the 20" flange located in the lower yard tunnel. Temp probe also placed inside of tank.		
Time Zone:	Hawaii	Country:	USA	Purpose of Test: (Annual Or Five-Year Requalification, New Commissioning, Post Repair, Other)	Possible Suspected Leak
Test Criteria: (Jurisdictional Regulation)	CSFM / UFC 3-460-03	Skillets Installed:	☐ Yes ☑ No		
(49 CFR 195.300, 49 CFR 192, 33 CFR 156.170, 33 CFR 154, 9-VAC-25-91, UFC 3-460-03, CCR: CA Code Regulations, State Code, Customer Policy, Project Specifications, Other)		Location(s): (List valve / tank number / ect.)	Valves and diffusers removed and test blinds installed.	Size:	
Test Procedure:	API RP-1110 / CSFM Guidelines / Willbros Test Procedure, Revision 9: June 5, 2014				
(API RP 1110, API-570, ASME B.31.1, ASME B31.3, ASME B31.4, ASME B B31.8, NFPA 329, CSFM, 49 CFR 195)					
Test Medium Disposal:	☐ Yes ☑ No	Disposal Company:	N/A		
Disposal Type & Amount (Gals):	Willbros will drain pipeline into portable totes for disposal outside of the tunnel.				

II. PIPE DESIGN DATA

System Design Data Code: (ASME B 31.1 (Power Piping) / B 31.3 (Process Piping) / B 31.4 (Liquid Fuels Transportation) / B 31.8 (Gas Transmission) / Other)					UNK - Assume ASME B31.3
Pipe Specification: (ASTM A53 (CS-Welded & Seamless) / A135 (ERW Pipe) / A312 (SS-Welded & Seamless) / API 5L (Welded & Seamless for Fuel Piping) / Other)					UNK - Assume API 5L ERW
Pipe Grade: (Pipe Grade A & B / Strength X42 - X60)	UNK	SMYS: (psi)	35,000	Pipe Information Source:	No pipe information was readily available from the facility.
Year Installed:	Circa 1943				

Known Repairs / Modifications:	Date:	Known Repairs / Modifications:	Date:
None known			

W_{JF} (Weld Joint Factor)	0.8	(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3) / Source:	Assumption		
D_F (Design Factor):	0.72	(.72 for Haz Liquid Pipelines per ASME B31.4 or State Other Criteria):	N/A		

III. TEST SECTIONS (If Loading Arm Present in Test Section Include Total Length & Volume from attachment I)

Pipe Section (Identification)	MP To (Location)	MP From (Location)	Nominal Pipe Ø (In)	Wall Thickness (In)	Outside Ø (In)	Inside Ø (In)	Pipe Material	Configuration (Buried-BG / Exposed-AG / Inside IN)	Length (Ft)	Section as % Total Pipe Length	Volume (Gallons)	Volume per Foot Pipe ID (Gal)	Length AG (%)(Ft)	Length BG (%)(Ft)	Length Inside (%)(Ft)
Non Exposed			32	0.375	32.000	31.25	CS / STD	Buried	44.0	91.67%	1753.12	39.84		44.0	
Nozzle Inside Tank			32	0.375	32.000	31.25	CS / STD	Inside	1.0	2.08%	39.84	39.84			1.0
Nozzle Outside Tank			20	0.375	20.000	19.25	CS / STD	Inside	3.0	6.25%	45.36	15.12			3.0
Total Pipe Sections in Test Section:		3	Averages:	0.375	31.250	27.250		Sum Of Factors:	1.00	Weight Of Factors: (=100%)				0.92	0.08
Total Volume Test Section (Gal):		1638.32	Total Volume Test Section (CF):		245.76	Total Length Test Section: (Ft)			48.0	Total Length AG / BG / Inside: (ft)				44.0	4.0
										Use Factoring For Volume Change & Pressure / Temperature Calculations		Total Number Factors:			2

Hydrostatic Pipeline Pressure Test Report 2014
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Pipeline Pressure Test Report (Continued)

IV. TEST PRESSURE INFORMATION

Test Pressure:(psi)	162.375	% SMYS:	19.33%	MAWP: (psi)	108.25	Stated MAOP:(psi)	108.25	Max System Design Pressure: (100% SMYS x WJF x DF)(Pipe Only - Does Not Include Fittings & Components)	484

How MAWP Determined: *(Customer Provided / Pipeline Questionnaire / SPCC Plan / Calculated / Pump Deadhead / PRV Settings / Other):* Max head from a full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

Does pipeline have a elevation difference of 100' or greater? ☐ Yes ☑ No

(If yes then attach profile drawing of the pipeline indicating locations of pressure sensors IAW 49 CFR 195 if applicable)

HP Elevation: (Ft)	9.5	Min Pressure @ High Point:	162.375	% SMYS:	19.33%
LP Elevation: (Ft)		Max Pressure @ Low Point:	166	% SMYS:	19.82%
Difference: (Ft)	9.5	Pressure at TE Elevation:	162	% SMYS:	19.33%
Test Equipment (TE) Elevation: (Ft)		9.24	*See Test Pressure Calculation Sheet*		

Flange Class: 150 lb

150 lb Class Flanges Max Test Pressure = 425 psi (MAOP: 275 psi) / 300 lb Class Flange Max Test Pressure = 1100 psi (MAOP: 720 psi)

Is Test Pneumatic or Hydro-Pneumatic? (Yes or No)	No	Joints / Welds Soaped? (Yes or No)	N/A
If Yes Use The Following Information if Test is Performed With Nitrogen:			
Estimated Volume of Nitrogen Needed From 0 psi to Test Pressure: (If Line Empty)(CF)	N/A	Equivalent Bottles:	N/A
+ 1 ATM) / 1 ATM = Volume CF of Nitrogen Needed (Note: 1 ATM = 14.7 psi)		Note: 1 Bottle = 300 CF	
Estimated Pipe Fill at Start of Pressurization: (%)(Existing product)		N/A	
Estimated Volume of Nitrogen Needed: (At Estimated Line Fill)	N/A	Equivalent Bottles:	N/A

Pressure Relief Valves: ☐ Yes ☑ No

ID	Size	Set Pressure	Location	Serial Number	Manufacturer

V. TEST SUMMARY

Weather (Test Start): Test Section Inside - Weather Not A Factor | Weather (Test End): N/A | Weather Comments: None

Note: Only Use Volume Calculations & Temperature Evaluation for Underground Hydrostatic or Hydraulic Testing (Not Applicable 100% AG Pipe for Pneumatic or Hydro-Pneumatic Testing).

Does Test Section Have UG Pipe? (Yes or No) Yes

Test Volume Calculation Summary: (See Attachment B)

Volume Calculated to Fill Pipeline: (DV / DP)(Gal)(If Empty)	1838.32	Actual Volume to Fill Pipeline: (Gallon)	1836.03	Difference:	-2.29	Difference: (%)	-0.12%
Volume Calculated to Reach Test Pressure from 0 PSI: (Pipeline must be full)(From Pre-Test Calculation Page):	1.6972 Gal	Difference:	17.7128 Gal	Pressurization DV/DP Diff (%) Volume:			91.26%
Actual Volume Required to Reach Test Pressure: (From Pre-Test Calculation Page):	19.41 Gal			Equivalent % Pipe Fill (At Pressurization >100% = Pipe Full)(<100% = Pipe has Trapped Vapor)			8.74%

Test Volume Correction Calculation Summary: (See Attachment B)

AVG Calculated DV / DP for Test Section: (Gal / psi) 0.0104524

dV/dP Change in volume with respect to pressure.

dP/dV (=1/dV/dP) (From Pre-Test Calcs)(psi/gal) = 95.67 PSI / Gal

dP/dV: Change in pressure with respect to volume.

dV/dT (From Pre-Test Calcs - Sum of all pipe sections)(gal/°F) = 0.203 Gal / °F

dV/dT: Change in volume with respect to temperature

dP/dT: =(dP/dV)x(dV/dT)(psi/°F) 19.44 PSI / °F

Change in pressure with respect to temperature

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)

1 Gallons = 95.67 PSI

Total Gal Drained = PSI

Equivalent Pressure Loss From Drained Amount: (Field DP / DV)

N/A Gallons = 41.87 PSI

Total Gal Drained = PSI

Pressure & Temperature Evaluation (From Attachment E)

Chg P expected = (°C converted to °F)	dP / dT		FChg T	°F =	Chg P	Change of Pressure Expected ▲P
	19.44	(psi / °F) x	-0.08		-1.63	

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.

Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail): Fail | Expected ▲ P: (Calculated Chg P) -1.6333

Total pressure differential (TPD) from Attachment A (Log Sheet) → | Observed ▲ P: (From Log Sheet) -3.2000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

Calculating Fluid Volume Gain / Loss (From Attachment F)

dV =Total Pipeline Volume*K_T*dT+ dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Gain	Actual Gain(+) / Loss(-)
Volume. Gain/8hrs	0.01	+		=	0.01	
Volume. Gain/hour	0.00	+		=	0.00	

Added or Subtracted During Test

CSFM Loss Allowable — Test Conclusion IAW CSFM / hr: Pass

Gal./hour 1.03 | Gal./8hours 8.22 | Test Conclusion IAW CSFM / 8 hrs: Pass

Test Acceptable: ☑ Yes ☐ No

(IAW Applicable Test Criteria & Regulation)

Test Readings Recap:

Start Test	Time:	2000	Start Pressure:	168	Average AG/IN Temp Start:	79.90	Average BG Temp Start:	79.90
End Test	Time:	2400	End Pressure:	164.8	Average AG/IN Temp End:	79.80	Average BG Temp End:	79.80
			Difference:	-3.2	Difference:	-0.10	Difference:	-0.10

Any Leaks or Weeps Detected During Pressurization or Test Period: ☑ Yes ☐ No

Remarks & Leak Corrections (Include Repairs Made Prior To Test): No visual leaks were identified on the test section after the 32" flange gasket inside of the tank was properly sealed. There was at least three periods of pressurization to allow for the gasket to be changed / replaced.

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Pipeline Pressure Test Report (Continued)

VI: ATTACHMENTS TO THIS REPORT: (All May Not Be Included or Required)

- [x] Attachment A / Test Pressure Calculations
- [x] Attachment B / Pre-Test Calculations & Pressurization Log
- [x] Attachment C / Pressure / Volume Plot
- [x] Attachment D / Pressure & Temp Log
- [x] Attachment E / Pressure & Temperature Evaluation
- [x] Attachment F / Volume Change Calculations
- [ ] Attachment G / Test Procedure & Valve Line-Up Sheet
- [ ] Attachment H / Loading Arm Information
- [ ] Attachment I / Photograph Page(s)
- [x] Pressure Graph
- [x] Temperature Graph
- [ ] Pipeline Elevation Drawing
- [x] Pipeline Test Section Drawing
- [ ] Test Equipment Drawing
- [ ] Disposal Manifest

VII: GENERAL TEST REMARKS: (List General Pipeline Condition / Recommendations from Visual Inspection)

Test considered inconclusive IAW applicable jurisdictional regulation, applied industry standards, and the intent of the test.

This is not a precision leak detection test and should not be considered as such. This hydrotest is considered a point-in-time, pressure decay, strength / stress / leak test against installed test blinds to determine if there are possible leaks at the stated MAOP / MAWP.

Test results are based on criteria established by (In Part) API-RP-1110, California State Fire Marshall Office (CSFM), as well as, calculated thermal pressure loss / gain, calculated volume loss / gain, no visual leaks identified in exposed piping during the test period, good engineering practice, and accepted industry practice. The pass/fail criteria may or may not be the required regulation however the criteria used is the accepted industry practice and is greater than or equal to the requirements in the jurisdictional regulation.

Initial pressurization attempted on 6/23/14 and the flange gasket inside of the tank began leaking at 60 psi when the pressurization pump was started. Attempts at tightening flange was unsuccessful. Remove flange and remove defective gasket. Install a rubber full faced gasket in conjunction with a new Garlok full faced gasket. Repressurize and this gasket combination began to leak at 75 psi. Remove flange for the second time and install two Garlok gaskets with high pressure / temperature silicone sealant between the flange face and gaskets and between the gaskets themselves.

The flange face is coated and uneven making proper sealing difficult. This combination leaked as well from a triangular notch that was cut out of the flange on the tank side of the pipe. The final configuration of a 1/4" thick neoprene gasket proved successful at sealing the flange for the test.

Interior of the pipe section was reported to be affected by corrosion pitting by the customer prior to our arrival and filling. This did not affect the test procedure and is added to this report only as additional information.

The line pressure never truly stabilized during the official test period, however the last 45 minutes of the following day (After the dataloggers were removed and the data recovered) appeared to achieve stabilization.

Evidence of the amount of trapped air in the line is the calculated volume to reach test pressure was approximately 1.7 gallons and it required over 19.4 gallons to reach test pressure which is equivalent to approximately 8.74% air by volume in the line.

We highly recommend a pneumatic test to confirm the existence of trapped air in the test section.

VIII: TEST EQUIPMENT INFORMATION: *(See drawing of testing apparatus if required and Calibration Certificates)*

All calibrations are performed third-party and are traceable to NIST.

Equipment Description:	PPSI Unit Number:	Manufacturer:	Serial Number:	Calibration Date:	Calibrated By:
Pipe Pressure Datalogger	Unit 1	MadgeTech	N84154	4/11/2014	Madgetech
4 Channel Temperature Datalogger (Thermocouple)	Unit 1	MadgeTech	N82430	8/21/2013	Madgetech
2 Channel Temperature Datalogger (Thermocouple)	Aux Unit 1	MadgeTech	N84147	8/20/2013	Madgetech
Digital Flowmeter / Totalizer (1/2")	Unit 3	GPI Industries	3206877	6/16/2014	Angels Instruments
Digital Flowmeter / Totalizer (1")	Unit 4	GPI Industries	3710745	6/16/2014	Angels Instruments
0-5000 psi Digital Deadweight Accurate Test Gauge	Unit 1	Crystal	870422	5/5/2014	Angels Instruments

IX: SIGNATURES

Tested By:	Dennis Cobb	Report Prepared By:	Dennis Cobb	Reviewed & Approved:	Dennis Cobb	Customer Witness:	James Hagen
Title:	Vice President	Title:	Vice President	Title	Vice President	Title:	Project Manager
Signed:		Signed:		Signed:		Company:	Willbros Government Services
						Signed: (If Required)	
Date:	6/26/2014	Date:	6/26/2014	Date:	6/26/2014	Date:	6/26/2014

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Piping Test Pressure Calculations (Attachment A)

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-01A	Test Section:	Tank 5 Fuel Piping - 32"
Dwg Code Color:	None	Customer:	Willbros Government Services
Date:	6/26/2014	Location:	Red Hill Fuel Farm
			Oahu, HI

TEST CALCULATIONS INPUT

NPS		32.000	in.	NPS= Nominal Pipe Size (Diameter Inches)
D	=	31.250	in.	D = Outside Diameter of pipe (in)(Avg of all sections x % total length)
t	=	0.375	in.	t = Pipe wall Thickness (in)(Avg of all sections x % total length)
W_{JF}	=	0.8		W_{JF} = Weld Joint Factor (From Report Page 1)(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3)
D_F	=	0.72		D_F = Design Factor (From Report Page 1)(.72 for Haz Liquid Pipelines per ASME B31.4)
SMYS	=	35,000	psi	SMYS = Specified Minimum Yield Strength (From Report Page 1)
P_{WP}	=	108.25	psi	P_{WP} = Maximum Working Pressure (psi)
G	=	1		G = Product (Test Medium) Specific Gravity
LE	=		feet	LE = Lowest elevation
HE	=	9.5	feet	HE = Highest elevation
TE	=	9.24	feet	TE = Test equipment elevation
▲E	=	9.5	feet	▲E = Elevation Difference (If pipeline has an elevation difference >100' attach pipeline profile dwg)

Describe How Elevations Determined: (Line of sight estimation, known data, current survey, information source, ect.)

Foot of hydrostatic head was calculated at 9.5' based on 4 psi static head pressure x .433 psi / ft (=9.24') + 6" at bottom of pipe not recorded by the gauge due to location of the gauge itself relative to the center of the pipe.

TEST PRESSURE CALCULATIONS RESULTS

Nominal Test Pressure: (PSI) 162.375

162.4	psi	Min. Pressure at High Point
166.5	psi	Max. Pressure at Low Point
162.5	psi	Pressure at Test Equipment Point
19.3%		Test Pressure as % SMYS
840.0	psi	100% SMYS
483.8	psi	Design Pressure (Calculated - Pipe Only)

Calculate Max Low Point Pressure:

(Factor .433 psi / ft for water or Total Ft x .433 (Specific Gravity: 1.0) or correct factor for other test medium):

Test Medium: Water

(Use Formula: p=.433(h)(SG) where p: Pressure / h: Head in Ft / SG: Specific Gravity Test Medium)

h: (Ft) 9.5

SG: 1

TEST RESULTS

P_{MAX}	=	168.0	psi	P_{MAX} = Maximum test gauge pressure
P_{MIN}	=	164.9	psi	P_{MIN} = Minimum test gauge pressure
Difference	=	-3.1	psi	

Remarks & Assumptions: We have to assume that the weld joint factor for this pipe is .08 for steel, however no data was available. We also have to assume that the design factor of .72 from ASME is the same because the line is in combustible liquid service.

Test pressure determined by max head from a full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

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PIPELINE PETROLEUM SERVICES, INC.

Pre-Test Calculations & Pressurization Log (Attachment B)

Note: Green cells that are blank indicate a value of 0 (Zero).

Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-01A	Dwg Code Color:	None
Customer:	Willbros Government Services	Date:	6/26/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm

Use this form to establish the pre-test DV/DP, line fill volume, and test pressure volume, as well as plot the actual DV/DP and fill volumes.

Calculated DV / DP Data

DV / DP (Change in Volume / Change in Pressure): DV / DP is defined as the change in volume for an associated change in pressure of a known volume under pressure. Two DV/DP calculations are used in these guidelines, a theoretical and a field value. A theoretical DV/DP will give the expected volume change for an associated change in pressure for the specified volume under test assuming that the volume under pressure is free of entrained gas. The field value of DV/DP is the actual volume change for an associated change in pressure for the specified volume under test. If air exists within the line under pressure, this value will be different than the theoretical value.

The theoretical DV/DP for aboveground (unrestrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t}\right)\left(\frac{5}{4} - \nu\right) + C\right]$$

The theoretical DV/DP for buried (restrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t}\right)(1 - \nu^2) + C\right]$$

where,

V = volume of the segment for the individual pipe diameter, D (gallons),
D = outside diameter of pipe (in),
E = elastic modulus of steel pipe (psi),
t = wall thickness of pipe (in),
ν = poisson's ratio of steel pipe,
C = compressibility of test media ($in^3/in^3/psi$).

NOTE: For a test segment with multiple diameters, sum the individual DV/DP's of each pipe diameter to obtain a total DV/DP for the entire test section.

Restrained Pipe (Underground) (Volume = 0.0408 x d² x L)		Unrestrained Pipe (Aboveground & Inside) (Volume = 0.0408 x d² x L)	
From Formula at Left (CSFM)		From Formula at Left (CSFM)	
V=	1753.12	V=	85.20
D=	31.25	D=	31.25
E=	2.95E+07	E=	2.95E+07
t=	0.375	t=	0.375
ν=	0.3	ν=	0.3
C=	3.11E-06	C=	3.11E-06
DV/DP=	0.000958516	DV/DP=	0.000493618
Weight of Restrained Pipe	0.92	Weight of Unrestrained Pipe:	0.08

(Values from Report Page 1)

AVG DV / DP for Test Section: (Gal) 0.0104524 (Use Avg DV/DP in Fill Chart - Page 3)

dV/dP: Change in volume with respect to pressure.

Use the Following Information for DV / DP Calculations - Values From Properties Charts Below

Test Medium:	Water		
B= Coef of Expansion:	1.23E-04	C=Compressibility of Test Media:	3.11E-06
Pipe Material #1:	Carbon Steel		
E = Elastic Modulus of Pipe #1 (PSI):			2.95E+07
ν = Poisson's Ratio of Pipe #1:			0.3
α = Linear Coefficient of Expansion: Pipe #1:			6.10E-06
Pipe Material #2:	N/A		
E = Elastic Modulus of Pipe #1 (PSI):			
ν = Poisson's Ratio of Pipe #1:			
α = Linear Coefficient of Expansion: Pipe #2:			
Number of Different Pipe Materials:			1
E Avg For Pipe Materials:			2.95E+07
ν Avg For Pipe Materials:			0.3
α Avg For Pipe Materials:			6.10E-06

Property Chart for Pipe Material

Pipe Material	Elastic Modulus: E	Coefficient of Expansion: a	Linear Coefficient of Expansion: α	Poisson's Ratio: ν
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	.27-.30
Stainless Steel	2.8E+07	9.60E-06		.30-.31
FRP	2.3E+06	1.16E-05	1.16E-05	0.33
Aluminum	1.00E+07			0.33

Property Chart for Test Medium

Test Medium	Compressibility: C = (1/β)	Bulk Modulus: (β)	Coefficient of Expansion: B	SG @ 60°F
JP-5 / JP-8	5.85E-06	1.71E+05	4.98E-04	0.81
Diesel	5.21E-06	1.92E+05	4.59E-04	0.85
Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Water	3.11E-06	3.22E+05	1.23E-04	1.00

Test Sections

Pipe Section (Identification)	Pipe Material	Nominal Pipe Ø (in)	Outside Ø (in)	Wall Thickness (in)	AVG Wall Thickness Exposed (AG)	AVG Wall Thickness Buried (BG)	AVG Wall Thickness Inside (IN)	dV/dT: Unrestrained (AG & IN) Pipe: Vx(B-3x) Restrained (Buried) Pipe: Vx(B-2x) (Total Last Cell)	Configuration (Buried-BG / Exposed-AG / Inside-IN)	Length (Ft)	Volume (Gallons)	Volume per Foot Pipe ID	Length AG (% Total Length)(Ft)	Length BG (% Total Length)(Ft)	Length Inside (% Total Length)(Ft)	Volume AG (% Total Length)(Ft)	Volume BG (% Total Length)(Ft)	Volume Inside (% Total Length)(Ft)
Non Exposed	CS / STD	32	32	0.375		0.375		0.196	Buried	44	1753.12	39.84		44			1753.12	
Nozzle Inside Tank	CS / STD	32	32	0.375			0.375	0.004	Inside	1	39.84	39.84			1			39.84
Nozzle Outside Tank	CS / STD	20	20	0.375			0.375	0.005	Inside	3	45.36	15.12			3			45.36
Total # AG Pipe Sections:						0.375	0.375	0.203	Total Length:	48	1838.32	Totals:		44	4		1753.12	85.20

Total # BG Pipe Sections:	1	AVG Wall AG & IN:	0.375	Note: AG & IN pipe is calculated as unrestrained.	
Total # IN Pipe Sections:	2	AVG Wall Buried:	0.375	Note: Buried (UG) pipe is calculated as restrained.	
Total # Pipe Sections:	3	Number Exposed Factors:	1		

dP/dV (=1/dV/dP) (dV/dP calculated above)(psi/gal) = 95.67

dP/dV: Change in pressure with respect to volume.

dV/dT (From above table - Sum of all pipe sections)(gal/°F) = 0.203

dV/dT: Change in volume with respect to temperature

dP/dT: =(dP/dV)x(dV/dT)(psi/°F) 19.44

Change in pressure with respect to temperature

Total Exposed Pipe Length: (AG & IN)	4	(Ft)	Total Exposed Volume: (AG & IN)	85.20	(Gal)
Total Non-Exposed Pipe Length: (UG)	44	(Ft)	Total Non-Exposed Volume: (UG)	1753.12	(Gal)

Total Volume to Fill Test Section (If Line Empty)(Gal): 1838.32

Test Pressure (From Report Page 1)(PSI): 162.375

Total Volume to Reach Test Pressure From 0 psi (Use DV / DP Chart Below)(Gal): 1.69721

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Pre-Test Calculations & Pressurization Log (Attachment B)(Page 2)

Field DV / DP Data

Field DV /DP: Before the test section is under full test pressure, a field value of DV / DP should be obtained. This value of DV/DP can be compared with the theoretical value of DV/DP calculated under section 3.5 (completed during pre-test calculations). A field value of DV/DP that is smaller than the theoretical DV/DP indicates an incorrect pressure reading, incorrect DV/DP calculation, or incorrect measurement of the volume under test. A field value of DV/DP that is greater than the theoretical DV/DP indicates the presence of entrapped air or other gas in the pipe section.

Obtaining Field DV / DP: During initial pressurization, the test section should be pressurized to approximately 50 psi and allowed to stabilize. Take an accurate pressure reading. Then bleed approximately 10 psi and allow the test section to stabilize. Take another accurate pressure reading. Carefully, measure the volume of the fluid that was bled and convert this to gallons if necessary. Take the volume bled and divide this number by the difference in the pressure readings. This is the field value of DV/DP.

Beginning Pressure: (psi)	162.2	Volume Bled (Gallons):	0.24			Field DV / DP:	0.024
Ending Pressure: (psi)	152.2	Equivalent Gallon / Unit Pressure (psi):	4.17	Gallon		Calculated DV / DP:	0.0104524
Difference: (psi)	10	Field Equivalent dP/dV (=1/dV/dP):	41.67	psi / Gal		Difference:	0.0135476
		Calculated dP/dV (=1/dV/dP):	95.67	psi / Gal			
		Percentage Difference:	0.44%				

Field DV/DP Acceptable (Must be Greater Than or Equal To Calculated): Yes

% Diff = (Difference/Subtrahend)*Difference

Air Entrapment Percentage: 0.18%

(Air entrapment percentage should be kept below 2% of total line volume if possible to increase the accuracy of the test. (API-RP-1110)(Pipe may be full or partially full at the beginning of pressurization. Bleed trapped vapor if possible or re-pack the line. Percentages over 100% = Line is packed or calculation error as described above.

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)				Equivalent Pressure Loss From Drained Amount: (Field DP / DV)			
1	Gallons =	95.67	PSI	1	Gallons =	41.67	PSI
	Total Gal Drained =		PSI		Total Gal Drained =		PSI

PRESSURIZATION DATA

Final Pressurization Log

DATE (mm/dd/yy)	TIME (24 hr) hr - min	Dead Weight Reading (psig)	Change in Pressure (psig)	Volume Metered (gal)	Volume Increment (gal)	Filling Totalizer Reading (gal)	Remarks
06/26/14	1838	48.7		17.88	17.88	17.88	Initial fill from main.
	1857	71.6	22.9	0.12	18.00	18.00	Pressurize with pump
	1912	165.0	93.4	1.50	19.50	19.50	
	1956	162.2	-2.8		19.50		
	1957	152.2	-10.0	-0.24	19.26		DV/DP check
	1958	168.1	15.9	0.15	19.41		
	2000	168.0	-0.1		19.41		Start Test
					19.41		
Start Test (Time & Press) (From Test Log)	2000	168		19.41	Final Volume Injected		

Is Pipeline Full? ☐ Yes ☑ No

Volume To Fill or Pack Pipeline: (Gal) 1836.03

Volume Fill Comments: See notes below for initial pressure.

Pressurize From 48.7 psi

Source of Initial Pressure:

Fill line with existing water main in the lower access tunnel. The maximum pressure from the water main is 48 psi. Allow water main to pressurize line after air was bled inside of tank.

General Pressurization Comments: (List any reasons for repressurization)(List injection media temp if different from the pipe temp at time of pressurization)

The listed values for pressurization are from the period of the evening of 6/26/14 even though initial filling took place on 6/23/14. There were several depressurizations and re-pressurizations due to the leaking gasket inside of the tank.

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Theoretical DV/DP (Test Pressure Fill Chart)(0-453 psi)

Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)
		51	0.53307417	101	1.0566969	151	1.578317627	201	2.100933857	252	2.634013523	302	3.159635254	352	3.679299984	403	4.21233115
1	0.010462435	51	0.53307417	101	1.0566969	151	1.578317627	202	2.111391792	252	2.634013523	302	3.159635254	353	3.689709419	404	4.222783584
2	0.020924869	52	0.5436286	102	1.06814833	152	1.588770081	203	2.12184427	253	2.644469957	303	3.170087588	354	3.700161853	405	4.233236019
3	0.031387304	53	0.55397903	103	1.07660077	153	1.599222496	204	2.132299961	254	2.654918392	304	3.1775412123	355	3.710614286	406	4.243688453
4	0.041809738	54	0.56443147	104	1.0870532	154	1.609674931	205	2.142749096	255	2.665370827	305	3.187992557	356	3.721066723	407	4.254140888
5	0.052262173	55	0.5748838	105	1.09750563	155	1.620127365	206	2.153201931	256	2.675823261	306	3.198444992	357	3.731519157	408	4.264593323
6	0.062714608	56	0.58533034	106	1.10795807	156	1.6305798	207	2.163653995	257	2.686275696	307	3.208897427	358	3.741971592	409	4.275045757
7	0.073167042	57	0.59578677	107	1.1184105	157	1.641032234	208	2.1741064	258	2.69672813	308	3.219349861	359	3.752424027	410	4.285498192
8	0.083619477	58	0.60624121	108	1.12886294	158	1.651484669	209	2.184558834	259	2.707180565	309	3.229802296	360	3.762876461	411	4.295950626
9	0.094071912	59	0.61669364	109	1.13931537	159	1.661937104	210	2.195011269	260	2.717633	310	3.24025473	361	3.773328896	412	4.306403061
10	0.104524346	60	0.62714608	110	1.14976781	160	1.672389538	211	2.205463704	261	2.728085434	311	3.250707165	362	3.783781333	413	4.316855496
11	0.114976781	61	0.63759851	111	1.16022024	161	1.682841973	212	2.215916138	262	2.738537869	312	3.2611596	363	3.794233765	414	4.327307931
12	0.125429215	62	0.64805095	112	1.17067268	162	1.693294408	213	2.226368573	263	2.748990304	313	3.271612034	364	3.8046862	415	4.337760365
13	0.13588165	63	0.65850338	113	1.18112511	163	1.703746842	214	2.236821007	264	2.759442738	314	3.282064469	365	3.815138634	416	4.3482128
14	0.146334085	64	0.66895582	114	1.19157755	164	1.714199277	215	2.247273442	265	2.769895173	315	3.292516904	366	3.825591069	417	4.358665234
15	0.156786519	65	0.67940825	115	1.20202998	165	1.724651711	216	2.257725877	266	2.780347607	316	3.302969338	367	3.836043503	418	4.369117669
16	0.167238954	66	0.68986068	116	1.21248242	166	1.735104146	217	2.268178311	267	2.790800042	317	3.313421773	368	3.846495938	419	4.379570103
17	0.177691388	67	0.70031312	117	1.22293485	167	1.745556581	218	2.278630745	268	2.801252477	318	3.323874207	369	3.856948373	420	4.390022538
18	0.188143823	68	0.71076555	118	1.23338728	168	1.756009015	219	2.289083181	269	2.811704911	319	3.334326642	370	3.867400807	421	4.400474973
19	0.198596258	69	0.72121799	119	1.24383972	169	1.76646145	220	2.299535615	270	2.822157346	320	3.344779077	371	3.877853242	422	4.410927407
20	0.209048692	70	0.73167042	120	1.25429215	170	1.776913884	221	2.309988805	271	2.83260978	321	3.355231511	372	3.888305677	423	4.421379842
21	0.219501127	71	0.74212286	121	1.26474458	171	1.787366319	222	2.320440484	272	2.843062215	322	3.365683946	373	3.898758111	424	4.431832276
22	0.229953562	72	0.75257529	122	1.27519702	172	1.797818754	223	2.330892919	273	2.85351465	323	3.37613638	374	3.909210546	425	4.442284711
23	0.240405996	73	0.76302773	123	1.28564946	173	1.808271188	224	2.341345354	274	2.863967084	324	3.386588815	375	3.91966298	426	4.452737146
24	0.250858431	74	0.77348016	124	1.29610189	174	1.818723623	225	2.351797788	275	2.874419519	325	3.39704125	376	3.930115415	427	4.46318958
25	0.261310865	75	0.7839326	125	1.30655433	175	1.829176058	226	2.362250223	276	2.884871954	326	3.407493684	377	3.94056785	428	4.473642015
26	0.2717633	76	0.79438503	126	1.31700676	176	1.839628492	227	2.372702657	277	2.895324388	327	3.417946119	378	3.951020284	429	4.48409445
27	0.282215736	77	0.80483747	127	1.3274592	177	1.850080927	228	2.383155092	278	2.905776823	328	3.428398554	379	3.961472719	430	4.494546884
28	0.292668169	78	0.8152899	128	1.33791163	178	1.860533361	229	2.393607527	279	2.916229257	329	3.438850988	380	3.971925153	431	4.504999319
29	0.303120604	79	0.82574233	129	1.34836407	179	1.870985796	230	2.404059961	280	2.926681692	330	3.449303423	381	3.982377588	432	4.515451753
30	0.313573038	80	0.83619477	130	1.3588165	180	1.881438231	231	2.414512396	281	2.937134127	331	3.459755857	382	3.992830023	433	4.525904188
31	0.324025473	81	0.8466472	131	1.36926893	181	1.891890665	232	2.424964831	282	2.947586561	332	3.470208292	383	4.003282457	434	4.536356623
32	0.334477908	82	0.85709964	132	1.37972137	182	1.9023431	233	2.435417265	283	2.958038996	333	3.480660727	384	4.013734892	435	4.546809057
33	0.344930342	83	0.86755207	133	1.3901738	183	1.912795534	234	2.4458697	284	2.96849143	334	3.491113161	385	4.024187327	436	4.557261492
34	0.355382777	84	0.87800451	134	1.40062624	184	1.923247969	235	2.456322134	285	2.978943865	335	3.501565596	386	4.034639761	437	4.567713926
35	0.365835212	85	0.88845694	135	1.41107867	185	1.933700404	236	2.466774569	286	2.9893963	336	3.51201803	387	4.045092196	438	4.578166361
36	0.376287646	86	0.89890938	136	1.42153111	186	1.944152838	237	2.477227004	287	2.999848734	337	3.522470465	388	4.05554463	439	4.588618796
37	0.386740081	87	0.90936181	137	1.43198354	187	1.954605273	238	2.487679438	288	3.010301169	338	3.5329229	389	4.065997065	440	4.59907123
38	0.397192515	88	0.91981425	138	1.44243598	188	1.965057707	239	2.498131873	289	3.020753604	339	3.543375334	390	4.0764495	441	4.609523665
39	0.40764495	89	0.93026668	139	1.45288841	189	1.975510142	240	2.508584307	290	3.031206038	340	3.553827769	391	4.086901934	442	4.6199761
40	0.418097385	90	0.94071912	140	1.46334085	190	1.985962577	241	2.519036742	291	3.041658473	341	3.564280203	392	4.097354369	443	4.630428534
41	0.428549819	91	0.95117155	141	1.47379328	191	1.996415011	242	2.529489177	292	3.052110907	342	3.574732638	393	4.107806803	444	4.640880969
42	0.439002254	92	0.96162398	142	1.48424572	192	2.006867446	243	2.539941611	293	3.062563342	343	3.585185073	394	4.118259238	445	4.651333403
43	0.449454688	93	0.97207642	143	1.49469815	193	2.017319881	244	2.550394046	294	3.073015777	344	3.595637507	395	4.128711673	446	4.661785838
44	0.459907123	94	0.98252885	144	1.50515059	194	2.027772315	245	2.560846481	295	3.083468211	345	3.606089942	396	4.139164107	447	4.672238273
45	0.470359558	95	0.99298129	145	1.51560302	195	2.03822475	246	2.571298915	296	3.093920646	346	3.616542377	397	4.149616542	448	4.682690707
46	0.480811992	96	1.00343372	146	1.52605545	196	2.048677184	247	2.58175135	297	3.10437308	347	3.626994811	398	4.160068977	449	4.693143142
47	0.491264427	97	1.01388616	147	1.53650789	197	2.059129619	248	2.592203784	298	3.114825515	348	3.637447246	399	4.170521411	450	4.703595576
48	0.501716861	98	1.02433859	148	1.54696032	198	2.069582054	249	2.602656219	299	3.12527795	349	3.64789968	400	4.180973846	451	4.714048011
49	0.512169296	99	1.03479103	149	1.55741276	199	2.080034488	250	2.613109654	300	3.135730384	350	3.658352115	401	4.19142628	452	4.724500446
50	0.522621731	100	1.04524346	150	1.56786519	200	2.090486923	251	2.623561088	301	3.146182819	351	3.66880455	402	4.201878715	453	4.73495288

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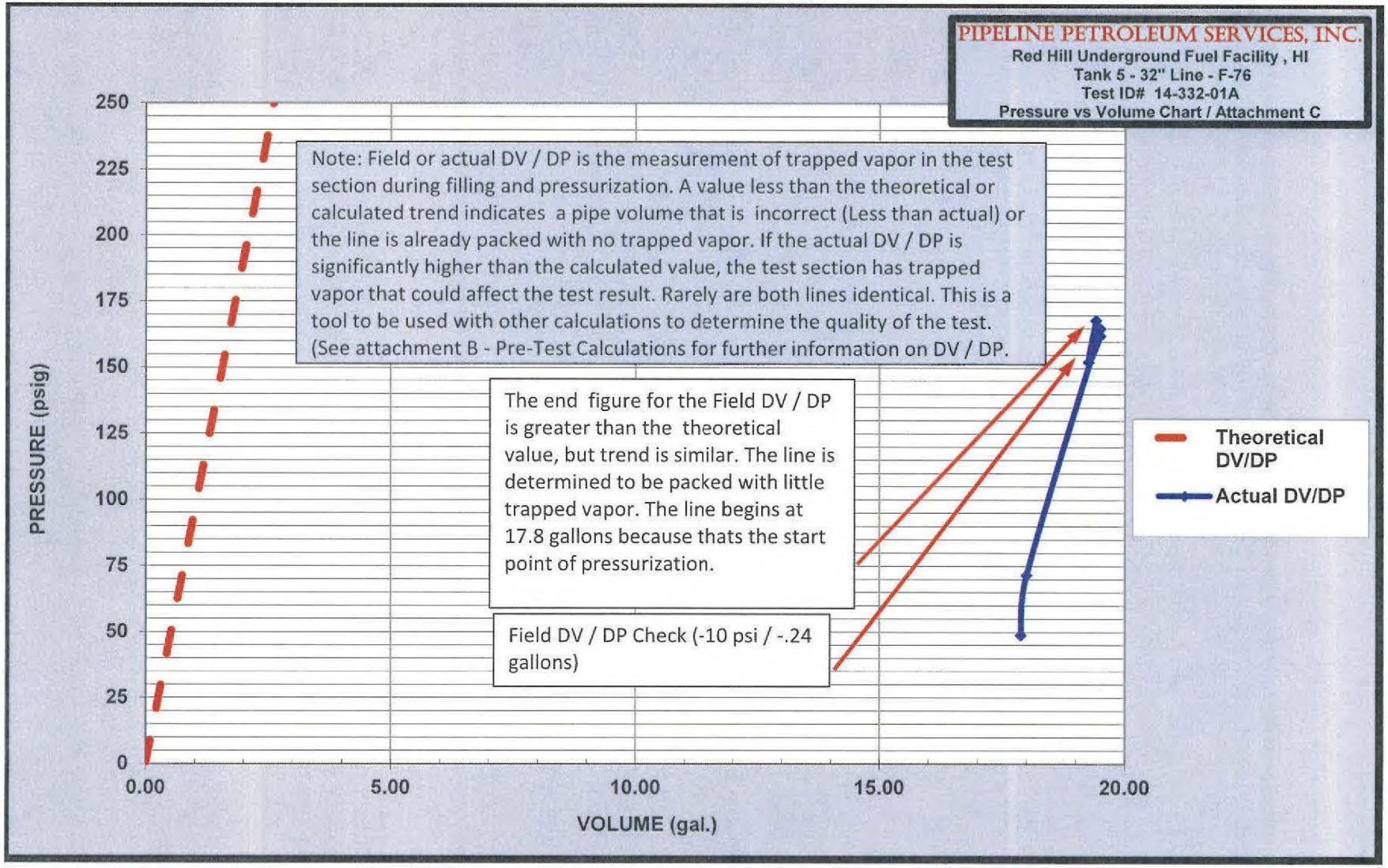
PIPELINE PETROLEUM SERVICES, INC.
Red Hill Underground Fuel Facility , HI
Tank 5 - 32" Line - F-76
Test ID# 14-332-01A
Pressure vs Volume Chart / Attachment C
Note: Field or actual DV / DP is the measurement of trapped vapor in the test section during filling and pressurization. A value less than the theoretical or calculated trend indicates a pipe volume that is incorrect (Less than actual) or the line is already packed with no trapped vapor. If the actual DV / DP is significantly higher than the calculated value, the test section has trapped vapor that could affect the test result. Rarely are both lines identical. This is a tool to be used with other calculations to determine the quality of the test. (See attachment B - Pre-Test Calculations for further information on DV / DP.
The end figure for the Field DV / DP is greater than the theoretical value, but trend is similar. The line is determined to be packed with little trapped vapor. The line begins at 17.8 gallons because thats the start point of pressurization.
Field DV / DP Check (-10 psi / -.24 gallons)
Theoretical DV/DP
Actual DV/DP
PRESSURE (psig)
250
225
200
175
150
125
100
75
50
25
0
0.00
5.00
10.00
15.00
20.00
VOLUME (gal.)

PIPELINE PETROLEUM SERVICES, INC.

Pipeline Pressure & Temperature Log (Attachment D)

Note: Enter readings every 15 minutes for first hour of test (Entries 1-5) and every 30 minutes for each hour there after.

Customer:	Willbros Government Services
Location:	Red Hill Fuel Farm
System:	Tank 5 Fuel Piping - 32"
Date:	6/26/2014
Test ID No:	14-332-01A
Dwg Color Code:	N/A

Pressure Location & Unit #:		Lower Yard Tunnel (Tank 5		Location 1 & Unit #: Lower Yard Tunnel (Tank 5)		Location 2 & Unit #:		Location 3 & Unit #:		Location 4 & Unit #:		Number AG/IN Sensors:	1	Initial Pressurization From:	48.7	PSI		
												Number BG Sensors:	1					
Entry ID Number	Time	Deadweight Pressure (psi)	Chart / Gauge Pressure (psig)	Aboveground / Exposed Pipe Temp (F) Location 1	Belowground / Non-Exposed Pipe Temp (F) Location 1	Aboveground / Exposed Pipe Temp (F) Location 2	Belowground / Non-Exposed Pipe Temp (F) Location 2	Aboveground / Exposed Pipe Temp (F) Location 3	Belowground / Non-Exposed Pipe Temp (F) Location 3	Aboveground / Exposed Pipe Temp (F) Location 4	Belowground / Non-Exposed Pipe Temp (F) Location 4	Inside Pipe Temp (F)	Ambient Temp (F)	Volume Added (Gal)	Volume Drained (Gal)	Percent Cloud Cover (0-100%)	Remarks (Weather Conditions)		
1	2000	168.0	*	79.90	79.90								79.90				Start Test	Time: 2000
2	2015	167.2		79.90	79.90								79.80				No weather effects - all piping is not exposed to the elements.	
3	2030	166.8		79.90	79.90								79.70					
4	2045	166.6		79.90	79.90								79.80					
5	2100	166.3		79.90	79.90								79.80					
6	2130	165.9		79.80	79.80								79.80					
7	2200	165.7		79.80	79.80								79.70					
8	2230	165.3		79.70	79.70								79.70					
9	2300	165.1		79.80	79.80								79.80					
10	2330	164.9		79.80	79.80								79.90					
11	2400	164.8		79.80	79.80								79.80					
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
	Final	164.8		79.80	79.80								79.80				End Test	Time: 2400
		PSI Diff		Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Total Added	Total Drained		Note: Average Temperatures are used in the calculations for the	
	Net Change	-3.2		-0.10	-0.10								-0.10				press / temp eval sheet and volume change calculations.	

Average AG/IN Temp Start:	79.90	Average AG/IN Temp End:	79.80	Average Temperature for Test: AG/IN:	79.85
Average BG Temp Start:	79.90	Average BG Temp End:	79.80	Average Temperature for Test: BG:	79.85

Net Volume Loss(+) / Gain (-):

Equivalent Pressure Loss From Drained Amount: (Field DP / DV)(Hydrotest Only)

1	Gallons =	41.67	PSI
	Total Gal Drained =		PSI

PSI Diff + PSI / Gal Equivalent from Drained Product (Calculated) = Total Pressure Differential (TPD)

TPD = -3.20 (Use on Evaluation Sheet - Attachment E)(Hydrotest Only)

Remarks: (Explanation of Any Pressure Discontinuities)

* See attached recorder chart. Average AG Temperature includes both Inside and Aboveground / Exposed Temperatures. (If needed)

Used the same temperatures for AG & BG pipe from the dataloggers in the tunnel and inside of the tank because there was no practical way to actually measure the temperature of the piping as it was encased in concrete. Due to the non-exposed nature of all of the piping we feel the temperatures should be very close to each other given the amount of stabilization time allowed.

Left pressure on the line from 1200 AM (Pressure 164.8 psi / Pipe temp: 79.07 + 79.1) to 0930 AM the next morning (June 27) and the pressure was at 163.4 psi with a pipe temperature of 79.34+ 79.718.

Note: Line never fully stabilized.

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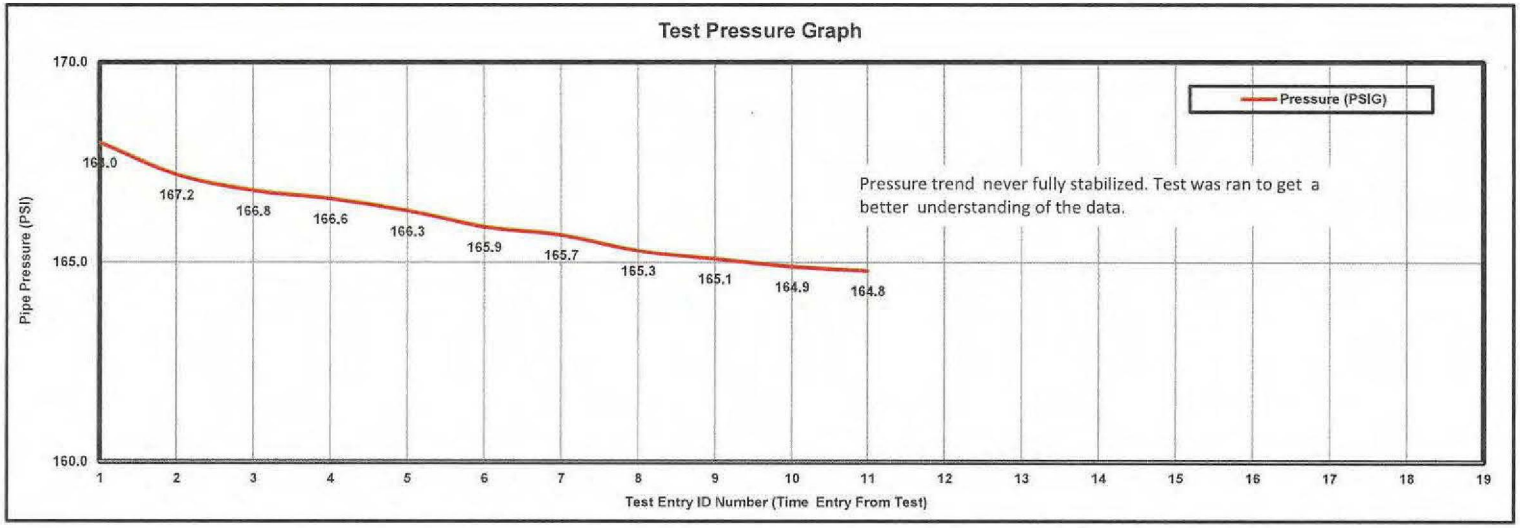

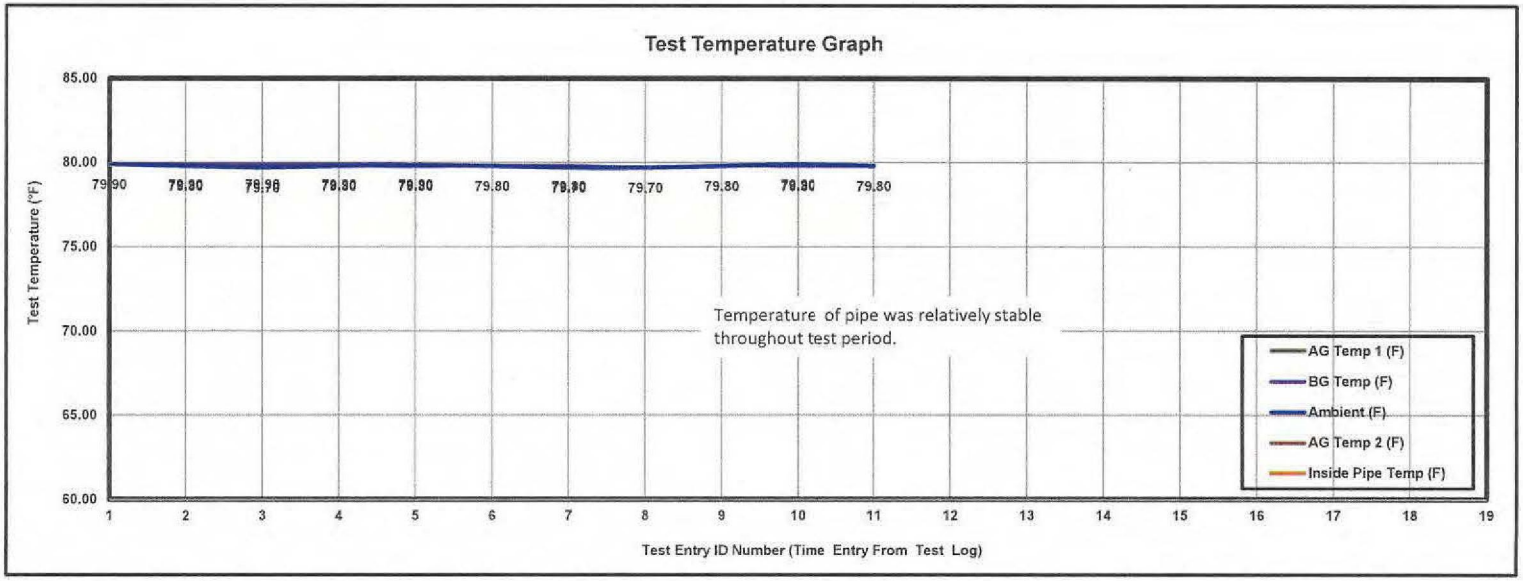

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PIPELINE PETROLEUM SERVICES, INC.

Hydrostatic Test Pressure and Temperature Evaluation Form (Attachment E)

Test ID Number:	14-332-01A	**Dwg Color Code:**	None	**Date:**	6/26/14
Customer:	Willbros Government Services	**Location:**	Red Hill Fuel Farm		
System Under Evaluation:	Tank 5 Fuel Piping - 32"				

Test Data:

Test Medium: (Water, Diesel, Gasoline, JP-5, JP-8, Kerosene, Other):	Water
Pipeline Total Length: ("L"): (All Test Sections)	48
Pipe Outside Diameter: ("D"): (Average From All Test Sections)	31.250
Pipe Wall Thickness: ("t"): (Average From All Test Sections)	0.375
D/t Ratio: (Pipe Ø / "t"): (Average From All Test Sections)	83.33
Pipeline Total Volume: (From Report Page 1)	1838.32

IN: Inside Pipe Temp
AG: Aboveground Pipe Temp
BG: Below Ground Pipe Temp
TL: Total Length
▲P: Pressure Change
▲T: Temperature Change
All temp in degrees Fahrenheit unless noted
All pressure in lb/in² (psi) unless noted

Beginning Test Pressure: ("Pb"):	168	**Ending Test Pressure: ("Pe"):**		164.8
Observed Pressure Change (Attachment A): (Change P observed = Pe - Pb):			-3.2	**▲P (PSI)**
Beginning Test Temperature AG: ("Tb AG"):	79.90	**Ending Test Temp AG: ("Te AG"):**		79.80
Length AG:		**Percent Total Length: (Length AG / Total Length): % TL AG:**		
Beginning Test Temperature BG: ("Tb BG"):	79.90	**Ending Test Temp BG: ("Te BG"):**		79.80
Length BG:	44	**Percent Total Length: (Length BG / Total Length): % TL BG:**		92%
Beginning Test Temperature Inside: ("Tb IN"):		**Ending Test Temp IN: ("Te IN"):**		
Length IN:	4	**Percent Total Length: (Length IN / Total Length): % TL IN:**		8%

▲T-AG: (Chg T=Te -Tb)	-0.10	**x %TL AG:**		**= Adjusted Average AG ▲T:**	
▲T-BG: (Chg T=Te -Tb)	-0.10	**x %TL BG:**	92%	**= Adjusted Average BG ▲T:**	-0.09
▲T-IN: (Chg T=Te -Tb)		**x %TL IN:**	8%	**= Adjusted Average IN ▲T:**	

(Final (FChg T) = Adjusted Avg AG ▲T + Adjusted Avg BG ▲T + Adjusted Avg IN ▲T / 3) **FChg T:** -0.08 **▲T (° F)**

Average Temp (T avg)	**(Tb AG + Tb BG + Tb IN) / 3 =**	76.20	**Tb**	Note: IN & AG are averaged together based on weighting factors.
	(Te AG + Te BG + Te IN) / 3 =	76.10	**Te**	
Average Fluid / Pipe Temperature (T avg = (Te + Tb) / 2):			**T avg:** 76.15	(For Test Duration)

Using T avg and D/t, find dP / dT from temperature compensation charts (exhibit 100,101,102, 103, 104, or 105) or calculate for the appropriate test medium:

dP / dT = 19.44 psi / ° F From Pre-Test Calculations - Attachment B

Formula for dP / dT Chart Development or Calculation used in Attachment B:

$$dP = \frac{[B-2a]/[Dx(1-v^2)/Et+C]}{T}$$

Formula and Results Validated by UFC 3-460-03 Section 9-3.5 / Pressure Relief Valves and CA State Hydrostatic Testing Worksheet. (Different Formula Variation)

dP=psig change per degree C or F
B=Coefficient of expansion of test medium
D=Pipe OD in inches
E=Modulus of elasticity for pipe material
v=Poisson's ratio, 0.3 for steel pipe
C=Compressibility factor for water (Or other test med), cu in/cu in/psig
a=Coefficient of expansion for steel,
t=Pipe wall thickness, in
T=Temperature, degrees C or F (20°C)(Or Tavg for test duration above)
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water	B=	1.23E-04	Bulk Modulus (β):	321,543
		C= (1/β)	3.11E-06	(Reciprocal of the Bulk Modulus (β) in lb/in²)	
Pipe Material #1:	Carbon Steel	E=	2.95E+07	a =	6.50E-06
Pipe Material #2:	N/A	E=		a =	
Pipe Material #3:	N/A	E=		a =	

List all Pipe Material & Test Medium Assumptions Made for Test Calculations: The type and grade of pipe material was assumed because no hard data was available from the original construction of the facility.

Test Variables for Calculations (Pipe Material Physical Properties from *(in part)* Appendix C, ASME B 31.3)

Pipe Material	E	a (in/in/°F)	α (Linear)	Test Medium	C = (1/β)	Bulk Modulus (β):	B (° F)	SG @ 60°F
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	JP-5 / JP-8 / Jet-A / Kerosene	5.18E-06	1.93E+05	4.98E-04	0.81
Stainless Steel	2.8E+07	9.60E-06		Diesel - LSD / ULSD / Dyed	5.21E-06	1.92E+05	4.59E-04	0.85
FRP	2.3E+06	1.16E-05		Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Aluminum	1.00E+07			Water	3.11E-06	3.22E+05	1.23E-04	1.00
Other				Other				

Calculate the expected pressure change: *Chg P expected = dP / dT x FChg T*

Figure corrected for various diameters of pipe within test section.

Chg P expected =	*dP / dT*		*FChg T*		*Chg P*	
(°C converted to °F)	19.44	(psi / °F) x	-0.08	°F =	-1.63	psi - Expected ▲P

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.
Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail): Fail **Expected ▲P:** (Calculated Chg P) -1.6333

Total pressure differential (TPD) from Attachment A (Log Sheet) → **Observed ▲P:** (From Log Sheet) -3.2000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

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Hydrostatic Test Volume Change Calculations (Attachment F) Page 1 of 2

Test ID Number:	14-332-01A	Dwg Code Color:	None
Customer:	Willbros Government Services	Date:	6/26/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm

Volume Change Calculations for Pipeline Hydrostatic Test (Calculated Volume/Pressure Slope Method)

Standard Formula: ▲V / V = Kp▲P + Kt▲T

Where: Kp = [(D/t)(5/4 -μ) / E] + 1/β = (1.9D / 2Et) + 1/β

And: Kt = 3a - g

▲P = Liquid Pressure Change
▲T = Liquid Temperature Change
▲V = Liquid Volume Added to Inside of Pipe (Negative if Flows Out)
V= Nominal Pipeline Volume (πD²L/4)
D= Inside Pipe Diameter
L= Pipe Length
t = Pipe Wall Thickness
μ = Poisson's Ratio = 0.3
E = Young's Modulus = 30x10^6 psi
β = Liquid Bulk Modulus, a function of Press & Temp
g = Liquid Volumetric Expansion Coefficient, a Function of Press & Temp
a = Linear Coefficient of Thermal Expansion
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water				Pipe Material:	Carbon Steel
API Gravity: (141.5/SG)-131.5	Specific Gravity: SG 141.5/(131.5+Degrees API)	ρ (SG x 1000)	(Liquid Coefficient of Expansion) B & g =	Compressibility: C = (1/β)	(Young's Modulus) E=	Linear Coefficient of Expansion: a=
10.00	0.9990	999.012	1.23E-04	3.11E-06	2.95E+07	6.50E-06

Pipe Data			Test Date	6/26/2014	API Gravity	10.00
Pipe Segment	Ø Outside (In)	Ø Inside (In)	Wall (In)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	32	31.250	0.375	44	1753.12	Buried
Nozzle Inside Tank	32	31.250	0.375	1	39.84	Inside
Nozzle Outside Tank	20	19.250	0.375	3	45.36	Inside
			Totals	48	1838.32	

Weighting for Pipeline Segment	% Total Length	Configuration	Buried	Exposed	Inside
Non Exposed	0.95	Buried	0.95		
Nozzle Inside Tank	0.02	Inside			0.02
Nozzle Outside Tank	0.02	Inside			0.02
Sum of Factors	1.00		Weight Factors	0.95		0.05

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected T1	DT1	
79.9	79.9		76.20	16.1900118	AVG. T
Final Test Temperatures					76.15
Buried	Exposed	Inside	Final Corrected T2	DT2	
79.8	79.8		76.10	16.0946465	

Corrected Temperature Difference	-0.10

NOTE: PIPE TYPE

	E	a
Carbon Steel	2.95E+07	6.50E-06
Stainless Steel	2.8E+07	9.60E-06
FRP	2.3E+06	1.16E-05
Aluminum	1.00E+07	

Test Pressure Difference

Initial Pressure P1	Final Pressure P2	dPressure
168	164.8	-3.2

Calculate (Kp)=(1.9D/2Et)+1β weighted value

Kp (1/P)

Calculating C_{PL}	C_{PL} 1	C_{PL} 2
C_{PL} = 1/(1-F_P*P) or Kp (1/P)=	1.0006114	1.0005996

Compressibility Factor (1/BETA) or (1β)

F_P 1	F_P 2
3.637E-06	3.636E-06

Calculate (Kt)=(3a-g) a=constant

Calculating C_{TL}	C_{TL} 1	C_{TL} 2	Coefficient Of Linear Expansion	Temperature Correction Factor (c)
C_{TL} = Exp(-α_{60}*DT*(1+0.8*α_{60}*(DT+δ_{60}))) or Kt(1/F)=	0.9946333	0.9946650	a	α_{60}
			6.50E-06	3.31E-04

Test Duration
Hours
4.00

Calculating Fluid Volume Gain / Loss

dV =V2-V1=V0/(C_{PL}2*C_{TL}2)-V0/(C_{PL}1*C_{TL}1))	dV=Total Pipeline Volume*(Kp*dP+Kt*dT) ▲V / V = Total Pipeline Volume Kp▲P + Kt▲T		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume. Loss/8hrs	-0.04	+		=	-0.04	
Volume. Loss/hour	0.00	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable			
Gal./hour	1.03	Gal./8hours	8.22

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Hydrostatic Test Volume Change Calculations (Attachment C) Page 2 of 2

Test ID Number:	14-332-01A	Code Color:	None
Customer:	Willbros Government Services	Date:	6/26/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm

Volume Change Calculations for Jet Fuel Pipeline (measured volume/pressure slope method)

Pipe Data			Test Date	6/26/2014	API Gravity	10
Pipe Segment	Ø Outside (In)	Ø Inside (In)	Wall (In)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	32	31.250	0.375	44	1753.12	Buried
Nozzle Inside Tank	32	31.250	0.375	1	39.84	Inside
Nozzle Outside Tank	20	19.250	0.375	3	45.36	Inside
			Totals	48	1838.32	

Weighting for segment	% Total Length	Configuration	Buried	Exposed	Inside
Non Exposed	0.95	Buried	0.95		
Nozzle Inside Tank	0.02	Inside			0.02
Nozzle Outside Tank	0.02	Inside			0.02
Sum of Factors	1.00		Weight Factors	0.95		0.05

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected	DT1	
79.9	79.9		76.20	18.1900118	AVG. T
					76.15

Final Test Temperatures

Buried	Exposed	Inside	Final Corrected	DT2
79.8	79.8		76.10	18.0946465

Corrected Temperature Difference	*-0.10*

Test Pressure Difference

Initial Pressure	Final Pressure	dPressure	AVG. Pressure
168	164.8	-3.2	166.4

Use Reference from Test Data

dV/dP Slope Calculations (Values are From Test Data)

Initial Pressure	Final Pressure	Initial Vol.	Final Vol.	dV/dP
48.7	168	17.88	19.41	0.012824811

Calculating K_T	K_T		Coefficient Of Linear Expansion	Temperature Correction Factor	Test Duration
$K_T = 3\alpha - \alpha_{60}$	-0.0003115		α	α_{60}	Hours
			6.50E-06	3.31E-04	4.00

Calculating Fluid Volume Gain / Loss

dV =Total Pipeline Volume*K_T* dT+dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Gain	*Actual Gain(+) / Loss(-)*
Volume. Gain/8hrs	*0.01*	+		=	0.01	
Volume. Gain/hour	*0.00*	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable				Test Conclusion IAW CSFM / hr	Pass
Gal./hour	1.03	Gal./8hours	8.22	Test Conclusion IAW CSFM / 8 hrs	Pass

Note: Use this pass/fail criteria to assist in determining a successful test with the temperature evaluation.

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PIPELINE PETROLEUM SERVICES, INC.
1324 Cavalier Blvd / PO BOX 6808
Chesapeake, VA 23323
Phone: (757) 544-0831

Pipeline Pressure Test Report - Test Summary

Form Revision Number: 5
Form Revision Date: 4-Jan-14

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

I. GENERAL TEST INFORMATION

Test ID No:	14-332-01B	Job No:	14-332	Type of Test:	Hydrostatic Pressure Decay (Hydrostatic x 150% MAWP, Hydraulic x 125% or 150% MAWP) (Hydro-Pneumatic x 110% or 150% MAWP, Pneumatic x 110% MAWP) (Pressure Decay, Strength Test, Leak Test, Spike Test, Ect.)
Minimum Test Duration: (Hrs)	4				
Date:	6/27/2014	Customer:	Willbros Government Services		
Dwg Color Code:	None				
Contract Number:	Willbros Contract # N62583-08-D-0132/003	System:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm, Oahu, HI
Test Medium:	Water				
Test Medium Source:	Water Line in Lower Access Tunnel	Tank #:	5	AST / UST:	UST
Product:	Water				
Test Medium Additives:	None	Specific Gravity: 141.5/(131.5 + Degrees API)	1	API Gravity:(141.5/SG)-131.5	10.00
Flash Point:	N/A				
Included Pipe Sections or Laterals: (Test Section)	32" - F-76 service lateral to Tank 5 from the 20" flange at the wall of the Lower Access Tunnel to the 32" flange inside of the tank where the diverter was connected. (Diverter removed for the test)			Test Connection: (Location / Size / Type)	Ported test blind on the 20" flange located in the lower yard tunnel. Temp probe also placed inside of tank.
Time Zone:	Hawaii	Country:	USA	Purpose of Test: (Annual Or Five-Year Requalification, New Commissioning, Post Repair, Other)	Possible Suspected Leak
Test Criteria: (Jurisdictional Regulation)	49 CFR 195.300 / CSFM / UFC 3-460-03			Skillets Installed:	☐ Yes ☑ No
(49 CFR 195.300, 49 CFR 192, 33 CFR 156.170, 33 CFR 154, 9-VAC-25-91, UFC 3-460-03, CCR; CA Code Regulations, State Code, Customer Policy, Project Specifications, Other)				Location(s): (List valve / tank number / ect.)	Size:
Test Procedure:	API RP-1110 / CSFM Guidelines / 49 CFR 195				
(API RP 1110, API 570, ASME B.31.1, ASME B31.3, ASME B31.4, ASME B 31.8, NFPA 329, CSFM, 49 CFR 195)				Valves and diffusers removed and test blinds installed.	
Test Medium Disposal:	☐ Yes ☑ No	Disposal Company:	N/A		
Disposal Type & Amount (Gals):	Willbros will drain pipeline into portable totes for disposal outside of the tunnel.				

II. PIPE DESIGN DATA

System Design Data Code: (ASME B 31.1 (Power Piping) / B 31.3 (Process Piping) / B 31.4 (Liquid Fuels Transportation) / B 31.8 (Gas Transmission) / Other)					UNK - Assume ASME B31.3
Pipe Specification: (ASTM A53 (CS-Welded & Seamless) / A135 (ERW Pipe) / A312 (SS-Welded & Seamless) / API 5L (Welded & Seamless for Fuel Piping) / Other)					UNK - Assume API 5L ERW
Pipe Grade: (Pipe Grade A & B / Strength X42 - X60)	UNK	SMYS: (psi)	35,000	Pipe Information Source:	No pipe information was readily available from the facility.
Year Installed:	Circa 1943				

Known Repairs / Modifications:	Date:	Known Repairs / Modifications:	Date:
None known			

W_{JF} (Weld Joint Factor)	0.8	(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3) / Source:	Assumption		
D_F (Design Factor):	0.72	(.72 for Haz Liquid Pipelines per ASME B31.4 or State Other Criteria):	N/A		

III. TEST SECTIONS (If Loading Arm Present in Test Section Include Total Length & Volume from attachment I)

Pipe Section (Identification)	MP To (Location)	MP From (Location)	Nominal Pipe Ø (In)	Wall Thickness (In)	Outside Ø (In)	Inside Ø (In)	Pipe Material	Configuration (Buried-BG / Exposed-AG / Inside IN)	Length (Ft)	Section as % Total Pipe Length	Volume (Gallons)	Volume per Foot Pipe ID (Gal)	Length AG (%)(Ft)	Length BG (%)(Ft)	Length Inside (%)(Ft)
Non Exposed			32	0.375	32.000	31.25	CS / STD	Buried	44.0	91.67%	1753.12	39.84		44.0	
Nozzle Inside Tank			32	0.375	32.000	31.25	CS / STD	Inside	1.0	2.08%	39.84	39.84			1.0
Nozzle Outside Tank			20	0.375	20.000	19.25	CS / STD	Inside	3.0	6.25%	45.36	15.12			3.0
Total Pipe Sections in Test Section:		3	Averages:	0.375	31.250	27.250		Sum Of Factors:		1.00	Weight Of Factors: (=100%)			0.92	0.08
Total Volume Test Section (Gal):		1838.32	Total Volume Test Section (CF):		245.76	Total Length Test Section: (Ft)			48.0	Total Length AG / BG / Inside: (ft)				44.0	4.0
								Use Factoring For Volume Change & Pressure / Temperature Calculations				Total Number Factors:		2	

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Pipeline Pressure Test Report (Continued)

IV. TEST PRESSURE INFORMATION

Test Pressure:(psi)	162.375	% SMYS:	19.33%	MAWP: (psi)	108.25	Stated MAOP:(psi)	108.25

Max System Design Pressure: (100% SMYS x WJF x DF)(Pipe Only - Does Not Include Fittings & Components): 484

How MAWP Determined: *(Customer Provided / Pipeline Questionnaire / SPCC Plan / Calculated / Pump Deadhead / PRV Settings / Other):* Max head from a full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

Does pipeline have a elevation difference of 100' or greater? ☐ Yes ☑ No

(If yes then attach profile drawing of the pipeline indicating locations of pressure sensors IAW 49 CFR 195 if applicable)

HP Elevation: (Ft)	8.5	Min Pressure @ High Point:	162.375	% SMYS:	19.33%
LP Elevation: (Ft)		Max Pressure @ Low Point:	166	% SMYS:	19.82%
Difference: (Ft)	9.5	Pressure at TE Elevation:	162	% SMYS:	19.33%
Test Equipment (TE) Elevation: (Ft)	9.24	*See Test Pressure Calculation Sheet*			

Flange Class: 150 lb

150 lb Class Flanges Max Test Pressure = 425 psi (MAOP: 275 psi) / 300 lb Class Flange Max Test Pressure = 1100 psi (MAOP: 720 psi)

Is Test Pneumatic or Hydro-Pneumatic? (Yes or No): No — Joints / Welds Soaped? (Yes or No): N/A

If Yes Use The Following Information If Test is Performed With Nitrogen:

Estimated Volume of Nitrogen Needed From 0 psi to Test Pressure: (If Line Empty)(CF)	N/A	Equivalent Bottles:	N/A
+ 1 ATM) / 1 ATM = Volume CF of Nitrogen Needed (Note: 1 ATM = 14.7 psi)		Note: 1 Bottle = 300 CF	
Estimated Pipe Fill at Start of Pressurization: (%)(Existing product)		N/A	
Estimated Volume of Nitrogen Needed: (At Estimated Line Fill)	N/A	Equivalent Bottles:	N/A

Pressure Relief Valves: ☐ Yes ☑ No

ID	Size	Set Pressure	Location	Serial Number	Manufacturer

V. TEST SUMMARY

Weather (Test Start): Test Section Inside - Weather Not A Factor — Weather (Test End): N/A — Weather Comments: None

Note: Only Use Volume Calculations & Temperature Evaluation for Underground Hydrostatic or Hydraulic Testing (Not Applicable 100% AG Pipe for Pneumatic or Hydro-Pneumatic Testing).

Does Test Section Have UG Pipe? (Yes or No): Yes

Test Volume Calculation Summary: (See Attachment B)

Volume Calculated to Fill Pipeline: (DV / DP)(Gal)(If Empty)	1838.32	Actual Volume to Fill Pipeline: (Gallon)	1836.03	Difference:	-2.29	Difference: (%)	-0.12%
Volume Calculated to Reach Test Pressure from 0 PSI: (Pipeline must be full)(From Pre-Test Calculation Page):	1.6972 Gal	Difference:	17.7128 Gal	Pressurization DV/DP Diff (%) Volume:			91.26%
Actual Volume Required to Reach Test Pressure: (From Pre-Test Calculation Page):	19.41 Gal			Equivalent % Pipe Fill (At Pressurization >100% = Pipe Full)(<100% = Pipe has Trapped Vapor)			8.74%

Test Volume Correction Calculation Summary: (See Attachment B)

AVG Calculated DV / DP for Test Section: (Gal / psi): 0.0104524

dV/dP: Change in volume with respect to pressure.

dP/dV (=1/dV/dP) (From Pre-Test Calcs)(psi/gal) = 95.67 PSI / Gal

dP/dV: Change in pressure with respect to volume.

dV/dT (From Pre-Test Calcs - Sum of all pipe sections)(gal/°F) = 0.203 Gal / °F

dV/dT: Change in volume with respect to temperature

dP/dT: =(dP/dV)x(dV/dT)(psi/°F): 19.44 PSI / °F

Change in pressure with respect to temperature

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)

1 Gallons = 95.67 PSI

Total Gal Drained = PSI

Equivalent Pressure Loss From Drained Amount: (Field DP / DV)

N/A Gallons = 41.67 PSI

Total Gal Drained = PSI

Pressure & Temperature Evaluation (From Attachment E)

Chg P expected = (°C converted to °F)	dP / dT		FChg T	°F =	Chg P	Change of Pressure Expected ▲P
	19.44	(psi / °F) x				

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.

Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail): Fail — Expected ▲ P: (Calculated Chg P)

Total pressure differential (TPD) from Attachment A (Log Sheet) → — Observed ▲ P: (From Log Sheet): -0.1000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

Calculating Fluid Volume Gain / Loss (From Attachment F)

dV =Total Pipeline Volume*K_T* dT+ dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume, Loss/8hrs	0.00	+		=	0.00	
Volume, Loss/hour	0.00	+		=	0.00	

Added or Subtracted During Test

CSFM Loss Allowable — Test Conclusion IAW CSFM / hr: Pass

Gal./hour 1.03 — Gal./8hours 8.22 — Test Conclusion IAW CSFM / 8 hrs: Pass

Test Acceptable: ☑ Yes ☐ No

(IAW Applicable Test Criteria & Regulation)

Test Readings Recap:

Start Test	Time:	845	Start Pressure:	163.5	Average AG/IN Temp Start:	79.34	Average BG Temp Start:	79.34
End Test	Time:	930	End Pressure:	163.4	Average AG/IN Temp End:	79.34	Average BG Temp End:	79.34
			Difference:	-0.1	Difference:		Difference:	

Any Leaks or Weeps Detected During Pressurization or Test Period: ☑ Yes ☐ No

Remarks & Leak Corrections (Include Repairs Made Prior To Test): No visual leaks were identified on the test section after the 32" flange gasket inside of the tank was properly sealed. There was at least three periods of pressurization to allow for the gasket to be changed / replaced.

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Pipeline Pressure Test Report (Continued)

VI: ATTACHMENTS TO THIS REPORT: (All May Not Be Included or Required)

- [x] Attachment A / Test Pressure Calculations
- [x] Attachment B / Pre-Test Calculations & Pressurization Log
- [x] Attachment C / Pressure / Volume Plot
- [x] Attachment D / Pressure & Temp Log
- [x] Attachment E / Pressure & Temperature Evaluation
- [x] Attachment F / Volume Change Calculations
- [ ] Attachment G / Test Procedure & Valve Line-Up Sheet
- [ ] Attachment H / Loading Arm Information
- [ ] Attachment I / Photograph Page(s)
- [x] Pressure Graph
- [x] Temperature Graph
- [ ] Pipeline Elevation Drawing
- [x] Pipeline Test Section Drawing
- [ ] Test Equipment Drawing
- [ ] Disposal Manifest

VII: GENERAL TEST REMARKS: (List General Pipeline Condition / Recommendations from Visual Inspection)

Test considered inconclusive IAW applicable jurisdictional regulation, applied industry standards, and the intent of the test.

This is not a precision leak detection test and should not be considered as such. This hydrotest is considered a point-in-time, pressure decay, strength / stress / leak test against installed test blinds to determine if there are possible leaks at the stated MAOP / MAWP.

Test results are based on criteria established by (In Part) API-RP-1110, 5th Edition, California State Fire Marshall Office (CSFM), as well as, calculated acceptable thermal pressure loss / gain, no visual leaks identified in exposed piping during the test period, good engineering practice, and accepted industry practice. The pass/fail criteria may or may not be the required regulation however the criteria used is the accepted industry practice and is greater than or equal to the requirements in the jurisdictional regulation.

Initial pressurization attempted on 6/23/14 and the flange gasket inside of the tank began leaking at 60 psi when the pressurization pump was started. Attempts at tightening flange was unsuccessful. Remove flange and remove defective gasket. Install a rubber full faced gasket in conjunction with a new Garlok full faced gasket. Repressurize and this gasket combination began to leak at 75 psi. Remove flange for the second time and install two Garlok gaskets with high pressure / temperature silicone sealant between the flange face and gaskets and between the gaskets themselves. The flange face is coated and uneven making proper sealing difficult. This combination leaked as well from a triangular notch that was cut out of the flange on the tank side of the pipe. The final configuration of a 1/4" thick neoprene gasket proved successful at sealing the flange for the test.

Interior of the pipe section was reported to be affected by corrosion pitting by the customer prior to our arrival and filling. This did not affect the test procedure and is added to this report only as additional information.

The pipeline never truly stabilized during the official test period, however the last 45 minutes of the following day (After the dataloggers were removed and the data recovered) appeared to achieve stabilization.

We highly recommend a pneumatic test to confirm the existence of trapped air in the test section.

This was a theroretical test using data from the last 45 minutes of the datalogger data. The results are the same with a volume loss passing result and a temperature evaluation resulting in a failure however the results are much closer; +/- .1 psi loss.

No data was changed from the "A" test other than the data entered in the log sheet to manipulate the calculations.

VIII: TEST EQUIPMENT INFORMATION:

(See drawing of testing apparatus if required and Calibration Certificates)

All calibrations are performed third-party and are traceable to NIST.

Equipment Description:	PPSI Unit Number:	Manufacturer:	Serial Number:	Calibration Date:	Calibrated By:
Pipe Pressure Datalogger	Unit 1	MadgeTech	N84154	4/11/2014	Madgetech
4 Channel Temperature Datalogger (Thermocouple)	Unit 1	MadgeTech	N82430	8/21/2013	Madgetech
2 Channel Temperature Datalogger (Thermocouple)	Aux Unit 1	MadgeTech	N84147	8/20/2013	Madgetech
Digital Flowmeter / Totalizer (1/2")	Unit 3	GPI Industries	3206877	6/16/2014	Angels Instruments
Digital Flowmeter / Totalizer (1")	Unit 4	GPI Industries	3710745	6/16/2014	Angels Instruments
0-5000 psi Digital Deadweight Accurate Test Gauge	Unit 1	Crystal	870422	5/5/2014	Angels Instruments

IX: SIGNATURES

Tested By:	Report Prepared By:	Reviewed & Approved:	Customer Witness:
Dennis Cobb	Dennis Cobb	Dennis Cobb	James Hagen
Title: Vice President	Title: Vice President	Title: Vice President	Title: Project Manager
Signed:	Signed:	Signed:	Company: Willbros Government Services
			Signed: (If Required)
Date: 6/27/2014	Date: 6/27/2014	Date: 6/27/2014	Date: 6/27/2014

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Piping Test Pressure Calculations (Attachment A)

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-01B	Test Section:	Tank 5 Fuel Piping - 32"
Dwg Code Color:	None	Customer:	Willbros Government Services
Date:	6/27/2014	Location:	Red Hill Fuel Farm
			Oahu, HI

TEST CALCULATIONS INPUT

NPS		32.000	in.	NPS= Nominal Pipe Size (Diameter Inches)
D	=	31.250	in.	D = Outside Diameter of pipe (in)(Avg of all sections x % total length)
t	=	0.375	in.	t = Pipe wall Thickness (in)(Avg of all sections x % total length)
W_{JF}	=	0.8		W_{JF} = Weld Joint Factor (From Report Page 1)(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3)
D_F	=	0.72		D_F = Design Factor (From Report Page 1)(.72 for Haz Liquid Pipelines per ASME B31.4)
SMYS	=	35,000	psi	SMYS = Specified Minimum Yield Strength (From Report Page 1)
P_{WP}	=	108.25	psi	P_{WP} = Maximum Working Pressure (psi)
G	=	1		G = Product (Test Medium) Specific Gravity
LE	=		feet	LE = Lowest elevation
HE	=	9.5	feet	HE = Highest elevation
TE	=	9.24	feet	TE = Test equipment elevation
▲E	=	9.5	feet	▲E = Elevation Difference (If pipeline has an elevation difference >100' attach pipeline profile dwg)

Describe How Elevations Determined: (Line of sight estimation, known data, current survey, information source, ect.)

Foot of hydrostatic head was calculated at 9.5' based on 4 psi static head pressure x .433 psi / ft (=9.24') + 6" at bottom of pipe not recorded by the gauge due to location of the gauge itself relative to the center of the pipe.

TEST PRESSURE CALCULATIONS RESULTS

Nominal Test Pressure: (PSI) 162.375

162.4	psi	Min. Pressure at High Point
166.5	psi	Max. Pressure at Low Point
162.5	psi	Pressure at Test Equipment Point
19.3%		Test Pressure as % SMYS
840.0	psi	100% SMYS
483.8	psi	Design Pressure (Calculated - Pipe Only)

Calculate Max Low Point Pressure:

(Factor .433 psi / ft for water or Total Ft x .433 (Specific Gravity: 1.0) or correct factor for other test medium):

Test Medium: Water

(Use Formula: p=.433(h)(SG) where p: Pressure / h: Head in Ft / SG: Specific Gravity Test Medium)

h: (Ft) 9.5

SG: 1

TEST RESULTS

P_{MAX}	=	163.5	psi	P_{MAX} = Maximum test gauge pressure
P_{MIN}	=	163.5	psi	P_{MIN} = Minimum test gauge pressure
Difference	=		psi	

Remarks & Assumptions: We have to assume that the weld joint factor for this pipe is .08 for steel, however no data was available. We also have to assume that the design factor of .72 from ASME is the same because the pipeline is in combustible liquid service.

Test pressure determined by max head from a full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

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Pre-Test Calculations & Pressurization Log (Attachment B)

Note: Green cells that are blank indicate a value of 0 (Zero).

Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-01B	**Dwg Code Color:**	None
Customer:	Willbros Government Services	**Date:**	6/27/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	**Location:**	Red Hill Fuel Farm

Use this form to establish the pre-test DV/DP, line fill volume, and test pressure volume, as well as plot the actual DV/DP and fill volumes.

Calculated DV / DP Data

DV / DP (Change in Volume / Change in Pressure): DV / DP is defined as the change in volume for an associated change in pressure of a known volume under pressure. Two DV/DP calculations are used in these guidelines, a theoretical and a field value. A theoretical DV/DP will give the expected volume change for an associated change in pressure for the specified volume under test assuming that the volume under pressure is free of entrained gas. The field value of DV/DP is the actual volume change for an associated change in pressure for the specified volume under test. If air exists within the line under pressure, this value will be different than the theoretical value.

The theoretical DV/DP for aboveground (unrestrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t} \right) \left(\frac{5}{4} - \nu \right) + C \right]$$

The theoretical DV/DP for buried (restrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t} \right) (1 - \nu^2) + C \right]$$

where,

V = volume of the segment for the individual pipe diameter, D (gallons),
D = outside diameter of pipe (in),
E = elastic modulus of steel pipe (psi),
t = wall thickness of pipe (in),
ν = poisson's ratio of steel pipe,
C = compressibility of test media ($in^3/in^3/psi$).

NOTE: For a test segment with multiple diameters, sum the individual DV/DP's of each pipe diameter to obtain a total DV/DP for the entire test section.

Restrained Pipe (Underground) (Volume = 0.0408 x d² x L)		Unrestrained Pipe (Aboveground & Inside) (Volume = 0.0408 x d² x L)	
From Formula at Left (CSFM) V=	1753.12	From Formula at Left (CSFM) V=	85.20
D=	31.25	D=	31.25
E=	2.95E+07	E=	2.95E+07
t=	0.375	t=	0.375
ν=	0.3	ν=	0.3
c=	3.11E-06	c=	3.11E-06
DV/DP=	0.009858816	DV/DP=	0.000493618
Weight of Restrained Pipe	0.92	Weight of Unrestrained Pipe	0.08

(Values from Report Page 1)

AVG DV / DP for Test Section: (Gal) 0.0104524 (Use Avg DV/DP in Fill Chart - Page 3)

dV/dP: Change in volume with respect to pressure.

Use the Following Information for DV / DP Calculations - Values From Properties Charts Below

Test Medium:	Water		
B= Coef of Expansion:	1.23E-04	C=Compressibility of Test Media:	3.11E-06
Pipe Material #1:	Carbon Steel		
E = Elastic Modulus of Pipe #1 (PSI):			2.95E+07
ν = Poisson's Ratio of Pipe #1:			0.3
α = Linear Coefficient of Expansion: Pipe #1:			6.10E-06
Pipe Material #2:	N/A		
E = Elastic Modulus of Pipe #1 (PSI):			
ν = Poisson's Ratio of Pipe #1:			
α = Linear Coefficient of Expansion: Pipe #2:			
Number of Different Pipe Materials:			1
E Avg For Pipe Materials:			2.95E+07
ν Avg For Pipe Materials:			0.3
α Avg For Pipe Materials:			6.10E-06

Property Chart for Pipe Material

Pipe Material	Elastic Modulus: E	Coefficient of Expansion: a	Linear Coefficient of Expansion: α	Poisson's Ratio: ν
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	.27-.30
Stainless Steel	2.8E+07	9.60E-06		.30-.31
FRP	2.3E+06	1.16E-05	1.16E-05	0.33
Aluminum	1.00E+07			0.33

Property Chart for Test Medium

Test Medium	Compressibility: C = (1/β)	Bulk Modulus: (β)	Coefficient of Expansion: B	SG @ 60°F
JP-5 / JP-8	5.85E-06	1.71E+05	4.98E-04	0.81
Diesel	5.21E-06	1.92E+05	4.59E-04	0.85
Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Water	3.11E-06	3.22E+05	1.23E-04	1.00

Test Sections

Pipe Section (Identification)	Pipe Material	Nominal Pipe Ø (in)	Outside Ø (in)	Wall Thickness (in)	AVG Wall Thickness Exposed (AG)	AVG Wall Thickness Buried (BG)	AVG Wall Thickness Inside (IN)	dV/dT: Unrestrained (AG & IN) Pipe: Vx(B-3α) Restrained (Buried) Pipe: Vx(B-2α) (Total Last Cell)	Configuration (Buried-BG / Exposed-AG / Inside-IN)	Length (Ft)	Volume (Gallons)	Volume per Foot Pipe ID	Length AG (% Total Length)(Ft)	Length BG (% Total Length)(Ft)	Length Inside (% Total Length)(Ft)	Volume AG (% Total Length)(Ft)	Volume BG (% Total Length)(Ft)	Volume Inside (% Total Length)(Ft)
Non Exposed	CS / STD	32	32	0.375		0.375		0.194	Buried	44	1753.12	39.84		44			1753.12	
Nozzle Inside Tank	CS / STD	32	32	0.375			0.375	0.004	Inside	1	39.84	39.84			1			39.84
Nozzle Outside Tank	CS / STD	20	20	0.375			0.375	0.005	Inside	3	45.36	15.12			3			45.36
						0.375	0.375	0.203	Total Length:	48	1838.32	Totals:		44	4		1753.12	85.20

Total # AG Pipe Sections:					
Total # BG Pipe Sections:	1	AVG Wall AG & IN:	0.375	Note: AG & IN pipe is calculated as unrestrained.	
Total # IN Pipe Sections:	2	AVG Wall Buried:	0.375	Note: Buried (UG) pipe is calculated as restrained.	
Total # Pipe Sections:	3	Number Exposed Factors:	1		

dP/dV (=1/dV/dP) (dV/dP calculated above)(psi/gal) = 95.67

dP/dV: Change in pressure with respect to volume.

dV/dT (From above table - Sum of all pipe sections)(gal/°F) = 0.203

dV/dT: Change in volume with respect to temperature

dP/dT: =(dP/dV)x(dV/dT)(psi/°F) 19.44

Change in pressure with respect to temperature

Total Exposed Pipe Length: (AG & IN)	4	(Ft)	Total Exposed Volume: (AG & IN)	85.20	(Gal)
Total Non-Exposed Pipe Length: (UG)	44	(Ft)	Total Non-Exposed Volume: (UG)	1753.12	(Gal)

Total Volume to Fill Test Section (If Line Empty)(Gal): 1838.32

Test Pressure (From Report Page 1)(PSI): 162.375

Total Volume to Reach Test Pressure From 0 psi (Use DV / DP Chart Below)(Gal): 1.69721

Hydrostatic Pipeline Pressure Test Report 2014
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Pre-Test Calculations & Pressurization Log (Attachment B)(Page 2)

Field DV / DP Data

Field DV /DP: Before the test section is under full test pressure, a field value of DV / DP should be obtained. This value of DV/DP can be compared with the theoretical value of DV/DP calculated under section 3.5 (completed during pre-test calculations). A field value of DV/DP that is smaller than the theoretical DV/DP indicates an incorrect pressure reading, incorrect DV/DP calculation, or incorrect measurement of the volume under test. A field value of DV/DP that is greater than the theoretical DV/DP indicates the presence of entrapped air or other gas in the pipe section.

Obtaining Field DV / DP: During initial pressurization, the test section should be pressurized to approximately 50 psi and allowed to stabilize. Take an accurate pressure reading. Then bleed approximately 10 psi and allow the test section to stabilize. Take another accurate pressure reading. Carefully, measure the volume of the fluid that was bled and convert this to gallons if necessary. Take the volume bled and divide this number by the difference in the pressure readings. This is the field value of DV/DP.

Beginning Pressure: (psi)	162.2	Volume Bled (Gallons):	0.24			Field DV/DP Acceptable (Must be Greater Than or Equal To Calculated):	Yes
Ending Pressure: (psi)	152.2	Equivalent Gallon / Unit Pressure (psi):	4.17	Gallon	Field DV / DP:	0.024	
Difference: (psi)	10	Field Equivalent dP/dV (=1/dV/dP):	41.67	psi / Gal	Calculated DV / DP:	0.0104524	% Diff = (Difference/subtrahend)*Difference
		Calculated dP/dV (=1/dV/dP):	95.67	psi / Gal	Difference:	0.0135476	Air Entrapment Percentage: 0.18%
		Percentage Difference:	0.44%				

(Air entrapment percentage should be kept below 2% of total line volume if possible to increase the accuracy of the test. (API-RP-1110)(Pipe may be full or partially full at the beginning of pressurization. Bleed trapped vapor if possible or re-pack the line. Percentages over 100% = Line is packed or calculation error as described above.

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)				Equivalent Pressure Loss From Drained Amount: (Field DP / DV)			
1	Gallons =	95.67	PSI	1	Gallons =	41.67	PSI
	Total Gal Drained =		PSI		Total Gal Drained =		PSI

PRESSURIZATION DATA

Final Pressurization Log

DATE (mm/dd/yy)	TIME (24 hr) hr - min	Dead Weight Reading (psig)	Change in Pressure (psig)	Volume Metered (gal)	Volume Increment (gal)	Filling Totalizer Reading (gal)	Remarks
06/27/14	1838	48.7		17.88	17.88	17.88	Initial fill from main.
	1857	71.6	22.9	0.12	18.00	18.00	Pressurize with pump
	1912	165.0	93.4	1.50	19.50	19.50	
	1956	162.2	-2.8		19.50		
	1957	152.2	-10.0	-0.24	19.26		DV/DP check
	1958	168.1	15.9	0.15	19.41		
	2000	168.0	-0.1		19.41		Start Test
					19.41		
Start Test (Time & Press) (From Test Log)	845	163.5		19.41	Final Volume Injected		

Is Pipeline Full? ☐ Yes ☑ No

Volume To Fill or Pack Pipeline: (Gal) 1836.03

Volume Fill Comments: See notes below for initial pressure.

Pressurize From 48.7 psi

Source of Initial Pressure:

Fill line with existing water main in the lower access tunnel. The maximum pressure from the water main is 48 psi. Allow water main to pressurize line after air was bled inside of tank.

General Pressurization Comments: (List any reasons for repressurization)(List injection media temp if different from the pipe temp at time of pressurization)

The listed values for pressurization are from the period of the evening of 6/26/14 even though initial filling took place on 6/23/14. There were several depressurizations and re-pressurizations due to the leaking gasket inside of the tank.

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Theoretical DV/DP (Test Pressure Fill Chart)(0-453 psi)

Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)
		51	0.53307417	101	1.0558959	151	1.578317627	201	2.100993957	252	2.634013923	302	3.156638254	352	3.679259984	403	4.21233116
1	0.010452436	51	0.53307417	101	1.0558959	151	1.578317627	202	2.111391792	252	2.634013523	302	3.156638254	353	3.689709419	404	4.222783984
2	0.020904869	52	0.5436266	102	1.06614833	152	1.589770061	203	2.12184427	253	2.644469997	303	3.167087698	354	3.700161853	405	4.233236019
3	0.031357304	53	0.55397903	103	1.07690077	153	1.599222495	204	2.132298661	254	2.654918392	304	3.177540123	355	3.710614288	406	4.243688453
4	0.041809738	54	0.56443147	104	1.0870532	154	1.609674931	205	2.142749096	255	2.665370827	305	3.187992557	356	3.721066723	407	4.254140888
5	0.052262173	55	0.5748839	105	1.09750563	155	1.620127365	206	2.153201531	256	2.675823261	306	3.198444992	357	3.731519157	408	4.264593323
6	0.062714608	56	0.58533634	106	1.10795807	156	1.6305708	207	2.163653965	257	2.686275696	307	3.208897427	358	3.741971592	409	4.275045757
7	0.073167042	57	0.59578877	107	1.1184105	157	1.641022234	208	2.1741064	258	2.69672813	308	3.219349861	359	3.752424027	410	4.285498192
8	0.083619477	58	0.60624121	108	1.12886294	158	1.651484669	209	2.184558834	259	2.707180565	309	3.229802296	360	3.762876461	411	4.295950626
9	0.094071912	59	0.61669364	109	1.13931537	159	1.661937104	210	2.195011269	260	2.717633	310	3.24025473	361	3.773328896	412	4.306403061
10	0.104524346	60	0.62714608	110	1.14976781	160	1.672389538	211	2.205463704	261	2.728085434	311	3.250707165	362	3.78378133	413	4.316855496
11	0.114976781	61	0.63759851	111	1.16022024	161	1.682841973	212	2.215916138	262	2.738537869	312	3.2611596	363	3.794233765	414	4.32730793
12	0.125429215	62	0.64805095	112	1.17067268	162	1.693294408	213	2.226368573	263	2.748990304	313	3.271612034	364	3.8046862	415	4.337760365
13	0.13588165	63	0.65850338	113	1.18112511	163	1.703746842	214	2.236821007	264	2.75944738	314	3.282064469	365	3.815138634	416	4.3482128
14	0.146334085	64	0.66895582	114	1.19157755	164	1.714199277	215	2.247273442	265	2.769895173	315	3.292516904	366	3.825591069	417	4.358665234
15	0.156786519	65	0.67940825	115	1.20202998	165	1.724651711	216	2.257725877	266	2.780347607	316	3.302969338	367	3.836043503	418	4.369117669
16	0.167238954	66	0.68986069	116	1.21248242	166	1.735104146	217	2.268178311	267	2.790800042	317	3.313421773	368	3.846495938	419	4.379570103
17	0.177691388	67	0.70031312	117	1.22293485	167	1.745556581	218	2.278630746	268	2.801252477	318	3.323874207	369	3.856948373	420	4.390022538
18	0.188143823	68	0.71076555	118	1.23338729	168	1.756009015	219	2.289083181	269	2.811704911	319	3.334326642	370	3.867400807	421	4.400474973
19	0.198596258	69	0.72121799	119	1.24383972	169	1.76646145	220	2.29953615	270	2.822157346	320	3.344779077	371	3.877853242	422	4.410927407
20	0.209048692	70	0.73167042	120	1.25429215	170	1.776913884	221	2.309988685	271	2.83260978	321	3.355231511	372	3.888305677	423	4.421379842
21	0.219501127	71	0.74212286	121	1.26474459	171	1.787366319	222	2.320440484	272	2.843062215	322	3.365683946	373	3.898758111	424	4.431832276
22	0.229953562	72	0.75257529	122	1.27519702	172	1.7978787754	223	2.330892919	273	2.85351465	323	3.37613838	374	3.909210546	425	4.442284711
23	0.240405996	73	0.76302773	123	1.28564946	173	1.808271189	224	2.341345354	274	2.863967084	324	3.386588815	375	3.919662981	426	4.452737146
24	0.250858431	74	0.77348016	124	1.29610189	174	1.818723623	225	2.351797788	275	2.874419519	325	3.397041249	376	3.930115415	427	4.46318958
25	0.261310865	75	0.7839326	125	1.30655433	175	1.829176058	226	2.362250223	276	2.884871954	326	3.407493684	377	3.94056785	428	4.473642015
26	0.2717633	76	0.79438503	126	1.31700676	176	1.839628492	227	2.372702657	277	2.895324388	327	3.417946119	378	3.951020284	429	4.48409445
27	0.282215735	77	0.80483747	127	1.3274192	177	1.850080927	228	2.383155092	278	2.905776823	328	3.428398554	379	3.961472719	430	4.494546884
28	0.292668169	78	0.8152899	128	1.33791163	178	1.860533361	229	2.393607527	279	2.916229257	329	3.438850988	380	3.971925153	431	4.504999319
29	0.303120604	79	0.82574233	129	1.34836407	179	1.870985796	230	2.404059961	280	2.926681692	330	3.449303423	381	3.982377588	432	4.515451753
30	0.313573038	80	0.83619477	130	1.3588165	180	1.881438231	231	2.414512396	281	2.937134127	331	3.459755857	382	3.992830023	433	4.525904188
31	0.324025473	81	0.8466472	131	1.36926893	181	1.891890665	232	2.424964831	282	2.947586561	332	3.470208292	383	4.003282457	434	4.536356623
32	0.334477908	82	0.85709964	132	1.37972137	182	1.9023431	233	2.435417265	283	2.958039396	333	3.480660727	384	4.013734892	435	4.546809057
33	0.344930342	83	0.86755207	133	1.3901738	183	1.912795534	234	2.4458697	284	2.96849143	334	3.491113161	385	4.024187327	436	4.557261492
34	0.355382777	84	0.87800451	134	1.40062624	184	1.923247969	235	2.456322134	285	2.978943865	335	3.501565596	386	4.034639761	437	4.567713926
35	0.365835212	85	0.88845694	135	1.41107867	185	1.933700404	236	2.466774569	286	2.9893963	336	3.51201803	387	4.045092196	438	4.578166361
36	0.376287646	86	0.89890938	136	1.42153111	186	1.944152838	237	2.477227004	287	2.999848734	337	3.522470465	388	4.05954463	439	4.588618796
37	0.386740081	87	0.90936181	137	1.43198354	187	1.954605273	238	2.487679438	288	3.010301169	338	3.5329229	389	4.065997065	440	4.59907123
38	0.397192515	88	0.91981425	138	1.44243598	188	1.965057707	239	2.498131873	289	3.020753604	339	3.543375334	390	4.0764495	441	4.609523665
39	0.40764495	89	0.93026668	139	1.4528884	189	1.975510142	240	2.508584307	290	3.031206038	340	3.553827769	391	4.086901934	442	4.6199761
40	0.418097385	90	0.94071912	140	1.46334083	190	1.985962577	241	2.519036742	291	3.041658473	341	3.564280203	392	4.097354369	443	4.630428534
41	0.428549819	91	0.95117155	141	1.47379327	191	1.996415011	242	2.529489177	292	3.052110907	342	3.574732638	393	4.107806803	444	4.640880969
42	0.439002254	92	0.96162399	142	1.48424572	192	2.006867446	243	2.539941611	293	3.062563342	343	3.585185073	394	4.118259238	445	4.651333403
43	0.449454688	93	0.97207642	143	1.49469815	193	2.017319881	244	2.550394046	294	3.073015777	344	3.595637507	395	4.128711673	446	4.661785838
44	0.459907123	94	0.98252886	144	1.50515058	194	2.027772315	245	2.560846481	295	3.083468211	345	3.606089942	396	4.139164107	447	4.672238273
45	0.470359558	95	0.99298129	145	1.51560302	195	2.03822475	246	2.57129892	296	3.093920646	346	3.616542377	397	4.149616542	448	4.682690707
46	0.480811992	96	1.00343372	146	1.52605545	196	2.048677184	247	2.58175135	297	3.10437308	347	3.626994811	398	4.160068977	449	4.693143142
47	0.491264427	97	1.01388616	147	1.53650789	197	2.059129619	248	2.592203764	298	3.114825515	348	3.637447246	399	4.170521411	450	4.703595576
48	0.501716861	98	1.02433859	148	1.54696032	198	2.069582054	249	2.602656219	299	3.12527795	349	3.647899968	400	4.180973846	451	4.714048011
49	0.512169296	99	1.03479103	149	1.55741276	199	2.080034488	250	2.613109054	300	3.135730384	350	3.658352115	401	4.19142628	452	4.724500446
50	0.522621731	100	1.04524346	150	1.56786519	200	2.090486923	251	2.623561088	301	3.146182819	351	3.66880455	402	4.201878715	453	4.73495288

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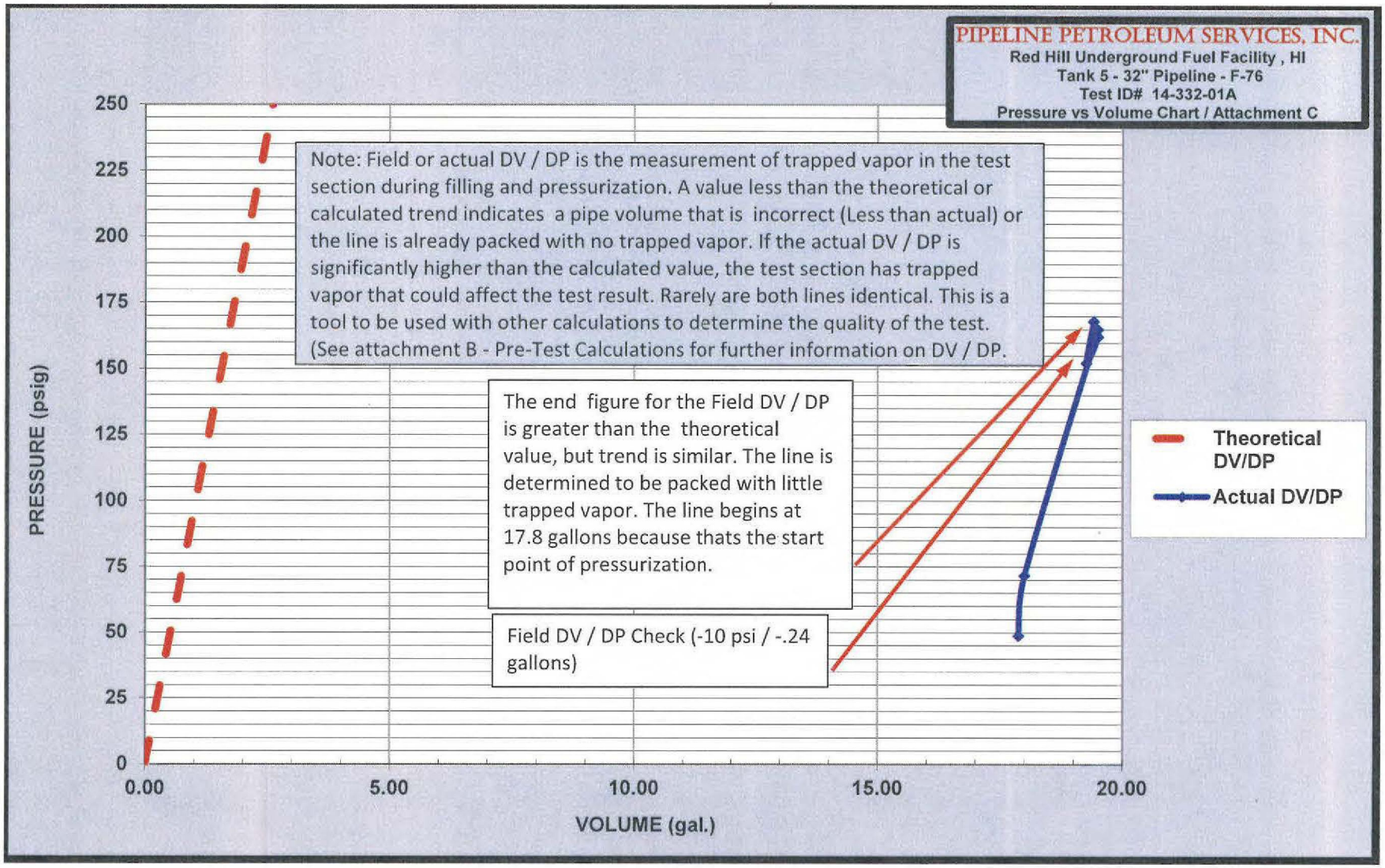
PIPELINE PETROLEUM SERVICES, INC.
Red Hill Underground Fuel Facility , HI
Tank 5 - 32" Pipeline - F-76
Test ID# 14-332-01A
Pressure vs Volume Chart / Attachment C
Note: Field or actual DV / DP is the measurement of trapped vapor in the test section during filling and pressurization. A value less than the theoretical or calculated trend indicates a pipe volume that is incorrect (Less than actual) or the line is already packed with no trapped vapor. If the actual DV / DP is significantly higher than the calculated value, the test section has trapped vapor that could affect the test result. Rarely are both lines identical. This is a tool to be used with other calculations to determine the quality of the test. (See attachment B - Pre-Test Calculations for further information on DV / DP.
The end figure for the Field DV / DP is greater than the theoretical value, but trend is similar. The line is determined to be packed with little trapped vapor. The line begins at 17.8 gallons because thats the start point of pressurization.
Field DV / DP Check (-10 psi / -.24 gallons)
Theoretical DV/DP
Actual DV/DP
PRESSURE (psig)
250
225
200
175
150
125
100
75
50
25
0
0.00
5.00
10.00
15.00
20.00
VOLUME (gal.)

PIPELINE PETROLEUM SERVICES, INC.

Pipeline Pressure & Temperature Log (Attachment D)

Note: Enter readings every 15 minutes for first hour of test (Entries 1-5) and every 30 minutes for each hour there after.

Customer:	Willbros Government Services
Location:	Red Hill Fuel Farm
System:	Tank 5 Fuel Piping - 32"

Date:	6/27/2014
Test ID No:	14-332-01B
Dwg Color Code:	N/A

Pressure Location & Unit #:			Location 1 & Unit #:		Location 2 & Unit #:		Location 3 & Unit #:		Location 4 & Unit #:		Number AG/IN Sensors:	1						
			Lower Yard Tunnel (Tank 5)								Number BG Sensors:	1	Initial Pressurization From:		48.7	PSI		
Entry ID Number	Time	Deadweight Pressure (psi)	Chart / Gauge Pressure (psig)	Aboveground / Exposed Pipe Temp (F) Location 1	Belowground / Non-Exposed Pipe Temp (F) Location 1	Aboveground / Exposed Pipe Temp (F) Location 2	Belowground / Non-Exposed Pipe Temp (F) Location 2	Aboveground / Exposed Pipe Temp (F) Location 3	Belowground / Non-Exposed Pipe Temp (F) Location 3	Aboveground / Exposed Pipe Temp (F) Location 4	Belowground / Non-Exposed Pipe Temp (F) Location 4	Inside Pipe Temp (F)	Ambient Temp (F)	Volume Added (Gal)	Volume Drained (Gal)	Percent Cloud Cover (0-100%)	Remarks (Weather Conditions)		
1	845	163.5	*	79.34	79.34								79.73				Start Test	Time: 845
2																	No weather effects - all piping is not exposed to the elements.	
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11	930	163.4		79.34	79.34								79.77					
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
	Final	163.4		79.34	79.34								79.77				End Test	Time: 930
		PSI Diff		Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Total Added	Total Drained	Note: Average Temperatures are used in the calculations for the press / temp eval sheet and volume change calculations.		
	Net Change	-0.1											0.04					

Average AG/IN Temp Start:	79.34	Average AG/IN Temp End:	79.34	Average Temperature for Test AG/IN:	79.34
Average BG Temp Start:	79.34	Average BG Temp End:	79.34	Average Temperature for Test BG:	79.34

Net Volume Loss(+) / Gain (-):

Equivalent Pressure Loss From Drained Amount: (Field DP / DV)(Hydrotest Only)

1 Gallons = 41.67 PSI

Total Gal Drained = PSI

PSI Diff + PSI / Gal Equivalent from Drained Product (Calculated) = Total Pressure Differential (TPD)

TPD = -0.10 (Use on Evaluation Sheet - Attachment E)(Hydrotest Only)

Remarks: (Explanation of Any Pressure Discontinuities)

* See attached recorder chart. Average AG Temperature includes both Inside and Aboveground / Exposed Temperatures. (If needed)

Used the same temperatures for AG & BG pipe from the dataloggers in the tunnel and inside of the tank because there was no practical way to actually measure the temperature of the piping as it was encased in concrete. Due to the non-exposed nature of all of the piping we feel the temperatures should be very close to each other given the amount of stabilization time allowed.

Left pressure on the line from 1200 AM to 0930 Am the next morning and the pressure was at 162.3 psi with a pipe temperature of 79.9.

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PIPELINE PETROLEUM SERVICES, INC.

Hydrostatic Test Pressure and Temperature Evaluation Form (Attachment E)

Test ID Number:	14-332-01B	**Dwg Color Code:**	None	**Date:**	6/27/14
Customer:	Willbros Government Services	**Location:**	Red Hill Fuel Farm		
System Under Evaluation:	Tank 5 Fuel Piping - 32"				

Test Data:

Test Medium: (Water, Diesel, Gasoline, JP-5, JP-8, Kerosene, Other):	Water
Pipeline Total Length: ("L"): (All Test Sections)	48
Pipe Outside Diameter: ("*D*"): (Average From All Test Sections)	31.250
Pipe Wall Thickness: ("*t*"): (Average From All Test Sections)	0.375
D/t Ratio: (Pipe Ø / "t"): (Average From All Test Sections)	83.33
Pipeline Total Volume: (From Report Page 1)	1838.32

IN: Inside Pipe Temp
AG: Aboveground Pipe Temp
BG: Below Ground Pipe Temp
TL: Total Length
▲P: Pressure Change
▲T: Temperature Change
All temp in degrees Fahrenheit unless noted
All pressure in lb/in² (psi) unless noted

Beginning Test Pressure: ("*Pb*"):	163.5	**Ending Test Pressure: ("*Pe*"):**	163.4	
Observed Pressure Change (Attachment A): (*Change P observed = Pe - Pb*):			-0.1	**▲P (PSI)**
Beginning Test Temperature AG: ("*Tb AG*"):	79.34	**Ending Test Temp AG: ("*Te AG*"):**	79.34	
Length AG:		**Percent Total Length: (Length AG / Total Length): % TL AG:**		
Beginning Test Temperature BG: ("*Tb BG*"):	79.34	**Ending Test Temp BG: ("*Te BG*"):**	79.34	
Length BG:	44	**Percent Total Length: (Length BG / Total Length): % TL BG:**	92%	
Beginning Test Temperature Inside: ("*Tb IN*"):		**Ending Test Temp IN: ("*Te IN*"):**		
Length IN:	4	**Percent Total Length: (Length IN / Total Length): % TL *IN*:**	8%	

▲T-AG: (Chg T=Te -Tb)		**x %TL AG:**		**= Adjusted Average AG ▲T:**
▲T-BG: (Chg T=Te -Tb)		**x %TL BG:**	92%	**= Adjusted Average BG ▲T:**
▲T-IN: (Chg T=Te -Tb)		**x %TL IN:**	8%	**= Adjusted Average IN ▲T:**

(Final (FChg T) = Adjusted Avg AG ▲T + Adjusted Avg BG ▲T + Adjusted Avg IN ▲T / 3) **FChg T:** **▲T (° F)**

Average Temp (T avg)	(Tb AG + Tb BG + Tb IN) / 3 =	75.66	**Tb**	Note: IN & AG are averaged together based on weighting factors.
	(Te AG + Te BG + Te IN) / 3 =	75.66	**Te**	
Average Fluid / Pipe Temperature (*T avg = (Te + Tb) / 2*):			**T avg:** 75.66	(For Test Duration)

Using T avg and D/t, find dP / dT from temperature compensation charts (exhibit 100,101,102, 103, 104, or 105) or calculate for the appropriate test medium:

dP / dT = 19.44 psi / ° F From Pre-Test Calculations - Attachment B

Formula for dP / dT Chart Development or Calculation used in Attachment B:

$$dP = \frac{[B-2a]/[Dx(1-v^2)/Et+C]}{T}$$

Formula and Results Validated by UFC 3-460-03 Section 9-3.5 / Pressure Relief Valves and CA State Hydrostatic Testing Worksheet. (Different Formula Variation)

dP=psig change per degree C or F
B=Coefficient of expansion of test medium
D=Pipe OD in inches
E=Modulus of elasticity for pipe material
v=Poisson's ratio, 0.3 for steel pipe
C=Compressibility factor for water (Or other test med), cu in/cu in/psig
a=Coefficient of expansion for steel,
t=Pipe wall thickness, in
T=Temperature, degrees C or F (20°C)(Or Tavg for test duration above)
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water	B=	1.23E-04	Bulk Modulus (β):	321,543
		C= (1/β)	3.11E-06	(Reciprocal of the Bulk Modulus (β) in lb/in²)	
Pipe Material #1:	Carbon Steel	E=	2.95E+07	a =	6.50E-06
Pipe Material #2:	N/A	E=		a =	
Pipe Material #3:	N/A	E=		a =	

List all Pipe Material & Test Medium Assumptions Made for Test Calculations: The type and grade of pipe material was assumed because no hard data was available from the original construction of the facility.

Test Variables for Calculations (Pipe Material Physical Properties from *(in part)* Appendix C, ASME B 31.3)

Pipe Material	E	a (in/in/per°F)	α (Linear)	Test Medium	C = (1/β)	Bulk Modulus (β):	B (° F)	SG @ 60°F
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	JP-5 / JP-8 / Jet-A / Kerosene	5.18E-06	1.93E+05	4.98E-04	0.81
Stainless Steel	2.8E+07	9.60E-06		Diesel - LSD / ULSD / Dyed	5.21E-06	1.92E+05	4.59E-04	0.85
FRP	2.3E+06	1.16E-05		Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Aluminum	1.00E+07			Water	3.11E-06	3.22E+05	1.23E-04	1.00
Other				Other				

Calculate the expected pressure change: *Chg P expected = dP / dT x FChg T*

Figure corrected for various diameters of pipe within test section.

Chg P expected =	*dP / dT*		*FChg T*		*Chg P*	
(°C converted to °F)	19.44	**(psi / °F) x**		**°F =**		**psi - Expected ▲P**

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.
Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail): Fail **Expected ▲P:** (Calculated Chg P)

Total pressure differential (TPD) from Attachment A (Log Sheet) → **Observed ▲P:** (From Log Sheet) -0.1000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

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Hydrostatic Test Volume Change Calculations (Attachment F) Page 1 of 2

Test ID Number:	14-332-01B	Dwg Code Color:	None
Customer:	Willbros Government Services	Date:	6/27/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm

Volume Change Calculations for Pipeline Hydrostatic Test (Calculated Volume/Pressure Slope Method)

Standard Formula: ▲V / V = Kp▲P + Kt▲T

Where: Kp = [(D/t)(5/4 -μ) / E] + 1/β = (1.9D / 2Et) + 1/β

And: Kt = 3a - g

▲P = Liquid Pressure Change
▲T = Liquid Temperature Change
▲V = Liquid Volume Added to Inside of Pipe (Negative if Flows Out)
V= Nominal Pipeline Volume (πD²L/4)
D= Inside Pipe Diameter

L= Pipe Length
t = Pipe Wall Thickness
μ = Poisson's Ratio = 0.3
E = Young's Modulus = 30x10^6 psi
β = Liquid Bulk Modulus, a function of Press & Temp
g = Liquid Volumetric Expansion Coefficient, a Function of Press & Temp
a = Linear Coefficient of Thermal Expansion
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water				Pipe Material:	Carbon Steel
API Gravity: (141.5/SG)-131.5	Specific Gravity: SG 141.5/(131.5+Degrees API)	ρ (SG x 1000)	(Liquid Coefficient of Expansion) B & g =	Compressibility: C = (1/β)	(Young's Modulus) E=	Linear Coefficient of Expansion: a=
10.00	0.9990	999.012	1.23E-04	3.11E-06	2.95E+07	6.50E-06

Pipe Data			Test Date	6/27/2014	API Gravity	10.00
Pipe Segment	Ø Outside (In)	Ø Inside (In)	Wall (In)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	32	31.250	0.375	44	1753.12	Buried
Nozzle Inside Tank	32	31.250	0.375	1	39.84	Inside
Nozzle Outside Tank	20	19.250	0.375	3	45.36	Inside
			Totals	48	1838.32	

Weighting for Pipeline Segment	% Total Length	Configuration	Buried	Exposed	Inside
Non Exposed	0.95	Buried	0.95		
Nozzle Inside Tank	0.02	Inside			0.02
Nozzle Outside Tank	0.02	Inside			0.02
Sum of Factors	1.00		Weight Factors	0.95		0.05

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected T1	DT1	
79.34	79.34		75.66	15.6559661	AVG. T
					75.66

Final Test Temperatures

Buried	Exposed	Inside	Final Corrected T2	DT2
79.34	79.34		75.66	15.6559661

Corrected Temperature Difference

NOTE: PIPE TYPE

	E	a
Carbon Steel	2.95E+07	6.50E-06
Stainless Steel	2.8E+07	9.60E-06
FRP	2.3E+06	1.16E-05
Aluminum	1.00E+07	

Test Pressure Difference

Initial Pressure P1	Final Pressure P2	dPressure
163.5	163.4	-0.1

Calculate (Kp)=(1.9D/2Et)+1β weighted value — Kp (1/P)

Compressibility Factor (1/BETA) or (1β)

Calculating C_{PL}	C_{PL} 1	C_{PL} 2	F_P 1	F_P 2
C_{PL} = 1/(1-F_P*P) or Kp (1/P)=	1.0005942	1.0005939	3.632E-06	3.632E-06

Calculate (Kt)=(3a-g) a=constant

Calculating C_{TL}	C_{TL} 1	C_{TL} 2	Coefficient Of Linear Expansion	Temperature Correction Factor (α)	Test Duration
C_{TL} = Exp(-α_{60}*DT*(1+0.8*α_{60}*(DT+δ_{60}))) or Kt(1/F)=	0.9948106	0.9948106	a	α_{60}	Hours
			6.50E-06	3.31E-04	4.00

Calculating Fluid Volume Gain / Loss

dV =V2-V1=V0/(C_{PL}2*C_{TL}2)-V0/(C_{PL}1*C_{TL}1))	dV=Total Pipeline Volume*(Kp*dP+Kt*dT) ▲V / V = Total Pipeline Volume Kp▲P + Kt▲T		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Gain	Actual Gain(+) / Loss(-)
Volume. Gain/8hrs	0.00	+		=	0.00	
Volume. Gain/hour	0.00	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable			
Gal./hour	1.03	Gal./8hours	8.22

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Hydrostatic Test Volume Change Calculations (Attachment C) Page 2 of 2

Test ID Number:	14-332-01B	Code Color:	None
Customer:	Willbros Government Services	Date:	6/27/2014
System Under Evaluation:	Tank 5 Fuel Piping - 32"	Location:	Red Hill Fuel Farm

Volume Change Calculations for Jet Fuel Pipeline (measured volume/pressure slope method)

Pipe Data			Test Date	6/27/2014	API Gravity	10
Pipe Segment	Ø Outside (In)	Ø Inside (In)	Wall (In)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	32	31.250	0.375	44	1753.12	Buried
Nozzle Inside Tank	32	31.250	0.375	1	39.84	Inside
Nozzle Outside Tank	20	19.250	0.375	3	45.36	Inside
			Totals	48	1838.32	

Weighting for segment	% Total Length	Configuration
Non Exposed	0.95	Buried
Nozzle Inside Tank	0.02	Inside
Nozzle Outside Tank	0.02	Inside
Sum of Factors	1.00	

Buried	Exposed	Inside
0.95		
		0.02
		0.02
Weight Factors	0.95	0.05

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected	DT1	
79.34	79.34		75.66	15.6559661	AVG. T
					75.66

Final Test Temperatures

Buried	Exposed	Inside	Final Corrected	DT2
79.34	79.34		75.66	15.6559661

Corrected Temperature Difference

Test Pressure Difference

Initial Pressure	Final Pressure	dPressure
163.5	163.4	-0.1

AVG. Pressure
163.45
Use Reference from Test Data

dV/dP Slope Calculations (Values are From Test Data)

Initial Pressure	Final Pressure	Initial Vol.	Final Vol.	dV/dP
48.7	163.5	17.88	19.41	0.013327526

Calculating K_T

$K_T = 3a-\alpha_{60}$

K_T	Coefficient Of Linear Expansion	Temperature Correction Factor
-0.0003115	a	α_{60}
	6.50E-06	3.31E-04

Test Duration

Hours
4.00

Calculating Fluid Volume Gain / Loss

dV =Total Pipeline Volume*K_T* dT+dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume. Loss/8hrs	0.00	+		=	0.00	
Volume. Loss/hour	0.00	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable				Test Conclusion IAW CSFM / hr	Pass
Gal./hour	1.03	Gal./8hours	8.22	Test Conclusion IAW CSFM / 8 hrs	Pass

Note: Use this pass/fail criteria to assist in determining a successful test with the temperature evaluation.

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PIPELINE PETROLEUM SERVICES, INC.
1324 Cavalier Blvd / PO BOX 6808
Chesapeake, VA 23323
Phone: (757) 544-0831

Pipeline Pressure Test Report - Test Summary

Form Revision Number: 6
Form Revision Date: 4-Jan-14

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

I. GENERAL TEST INFORMATION

Test ID No:	14-332-02	Job No:	14-332	Type of Test:	Hydrostatic Pressure Decay
Date:	6/25/2014	Customer:	Willbros Government Services		

(Hydrostatic x 150% MAWP, Hydraulic x 125% or 150% MAWP)
(Hydro-Pneumatic x 110% or 150% MAWP, Pneumatic x 110% MAWP)
(Pressure Decay, Strength Test, Leak Test, Spike Test, Ect.)

Minimum Test Duration: (Hrs) 4
Dwg Color Code: None

Contract Number:	N/A	System:	Tank 5 Fuel Piping - 18"	Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor, Oahu, HI
Test Medium:	Water				
Test Medium Source:	Water Line in Lower Access Tunnel	Tank #:	5	AST / UST:	UST
Test Medium Additives:	None	Specific Gravity: 141.5/(131.5 + Degrees API)	1	Product:	Water
				API Gravity:(141.5/SG)-131.5	10.00
				Flash Point:	N/A

Included Pipe Sections or Laterals: (Test Section)	18" - JP-8 service lateral to Tank 5 from the 12" flange at the wall of the Lower Access Tunnel to the 18" flange inside of the tank where the diverter was connected. (Diverter removed for the test)
Test Connection: (Location / Size / Type)	Ported test blind on the 12" flange located in the lower yard tunnel. Temp probe also placed inside of tank.

Time Zone:	Hawaii	Country:	USA	Purpose of Test: (Annual Or Five-Year Requalification, New Commissioning, Post Repair, Other)	Possible Suspected Leak

Test Criteria: (Jurisdictional Regulation)	CSFM / UFC 3-460-03	Skillets Installed:	☐ Yes ☑ No

(49 CFR 195.300, 49 CFR 192, 33 CFR 156.170, 33 CFR 154, 9-VAC-25-91, UFC 3-460-03, CCR: CA Code Regulations, State Code, Customer Policy, Project Specifications, Other)

Test Procedure:	API RP-1110 / CSFM Guidelines / Willbros Test Procedure, Revision 9: June 5, 2014	Location(s): (List valve / tank number / ect.)	Size:
(API RP 1110, API-570, ASME B.31.1, ASME B31.3, ASME B31.4, ASME B 31.8, NFPA 329, CSFM, 49 CFR 195)		Valves and diffusers removed and test blinds installed.	
Test Medium Disposal:	☐ Yes ☑ No	Disposal Company: N/A	
Disposal Type & Amount (Gals):	N/A		

II. PIPE DESIGN DATA

System Design Data Code: (ASME B 31.1 (Power Piping) / B 31.3 (Process Piping) / B 31.4 (Liquid Fuels Transportation) / B 31.8 (Gas Transmission) / Other)					UNK - Assume ASME B31.3
Pipe Specification: (ASTM A53 (CS-Welded & Seamless) / A135 (ERW Pipe) / A312 (SS-Welded & Seamless) / API 5L (Welded & Seamless for Fuel Piping) / Other)					UNK - Assume API 5L ERW
Pipe Grade: (Pipe Grade A & B / Strength X42 - X60)	UNK	SMYS: (psi)	35,000	Pipe Information Source:	No pipe information was readily available from the facility.
Year Installed:	Circa 1943				

Known Repairs / Modifications:	Date:	Known Repairs / Modifications:	Date:
None known.			

W_{JF} (Weld Joint Factor)	0.8	(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3) / Source:	Assumption	
D_F (Design Factor):	0.72	(.72 for Haz Liquid Pipelines per ASME B31.4 or State Other Criteria):	N/A	

III. TEST SECTIONS (If Loading Arm Present in Test Section Include Total Length & Volume from attachment I)

Pipe Section (Identification)	MP To (Location)	MP From (Location)	Nominal Pipe Ø (in)	Wall Thickness (in)	Outside Ø (In)	Inside Ø (In)	Pipe Material	Configuration (Buried-BG / Exposed-AG / Inside IN)	Length (Ft)	Section as % Total Pipe Length	Volume (Gallons)	Volume per Foot Pipe ID (Gal)	Length AG (%)(Ft)	Length BG (%)(Ft)	Length Inside (%)(Ft)
Non Exposed			18	0.375	18.000	17.25	CS / STD	Buried	58.0	89.23%	704.15	12.14		58.0	
Nozzle Inside Tank			18	0.375	18.000	17.25	CS / STD	Inside	3.0	4.62%	36.42	12.14			3.0
Nozzle Outside Tank			12	0.375	12.750	12	CS / STD	Inside	4.0	6.15%	23.50	5.88			4.0
Total Pipe Sections in Test Section:		3	Averages:	0.375	17.677	15.500		Sum Of Factors:		1.00	Weight Of Factors: (=100%)			0.89	0.11
Total Volume Test Section (Gal):		764.07	Total Volume Test Section (CF):		102.15	Total Length Test Section: (Ft)			65.0		Total Length AG / BG / Inside: (ft)			58.0	7.0

Use Factoring For Volume Change & Pressure / Temperature Calculations — Total Number Factors: 2

Hydrostatic Pipeline Pressure Test Report 2014
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Pipeline Pressure Test Report (Continued)

IV. TEST PRESSURE INFORMATION

Test Pressure:(psi)	162.375	% SMYS:	10.93%	MAWP: (psi)	108.25	Stated MAOP:(psi)	108.25	Max System Design Pressure: (100% SMYS x WJF x DF)(Pipe Only - Does Not Include Fittings & Components)	855

How MAWP Determined: *(Customer Provided / Pipeline Questionnaire / SPCC Plan / Calculated / Pump Deadhead / PRV Settings / Other)*: Max head from ± full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

Does pipeline have a elevation difference of 100' or greater? ☐ Yes ☑ No

(If yes then attach profile drawing of the pipeline indicating locations of pressure sensors IAW 49 CFR 195 if applicable)

HP Elevation: (Ft)	9.5	Min Pressure @ High Point:	162.375	% SMYS:	10.93%
LP Elevation: (Ft)		Max Pressure @ Low Point:	166	% SMYS:	11.21%
Difference: (Ft)	9.5	Pressure at TE Elevation:	162	% SMYS:	10.93%
Test Equipment (TE) Elevation: (Ft)	9.24	See Test Pressure Calculation Sheet			

Flange Class: 150 lb

150 lb Class Flanges Max Test Pressure = 425 psi (MAOP: 275 psi) / 300 lb Class Flange Max Test Pressure = 1100 psi (MAOP: 720 psi)

Is Test Pneumatic or Hydro-Pneumatic? (Yes or No)	No	Joints / Welds Soaped? (Yes or No)	N/A
If Yes Use The Following Information if Test is Performed With Nitrogen:			
Estimated Volume of Nitrogen Needed From 0 psi to Test Pressure: (If Line Empty)(CF)	N/A	Equivalent Bottles:	N/A
+ 1 ATM) / 1 ATM = Volume CF of Nitrogen Needed (Note: 1 ATM = 14.7 psi)		Note: 1 Bottle = 300 CF	
Estimated Pipe Fill at Start of Pressurization: (%)(Existing product)		N/A	
Estimated Volume of Nitrogen Needed: (At Estimated Line Fill)	N/A	Equivalent Bottles:	N/A

Pressure Relief Valves: ☐ Yes ☑ No

ID	Size	Set Pressure	Location	Serial Number	Manufacturer

V. TEST SUMMARY

Weather (Test Start): Test Section Inside - Weather Not A Factor | Weather (Test End): N/A | Weather Comments: None

Note: Only Use Volume Calculations & Temperature Evaluation for Underground Hydrostatic or Hydraulic Testing (Not Applicable 100% AG Pipe for Pneumatic or Hydro-Pneumatic Testing).

Does Test Section Have UG Pipe? (Yes or No): Yes

Test Volume Calculation Summary: (See Attachment B)

Volume Calculated to Fill Pipeline: (DV / DP)(Gal)(If Empty)	764.07	Actual Volume to Fill Pipeline: (Gallon)	764.07	Difference:		Difference: (%)	
Volume Calculated to Reach Test Pressure from 0 PSI: (Pipeline must be full)(From Pre-Test Calculation Page):	0.5669 Gal	Difference:	1.9531 Gal	Pressurization DV/DP Diff (%) Volume:			77.51%
Actual Volume Required to Reach Test Pressure: (From Pre-Test Calculation Page):	2.52 Gal			Equivalent % Pipe Fill (At Pressurization >100% = Pipe Full)(<100% = Pipe has Trapped Vapor)			22.49%

Test Volume Correction Calculation Summary: (See Attachment B)

AVG Calculated DV / DP for Test Section: (Gal / psi) 0.0034911

dV/dP: Change in volume with respect to pressure.

dP/dV (=1/dV/dP) (From Pre-Test Calcs)(psi/gal) = 286.44 PSI / Gal

dP/dV: Change in pressure with respect to volume.

dP/dT: =(dP/dV)x(dV/dT)(psi/°F) 24.15 PSI / °F

Change in pressure with respect to temperature

dV/dT (From Pre-Test Calcs - Sum of all pipe sections)(gal/°F) = 0.084 Gal / °F

dV/dT: Change in volume with respect to temperature

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)				Equivalent Pressure Loss From Drained Amount: (Field DP / DV)			
1	Gallons =	286.44	PSI	N/A	Gallons =	111.11	PSI
	Total Gal Drained =		PSI		Total Gal Drained =		PSI

Pressure & Temperature Evaluation (From Attachment E)

	dP / dT		FChg T		Chg P	
Chg P expected =						Change of Pressure Expected ▲P
(°C converted to °F)	24.15	(psi / °F) x	-0.07	°F =	-1.73	

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.

Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail): Fail | Expected ▲ P: (Calculated Chg P) -1.7302

Total pressure differential (TPD) from Attachment A (Log Sheet) → | Observed ▲ P: (From Log Sheet) -3.2000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

Calculating Fluid Volume Gain / Loss (From Attachment F)

dV =Total Pipeline Volume*K1* dT+ dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume, Loss/8hrs	-0.01	+		=	-0.01	
Volume, Loss/hour	0.00	+		=	0.00	

Added or Subtracted During Test

CSFM Loss Allowable: Gal./hour 1.02 | Gal./8hours 8.17 | Test Conclusion IAW CSFM / hr: Pass | Test Conclusion IAW CSFM / 8 hrs: Pass

Test Acceptable: ☑ Yes ☐ No (IAW Applicable Test Criteria & Regulation)

Test Readings Recap:

Start Test	Time:	2237	Start Pressure:	165.2	Average AG/IN Temp Start:	79.84	Average BG Temp Start:	79.84
End Test	Time:	0137	End Pressure:	162	Average AG/IN Temp End:	79.75	Average BG Temp End:	79.75
			Difference:	-3.2	Difference:	-0.09	Difference:	-0.09

Any Leaks or Weeps Detected During Pressurization or Test Period: ☐ Yes ☑ No

Remarks & Leak Corrections (Include Repairs Made Prior To Test): No visual leaks were identified on the test section after the 18" flange gasket inside of the tank was properly sealed. There were two separate periods of pressurization to allow for the gasket to be changed / replaced.

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Pipeline Pressure Test Report (Continued)

VI: ATTACHMENTS TO THIS REPORT: (All May Not Be Included or Required)

- ☑ Attachment A / Test Pressure Calculations
- ☑ Attachment B / Pre-Test Calculations & Pressurization Log
- ☑ Attachment C / Pressure / Volume Plot
- ☑ Attachment D / Pressure & Temp Log
- ☑ Attachment E / Pressure & Temperature Evaluation
- ☑ Attachment F / Volume Change Calculations
- ☐ Attachment G / Test Procedure & Valve Line-Up Sheet
- ☐ Attachment H / Loading Arm Information
- ☐ Attachment I / Photograph Page(s)
- ☑ Pressure Graph
- ☑ Temperature Graph
- ☐ Pipeline Elevation Drawing
- ☐ Pipeline Test Section Drawing
- ☐ Test Equipment Drawing
- ☐ Disposal Manifest

VII: GENERAL TEST REMARKS: (List General Pipeline Condition / Recommendations from Visual Inspection)

Test considered inconclusive IAW applicable jurisdictional regulation, applied industry standards, and the intent of the test.
This is not a precision leak detection test and should not be considered as such. This hydrotest is considered a point-in-time, pressure decay, strength / stress / leak test against installed test blinds to determine if there are possible leaks at the stated MAOP / MAWP.
Test results are based on criteria established by (In Part) API-RP-1110, California State Fire Marshall Office (CSFM), as well as, calculated thermal pressure loss / gain, calculated volume loss / gain, no visual leaks identified in exposed piping during the test period, good engineering practice, and accepted industry practice. The pass/fail criteria may or may not be the required regulation however the criteria used is the accepted industry practice and is greater than or equal to the requirements in the jurisdictional regulation.

Initial pressurization attempted on the morning of 6/25/14 and the flange gasket inside of the tank began leaking at 162 psi when the stabilization was started. Attempts at tightening flange was unsuccessful. Remove flange and remove defective gasket. Install a new garlok gasket.
Re-pressurize to test pressure and flange was tight.

The line pressure never truly stabilized at any time throughout the project.
Evidence of the amount of trapped air in the line is the calculated volume to reach test pressure was approximately .57 gallons and it required over 2.5 gallons to reach test pressure.
We highly recommend a pneumatic test to confirm the existence of trapped air in the test section.

VIII: TEST EQUIPMENT INFORMATION: *(See drawing of testing apparatus if required and Calibration Certificates)*

All calibrations are performed third-party and are traceable to NIST.

Equipment Description:	PPSI Unit Number:	Manufacturer:	Serial Number:	Calibration Date:	Calibrated By:
Pipe Pressure Datalogger	Unit 1	MadgeTech	N84154	4/11/2014	Madgetech
4 Channel Temperature Datalogger (Thermocouple)	Unit 1	MadgeTech	N82430	8/21/2013	Madgetech
2 Channel Temperature Datalogger (Thermocouple)	Aux Unit 1	MadgeTech	N84147	8/20/2013	Madgetech
Digital Flowmeter / Totalizer (1/2")	Unit 3	GPI Industries	3206877	6/16/2014	Angels Instruments
Digital Flowmeter / Totalizer (1")	Unit 4	GPI Industries	3710745	6/16/2014	Angels Instruments
0-5000 psi Digital Deadweight Accurate Test Gauge	Unit 1	Crystal	870422	5/5/2014	Angels Instruments

IX: SIGNATURES

Tested By:	Dennis Cobb	Report Prepared By:	Dennis Cobb	Reviewed & Approved:	Dennis Cobb	Customer Witness:	James Hagen
Title:	Vice President	Title:	Vice President	Title	Vice President	Title:	Project Manager
Signed:		Signed:		Signed:		Company:	Willbros Government Services
						Signed: (If Required)	
Date:	6/25/2014	Date:	6/25/2014	Date:	6/25/2014	Date:	6/25/2014

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PIPELINE PETROLEUM SERVICES, INC.

Piping Test Pressure Calculations (Attachment A)

Note: Green cells that are blank indicate a value of 0 (Zero).
Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-02	Test Section:	Tank 5 Fuel Piping - 18"
Dwg Code Color:	None	Customer:	Willbros Government Services
Date:	6/25/2014	Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor Oahu, HI

TEST CALCULATIONS INPUT

NPS		18.000	in.	NPS= Nominal Pipe Size (Diameter Inches)
D	=	17.677	in.	D = Outside Diameter of pipe (in)(Avg of all sections x % total length)
t	=	0.375	in.	t = Pipe wall Thickness (in)(Avg of all sections x % total length)
W_{JF}	=	0.8		W_{JF} = Weld Joint Factor (From Report Page 1)(Range (.6 - 1.0) per ASME B 31.4 Table 402.4.3)
D_F	=	0.72		D_F = Design Factor (From Report Page 1)(.72 for Haz Liquid Pipelines per ASME B31.4)
SMYS	=	35,000	psi	SMYS = Specified Minimum Yield Strength (From Report Page 1)
P_{WP}	=	108.25	psi	P_{WP} = Maximum Working Pressure (psi)
G	=	1		G = Product (Test Medium) Specific Gravity
LE	=		feet	LE = Lowest elevation
HE	=	9.5	feet	HE = Highest elevation
TE	=	9.24	feet	TE = Test equipment elevation
▲E	=	9.5	feet	▲E = Elevation Difference (If pipeline has an elevation difference >100' attach pipeline profile dwg)

Describe How Elevations Determined: (Line of sight estimation, known data, current survey, information source, ect.)

Foot of hydrostatic head was calculated at 9.5' based on 4 psi static head pressure x .433 psi / ft (=9.24') + 6" at bottom of pipe not recorded by the gauge due to location of the gauge itself relative to the center of the pipe.

TEST PRESSURE CALCULATIONS RESULTS

Nominal Test Pressure: (PSI) 162.375

162.4	psi	Min. Pressure at High Point
166.5	psi	Max. Pressure at Low Point
162.5	psi	Pressure at Test Equipment Point
10.9%		Test Pressure as % SMYS
1485.0	psi	100% SMYS
855.4	psi	Design Pressure (Calculated - Pipe Only)

Calculate Max Low Point Pressure:

(Factor .433 psi / ft for water or Total Ft x .433 (Specific Gravity: 1.0) or correct factor for other test medium):

Test Medium: Water

(Use Formula: p=.433(h)(SG) where p: Pressure / h: Head in Ft / SG: Specific Gravity Test Medium)

h: (Ft) 9.5

SG: 1

TEST RESULTS

P_{MAX}	=	165.2	psi	P_{MAX} = Maximum test gauge pressure
P_{MIN}	=	165.2	psi	P_{MIN} = Minimum test gauge pressure
Difference	=		psi	

Remarks & Assumptions: We have to assume that the weld joint factor for this pipe is .08 for steel, however no data was available. We also have to assume that the design factor of .72 from ASME is the same because the line is in combustible liquid service.

Test pressure determined by max head from a full tank calculated by (.433)(SG)(Height) = 250' high x 1 (SG of water) x .433 = 108.25 x 1.5 = 162.375

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PIPELINE PETROLEUM SERVICES, INC.

Pre-Test Calculations & Pressurization Log (Attachment B)

Note: Green cells that are blank indicate a value of 0 (Zero).

Note: Fill in blue cells with required information / Green cells are calculated values.

Test ID Number:	14-332-02	Dwg Code Color:	None
Customer:	Willbros Government Services	Date:	6/25/2014
System Under Evaluation:	Tank 5 Fuel Piping - 18"	Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor

Use this form to establish the pre-test DV/DP, line fill volume, and test pressure volume, as well as plot the actual DV/DP and fill volumes.

Calculated DV / DP Data

DV / DP (Change in Volume / Change in Pressure): DV / DP is defined as the change in volume for an associated change in pressure of a known volume under pressure. Two DV/DP calculations are used in these guidelines, a theoretical and a field value. A theoretical DV/DP will give the expected volume change for an associated change in pressure for the specified volume under test assuming that the volume under pressure is free of entrained gas. The field value of DV/DP is the actual volume change for an associated change in pressure for the specified volume under test. If air exists within the line under pressure, this value will be different than the theoretical value.

The theoretical DV/DP for aboveground (unrestrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t} \right) \left(\frac{5}{4} - \nu \right) + C \right]$$

The theoretical DV/DP for buried (restrained) pipe is calculated through the following equation:

$$\frac{DV}{DP} = V * \left[\left(\frac{D}{E * t} \right) (1 - \nu^2) + C \right]$$

where,

V = volume of the segment for the individual pipe diameter, D (gallons),
D = outside diameter of pipe (in),
E = elastic modulus of steel pipe (psi),
t = wall thickness of pipe (in),
ν = poisson's ratio of steel pipe,
C = compressibility of test media ($in^3/in^3/psi$).

NOTE: For a test segment with multiple diameters, sum the individual DV/DP's of each pipe diameter to obtain a total DV/DP for the entire test section.

Restrained Pipe (Underground) (Volume = 0.0408 x d² x L)		Unrestrained Pipe (Aboveground & Inside) (Volume = 0.0408 x d² x L)	
From Formula at Left (CSFM) V=	704.15	From Formula at Left (CSFM) V=	59.92
D=	17.67692308	D=	17.67692308
E=	2.95E+07	E=	2.95E+07
t=	0.375	t=	0.375
ν=	0.3	ν=	0.3
c=	3.11E-06	c=	3.11E-06
DV/DP=	0.003213813	DV/DP=	0.000277322
Weight of Restrained Pipe:	0.89	Weight of Unrestrained Pipe:	0.11

(Values from Report Page 1)

AVG DV / DP for Test Section: (Gal) **0.0034911** (Use Avg DV/DP in Fill Chart - Page 3)

dV/dP: Change in volume with respect to pressure.

Use the Following Information for DV / DP Calculations - Values From Properties Charts Below

Test Medium:	Water		
B= Coef of Expansion:	1.23E-04	C=Compressibility of Test Media:	3.11E-06
Pipe Material #1:	Carbon Steel		
E = Elastic Modulus of Pipe #1 (PSI):	2.95E+07		
ν = Poisson's Ratio of Pipe #1:	0.3		
α = Linear Coefficient of Expansion: Pipe #1:	6.10E-06		
Pipe Material #2:	N/A		
E = Elastic Modulus of Pipe #1 (PSI):			
ν = Poisson's Ratio of Pipe #1:			
α = Linear Coefficient of Expansion: Pipe #2:			
Number of Different Pipe Materials:	1		
E Avg For Pipe Materials:	2.95E+07		
ν Avg For Pipe Materials:	0.3		
α Avg For Pipe Materials:	6.10E-06		

Property Chart for Pipe Material

Pipe Material	Elastic Modulus: E	Coefficient of Expansion: α	Linear Coefficient of Expansion: α	Poisson's Ratio: ν
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	.27-.30
Stainless Steel	2.8E+07	9.60E-06		.30-.31
FRP	2.3E+06	1.16E-05	1.16E-05	0.33
Aluminum	1.00E+07			0.33

Property Chart for Test Medium

Test Medium	Compressibility: C = (1/β)	Bulk Modulus: (β)	Coefficient of Expansion: B	SG @ 60°F
JP-5 / JP-8	5.85E-06	1.71E+05	4.98E-04	0.81
Diesel	5.21E-06	1.92E+05	4.59E-04	0.85
Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Water	3.11E-06	3.22E+05	1.23E-04	1.00

Test Sections

Pipe Section (Identification)	Pipe Material	Nominal Pipe Ø (in)	Outside Ø (in)	Wall Thickness (in)	AVG Wall Thickness Exposed (AG)	AVG Wall Thickness Buried (BG)	AVG Wall Thickness Inside (IN)	dV/dT: Unrestrained (AG & IN) Pipe: Vx(B-3a) Restrained (Buried) Pipe: Vx(B-2a) (Total Last Cell)	Configuration (Buried-BG / Exposed-AG / Inside-IN)	Length (Ft)	Volume (Gallons)	Volume per Foot Pipe ID	Length AG (% Total Length)(Ft)	Length BG (% Total Length)(Ft)	Length Inside (% Total Length)(Ft)	Volume AG (% Total Length)(Ft)	Volume BG (% Total Length)(Ft)	Volume Inside (% Total Length)(Ft)
Non Exposed	CS / STD	18	18	0.375		0.375		0.078	Buried	58	704.15	12.14		58			704.15	
Nozzle Inside Tank	CS / STD	18	18	0.375			0.375	0.004	Inside	3	36.42	12.14			3			36.42
Nozzle Outside Tank	CS / STD	12	12.75	0.375			0.375	0.002	Inside	4	23.50	5.88			4			23.50
Total # AG Pipe Sections:			AVG Wall AG & IN:		0.375	0.375	0.084	Total Length:		65	764.07	Totals:		58	7		704.15	59.92
Total # BG Pipe Sections:	1		AVG Wall Buried:		0.375	Note: AG & IN pipe is calculated as unrestrained.			dP/dV (=1/dV/dP) (dV/dP calculated above)(psi/gal) =			266.44	dP/dT: =(dP/dV)x(dV/dT)(psi/°F)		24.15			
Total # IN Pipe Sections:	2					Note: Buried (UG) pipe is calculated as restrained.			dP/dV: Change in pressure with respect to volume.				Change in pressure with respect to temperature					
Total # Pipe Sections:	3		Number Exposed Factors:		1				dV/dT (From above table - Sum of all pipe sections)(gal/°F) =			0.084						
									dV/dT: Change in volume with respect to temperature									
									Total Volume to Fill Test Section (If Line Empty)(Gal):						764.07			
Total Exposed Pipe Length: (AG & IN)	7	(Ft)	Total Exposed Volume: (AG & IN)		59.92	(Gal)			Test Pressure (From Report Page 1)(PSI):						162.375			
Total Non-Exposed Pipe Length: (UG)	58	(Ft)	Total Non-Exposed Volume: (UG)		704.15	(Gal)			Total Volume to Reach Test Pressure From 0 psi (Use DV / DP Chart Below)(Gal):							0.56687		

Hydrostatic Pipeline Pressure Test Report 2014
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Pre-Test Calculations & Pressurization Log (Attachment B)(Page 2)

Field DV / DP Data

Field DV /DP: Before the test section is under full test pressure, a field value of DV / DP should be obtained. This value of DV/DP can be compared with the theoretical value of DV/DP calculated under section 3.5 (completed during pre-test calculations). A field value of DV/DP that is smaller than the theoretical DV/DP indicates an incorrect pressure reading, incorrect DV/DP calculation, or incorrect measurement of the volume under test. A field value of DV/DP that is greater than the theoretical DV/DP indicates the presence of entrapped air or other gas in the pipe section.

Obtaining Field DV / DP: During initial pressurization, the test section should be pressurized to approximately 50 psi and allowed to stabilize. Take an accurate pressure reading. Then bleed approximately 10 psi and allow the test section to stabilize. Take another accurate pressure reading. Carefully, measure the volume of the fluid that was bled and convert this to gallons if necessary. Take the volume bled and divide this number by the difference in the pressure readings. This is the field value of DV/DP.

Beginning Pressure: (psi)	102.2	Volume Bled (Gallons):	0.09			Field DV / DP:	0.009
Ending Pressure: (psi)	92.2	Equivalent Gallon / Unit Pressure (psi):	11.11	Gallon		Calculated DV / DP:	0.0034911
Difference: (psi)	10	Field Equivalent dP/dV (=1/dV/dP):	111.11	psi / Gal		Difference:	0.0055089
		Calculated dP/dV (=1/dV/dP):	286.44	psi / Gal			
		Percentage Difference:	0.39%				

Field DV/DP Acceptable (Must be Greater Than or Equal To Calculated): Yes

% Diff =(Difference/subtrahend)*Difference

Air Entrapment Percentage: 0.09%

(Air entrapment percentage should be kept below 2% of total line volume if possible to increase the accuracy of the test. (API-RP-1110)(Pipe may be full or partially full at the beginning of pressurization. Bleed trapped vapor if possible or re-pack the line. Percentages over 100% = Line is packed or calculation error as described above.

Equivalent Pressure Loss From Drained Amount: (Calculated DP / DV)				Equivalent Pressure Loss From Drained Amount: (Field DP / DV)			
1	Gallons =	286.44	PSI	1	Gallons =	111.11	PSI
	Total Gal Drained =		PSI		Total Gal Drained =		PSI

PRESSURIZATION DATA

Final Pressurization Log

DATE (mm/dd/yy)	TIME (24 hr) hr - min	Dead Weight Reading (psig)	Change in Pressure (psig)	Volume Metered (gal)	Volume Increment (gal)	Filling Totalizer Reading (gal)	Remarks
06/25/14	0700						
		47.0	47.0	1.65	1.65	1.65	Fill from water main
	0742	102.2	55.2	0.65	2.30	2.30	Begin using pressure pump
		92.2	-10.0	-0.09	2.21		DV / DP Check
	0747	163.0	70.8	0.31	2.52	2.67	

Theoretical DV/DP (Test Pressure Fill Chart)(0-453 psi)

Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)	Pressure (PSI)	Volume (Gallons)
		51	0.17804788	101	0.35260463	151	0.527161371	201	0.701718117	252	0.879765997	302	1.054322742	352	1.228879488	403	1.40662737		
1	0.003491135	51	0.17804788	101	0.35260463	151	0.527161371	202	0.705209252	252	0.879765997	302	1.054322742	353	1.232370623	404	1.4104185		
2	0.00698227	52	0.18153902	102	0.35609576	152	0.530652508	203	0.708700386	253	0.883257132	303	1.057813877	354	1.235861758	405	1.41390964		
3	0.010473405	53	0.18503015	103	0.3595869	153	0.534143641	204	0.712191521	254	0.886748267	304	1.061305012	355	1.239352893	406	1.41740077		
4	0.013964454	54	0.18852129	104	0.36307803	154	0.537634776	205	0.715682656	255	0.890239402	305	1.064796147	356	1.242844028	407	1.42089191		
5	0.017455675	55	0.19201242	105	0.36656917	155	0.541125911	206	0.719173791	256	0.893730537	306	1.068287282	357	1.246335162	408	1.42438304		
6	0.020946809	56	0.19550356	106	0.3700603	156	0.544617046	207	0.722664926	257	0.897221672	307	1.071778417	358	1.249826297	409	1.42787418		
7	0.024437944	57	0.19899469	107	0.37355144	157	0.548108181	208	0.726156061	258	0.900712806	308	1.075269552	359	1.253317432	410	1.43136531		
8	0.027929078	58	0.20248582	108	0.37704257	158	0.551599316	209	0.729647196	259	0.904203941	309	1.078760687	360	1.256808567	411	1.43485645		
9	0.031420214	59	0.20597696	109	0.38053371	159	0.555090451	210	0.733138331	260	0.907695076	310	1.082251822	361	1.260299702	412	1.43834758		
10	0.034911349	60	0.20946809	110	0.38402484	160	0.558581585	211	0.736628466	261	0.911186211	311	1.085742957	362	1.263790837	413	1.44183872		
11	0.038402484	61	0.21295923	111	0.38751597	161	0.56207272	212	0.740120601	262	0.914677346	312	1.089234092	363	1.267281972	414	1.44532985		
12	0.041893619	62	0.21645036	112	0.39100711	162	0.565563855	213	0.743611736	263	0.918168481	313	1.092725226	364	1.270773107	415	1.44882099		
13	0.045384754	63	0.2199415	113	0.39449824	163	0.56905499	214	0.74710287	264	0.921659616	314	1.096216361	365	1.274264242	416	1.45231212		
14	0.048875889	64	0.22343263	114	0.39798938	164	0.572546125	215	0.750594005	265	0.925150751	315	1.099707496	366	1.277755377	417	1.45580326		
15	0.052367024	65	0.22692377	115	0.40148051	165	0.57603726	216	0.75408514	266	0.928641886	316	1.103198631	367	1.281246512	418	1.45929439		
16	0.055858159	66	0.2304149	116	0.40497165	166	0.579528395	217	0.757576275	267	0.932133021	317	1.106689766	368	1.284737646	419	1.46278553		
17	0.059349293	67	0.23390604	117	0.40846278	167	0.58301953	218	0.76106741	268	0.935624156	318	1.110180901	369	1.288228781	420	1.46627666		
18	0.062840428	68	0.23739717	118	0.41195392	168	0.586510665	219	0.764558545	269	0.93911529	319	1.113672036	370	1.291719916	421	1.4697678		
19	0.066331563	69	0.24088831	119	0.41544505	169	0.5900018	220	0.76804968	270	0.942606425	320	1.117163171	371	1.295211051	422	1.47325893		
20	0.069822698	70	0.24437944	120	0.41893619	170	0.593492935	221	0.771540815	271	0.94609756	321	1.120654306	372	1.298702186	423	1.47675007		
21	0.073313833	71	0.24787058	121	0.42242732	171	0.596984069	222	0.77503195	272	0.949588695	322	1.124145441	373	1.302193321	424	1.4802412		
22	0.076804968	72	0.25136171	122	0.42591846	172	0.600475204	223	0.778523086	273	0.95307983	323	1.127636576	374	1.305684456	425	1.48373234		
23	0.080296103	73	0.25485285	123	0.42940959	173	0.603966339	224	0.78201422	274	0.956570965	324	1.13112771	375	1.309175591	426	1.48722347		
24	0.083787238	74	0.25834398	124	0.43290073	174	0.607457474	225	0.785505356	275	0.9600621	325	1.134618845	376	1.312666726	427	1.49071461		
25	0.087278373	75	0.26183512	125	0.43630186	175	0.610948609	226	0.788996491	276	0.963553235	326	1.13810998	377	1.316157861	428	1.49420574		
26	0.090769508	76	0.26532625	126	0.439883	176	0.614439744	227	0.792487626	277	0.96704437	327	1.141601115	378	1.319648996	429	1.49769688		
27	0.094260643	77	0.26881739	127	0.44337413	177	0.617930879	228	0.795978761	278	0.970535505	328	1.14509225	379	1.32314013	430	1.50118801		
28	0.097751777	78	0.27230852	128	0.44686527	178	0.621422014	229	0.799469894	279	0.97402664	329	1.148583385	380	1.326631265	431	1.50467915		
29	0.101242912	79	0.27579966	129	0.4503564	179	0.624913149	230	0.802961029	280	0.977517774	330	1.15207452	381	1.3301224	432	1.50817028		
30	0.104734047	80	0.27929079	130	0.45384754	180	0.628404284	231	0.806452164	281	0.981008909	331	1.155565655	382	1.333613535	433	1.51168142		
31	0.108225182	81	0.28278193	131	0.45733867	181	0.631895418	232	0.809943299	282	0.984500044	332	1.159056789	383	1.33710467	434	1.51515255		
32	0.111716317	82	0.28627306	132	0.46082981	182	0.635386553	233	0.813434434	283	0.987991179	333	1.162547925	384	1.340595805	435	1.51864369		
33	0.115207452	83	0.2897642	133	0.46432094	183	0.638877688	234	0.816925569	284	0.991482314	334	1.16603906	385	1.34408894	436	1.52213482		
34	0.118698587	84	0.29325533	134	0.46781208	184	0.642368823	235	0.820416704	285	0.994973449	335	1.169530194	386	1.347578075	437	1.52562596		
35	0.122189722	85	0.29674647	135	0.47130321	185	0.645859958	236	0.823907838	286	0.998464584	336	1.173021329	387	1.35106921	438	1.52911709		
36	0.125680857	86	0.3002376	136	0.47479435	186	0.649351093	237	0.827398973	287	1.001955719	337	1.176512464	388	1.354560345	439	1.53260822		
37	0.129171992	87	0.30372874	137	0.47828548	187	0.652842228	238	0.830890108	288	1.005446854	338	1.180003598	389	1.35805148	440	1.53609936		
38	0.132663127	88	0.30721987	138	0.48177662	188	0.656333363	239	0.834381243	289	1.008937989	339	1.183494734	390	1.361542614	441	1.53959049		
39	0.136154261	89	0.31071101	139	0.48526775	189	0.659824498	240	0.837872378	290	1.012429124	340	1.186985869	391	1.365033749	442	1.54308163		
40	0.139645396	90	0.31420214	140	0.48875889	190	0.663315633	241	0.841363513	291	1.015920258	341	1.190477004	392	1.368524884	443	1.54657276		
41	0.143136531	91	0.31769328	141	0.49225002	191	0.666806768	242	0.844854648	292	1.019411393	342	1.193968139	393	1.372016018	444	1.5500639		
42	0.146627666	92	0.32118441	142	0.49574116	192	0.670297902	243	0.848345783	293	1.022902528	343	1.197459274	394	1.375507153	445	1.55355503		
43	0.150116801	93	0.32467555	143	0.49923229	193	0.673788037	244	0.851836918	294	1.026393663	344	1.200950409	395	1.378998288	446	1.55704617		
44	0.153809936	94	0.32816668	144	0.50272343	194	0.677280172	245	0.855328053	295	1.029884798	345	1.204441544	396	1.382489424	447	1.5605373		
45	0.157101071	95	0.33165782	145	0.50621456	195	0.680771307	246	0.858819188	296	1.033375933	346	1.207932678	397	1.385980559	448	1.56402844		
46	0.160592206	96	0.33514895	146	0.5097057	196	0.684262442	247	0.862310322	297	1.036867068	347	1.211423813	398	1.389471694	449	1.56751957		
47	0.164083341	97	0.33864009	147	0.51319683	197	0.687763577	248	0.865801457	298	1.040358203	348	1.214914948	399	1.392962829	450	1.57101071		
48	0.167574476	98	0.34213122	148	0.51668797	198	0.691244712	249	0.869292592	299	1.043849338	349	1.218406083	400	1.396453964	451	1.57450184		
49	0.171065611	99	0.34562236	149	0.5201791	199	0.694735847	250	0.872783727	300	1.047340473	350	1.221897218	401	1.399945098	452	1.57799298		
50	0.174556745	100	0.34911349	150	0.52367024	200	0.698226982	251	0.876274862	301	1.050831608	351	1.225388353	402	1.403436233	453	1.58148411		

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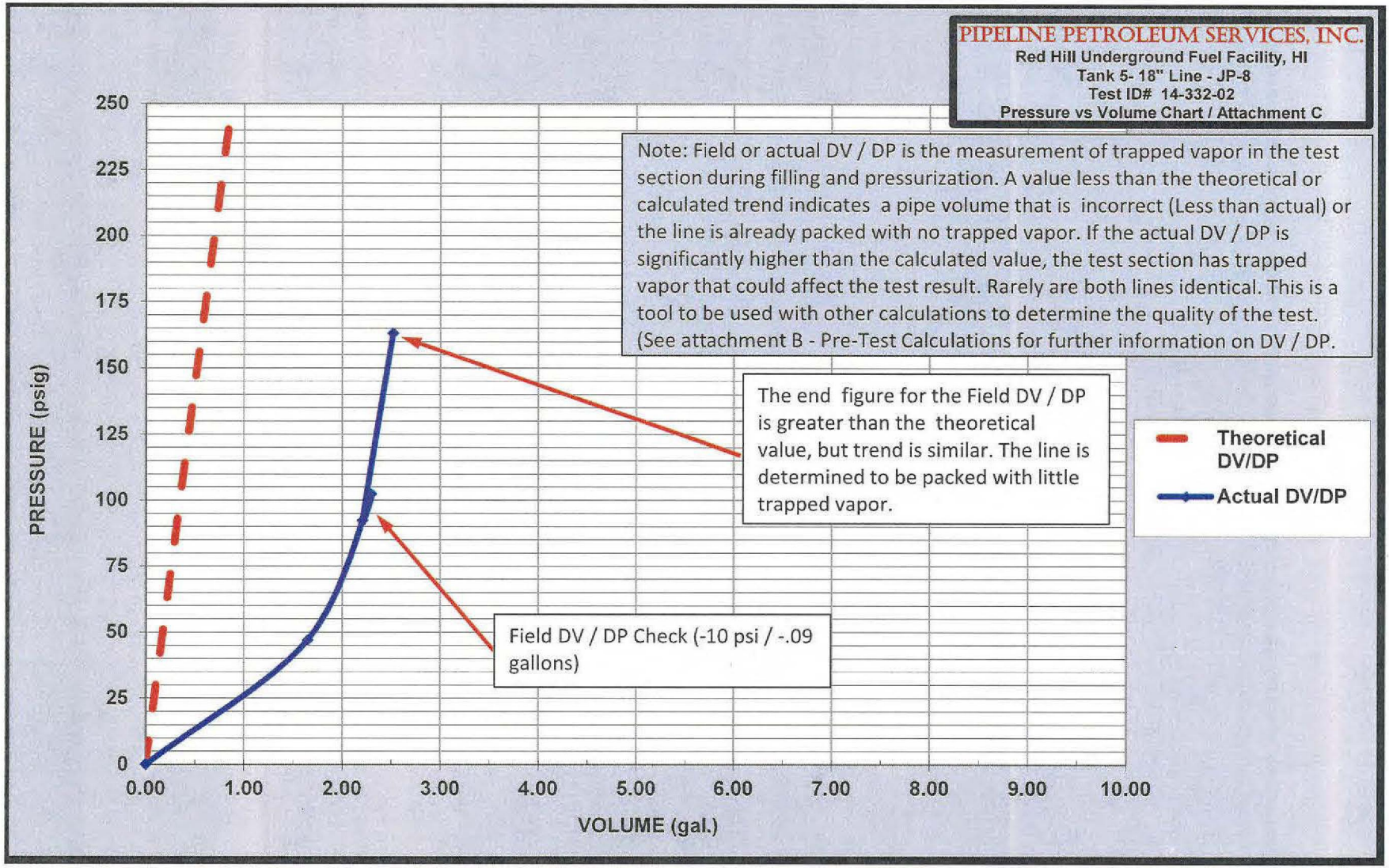
PIPELINE PETROLEUM SERVICES, INC.
Red Hill Underground Fuel Facility, HI
Tank 5- 18" Line - JP-8
Test ID# 14-332-02
Pressure vs Volume Chart / Attachment C
Note: Field or actual DV / DP is the measurement of trapped vapor in the test section during filling and pressurization. A value less than the theoretical or calculated trend indicates a pipe volume that is incorrect (Less than actual) or the line is already packed with no trapped vapor. If the actual DV / DP is significantly higher than the calculated value, the test section has trapped vapor that could affect the test result. Rarely are both lines identical. This is a tool to be used with other calculations to determine the quality of the test. (See attachment B - Pre-Test Calculations for further information on DV / DP.
The end figure for the Field DV / DP is greater than the theoretical value, but trend is similar. The line is determined to be packed with little trapped vapor.
Field DV / DP Check (-10 psi / -.09 gallons)
Theoretical DV/DP
Actual DV/DP
PRESSURE (psig)
250
225
200
175
150
125
100
75
50
25
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
VOLUME (gal.)

PIPELINE PETROLEUM SERVICES, INC.

Pipeline Pressure & Temperature Log (Attachment D)

Note: Enter readings every 15 minutes for first hour of test (Entries 1-5) and every 30 minutes for each hour there after.

Customer:	Willbros Government Services
Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor
System:	Tank 5 Fuel Piping - 18"

Date:	6/25/2014
Test ID No:	14-332-02
Dwg Color Code:	N/A

	Pressure Location & Unit #:	Location 1 & Unit #:	Location 2 & Unit #:	Location 3 & Unit #:	Location 4 & Unit #:
	Lower Yard Tunnel (Tank 5	Lower Yard Tunnel (Tank 5)			

Number AG/IN Sensors: 1

Number BG Sensors: 1

Initial Pressurization From: PSI

Entry ID Number	Time	Deadweight Pressure (psi)	Chart / Gauge Pressure (psig)	Aboveground / Exposed Pipe Temp (F) Location 1	Belowground / Non-Exposed Pipe Temp (F) Location 1	Aboveground / Exposed Pipe Temp (F) Location 2	Belowground / Non-Exposed Pipe Temp (F) Location 2	Aboveground / Exposed Pipe Temp (F) Location 3	Belowground / Non-Exposed Pipe Temp (F) Location 3	Aboveground / Exposed Pipe Temp (F) Location 4	Belowground / Non-Exposed Pipe Temp (F) Location 4	Inside Pipe Temp (F)	Ambient Temp (F)	Volume Added (Gal)	Volume Drained (Gal)	Percent Cloud Cover (0-100%)	Remarks (Weather Conditions)
1	2237	165.2	*	79.84	79.84								79.81				Start Test Time: 2237
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11	0137	162.0		79.75	79.75								79.68				
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
	Final	162.0		79.75	79.75								79.68				End Test Time: 0137
		PSI Diff		Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Temp Diff	Total Added	Total Drained		
	Net Change	-3.2		-0.09	-0.09								-0.13				

Average AG/IN Temp Start:	79.84	Average AG/IN Temp End:	79.75	Average Temperature for Test AG/IN:	79.80
Average BG Temp Start:	79.84	Average BG Temp End:	79.75	Average Temperature for Test BG:	79.80

Net Volume Loss(+) / Gain (-):

Note: Average Temperatures are used in the calculations for the press / temp eval sheet and volume change calculations.

Equivalent Pressure Loss From Drained Amount: (Field DP / DV)(Hydrotest Only)

1	Gallons =	111.11	PSI
	Total Gal Drained =		PSI

PSI Diff + PSI / Gal Equivalent from Drained Product (Calculated) = Total Pressure Differential (TPD)

TPD = -3.20 (Use on Evaluation Sheet - Attachment E)(Hydrotest Only)

Remarks: (Explanation of Any Pressure Discontinuities)

* See attached recorder chart. Average AG Temperature includes both Inside and Aboveground / Exposed Temperatures. (If needed)

Used the same temperatures for AG & BG pipe from the dataloggers in the tunnel and inside of the tank because there was no practical way to actually measure the temperature of the piping as it was encased in concrete. Due to the non-exposed nature of all of the piping we feel the temperatures should be very close to each other given the amount of stabilization time allowed.

Left pressure on the line from 1600 on June 25 (Pressure: 167.65 / Pipe Temp: 80.024 + 79.466) to 0915 AM the next morning and the pressure was at 154.7 psi with a pipe temperature of 79.826 + 79.61.

Note: Line never fully stabilized.

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PIPELINE PETROLEUM SERVICES, INC.

Hydrostatic Test Pressure and Temperature Evaluation Form (Attachment E)

Test ID Number:	14-332-02	**Dwg Color Code:**	None	**Date:**	6/25/14
Customer:	Willbros Government Services	**Location:**	Red Hill Fuel Farm, Naval Station Pearl Harbor		
System Under Evaluation:	Tank 5 Fuel Piping - 18"				

Test Data:

Test Medium: (Water, Diesel, Gasoline, JP-5, JP-8, Kerosene, Other):	Water
Pipeline Total Length: ("L"): (All Test Sections)	65
Pipe Outside Diameter: ("*D*"): (Average From All Test Sections)	17.677
Pipe Wall Thickness: ("*t*"): (Average From All Test Sections)	0.375
D/t Ratio: (Pipe Ø / "t"): (Average From All Test Sections)	47.14
Pipeline Total Volume: (From Report Page 1)	764.07

IN: Inside Pipe Temp
AG: Aboveground Pipe Temp
BG: Below Ground Pipe Temp
TL: Total Length
▲P: Pressure Change
▲T: Temperature Change
All temp in degrees Fahrenheit unless noted
All pressure in lb/in² (psi) unless noted

Beginning Test Pressure: ("*Pb*"):	165.2	**Ending Test Pressure: ("*Pe*"):**	162		
Observed Pressure Change (Attachment A): (*Change P observed = Pe - Pb*):	-3.2	**▲P (PSI)**			
Beginning Test Temperature AG: ("*Tb AG*"):	79.84	**Ending Test Temp AG: ("*Te AG*"):**	79.75		
Length AG:		**Percent Total Length: (Length AG / Total Length): % TL AG:**			
Beginning Test Temperature BG: ("*Tb BG*"):	79.84	**Ending Test Temp BG: ("*Te BG*"):**	79.75		
Length BG:	58	**Percent Total Length: (Length BG / Total Length): % TL BG:**	89%		
Beginning Test Temperature Inside: ("*Tb IN*"):		**Ending Test Temp IN: ("*Te IN*"):**			
Length IN:	7	**Percent Total Length: (Length IN / Total Length): % TL *IN*:**	11%		

▲T-AG: (Chg T=Te -Tb)	-0.09	**x %TL AG:**		**= Adjusted Average AG ▲T:**	
▲T-BG: (Chg T=Te -Tb)	-0.09	**x %TL BG:**	89%	**= Adjusted Average BG ▲T:**	-0.08
▲T-IN: (Chg T=Te -Tb)		**x %TL IN:**	11%	**= Adjusted Average IN ▲T:**	

(Final (FChg T) = Adjusted Avg AG ▲T + Adjusted Avg BG ▲T + Adjusted Avg IN ▲T / 3) **FChg T:** -0.07 **▲T (° F)**

Average Temp (T avg)	**(Tb AG + Tb BG + Tb IN) / 3 =**	73.58	**Tb**	Note: IN & AG are averaged together based on weighting factors.
	(Te AG + Te BG + Te IN) / 3 =	73.50	**Te**	
Average Fluid / Pipe Temperature (*T avg = (Te + Tb) / 2*):			**T avg:**	73.54 (For Test Duration)

Using T avg and D/t, find dP / dT from temperature compensation charts (exhibit 100,101,102, 103, 104, or 105) or calculate for the appropriate test medium:

dP / dT = 24.15 psi / ° F From Pre-Test Calculations - Attachment B

Formula for dP / dT Chart Development or Calculation used in Attachment B:

$$dP = \frac{[B-2a]/[Dx(1-v^2)/Et+C]}{T}$$

Formula and Results Validated by UFC 3-460-03 Section 9-3.5 / Pressure Relief Valves and CA State Hydrostatic Testing Worksheet. (Different Formula Variation)

dP=psig change per degree C or F
B=Coefficient of expansion of test medium
D=Pipe OD in inches
E=Modulus of elasticity for pipe material
v=Poisson's ratio, 0.3 for steel pipe
C=Compressibility factor for water (Or other test med), cu in/cu in/psig
a=Coefficient of expansion for steel,
t=Pipe wall thickness, in
T=Temperature, degrees C or F (20°C)(Or Tavg for test duration above)
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water	B=	1.23E-04	Bulk Modulus (β):	321,543
		C= (1/β)	3.11E-06	(Reciprocal of the Bulk Modulus (β) in lb/in²)	
Pipe Material #1:	Carbon Steel	E=	2.95E+07	a =	6.50E-06
Pipe Material #2:	N/A	E=		a =	
Pipe Material #3:	N/A	E=		a =	

List all Pipe Material & Test Medium Assumptions Made for Test Calculations:

Test Variables for Calculations (Pipe Material Physical Properties from *(in part)* Appendix C, ASME B 31.3)

Pipe Material	E	a (in/in/per°F)	α (Linear)	Test Medium	C = (1/β)	Bulk Modulus (β):	B (° F)	SG @ 60°F
Carbon Steel	2.95E+07	6.50E-06	6.10E-06	JP-5 / JP-8 / Jet-A / Kerosene	5.18E-06	1.93E+05	4.98E-04	0.81
Stainless Steel	2.8E+07	9.60E-06		Diesel - LSD / ULSD / Dyed	5.21E-06	1.92E+05	4.59E-04	0.85
FRP	2.3E+06	1.16E-05		Gasoline	5.29E-06	1.89E+05	4.57E-04	0.84
Aluminum	1.00E+07			Water	3.11E-06	3.22E+05	1.23E-04	1.00
Other				Other				

Calculate the expected pressure change: *Chg P expected = dP / dT x FChg T*

Figure corrected for various diameters of pipe within test section

Chg P expected =	*dP / dT*		*FChg T*		*Chg P*	
(°C converted to °F)	24.15	(psi / °F) x	-0.07	°F =	-1.73	psi - Expected ▲P

Pressure increases (Chg P > 0): If Chg P observed > Chg P expected test is successful.
Pressure decreases (Chg P < 0): If Abs (Chg P observed) < Abs (Chg P expected) test is successful.

Test Successful: (Pass / Fail):	Fail	**Expected ▲P:** (Calculated Chg P)	-1.7302
Total pressure differential (TPD) from Attachment A (Log Sheet) →		**Observed ▲P:** (From Log Sheet)	-3.2000

Note: The sign (+/-) of the observed pressure change should be consistent with the sign of the temperature change (FChg T).

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Hydrostatic Test Volume Change Calculations (Attachment F) Page 1 of 2

Test ID Number:	14-332-02	Dwg Code Color:	None
Customer:	Willbros Government Services	Date:	6/25/2014
System Under Evaluation:	Tank 5 Fuel Piping - 18"	Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor

Volume Change Calculations for Pipeline Hydrostatic Test (Calculated Volume/Pressure Slope Method)

Standard Formula: ▲V / V = Kp▲P + Kt▲T

Where: Kp = [(D/t)(5/4 -μ) / E] + 1/β = (1.9D / 2Et) + 1/β

And: Kt = 3a - g

▲P = Liquid Pressure Change
▲T = Liquid Temperature Change
▲V = Liquid Volume Added to Inside of Pipe (Negative if Flows Out)
V= Nominal Pipeline Volume (πD²L/4)
D= Inside Pipe Diameter

L= Pipe Length
t = Pipe Wall Thickness
μ = Poisson's Ratio = 0.3
E = Young's Modulus = 30x10^6 psi
β = Liquid Bulk Modulus, a function of Press & Temp
g = Liquid Volumetric Expansion Coefficient, a Function of Press & Temp
a = Linear Coefficient of Thermal Expansion
Note: Modulus of Elasticity = Young's Modulus = Elastic Modulus

Test Medium:	Water				Pipe Material:	Carbon Steel
API Gravity: (141.5/SG)-131.5	Specific Gravity: SG 141.5/(131.5+Degrees API)	ρ (SG x 1000)	(Liquid Coefficient of Expansion) B & g =	Compressibility: C = (1/β)	(Young's Modulus) E=	Linear Coefficient of Expansion: a=
10.00	0.9990	999.012	1.23E-04	3.11E-06	2.95E+07	6.50E-06

Pipe Data			Test Date	6/25/2014	API Gravity	10.00
Pipe Segment	Ø Outside (In)	Ø Inside (In)	Wall (In)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	18	17.250	0.375	58	704.15	Buried
Nozzle Inside Tank	18	17.250	0.375	3	36.42	Inside
Nozzle Outside Tank	12.75	12.000	0.375	4	23.50	Inside
			Totals	65	764.07	

Weighting for Pipeline Segment	% Total Length	Configuration	Buried	Exposed	Inside
Non Exposed	0.92	Buried	0.92		
Nozzle Inside Tank	0.05	Inside			0.05
Nozzle Outside Tank	0.03	Inside			0.03
Sum of Factors	1.00	Weight Factors	0.92		0.08

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected T1	DT1	AVG. T
79.84	79.844		73.58	13.5716816	73.54

Final Test Temperatures

Buried	Exposed	Inside	Final Corrected T2	DT2
79.75	79.754		73.50	13.4887398

Corrected Temperature Difference -0.08

NOTE: PIPE TYPE

	E	a
Carbon Steel	2.95E+07	6.50E-06
Stainless Steel	2.8E+07	9.60E-06
FRP	2.3E+06	1.16E-05
Aluminum	1.00E+07	

Test Pressure Difference

Initial Pressure P1	Final Pressure P2	dPressure
165.2	162	-3.2

Calculate (Kp)=(1.9D/2Et)+1/β weighted value — Kp (1/P)

Compressibility Factor (1/BETA) or (1/β)

Calculating C_{PL}	C_{PL} 1	C_{PL} 2	F_P 1	F_P 2
C_{PL} = 1/(1-F_p*P) or Kp (1/P)=	1.0005973	1.0005856	3.614E-06	3.613E-06

Calculate (Kt)=(3a-g)a=constant

Calculating C_{TL}	C_{TL} 1	C_{TL} 2	Coefficient Of Linear Expansion	Temperature Correction Factor (α)	Test Duration
C_{TL} = Exp(-α_{60}*DT*(1+0.8*α_{60}*(DT+δ_{60}))) or Kt(1/F)=	0.9955024	0.9955299	a	α_{60}	Hours
			6.50E-06	3.31E-04	4.00

Calculating Fluid Volume Gain / Loss

dV =V2-V1=V0/(C_{PL}2*C_{TL}2)-V0/(C_{PL}1*C_{TL}1))	dV=Total Pipeline Volume*(Kp*dP+Kt*dT) ▲V / V = Total Pipeline Volume Kp▲P + Kt▲T		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume. Loss/8hrs	-0.01	+		=	-0.01	
Volume. Loss/hour	0.00	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable			
Gal./hour	1.02	Gal./8hours	8.17

Hydrostatic Pipeline Pressure Test Report 2014
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Hydrostatic Test Volume Change Calculations (Attachment C) Page 2 of 2

Test ID Number:	14-332-02	Code Color:	None
Customer:	Willbros Government Services	Date:	6/25/2014
System Under Evaluation:	Tank 5 Fuel Piping - 18"	Location:	Red Hill Fuel Farm, Naval Station Pearl Harbor

Volume Change Calculations for Jet Fuel Pipeline (measured volume/pressure slope method)

Pipe Data			Test Date	6/25/2014	API Gravity	10
Pipe Segment	Ø Outside (in)	Ø Inside (in)	Wall (in)	Length (Ft)	Volume (Gal)	Configuration
Non Exposed	18	17.250	0.375	58	704.15	Buried
Nozzle Inside Tank	18	17.250	0.375	3	36.42	Inside
Nozzle Outside Tank	12.75	12.000	0.375	4	23.50	Inside
			Totals	65	764.07	

Weighting for segment	% Total Length	Configuration	Buried	Exposed	Inside
Non Exposed	0.92	Buried	0.92		
Nozzle Inside Tank	0.05	Inside			0.05
Nozzle Outside Tank	0.03	Inside			0.03
Sum of Factors	1.00		Weight Factors	0.92		0.08

The above factors are used for weighting segment temperatures.

Corrected Temperatures

Initial Test Temperatures

Buried	Exposed	Inside	Initial Corrected	DT1	
79.84	79.844		73.58	13.5716816	AVG. T
					73.54

Final Test Temperatures

Buried	Exposed	Inside	Final Corrected	DT2
79.75	79.754		73.50	13.4867398

Corrected Temperature Difference	*-0.08*

Test Pressure Difference

Initial Pressure	Final Pressure	dPressure	AVG. Pressure
165.2	162	-3.2	163.6
			Use Reference from Test Data

dV/dP Slope Calculations (Values are From Test Data)

Initial Pressure	Final Pressure	Initial Vol.	Final Vol.	dV/dP
	165.2		2.52	0.015254237

Calculating K_T	K_T		Coefficient Of Linear Expansion	Temperature Correction Factor		Test Duration
$K_T = 3a\text{-}\alpha_{60}$	-0.0003115		a	α_{60}		Hours
			6.50E-06	3.31E-04		4.00

Calculating Fluid Volume Gain / Loss

dV =Total Pipeline Volume*K_T* dT+dV/dP*dP	dV		Net Volume Removed (Accountable Loss(-) / Gain(+) - From Log Sheet)		Unaccountable Loss	Actual Gain(+) / Loss(-)
Volume. Loss/8hrs	-0.01	+		=	-0.01	
Volume. Loss/hour	0.00	+		=	0.00	
			Added or Subtracted During Test			

CSFM Loss Allowable				Test Conclusion IAW CSFM / hr	Pass
Gal./hour	1.02	Gal./8hours	8.17	Test Conclusion IAW CSFM / 8 hrs	Pass

Note: Use this pass/fail criteria to assist in determining a successful test with the temperature evaluation.

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APPENDIX D –

RAW TEST DATA FROM DATALOGGER – 32" F-76 LINE
RAW TEST DATA FROM DATALOGGER – 18" JP-8 LINE

Table 6: [illegible] Data Analysis

Note: [illegible] and [illegible] are the [illegible] [illegible] [illegible]

464	2014-06-26 19:13:02	180.5	165.8	464	2014-06-26 19:13:23	79.916	73.022	464	2014-06-26 19:13:52	80.042	80.096
465	2014-06-26 19:14:02	180.25	165.55	465	2014-06-26 19:14:23	79.808	72.608	465	2014-06-26 19:14:52	80.078	80.15
466	2014-06-26 19:15:02	180.1	165.4	466	2014-06-26 19:15:23	79.808	73.004	466	2014-06-26 19:15:52	80.078	80.15
467	2014-06-26 19:16:02	180	165.3	467	2014-06-26 19:16:23	79.808	73.094	467	2014-06-26 19:16:52	80.078	80.132
468	2014-06-26 19:17:02	179.85	165.15	468	2014-06-26 19:17:23	79.808	73.13	468	2014-06-26 19:17:52	80.042	80.186
469	2014-06-26 19:18:02	179.75	165.05	469	2014-06-26 19:18:23	79.808	73.184	469	2014-06-26 19:18:52	79.934	80.132
470	2014-06-26 19:19:02	179.65	164.95	470	2014-06-26 19:19:23	79.808	73.004	470	2014-06-26 19:19:52	79.952	80.132
471	2014-06-26 19:20:02	179.6	164.9	471	2014-06-26 19:20:23	79.808	73.13	471	2014-06-26 19:20:52	79.916	80.15
472	2014-06-26 19:21:02	179.55	164.85	472	2014-06-26 19:21:23	79.808	73.274	472	2014-06-26 19:21:52	79.916	80.096
473	2014-06-26 19:22:02	179.45	164.75	473	2014-06-26 19:22:23	79.808	73.364	473	2014-06-26 19:22:52	79.952	80.078
474	2014-06-26 19:23:02	179.35	164.65	474	2014-06-26 19:23:23	79.808	73.49	474	2014-06-26 19:23:52	79.97	80.078
475	2014-06-26 19:24:02	179.3	164.6	475	2014-06-26 19:24:23	79.808	73.58	475	2014-06-26 19:24:52	79.916	80.132
476	2014-06-26 19:25:02	179.25	164.55	476	2014-06-26 19:25:23	79.808	73.706	476	2014-06-26 19:25:52	80.006	80.096
477	2014-06-26 19:26:02	179.2	164.5	477	2014-06-26 19:26:23	79.7	73.598	477	2014-06-26 19:26:52	79.952	80.132
478	2014-06-26 19:27:02	179.15	164.45	478	2014-06-26 19:27:23	79.808	73.832	478	2014-06-26 19:27:52	79.916	80.096
479	2014-06-26 19:28:02	179.1	164.4	479	2014-06-26 19:28:23	79.808	73.976	479	2014-06-26 19:28:52	79.916	80.132
480	2014-06-26 19:29:02	179.05	164.35	480	2014-06-26 19:29:23	79.808	74.066	480	2014-06-26 19:29:52	79.898	80.132
481	2014-06-26 19:30:02	179	164.3	481	2014-06-26 19:30:23	79.7	74.084	481	2014-06-26 19:30:53	79.898	80.078
482	2014-06-26 19:31:02	178.95	164.25	482	2014-06-26 19:31:23	79.7	74.21	482	2014-06-26 19:31:52	79.88	80.132
483	2014-06-26 19:32:02	178.9	164.2	483	2014-06-26 19:32:23	79.808	74.462	483	2014-06-26 19:32:52	79.88	80.024
484	2014-06-26 19:33:02	178.85	164.15	484	2014-06-26 19:33:23	79.7	74.48	484	2014-06-26 19:33:52	79.934	80.132
485	2014-06-26 19:34:02	178.85	164.15	485	2014-06-26 19:34:23	79.7	74.606	485	2014-06-26 19:34:52	79.88	80.132
486	2014-06-26 19:35:02	178.8	164.1	486	2014-06-26 19:35:23	79.7	74.696	486	2014-06-26 19:35:52	79.988	80.042
487	2014-06-26 19:36:02	178.75	164.05	487	2014-06-26 19:36:23	79.7	74.822	487	2014-06-26 19:36:52	79.934	80.042
488	2014-06-26 19:37:02	178.7	164	488	2014-06-26 19:37:23	79.808	75.02	488	2014-06-26 19:37:52	80.006	80.042
489	2014-06-26 19:38:02	178.7	164	489	2014-06-26 19:38:23	79.7	75.002	489	2014-06-26 19:38:53	80.024	80.042
490	2014-06-26 19:39:02	178.65	163.95	490	2014-06-26 19:39:23	79.7	75.128	490	2014-06-26 19:39:52	80.024	80.042
491	2014-06-26 19:40:02	178.6	163.9	491	2014-06-26 19:40:23	79.7	75.218	491	2014-06-26 19:40:53	80.078	80.006
492	2014-06-26 19:41:02	178.55	163.85	492	2014-06-26 19:41:23	79.7	75.308	492	2014-06-26 19:41:52	80.024	80.096
493	2014-06-26 19:42:02	178.5	163.8	493	2014-06-26 19:42:23	79.7	75.398	493	2014-06-26 19:42:52	80.024	80.006
494	2014-06-26 19:43:02	178.5	163.8	494	2014-06-26 19:43:23	79.7	75.452	494	2014-06-26 19:43:52	80.006	80.078
495	2014-06-26 19:44:02	178.5	163.8	495	2014-06-26 19:44:23	79.7	75.524	495	2014-06-26 19:44:52	79.862	80.06
496	2014-06-26 19:45:02	178.45	163.75	496	2014-06-26 19:45:23	79.7	75.578	496	2014-06-26 19:45:52	79.916	80.024
497	2014-06-26 19:46:02	178.45	163.75	497	2014-06-26 19:46:23	79.7	75.668	497	2014-06-26 19:46:52	79.934	80.078
498	2014-06-26 19:47:02	178.4	163.7	498	2014-06-26 19:47:23	79.7	75.704	498	2014-06-26 19:47:52	79.88	80.06
499	2014-06-26 19:48:02	178.4	163.7	499	2014-06-26 19:48:23	79.808	75.866	499	2014-06-26 19:48:52	79.916	80.024
500	2014-06-26 19:49:02	178.35	163.65	500	2014-06-26 19:49:23	79.7	75.83	500	2014-06-26 19:49:52	79.952	79.97
501	2014-06-26 19:50:02	178.35	163.65	501	2014-06-26 19:50:23	79.7	75.92	501	2014-06-26 19:50:52	79.916	79.97
502	2014-06-26 19:51:02	178.3	163.6	502	2014-06-26 19:51:23	79.7	75.974	502	2014-06-26 19:51:52	79.916	80.006
503	2014-06-26 19:52:02	178.3	163.6	503	2014-06-26 19:52:23	79.7	76.01	503	2014-06-26 19:52:52	79.88	80.024
504	2014-06-26 19:53:02	178.25	163.55	504	2014-06-26 19:53:23	79.7	75.884	504	2014-06-26 19:53:52	79.952	80.006
505	2014-06-26 19:54:02	178.25	163.55	505	2014-06-26 19:54:23	79.7	76.19	505	2014-06-26 19:54:52	79.952	79.952
506	2014-06-26 19:55:02	178.2	163.5	506	2014-06-26 19:55:23	79.7	76.892	506	2014-06-26 19:55:52	79.952	79.97
507	2014-06-26 19:56:02	178.2	163.5	507	2014-06-26 19:56:23	79.808	75.596	507	2014-06-26 19:56:52	79.88	79.97
508	2014-06-26 19:57:02	178.15	163.45	508	2014-06-26 19:57:23	80.024	75.812	508	2014-06-26 19:57:52	79.88	79.952
509	2014-06-26 19:58:02	178.15	163.45	509	2014-06-26 19:58:23	80.132	75.92	509	2014-06-26 19:58:52	79.88	80.006
510	2014-06-26 19:59:02	178.1	163.4	510	2014-06-26 19:59:23	80.132	75.974	510	2014-06-26 19:59:52	79.862	79.97
511	2014-06-26 20:00:02	178.1	163.4	511	2014-06-26 20:00:23	80.258	76.172	511	2014-06-26 20:00:52	79.88	79.88
512	2014-06-26 20:01:02	168.15	153.45	512	2014-06-26 20:01:23	80.258	76.262	512	2014-06-26 20:01:52	79.898	80.006
513	2014-06-26 20:02:02	168.2	153.5	513	2014-06-26 20:02:23	80.258	76.406	513	2014-06-26 20:02:52	79.952	80.006
514	2014-06-26 20:03:02	176.65	161.95	514	2014-06-26 20:03:23	80.258	76.442	514	2014-06-26 20:03:52	79.898	80.006
515	2014-06-26 20:04:02	183.8	169.1	515	2014-06-26 20:04:23	80.258	76.496	515	2014-06-26 20:04:52	79.97	80.024
516	2014-06-26 20:05:02	183.75	169.05	516	2014-06-26 20:05:23	80.258	76.532	516	2014-06-26 20:05:52	79.97	79.952
517	2014-06-26 20:06:02	183.65	168.95	517	2014-06-26 20:06:23	80.366	76.676	517	2014-06-26 20:06:52	79.916	79.97
518	2014-06-26 20:07:02	183.6	168.9	518	2014-06-26 20:07:23	80.366	76.73	518	2014-06-26 20:07:52	80.024	79.97
519	2014-06-26 20:08:02	183.5	168.8	519	2014-06-26 20:08:23	80.366	76.766	519	2014-06-26 20:08:52	79.952	80.006
520	2014-06-26 20:09:02	183.45	168.75	520	2014-06-26 20:09:23	80.366	76.82	520	2014-06-26 20:09:52	79.916	79.952
521	2014-06-26 20:10:02	183.45	168.75	521	2014-06-26 20:10:23	80.366	76.91	521	2014-06-26 20:10:52	79.916	80.006
522	2014-06-26 20:11:02	183.35	168.65	522	2014-06-26 20:11:23	80.366	76.91	522	2014-06-26 20:11:52	79.826	79.97
523	2014-06-26 20:12:02	183.3	168.6	523	2014-06-26 20:12:23	80.366	76.982	523	2014-06-26 20:12:52	79.808	80.024
524	2014-06-26 20:13:02	183.25	168.55	524	2014-06-26 20:13:23	80.258	76.874	524	2014-06-26 20:13:52	79.826	80.006
525	2014-06-26 20:14:02	183.25	168.55	525	2014-06-26 20:14:23	80.258	77.018	525	2014-06-26 20:14:52	79.862	80.006
526	2014-06-26 20:15:02	183.2	168.5	526	2014-06-26 20:15:23	80.258	77.018	526	2014-06-26 20:15:52	79.772	80.006
527	2014-06-26 20:16:02	183.2	168.5	527	2014-06-26 20:16:23	80.258	77.054	527	2014-06-26 20:16:52	79.808	79.97
528	2014-06-26 20:17:02	183.15	168.45	528	2014-06-26 20:17:23	80.258	77.108	528	2014-06-26 20:17:52	79.79	79.952
529	2014-06-26 20:18:02	183.1	168.4	529	2014-06-26 20:18:23	80.258	77.054	529	2014-06-26 20:18:52	79.826	80.006
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531	2014-06-26 20:20:02	183.05	168.35	531	2014-06-26 20:20:23	80.258	77.108	531	2014-06-26 20:20:52	79.826	79.952
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534	2014-06-26 20:23:02	182.9	168.2	534	2014-06-26 20:23:23	80.258	77.234	534	2014-06-26 20:23:52	79.772	79.97
535	2014-06-26 20:24:02	182.9	168.2	535	2014-06-26 20:24:23	80.258	77.234	535	2014-06-26 20:24:52	79.754	79.916
536	2014-06-26 20:25:02	182.85	168.15	536	2014-06-26 20:25:23	80.258	77.234	536	2014-06-26 20:25:52	79.79	79.97
537	2014-06-26 20:26:02	182.85	168.15	537	2014-06-26 20:26:23	80.258	77.198	537	2014-06-26 20:26:52	79.754	79.862
538	2014-06-26 20:27:02	182.8	168.1	538	2014-06-26 20:27:23	80.258	77.234	538	2014-06-26 20:27:52	79.754	79.916
539	2014-06-26 20:28:02	182.75	168.05	539	2014-06-26 20:28:23	80.258	77.234	539	2014-06-26 20:28:52	79.736	79.97
540	2014-06-26 20:29:02	182.75	168.05	540	2014-06-26 20:29:23	80.258	77.198	540	2014-06-26 20:29:52	79.754	79.952
541	2014-06-26 20:30:02	182.7	168	541	2014-06-26 20:30:23	80.366	77.342	541	2014-06-26 20:30:52	79.754	79.916
542	2014-06-26 20:31:02	182.7	168	542	2014-06-26 20:31:23	80.258	77.198	542	2014-06-26 20:31:52	79.79	79.898
543	2014-06-26 20:32:02	182.65	167.95	543	2014-06-26 20:32:23	80.258	77.234	543	2014-06-26 20:32:52	79.754	79.844
544	2014-06-26 20:33:02	182.6	167.9	544	2014-06-26 20:33:23	80.366	77.378	544	2014-06-26 20:33:52	79.79	79.916
545	2014-06-26 20:34:02	182.6	167.9	545	2014-06-26 20:34:23	80.258	77.27	545	2014-06-26 20:34:52	79.79	79.898
546	2014-06-26 20:35:02	182.6	167.9	546	2014-06-26 20:35:23	80.258	77.27	546	2014-06-26 20:35:52	79.754	79.898
547	2014-06-26 20:36:02	182.6	167.9	547	2014-06-26 20:36:23	80.258	77.27	547	2014-06-26 20:36:52	79.862	79.952
548	2014-06-26 20:37:02	182.55	167.85	548	2014-06-26 20:37:23	80.366	77.468	548	2014-06-26 20:37:52	79.79	79.898
549	2014-06-26 20:38:02	182.55	167.85	549	2014-06-26 20:38:23	80.258	77.36	549	2014-06-26 20:38:52	79.736	79.934
550	2014-06-26 20:39:02	182.55	167.85	550	2014-06-26 20:39:23	80.258	77.414	550	2014-06-26 20:39:52	79.754	79.952
551	2014-06-26 20:40:02	182.5	167.8	551	2014-06-26 20:40:23	80.258	77.45	551	2014-06-26 20:40:52	79.754	79.952
552	2014-06-26 20:41:02	182.5	167.8	552	2014-06-26 20:41:23	80.258	77.504	552	2014-06-26 20:41:52	79.754	79.88
553	2014-06-26 20:42:02	182.45	167.75	553	2014-06-26 20:42:23	80.258	77.54	553	2014-06-26 20:42:52	79.736	79.88
554	2014-06-26 20:43:02	182.45	167.75	554	2014-06-26 20:43:23	80.366	77.648	554	2014-06-26 20:43:52	79.736	79.844
555	2014-06-26 20:44:02	182.4	167.7	555	2014-06-26 20:44:23	80.258	77.576	555	2014-06-26 20:44:52	79.736	79.88
556	2014-06-26 20:45:02	182.4	167.7	556	2014-06-26 20:45:23	80.366	77.612	556	2014-06-26 20:45:52	79.754	79.88
557	2014-06-26 20:46:02	182.35	167.65	557	2014-06-26 20:46:23	80.474	77.666	557	2014-06-26 20:46:52	79.79	79.88
558	2014-06-26 20:47:02	182.35	167.65	558	2014-06-26 20:47:23	80.474	77.666	558	2014-06-26 20:47:52	79.79	79.934

749	2014-06-26 23:58:02	180.6	165.9	749	2014-06-26 23:58:23	80.6	79.07	749	2014-06-26 23:58:52	79.844	79.808
750	2014-06-26 23:59:02	180.6	165.9	750	2014-06-26 23:59:23	80.6	79.07	750	2014-06-26 23:59:52	79.844	79.808
751	2014-06-27 00:00:02	180.6	165.9	751	2014-06-27 00:00:23	80.6	79.07	751	2014-06-27 00:00:52	79.844	79.772
752	2014-06-27 00:01:02	180.6	165.9	752	2014-06-27 00:01:23	80.6	78.98	752	2014-06-27 00:01:52	79.826	79.862
753	2014-06-27 00:02:02	180.6	165.9	753	2014-06-27 00:02:23	80.708	79.052	753	2014-06-27 00:02:52	79.808	79.934
754	2014-06-27 00:03:02	180.6	165.9	754	2014-06-27 00:03:23	80.708	78.962	754	2014-06-27 00:03:52	79.862	79.898
755	2014-06-27 00:04:02	180.55	165.85	755	2014-06-27 00:04:23	80.708	78.908	755	2014-06-27 00:04:52	79.916	79.844
756	2014-06-27 00:05:02	180.55	165.85	756	2014-06-27 00:05:23	80.708	78.908	756	2014-06-27 00:05:52	79.862	79.934
757	2014-06-27 00:06:02	180.55	165.85	757	2014-06-27 00:06:23	80.708	78.872	757	2014-06-27 00:06:52	79.916	79.97
758	2014-06-27 00:07:02	180.55	165.85	758	2014-06-27 00:07:23	80.816	78.926	758	2014-06-27 00:07:52	79.88	79.844
759	2014-06-27 00:08:02	180.55	165.85	759	2014-06-27 00:08:23	80.816	78.926	759	2014-06-27 00:08:52	79.88	79.88
760	2014-06-27 00:09:02	180.55	165.85	760	2014-06-27 00:09:23	80.816	78.89	760	2014-06-27 00:09:52	79.88	79.844
761	2014-06-27 00:10:02	180.55	165.85	761	2014-06-27 00:10:23	80.816	78.89	761	2014-06-27 00:10:52	79.898	79.934
762	2014-06-27 00:11:02	180.55	165.85	762	2014-06-27 00:11:23	80.924	78.998	762	2014-06-27 00:11:52	79.916	79.898
763	2014-06-27 00:12:02	180.5	165.8	763	2014-06-27 00:12:23	80.924	79.034	763	2014-06-27 00:12:52	79.934	79.88
764	2014-06-27 00:13:02	180.5	165.8	764	2014-06-27 00:13:23	80.816	78.926	764	2014-06-27 00:13:52	79.916	79.898
765	2014-06-27 00:14:02	180.5	165.8	765	2014-06-27 00:14:23	80.816	79.016	765	2014-06-27 00:14:52	79.934	79.898
766	2014-06-27 00:15:02	180.5	165.8	766	2014-06-27 00:15:23	80.816	79.016	766	2014-06-27 00:15:52	79.898	79.88
767	2014-06-27 00:16:02	180.5	165.8	767	2014-06-27 00:16:23	80.816	79.016	767	2014-06-27 00:16:52	79.88	79.88
768	2014-06-27 00:17:02	180.5	165.8	768	2014-06-27 00:17:23	80.816	79.07	768	2014-06-27 00:17:52	79.808	79.88
769	2014-06-27 00:18:02	180.45	165.75	769	2014-06-27 00:18:23	80.816	79.106	769	2014-06-27 00:18:52	79.808	79.898
770	2014-06-27 00:19:02	180.5	165.8	770	2014-06-27 00:19:23	80.816	79.106	770	2014-06-27 00:19:52	79.808	79.88
771	2014-06-27 00:20:02	180.45	165.75	771	2014-06-27 00:20:23	80.816	79.106	771	2014-06-27 00:20:52	79.826	79.844
772	2014-06-27 00:21:02	180.45	165.75	772	2014-06-27 00:21:23	80.816	79.106	772	2014-06-27 00:21:52	79.808	79.88
773	2014-06-27 00:22:02	180.45	165.75	773	2014-06-27 00:22:23	80.708	79.052	773	2014-06-27 00:22:52	79.826	79.934
774	2014-06-27 00:23:02	180.45	165.75	774	2014-06-27 00:23:23	80.708	79.052	774	2014-06-27 00:23:52	79.772	79.844
775	2014-06-27 00:24:02	180.45	165.75	775	2014-06-27 00:24:23	80.708	79.088	775	2014-06-27 00:24:52	79.772	79.844
776	2014-06-27 00:25:02	180.4	165.7	776	2014-06-27 00:25:23	80.708	79.088	776	2014-06-27 00:25:52	79.772	79.844
777	2014-06-27 00:26:02	180.45	165.75	777	2014-06-27 00:26:23	80.708	79.088	777	2014-06-27 00:26:52	79.736	79.88
778	2014-06-27 00:27:02	180.4	165.7	778	2014-06-27 00:27:23	80.708	79.124	778	2014-06-27 00:27:52	79.772	79.826
779	2014-06-27 00:28:02	180.4	165.7	779	2014-06-27 00:28:23	80.708	79.124	779	2014-06-27 00:28:52	79.79	79.808
780	2014-06-27 00:29:02	180.4	165.7	780	2014-06-27 00:29:23	80.708	79.178	780	2014-06-27 00:29:52	79.736	79.808
781	2014-06-27 00:30:02	180.4	165.7	781	2014-06-27 00:30:23	80.6	79.07	781	2014-06-27 00:30:52	79.772	79.88
782	2014-06-27 00:31:02	180.4	165.7	782	2014-06-27 00:31:23	80.6	79.106	782	2014-06-27 00:31:52	79.772	79.844
783	2014-06-27 00:32:02	180.4	165.7	783	2014-06-27 00:32:23	80.6	79.106	783	2014-06-27 00:32:52	79.682	79.844
784	2014-06-27 00:33:02	180.4	165.7	784	2014-06-27 00:33:23	80.6	79.106	784	2014-06-27 00:33:52	79.682	79.826
785	2014-06-27 00:34:02	180.35	165.65	785	2014-06-27 00:34:23	80.6	79.16	785	2014-06-27 00:34:52	79.682	79.88
786	2014-06-27 00:35:02	180.4	165.7	786	2014-06-27 00:35:23	80.6	79.16	786	2014-06-27 00:35:52	79.664	79.808
787	2014-06-27 00:36:02	180.35	165.65	787	2014-06-27 00:36:23	80.6	79.16	787	2014-06-27 00:36:52	79.736	79.826
788	2014-06-27 00:37:02	180.35	165.65	788	2014-06-27 00:37:23	80.6	79.16	788	2014-06-27 00:37:52	79.736	79.808
789	2014-06-27 00:38:02	180.35	165.65	789	2014-06-27 00:38:23	80.474	79.07	789	2014-06-27 00:38:52	79.718	79.862
790	2014-06-27 00:39:02	180.35	165.65	790	2014-06-27 00:39:23	80.474	79.124	790	2014-06-27 00:39:52	79.682	79.808
791	2014-06-27 00:40:02	180.35	165.65	791	2014-06-27 00:40:23	80.474	79.124	791	2014-06-27 00:40:52	79.772	79.844
792	2014-06-27 00:41:02	180.35	165.65	792	2014-06-27 00:41:23	80.474	79.124	792	2014-06-27 00:41:52	79.718	79.826
793	2014-06-27 00:42:02	180.35	165.65	793	2014-06-27 00:42:23	80.474	79.16	793	2014-06-27 00:42:52	79.718	79.862
794	2014-06-27 00:43:02	180.35	165.65	794	2014-06-27 00:43:23	80.474	79.16	794	2014-06-27 00:43:52	79.736	79.826
795	2014-06-27 00:44:02	180.3	165.6	795	2014-06-27 00:44:23	80.474	79.196	795	2014-06-27 00:44:52	79.718	79.772
796	2014-06-27 00:45:02	180.3	165.6	796	2014-06-27 00:45:23	80.474	79.16	796	2014-06-27 00:45:52	79.736	79.826
797	2014-06-27 00:46:02	180.3	165.6	797	2014-06-27 00:46:23	80.474	79.196	797	2014-06-27 00:46:52	79.682	79.772
798	2014-06-27 00:47:02	180.3	165.6	798	2014-06-27 00:47:23	80.474	79.196	798	2014-06-27 00:47:52	79.736	79.826
799	2014-06-27 00:48:02	180.3	165.6	799	2014-06-27 00:48:23	80.474	79.196	799	2014-06-27 00:48:52	79.736	79.862
800	2014-06-27 00:49:02	180.3	165.6	800	2014-06-27 00:49:23	80.474	79.25	800	2014-06-27 00:49:52	79.718	79.772
801	2014-06-27 00:50:02	180.3	165.6	801	2014-06-27 00:50:23	80.366	79.088	801	2014-06-27 00:50:52	79.736	79.772
802	2014-06-27 00:51:02	180.25	165.55	802	2014-06-27 00:51:23	80.366	79.142	802	2014-06-27 00:51:52	79.754	79.772
803	2014-06-27 00:52:02	180.25	165.55	803	2014-06-27 00:52:23	80.474	79.25	803	2014-06-27 00:52:52	79.718	79.772
804	2014-06-27 00:53:02	180.25	165.55	804	2014-06-27 00:53:23	80.366	79.178	804	2014-06-27 00:53:52	79.682	79.826
805	2014-06-27 00:54:02	180.25	165.55	805	2014-06-27 00:54:23	80.366	79.142	805	2014-06-27 00:54:52	79.682	79.772
806	2014-06-27 00:55:02	180.25	165.55	806	2014-06-27 00:55:23	80.366	79.178	806	2014-06-27 00:55:52	79.736	79.772
807	2014-06-27 00:56:02	180.25	165.55	807	2014-06-27 00:56:23	80.366	79.178	807	2014-06-27 00:56:52	79.682	79.826
808	2014-06-27 00:57:02	180.25	165.55	808	2014-06-27 00:57:23	80.366	79.178	808	2014-06-27 00:57:52	79.736	79.808
809	2014-06-27 00:58:02	180.2	165.5	809	2014-06-27 00:58:23	80.366	79.178	809	2014-06-27 00:58:52	79.718	79.826
810	2014-06-27 00:59:02	180.2	165.5	810	2014-06-27 00:59:23	80.366	79.178	810	2014-06-27 00:59:52	79.682	79.808
811	2014-06-27 01:00:02	180.25	165.55	811	2014-06-27 01:00:23	80.366	79.232	811	2014-06-27 01:00:52	79.682	79.808
812	2014-06-27 01:01:02	180.2	165.5	812	2014-06-27 01:01:23	80.366	79.232	812	2014-06-27 01:01:52	79.718	79.808
813	2014-06-27 01:02:02	180.2	165.5	813	2014-06-27 01:02:23	80.366	79.232	813	2014-06-27 01:02:52	79.808	79.772
814	2014-06-27 01:03:02	180.2	165.5	814	2014-06-27 01:03:23	80.258	79.124	814	2014-06-27 01:03:52	79.754	79.772
815	2014-06-27 01:04:02	180.2	165.5	815	2014-06-27 01:04:23	80.366	79.268	815	2014-06-27 01:04:52	79.772	79.754
816	2014-06-27 01:05:02	180.2	165.5	816	2014-06-27 01:05:23	80.366	79.268	816	2014-06-27 01:05:52	79.772	79.772
817	2014-06-27 01:06:02	180.2	165.5	817	2014-06-27 01:06:23	80.366	79.268	817	2014-06-27 01:06:52	79.754	79.808
818	2014-06-27 01:07:02	180.2	165.5	818	2014-06-27 01:07:23	80.258	79.16	818	2014-06-27 01:07:52	79.718	79.754
819	2014-06-27 01:08:02	180.2	165.5	819	2014-06-27 01:08:23	80.258	79.16	819	2014-06-27 01:08:52	79.718	79.862
820	2014-06-27 01:09:02	180.2	165.5	820	2014-06-27 01:09:23	80.366	79.268	820	2014-06-27 01:09:52	79.718	79.754
821	2014-06-27 01:10:02	180.2	165.5	821	2014-06-27 01:10:23	80.258	79.214	821	2014-06-27 01:10:52	79.772	79.772
822	2014-06-27 01:11:02	180.15	165.45	822	2014-06-27 01:11:23	80.258	79.214	822	2014-06-27 01:11:52	79.7	79.754
823	2014-06-27 01:12:02	180.15	165.45	823	2014-06-27 01:12:23	80.258	79.214	823	2014-06-27 01:12:52	79.718	79.718
824	2014-06-27 01:13:02	180.15	165.45	824	2014-06-27 01:13:23	80.258	79.25	824	2014-06-27 01:13:52	79.718	79.754
825	2014-06-27 01:14:02	180.15	165.45	825	2014-06-27 01:14:23	80.258	79.25	825	2014-06-27 01:14:52	79.718	79.718
826	2014-06-27 01:15:02	180.15	165.45	826	2014-06-27 01:15:23	80.258	79.214	826	2014-06-27 01:15:52	79.664	79.754
827	2014-06-27 01:16:02	180.15	165.45	827	2014-06-27 01:16:23	80.258	79.25	827	2014-06-27 01:16:52	79.718	79.718
828	2014-06-27 01:17:02	180.15	165.45	828	2014-06-27 01:17:23	80.258	79.25	828	2014-06-27 01:17:52	79.754	79.754
829	2014-06-27 01:18:02	180.15	165.45	829	2014-06-27 01:18:23	80.258	79.25	829	2014-06-27 01:18:52	79.754	79.772
830	2014-06-27 01:19:02	180.15	165.45	830	2014-06-27 01:19:23	80.258	79.25	830	2014-06-27 01:19:52	79.718	79.718
831	2014-06-27 01:20:02	180.1	165.4	831	2014-06-27 01:20:23	80.258	79.286	831	2014-06-27 01:20:52	79.7	79.808
832	2014-06-27 01:21:02	180.1	165.4	832	2014-06-27 01:21:23	80.132	79.16	832	2014-06-27 01:21:52	79.646	79.718
833	2014-06-27 01:22:02	180.1	165.4	833	2014-06-27 01:22:23	80.132	79.16	833	2014-06-27 01:22:52	79.7	79.808
834	2014-06-27 01:23:02	180.1	165.4	834	2014-06-27 01:23:23	80.132	79.16	834	2014-06-27 01:23:52	79.7	79.7
835	2014-06-27 01:24:02	180.1	165.4	835	2014-06-27 01:24:23	80.132	79.16	835	2014-06-27 01:24:52	79.7	79.772
836	2014-06-27 01:25:02	180.1	165.4	836	2014-06-27 01:25:23	80.132	79.16	836	2014-06-27 01:25:52	79.718	79.772
837	2014-06-27 01:26:02	180.1	165.4	837	2014-06-27 01:26:23	80.258	79.286	837	2014-06-27 01:26:52	79.754	79.772
838	2014-06-27 01:27:02	180.1	165.4	838	2014-06-27 01:27:23	80.132	79.16	838	2014-06-27 01:27:52	79.682	79.808
839	2014-06-27 01:28:02	180.05	165.35	839	2014-06-27 01:28:23	80.132	79.214	839	2014-06-27 01:28:52	79.646	79.718
840	2014-06-27 01:29:02	180.05	165.35	840	2014-06-27 01:29:23	80.132	79.214	840	2014-06-27 01:29:52	79.664	79.808
841	2014-06-27 01:30:02	180.05	165.35	841	2014-06-27 01:30:23	80.132	79.214	841	2014-06-27 01:30:52	79.664	79.754
842	2014-06-27 01:31:02	180.05	165.35	842	2014-06-27 01:31:23	80.132	79.214	842	2014-06-27 01:31:52	79.7	79.718
843	2014-06-27 01:32:02	180.05	165.35	843	2014-06-27 01:32:23	80.132	79.214	843	2014-06-27 01:32:52	79.7	79.772

Tank 8 18" Line Test Data

Note: Pressure and temperature readings are taken approximately every minute.

Device Name:	P1200
Device Description:	Pressure Recorder with 1/10 Gauge
Serial Number:	N86636
Device ID:	Press Unit 2

Location: Flange in Lower Access Tunnel

		Channel 1	
Reading Number	Date and Time (MST)	Absolute Pressure (PSIA)	Gauge Pressure (PSIG)[5-14.7]
Column1	Column2	Column3	Column4
1	2014-06-25 07:28:17	185.7	
2	2014-06-25 07:27:28	186.1	1.37
3	2014-06-25 07:26:27	186.9	1.71
4	2014-06-25 07:25:27	186.63	1.71
5	2014-06-25 07:24:27	186.9	1.71
6	2014-06-25 07:23:27	186.6	1.9
7	2014-06-25 07:22:28	186.89	1.71
8	2014-06-25 07:21:28	186.6	1.9
9	2014-06-25 07:20:27	186.6	1.9
10	2014-06-25 07:19:27	186.4	1.71
11	2014-06-25 07:18:27	186.4	1.71
12	2014-06-25 07:17:28	186.4	1.71
13	2014-06-25 07:16:27	186.89	1.71
14	2014-06-25 07:15:27	186.4	1.71
15	2014-06-25 07:14:27	186.4	1.71
16	2014-06-25 07:13:27	186.4	1.71
17	2014-06-25 07:12:27	186.4	1.71
18	2014-06-25 07:11:27	186.4	1.71
19	2014-06-25 07:10:27	186.4	1.71
20	2014-06-25 07:09:27	186.4	1.71
21	2014-06-25 07:08:27	186.4	1.71
22	2014-06-25 07:07:27	186.4	1.71
23	2014-06-25 07:06:27	186.4	1.71
24	2014-06-25 07:05:27	186.4	1.71
25	2014-06-25 07:04:27	186.4	1.71
26	2014-06-25 07:03:27	186.4	1.71
27	2014-06-25 07:02:27	186.4	1.71
28	2014-06-25 07:01:27	186.4	1.71
29	2014-06-25 07:00:27	186.4	1.71
30	2014-06-25 06:59:27	186.4	1.71
31	2014-06-25 06:58:27	186.4	1.71
32	2014-06-25 06:57:27	186.4	1.71
33	2014-06-25 06:56:27	186.4	1.71
34	2014-06-25 06:55:27	186.4	1.71
35	2014-06-25 06:54:27	186.4	1.71
36	2014-06-25 06:53:27	186.4	1.71
37	2014-06-25 06:52:27	186.4	1.71
38	2014-06-25 06:51:27	186.4	1.71
39	2014-06-25 06:50:27	186.4	1.71
40	2014-06-25 06:49:27	186.4	1.71
41	2014-06-25 06:48:27	186.4	1.71
42	2014-06-25 06:47:27	186.4	1.71
43	2014-06-25 06:46:27	186.4	1.71
44	2014-06-25 06:45:27	186.4	1.71
45	2014-06-25 06:44:27	186.4	1.71
46	2014-06-25 06:43:27	186.4	1.71
47	2014-06-25 06:42:27	186.4	1.71
48	2014-06-25 06:41:27	186.4	1.71
49	2014-06-25 06:40:27	186.4	1.71
50	2014-06-25 06:39:27	186.4	1.71
51	2014-06-25 06:38:27	186.4	1.71
52	2014-06-25 06:37:27	186.4	1.71
53	2014-06-25 06:36:27	186.4	1.71
54	2014-06-25 06:35:27	186.4	1.71
55	2014-06-25 06:34:27	186.4	1.71
56	2014-06-25 06:33:27	186.4	1.71
57	2014-06-25 06:32:27	186.4	1.71
58	2014-06-25 06:31:27	186.4	1.71
59	2014-06-25 06:30:27	186.4	1.71
60	2014-06-25 06:29:27	186.4	1.71
61	2014-06-25 06:28:27	186.4	1.71
62	2014-06-25 06:27:27	186.4	1.71
63	2014-06-25 06:26:27	186.4	1.71
64	2014-06-25 06:25:27	186.4	1.71
65	2014-06-25 06:24:27	186.4	1.71
66	2014-06-25 06:23:27	186.4	1.71
67	2014-06-25 06:22:27	186.4	1.71
68	2014-06-25 06:21:27	186.4	1.71
69	2014-06-25 06:20:27	186.4	1.71
70	2014-06-25 06:19:27	186.4	1.71
71	2014-06-25 06:18:27	186.4	1.71
72	2014-06-25 06:17:27	186.4	1.71

Device Name:	QuadTemp
Device Description:	4 Channel Thermocouple Temperature Recorder
Serial Number:	N86235
Device ID:	Temp Unit 3

Location: Lower Access Tunnel

		Channel 2	Channel 3
Reading Number	Date and Time (MST)	Thermocouple 1 (Ambient) (°F)	Thermocouple 2 (Air Pipe) (°F)
Column1	Column2	Column7	Column8
1	2014-06-25 07:28:28	80.696	80.696
2	2014-06-25 07:27:28	80.696	82.85
3	2014-06-25 07:26:28	80.82	82.043
4	2014-06-25 07:25:28	80.735	82.472
5	2014-06-25 07:24:28	80.696	82.536
6	2014-06-25 07:23:28	80.437	82.148
7	2014-06-25 07:22:28	80.396	82.663
8	2014-06-25 07:21:28	80.402	81.968
9	2014-06-25 07:20:28	80.137	82.924
10	2014-06-25 07:19:28	80.43	82.663
11	2014-06-25 07:18:28	80.396	82.278
12	2014-06-25 07:17:28	80.396	82.278
13	2014-06-25 07:16:28	80.137	81.93
14	2014-06-25 07:15:28	80.137	81.804
15	2014-06-25 07:14:28	80.078	81.588
16	2014-06-25 07:13:28	80.08	81.803
17	2014-06-25 07:12:28	80.325	81.84
18	2014-06-25 07:11:28	80.086	81.194
19	2014-06-25 07:10:28	80.078	81.474
20	2014-06-25 07:09:28	80.086	81.194
21	2014-06-25 07:08:28	80.078	81.194
22	2014-06-25 07:07:28	80.137	81.194
23	2014-06-25 07:06:28	80.137	81.194
24	2014-06-25 07:05:28	80.137	81.194
25	2014-06-25 07:04:28	80.137	81.194
26	2014-06-25 07:03:28	80.137	81.194
27	2014-06-25 07:02:28	80.137	81.194
28	2014-06-25 07:01:28	80.137	81.194
29	2014-06-25 07:00:28	80.137	81.194
30	2014-06-25 06:59:28	80.137	81.194
31	2014-06-25 06:58:28	80.137	81.194
32	2014-06-25 06:57:28	80.137	81.194
33	2014-06-25 06:56:28	80.137	81.194
34	2014-06-25 06:55:28	80.137	81.194
35	2014-06-25 06:54:28	80.137	81.194
36	2014-06-25 06:53:28	80.137	81.194
37	2014-06-25 06:52:28	80.137	81.194
38	2014-06-25 06:51:28	80.137	81.194
39	2014-06-25 06:50:28	80.137	81.194
40	2014-06-25 06:49:28	80.137	81.194
41	2014-06-25 06:48:28	80.137	81.194
42	2014-06-25 06:47:28	80.137	81.194
43	2014-06-25 06:46:28	80.137	81.194
44	2014-06-25 06:45:28	80.137	81.194
45	2014-06-25 06:44:28	80.137	81.194
46	2014-06-25 06:43:28	80.137	81.194
47	2014-06-25 06:42:28	80.137	81.194
48	2014-06-25 06:41:28	80.137	81.194
49	2014-06-25 06:40:28	80.137	81.194
50	2014-06-25 06:39:28	80.137	81.194
51	2014-06-25 06:38:28	80.137	81.194
52	2014-06-25 06:37:28	80.137	81.194
53	2014-06-25 06:36:28	80.137	81.194
54	2014-06-25 06:35:28	80.137	81.194
55	2014-06-25 06:34:28	80.137	81.194
56	2014-06-25 06:33:28	80.137	81.194
57	2014-06-25 06:32:28	80.137	81.194
58	2014-06-25 06:31:28	80.137	81.194
59	2014-06-25 06:30:28	80.137	81.194
60	2014-06-25 06:29:28	80.137	81.194
61	2014-06-25 06:28:28	80.137	81.194
62	2014-06-25 06:27:28	80.137	81.194
63	2014-06-25 06:26:28	80.137	81.194
64	2014-06-25 06:25:28	80.137	81.194
65	2014-06-25 06:24:28	80.137	81.194
66	2014-06-25 06:23:28	80.137	81.194
67	2014-06-25 06:22:28	80.137	81.194
68	2014-06-25 06:21:28	80.137	81.194
69	2014-06-25 06:20:28	80.137	81.194
70	2014-06-25 06:19:28	80.137	81.194
71	2014-06-25 06:18:28	80.137	81.194
72	2014-06-25 06:17:28	80.137	81.194

Device Name:	TCTemp8568
Device Description:	Thermocouple Temperature Recorder
Serial Number:	N86345
Device ID:	Air Temp 1

Location: Inside Tank 5 on Flange

		Channel 1	Channel 2
Reading Number	Date and Time (MST)	Ambient Temperature (°F)	Thermocouple 1 (°F)
Column9	Column10	Column11	Column12
1	2014-06-25 07:28:56	78.958	77.844
2	2014-06-25 07:27:56	79.016	78.697
3	2014-06-25 07:26:56	79.158	79.132
4	2014-06-25 07:25:56	79.071	78.74
5	2014-06-25 07:24:56	78.9	78.474
6	2014-06-25 07:23:56	78.958	78.474
7	2014-06-25 07:22:56	78.958	78.697
8	2014-06-25 07:21:56	78.958	78.474
9	2014-06-25 07:20:56	78.958	78.474
10	2014-06-25 07:19:56	79	78.474
11	2014-06-25 07:18:56	78.958	78.474
12	2014-06-25 07:17:56	77.188	78.474
13	2014-06-25 07:16:56	77.255	78.474
14	2014-06-25 07:15:56	77.255	78.474
15	2014-06-25 07:14:56	77.188	78.474
16	2014-06-25 07:13:56	77.188	78.474
17	2014-06-25 07:12:56	77.188	78.474
18	2014-06-25 07:11:56	77.188	78.474
19	2014-06-25 07:10:56	77.188	78.474
20	2014-06-25 07:09:56	77.188	78.474
21	2014-06-25 07:08:56	77.188	78.474
22	2014-06-25 07:07:56	77.188	78.474
23	2014-06-25 07:06:56	77.188	78.474
24	2014-06-25 07:05:56	77.188	78.474
25	2014-06-25 07:04:56	77.188	78.474
26	2014-06-25 07:03:56	77.188	78.474
27	2014-06-25 07:02:56	77.188	78.474
28	2014-06-25 07:01:56	77.188	78.474
29	2014-06-25 07:00:56	77.188	78.474
30	2014-06-25 06:59:56	77.188	78.474
31	2014-06-25 06:58:56	77.188	78.474
32	2014-06-25 06:57:56	77.188	78.474
33	2014-06-25 06:56:56	77.188	78.474
34	2014-06-25 06:55:56	77.188	78.474
35	2014-06-25 06:54:56	77.188	78.474
36	2014-06-25 06:53:56	77.188	78.474
37	2014-06-25 06:52:56	77.188	78.474
38	2014-06-25 06:51:56	77.188	78.474
39	2014-06-25 06:50:56	77.188	78.474
40	2014-06-25 06:49:56	77.188	78.474
41	2014-06-25 06:48:56	77.188	78.474
42	2014-06-25 06:47:56	77.188	78.474
43	2014-06-25 06:46:56	77.188	78.474
44	2014-06-25 06:45:56	77.188	78.474
45	2014-06-25 06:44:56	77.188	78.474
46	2014-06-25 06:43:56	77.188	78.474
47	2014-06-25 06:42:56	77.188	78.474
48	2014-06-25 06:41:56	77.188	78.474
49	2014-06-25 06:40:56	77.188	78.474
50	2014-06-25 06:39:56	77.188	78.474
51	2014-06-25 06:38:56	77.188	78.474
52	2014-06-25 06:37:56	77.188	78.474
53	2014-06-25 06:36:56	77.188	78.474
54	2014-06-25 06:35:56	77.188	78.474
55	2014-06-25 06:34:56	77.188	78.474
56	2014-06-25 06:33:56	77.188	78.474
57	2014-06-25 06:32:56	77.188	78.474
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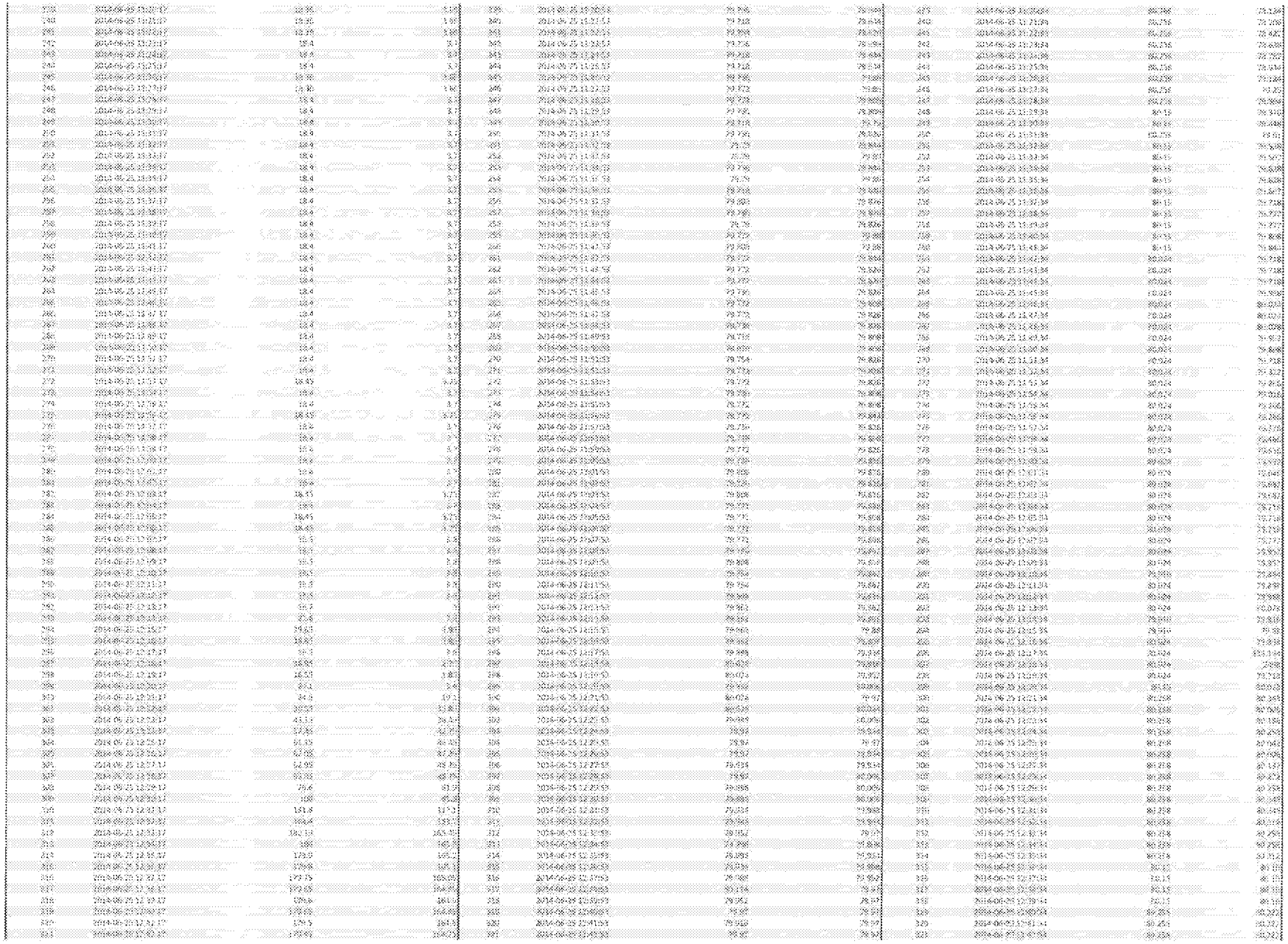

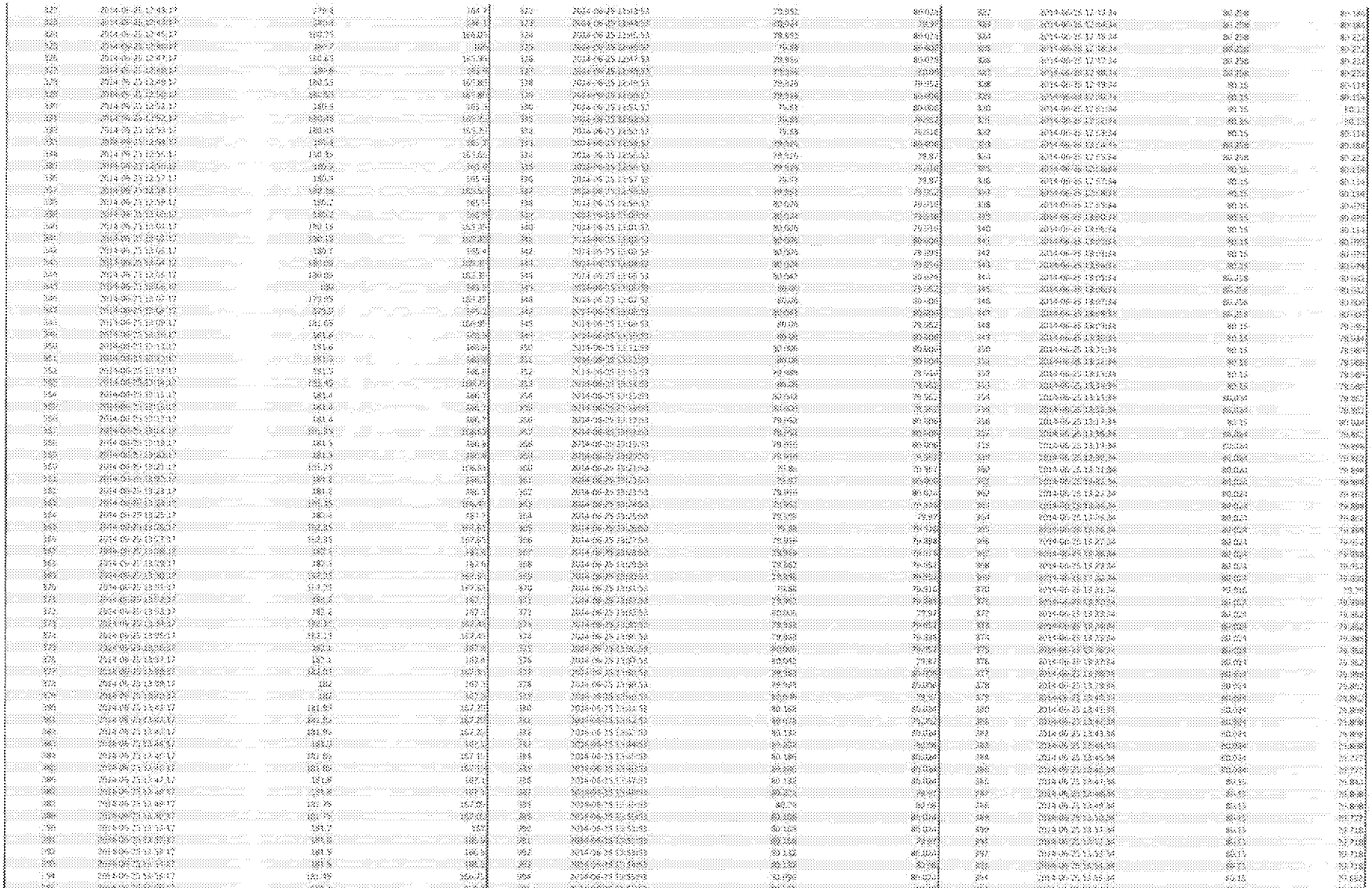

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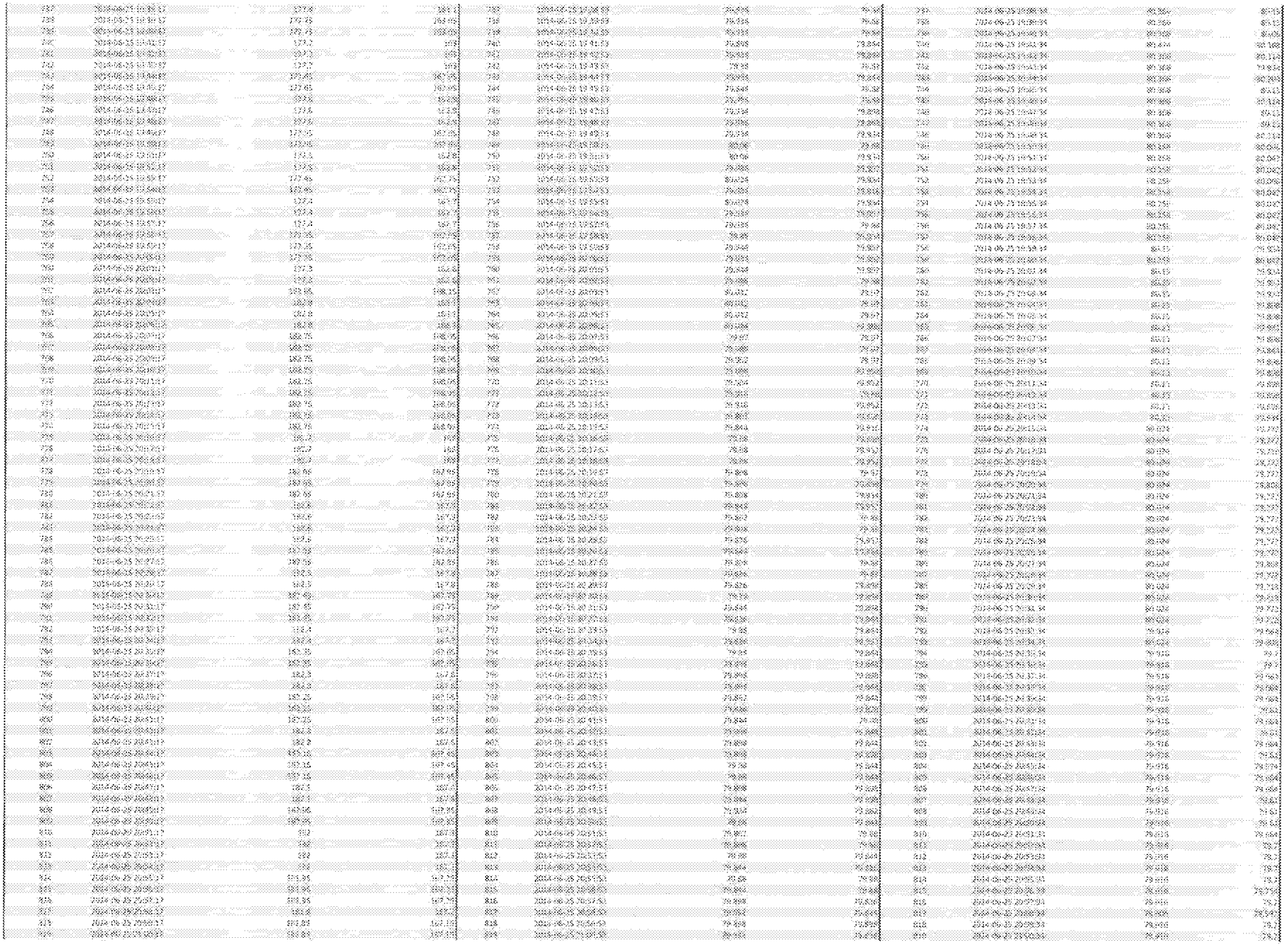

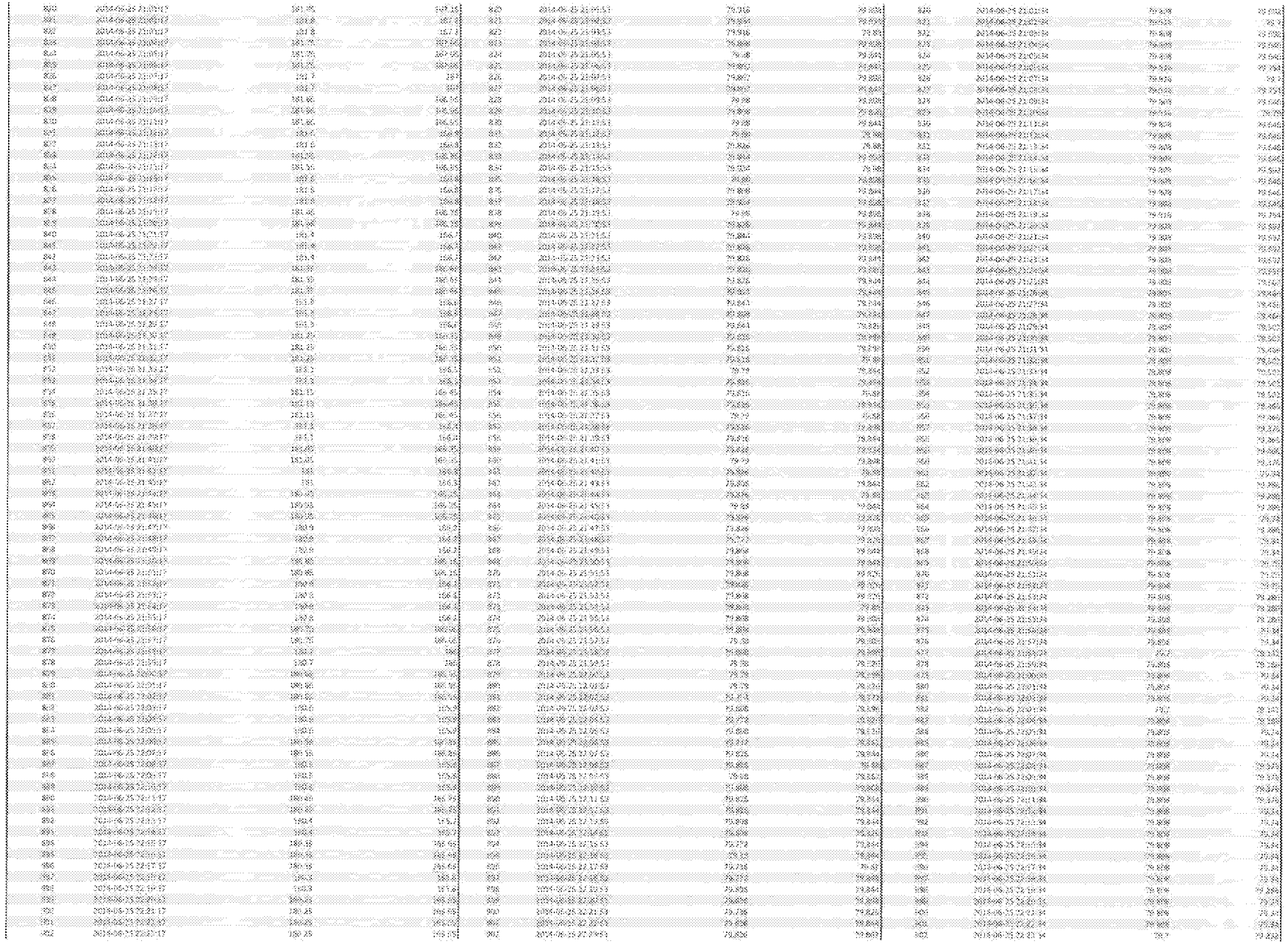

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937	2014-06-25 22:58:17	179.6	164.9	937	2014-06-25 22:58:53	79.736	79.826	937	2014-06-25 22:58:34	79.808	79.412
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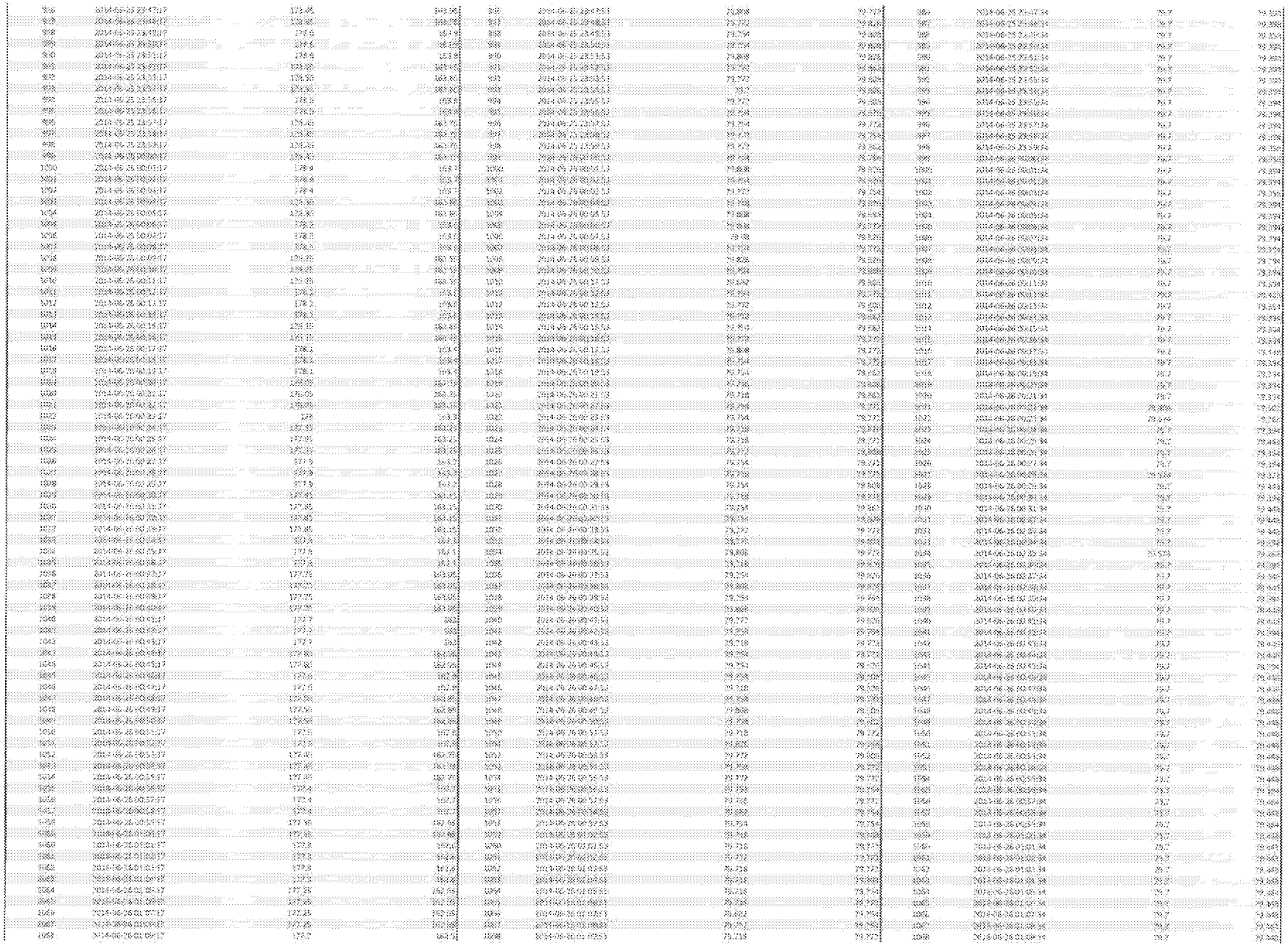
980	2014-06-25 23:41:17	178.8	164.1	980	2014-06-25 23:41:53	79.754	79.754	980	2014-06-25 23:41:34	79.7	79.358
981	2014-06-25 23:42:17	178.75	164.05	981	2014-06-25 23:42:53	79.736	79.826	981	2014-06-25 23:42:34	79.7	79.394
982	2014-06-25 23:43:17	178.75	164.05	982	2014-06-25 23:43:53	79.754	79.808	982	2014-06-25 23:43:34	79.7	79.358
983	2014-06-25 23:44:17	178.7	164	983	2014-06-25 23:44:53	79.754	79.862	983	2014-06-25 23:44:34	79.7	79.394
984	2014-06-25 23:45:17	178.7	164	984	2014-06-25 23:45:53	79.772	79.772	984	2014-06-25 23:45:34	79.7	79.358
985	2014-06-25 23:46:17	178.7	164	985	2014-06-25 23:46:53	79.808	79.772	985	2014-06-25 23:46:34	79.7	79.358



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1077	2014-06-26 01:18:17	177.05	162.35	1077	2014-06-26 01:18:53	79.718	79.808	1077	2014-06-26 01:18:34	79.7	79.448
1078	2014-06-26 01:19:17	177.05	162.35	1078	2014-06-26 01:19:53	79.718	79.754	1078	2014-06-26 01:19:34	79.7	79.448
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1080	2014-06-26 01:21:17	177	162.3	1080	2014-06-26 01:21:53	79.682	79.718	1080	2014-06-26 01:21:34	79.7	79.448
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1100	2014-06-26 01:41:17	176.65	161.95	1100	2014-06-26 01:41:53	79.682	79.718	1100	2014-06-26 01:41:34	79.7	79.484
1101	2014-06-26 01:42:17	176.65	161.95	1101	2014-06-26 01:42:53	79.718	79.754	1101	2014-06-26 01:42:34	79.7	79.448
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1103	2014-06-26 01:44:17	176.6	161.9	1103	2014-06-26 01:44:53	79.7	79.7	1103	2014-06-26 01:44:34	79.7	79.484
1104	2014-06-26 01:45:17	176.6	161.9	1104	2014-06-26 01:45:53	79.718	79.772	1104	2014-06-26 01:45:34	79.7	79.484
1105	2014-06-26 01:46:17	176.55	161.85	1105	2014-06-26 01:46:53	79.682	79.808	1105	2014-06-26 01:46:34	79.7	79.484
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1107	2014-06-26 01:48:17	176.5	161.8	1107	2014-06-26 01:48:53	79.682	79.718	1107	2014-06-26 01:48:34	79.574	79.358
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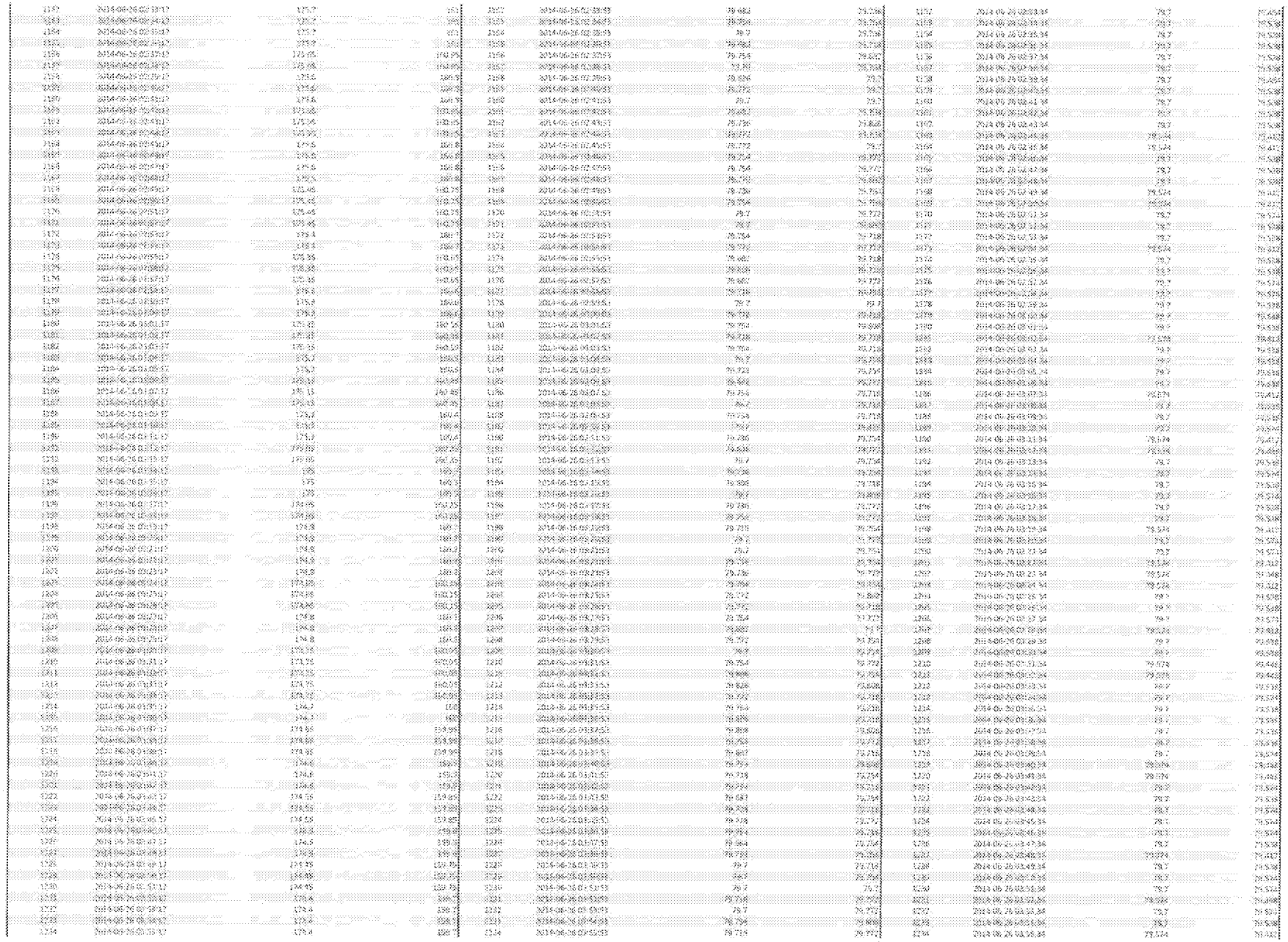

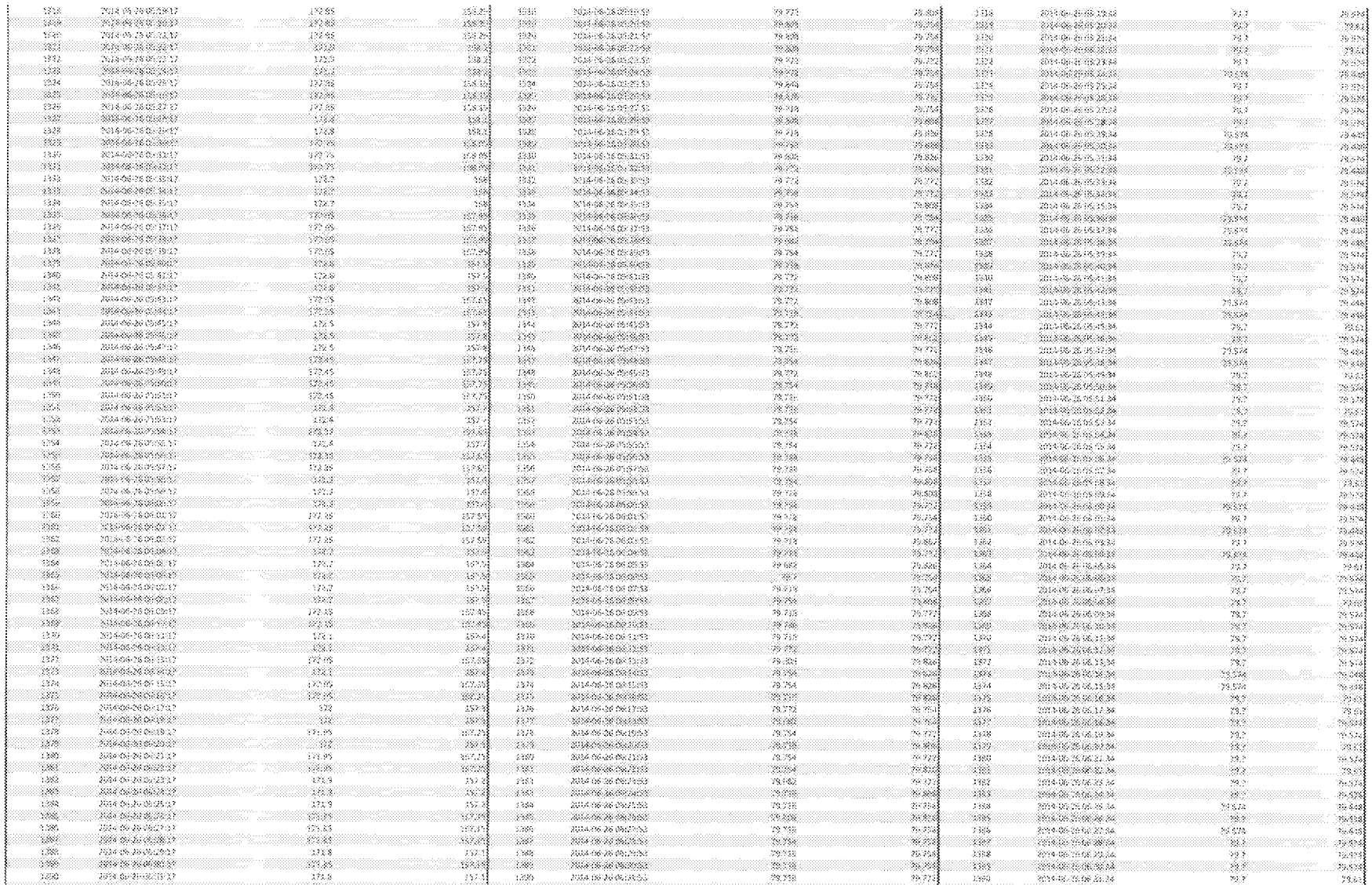

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1487	2014-06-26 08:08:17	170.45	155.75	1487	2014-06-26 08:08:53	79.88	79.844	1487	2014-06-26 08:08:34	79.7	79.61
1488	2014-06-26 08:09:17	170.45	155.75	1488	2014-06-26 08:09:53	79.934	79.97	1488	2014-06-26 08:09:34	79.7	79.574
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1493	2014-06-26 08:14:17	170.4	155.7	1493	2014-06-26 08:14:53	79.844	79.88	1493	2014-06-26 08:14:34	79.7	79.574
1494	2014-06-26 08:15:17	170.35	155.65	1494	2014-06-26 08:15:53	79.862	79.898	1494	2014-06-26 08:15:34	79.7	79.574
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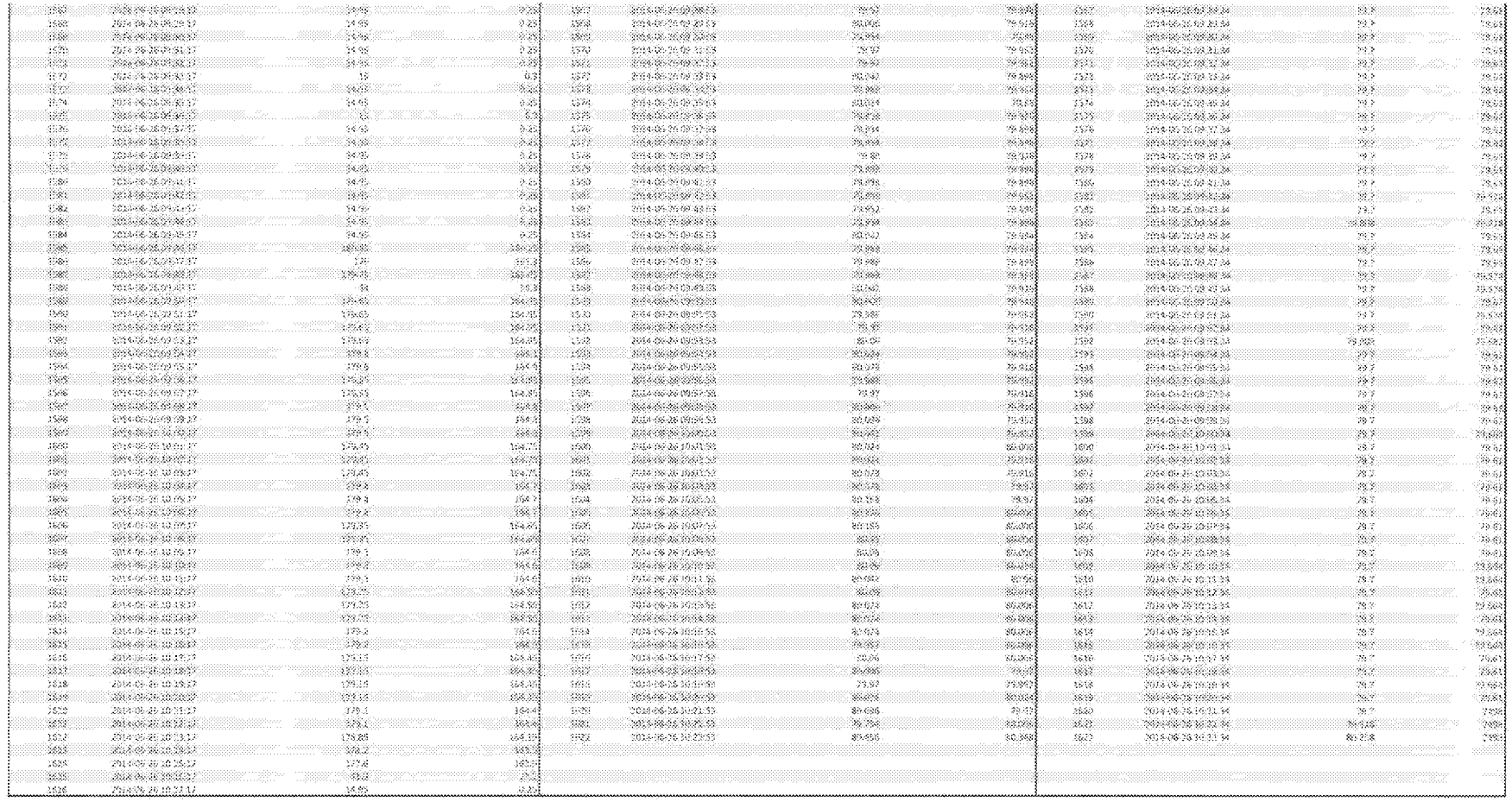

APPENDIX E –

INSTRUMENT CALIBRATION CERTIFICATES

MADGETECH
WE BUILD DATA LOGGERS

CERTIFICATE OF CALIBRATION

Certificate Information		Device Information	
Certificate Number:	NC-14-04-11-001	Device Name:	PR2000-500psi
Calibration Technician:	James Day	Device ID:	Unit 1 Press
Calibration Date:	2014-04-11	Serial Number:	N84154
Next Calibration Due:	2015-04-11	Model Description:	Pressure Data Logger with Display

MadgeTech, Inc. certifies that the instrument identified below has been calibrated (except where otherwise noted) using calibration standards that are traceable to the National Institute of Standards and Technology (NIST). This certificate is copyrighted and may not be reproduced, except in full, without prior written approval of MadgeTech, Inc..

PR2000-500psi - Pressure (absolute) - Serial Number: N84154

The Pressure (absolute) channel of the device under test (DUT) was calibrated in direct comparison to the reference equipment listed on the last page of this calibration certificate.

Published Device Specifications

Calibrated Accuracy: ±10.00 psi
Calibrated Accuracy Range: 5 psi to 500 psi
Resolution: 0.05 psi
Notes:

Channel 1 - Units of psi

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device - Standard	Device Allowable Limits = Standard ± Accuracy	DUT Corrected Device As Left	Device Error =Device - Standard
1	14.750	14.75	0.00	4.75 to 24.75	14.75	0.00
2	400.000	399.95	-0.05	390.00 to 410.00	400.00	0.00

	Initial Correction Values	Applied Correction Values
Gain:	0.9928412	0.9926453
Offset:	-3.36535 psi	-3.3610001 psi

Maintaining Calibration:

This product is manufactured from the highest quality components. The unit has been designed to remain within its specifications during normal use. However, the length of in-tolerance service can be affected by low battery voltage, age, temperature, humidity, shock, and other environmental influences. For those users with critical performance or validation requirements, MadgeTech, Inc. recommends that the unit be serviced and calibrated at regular periodic intervals.

Reference Equipment	Serial #	Certificate #	Last Calibration Date	Next Calibration Due
Mensor CPC6000	611758	96293 / 96304	2013-12-13	2014-12-13

Calibration and Service:

For information regarding this calibration or to arrange factory calibration or other service for this product, contact MadgeTech, Inc. or an authorized reseller. Products shipped directly to MadgeTech, Inc. will require a Return Merchandise Authorization (RMA) number.

Calibration Notes:

Issued By:	J. Daly	Date:	2014-04-11
Approved By:	K. Strese	Date:	2014-04-11

MADGETECH
WE BUILD DATA LOGGERS

CERTIFICATE OF CALIBRATION

Certificate Information:

Certificate Number:	AR-13-08-20-003
Calibration Technician:	J Day
Calibration Date:	8/20/2013
Next Calibration Due:	8/20/2014

Device Information:

Device Name:	TCTemp2000
Device ID:	Aux Temp & Unit 1
Serial Number:	N84147
Model Description:	Thermocouple Temperature Recorder
Calibration Date As Received:	7/16/2012
Condition As Received:	Used
Condition As Left:	In Tolerance

MadgeTech, Inc. certifies that the instrument identified below has been calibrated using calibration standards that are traceable to the National Institute of Standards and Technology(NIST). This certificate is copyrighted and may not be reproduced, except in full, without prior written approval of MadgeTech, Inc.

TCTemp2000 -Temperature Channel- Serial Number: N84147

The Temperature channel of the device under test (DUT) was calibrated in direct comparison to the reference equipment listed on the last page of this calibration certificate.

Published Device Specifications

Accuracy:	±0.5°C
Range:	0 to +50°C
Resolution:	0.01

Channel 1 - All data is in degrees Celsius (±°C)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	25	24.76	-0.24	24.5 to 25.5	25	0

	Initial Correction Values	Applied Correction Values
Gain:	1	1
Offset:	0.12	-0.12

TCTemp2000 -T/C Channel- Serial Number: N84147

Channel 2 - All data is in Millivolts (mV)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	0	-0.000064	0	N/A	0	0

	Initial Correction	Applied Correction Values
Gain:	1	1
Offset:	-0.000086	-0.00015000001

Maintaining Calibration:

This product is manufactured from the highest quality components. The unit has been designed to remain within its specifications during normal use. However, the length of in-tolerance service can be affected by low battery voltage, age, temperature, humidity, shock, and other environmental influences. For those users with critical performance or validation requirements, MadgeTech, Inc. recommends that the unit be serviced and calibrated at regular periodic intervals.

Calibration And Service:

For information regarding this calibration, or to arrange factory calibration or other service for this product, contact MadgeTech or an authorized reseller. Products shipped directly to MadgeTech, Inc. will require a Return Material Authorization (RMA) number.

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CERTIFICATE OF CALIBRATION

Issued By: J. Day **Date:** 8/20/2013

Approved By: J. Heald **Date:** 8/20/2013

Reference Equipment	Serial No	Certificate No	Last Cal Date	Next Cal Due
Rotronic HygroClip IC1 Thermo-Hygrometer	43142019	2013.30047	4/30/2013	4/13/2014

Company Contact Information: MadgeTech, 6 Warner Road, Warner NH 03278
(603) 456-2011 (Tel)
(603) 456-2012 (Fax)
info@madgetech.com (E)
http://www.madgetech.com (W)

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CERTIFICATE OF CALIBRATION

Certificate Information:		Device Information:	
Certificate Number:	AR-13-08-21-001	Device Name:	QuadTemp2000
Calibration Technician:	J Day	Device ID:	Temp Unit 1
Calibration Date:	8/21/2013	Serial Number:	N82430
Next Calibration Due:	8/21/2014	Model Description:	Four Channel Thermocouple Recorder
		Calibration Date As Received:	7/16/2012
		Condition As Received:	Used
		Condition As Left:	In Tolerance

MadgeTech, Inc. certifies that the instrument identified below has been calibrated using calibration standards that are traceable to the National Institute of Standards and Technology(NIST). This certificate is copyrighted and may not be reproduced, except in full, without prior written approval of MadgeTech, Inc.

QuadTemp2000 -Temperature Channel- Serial Number: N82430

The Temperature channels of the device under test (DUT) were calibrated in direct comparison to the reference equipment listed on the last page of this calibration certificate.

Published Device Specifications

Accuracy: ±0.5°C
Range: 0 to + 50°C
Resolution: 0.01

Channel 1 - All data is in degrees Celsius (±°C)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	25	24.79	-0.21	24.5 to 25.5	24.99	-0.01
2	60	60.35	0.35	59.5 to 60.5	60.02	0.02

	Initial Correction Values	Applied Correction Values
Gain:	1.0008	1.0168571
Offset:	1.350008	0.73857141

Channel 3 - All data is in degrees Celsius (±°C)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	25	24.71	-0.29	24.5 to 25.5	25	0
2	60	60.32	0.32	59.5 to 60.5	60.02	0.02

	Initial Correction Values	Applied Correction Values
Gain:	1.0024	1.0197144
Offset:	-2.2799759	-3.0028572

Channel 5 - All data is in degrees Celsius (±°C)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	25	24.65	-0.35	24.5 to 25.5	25.01	0.01
2	60	60.27	0.27	59.5 to 60.5	59.99	-0.01

	Initial Correction Values	Applied Correction Values
Gain:	1	1.0177143
Offset:	0.81	0.017142856

Channel 7 - All data is in degrees Celsius (±°C)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	25	24.52	-0.48	24.5 to 25.5	24.99	-0.01
2	60	60.15	0.15	59.5 to 60.5	60	0

	Initial Correction Values	Applied Correction Values
Gain:	0.98839998	1.006

Company Contact Information: MadgeTech
6 Warner Road
Warner NH 03278
(603) 456-2011 (Tel)
(603) 456-2012 (Fax)
info@madgetech.com (E)
http://www.madgetech.com (W)

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Offset:	0.079884	-0.82999998

QuadTemp2000 -T/C Channel- **Serial Number: N82430**

Channel 2 - All data is in Millivolts (mV)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	0	-0.000326	0	N/A	0	0

	Initial Correction	Applied Correction Values
Gain:	1	1
Offset:	-0.00050700002	-0.000833

Channel 4 - All data is in Millivolts (mV)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	0	0.000212	0	N/A	0	0

	Initial Correction	Applied Correction Values
Gain:	1	1
Offset:	-0.000439	-0.000227

Channel 6 - All data is in Millivolts (mV)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	0	-0.000108	0	N/A	0	0

	Initial Correction	Applied Correction Values
Gain:	1	1
Offset:	-0.00079999998	-0.00090799999

Channel 8 - All data is in Millivolts (mV)

Point	Standard Actual Test Point	DUT Uncorrected Device As Found	Device Error = Device-Standard	Allowable Device Limits = Standard±Accuracy	DUT Corrected Device As Left	Device Error = Device-Standard
1	0	-0.000165	0	N/A	0	0

	Initial Correction	Applied Correction Values
Gain:	1	1
Offset:	0.000014	-0.000151

Maintaining Calibration:

This product is manufactured from the highest quality components. The unit has been designed to remain within its specifications during normal use. However, the length of in-tolerance service can be affected by low battery voltage, age, temperature, humidity, shock, and other environmental influences. For those users with critical performance or validation requirements, MadgeTech, Inc. recommends that the unit be serviced and calibrated at regular periodic intervals.

Calibration And Service:

For information regarding this calibration, or to arrange factory calibration or other service for this product, contact MadgeTech or an authorized reseller. Products shipped directly to MadgeTech, Inc. will require a Return Material Authorization (RMA) number.

Issued By: J. Day **Date:** 8/21/2013

Approved By: J. Heald **Date:** 8/21/2013

Certificate Number:	AR-13-08-21-001	Company Contact Information:	MadgeTech	(603) 456-2011 (Tel)
Date Created:	8/21/2013		6 Warner Road	(603) 456-2012 (Fax)
Date Printed:	8/21/2013		Warner NH 03278	info@madgetech.com (E)
Certificate Page:	Page 2			http://www.madgetech.com (W)

Angel's Instrumentation INC. ISO 17025 ACCREDITED

CERTIFICATE OF CALIBRATION

Angel's Instrumentation Inc.
928 Canal Drive
Chesapeake, VA 23323

UNIT UNDER TEST(UUT): 10 GPM Flow Meter
MANUFACTURER: GPI
MODEL NUMBER: G2S05N09GMA
SERIAL NUMBER: 3206877
CUSTOMER ID NUMBER: 211871 UNIT 3
PROCEDURE NAME: 17-20MG-38 (Rev. 8/1/2010)
CALIBRATED BY: Dante Daneri
CONTACT NAME: Dennis Cobb
CUSTOMER: Pipeline Petroleum Service
1324 Cavalier Blvd
CHESAPEAKE, VA 23323

TEST RESULT: PASS
PERFORMED ON: 6/16/2014
TEMPERATURE: 22.4°C
HUMIDITY: 46%
CAL DATE: 6/16/2014
NEXT CAL DUE: 6/16/2015
WORKORDER#: 25137
CERTIFICATE#: 211871:6856481481
Purchase Order#: Verbal Dennis
DATA TYPE: FOUND-LEFT
PERFORMED AT Angel's Instrumentation Inc.

Angel's Instrumentation Inc. certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ISO-IEC 17025-2005, ANSI/NCSL Z540-1-1994, and/or ANSI/NCSL Z540.3-2006.

Complete records of work performed are maintained by Angel's Instrumentation and are available for inspection. All calibrations have been performed using processes that have a test uncertainty ratio of four or more times greater than the unit calibrated. Uncertainties have been estimated at 95 percent confidence level (k=2). Calibration at 4:1 TUR provides reasonable confidence that the instrument is within the manufacturer's published specifications.

This report may not be reproduced, except in full, unless permission for the publication of an approved abstract is obtained in writing from the calibration organization issuing this report.

Note: Any Test Uncertainty Ratio (TUR) that is less than four to one will appear in the remarks section of this report and identified with an asterisk (*) in the readings section.

Note: Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired. The customer is responsible for assigning intervals. Angel's Instrumentation does not recommend calibration intervals.

Angel's Instrumentation is responsible for the calibration process results during the time of the calibration process, and this certificate of calibration is neither a contract nor a contractual representation.

REMARKS: Received on 6/16/2014.

Received Condition: Fair / In Tolerance

Standards Used

Asset	Description	CAL DUE DATE
300018	Flow Meter	28-May-16

Test Data

Flow Calibration

Range	Applied	As Found	As Left	Lower Limit	Upper Limit	
10 GPM	2 GPM	1.99	1.99	1.96	2.04	PASS
.	4 GPM	3.99	3.99	3.92	4.08	PASS
.	6 GPM	5.99	5.99	5.88	6.12	PASS
.	8 GPM	7.99	7.99	7.84	8.16	PASS

End of Test Data

Signed: _____
Authorized Service Technician/Manager

Signed: _____
Designated Service QA Manager

Angel's Instrumentation
INC. ISO 17025 ACCREDITED

CERTIFICATE OF CALIBRATION

Angel's Instrumentation Inc.
928 Canal Drive
Chesapeake, VA 23323

UNIT UNDER TEST(UUT): 5-50 GPM Flow Meter
MANUFACTURER: GPI
MODEL NUMBER: G2S10N09GMA
SERIAL NUMBER: 3710745
CUSTOMER ID NUMBER: 211872 UNIT 4 - 1" ϕ
PROCEDURE NAME: 17-20MG-38 (Rev. 8/1/2014)
CALIBRATED BY: Dante Daneri
CONTACT NAME: Dennis Cobb
CUSTOMER: Pipeline Petroleum Service
1324 Cavalier Blvd
CHESAPEAKE, VA 23323

TEST RESULT: PASS
PERFORMED ON: 6/16/2014
TEMPERATURE: 22.4°C
HUMIDITY: 46%
CAL DATE: 6/16/2014
NEXT CAL DUE: 6/16/2015
WORKORDER#: 25137
CERTIFICATE#: 211872:6885416667
Purchase Order#: Verbal Dennis
DATA TYPE: FOUND-LEFT
PERFORMED AT Angel's Instrumentation Inc.

Angel's Instrumentation Inc. certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ISO-IEC 17025-2005, ANSI/NCSL Z540-1-1994, and/or ANSI/NCSL Z540.3-2006.

Complete records of work performed are maintained by Angel's Instrumentation and are available for inspection. All calibrations have been performed using processes that have a test uncertainty ratio of four or more times greater than the unit calibrated. Uncertainties have been estimated at 95 percent confidence level (k=2). Calibration at 4:1 TUR provides reasonable confidence that the instrument is within the manufacturer's published specifications.

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Note: Any Test Uncertainty Ratio (TUR) that is less than four to one will appear in the remarks section of this report and identified with an asterisk (*) in the readings section.

Note: Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired. The customer is responsible for assigning intervals. Angel's Instrumentation does not recommend calibration intervals.

Angel's Instrumentation is responsible for the calibration process results during the time of the calibration process, and this certificate of calibration is neither a contract nor a contractual representation.

REMARKS: Received on 6/16/2014.

Received Condition: Fair / In Tolerance

Standards Used

Asset	Description	CAL DUE DATE
300018	Flow Meter	28-May-16

Test Data

Flow Calibration

Range	Applied	As Found	As Left	Lower Limit	Upper Limit	
5 GPM	10 GPM	9.95	9.95	9.85	10.15	PASS
.	20 GPM	19.96	19.96	19.70	20.30	PASS
.	30 GPM	29.95	29.95	29.55	30.45	PASS
30 GPM	40 GPM	39.94	39.94	39.40	40.60	PASS

End of Test Data

Signed: _____
Authorized Service Technician/Manager

Signed: _____
Designated Service QA Manager

Angel's Instrumentation
INC. ISO 17025 ACCREDITED

CERTIFICATE OF CALIBRATION

Angel's Instrumentation Inc.
928 Canal Drive
Chesapeake, VA 23323

UNIT UNDER TEST(UUT): 5000 PSI Pressure Gauge
MANUFACTURER: Crystal Engineering
MODEL NUMBER: XP2i 5000
SERIAL NUMBER: 870422
CUSTOMER ID NUMBER: 211596 UNIT 1
PROCEDURE NAME: AILCP-136 (Rev. 2)
CALIBRATED BY: Dante Daneri
CONTACT NAME: Joe Jackson
CUSTOMER: Pipeline Petroleum Service
1324 Cavalier Blvd
CHESAPEAKE, VA 23323

TEST RESULT: PASS
PERFORMED ON: 5/5/2014
TEMPERATURE: 20.2°C
HUMIDITY: 47%
CAL DATE: 5/5/2014
NEXT CAL DUE: 5/5/2015
WORKORDER#: 24846
CERTIFICATE#: 211596:6267592593
Purchase Order#: CHARGE
DATA TYPE: FOUND-LEFT
PERFORMED AT Angel's Instrumentation Inc.

Angel's Instrumentation Inc. certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. It has been calibrated using measurement standards traceable to the National Institute of Standards and Technology (NIST), to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with ISO-IEC 17025-2005, ANSI/NCSL Z540-1-1994, and/or ANSI/NCSL Z540.3-2006.
Complete records of work performed are maintained by Angel's Instrumentation and are available for inspection. All calibrations have been performed using processes that have a test uncertainty ratio of four or more times greater than the unit calibrated. Uncertainties have been estimated at 95 percent confidence level (k=2). Calibration at 4:1 TUR provides reasonable confidence that the instrument is within the manufacturer's published specifications.
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Note: Any Test Uncertainty Ratio (TUR) that is less than four to one will appear in the remarks section of this report and identified with an asterisk (*) in the readings section.
Note: Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired. The customer is responsible for assigning intervals. Angel's Instrumentation does not recommend calibration intervals.
Angel's Instrumentation is responsible for the calibration process results during the time of the calibration process, and this certificate of calibration is neither a contract nor a contractual representation.

REMARKS: Received on 5/5/2014.

Received Condition: Good / In Tolerance

Standards Used

Asset	Description	CAL DUE DATE
301068	RTD Probe w/ Indicator	16-Dec-15
301069	100 Kg Mass Set	04-Oct-14
301071	500 PSI Piston	10-Sep-14

Test Data

Digital Pressure Calibration

DUT

Set Point	Applied	As Found	As Left	Lower Limit	Upper Limit	
500 PSI	499.797	500.0	500.0	498.80	500.80	Pass
1000 PSI	999.845	1000.0	1000.0	998.85	1000.85	Pass
1500 PSI	1499.893	1500.0	1500.0	1498.39	1501.39	Pass
2000 PSI	1999.937	1999.8	1999.8	1997.94	2001.94	Pass
2500 PSI	2499.983	2499.5	2499.5	2497.48	2502.48	Pass
3000 PSI	3000.027	2999.5	2999.5	2997.03	3003.03	Pass
3500 PSI	3500.063	3499.5	3499.5	3496.56	3503.56	Pass
4000 PSI	4000.098	3999.5	3999.5	3996.10	4004.10	Pass
4500 PSI	4500.128	4499.4	4499.4	4495.63	4504.63	Pass
5000 PSI	5000.162	4999.6	4999.6	4995.16	5005.16	Pass

Device Under Test Accuracy +/- .02% F.S. from 0-20% of F.S. and +/- .1% Rdg from 20-100% of F.S.

End of Test Data

Signed: _____
Authorized Service Technician/Manager

Signed: _____
Designated Service QA Manager