Innovative approaches
Practical results
Outstanding service

PALM STREET WATER PLANT

CONDITION ASSESSMENT

Prepared for:

City of Huntsville

November 9, 2015

Prepared by:

FREESE AND NICHOLS, INC.
11200 Broadway Street
Offices West, Suite 2332
Pearland, TX 77584
832-456-4700

Innovative approaches
Practical results
Outstanding service

PALM STREET WATER PLANT CONDITION ASSESSMENT

Prepared for:

City of Huntsville

Nov 9 2015

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

Prepared by:

FREESE AND NICHOLS, INC.
11200 Broadway Street
Offices West, Suite 2332
Pearland, TX 77584
832-456-4700

HVL15274

TABLE OF CONTENTS

Table of Figures

Table of Tables

APPENDICES

EXECUTIVE SUMMARY

The City of Huntsville's Palm Street Water Plant consists of two pump stations, referred to as the old and new pump stations. The old pump station was built in 1960 and the new pump station was added in 1983. The old pump station has performed exceptionally well over time requiring only one motor replacement and no pump replacements. The new pump station has seen more problems with three of the four pumps being replaced since the original installation. Both pump stations have exceeded their expected service life and are in need of improvements to continue providing the City of Huntsville with a reliable source of water. To this end, the City has contracted with Freese and Nichols, Inc. (FNI) to conduct a condition assessment to determine which components of the plant, specifically the pump stations, need improvements in order to continue serving the City.

A risk based assessment was conducted after a site visit and discussions with the City, based on this assessment the following recommended improvements with their risk rating and opinion of probable total project costs have been developed.

Table 1: Recommendations Summary

Facility	Component	Condition Rating	Criticality Rating	Risk	Opinion of Probable Total Project Cost*
Old PS	MCC	Poor	Very High	High Risk	$260,800
New PS	MCC	Poor	Very High	High Risk	$420,800
Old PS	Pumps	Poor	High	High Risk	$172,000
New PS	Roof	Poor	Moderate	Moderate Risk	$45,900
New PS	Instrumentation	Poor	Moderate	Moderate Risk	$99,500
Old PS	Roof	Poor	Moderate	Moderate Risk	$18,500
Old PS	Motors	Fair	High	Moderate Risk	$90,400
New PS	Pumps	Fair	High	Moderate Risk	$71,300
New PS	Motors	Fair	High	Moderate Risk	$67,400
Old PS	Alternate Power	Good	Very High	Moderate Risk	$23,000
Old PS	HVAC	Poor	Low	Moderate Risk	$22,100
Old PS	Valves	Poor	Low	Moderate Risk	$50,400
New PS	HVAC	Poor	Moderate	Moderate Risk	$32,600
New PS	Valves	Poor	Low	Moderate Risk	$45,600
Old PS	Walls	Fair	Moderate	Moderate Risk	$13,900
Old PS	Instrumentation	Fair	Low	Moderate Risk	$30,600
Other	Yard Piping	Fair	Moderate	Moderate Risk	$51,500
New PS	Alternate Power	Very Good	Very High	Moderate Risk	
Old PS	Piping	Fair	Low	Moderate Risk	$5,500
New PS	Piping	Fair	Low	Moderate Risk	$5,000
Other	Tank Overflows	Fair	Low	Moderate Risk	$80,000

Facility	Component	Condition Rating	Criticality Rating	Risk	Opinion of Probable Total Project Cost*
New PS	Walls	Fair	Moderate	Moderate Risk	$27,600
New PS	Foundation	Fair	Moderate	Moderate Risk	$10,100
New PS	SCADA	Very Good	Moderate	Low Risk	
Other	Site Drainage	Fair	Very Low	Low Risk	
Other	Entrance Gate	Fair	Very Low	Low Risk	
Other	Video Surveillance	Fair	Very Low	Low Risk	
Other	New PS Discharge Meter	Fair	Very Low	Low Risk	
Old PS	Crane	Good	Low	Low Risk	
New PS	Crane	Good	Low	Low Risk	
Old PS	Instrumentation	Good	Low	Low Risk	
New PS	Chlorine Analyzer	Good	Low	Low Risk	
Other	Fencing	Good	Low	Low Risk	
Old PS	SCADA	Very Good	Moderate	Low Risk	
Old PS	Foundation	Very Good	Moderate	Low Risk	
Miscellaneous Improvements				Low Risk	$200,000
				Total:	$1,844,500

* Cost includes mobilization, contingency, construction management, materials testing and professional services

Additionally, FNI evaluated the potential for adding filtration to the water plant. This is a feasible alternative to the City though the filters would need to be located across the street on the elevated storage tank site due to space constraints on the main Palm St. Water Plant site. Another alternative the City could consider is to locate smaller filtration units at each of the well sites that have the most water quality issues.

An alternative option available to the City is to construct a new pump station and abandon the two existing pump stations. Since the Palm Street WP currently pumps into only one of the City's pressure planes, a dual pump station system is not necessary and potentially better system efficiencies could be realized by combining the pumping into one pump station. This would also provide the City an opportunity to simplify the piping network within the plant and have a pump station that will be completely new, as opposed to two rehabilitated pump stations. The same space that is currently available for the filtration site could also be used for the new pump station site. The existing pump station has a total pumping capacity of 18.7 MGD with a firm capacity of 15.8 MGD. A high level estimate of the project cost for a 16.0 MGD firm capacity pump station is $4.4 million.

1.0 INTRODUCTION

The City of Huntsville's Palm Street Water Plant consists of two pump stations, referred to as the old and new pump stations. The old pump station was built in 1960 and the new pump station was added in 1983. The old pump station has performed exceptionally well over time requiring only one motor replacement and no pump replacements. The new pump station has seen more problems with three of the four pumps being replaced since the original installation. Both pump stations have exceeded their expected service life and are in need of improvements to continue providing the City of Huntsville with a reliable source of water. To this end, the City has contracted with Freese and Nichols, Inc. (FNI) to conduct a condition assessment to determine which components of the plant, specifically the pump stations, need improvements in order to continue serving the City.

A site visit was conducted with the City and FNI on March 12, 2015 to collect data, take readings, and talk to the plant operator to help identify the needs. Smith Pump Co. visited the plant on June 1-3, 2015 to complete testing on the pumps in order to make the best recommendations about remaining pump life. Additionally, FNI met with the City on June 30, 2015 for a workshop to discuss initial findings and get input from the City on their priorities. Taking the data from these site visits and discussions FNI rated each component based on its condition and criticality to the system to determine the risk associated with that component. Each component was then prioritized by risk and ranked for the City to use in developing an improvements project to address the most critical needs to the plant.

FNI also evaluated the potential for implementing filters at the Palm Street Water Plant. It was determined that the footprint for the filter site was too large to fit on the Palm Street Water Plant site north of Palm St. but that there was available space on the site south of Palm St. A plan for the filter location has been included in this report.

During discussions with the City, it was suggested that a new pump station be evaluated to determine the feasibility and potential costs in comparison to a rehab project of the existing pump station. This evaluation will look at the pump station from a high level to give the City an idea of what it could cost, if the City decides to pursue this a more detailed evaluation would be necessary to understand the specifics of a new pump station.

2.0 CONDITION ASSESSMENT METHODOLOGY

In order to quantitatively assess the risk associated with each component at the water plant, a condition score and a criticality score have been assigned to rate each component. Using a risk-based approach allows the City to easily evaluate which components should be included in an improvements project and plan for a capital improvements project. Engineers use their judgement, expertise, and experience to assign the scores for condition and criticality of each component.

2.1 CONDITION ASSESSMENT SCORING

The condition is a measure of the probability of failure. There are many factors that are considered when assessing the condition, not limited to the physical condition, wear, damage, corrosion, vibration, noise, and functionality of the component. The table below describes the scale for determining the condition scores and what rating those scores reflect.

Table 2: Condition Assessment Scoring Legend

Condition Rating	Scoring Guidelines
1	**Very good** condition; no improvements recommended to maintain function
2	**Good** condition; minor improvements recommended to maintain function
3	**Fair** condition; improvements recommended to improve performance or efficiency
4	**Poor** condition; improvements recommended to maintain reliability
5	**Very Poor** condition; rehabilitation or replacement required

2.2 CRITICALITY ASSESSMENT SCORING

In addition to determining the probability of failure, it is important to evaluate the consequence of a failure. Performing a criticality assessment helps to determine the magnitude of the consequence of a failure. The factors that can impact the criticality of a component include pumping capacity, efficiency, environment, safety, and outage duration. Three quantifiable factors were used to determine the criticality score for each component. The following table shows these factors and the weight given to each factor.

Table 3: Criticality Assessment Scoring Factors

Criticality Factors and Weighting System					
Capacity Lost Due to Failure (50%)		**Redundancy (20%)**		**Outage Duration (30%)**	
1	No Loss	1	Full Redundancy	1	≤ 2 Days
3	Partial Loss	3	Partial Redundancy	3	3-14 Days
5	Complete Loss	5	No Redundancy	5	≥ 15 Days

Once each of these three factors are taken into account an overall score can be determined. The following table describes the scoring method to determine the impact of a failure of a component.

Table 4: Criticality Assessment Scoring Legend

Criticality Rating	Scoring Guidelines
1	**Very Low Impact**
2	**Low Impact**
3	**Moderate Impact**
4	**High Impact**
5	**Very High Impact**

2.3 RISK DETERMINATION

Once the condition and criticality of a component have been assessed it can be input into a risk matrix to determine the level of risk associated with the given component. Risk is a function of the condition and criticality ratings. Table 5 provides a guide for determining the risk with given condition and criticality ratings. These risk ratings are very helpful in determining which projects should be prioritized over others.

Table 5: Risk Determination Based on Condition and Criticality Ratings

		Condition				
		Very Good	Good	Fair	Poor	Very Poor
Criticality	Very Low Impact	LOW RISK				
	Low Impact					
	Moderate Impact		MODERATE RISK			
	High Impact				HIGH RISK	
	Very High Impact					

3.0 WATER PLANT ASSESSMENT

3.1 OLD PUMP STATION

3.1.1 Overview

The Old Pump Station was built in 1960 and consists of four vertical turbine pumps. The two smaller pumps have a design capacity of 1,000 gpm while the two larger pumps can pump 2,000 gpm. There is a space allocated for a 5th pump in the pump station originally intended for future expansion. Only one motor has been replaced on the pumps since the original installation and the pumps have not been pulled for service in 14 years. The pumps are all original.

The pump station building is small and does not have an HVAC system. There is a 1.5 ton overhead crane for pulling pumps but due to the low ceiling it is difficult to pull pumps or motors and have space to move within the pump station. Additionally, there is no truck access at the entrance to the pump station.

3.1.2 MCC

The Motor Control Center (MCC) was installed in the 1960s, has passed its life expectancy of thirty years, and is no longer supported by the manufacturer. Individual MCC components will no longer be available after they fail. Parts are replaced with comparable components that will fit within the shallow buckets and safety clearances are compensated to get the equipment into working conditions. Wiring inside the MCC is insulated with cloth, which losses its protective properties over time and subjects the equipment to faults. Past faults are evident within the MCC by the indications of carbon deposits on the interior walls. Inside the MCC are water lines used to monitor the tank water level. Water pipe installed inside electrical gear is no longer a good practice because of the ramifications of water leaking on electrical wires, busses and components.

Table 6: MCC Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	5	Very High Impact
Risk	9	High Risk

Recommendation: Replace wiring and the MCC.

3.1.3 Alternate Power

Utility and backup generator power comes through an automatic transfer switch. The generator and Automatic Transfer Switch (ATS) are new and were installed after Hurricane Rita. The automatic transfer switch is installed outdoors and is showing signs of corrosion due to condensation and possible water infiltration from conduits penetrating through the top of the enclosure. Condensation was present inside the ATS during the time of inspection. Conduits penetrating the top of the enclosure have been sealed to prevent further infiltration but the ATS cabinet is rarely opened and a new leak will not be immediately detected.

Table 7: Alternate Power Rating

	Score	Rating
Condition	2	Good Condition
Criticality	5	Very High Impact
Risk	7	Moderate Risk

Recommendation: Reroute conductors and conduits.

3.1.4 HVAC

The HVAC in the old pump station consists of a single thermostatically controlled gas-fired unit heater for freeze protection, a floor portable rolling fan to circulate air, and operable windows. The single unit heater is in good condition, but the lack of redundancy and the lack of a permanent ventilation system lead to the overall HVAC condition being considered poor. The pump station has operated without a permanent mechanical ventilation system since it was built, so the impact of the lack of a ventilation system is low.

It is recommended that a second unit heater be added to the space for redundancy, to ensure that if one unit heater fails, the other can protect the space from freezing. It is also recommended that a dedicated mechanical ventilation system be installed. Although the pump station has been operating without one, a dedicated mechanical ventilation system would help increase the motor life by preventing overheating. Installing this system would involve removing a section of windows on one side of the building, and replacing it with a motorized combination louver/damper for air intake. On the opposite wall, a wall-mounted propeller exhaust fan would be installed for cross ventilation. The fan would be controlled by a thermostat so that when the room reached a certain temperature setpoint, the fan would turn on, the damper would open, and the system would ventilate the space until the setpoint was reached.

Table 8: HVAC Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	2	Low Impact
Risk	6	Moderate Risk

Recommendation: Install wall mounted exhaust fan, combination louver damper, and gas fired unit heater.

3.1.5 Piping

The piping at the Old Pump Station is original though it has been recoated since the original installation. The piping itself is in good condition but the coating has begun to crack and peel in some places. The pipe is made of ductile iron and will corrode if the coating is not repaired. The piping for the two larger pumps (Pumps 3 & 4) is not supported at the bends and valve the way the smaller pumps (Pumps 1 & 2) are supported.

Table 9: Piping Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	2	Low Impact
Risk	5	Moderate Risk

Recommendation: Replace aboveground piping.

3.1.6 Valves

Pumps 1 & 2 have tilting disc check valves while Pumps 3 & 4 have double swing check valves. There are gate valves on the suction and discharge sides of the pumps. The condition of the suction side valves is not known but the discharge valves are inoperable. Plant operators indicated that the discharge valves have never been used. The coatings on these valves are also in need of reapplication. It is recommended that these valves be replaced to be able to isolate a pump to do maintenance or repairs.

Table 10: Valves Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	2	Low Impact
Risk	6	Moderate Risk

Recommendation: Replace gate valves and check valves on the discharge pipe, implement valve operating routine to exercise isolation valves periodically.

3.1.7 Pumps

The pumps are Layne 12WMC and 12THC pumps originally installed in 1960. Each pump is in a different condition, but for the purposes of this report the overall condition has been given a 'poor' rating. Specifically, Pumps 1 & 2 are in poor condition, Pump 3 is in fair condition, and Pump 4 is in very poor condition. Below is a list of the notable issues with each pump.

- Pump 1
  - The discharge head is in good condition.
  - The coupling guard could not be removed.
  - The highest vibration reading is 0.918 in/sec rms, or seven (7) times higher than the HI limit.
- Pump 2
  - The discharge head is in good condition.
  - The coupling guard could not be removed.
  - The highest vibration reading is 0.297 in/sec rms, or two (2) times higher than the HI limit.
- Pump 3
  - The discharge head is in good condition.
  - The stuffing box is severely corroded and it appears the packing gland studs are gone.
  - The packing gland was not perpendicular to the shaft
  - The highest vibration reading is 0.189 in/sec rms, slightly higher than the HI limit.
- Pump 4
  - The discharge head is in good condition.
  - The stuffing box is severely corroded and it appears the packing gland studs are gone.
  - The packing gland was not perpendicular to the shaft
  - The highest vibration reading is 0.383 in/sec rms, or 2.5 times higher than the HI limit.

Generally these pumps are seeing vibration well above the recommended Hydraulic Institute (HI) limit. The vibration was tested by Smith Pump Co. and can be seen in Appendix C. The coupling guards are recommended to be replaced due to the difficulty in accessing the pump shaft. Visual inspection of the pump shaft indicated significant corrosion as well as a leaking seal. The hydraulic results from the pump tests were not realistic due to the non-ideal placement of the strap on flow meter. There was no straight section of pipe with adequate length available to obtain an accurate flow reading. Since these pumps are original and given the observed corrosion and vibration issues, it is likely that the pumps are not running very efficiently. Additionally, any cast parts are not likely to be available if a repair is needed.

Table 11: Pumps Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	4	High Impact
Risk	8	High Risk

Recommendation: Replace all four pumps, due to age and unavailability of cast parts.

3.1.8 Motors

Motors on the three of the four pumps were manufactured in 1960 and have not been rewound or serviced, but are still running.

Table 12: Motors Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	4	High Impact
Risk	7	Moderate Risk

Recommendation: Replace all four motors.

3.1.9 Crane

The 1-1/2 ton capacity manual trolley hoist and monorail beam is located over the pumps. The monorail beam is attached to the bottom of roof slab. Due to low roof slab height above floor, it is difficult to lift

pumps and/or motors and have space to move within the pump station room. The operation of the trolley hoist was not observed but visually the trolley hoist, chains, and hook appear to be in good condition. The monorail beam needs painting.

Table 13: Crane Rating

	Score	Rating
Condition	2	Good Condition
Criticality	2	Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.1.10 Walls

The pump station is a structural concrete framed building with concrete slab roof, concrete beams, and concrete columns. The exterior walls are non-load bearing with glazed tile masonry on interior with exterior brick veneer. The interior face of concrete columns are clad with glazed tile.

The interior face of glazed tile is cracked at two columns on each side of one window. It appears the glazed tile may have become load bearing which resulted in cracking. Also, the glazed tile is cracked in one corner by an interior door. Exterior brick veneer is in good condition. Some minor rust spots were observed on steel lintel angles supporting brick veneer over windows and doors. The paint on exposed concrete beams is peeling and flaking.

No signs of distress in the concrete beams and columns was observed.

The office area was locked during site visit and was not accessed for observation.

Table 14: Walls Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	3	Moderate Impact
Risk	6	Moderate Risk

Recommendation: Replace broken glazed tile and repaint.

3.1.11 Roof

The pump station roof is a concrete slab. No signs of distress in slab was observed from interior of pump station room. The paint on exposed bottom of concrete roof slab is peeling and flaking.

Two hairline cracks were observed on underside of exterior cantilevered roof slab at covered area adjacent to main entrance into pump station office area. There was evidence of water leaking through these hairline cracks.

A small area of the concrete roof slab at the edge of the overhang is cracking and starting to spall. This area is located above the pump station window on the side of the building with the LAS storage.

Gutter and roofing is damaged at edge of roof at front of pump station building. Access on roof was not provided, therefore, roofing was not observed.

Table 15: Roof Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	3	Moderate Impact
Risk	7	Moderate Risk

Recommendation: Repair roofing, repair cracked/spalled concrete roof slab.

3.1.12 Foundation

From visual observations, the foundation/slab appears to be in very good condition. No signs of distress were observed. A few bearing bars on the floor grating are bent but do not present a structural problem.

Table 16: Foundation Rating

	Score	Rating
Condition	1	Very Good Condition
Criticality	3	Moderate Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.1.13 Instrumentation/Controls

A pump controller is mounted to the front of an MCC door and is an older technology. The pump controller is used to automatically control the pumps based on level in the tanks. The manufacturer no longer supports the current controller and past repairs required the plant to send the controller to a third party repair service. The company supporting repairs has recently stopped repairing similar controllers for the lift stations. A manual control panel for the old and new pump station is located near the MCC and the pushbuttons, lights, and wiring needs to be updated for proper documentation. Over the years, repairs and modifications have not been documented and future repairs can become problematic to troubleshoot.

Table 17: Instrumentation/Controls Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	2	Low Impact
Risk	5	Moderate Risk

Recommendation: Replace outdated pump station controller with newer technology. The PLC in the pump station is a viable option for the replacement and can control the old and new pump station.

3.1.14 SCADA

SCADA hardware in the pump station has been recently replaced and is considered a low risk of failure. The chart recorders used to monitor pressures and flows are in working condition but are an older technology.

Table 18: SCADA Rating

	Score	Rating
Condition	1	Very Good Condition
Criticality	3	Moderate Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.2 NEW PUMP STATION

3.2.1 Overview

The New Pump Station was built in 1983 consists of four horizontal split case pumps each with a design capacity of 1,750 gpm. Generally the City's operators have had more problems with this pump station than the old pump station. Three of the four pumps have been replaced since the original installation. There is a 2 ton overhead bridge crane for pulling pumps and equipment and good access for vehicles to enter through double sliding doors to the pump station.

3.2.2 MCC

The Motor Control Center (MCC), installed in the mid-1980s, has passed its life expectancy of thirty years and parts are not readily available. An infrared camera was used during the site visit and temperatures indicate the equipment is operating within manufacturers specifications. A few hot spots were detected at wire terminations which can be corrected by the City's electrician. Although the infrared camera is used to help determine the operating temperature of the equipment, failures can occur due to other protective characteristic changes due to age.

Table 19: MCC Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	5	Very High Impact
Risk	9	High Risk

Recommendation: Replace wiring, MCC, and automatic transfer switch.

3.2.3 Alternate Power

Utility and backup generator power comes through an automatic transfer switch. The generator and Automatic Transfer Switch (ATS) were installed in 1984 and the generator has failed. A temporary generator has been installed. The automatic transfer switch currently works but is no longer supported by the manufacturer and replacement parts will not be available when current stock is sold out. A failure

of the ATS could leave the pump station out of service for an extended period of time. However, the City has recently begun a project to replace the generator. Therefore the condition rating is very good.

Table 20: Alternate Power Rating

	Score	Rating
Condition	1	Very Good Condition
Criticality	5	Very High Impact
Risk	6	Moderate Risk

Recommendation: No improvements recommended at this time due to the newly replaced generator.

3.2.4 HVAC

The HVAC assessment of the new pump station includes: the pump building, electrical building, chlorine room, and fluoride room. Together, the HVAC systems for these spaces have a moderate impact on the overall operation of the pump station. Each of the components is easy to replace if they were to fail, but in several cases the pump station may not be able to operate without these systems in place; such as if the exhaust fan in the electrical building went out, the electrical gear may overheat if operated.

The current HVAC system consists of a wall-mounted propeller exhaust fan, two wall-mounted gravity dampers, and a single electric unit heater. The ventilation system in the new pump station is operable, but in need of repair.

The exhaust fan is nearing the end of its useful life and should be replaced. Included in the fan replacement, should be a wall-collar, OSHA guards, and a weatherhood. The gravity dampers in the doors allow water penetration and should be replaced with combination louver/damper rated for wind-driven rain. The electric unit heater, used for freeze protection in the space, is nonfunctional and should be replaced. It is also recommended that a second unit heater be added for redundancy; this would insure that if one unit heater was to fail, the other would protect the pipes from freezing.

The ventilation system in the electrical building consists of a roof-mounted exhaust fan and a wall-mounted motorized louver/damper.

The exhaust fan appears to be nearing the end of its useful life, and replacement in the near future is recommended. Also, the motorized damper is no longer operable, the actuator no longer works and will not properly operate the damper. It is recommended it be replaced with a wall-mounted gravity backdraft combination louver/damper. This type of louver/damper does not require an actuator and would open when the exhaust fan is on, and close by gravity when the exhaust fan is off.

The HVAC system in the chlorine room consists of a wall-mounted exhaust fan and door louver, each mounted approximately 12” above finished floor. The chlorine room also has a portable electric unit heater, and a chlorine gas detection system with a single sensor. The overall ventilation system is in fair condition.

It is recommended that an air intake high in the wall should be added to allow ventilation air to sweep the entire room instead of the ventilation air coming in low from the current door louver. A thermostatically controlled wall-mounted unit heater should be added for freeze protection. The condition of the current

chlorine sensor is unknown, regular testing of the system should be implemented to ensure it remains operable. In addition, a second chlorine detector should be added for redundancy.

The ventilation system in the fluoride room consists of a wall-mounted exhaust fan, door mounted louver, and residential style grille installed in the wall above the door. The overall condition of the equipment is poor. The exhaust fan is highly corroded and almost no airflow is being allowed through. The grille above the door is not properly installed, is not the proper type, and allows water penetration

It is recommended the exhaust fan should be replaced immediately. Also, the grille high in the wall should be replaced with a properly installed industrial grade wall-mounted louver.

Table 21: HVAC Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	3	Moderate Impact
Risk	7	Moderate Risk

Recommendation: Replace exhaust fan and louver damper in the new pump station. Install a chlorine detector, unit heater, and exhaust fan in the Chlorine room. Replace exhaust fan and louver in the Fluoride Room

3.2.5 Piping

The piping at the new pump station is steel and is in fair condition. There are a few segments where taps have been made or other work done on the pipe that have removed the coatings and have allowed for significant corrosion, specifically on Pump 1. There are also a few sections of pipe that have been damaged as evidenced through visible dents in the pipe. The suction piping does not follow HI standards due to the eccentric reducer being located too close to the pumps.

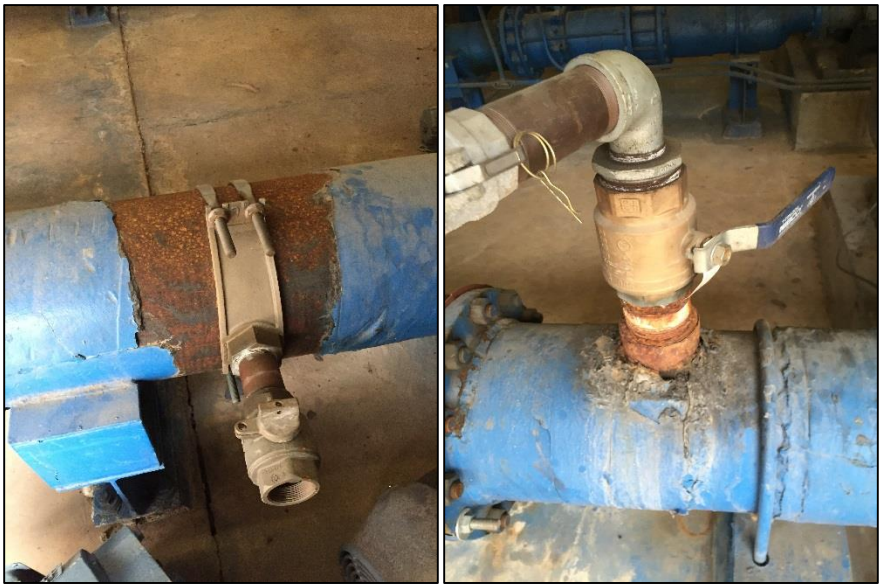


Table 22: Piping Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	2	Low Impact
Risk	5	Moderate Risk

Recommendation: Replace piping and appurtenances.

3.2.6 Valves

Butterfly valves are currently utilized for both the suction and discharge sides of the pump. Some noise was observed by the upstream butterfly valve, which indicates turbulent flow and the potential for cavitation. Additionally, an older valve that had been pulled was still on site and showed evidence of significant corrosion. Flow characteristics through the pumps could be improved if the upstream butterfly valves were replaced with a full port valve.

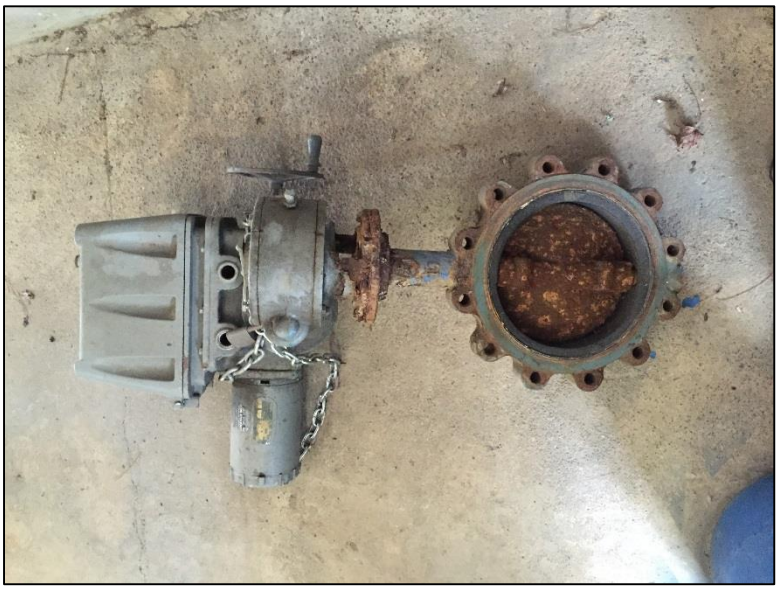


Table 23: Valves Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	2	Low Impact
Risk	6	Moderate Risk

Recommendation: Replace three 12" discharge side BFVs with motor operated actuator and replace suction side BFV's with 12" gate valves.

3.2.7 Pumps

The pumps are Goulds 3405 pumps and originally installed in 1983. Each pump is in a different condition, but for the purposes of this report the overall condition has been given a 'fair' rating. Specifically, Pumps 1 & 2 are in very good condition and Pumps 3 & 4 are in fair condition. Below is a list of the notable issues with each pump.

- Pump 1
  - The efficiency is low, likely caused by excessive wear ring clearance.
  - Very low vibration, maximum 0.076 in/sec rms.
  - The alignment is severely off and motor would be bolt bound
  - Suction piping configuration does not follow HI standards, an eccentric reducer is located too close to the suction of the pump.
- Pump 2
  - Very low vibration, maximum 0.052 in/sec rms.
  - The alignment is off
  - Suction piping configuration does not follow HI standards, an eccentric reducer is located too close to the suction of the pump.
- Pump 3
  - Very low vibration, maximum 0.028 in/sec rms.
  - The alignment is off
  - Suction piping configuration does not follow HI standards, an eccentric reducer is located too close to the suction of the pump.
- Pump 4
  - Vibration is close to HI limit, maximum was 0.139 in/sec rms.
  - The alignment is severely off but the motor feet are already directly on the motor pad and cannot be lowered any more
  - Suction piping configuration does not follow HI standards, an eccentric reducer is located too close to the suction of the pump.

Plant operators have indicated that these pumps have given them more difficulties than the pumps at the Old Pump Station. It was noted by Smith Pump Co. that several of the pump alignments were off. Most of the pumps had low vibration except for Pump 4 which was close to the HI limit but still below it. Pump curves were not available for pumps 2, 3, and 4, though the hydraulic performance appeared to be close to the pump curve for Pump 1.

Table 24: Pumps Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	4	High Impact
Risk	7	Moderate Risk

Recommendation: Replace oldest pump and rehab the next two oldest pumps, the newest pump is not recommended for rehab at this time.

3.2.8 Motors

Pump motor disconnect copper blades are showing signs of surface corrosion. Surface corrosion on copper blades cause hot spots where copper on copper connections are made. Surface corrosion can cause a detrimental failure. The disconnect enclosures are rusting from the inside out.

Pump motors have periodically been replaced as they fail and the pump control valve actuators are no longer supported by the manufacturer. Replacement pump valve actuators are available from various manufacturers, but controls for the current valve actuators and pumps must be modified. Valve actuator manufacturers have made significant control modifications and do not require separate control panels. Modifications to the pump control system are required as the valve actuators get replaced.

Table 25: Motors Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	4	High Impact
Risk	7	Moderate Risk

Recommendation: Replace the three oldest motors with Siemens motors, the newest motor is not recommended for replacement at this time.

3.2.9 Crane

The bridge crane is a 2 ton capacity under running single girder bridge crane with trolley hoist. The operation of the bridge crane was not observed but visually the bridge crane, including trolley hoist, chains, hook, and runway beams, appear to be in good condition.

The fluoride and chlorine building has a 2 ton capacity manual trolley hoist. The operation of the trolley hoist was not observed but visually the trolley hoist, chains, and hook appear to be in fair condition. The chain and hook shows signs of light to moderate rusting.

Table 26: Crane Rating

	Score	Rating
Condition	2	Good Condition
Criticality	2	Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.2.10 Walls

The pump station is a pre-engineered metal building on top of 2.5 feet high concrete perimeter wall and pedestals at columns. The structural steel framing, including columns and wall girts, are in fair to good condition. In three or four places, strap bracing is broken apart and is in very poor condition. There is water leakage at the top of wall and roof edge interface. The steel framing members in areas with leakage show signs of mild corrosion and the primer coating is peeling. The primer coating has been compromised at the steel jambs at the sliding doors. The exterior metal wall panels have several dents near the bottom probably due to being hit by lawn maintenance equipment or trailers. This damage to wall panels is only aesthetic and not structural. The insulation on the interior face of wall panels is in very poor condition with holes, tears, and sections falling apart.

The fluoride and chlorine building is a pre-engineered metal building with one-half of the building enclosed with masonry walls and metal wall panels. The other half of the building is open with canopy roof. The exterior exposed structural steel columns show signs of mild corrosion and the paint coating has failed at bottom of columns and base. Inside the chlorine room, there is mild rusting on the interior face of metal wall panels and steel framing. There are minor dents on exterior face of metal wall panels.

The electrical building is a pre-engineered metal building and is in good condition. There are minor dents on exterior face of metal wall panels.

Table 27: Walls Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	3	Moderate Impact
Risk	6	Moderate Risk

Recommendation: Make repairs to fix leaks and repair/replace damage components and replace insulation.

3.2.11 Roof

The pump station roof is a standard pre-engineered metal building roof. The structural steel framing, including girders and purlins, are in good condition. In three or four places, strap bracing is broken apart and is in very poor condition. There is water leakage at the roof edge and top of wall interface. The steel framing members in areas with leakage show signs of mild corrosion and the primer coating is peeling.

Metal roof deck at corner adjacent to front door shows signs of moderate to severe corrosion. In this area, the roof deck's coating has failed, there is a small hole through deck, and was leaking while it was raining during the site visit. The insulation on the interior face of roof deck is in very poor condition with holes, tears, and sections falling apart.

The fluoride and chlorine building roof is a standard pre-engineered metal building roof. The structural steel framing, including girders and purlins, are in good condition, except inside the chlorine room, there is mild rusting on the steel framing members. There are minor dents on exterior face of metal wall panels.

The electrical building roof is a standard pre-engineered metal building roof and is in good condition.

Table 28: Roof Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	3	Moderate Impact
Risk	7	Moderate Risk

Recommendation: Make repairs to fix leaks and repair/replace damage components and replace insulation.

3.2.12 Foundation

For the pump station, from visual observations, the concrete foundation/slab appears to be in fair to good condition. The concrete floor slab is isolated from the perimeter concrete grade beams/walls/pedestals and the concrete mat foundations supporting the pumps. The floor slab and the mat foundations supporting the pumps appear to be in fair to good condition. Some very minor settlement of the floor slab was observed. There is some minor concrete spalling at the expansion joints between the floor slab and the pumps' mat foundations. The joint sealant has failed. Grout under three or four pipe support bases was cracked and/or spalled.

For the fluoride and chlorine building, from visual observations, the concrete foundation/slab appears to be in good condition.

For the electrical building, from visual observations, the concrete foundation/slab appears to be in good condition.

Table 29: Foundation Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	3	Moderate Impact
Risk	6	Moderate Risk

Recommendation: Repair concrete cracks/spalling, seal joints, and grout under pipe supports.

3.2.13 Chlorine Analyzer

While the existing analyzer is in good condition, the City prefers to have a new chlorine analyzer at the new pump station similar to the ProMinent Chlorine Analyzer that was recently installed at the old pump station.

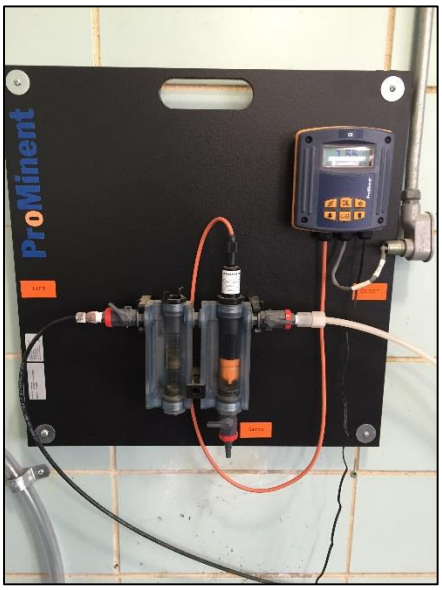


Table 30: Chlorine Analyzer Rating

	Score	Rating
Condition	2	Good Condition
Criticality	2	Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time, though an allowance for this item is included under miscellaneous improvements in the cost estimate.

3.2.14 Instrumentation/Controls

The pumps are controlled from relays in the old pump station. Control stations can wear out with use over time. Control stations can wear out over time. Replacement parts are readily available. Modifications to the controls for pump number 1 have left little documentation for wiring causing potential extended outages due to troubleshooting.

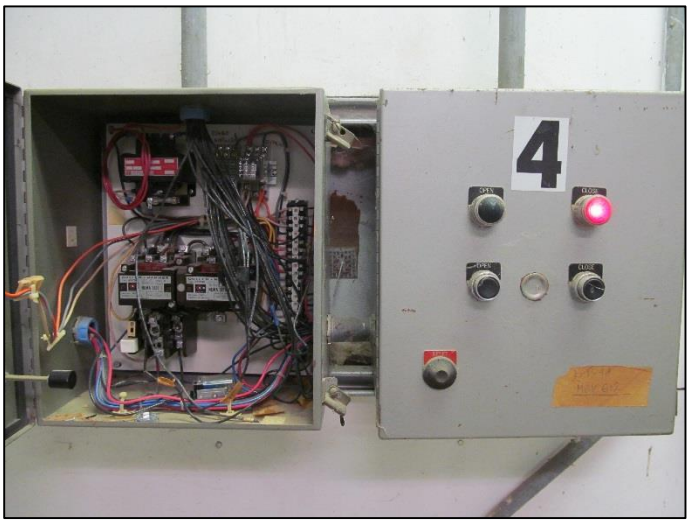


Table 31: Instrumentation/Controls Rating

	Score	Rating
Condition	4	Poor Condition
Criticality	3	Moderate Impact
Risk	7	Moderate Risk

Recommendation: Replace pump controls and install new motor operated actuators

3.2.15 SCADA

The new pump station is connected to the old pump station SCADA system. The SCADA system is new and no new hardware is required.

Table 32: SCADA Rating

	Score	Rating
Condition	1	Very Good Condition
Criticality	3	Moderate Impact
Risk	4	Low Risk

Recommendation: No improvements recommended.

3.3 OTHER SITE ITEMS

3.3.1 Site Drainage

During the site visit it was observed that there was ponding in a few areas across the site, specifically, around the ground storage tanks and underneath the elevated storage tank. This is likely due to ground settlement after construction. While it does not appear to have caused any problems to date, it could allow for corrosion to begin at the base of the tanks.

Table 33: Site Drainage Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	1	Very Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.3.2 New Pump Station Discharge Meter

The flow meter on the discharge header of the New Pump Station is above ground in a vertical position directly downstream of a 135° bend. This does not meet the typical standard for mag meters which requires five upstream pipe diameters of straight pipe and two downstream pipe diameters of straight pipe. Relocating this valve to a straight section of pipe would provide more accurate readings for the flow

coming from the New Pump Station. However it is our understanding that the meter is calibrated annually and is achieving acceptable levels of accuracy.

Table 34: New Pump Station Discharge Meter Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	1	Very Low Impact
Risk	6	Low Risk

Recommendation: No improvements recommended at this time.

3.3.3 Entrance Gate

Currently the Palm St. Water Plant has a double swing gate but plant operators noted that a roller gate would be preferred.

Table 35: Entrance Gate Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	1	Very Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.3.4 Video Surveillance

There is an existing camera at the entrance gate but this is the only video surveillance provided at the site. Plant operators noted that additional video surveillance would increase security at the plant.

Table 36: Video Surveillance Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	1	Very Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.3.5 Tank Overflows

The existing tank overflows discharge on the north side of the plant on a slope away from the tanks offsite towards an apartment complex. Under normal circumstances any overflow water would still drain away from the apartment complexes but there is some risk of erosion on the slope. High flows or unforeseen circumstances may put the adjacent apartment complex at risk of flooding. The tank overflow piping could be extended to the northeast to discharge into the drainage ditch to mitigate this risk.

Table 37: Tank Overflows Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	2	Low Impact
Risk	5	Moderate Risk

Recommendation: Reroute overflow piping towards northeast corner of property away from the apartment complex

3.3.6 Fencing

Plant operators indicated that some fencing has been damaged in recent storms although it was minor and did not compromise the security of the facility.

Table 38: Fencing Rating

	Score	Rating
Condition	2	Good Condition
Criticality	2	Low Impact
Risk	4	Low Risk

Recommendation: No improvements recommended at this time.

3.3.7 Yard Piping

There is currently no isolation valve on the 3.0 MG ground storage tank on the east side of the site which prevents the City from being able to shut down that tank for maintenance without having to shut down other tanks. For operational flexibility it would be beneficial to add a valve there. Other piping around the site also appeared to be in need of some coating touch ups.

Table 39: Yard Piping Rating

	Score	Rating
Condition	3	Fair Condition
Criticality	3	Moderate Impact
Risk	6	Moderate Risk

Recommendation: Install 30" isolation valve on inlet to 3.0 MG ground storage tank.

3.4 RISK ASSESSMENT SUMMARY

Summarizing all of the component scores allows us to rank the components by risk. The components at the Palm St. Water Plant have been summarized to show this ranking and provide insight as to which components should be repaired or replaced before others.

Table 40: Risk Assessment Summary

Facility	Component	Condition	Condition Rating	Criticality	Criticality Rating	Risk
Old PS	MCC	4	Poor	5	Very High	High Risk
New PS	MCC	4	Poor	5	Very High	High Risk
Old PS	Pumps	4	Poor	4	High	High Risk
New PS	Roof	4	Poor	3	Moderate	Moderate Risk
New PS	Instrumentation	4	Poor	3	Moderate	Moderate Risk
Old PS	Roof	4	Poor	3	Moderate	Moderate Risk
New PS	HVAC	4	Poor	3	Moderate	Moderate Risk
Old PS	Motors	3	Fair	4	High	Moderate Risk
New PS	Pumps	3	Fair	4	High	Moderate Risk
New PS	Motors	3	Fair	4	High	Moderate Risk
Old PS	Alternate Power	2	Good	5	Very High	Moderate Risk
Old PS	HVAC	4	Poor	2	Low	Moderate Risk
Old PS	Valves	4	Poor	2	Low	Moderate Risk
New PS	Valves	4	Poor	2	Low	Moderate Risk
Old PS	Walls	3	Fair	3	Moderate	Moderate Risk
Other	Yard Piping	3	Fair	3	Moderate	Moderate Risk
New PS	Alternate Power	1	Very Good	5	Very High	Moderate Risk
Old PS	Piping	3	Fair	2	Low	Moderate Risk
New PS	Piping	3	Fair	2	Low	Moderate Risk
Other	Tank Overflows	3	Fair	2	Low	Moderate Risk
New PS	Walls	3	Fair	3	Moderate	Moderate Risk
New PS	Foundation	3	Fair	3	Moderate	Moderate Risk
Old PS	Instrumentation	3	Fair	2	Low	Moderate Risk
New PS	SCADA	1	Very Good	3	Moderate	Low Risk
Other	Site Drainage	3	Fair	1	Very Low	Low Risk
Other	Entrance Gate	3	Fair	1	Very Low	Low Risk
Other	Video Surveillance	3	Fair	1	Very Low	Low Risk
Other	New PS Discharge Meter	3	Fair	1	Very Low	Low Risk
Old PS	Crane	2	Good	2	Low	Low Risk
New PS	Crane	2	Good	2	Low	Low Risk
New PS	Chlorine Analyzer	2	Good	2	Low	Low Risk
Other	Fencing	2	Good	2	Low	Low Risk
Old PS	SCADA	1	Very Good	3	Moderate	Low Risk
Old PS	Foundation	1	Very Good	3	Moderate	Low Risk

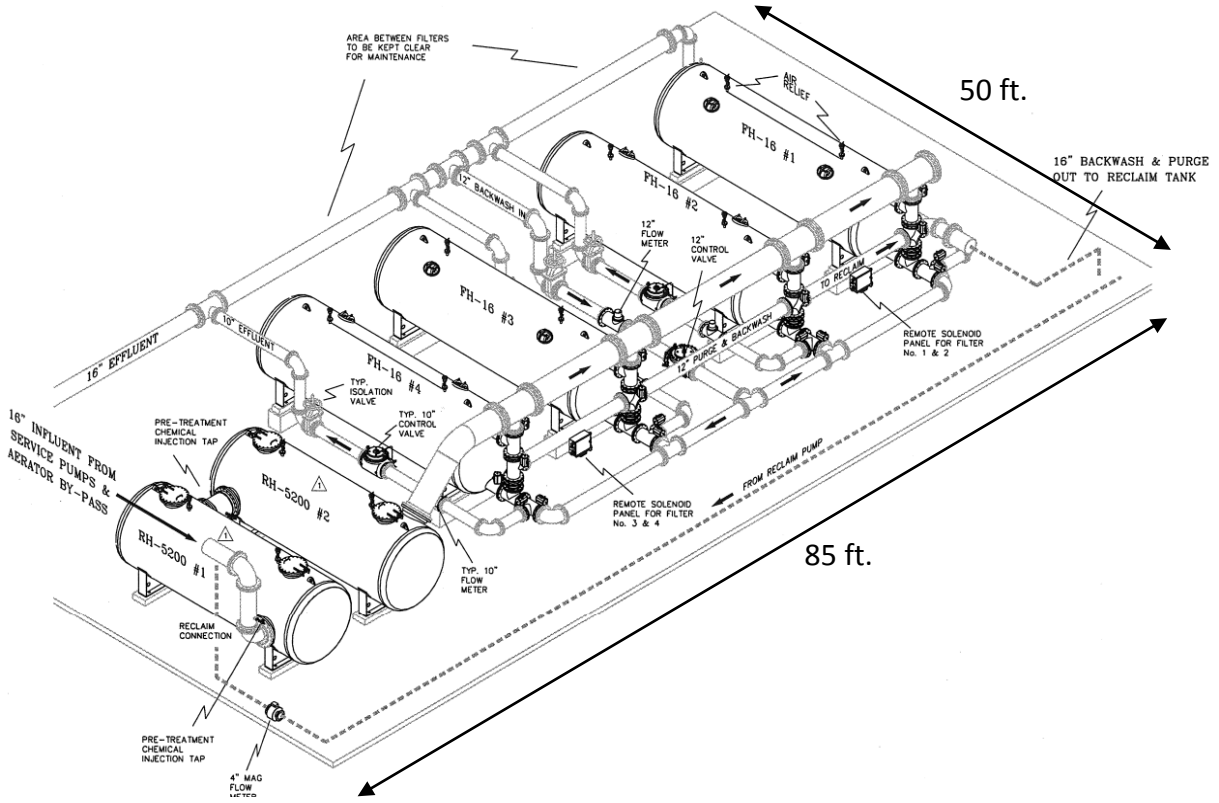
4.0 FILTERS

Iron and manganese are common in groundwater supplies used by many small water systems. Exceeding the suggested maximum contaminant levels (MCL) usually results in discolored water, laundry, and plumbing fixtures. This, in turn, results in consumer complaints and a general dissatisfaction with the water utility. How iron and manganese are removed depends on the type and concentration and this helps determine the best procedure and (possible) equipment to use.

The City currently does not filter water that comes through the Palm Street Water Plant; however, the City does filter water through the Spring Lake Water Plant to improve water quality. Water quality is typically not a problem at the Palm Street Water Plant, but in the past when the wells have been used exclusively, instead of a blend of TRA supplied surface water and well water, there have been complaints about water quality. FNI has evaluated the site requirements necessary to install filters at the Palm Street Water Plant and determined that there is not space on the site north of Palm St. for the filters but there is space on the site south of Palm St. The anticipated site requirements are 85 ft. by 50 ft. to treat an estimated max flow of 6.07 MGD. To locate the filters on the south side of Palm St. would provide an opportunity to simplify the piping coming into the water plant as well as provide a good site with existing infrastructure (electrical, fencing, access, etc.) for the filters. This filter set up is estimated to cost $3.05 million. Figure 1 shows what a filter structure on site would look like.

As discussed in the workshop with the City, it may also be possible to place smaller filtration stations at the individual well sites. This could allow the City to spread out capital expenditures and select the wells with the lowest water quality for filtration rather than filtering all the water. However, adding filters on the discharge of the well pumps will introduce additional headloss which will reduce the capacity of these wells to deliver water to the water plant.

Figure 1: Filters Isometric View



An alternative to filtration would be to add a sequestering agent, such as inorganic polyphosphate. Sequestration is the addition of chemicals to groundwater aimed at controlling problems caused by iron and manganese without removing them. These chemicals are added to groundwater at the well head or at the pump intake before the water has a chance to come in contact with air or chlorine. This ensures that the iron and manganese stays in a soluble form. If the water contains less than 1.0 mg/L iron and less than 0.3 mg/L manganese, using polyphosphates followed by chlorination can be an effective and inexpensive method for mitigating iron and manganese problems. Below these concentrations, the polyphosphates combine with the iron and manganese preventing them from being oxidized.

Further evaluation of the water quality, well sites, and the well pumping capacities would be necessary to determine the feasibility of either option. Figure 2 on the following page shows a potential site for the filters at the Water Plant.

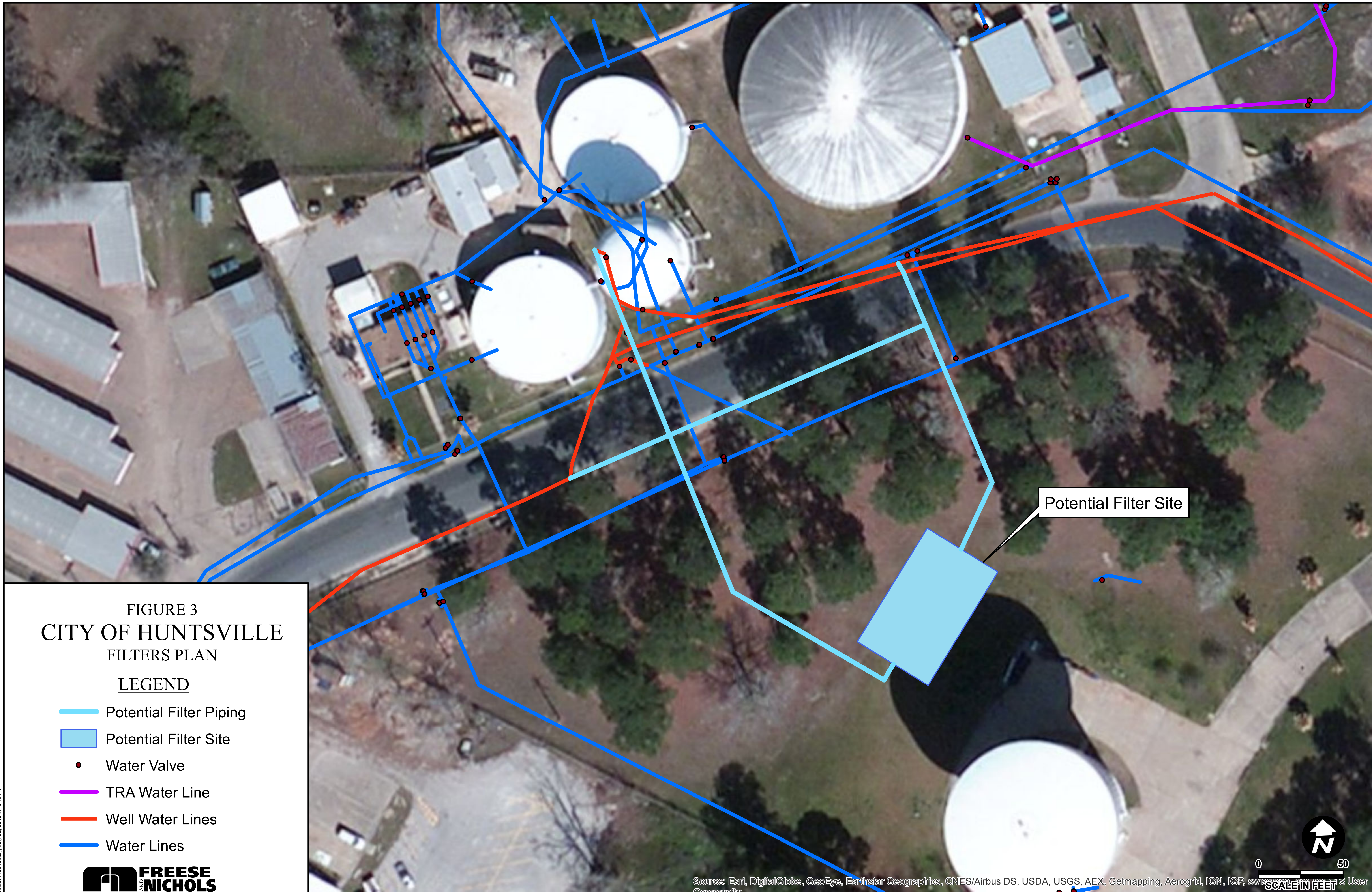


FIGURE 3

CITY OF HUNTSVILLE

FILTERS PLAN

LEGEND

- Potential Filter Piping
- Potential Filter Site
- Water Valve
- TRA Water Line
- Well Water Lines
- Water Lines

FREESE AND NICHOLS

Created By Freese and Nichols, Inc.
Job No.: (Manually Type Job Number Here)
Location: T:\2.0 STUDY\2.04 Study-Rpts\Exhibit\Filters.mxd
Updated: Wednesday, July 22, 2015 8:49:19 AM

5.0 RECOMMENDATIONS

5.1 RECOMMENDED IMPROVEMENTS & COST SUMMARY

Each of the components that were determined to have a 'moderate' or 'high' risk rating and did not receive a 'very good' condition rating have been recommended for rehabilitation. In many cases the equipment has been recommended to be completely replaced, when possible repairs have also been recommended. Each of these improvements have been included in the table below with their probable total project costs.

Table 41: Recommended Improvements Summary

Facility	Component	Risk	Recommended Improvement	Opinion of Probable Total Project Cost*
Old PS	MCC	High Risk	Replace New Pump Station MCC	$260,800
New PS	MCC	High Risk	Replace Old Pump Station MCC	$420,800
Old PS	Pumps	High Risk	Replace Old Pump Station Pumps	$172,000
New PS	Roof	Moderate Risk	Repair New Pump Station Roof	$45,900
New PS	Instrumentation	Moderate Risk	Replace New Pump Station Instrumentation	$99,500
Old PS	Roof	Moderate Risk	Repair Old Pump Station Roof	$18,500
Old PS	Motors	Moderate Risk	Replace Old Pump Station Motors	$90,400
New PS	Pumps	Moderate Risk	Repair/Replace New Pump Station Pumps	$71,300
New PS	Motors	Moderate Risk	Replace New Pump Station Three Oldest Motors	$67,400
Old PS	Alternate Power	Moderate Risk	Old Pump Station Alternate Power Improvements	$23,000
Old PS	HVAC	Moderate Risk	Install Old Pump Station HVAC System	$22,100
Old PS	Valves	Moderate Risk	Replace Old Pump Station Valves	$50,400
New PS	HVAC	Moderate Risk	Replace New Pump Station HVAC System	$32,600
New PS	Valves	Moderate Risk	Replace New Pump Station Valves	$45,600
Old PS	Walls	Moderate Risk	Repair Old Pump Station Walls	$13,900
Old PS	Instrumentation	Moderate Risk	Replace Controller	$30,600
Other	Yard Piping	Moderate Risk	Install Isolation Valve on 3.0 MG Ground Storage Tank	$51,500
Old PS	Piping	Moderate Risk	Replace Old Pump Station Aboveground Piping	$5,500
New PS	Piping	Moderate Risk	Replace New Pump Station Aboveground Piping	$5,000

Facility	Component	Risk	Recommended Improvement	Opinion of Probable Total Project Cost*
Other	Tank Overflows	Moderate Risk	Reroute Tank Overflows Away from Apartments	$80,000
New PS	Walls	Moderate Risk	Repair New Pump Station Walls	$27,600
New PS	Foundation	Moderate Risk	Repair New Pump Station Foundation	$10,100
All	Miscellaneous	Low Risk	Miscellaneous Improvements	$200,000
			Total Project Costs	**$1,844,500**

* Cost includes mobilization, contingency, construction management, materials testing and professional services

5.2 SCHEDULE

Since the Palm St. Water Plant supplies the majority of the water to the City of Huntsville, project scheduling will be a critical element to the successful implementation of any rehabilitation project. To be able to reduce the impact to customers it is recommended to time construction during winter months when demand is the lowest. This will allow the pumps to be taken down with minimal impact on the system. FNI has developed three alternatives for scheduling the project. The first alternative is to schedule the electrical repairs/replacements to take place first. Since the MCCs at both of the pump stations are the two highest risk items, addressing those issues first is a good option. Repairs at the old pump station could then take place after the electrical package is complete. Finally the new pump station rehab could take place last since it is generally in better condition than the old pump station.

Table 42: Schedule Alternate 1

Project and Phase	Estimated Duration	OPPC	2016	2017	2018	2019
Electrical Package		$735,000				
Design	4 months					
Bid	2 months					
Construction	6 months					
Old Pump Station		$473,000				
Design	4 months					
Bid	2 months					
Construction	8 months					
New Pump Station		$637,000				
Design	4 months					
Bid	2 months					
Construction	8 months					

Alternative 2 would incorporate the electrical repairs/replacement into each of the pump station packages. This would extend the project duration of each pump station package but reduce the number of construction packages that the City would have to administer. The lengthier construction would have to be well timed to ensure that everything could take place during a low demand season.

Table 43: Schedule Alternate 2

Project and Phase	Estimated Duration	OPCC	2016	2017	2018
Old Pump Station		$947,000			
Design	6 months				
Bid	2 months				
Construction	10 months				
New Pump Station		$897,000			
Design	6 months				
Bid	2 months				
Construction	10 months				

Finally, the City could choose to include all of the recommended improvements into one package. The construction may take significantly longer this way as the contractor may need to be under contract through two low demand seasons to be able to complete all the work with the least impact to the users.

Table 44: Schedule Alternate 3

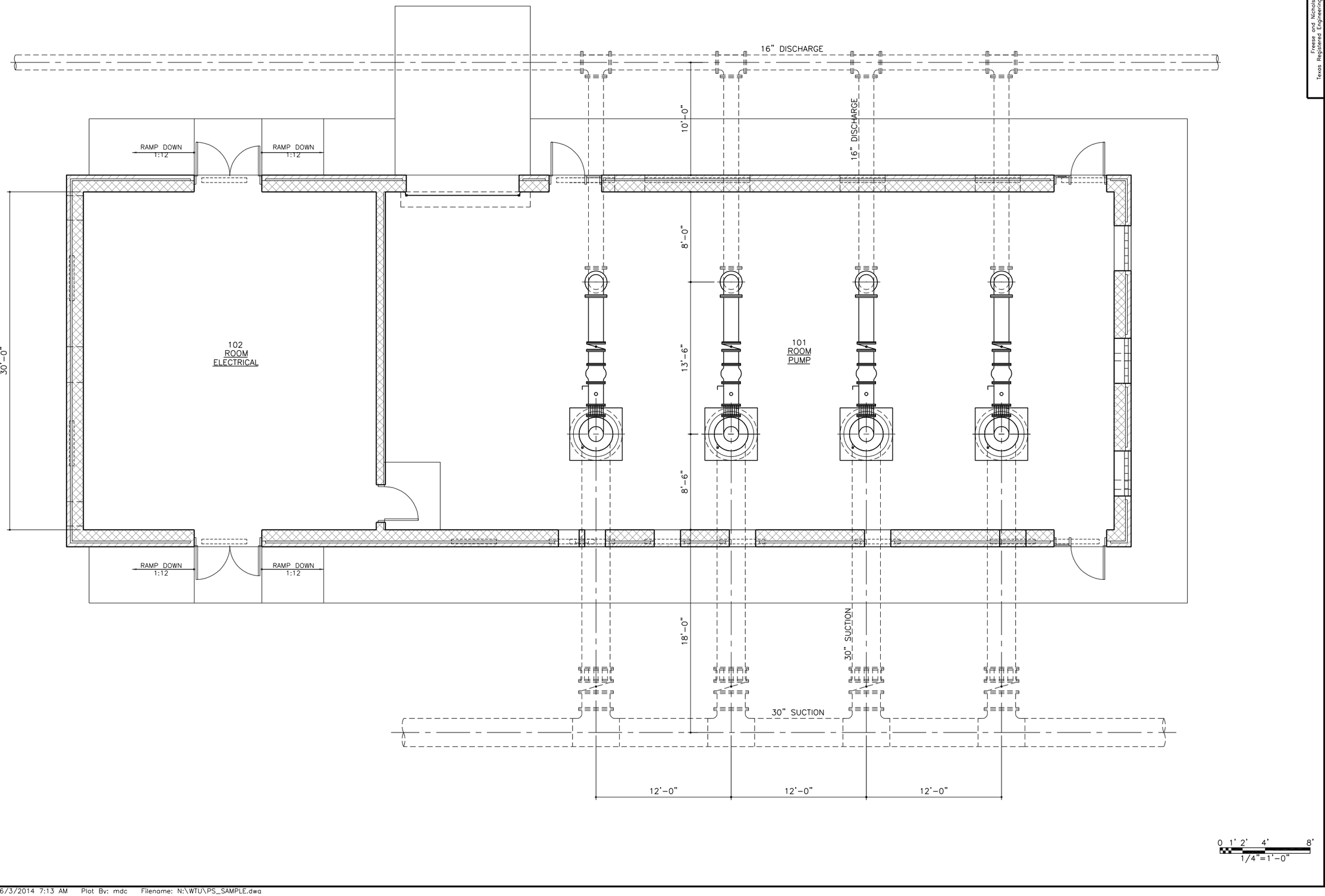
Project and Phase	Estimated Duration	OPCC	2016	2017	2018
Old & New Pump Station		$1,844,500			
Design	6 months				
Bid	2 months				
Construction	17 months				

6.0 CONSTRUCTION OF A NEW PUMP STATION

Another option available to the City is to construct a new pump station and abandon the two existing pump stations. Since the City is currently on one pressure plane, a dual pump station system is not necessary and potentially better system efficiencies could be realized by combining the pumping into one pump station. This would also provide the City an opportunity to simplify the piping network within the plant and have a pump station that will be completely new, as opposed to two rehabilitated pump stations. It appears that there is sufficient space on the site to the south of Palm St. by the elevated storage tank for a new pump station. Additionally, this would allow for fewer pumps to be installed than the eight that the water plant currently has, which would reduce maintenance costs and time and potentially provide some economy of scale for pump costs. To evaluate what the probable construction cost would be, FNI pulled several recent pump station bids of a similar size (ranging from 4.3 to 20 MGD firm capacity) and developed a trendline to determine what the anticipated cost would be for a 16.0 MGD firm capacity pump station. Using this method FNI estimates that a new 16.0 MGD firm capacity pump station would cost approximately $4.4 million. This includes a contingency and professional services and is in 2015 dollars.

The figures below shows where the potential pump station could be located and what a 16.0 MGD pump station plan could look like.

Figure 3: New Pump Station Potential Site



Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

FREESE NICHOLS
4055 International Plaza, Suite 200
Fort Worth, Texas 76109-4895
Phone - (817) 735-7300
Fax - (817) 735-7491
Web - www.freese.com

CITY OF HUNTSVILLE
PALM ST. WATER PLANT

NEW PUMP STATION PLAN

NO.	ISSUE	BY	DATE

F&N JOB NO. OFF14935
DATE 06/03/14
DESIGNED KWW
DRAWN MDC
REVISED
CHECKED KWW
FILE NAME PS_SAMPLE.dwg

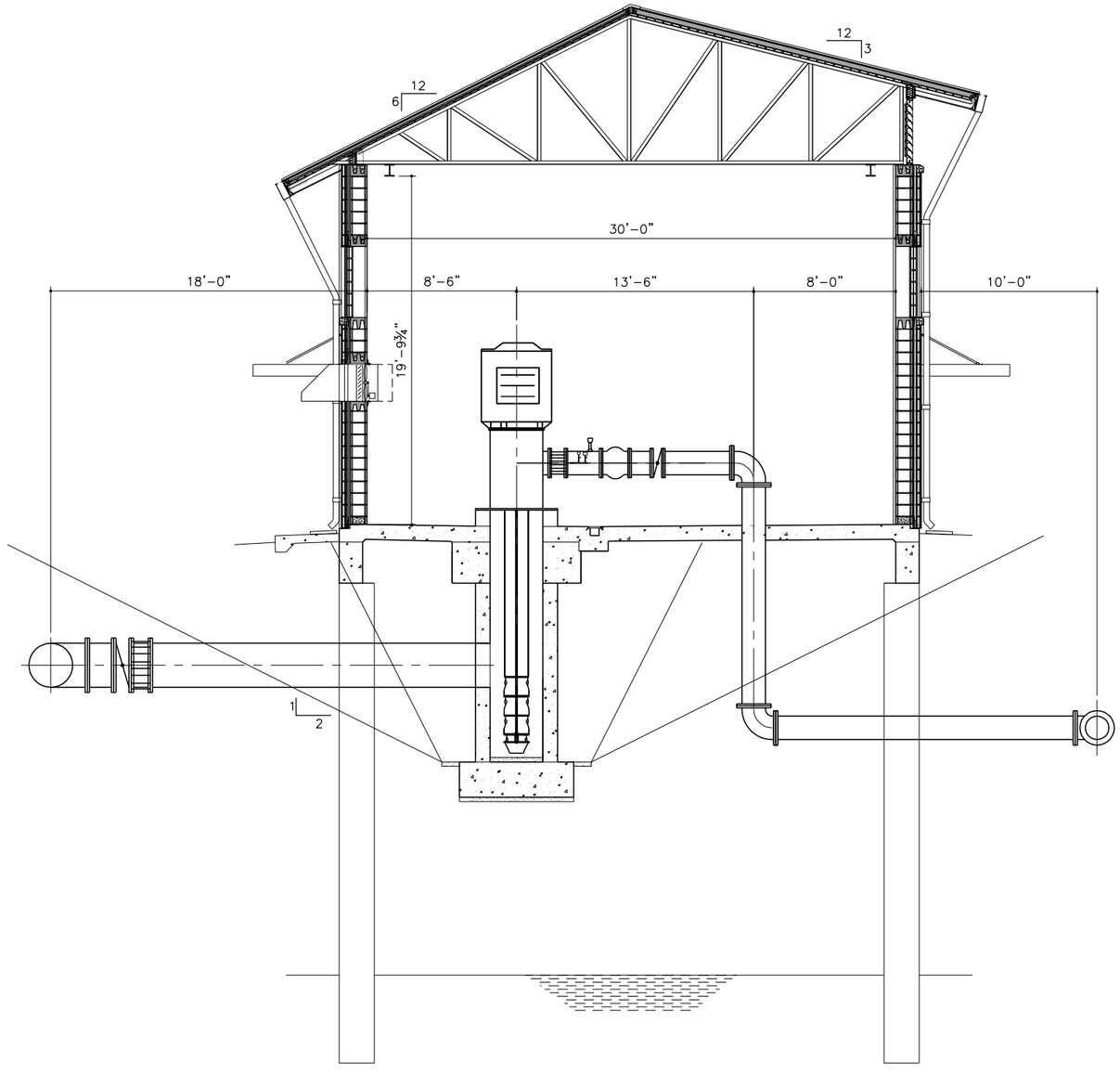
VERIFY SCALE Bar is one inch on original drawing. If not one inch on this sheet, adjust scale.
0 1"

SHEET 1

Fig. 4

ACAD Rel: 19.1s (LMS Tech)
Filename: N:\WTU\PS_SAMPLE.dwg
Last Saved: 6/3/2014 7:12 AM Saved By: mdc

Plot Date: 6/3/2014 7:13 AM Plot By: mdc Filename: N:\WTU\PS_SAMPLE.dwg



0 1' 2' 4' 8'
1/4"=1'-0"

Freese and Nichols, Inc.
Texas Registered Engineering Firm F-2144

FREESE NICHOLS
4055 International Plaza, Suite 200
Fort Worth, Texas 76109-4895
Phone - (817) 735-7300
Fax - (817) 735-7491
Web - www.freese.com

CITY OF HUNTSVILLE
PALM ST. WATER PLANT

NEW PUMP STATION SECTION

F&N JOB NO. OFF14935
DATE 06/03/14
DESIGNED KWW
DRAWN MDC
REVISED MDC
CHECKED KWW
FILE NAME PS_SAMPLE.dwg

NO.	ISSUE	BY	DATE

VERIFY SCALE Bar is one inch on original drawing. If not one inch on this sheet, adjust scale.
0 1"

SHEET 2

Fig. 5

ACAD Rel: 19.1s (LMS Tech)
Filename: N:\WTU\PS_SAMPLE.dwg
Last Saved: 6/3/2014 7:28 AM Saved By: mdc

Plot Date: 6/3/2014 7:29 AM Plot By: mdc Filename: N:\WTU\PS_SAMPLE.dwg

APPENDIX A
CONDITION ASSESSMENT SCORING SHEETS

Palm Street Water Plant
(Old Pump Station)

Inspection Date: 5/12/2015

Facility Information:

Date In Service:	
Number of Pumps:	4
Total Capacity (gpm):	6,000
Firm Capacity (gpm):	4,000

	Design Point Flow (gpm)	Design Point Head (ft)
Pump 1	1,000	
Pump 2	1,000	
Pump 3	2,000	
Pump 4	2,000	

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group		Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Electrical	MCC, Switchgear	4	5	9	High	● Components have been replaced but indications of arc flashes have occurred. ● Water piping routed through MCC for instrumentation.
Electrical	Alternate Power (dual power feed or back up generator)	2	5	7	Moderate	●Moisture is present in the ATS.
Mechanical	HVAC	4	2	6	Moderate	● No permanent mechanical ventilation in pump room. Installing one is recommended. Redundant unit heater is recommended.
Mechanical	Piping	3	2	5	Moderate	● Original piping from 1960
Mechanical	Valves	4	2	6	Moderate	● Gate valves on discharge piping do not turn
Pumps		4	4	8	High	● Original pump from 1960 ● High vibration ● Stuffing box corroded, packing gland studs no longer exist ● Packing gland not perpendicular to the shaft

Palm Street Water Plant
(Old Pump Station)

Inspection Date: 5/12/2015

Facility Information:

Date In Service:	
Number of Pumps:	4
Total Capacity (gpm):	6,000
Firm Capacity (gpm):	4,000

	Design Point Flow (gpm)	Design Point Head (ft)
Pump 1	1,000	
Pump 2	1,000	
Pump 3	2,000	
Pump 4	2,000	

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group		Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Motors		3	4	7	Moderate	● 3 motors are original from 1960
Structure	Crane	2	2	4	Low	● 1.5 ton crane ● Would prefer automated crane
	Walls	3	3	6	Moderate	● Cracked Tile ● Potential for Asbestos
	Roof	4	3	7	Moderate	● Gutters need to be repaired
	Foundation	1	3	4	Low	
Instrumentation		3	1	4	Low	● Pressure transmitters could be relocated outside of the MCC. ● Circular graph charts could be replaced and information could be stored on SCADA
SCADA		1	3	4	Low	

Palm Street Water Plant
(New Pump Station)

Inspection Date: 5/12/2015

Facility Information:

Date In Service:	
Number of Pumps:	4
Total Capacity (gpm):	7,000
Firm Capacity (gpm):	5,250

	Design Point Flow (gpm)	Design Point Head (ft)
Pump 1	1,750	
Pump 2	1,750	
Pump 3	1,750	
Pump 4	1,750	

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group		Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Electrical	MCC, Switchgear	4	5	9	High	● Hot spots indicated on starter(s), replacement parts not available
Electrical	Alternate Power (dual power feed or back up generator)	1	5	6	Moderate	● New generators have been ordered already
Mechanical	HVAC	4	3	7	Moderate	● Exhaust fan in pump room is near end of usefull life, should be replaced, OSHA guards and wall collar added. Unit heater does not work and should be replaced, redundancy is recommended. Electrical room exhaust fan and louver replacement is recommended. Chlorine room needs a wall-mounted unit heater and redundant chlorine sensor. Fluoride room is highly corroded, new fan is needed.
Mechanical	Piping	3	2	5	Moderate	● Pump 1's piping is corroded where taps have been made
Mechanical	Valves	4	2	6	Moderate	● BFVs upstream of pump could be replaced with full port valves to improve flow characteristics

Palm Street Water Plant
(New Pump Station)

Inspection Date: 5/12/2015

Facility Information:

Date In Service:	
Number of Pumps:	4
Total Capacity (gpm):	7,000
Firm Capacity (gpm):	5,250

	Design Point Flow (gpm)	Design Point Head (ft)
Pump 1	1,750	
Pump 2	1,750	
Pump 3	1,750	
Pump 4	1,750	

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group		Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Pumps		3	4	7	Moderate	● 3 Pumps have been replaced once before ● More problematic than the vertical pumps ● Water lubricated ● Alignments off
Motors		3	4	7	Moderate	● 50 hp motors
Structure	Crane	2	2	4	Low	● 2 ton crane ● Would prefer automated crane
	Walls	3	3	6	Moderate	● Insulation damaged ● Some corrosion around exterior
	Roof	4	3	7	Moderate	● Insulation damaged ● Leaking ● Some corrosion ● Strap bracing
	Foundation	3	3	6	Moderate	● Some ponding around exterior ● Expansion joint repair
Chlorine Analyzer		2	2	4	Low	● The City would prefer a new chlorine analyzer like the one in the old PS

Palm Street Water Plant
(New Pump Station)

Inspection Date: 5/12/2015

Facility Information:

Date In Service:	
Number of Pumps:	4
Total Capacity (gpm):	7,000
Firm Capacity (gpm):	5,250

	Design Point Flow (gpm)	Design Point Head (ft)
Pump 1	1,750	
Pump 2	1,750	
Pump 3	1,750	
Pump 4	1,750	

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group	Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Instrumentation/Controls	4	3	7	Moderate	● Pressure Switch on Pump 1 not connected ● MOV control panels have been modified over time an lack documentation.Flow meter is obsolete, replacement parts not available. ● TRA flow meter is not supported by manufacture, parts are not available.
SCADA	2	3	5	Moderate	● New SCADA system was recently installed.

Palm Street Water Plant
(Other Site Work)

Inspection Date: 5/12/2015

Condition Scoring Guidelines	
1	Very Good condition; no improvements recommended to maintain function
2	Good condition; minor improvements recommended to maintain function
3	Fair condition; improvements recommended to improve performance or efficiency
4	Poor condition; improvements recommended to maintain reliability
5	Very Poor condition; rehabilitation or replacement required

Criticality Scoring Guidelines	
1	Very Low impact
2	Low impact
3	Moderate impact
4	High impact
5	Very High impact

Component Group	Component Condition Rating	Component Criticality Rating	Overall Risk Rating	Risk Category	Comments
Site Drainage	3	1	4	Low	● Ponding underneath EST ● Ponding around edges of GSTs
New PS Discharge Meter	3	1	4	Low	● Standard upstream and downstream requirements from flow meter are not being met
Entrance Gate	3	1	4	Low	● The City would prefer to have an electric rolling gate than the existing swing gate
Video Surveillance	3	1	4	Low	● No video surveillance of the site, only at the gate
Tank Overflows	3	2	5	Moderate	● The City would prefer to route overflow away from apartments
Fencing	2	2	4	Low	● Some barbed wire damaged from storms
Yard Piping	3	3	6	Moderate	● No isolation valve on line into GST from TRA line ● BFV at 1.0 MG steel tank hasn't been used since 2007

APPENDIX B
DETAILED COST BREAKDOWN

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
REPLACE NEW PUMP STATION MCC					
1	MCC Equipment	1	LS	$ 100,250.00	$100,250
	Disconnect switches	1	LS	$ 40,000.00	$40,000
	Wiring	1	LS	$ 20,000.00	$20,000
	Demolition	1	LS	$ 10,000.00	$10,000
		SUBTOTAL:			$170,250
		MOBILIZATION		5%	$8,600
		PROF. SERVICES		12%	$20,500
		CMI & MT		6%	$10,300
		CONTINGENCY		30%	$51,100
				REPLACE NEW PUMP STATION MCC SUBTOTAL:	$260,800
REPLACE OLD PUMP STATION MCC					
2	MCC Equipment	1	LS	$ 105,000.00	$105,000
	Disconnect switches	1	LS	$ 40,000.00	$40,000
	New MCC Building	1	LS	$ 100,000.00	$100,000
	Wiring	1	LS	$ 20,000.00	$20,000
	Demolition	1	LS	$ 10,000.00	$10,000
		SUBTOTAL:			$275,000
		MOBILIZATION		5%	$13,800
		PROF. SERVICES		12%	$33,000
		CMI & MT		6%	$16,500
		CONTINGENCY		30%	$82,500
				REPLACE OLD PUMP STATION MCC SUBTOTAL:	$420,800
REPLACE OLD PUMP STATION PUMPS					
3	Replace 1,000 gpm pumps	2	EA	$ 24,750.00	$49,500
	Replace 2,000 gpm pumps	2	EA	$ 26,400.00	$52,800
	Demolition	1	LS	$ 10,000.00	$10,000
		SUBTOTAL:			$112,300
		MOBILIZATION		5%	$5,700
		PROF. SERVICES		12%	$13,500
		CMI & MT		6%	$6,800
		CONTINGENCY		30%	$33,700
				REPLACE OLD PUMP STATION PUMPS SUBTOTAL:	$172,000
REPAIR NEW PUMP STATION ROOF					
4	Make repairs to fix leaks and repair/replace damaged components	1	LS	$ 25,000.00	$25,000
	Demolition	1	LS	$ 5,000.00	$5,000
		SUBTOTAL:			$30,000
		MOBILIZATION		5%	$1,500
		PROF. SERVICES		12%	$3,600
		CMI & MT		6%	$1,800
		CONTINGENCY		30%	$9,000
				REPAIR NEW PUMP STATION ROOF SUBTOTAL:	$45,900

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
REPLACE NEW PUMP STATION INSTRUMENTATION					
5	Valve Actuators	4	EA	$ 8,000.00	$32,000
	18" Mag Meter	1	EA	$ 18,000.00	$18,000
	Meter Vault	1	EA	$ 15,000.00	$15,000
		SUBTOTAL:			$65,000
		MOBILIZATION		5%	$3,300
		PROF. SERVICES		12%	$7,800
		CMI & MT		6%	$3,900
		CONTINGENCY		30%	$19,500
		REPLACE NEW PUMP STATION INSTRUMENTATION SUBTOTAL:			$99,500
REPAIR OLD PUMP STATION ROOF					
6	Repair roofing	1	LS	$ 8,000.00	$8,000
	Repair cracked/spalled concrete roof slab	1	LS	$ 1,500.00	$1,500
	Demolition	1	LS	$ 2,500.00	$2,500
		SUBTOTAL:			$12,000
		MOBILIZATION		5%	$600
		PROF. SERVICES		12%	$1,500
		CMI & MT		6%	$800
		CONTINGENCY		30%	$3,600
		REPAIR OLD PUMP STATION ROOF SUBTOTAL:			$18,500
REPLACE OLD PUMP STATION MOTORS					
7	Replace pump motors (40 hp)	2	EA	$ 12,000.00	$24,000
	Replace pump motors (75 hp)	2	EA	$ 15,000.00	$30,000
	Demolition	1	LS	$ 5,000.00	$5,000
		SUBTOTAL:			$59,000
		MOBILIZATION		5%	$3,000
		PROF. SERVICES		12%	$7,100
		CMI & MT		6%	$3,600
		CONTINGENCY		30%	$17,700
		REPLACE OLD PUMP STATION MOTORS SUBTOTAL:			$90,400
REPAIR/REPLACE NEW PUMP STATION PUMPS					
8	Replace oldest pump	1	EA	$ 20,000.00	$20,000
	Rehab newer pumps	2	EA	$ 12,000.00	$24,000
	Demolition	1	LS	$ 2,500.00	$2,500
		SUBTOTAL:			$46,500
		MOBILIZATION		5%	$2,400
		PROF. SERVICES		12%	$5,600
		CMI & MT		6%	$2,800
		CONTINGENCY		30%	$14,000
		REPAIR/REPLACE NEW PUMP STATION PUMPS SUBTOTAL:			$71,300
REPLACE NEW PUMP STATION THREE OLDEST MOTORS					
9	Replace pump motors (50 hp)	3	EA	$ 13,000.00	$39,000
	Demolition	1	LS	$ 5,000.00	$5,000
		SUBTOTAL:			$44,000
		MOBILIZATION		5%	$2,200
		PROF. SERVICES		12%	$5,300
		CMI & MT		6%	$2,700
		CONTINGENCY		30%	$13,200
		REPLACE NEW PUMP STATION THREE OLDEST MOTORS SUBTOTAL:			$67,400

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
OLD PUMP STATION ALTERNATE POWER IMPROVEMENTS					
10	Reroute conductors and conduits	1	LS	$ 15,000.00	$15,000
		SUBTOTAL:			$15,000
		MOBILIZATION		5%	$800
		PROF. SERVICES		12%	$1,800
		CMI & MT		6%	$900
		CONTINGENCY		30%	$4,500
		OLD PUMP STATION ALTERNATE POWER IMPROVEMENTS SUBTOTAL:			$23,000
INSTALL OLD PUMP STATION HVAC SYSTEM					
11	4,000 CFM wall mounted exhaust fan	1	EA	$ 3,000.00	$3,000
	3'x4' combination louver damper	1	EA	$ 1,200.00	$1,200
	20 MBH gas fired unit heater	2	EA	$ 2,550.00	$5,100
	Demolition	1	LS	$ 5,000.00	$5,000
		SUBTOTAL:			$14,300
		MOBILIZATION		5%	$800
		PROF. SERVICES		12%	$1,800
		CMI & MT		6%	$900
		CONTINGENCY		30%	$4,300
		INSTALL OLD PUMP STATION HVAC SYSTEM SUBTOTAL:			$22,100
REPLACE OLD PUMP STATION VALVES					
12	Replace 8" Gate Valves	2	EA	$ 1,500.00	$3,000
	Replace 12" Gate Valves	2	EA	$ 2,300.00	$4,600
	Replace 8" Check Valves	2	EA	$ 4,000.00	$8,000
	Replace 12" Check Valves	2	EA	$ 6,100.00	$12,200
	Demolition	1	LS	$ 5,000.00	$5,000
		SUBTOTAL:			$32,800
		MOBILIZATION		5%	$1,700
		PROF. SERVICES		12%	$4,000
		CMI & MT		6%	$2,000
		CONTINGENCY		30%	$9,900
		REPLACE OLD PUMP STATION VALVES SUBTOTAL:			$50,400
REPLACE NEW PUMP STATION HVAC SYSTEM					
13	4,000 CFM wall mounted exhaust fan	1	EA	$ 3,000.00	$3,000
	3'x4' combination louver damper	2	EA	$ 1,200.00	$2,400
	5 kW electric unit heater	2	EA	$ 825.00	$1,650
	500 CFM roof mounted exhaust fan	2	EA	$ 1,500.00	$3,000
	1'x1' combination louver damper	2	EA	$ 500.00	$1,000
	3 kW electric unit heater	1	EA	$ 1,100.00	$1,100
	Chlorine detector sensor	2	EA	$ 750.00	$1,500
	Demolition	1	LS	$ 7,500.00	$7,500
		SUBTOTAL:			$21,150
		MOBILIZATION		5%	$1,100
		PROF. SERVICES		12%	$2,600
		CMI & MT		6%	$1,300
		CONTINGENCY		30%	$6,400
		REPLACE NEW PUMP STATION HVAC SYSTEM SUBTOTAL:			$32,600

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
REPLACE NEW PUMP STATION VALVES					
14	12" Gate Valves	4	EA	$ 2,300.00	$9,200
	Replace 12" BFVs with motor operated actuator	3	EA	$ 6,000.00	$18,000
	Demolition	1	LS	$ 2,500.00	$2,500
		SUBTOTAL:			$29,700
		MOBILIZATION		5%	$1,500
		PROF. SERVICES		12%	$3,600
		CMI & MT		6%	$1,800
		CONTINGENCY		30%	$9,000
		REPLACE NEW PUMP STATION VALVES SUBTOTAL:			$45,600
REPAIR OLD PUMP STATION WALLS					
15	Replace glazed tile	1	LS	$ 7,500.00	$7,500
	Paint	1	LS	$ 1,500.00	$1,500
		SUBTOTAL:			$9,000
		MOBILIZATION		5%	$500
		PROF. SERVICES		12%	$1,100
		CMI & MT		6%	$600
		CONTINGENCY		30%	$2,700
		REPAIR OLD PUMP STATION WALLS SUBTOTAL:			$13,900
REPLACE OLD PUMP STATION CONTROLLER					
16	Replace Pump Controller	1	EA	$ 20,000.00	$20,000
		SUBTOTAL:			$20,000
		MOBILIZATION		5%	$1,000
		PROF. SERVICES		12%	$2,400
		CMI & MT		6%	$1,200
		CONTINGENCY		30%	$6,000
		REPLACE OLD PUMP STATION CONTROLLER SUBTOTAL:			$30,600
INSTALL ISOLATION VALVE ON 3.0 MG GROUND STORAGE TANK					
17	30" Butterfly Valve	1	EA	$ 16,000.00	$16,000
	Excavation and Backfill	1	LS	$ 10,000.00	$10,000
	Dewatering	1	LS	$ 7,500.00	$7,500
		SUBTOTAL:			$33,500
		MOBILIZATION		5%	$1,700
		PROF. SERVICES		12%	$4,100
		CMI & MT		6%	$2,100
		CONTINGENCY		30%	$10,100
		INSTALL ISOLATION VALVE ON 3.0 MG GROUND STORAGE TANK SUBTOTAL:			$51,500

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
RECOAT OLD PUMP STATION ABOVEGROUND PIPING					
18	Recoat Piping	60	LF	$ 40.00	$2,400
	Install Concrete Supports	2	EA	$ 500.00	$1,000
		SUBTOTAL:			$3,400
		MOBILIZATION		5%	$200
		PROF. SERVICES		12%	$500
		CMI & MT		6%	$300
		CONTINGENCY		30%	$1,100
		RECOAT OLD PUMP STATION ABOVEGROUND PIPING SUBTOTAL:			$5,500
RECOAT NEW PUMP STATION ABOVEGROUND PIPING					
19	Recoat 12" Steel Pipe	80	LF	$ 40.00	$3,200
		SUBTOTAL:			$3,200
		MOBILIZATION		5%	$200
		PROF. SERVICES		12%	$400
		CMI & MT		6%	$200
		CONTINGENCY		30%	$1,000
		RECOAT NEW PUMP STATION ABOVEGROUND PIPING SUBTOTAL:			$5,000
REROUTE TANK OVERFLOWS AWAY FROM APARTMENTS					
20	12" Ductile Iron Pipe	330	LF	$ 108.00	$35,640
	Outfall Structure	1	LS	$ 7,500.00	$7,500
	Ground Water Control	330	LF	$ 25.00	$8,250
	Trench Safety	330	LF	$ 2.00	$660
		SUBTOTAL:			$52,050
		MOBILIZATION		5%	$2,700
		PROF. SERVICES		12%	$6,300
		CMI & MT		6%	$3,200
		CONTINGENCY		30%	$15,700
		REROUTE TANK OVERFLOWS AWAY FROM APARTMENTS SUBTOTAL:			$80,000
REPAIR NEW PUMP STATION WALLS					
21	Make repairs to fix leaks and repair/replace damaged components	1	LS	$ 14,000.00	$14,000
	Replace insulation	1	LS	$ 4,000.00	$4,000
		SUBTOTAL:			$18,000
		MOBILIZATION		5%	$900
		PROF. SERVICES		12%	$2,200
		CMI & MT		6%	$1,100
		CONTINGENCY		30%	$5,400
		REPAIR NEW PUMP STATION WALLS SUBTOTAL:			$27,600

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

OPINION OF PROBABLE CONSTRUCTION COSTS

PROJECT TITLE	**Palm St. Water Plant Condition Assessment**	DATE	11/9/2015
CLIENT	City of Huntsville	GROUP	1150
SUBMITTAL	Conceptual	PM	Clay Herndon

ESTIMATOR	CHECKED BY	FNI PROJECT NO.
JMB	WCH	HVL15274

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
REPAIR NEW PUMP STATION FOUNDATION					
22	Repair concrete cracks/spalling	90	LF	$ 50.00	$4,500
	Seal joints	180	LF	$ 10.00	$1,800
	Grout under pipe supports	1	LS	$ 200.00	$200
		SUBTOTAL:			$6,500
		MOBILIZATION		5%	$400
		PROF. SERVICES		12%	$800
		CMI & MT		6%	$400
		CONTINGENCY		30%	$2,000
		REPAIR NEW PUMP STATION FOUNDATION SUBTOTAL:			$10,100
MISCELLANEOUS IMPROVEMENTS					
24	Site/Civil Improvements, Buried Valves, and Other Infrastructure	1	LS	$ 200,000.00	$200,000
		MISCELLANEOUS IMPROVEMENTS SUBTOTAL:			$200,000
PROJECT TOTAL					**$1,844,500**

NOTES:

1. Costs shown are in 2015 Dollars
2. Buried infrastructure such as valves and pipin were not investigated as part of this condition assessment.

APPENDIX C
SMITH PUMP CO. PUMP ASSESSMENT

PALM STREET WATER PLANT, BOOSTER PUMP STATION
FIELD CONDITION ASSESSMENT

OWNER: CITY OF HUNTSVILLE

ENGINEER: FREESE & NICHOLS

PUMP STATIONS: OLD BOOSTER P.S.

NEW BOOSTER P.S.

EXECUTIVE SUMMARY

BRIEF REVIEW OF PUMP STATIONS AND RESULTS

EXECUTIVE SUMMARY

BACKGROUND

Charged with documenting the condition of the booster pumps and motors for the City of Houston, Smith Pump Co. inspected eight (8) pumps. From our inspections we can characterize the condition of each unit and make some generalizations about needed repair/maintenance.

This summary will briefly describe the observations made during testing for each unit. This includes mechanical soundness and hydraulic performance. To rate each category we will use a five point scale. In order from best to worst these points are… Good, Fair, Ok, Below Average, Poor. Below you will also find our determination on whether to repair or replace.

OLD BOOSTER P.S., BP-1

Description

The pump tested is a Layne 12WMC vertical turbine pump with a US Motors vertical induction motor. This pump has a heavy gage steel coupling guard that could not be removed, therefore shaft and packing conditions could not be observed.

Hydraulic Performance

The hydraulic performance appears to match the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair. This can possibly be explained by the non-ideal placement of the flow meter giving higher than expected readings.

Mechanical Inspection

Mechanically, BP-1 is in “Below Average” condition. Inspection of this pump is for the discharge head and motor only.

- The discharge head appears to be in good condition
- The coupling guard should be replaced with something easier to remove in order to allow access to adjust the packing
- The highest vibration reading of **0.918** in/sec rms, or seven (7) times higher than the HI limit, was recorded at the top of the motor
- This unit should only be run if absolutely necessary due to the excessive vibration

Other Observations

N/A

Recommendations

This pump could not be inspected below the barrel flange, but with the high vibration it is recommended that this unit be pulled, disassembled, and inspected.

OLD BOOSTER P.S., BP-2

Description

The pump tested is a Layne 12WMC vertical turbine pump with a US Motors vertical induction motor. This pump has a heavy gage steel coupling guard that could not be removed, therefore shaft and packing conditions could not be observed.

Hydraulic Performance

The hydraulic performance appears to be slightly better than the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair. This can possibly be explained by the non-ideal placement of the flow meter giving higher than expected readings.

Mechanical Inspection

Mechanically, BP-2 is in "Below Average" condition. Inspection of this pump is for the discharge head and motor only.

- The discharge head appears to be in good condition
- The coupling guard should be replaced with something easier to remove in order to allow access to adjust the packing
- The highest vibration reading of **0.297** in/sec rms, or two (2) times higher than the HI limit, was recorded at the top of the motor

Other Observations

N/A

Recommendations

This pump could not be inspected below the barrel flange, but with the high vibration it is recommended that this unit be pulled, disassembled, and inspected.

OLD BOOSTER P.S., BP-3

Description

The pump tested is a Layne 12THC vertical turbine pump with a US Motors vertical induction motor.

Hydraulic Performance

The hydraulic performance appears to be slightly better than the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair. This can possibly be explained by the non-ideal placement of the flow meter giving higher than expected readings.

Mechanical Inspection

Mechanically, BP-3 is in "OK" condition. Inspection of this pump is for the discharge head, stuffing box, motor shaft, and motor only.

- The discharge head appears to be in good condition
- The stuffing box is severely corroded and it appears as if the packing gland studs no longer exist
- The packing gland was not perpendicular to the shaft
- The highest vibration reading of **0.189** in/sec rms, or slightly higher than the HI limit, was recorded at the top of the motor

Other Observations

N/A

Recommendations

This pump could not be inspected below the barrel flange, but with the slightly higher vibration it is recommended that this unit be field balanced in an attempt to reduce the vibration.

OLD BOOSTER P.S., BP-4

Description

The pump tested is a Layne 12THC vertical turbine pump with a US Motors vertical induction motor.

Hydraulic Performance

The hydraulic performance appears to be slightly better than the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair. This can possibly be explained by the non-ideal placement of the flow meter giving higher than expected readings.

Mechanical Inspection

Mechanically, BP-4 is in "Poor" condition. Inspection of this pump is for the discharge head, stuffing box, motor shaft, and motor only.

- The discharge head appears to be in good condition

- The stuffing box is severely corroded and it appears as if the packing gland studs no longer exist
- The packing gland was not perpendicular to the shaft
- The highest vibration reading of **0.383** in/sec rms, or 2.5 times higher than the HI limit, was recorded at the top of the motor

Other Observations

N/A

Recommendations

This pump could not be inspected below the barrel flange, but with the high vibration it is recommended that this unit be pulled, disassembled, and inspected.

NEW BOOSTER P.S. BP-1

Description

The pump tested is a Goulds 3405 6x8-12 horizontal split case pump with a Siemens horizontal induction motor.

Hydraulic Performance

The pump matches the pump curve very closely and appears to be 6 ft TDH low. The efficiency is approximately 10 percentage points low.

Mechanical Inspection

Mechanically, BP-1 is in "Good" condition.

- The efficiency is a little low and is likely caused by excessive wear ring clearance
- The pump has very low vibration, maximum was 0.076 in/sec rms
- The alignment is severely off and motor would be bolt bound

Other Observations

The suction piping configuration does not follow HI standards. An eccentric reducer is located too close to the suction of the pump.

Recommendations

This pump has low vibration and can be run. The alignment should be corrected.

NEW BOOSTER P.S. BP-2

Description

The pump tested is a Goulds 3405 6x8-12 horizontal split case pump with a Siemens horizontal induction motor.

Hydraulic Performance

Hydraulic performance cannot be determined as neither the city nor the manufacture has been able to locate a curve.

Mechanical Inspection

Mechanically, BP-2 is in "Good" condition.

- The pump has very low vibration, maximum was 0.052 in/sec rms
- The alignment is off and appears to be easily corrected

Other Observations

The suction piping configuration does not follow HI standards. An eccentric reducer is located too close to the suction of the pump.

Recommendations

This pump has low vibration and can be run. The alignment should be corrected.

NEW BOOSTER P.S. BP-3

Description

The pump tested is a Goulds 3405 6x8-12 horizontal split case pump with a Power Tech horizontal induction motor.

Hydraulic Performance

Hydraulic performance cannot be determined as neither the city nor the manufacture has been able to locate a curve.

Mechanical Inspection

Mechanically, BP-3 is in "OK" condition.

- The pump has very low vibration, maximum was 0.028 in/sec rms
- The motor has high vibration, maximum was 0.153 in/sec rms, but isnt' severe
- The alignment is off and appears to be easily corrected

Other Observations

The suction piping configuration does not follow HI standards. An eccentric reducer is located too close to the suction of the pump.

Recommendations

This motor has slightly high vibration but can be run. The alignment should be corrected and may bring the motor vibration under the HI limit.

NEW BOOSTER P.S. BP-4

Description

The pump tested is a Goulds 3405 6x8-12 horizontal split case pump with a Siemens horizontal induction motor.

Hydraulic Performance

Hydraulic performance cannot be determined as neither the city nor the manufacture has been able to locate a curve.

Mechanical Inspection

Mechanically, BP-4 is in "OK" condition.

- The pump vibration is close to the HI limit, maximum was 0.139 in/sec rms
- The alignment is severely off but the motor feet are already directly on the motor pad and cannot be lowered any more

Other Observations

The suction piping configuration does not follow HI standards. An eccentric reducer is located too close to the suction of the pump.

Recommendations

This pump has slightly high vibration and can be run. The alignment needs to be corrected, which may require shimming the pump. This not the preferred setup and may increase the vibration level.

REPORT OUTLINE

PUMP EVALUATION PROCEDURE

HYDRAULIC TEST PROCEDURE

OBJECTIVE

The objective is to measure certain parameters of the pumps and motors in the field to determine the condition, and degree of wear of the equipment.

TYPE OF TESTS

Smith Pump Co. measured the flow, head, speed, input power, and vibration for eight (8) pumps. The pumps were allowed to operate normally into the system and two (2) sets of data were taken ten to fifteen minutes apart to ensure consistent data.

VIBRATION LIMITS

For vertical turbine pumps, the vibration is measured at five (5) locations, three (3) locations at the top of the motor and two (2) locations on the bottom flange of the motor. If the Hydraulic Institute Standard 9.6.4 (2009) applies, the unfiltered vibration amplitude limit is 0.13 in/sec rms at any speed within the Preferred Operating Range (POR) and 0.17 in/sec rms at any speed within the Allowable Operating Range (AOR) but outside the POR.

For horizontal split case pumps, the vibration is measured at ten (10) locations; three (3) locations on the opposite drive end motor bearing, two (2) locations on the drive end motor bearing, two (2) locations on the drive end pump bearing, and three (3) locations on the opposite drive end pump bearing. If the HIS 9.6.4 (2009) applies, the unfiltered vibration amplitude limit is 0.15 in/sec rms at any speed within the POR and 0.20 in/sec rms at any speed within the AOR but outside the POR.

PIPING ARRANGEMENT

The suction and discharge headers will be 100% open while gathering performance test data.

PERFORMANCE TEST PROCEDURE

Prior to starting the performance test:

- Check that all instruments are within their calibration period
- Proper position of valves will be verified
- Pressure gages will be place on the suction and discharge pipe
- Portable flow meter will be place on longest run of straight pipe
- The motor will be run at full speed
- The flow will be allowed to stabilize
- After 10 minutes, record first set of data
    - Measure flow and pressure close to the same time
    - Measure voltage, current, and power factor or input kilowatts

- Measure vibration
- After 25 minutes, record second set of data
  - See above

INSTRUMENTATION

The following instrumentation was used:

Figure 1: GE Panametrics PT878

-Flow — GE Panametrics PT878 Ultrasonic Portable Flow Meter. S/N: 02368 (Vertical Turbine Pumps)

City of Huntsville's Accumulation Flow Meter (Horizontal Split Case Pumps)

-Suction Pressure — Ashcroft 1082 150 mm combination test quality pressure gauge. Gauge No. TGC-7101. Set to read pressure on a scale of 0 to 30 psig positive and 0 to 30 in Hg of vacuum.

-Disch. Pressure — Ashcroft 1082 150 mm combination test quality pressure gauge. Gauge No. E219115. Set to read pressure on a scale of 0 to 460 ft of H2O

Figure 2: VibXpert VIB 5.480-P

-Speed — Prufftecknik VibeScanner Data Analyzer type VIB 5.480-P. S/N: 03642

-Power — Extech True RMS Power Meter type 380976-K. S/N: 120210916

-Vibration — Prufftecknik VibeScanner Data Analyzer type VIB 5.480-P. S/N: 03642

TEST RESULTS

HEAD

- As a function of flow is determined by calculation of the total dynamic head

PUMP BRAKE HORSEPOWER

- As a function of flow is independently measured from Smith Pump's Extech True RMS Power Meter

EFFICIENCY

- As a function of flow is calculated from the pump brake horsepower

VIBRATION MEASURMENT LOCATIONS

VERTICAL TURBINE PUMP

MT = Motor top

MB = Motor bottom

MV = Motor in the vertical direction

0 = In line with the discharge

90 = 90° to discharge

For example, MT-90 is a data point taken at the top of the motor and perpendicular to the discharge.

HORIZONTAL SPLIT CASE PUMP

ODE = Opposite Drive End

DE = Drive End

X = Perpendicular to the shaft and parallel to the floor

Y = Perpendicular to the shaft and the floor

Z = In the direction of the shaft

For example, Motor ODE-X is a data point taken on the opposite drive end of the motor in the X direction.

FIELD INSPECTION PROCEDURE (VERTICAL TURBINE PUMPS)

NOT APPLICABLE

FIELD INSPECTION PROCEDURE (HORIZONTAL SPLIT CASE PUMP)

OBJECTIVE

Determine whether the pump is aligned to the motor.

TYPE OF TESTS

Smith Pump Co. pump servicemen to record alignment with an Aligneo laser alignment.

INSTRUMENTATION

The following instrumentation was used:

-Alignment Ludeca Aligneo, Model ALI 11.100. Transducer S/N: 1207 1272, Prism S/N: 1407 9959

Figure 3: Ludeca Aligneo

OLD BOOSTER PUMP STATION

FIELD PERFORMANCE TEST REPORT

GENERAL ARRANGEMENT

This station has four (4) vertical turbine pumps. Booster pump #1 and #2 are Layne 12WMC pumps with 40 hp vertical hollow shaft motors. Booster pumps #3 and #4 are Layne 12THC pumps with 75 hp vertical hollow shaft motors.

PERFORMANCE TESTING VARIANCES

None

BOOSTER PUMP #1

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The composite curve below, Figure 4, shows the field data plotted with the curve provided by the city.

The pump performance test data (hydraulic and electrical) shows the two (2) field test points are shown in the same color as each curve. The instrument values are recorded in concert with one another. The data is reduced to result in the points that show up in the composite curve chart. The data is speed corrected to the catalog curve test speed so that the test data can be compared.

Winding and bearing temperatures could not be recorded as there were not any displays for this data.

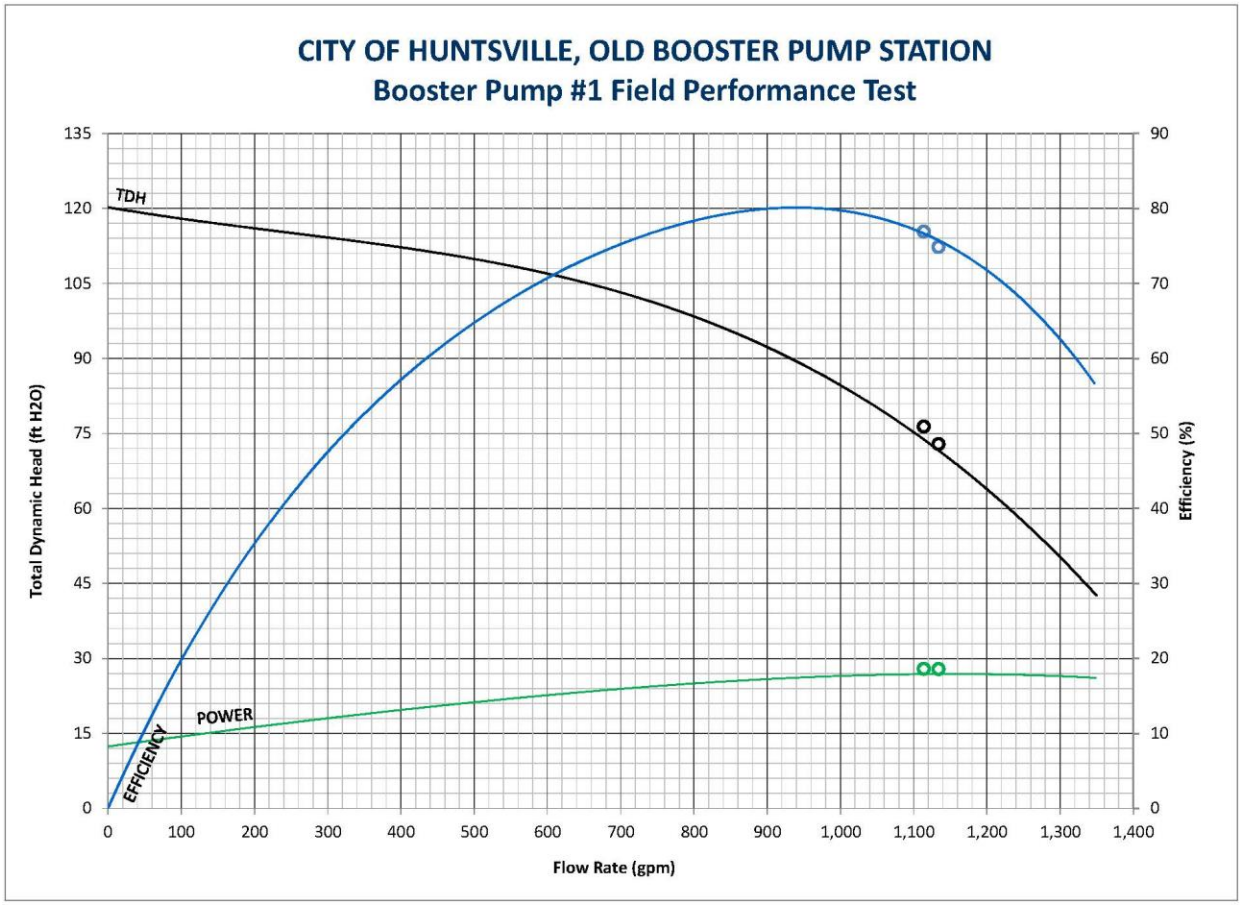


Figure 4: Old Booster Pump Station, Booster Pump #1 Field Performance Curve

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS		
Location	**Reading (in/sec rms)**	**Below HI Limits?**
MT-0	**0.918**	No
	0.885	No
MT-90	**0.359**	No
	0.357	No
MT-V	**0.085**	Yes
	0.083	Yes
MB-0	**0.707**	No
	0.684	No
MB-90	**0.221**	No
	0.238	No

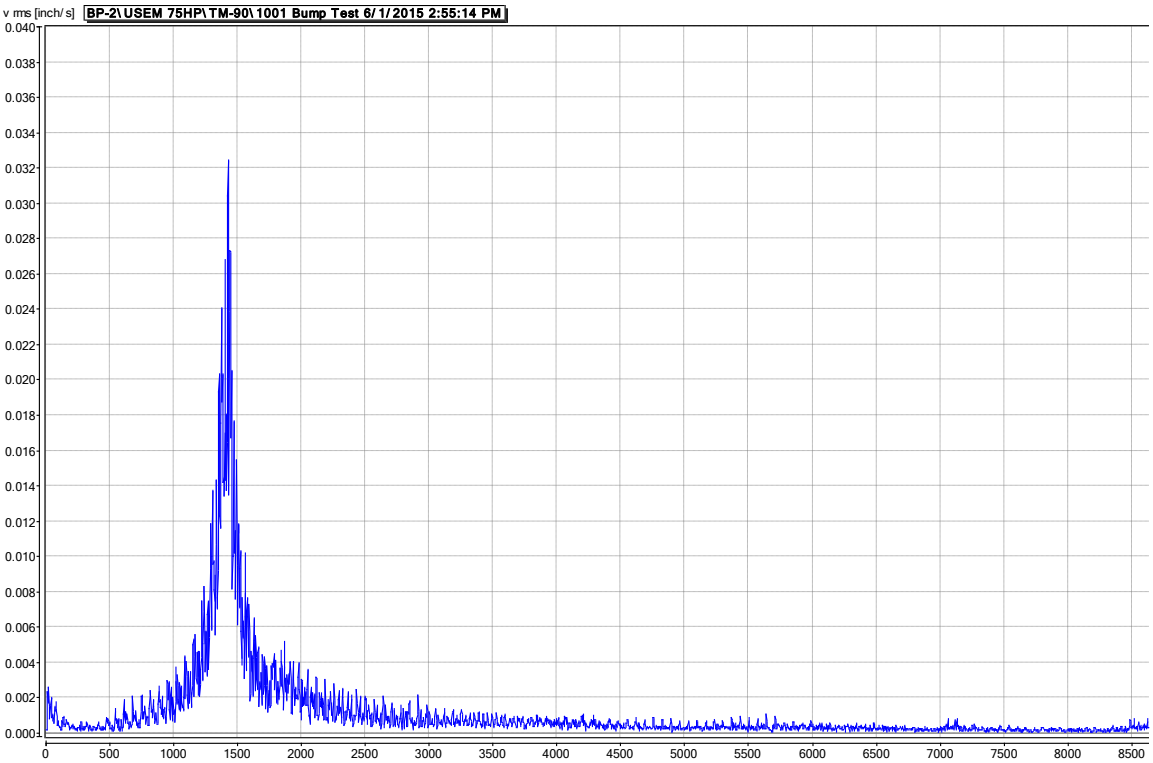


Figure 5: MT-90 Bump Test, Reed Frequency at 1,424 cpm, Motor Speed is 1,785 rpm

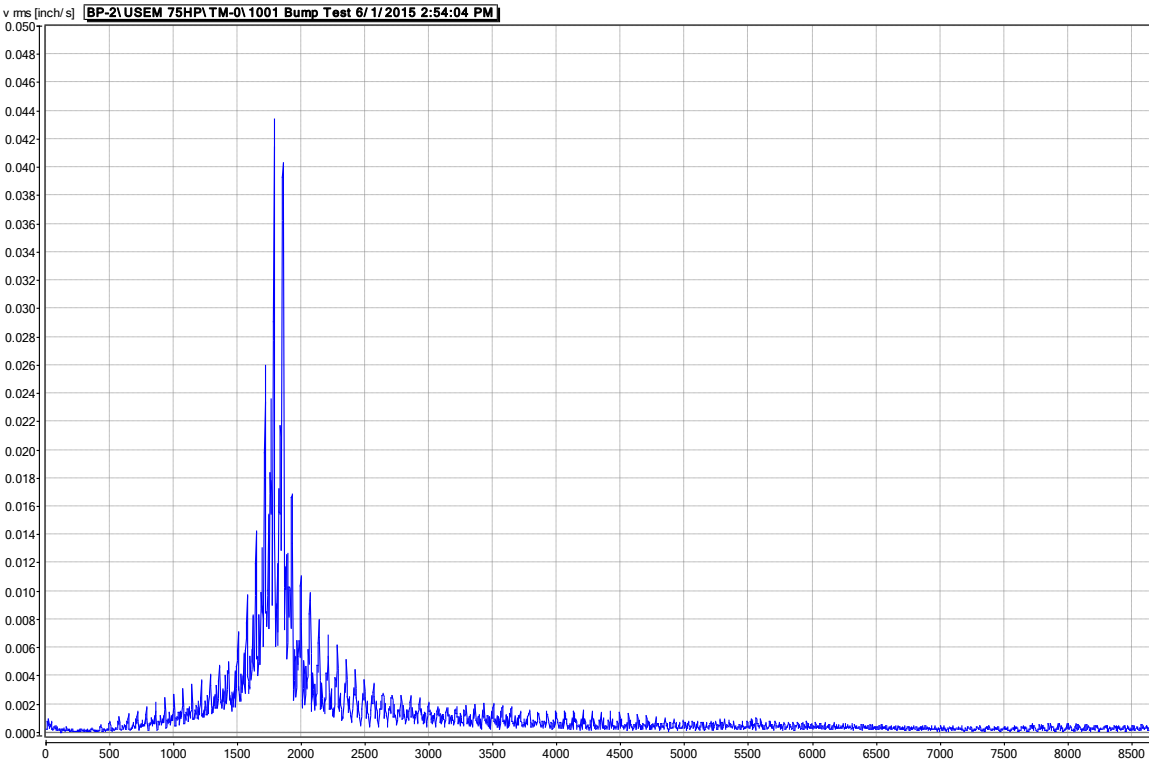


Figure 6: MT-0 Bump Test, Reed Frequency at 1,789 cpm, Motor Speed is 1,785 rpm

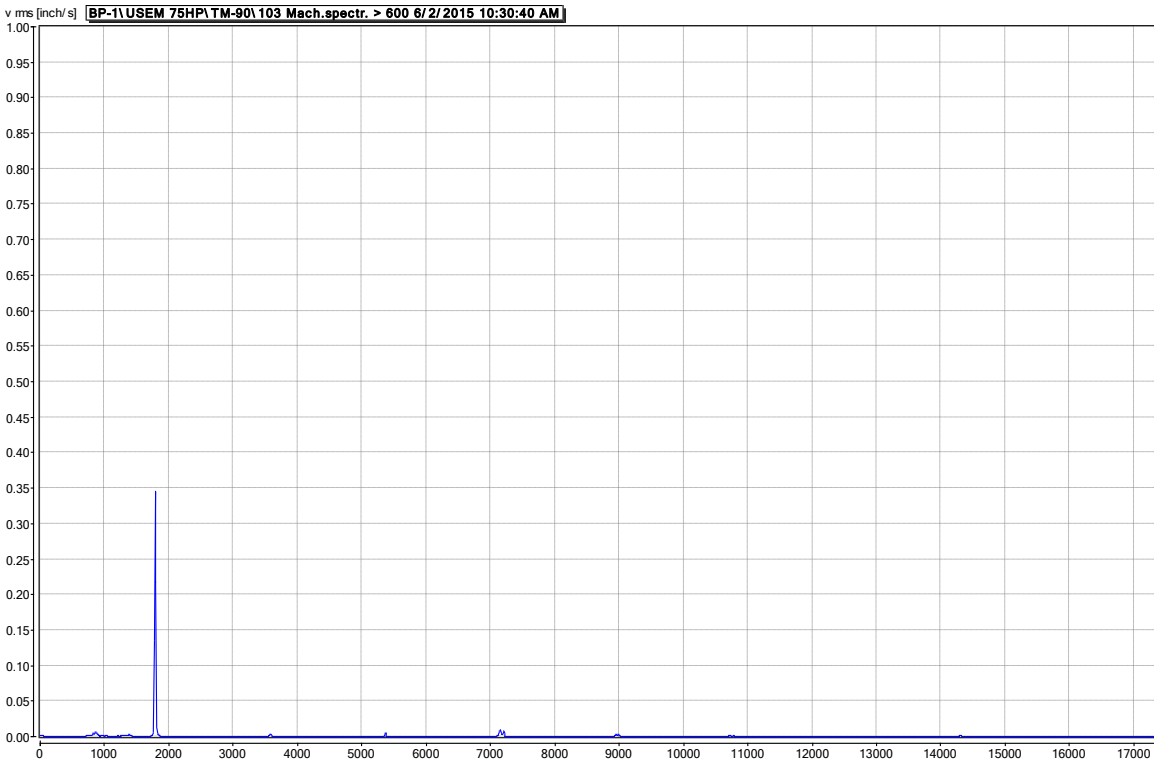


Figure 7: MT-90 Filtered Vibration, highest peak is 0.346 in/sec rms at 1,788 cpm (1X run speed)

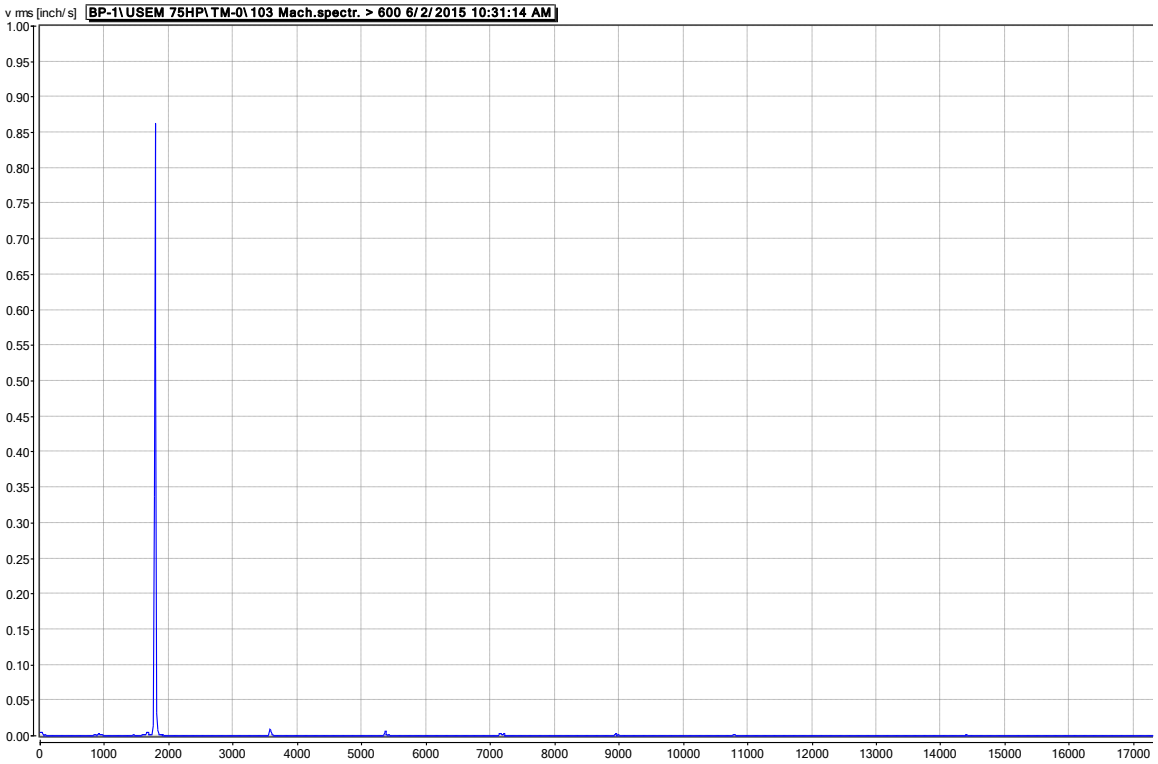


Figure 8: MT-0 Filtered Vibration, highest peak is 0.863 in/sec at 1,788 cpm (1X run speed)

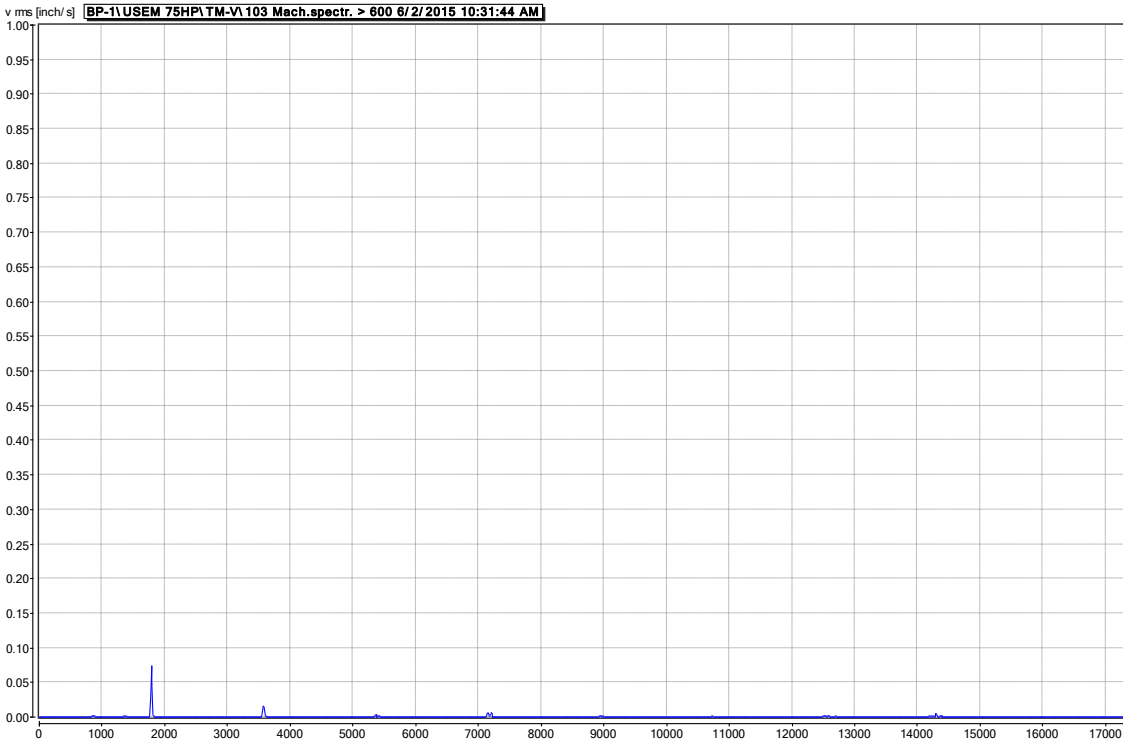


Figure 9: MT-V Filtered Vibration, highest peak is 0.074 in/sec at 1,788 cpm (1X run speed) and the next highest peak is 0.016 in/sec at 3,574 cpm (2X run speed)

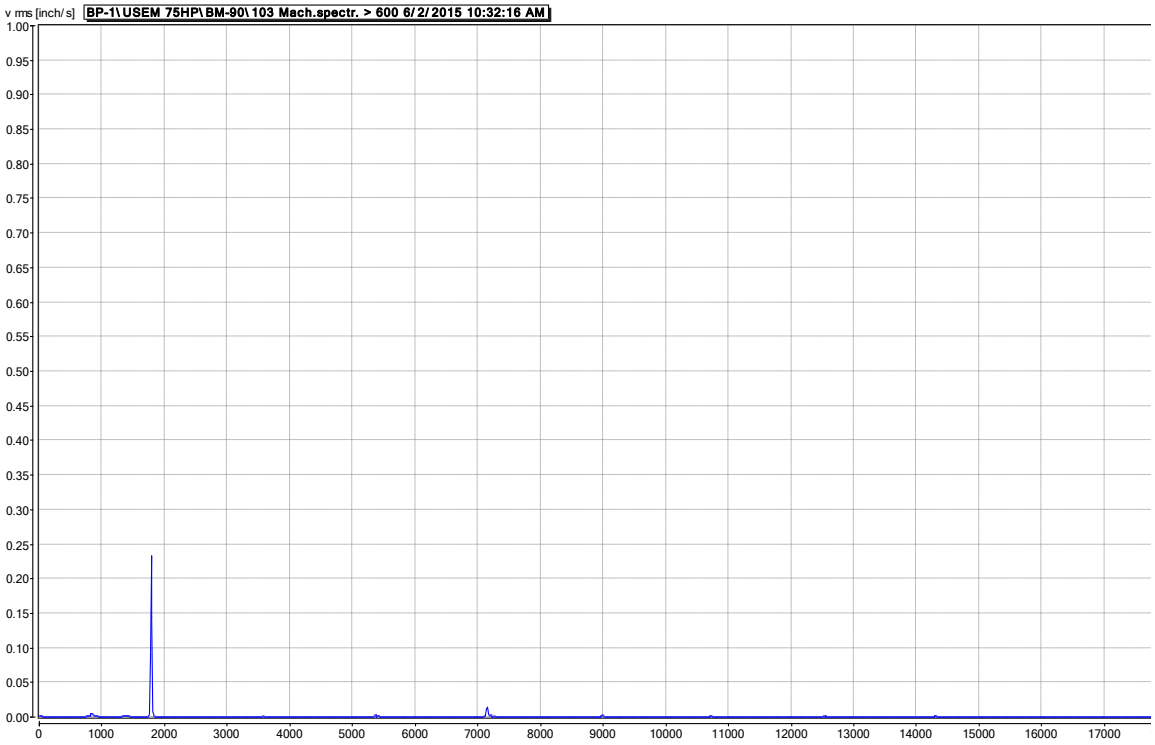


Figure 10: MB-90 Filtered Vibration, highest peak is 0.223 in/sec at 1,788 cpm (1X run speed), the next peak is 0.014 in/sec at 7,148 cpm (4X run speed)

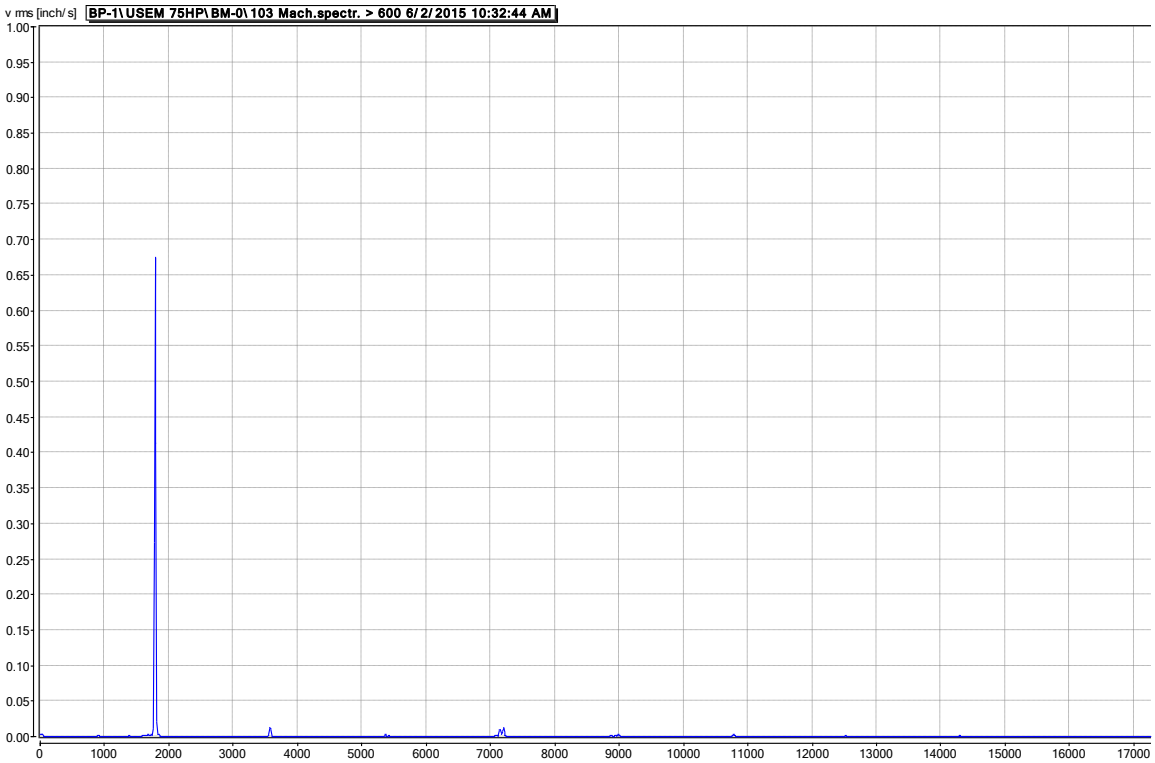


Figure 11: MB-0 Filtered Vibration, highest peak is 0.675 in/sec at 1,788 cpm (1X run speed)

The reed frequency, as shown in Figures 5, is at 1,424 cpm 90 degrees to discharge which is 20% from run speed and should not cause any issues. The reed frequency, as shown in Figure 6, is at 1,789 cpm which is at run speed and will exacerbate and amplify any vibration.

The vibration at all of the locations has a dominant peak at 1X run speed. This is a typical signature of rotating equipment and indicates a slight imbalance and/or misalignment or looseness. The amplitude is very high at all locations, except for the vertical direction, and should be corrected. Field balancing may resolve the issue but it may be caused by loose pump bearings which would require the pump to be pulled and repaired

TEST DISCUSSIONS

HYDRAULIC OPERATION

- The hydraulic performance appears to match the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair.

ELECTRICAL OPERATION

- Voltage and current were measured using Smith Pump's Extech True RMS Power Meter

- During the test, a maximum current of 34 amps was recorded which is less than the full load amps of this motor

MECHANICAL OPERATION

- Pump vibration is above the Hydraulic Institute Standards with the highest vibration being 0.918 in/sec rms
- Pump should not be run unless absolutely necessary

BOOSTER PUMP #2

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The composite curve below, Figure 12, shows the field data plotted with the curve provided by the city.

The pump performance test data (hydraulic and electrical) shows the two (2) field test points are shown in the same color as each curve. The instrument values are recorded in concert with one another. The data is reduced to result in the points that show up in the composite curve chart. The data is speed corrected to the catalog curve test speed so that the test data can be compared.

Winding and bearing temperatures could not be recorded as there were not any displays for this data.

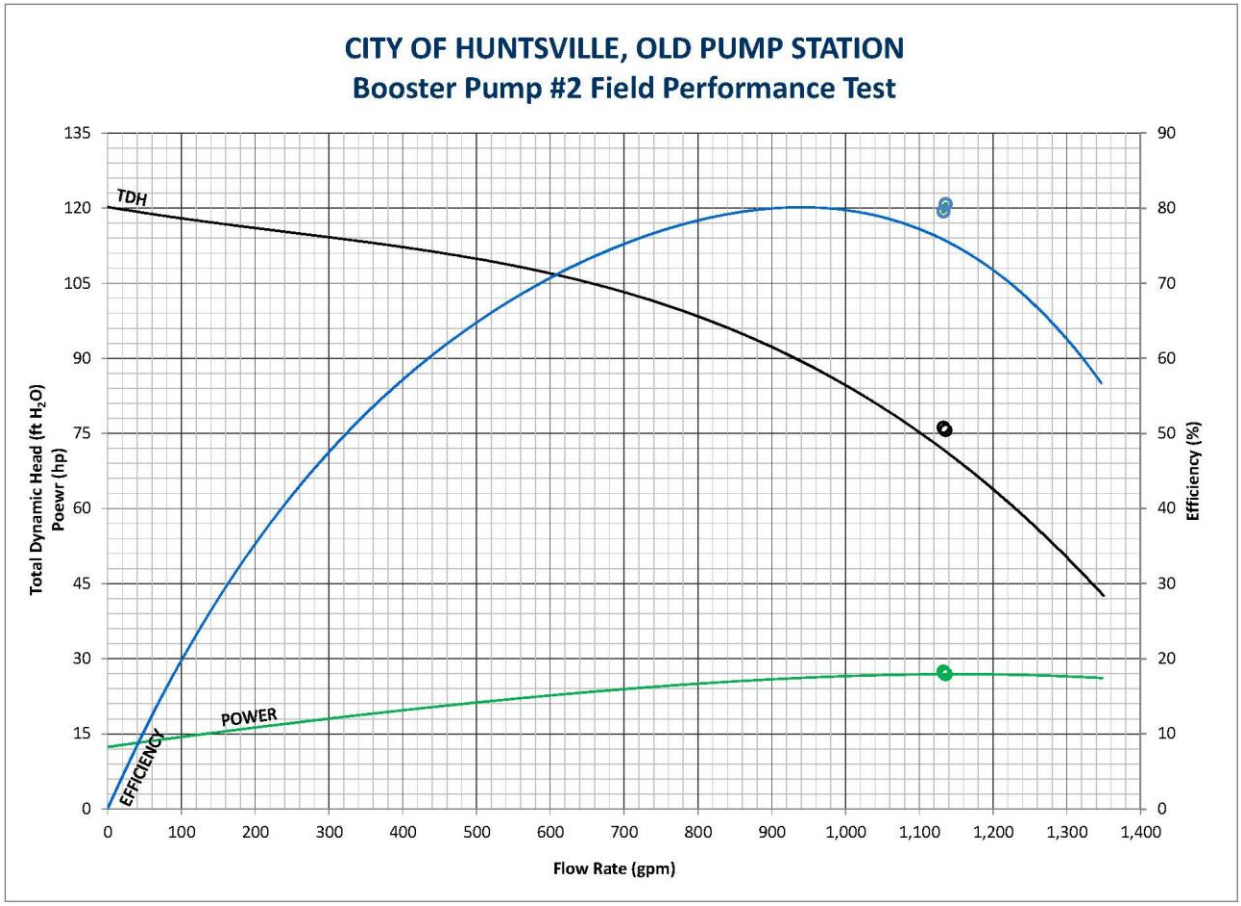


Figure 12: Old Booster Pump Station, Booster Pump #2 Field Performance Curve

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS		
Location	**Reading (in/sec rms)**	**Below HI Limits?**
MT-0	0.281	No
	0.297	No
MT-90	0.070	Yes
	0.068	Yes
MT-V	0.043	Yes
	0.043	Yes
MB-0	0.224	No
	0.225	No
MB-90	0.046	Yes
	0.047	Yes

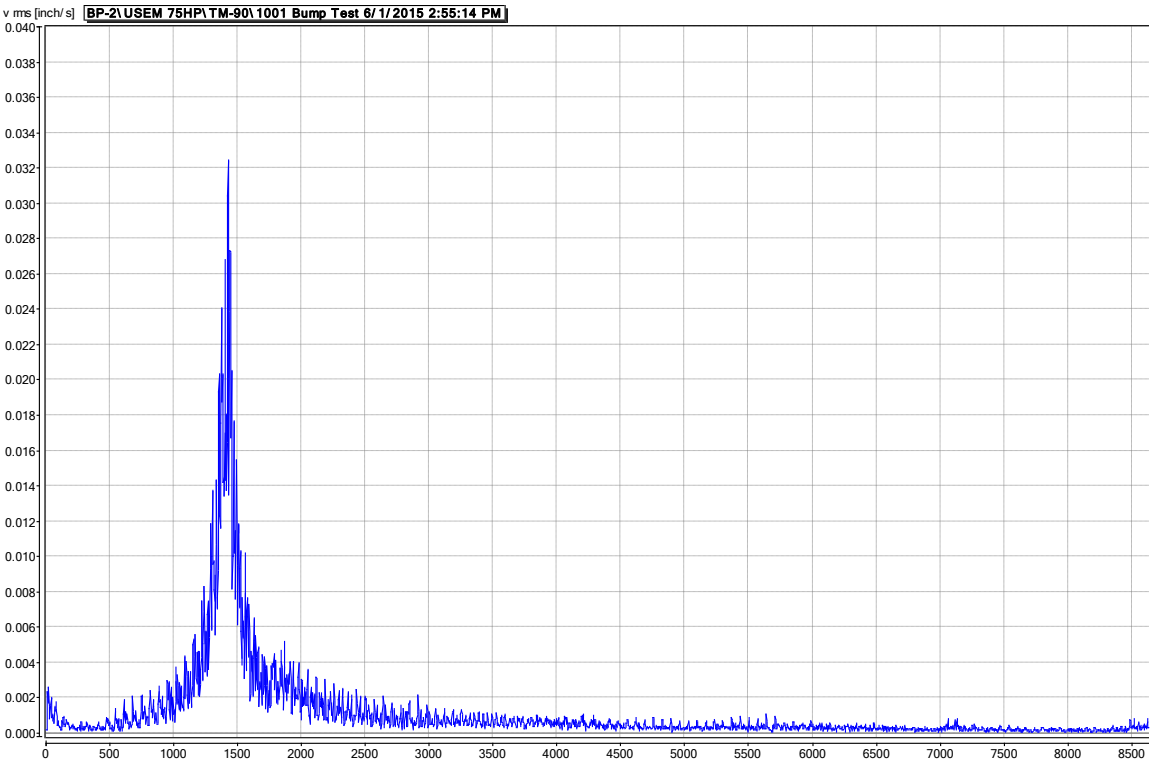


Figure 13: MT-90 Bump Test, Reed Frequency at 1,420 cpm, Motor Speed is 1,785 rpm

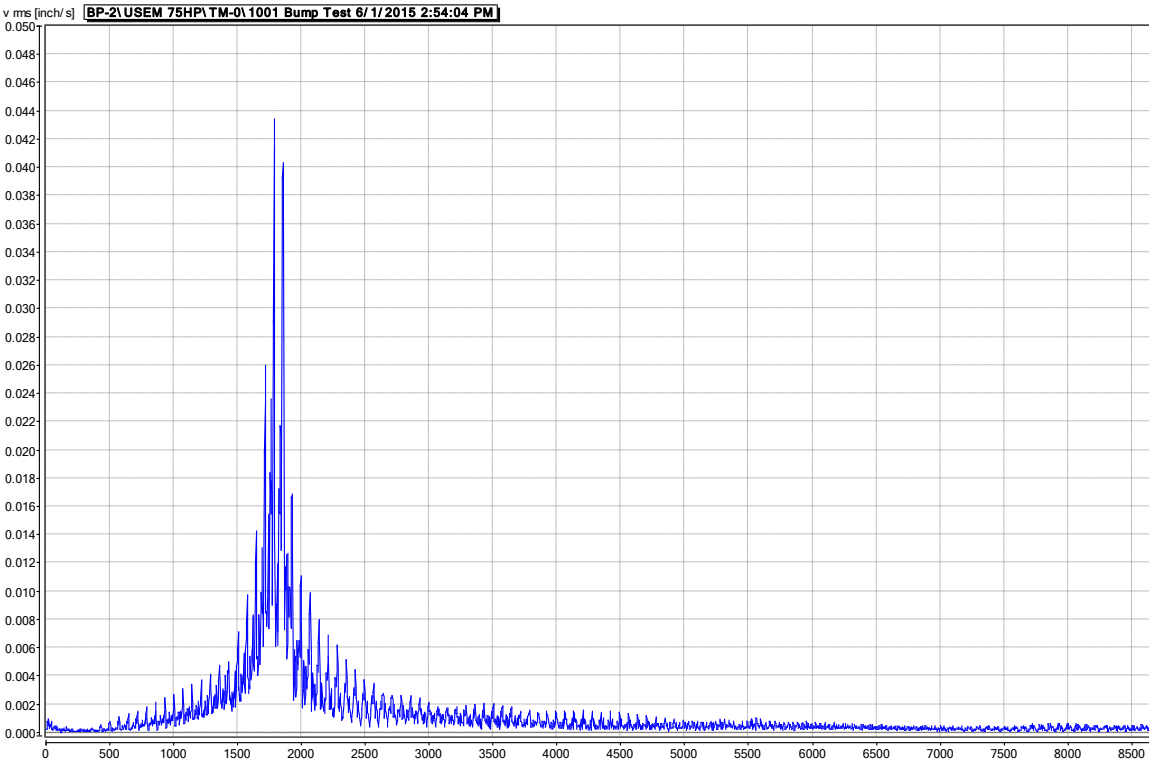


Figure 14: MT-0 Bump Test, Reed Frequency at 1,790 cpm, Motor Speed is 1,785 rpm

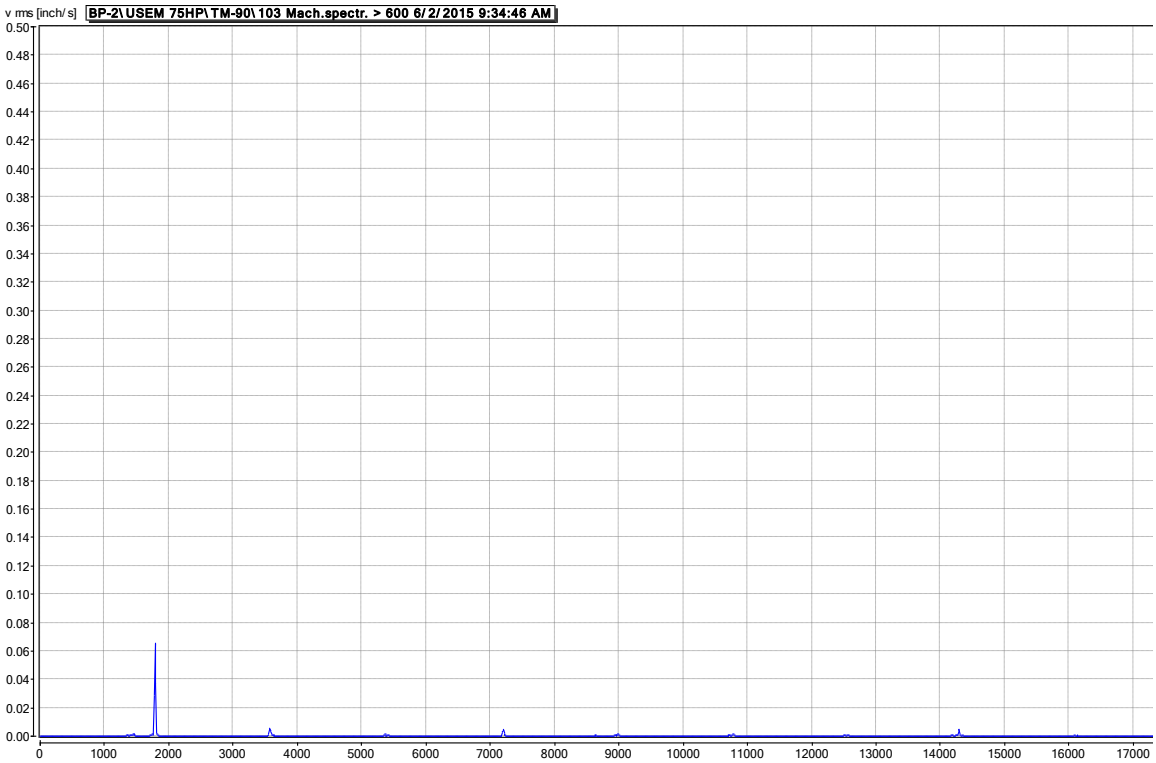


Figure 15: MT-90 Filtered Vibration, highest peak is 0.065 in/sec rms at 1,785 cpm (1X run speed)

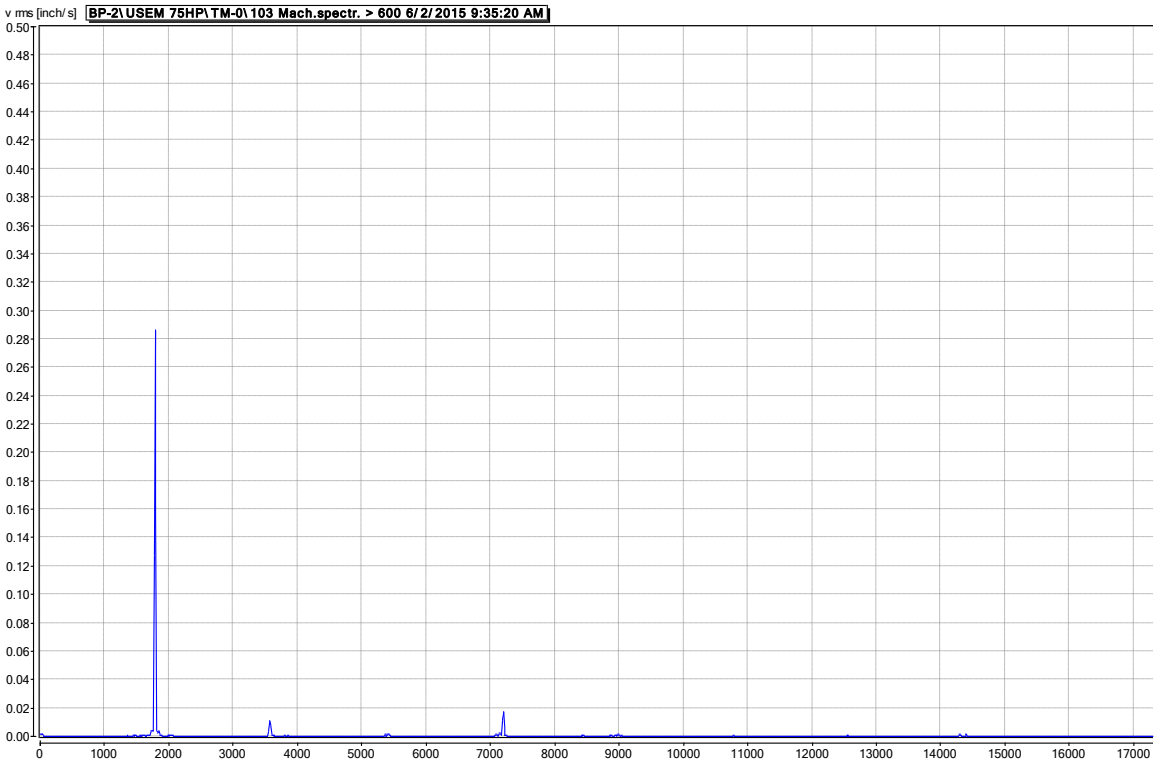


Figure 16: MT-0 Filtered Vibration, highest peak is 0.286 in/sec at 1,785 cpm (1X run speed) and the next highest peak is 0.017 in/sec at 7,196 cpm (4X run speed)

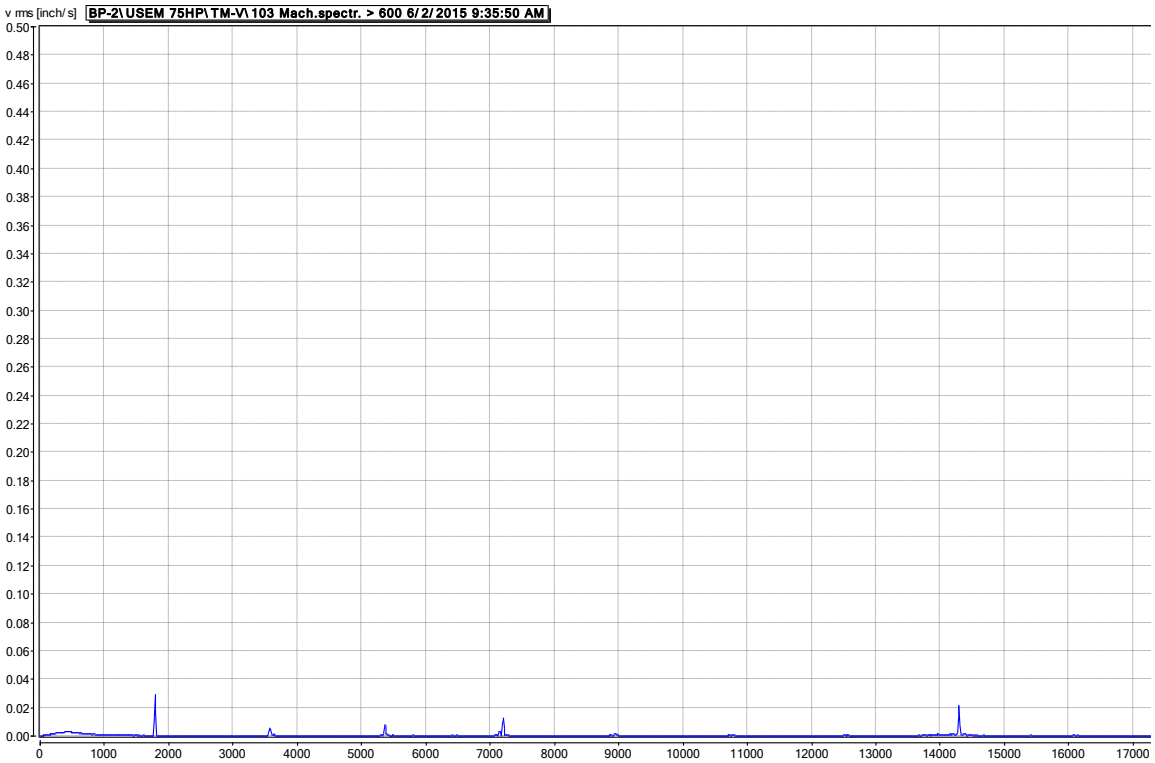


Figure 17: MT-V Filtered Vibration, highest peak is 0.029 in/sec at 1,785 cpm (1X run speed) and the next highest peak is 0.021 in/sec at 14,291 cpm (8X run speed)

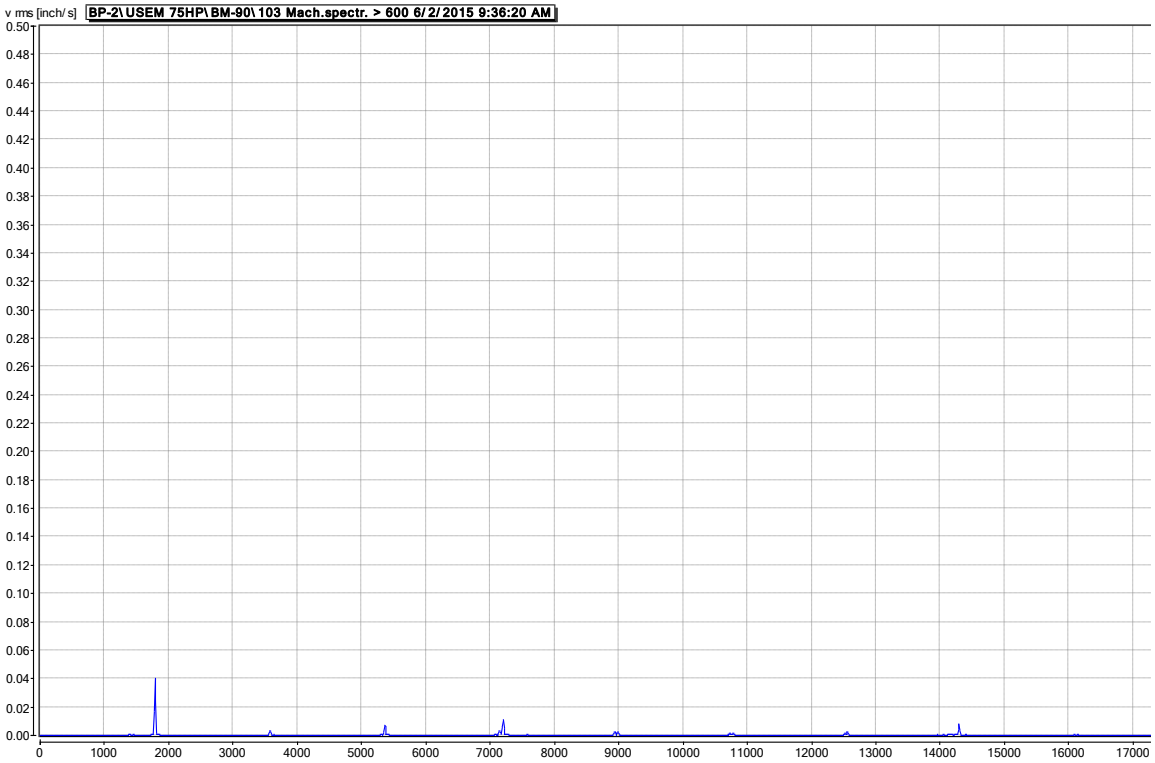


Figure 18: MB-90 Filtered Vibration, highest peak is 0.040 in/sec at 1,785 cpm (1X run speed)

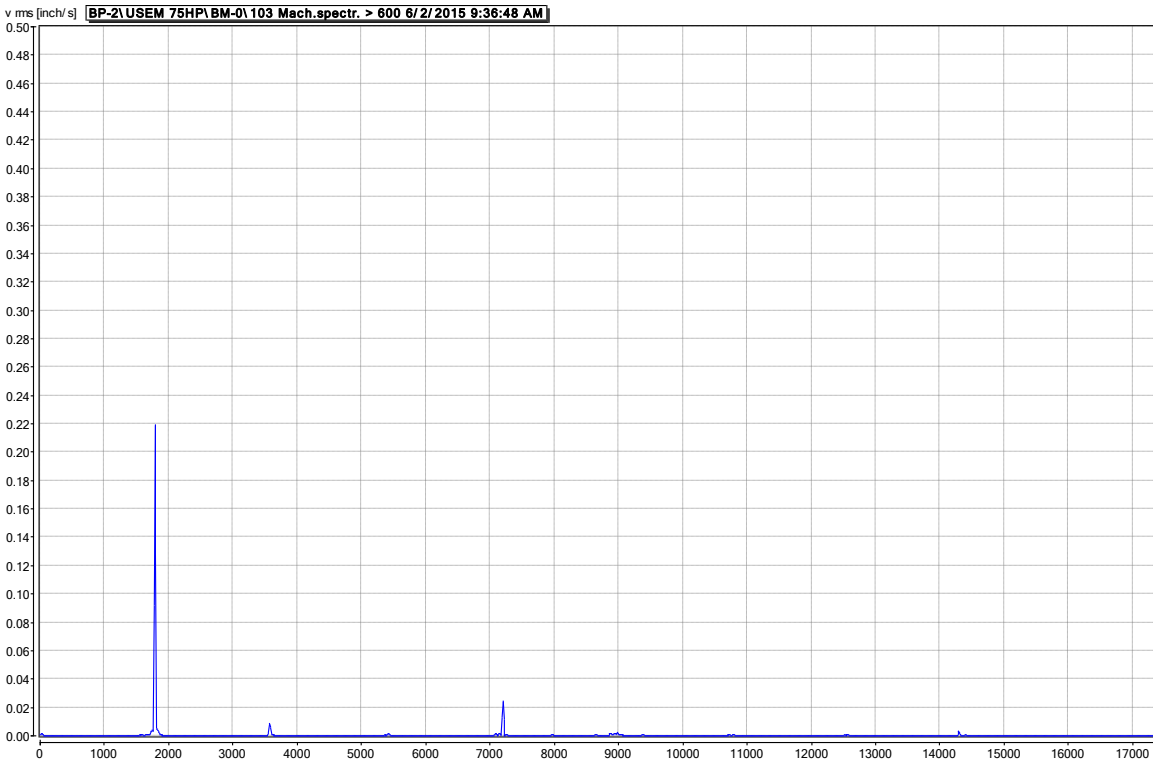


Figure 19: MB-0 Filtered Vibration, highest peak is 0.219 in/sec at 1,785 cpm (1X run speed) and the next highest peak is 0.025 in/sec at 7,200 cpm (4X run speed)

The reed frequency, as shown in Figures 13, is at 1,420 cpm 90 degrees to discharge which is 20% from run speed and should not cause any issues. The reed frequency, as shown in Figure 14, is at 1,790 cpm which is at run speed and will exacerbate and amplify any vibration.

The vibration at all of the locations has a dominant peak at 1X run speed. This is a typical signature of rotating equipment and indicates a slight imbalance and/or misalignment or looseness. The amplitude is very high at the locations that are in-line with the discharge and should be corrected. Field balancing may resolve the issue but it may be caused by loose pump bearings which would require the pump to be pulled and repaired

TEST DISCUSSIONS

HYDRAULIC OPERATION

- The pump appears to outperform the pump curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair.

ELECTRICAL OPERATION

- Voltage and current were measured using Smith Pump's Extech True RMS Power Meter

- During the test, a maximum current of 33 amps was recorded which is less than the full load amps of this motor

MECHANICAL OPERATION

- Pump vibration is above the Hydraulic Institute Standards with the highest vibration being 0.297 in/sec rms
- Pump runtime should be kept to a minimum

BOOSTER PUMP #3

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The composite curve below, Figure 20, shows the field data plotted with the curve provided by the city.

The pump performance test data (hydraulic and electrical) shows the two (2) field test points are shown in the same color as each curve. The instrument values are recorded in concert with one another. The data is reduced to result in the points that show up in the composite curve chart. The data is speed corrected to the catalog curve test speed so that the test data can be compared.

Winding and bearing temperatures could not be recorded as there were not any displays for this data.

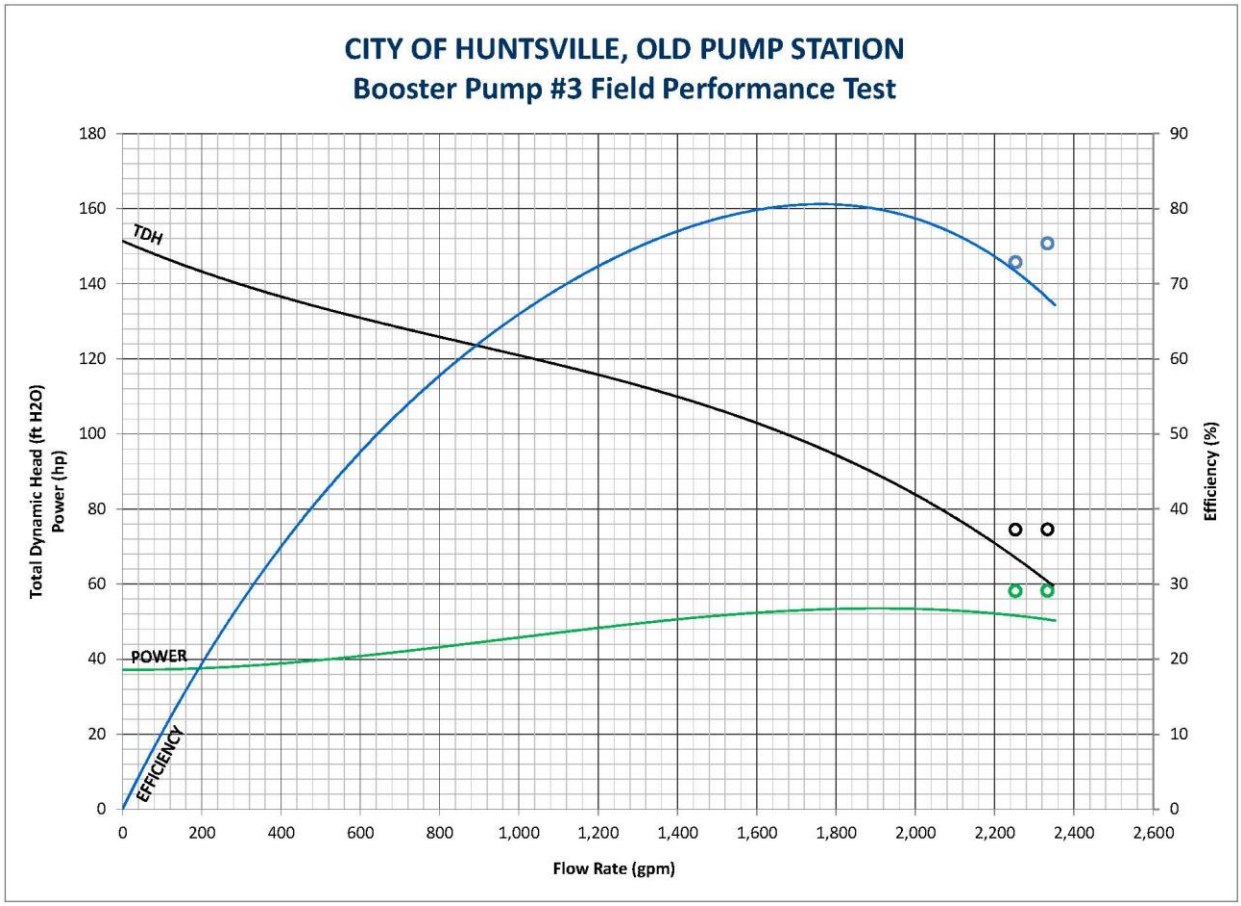


Figure 20: Old Booster Pump Station, Booster Pump #3 Field Performance Curve

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS		
Location	**Reading (in/sec rms)**	**Below HI Limits?**
MT-0	**0.181**	No
	0.189	No
MT-90	**0.061**	Yes
	0.080	Yes
MT-V	**0.048**	Yes
	0.037	Yes
MB-0	**0.084**	Yes
	0.129	Yes
MB-90	**0.034**	Yes
	0.036	Yes

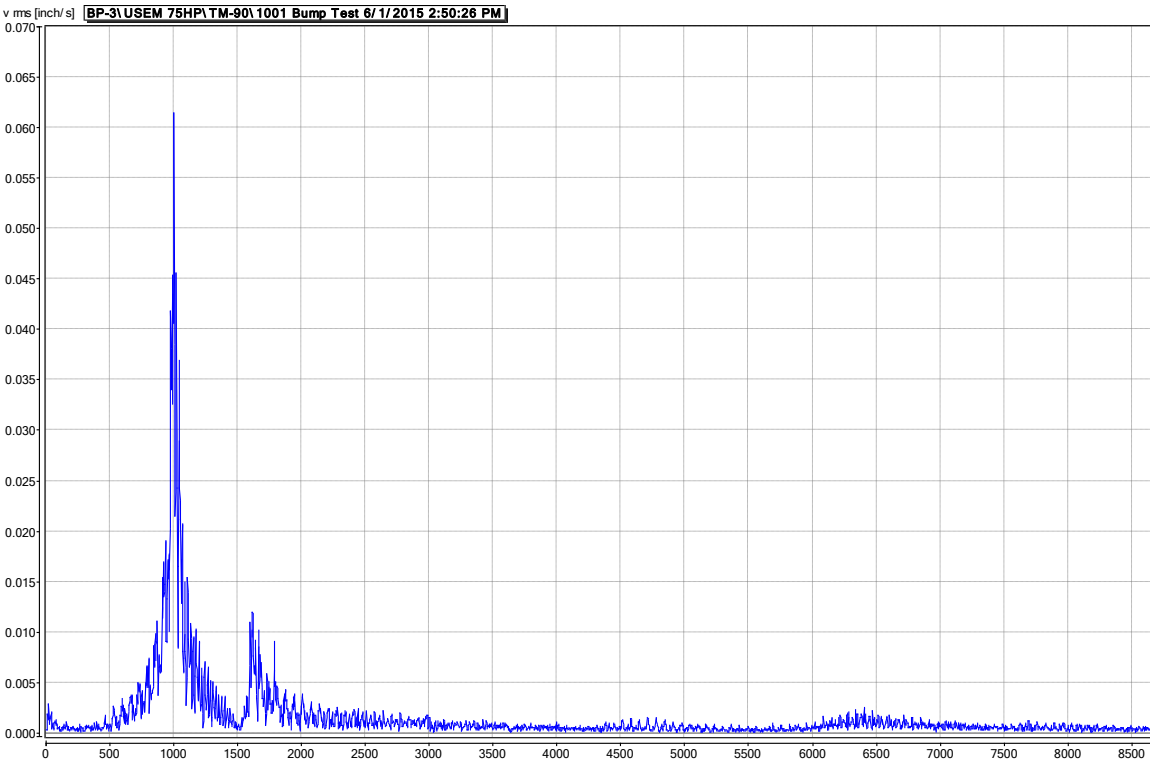


Figure 21: MT-90 Bump Test, Reed Frequency at 1,002 cpm, Motor Speed is 1,785 rpm

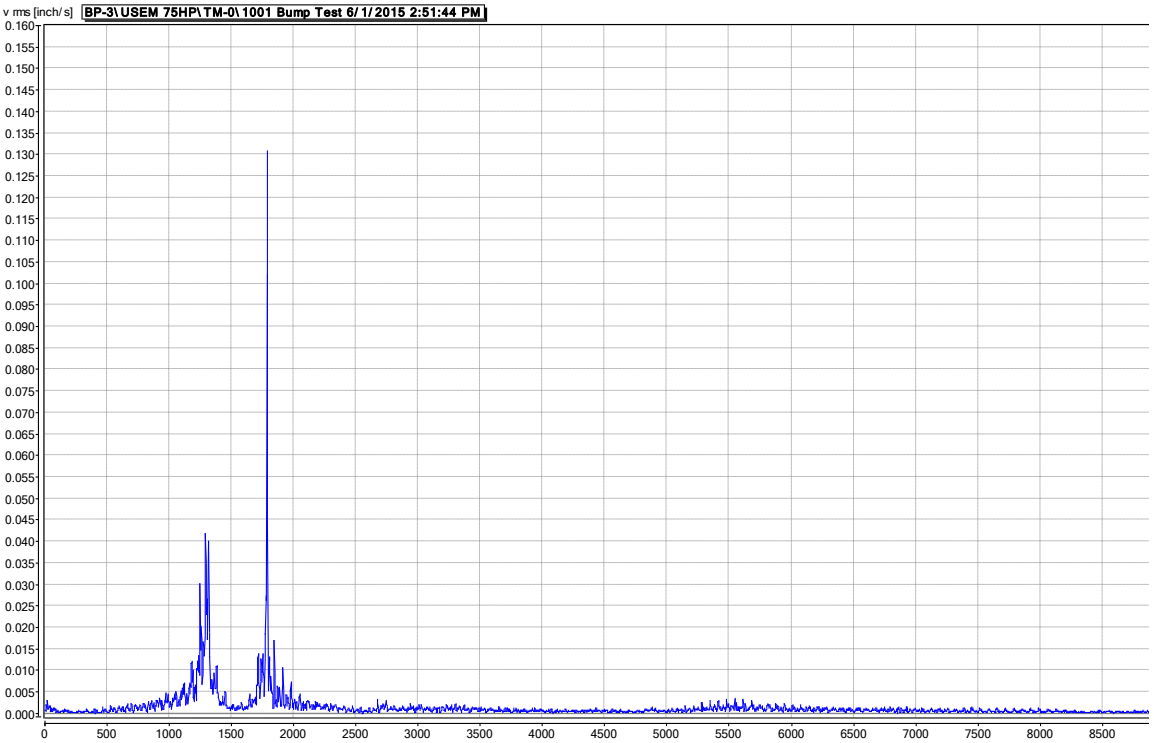


Figure 22: MT-0 Bump Test, Reed Frequency at 1,291 cpm, Motor Speed is 1,785 rpm. The highest peak is from the sister unit running while this unit was being bump tested.

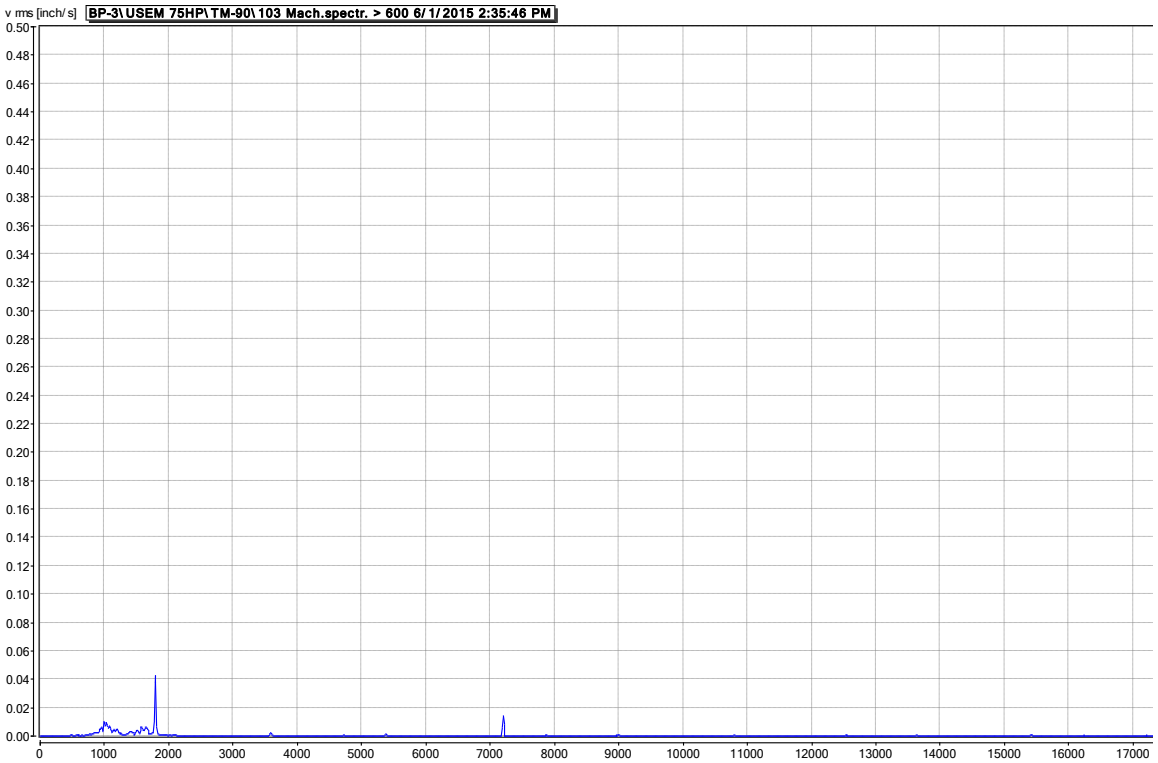


Figure 23: MT-90 Filtered Vibration, highest peak is 0.042 in/sec rms at 1,792 cpm (1X run speed)

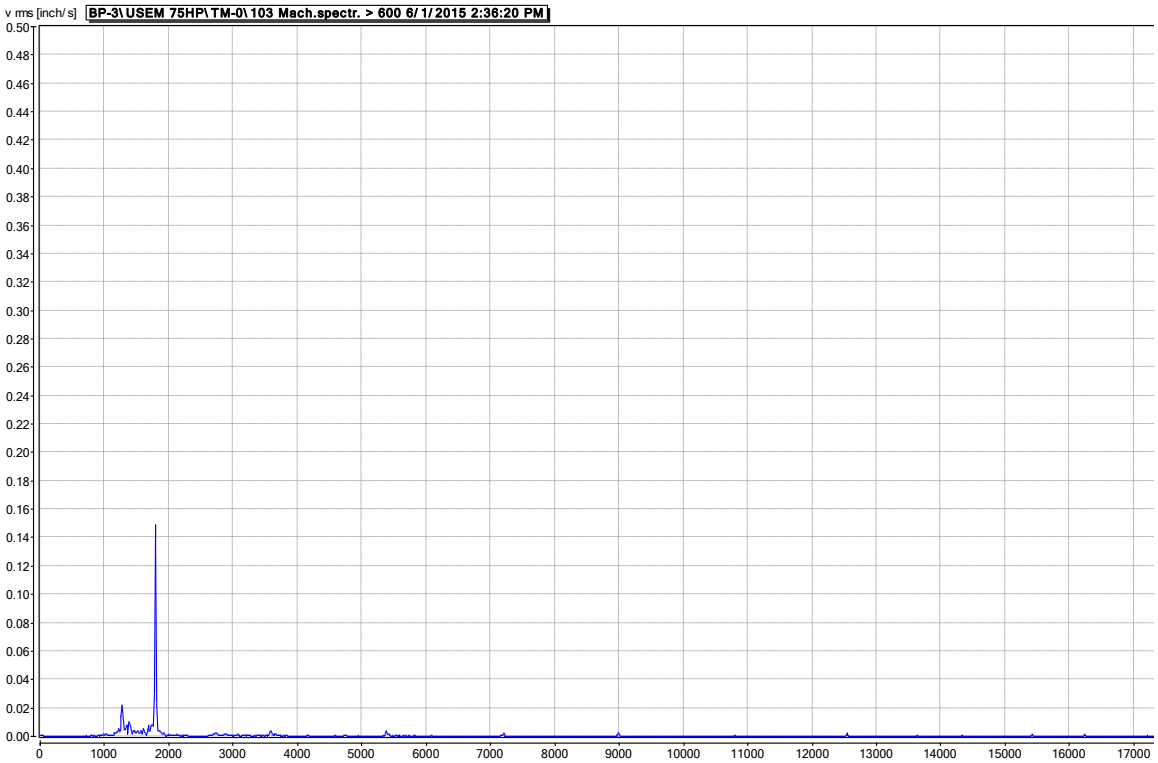


Figure 24: MT-0 Filtered Vibration, highest peak is 0.149 in/sec at 1,792 cpm (1X run speed)

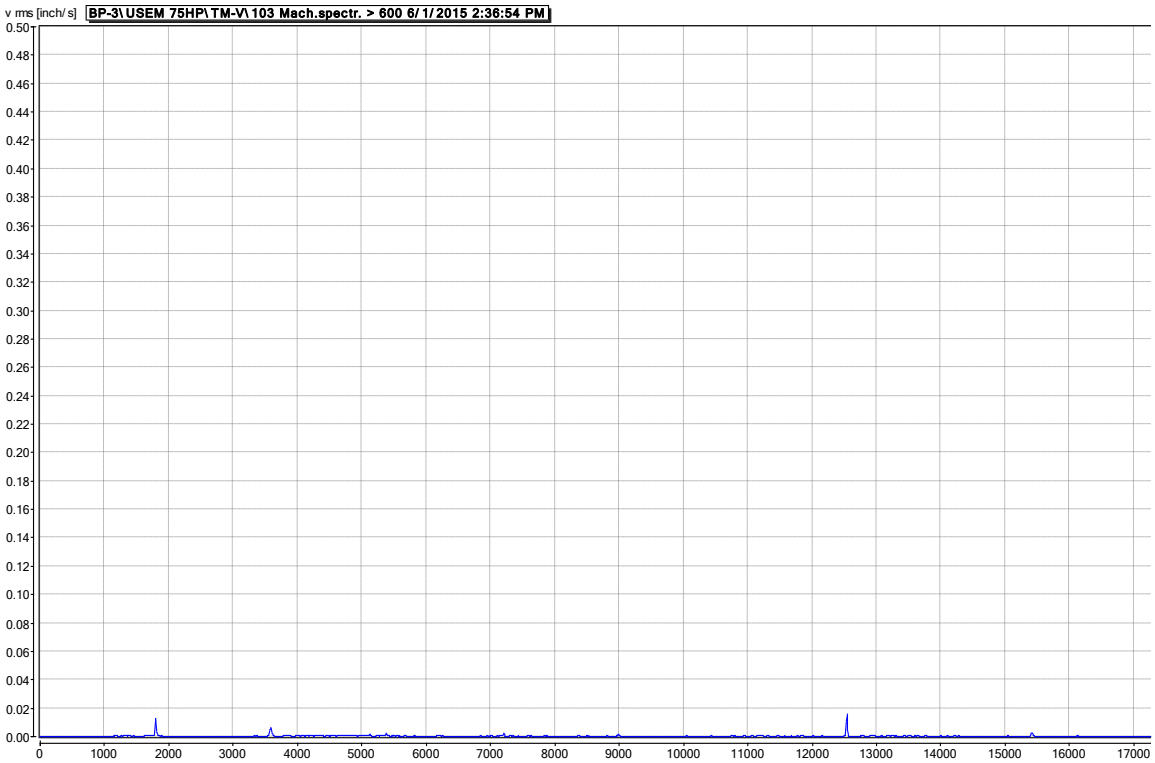


Figure 25: MT-V Filtered Vibration, all data is below 0.020 in/sec

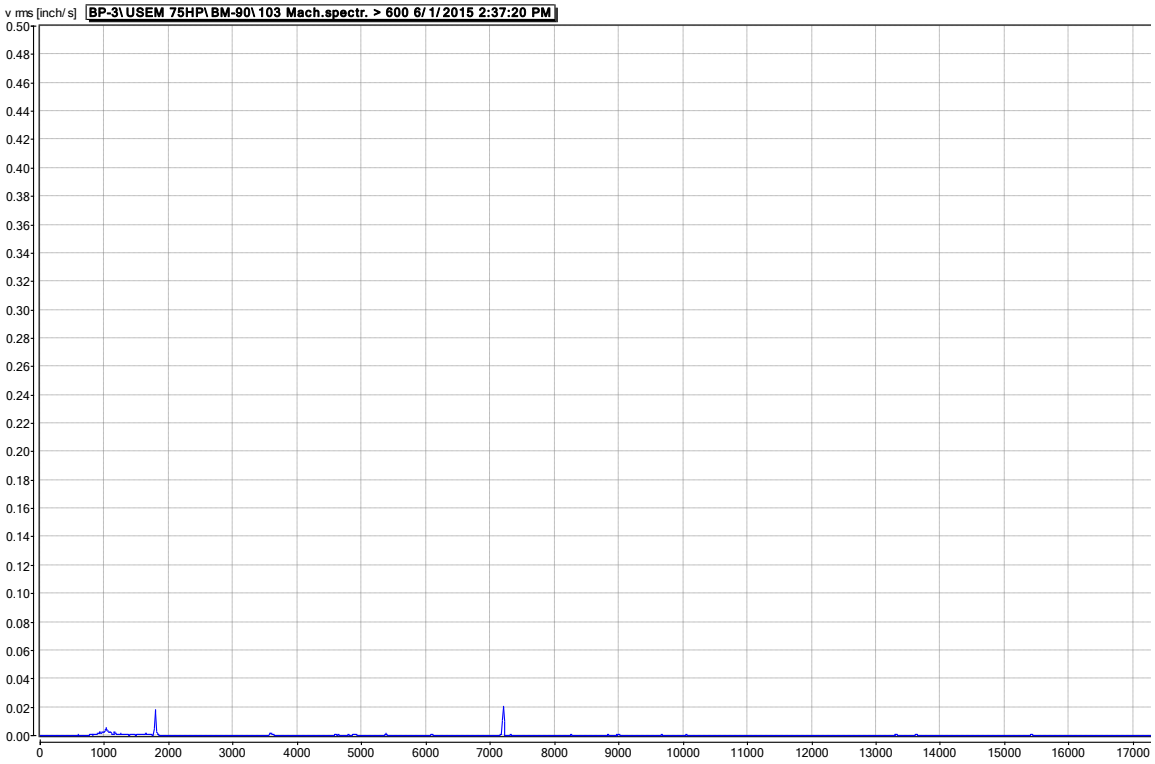


Figure 26: MB-90 Filtered Vibration, all data is below 0.020 in/sec

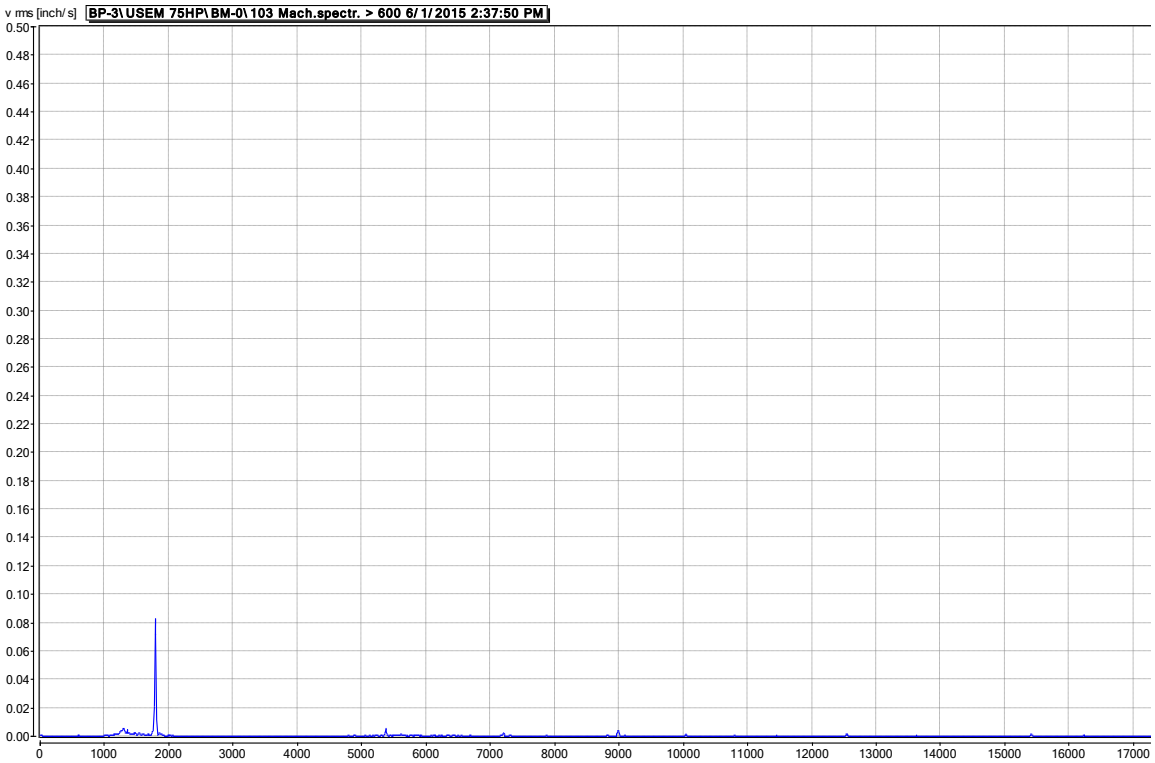


Figure 27: MB-0 Filtered Vibration, highest peak is 0.082 in/sec at 1,792 cpm (1X run speed)

The reed frequency, as shown in Figures 21, is at 1,002 cpm 90 degrees to discharge which is 44% from run speed and should not cause any issues. The reed frequency, as shown in Figure 22, is at 1,291 cpm which is 28% from run speed and should not cause any issues.

The vibration at all of the locations has a dominant peak at 1X run speed. This is a typical signature of rotating equipment and indicates a slight imbalance and/or misalignment or looseness. The amplitude for the most part is low but the vibration at the top of the motor in-line with the discharge is slightly above the HI limits. Field balancing would likely resolve this issue.

TEST DISCUSSIONS

HYDRAULIC OPERATION

- The pump appears to outperform the catalog curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair.

ELECTRICAL OPERATION

- Voltage and current were measured using Smith Pump's Extech True RMS Power Meter
- During the test, a maximum current of 81 amps was recorded which is less than the full load amps of this motor

MECHANICAL OPERATION

- Pump vibration is slightly above the Hydraulic Institute Standards with the highest vibration being 0.189 in/sec rms
- There are no foreseeable issues with running this pump as-is.

BOOSTER PUMP #4

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The composite curve below, Figure 28, shows the field data plotted with the curve provided by the city.

The pump performance test data (hydraulic and electrical) shows the two (2) field test points are shown in the same color as each curve. The instrument values are recorded in concert with one another. The data is reduced to result in the points that show up in the composite curve chart. The data is speed corrected to the catalog curve test speed so that the test data can be compared.

Winding and bearing temperatures could not be recorded as there were not any displays for this data.

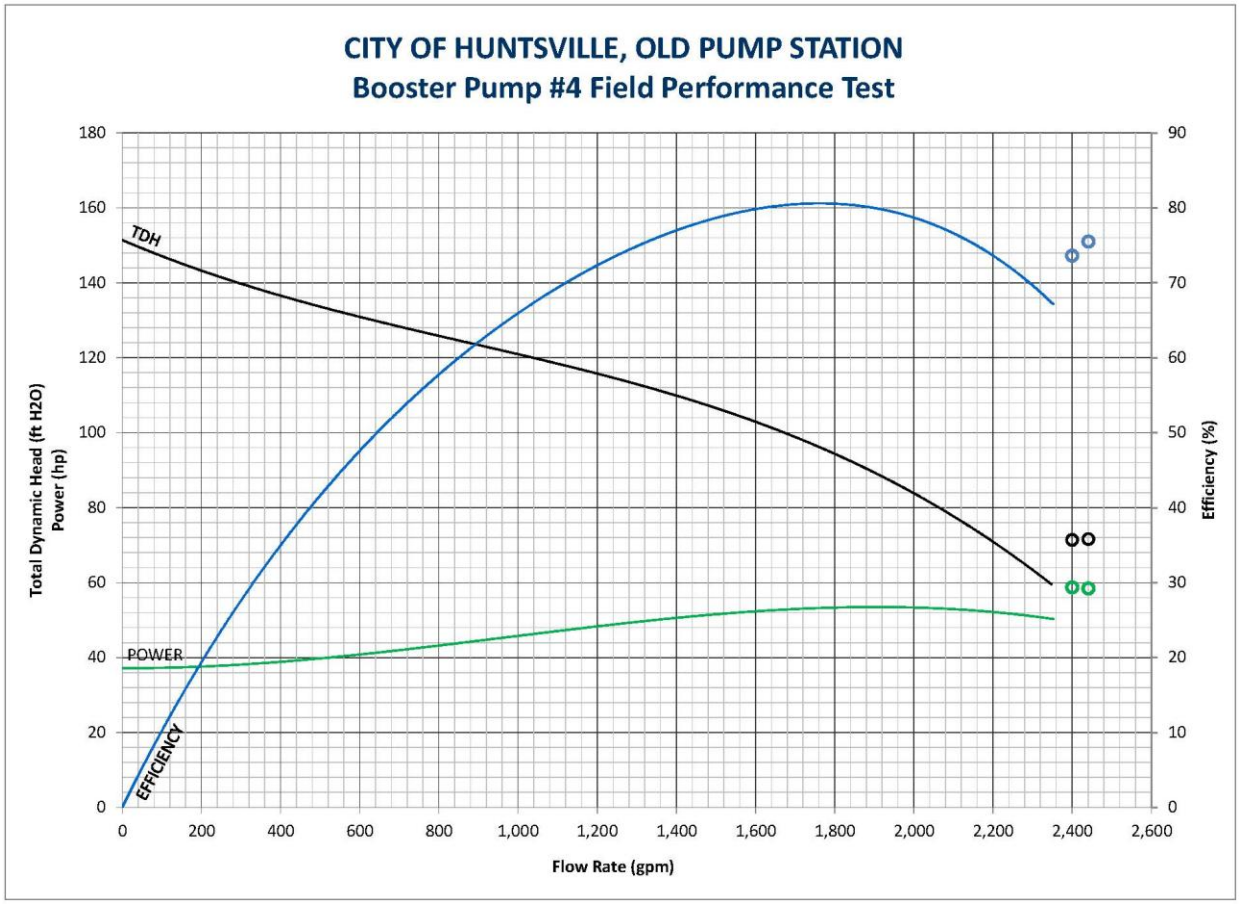


Figure 28: Old Booster Pump Station, Booster Pump #4 Field Performance Curve

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS		
Location	**Reading (in/sec rms)**	**Below HI Limits?**
MT-0	**0.371**	No
	0.383	No
MT-90	**0.328**	No
	0.298	No
MT-V	**0.103**	Yes
	0.099	Yes
MB-0	**0.246**	No
	0.255	No
MB-90	**0.184**	No
	0.171	No

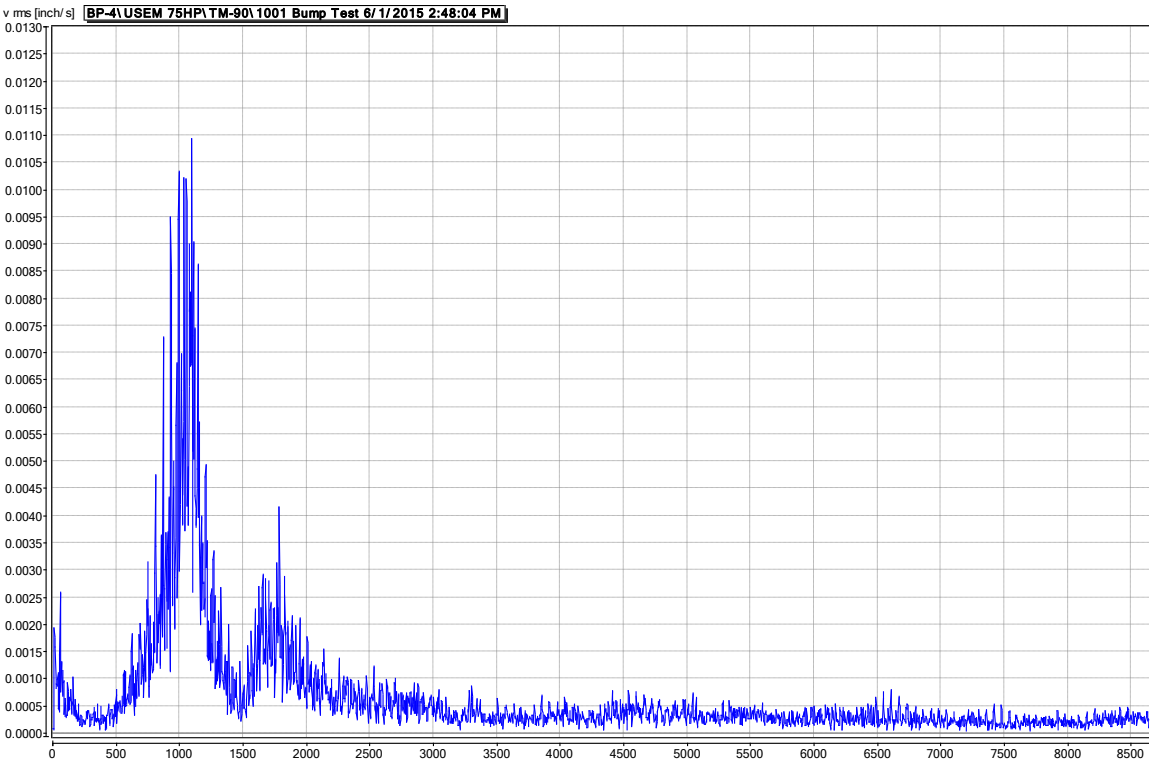


Figure 29: MT-90 Bump Test, Reed Frequency at 1,095 cpm, Motor Speed is 1,785 rpm

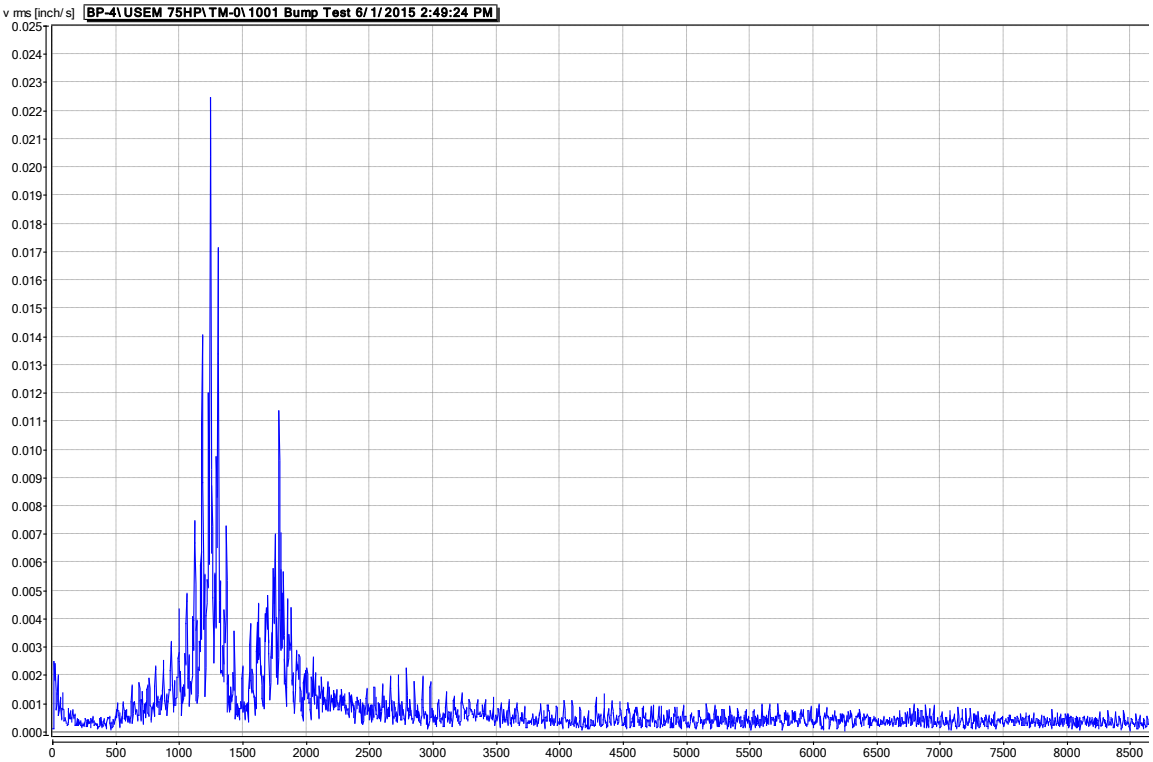


Figure 30: MT-0 Bump Test, Reed Frequency at 1,243 cpm, Motor Speed is 1,785 rpm

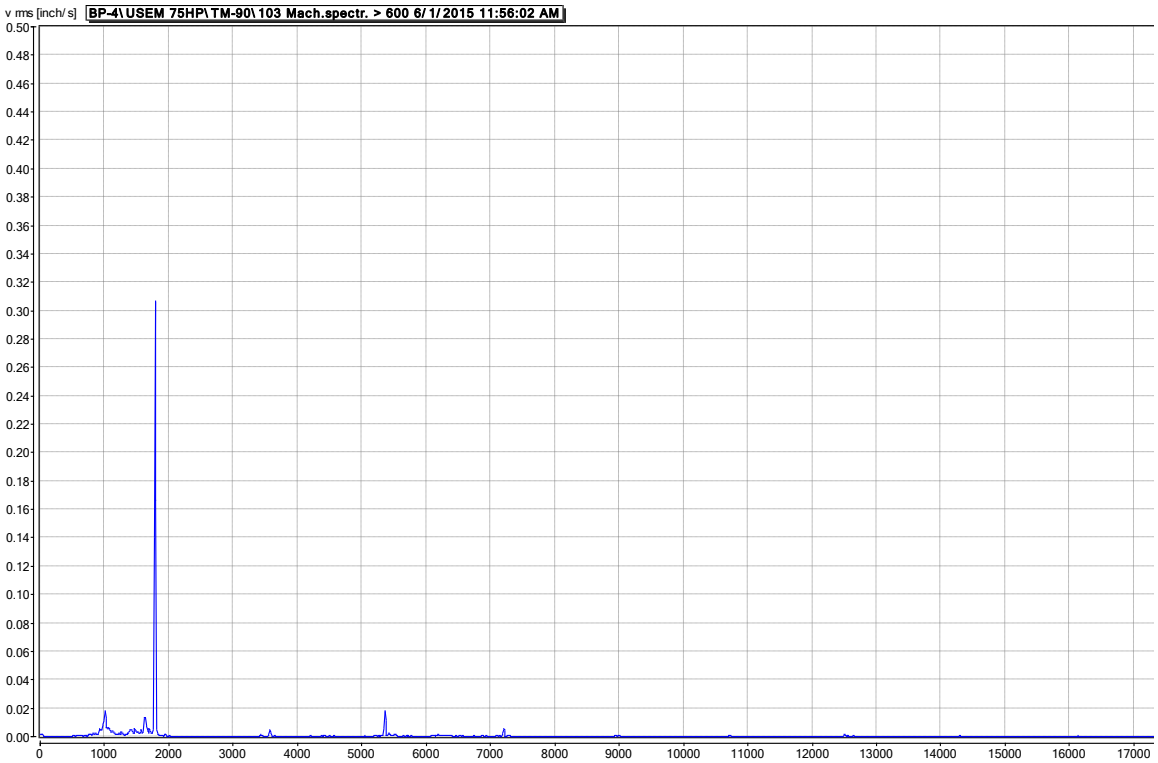


Figure 31: MT-90 Filtered Vibration, highest peak is 0.307 in/sec rms at 1,785 cpm (1X run speed)

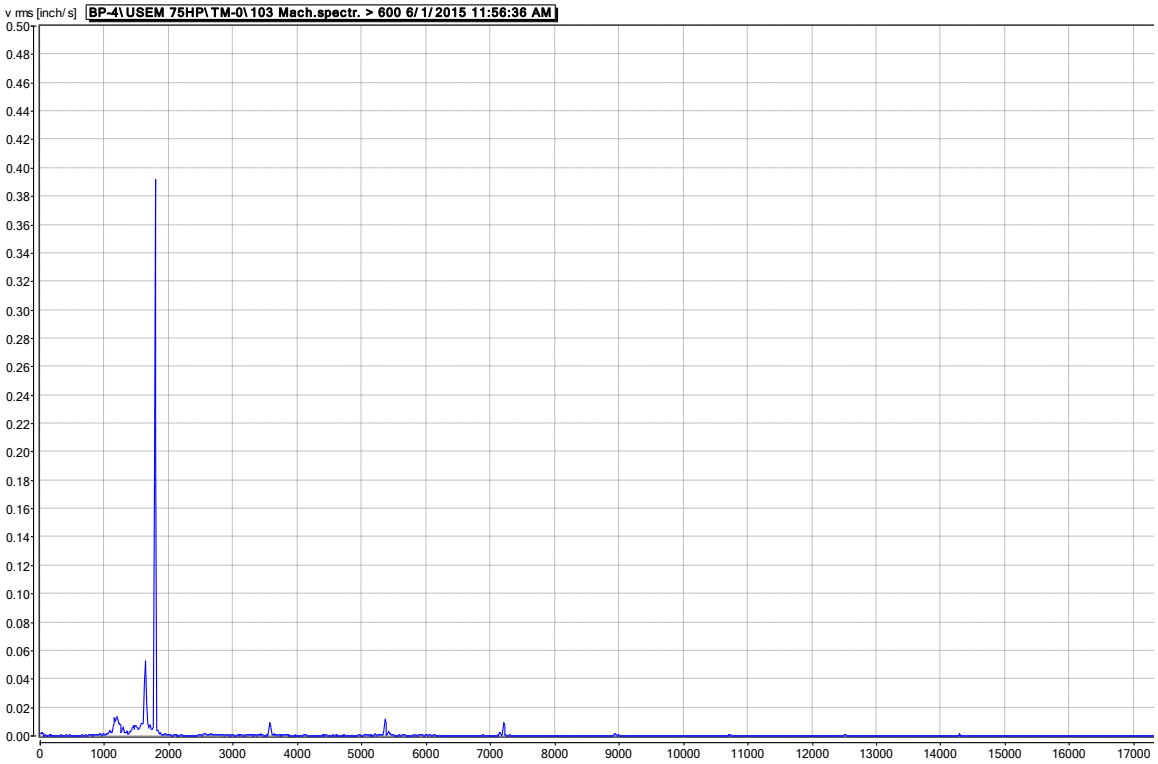


Figure 32: MT-0 Filtered Vibration, highest peak is 0.392 in/sec at 1,785 cpm (1X run speed)

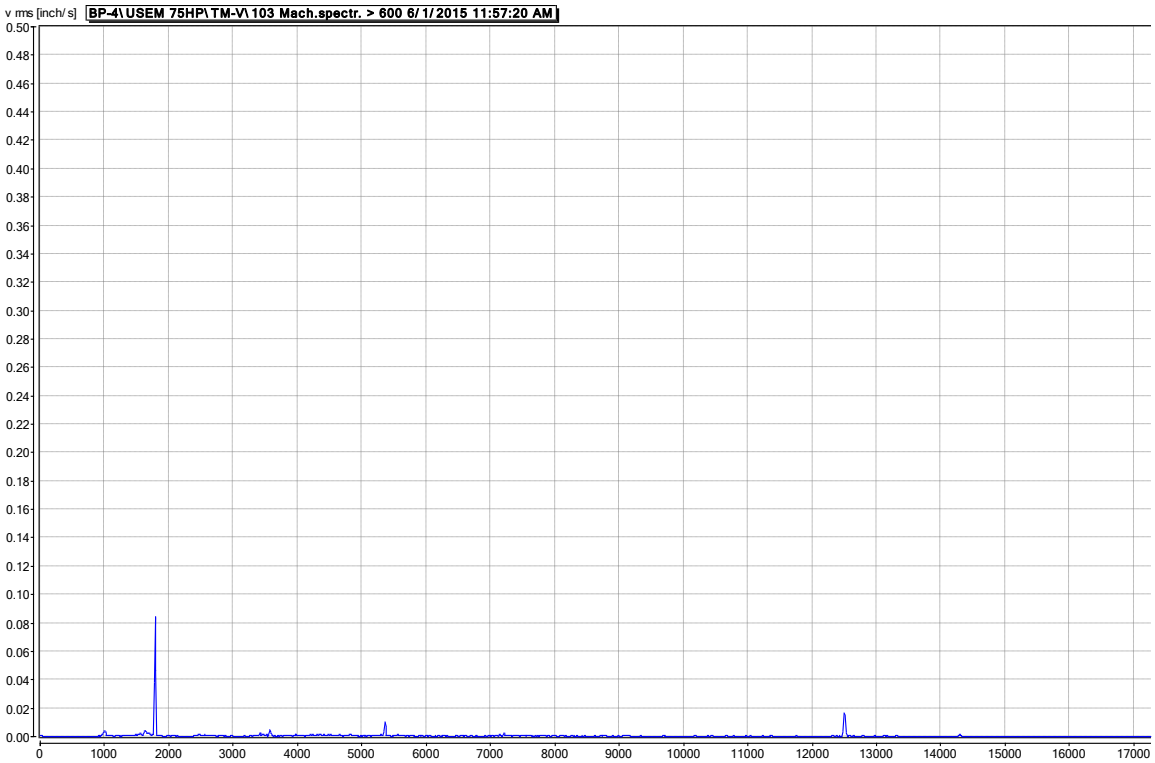


Figure 33: MT-V Filtered Vibration, highest peak is 0.084 in/sec at 1,785 cpm (1X run speed)

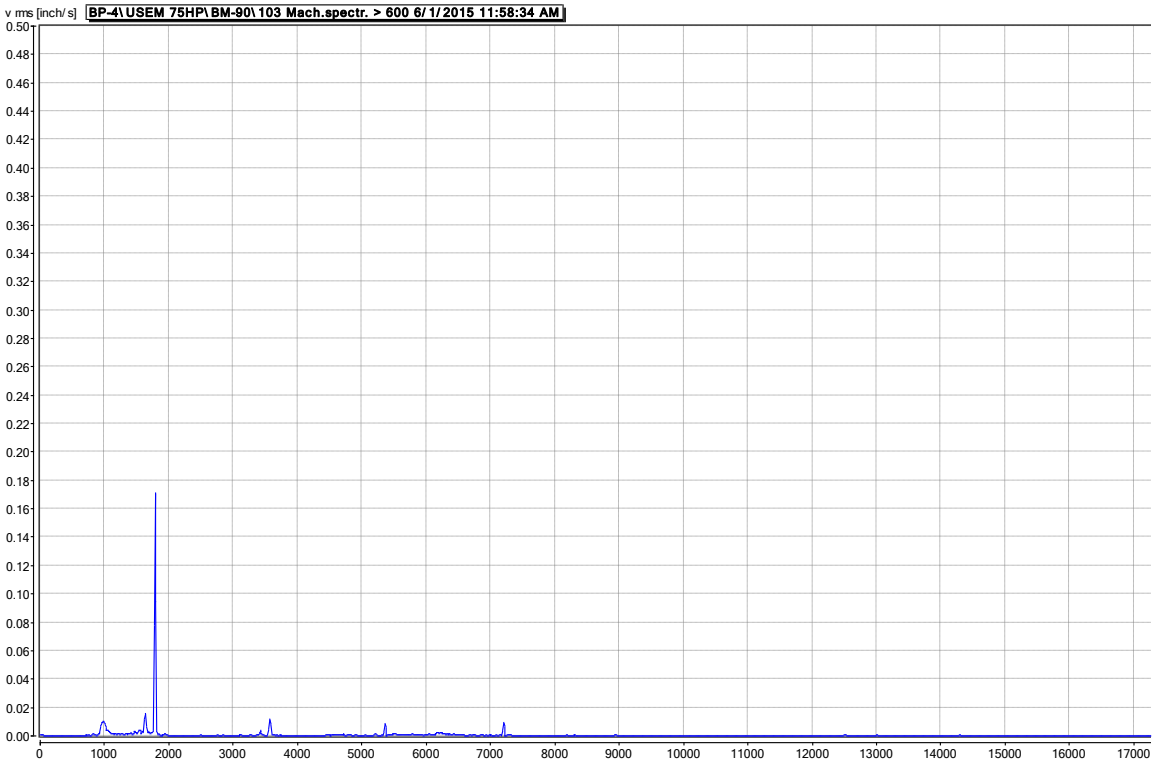


Figure 34: MB-90 Filtered Vibration, highest peak is 0.171 in/sec at 1,785 cpm (1X run speed)

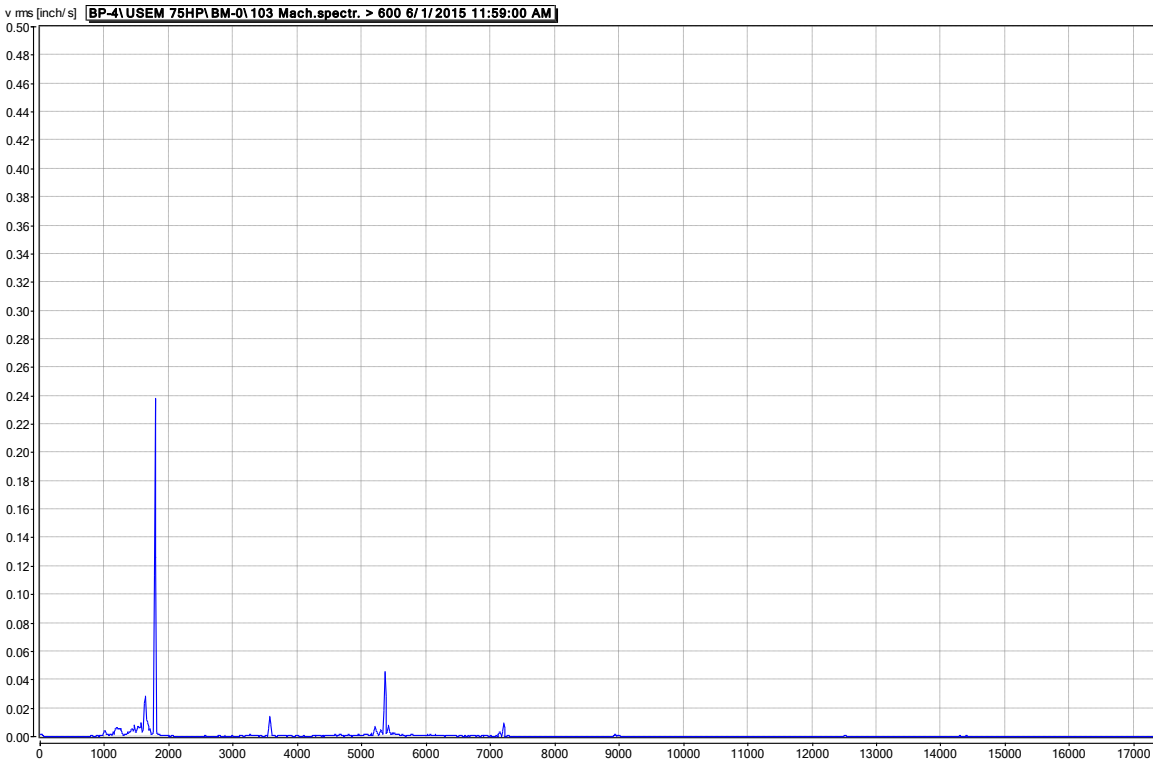


Figure 35: MB-0 Filtered Vibration, highest peak is 0.238 in/sec at 1,785 cpm (1X run speed) and the second highest peak is 0.046 in/sec at 5,358 cpm

The reed frequency, as shown in Figures 29, is at 1,095 cpm 90 degrees to discharge which is 39% from run speed and should not cause any issues. The reed frequency, as shown in Figure 30, is at 1,243 cpm which is 30% from run speed and should not cause any issues.

The vibration at all of the locations has a dominant peak at 1X run speed. This is a typical signature of rotating equipment and indicates a slight imbalance and/or misalignment or looseness. The amplitude is very high at the locations that are in-line and 90 degree to the discharge and should be corrected. Field balancing may resolve the issue but it is more likely caused by loose pump bearings which would require the pump to be pulled and repaired

TEST DISCUSSIONS

HYDRAULIC OPERATION

- The pump appears to outperform the catalog curve provided by the city. The data points seem unrealistic when taking into account the number of years since the previous repair.

ELECTRICAL OPERATION

- Voltage and current were measured using Smith Pump's Extech True RMS Power Meter

- During the test, a maximum current of 68 amps was recorded which is less than the full load amps of this motor

MECHANICAL OPERATION

- Pump vibration is well above the Hydraulic Institute Standards with the highest vibration being 0.383 in/sec rms
- This pump's runtime should be kept to a minimum

NEW BOOSTER PUMP STATION

FIELD PERFORMANCE TEST REPORT

GENERAL ARRANGEMENT

This station has four (4) horizontal split case pumps. All of the pumps are the same size. The pumps are Goulds 3405 6x8-12 horizontal split case pump with three (3) Siemens and one (1) Power Tech horizontal induction motors.

PERFORMANCE TESTING VARIANCES

None

BOOSTER PUMP #1

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The pump performance test data (hydraulic) shows the two (2) field test points recorded for each pump, shown with circles, and the catalog curve. The instrument values are recorded in concert with one another. The data is reduced to result in the points that show up in the composite curve chart in Figure 36 below. The data is speed corrected to the catalog curve test speed so that the test data can be compared.

Winding and bearing temperatures could not be recorded as there were not any displays for this data.

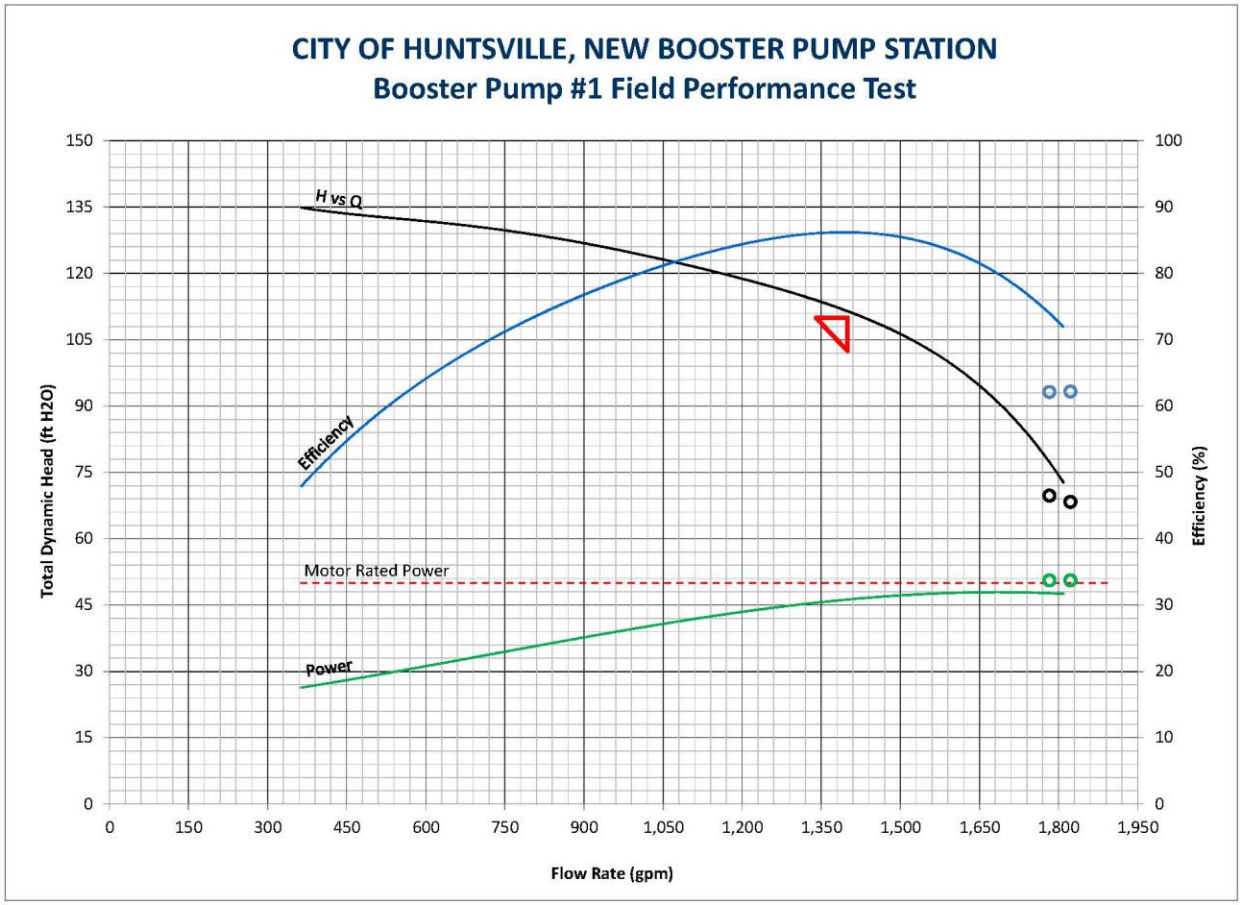


Figure 36: New Booster PS, Booster Pump #1 Field Performance Curve

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS			
Location		**Reading (in/sec rms)**	**Below HI Limits?**
MOTOR	ODE-X	**0.044**	Yes
		0.037	Yes
	ODE-Y	**0.055**	Yes
		0.066	Yes
	ODE-Z	**0.067**	Yes
		0.057	Yes
	DE-X	**0.076**	Yes
		0.072	Yes
	DE-Y	**0.043**	Yes
		0.041	Yes

PUMP	DE-X	0.034	Yes
		0.038	Yes
	DE-Y	0.026	Yes
		0.028	Yes
	ODE-X	0.021	Yes
		0.020	Yes
	ODE-Y	0.014	Yes
		0.014	Yes
	ODE-Z	0.031	Yes
		0.030	Yes

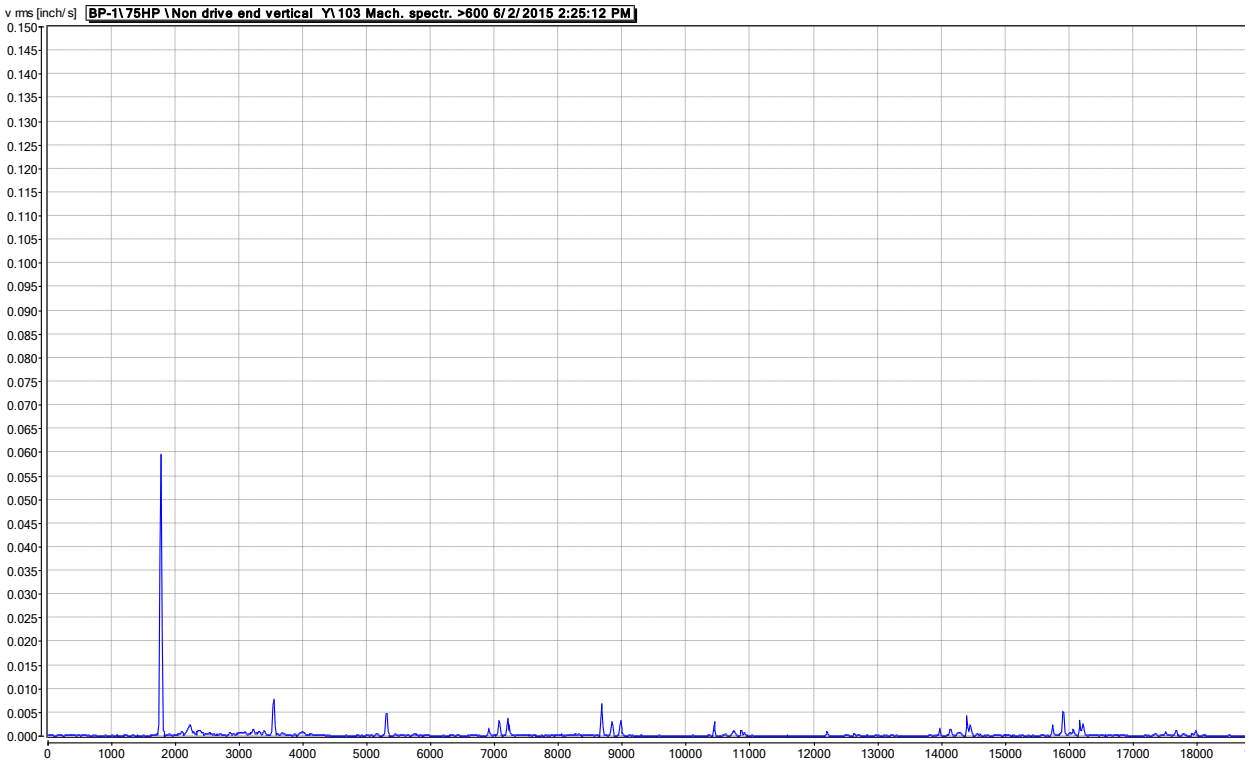


Figure 37: Motor ODE-Y Filtered Vibration, highest peak is 0.060 in/sec at 1,766 cpm (1X run speed)

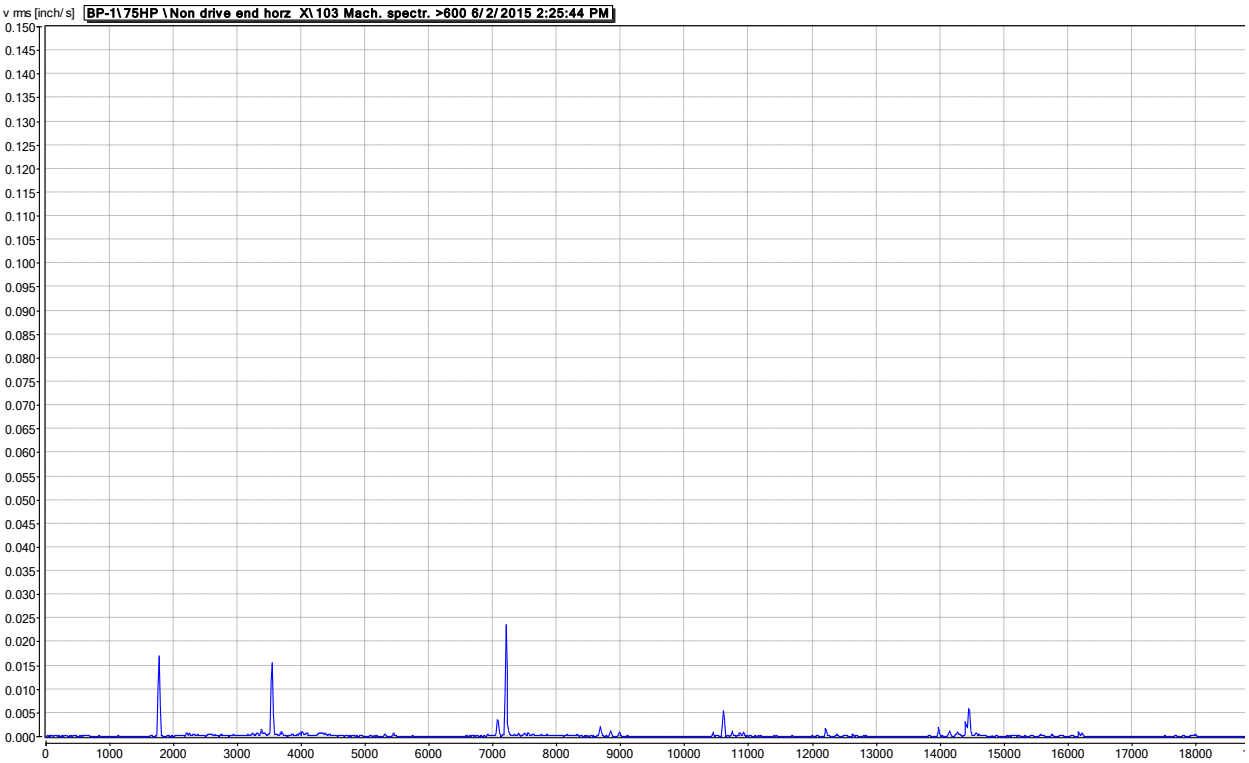


Figure 38: Motor ODE-X Filtered Vibration, highest peak is 0.024 in/sec at 7,200 cpm (1X run speed) with other peaks at 1,766 cpm (1X run speed) and 3,536 cpm (2X run speed)

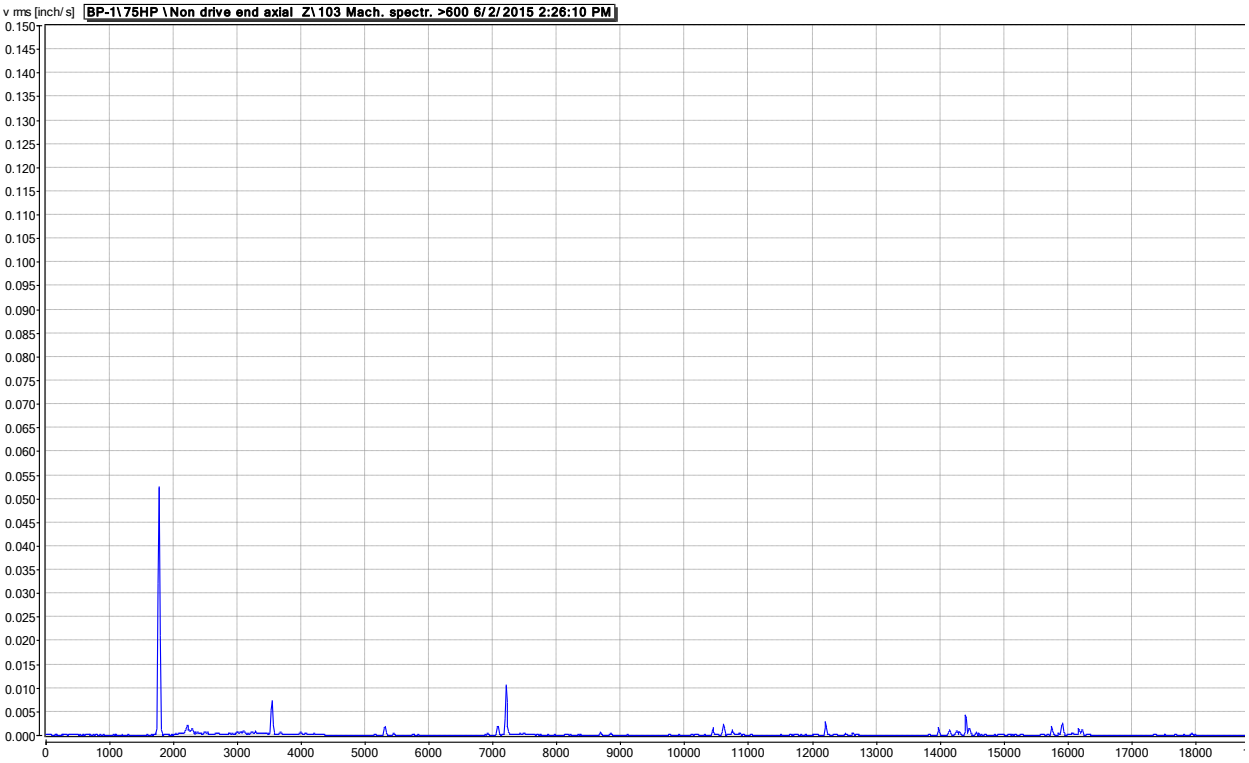


Figure 39: Motor ODE-Z Filtered Vibration, highest peak is 0.053 in/sec at 1,785 cpm (1X run speed)

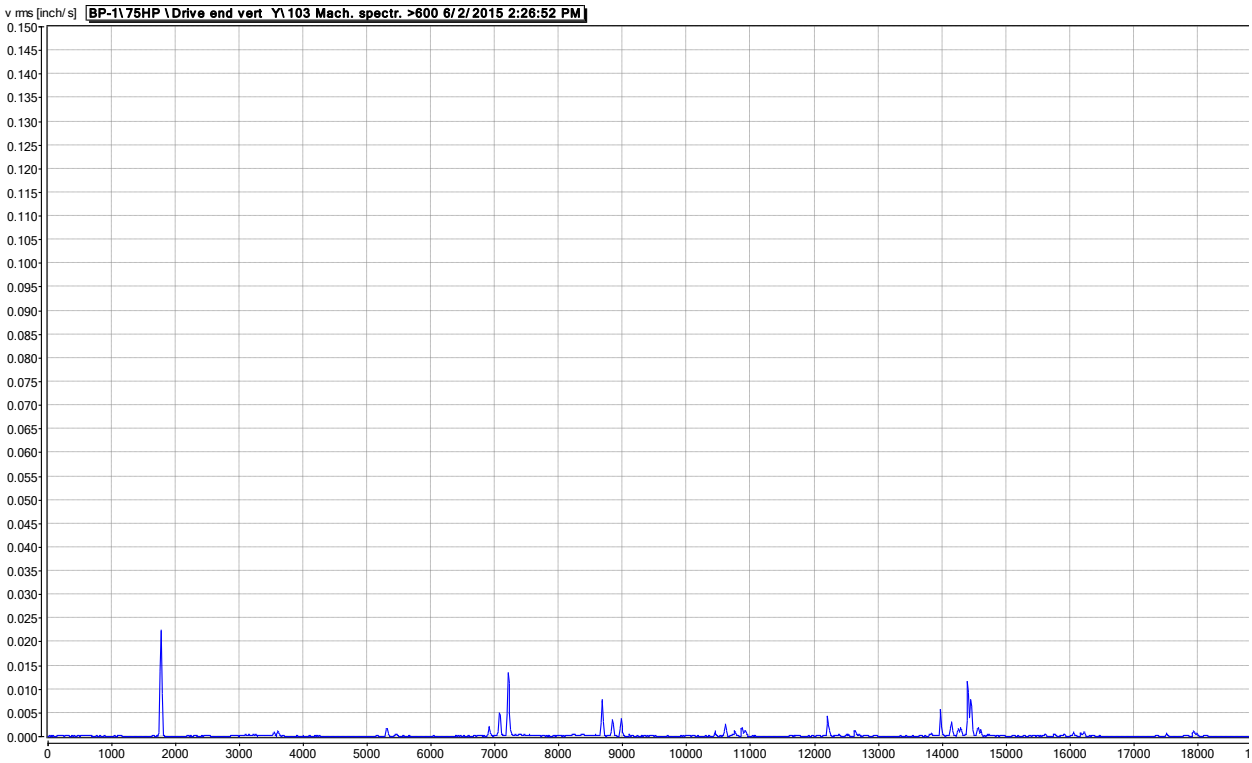


Figure 40: Motor DE-Y Filtered Vibration, highest peak is 0.022 in/sec at 1,766 cpm (1X run speed) with a smaller peak at 7,200 cpm (electrical frequency)

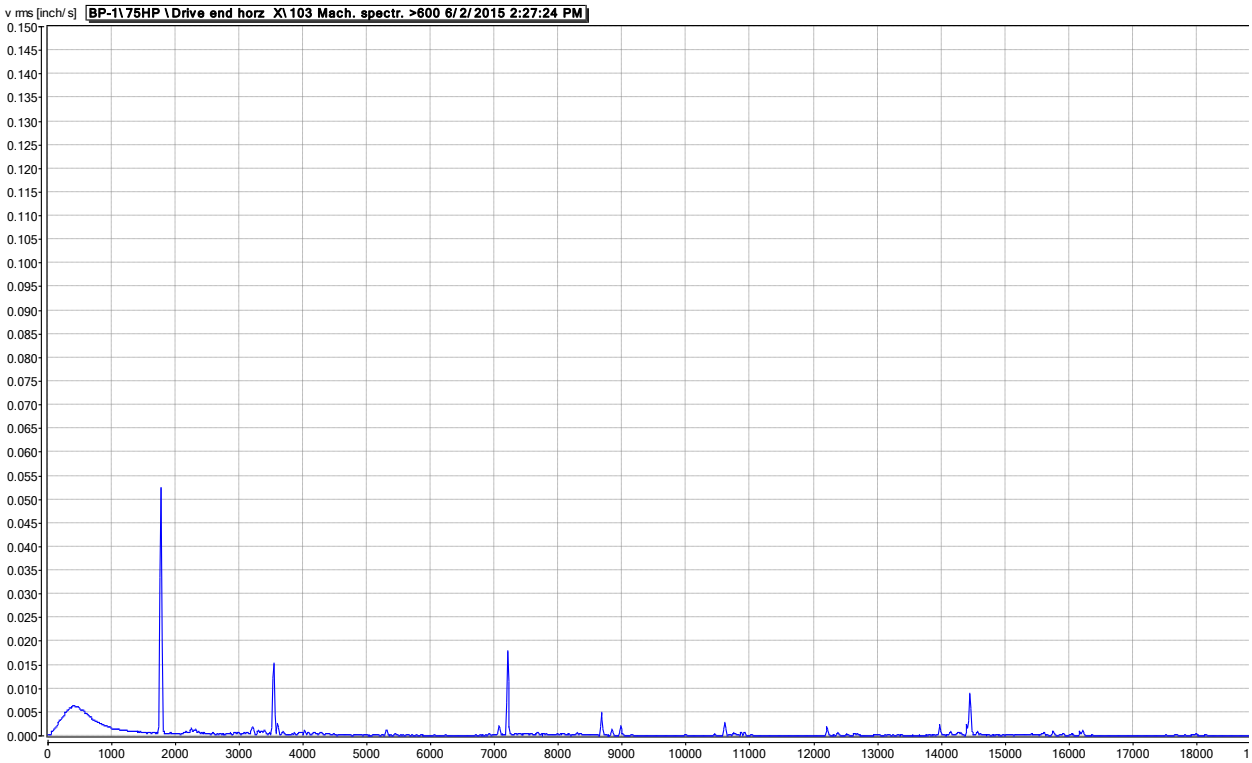


Figure 41: Motor DE-X Filtered Vibration, highest peak is 0.053 in/sec at 1,766 cpm (1X run speed) with a smaller peak at 3,536 cpm (2X run speed) and 7,200 cpm (electrical frequency)

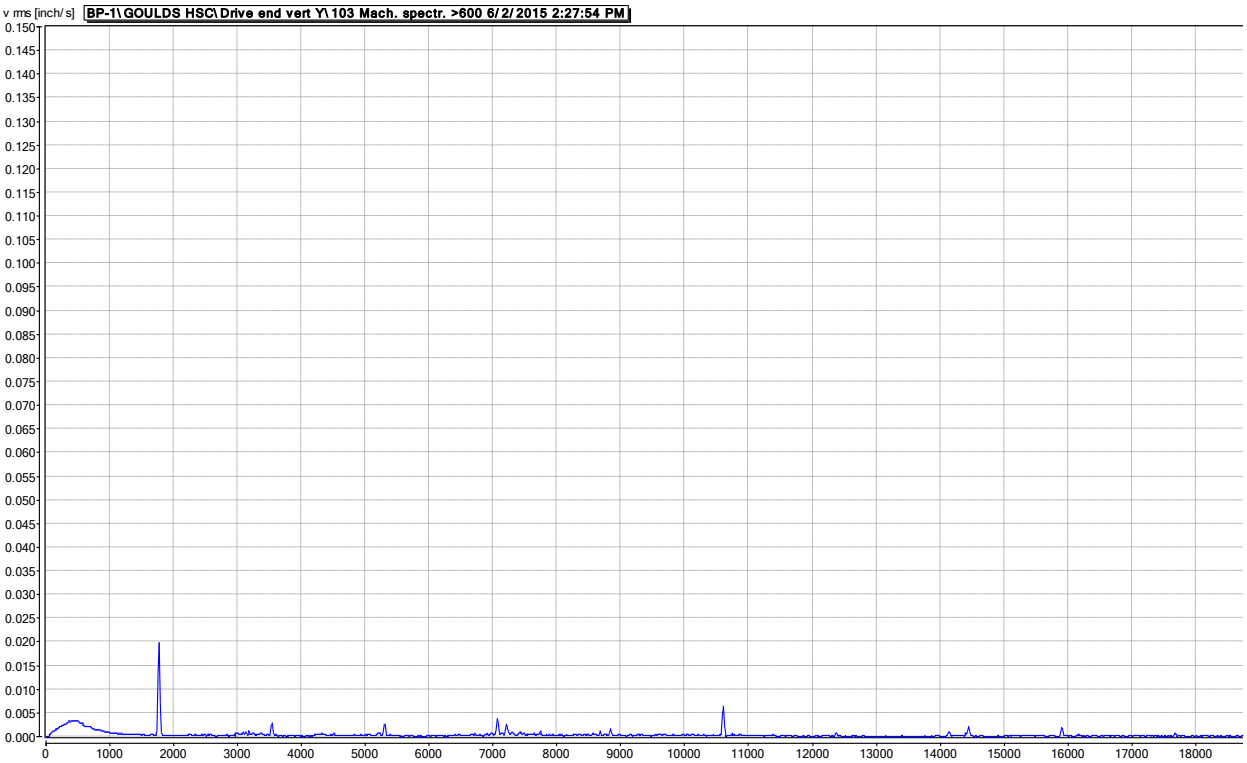


Figure 42: Pump DE-Y Filtered Vibration, highest peak is 0.020 in/sec at 1,766 cpm (1X run speed)

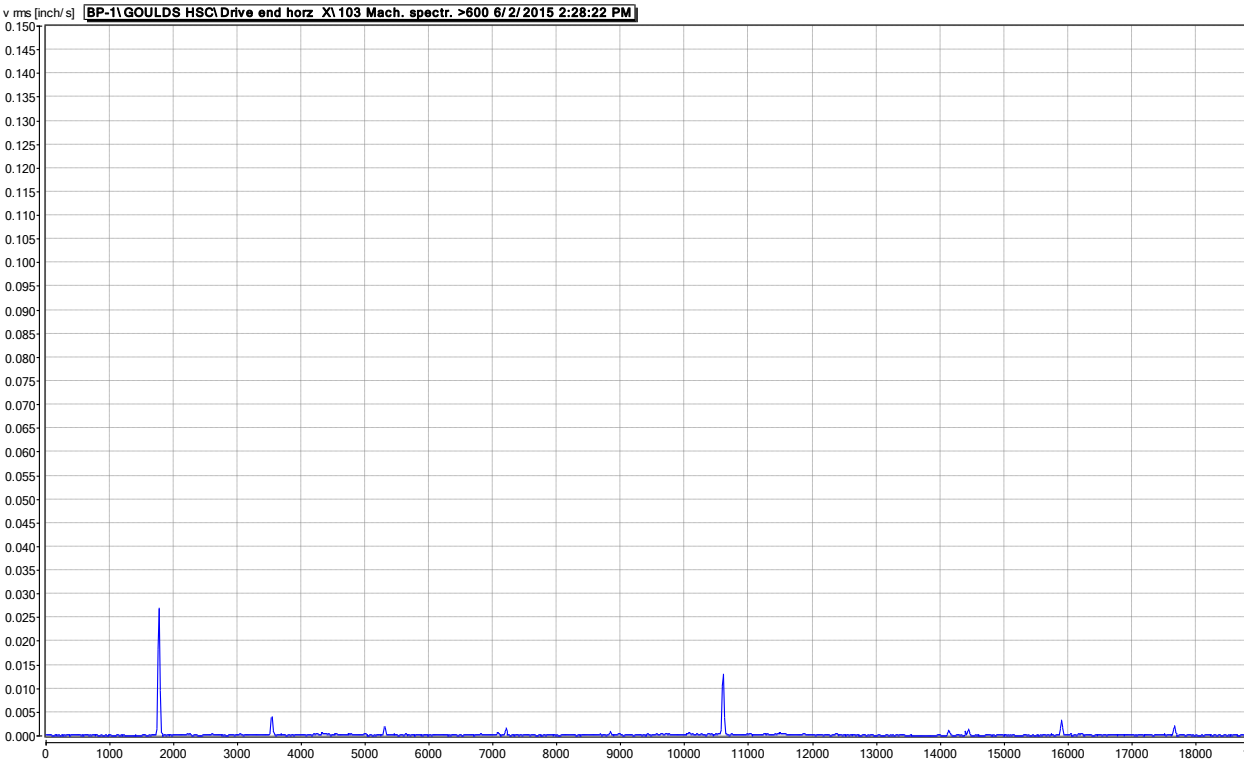


Figure 43: Pump DE-X Filtered Vibration, highest peak is 0.027 in/sec at 1,766 cpm (1X run speed) with a smaller peak at 10,601 cpm (6X run speed)

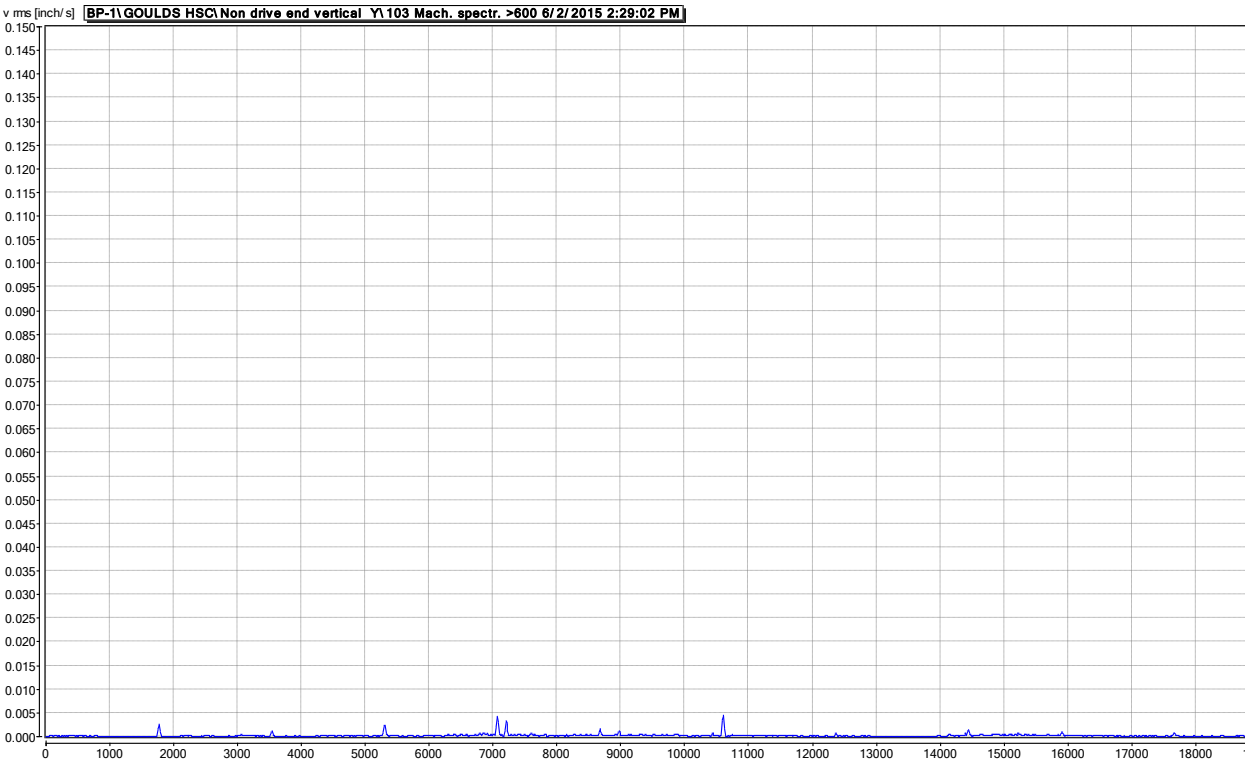


Figure 44: Pump ODE-Y Filtered Vibration, all peaks are below 0.005 in/sec

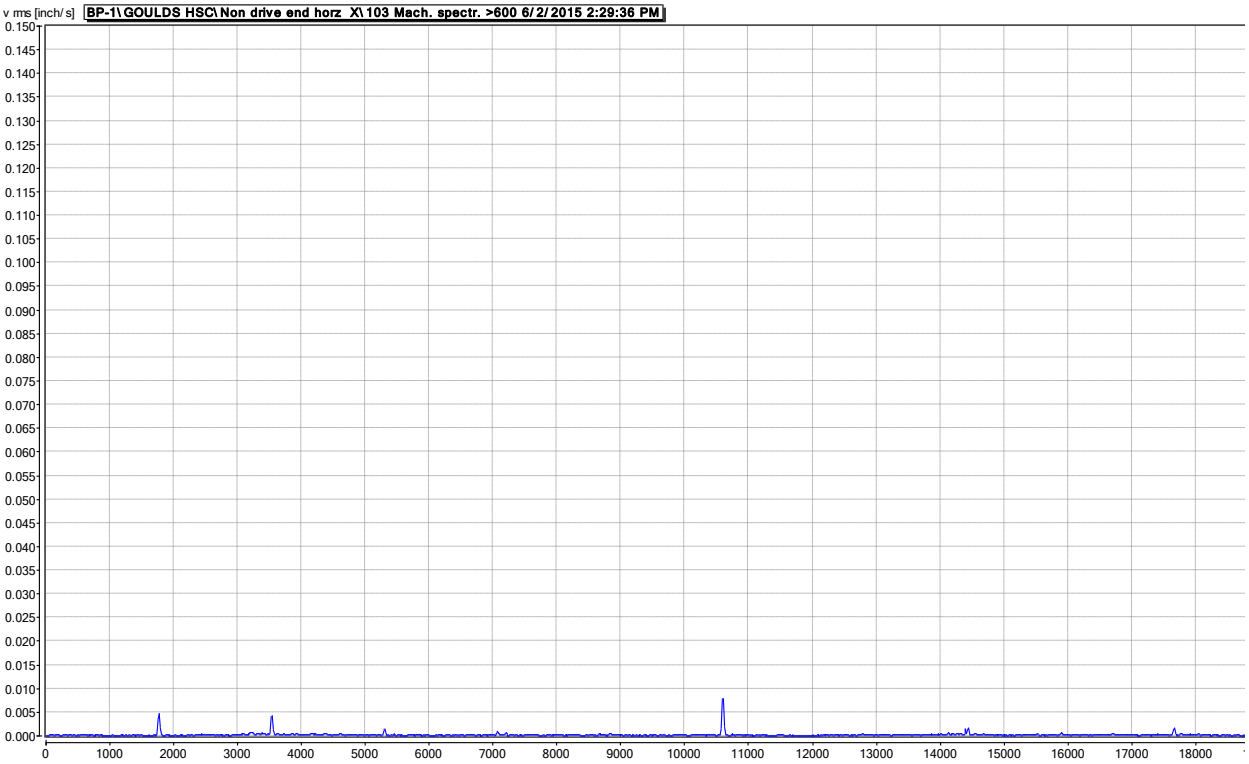


Figure 45: Pump ODE-X Filtered Vibration, all peaks are below 0.010 in/sec

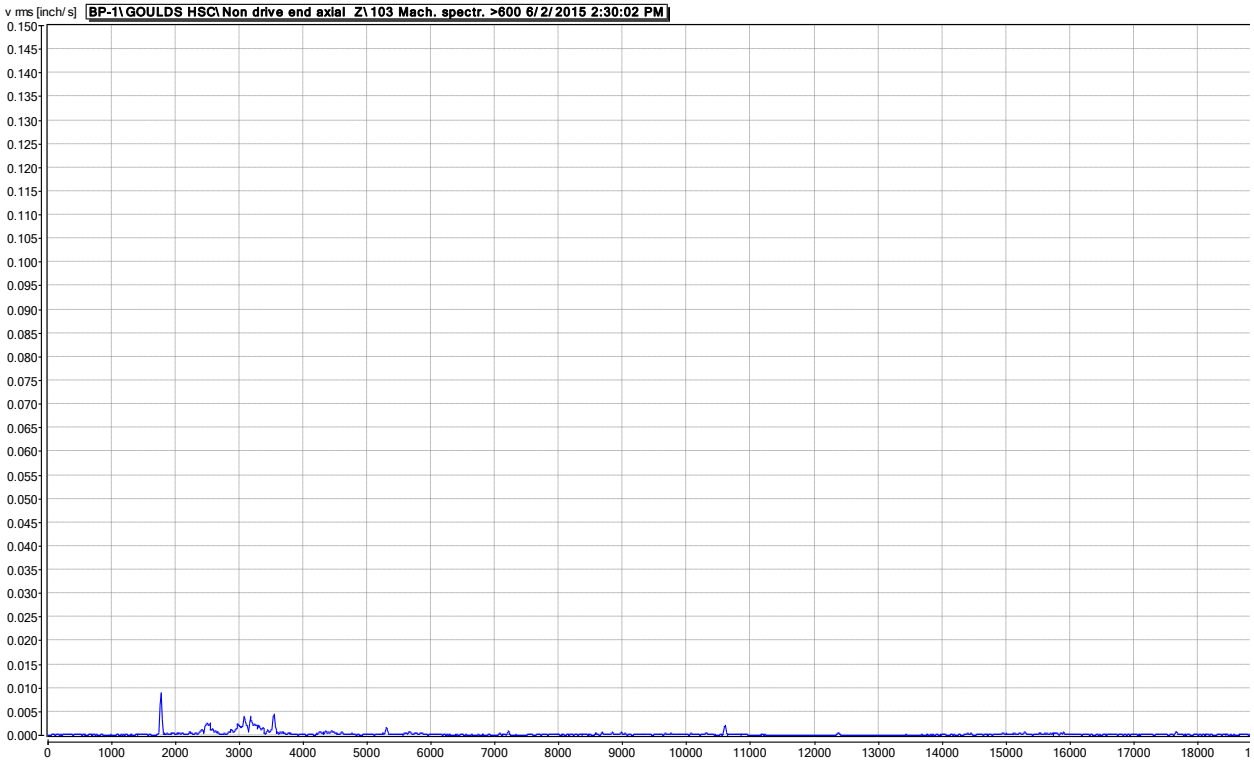


Figure 46: Pump ODE-Z Filtered Vibration, all peaks are below 0.010 in/sec

The motor and pump vibration are very low at all locations.

TEST DISCUSSIONS

HYDRAULIC OPERATION

- The pump matches the catalog curve provided by the manufacturer.
- The total dynamic head is approximately 3 ft low
- The efficiency is approximately 11 percentage points low

ELECTRICAL OPERATION

- Voltage and current were measured using Smith Pump's Extech True RMS Power Meter
- During the test, a maximum current of 66 amps was recorded which is more than the full load amps of this motor and should be monitored
- The pump overloads the motor but it is likely caused by only one pump running instead of two

MECHANICAL OPERATION

- Pump vibration is well below the Hydraulic Institute Standards with the highest vibration being 0.076 in/sec rms
- This pump is running very well

FIELD INSPECTION

TEST RESULTS

The alignment between the pump and motor shaft was measured. The vertical offset misalignment is 0.0078” and the angular misalignment is 0.0193”. The horizontal offset misalignment is 0.0348” and the angular misalignment is 0.1212”. The motor cannot be repositioned to align to the pump because the motor bolt holes do not have enough slack.

OTHER OBSERVATIONS

The eccentric reducer on the suction side of the pump is located too close to the pump, see Figure 47. This reducer should be positioned farther from the pump to ensure no cavitation or hydraulic issues.

Figure 47: Suction Piping of Booster Pump #1

BOOSTER PUMP #2

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The coupling on the discharge piping was to be used for the discharge gage. The discharge and suction valves were closed but the pressure could not be relieved. The plug in the coupling could not be pulled because the valves would not seal off the pressure.

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS			
Location		Reading (in/sec rms)	Below HI Limits?
MOTOR	ODE-X	0.025	Yes
	ODE-Y	0.025	Yes
	ODE-Z	0.022	Yes
	DE-X	0.052	Yes
	DE-Y	0.050	Yes
PUMP	DE-X	0.029	Yes
	DE-Y	0.019	Yes
	ODE-X	0.021	Yes
	ODE-Y	0.020	Yes
	ODE-Z	0.027	Yes

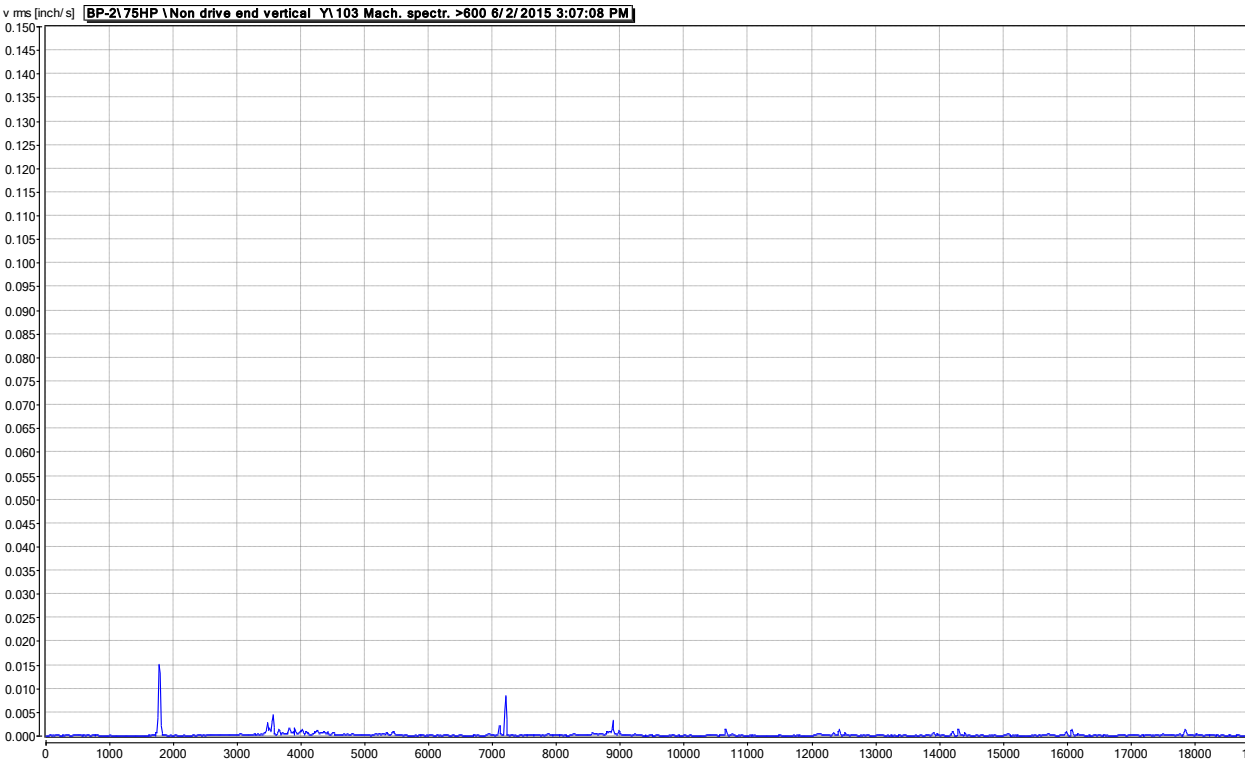


Figure 48: Motor ODE-Y Filtered Vibration, all peaks are below 0.015 in/sec

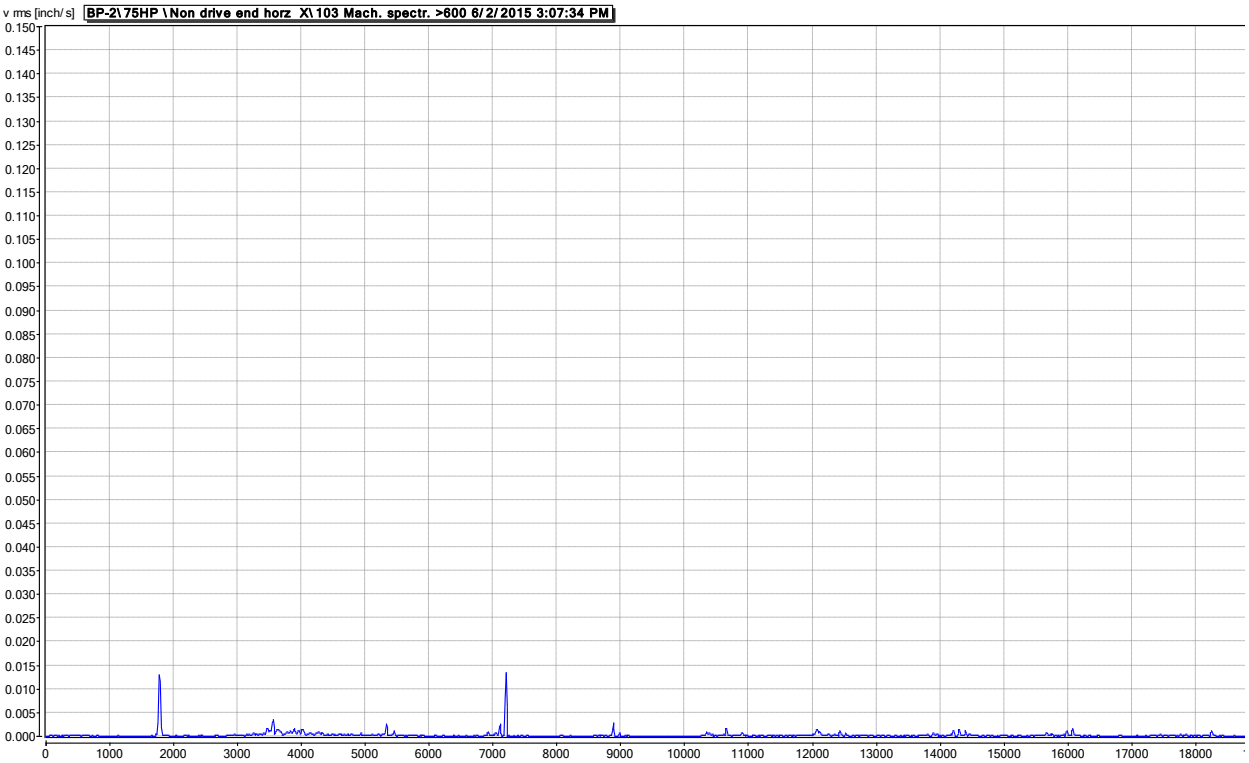


Figure 49: Motor ODE-X Filtered Vibration, all peaks are below 0.015 in/sec

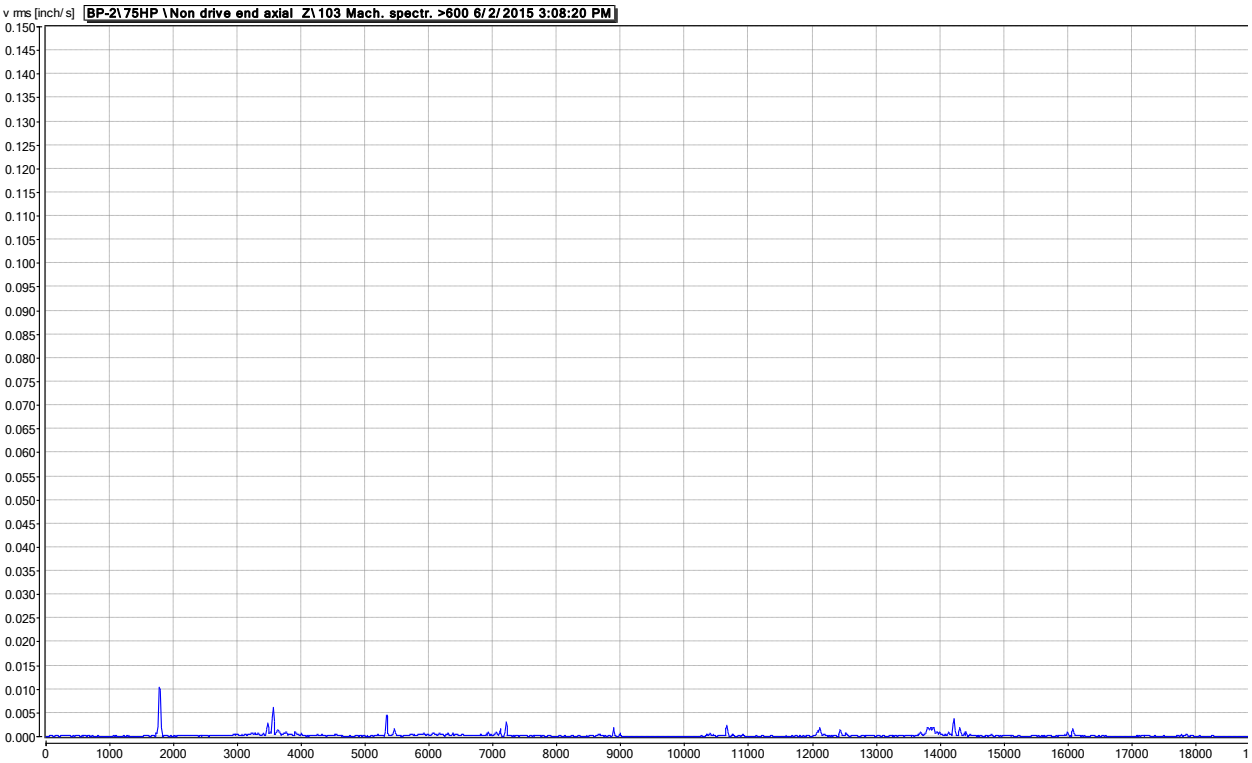


Figure 50: Motor ODE-Z Filtered Vibration, all peaks are below 0.010 in/sec

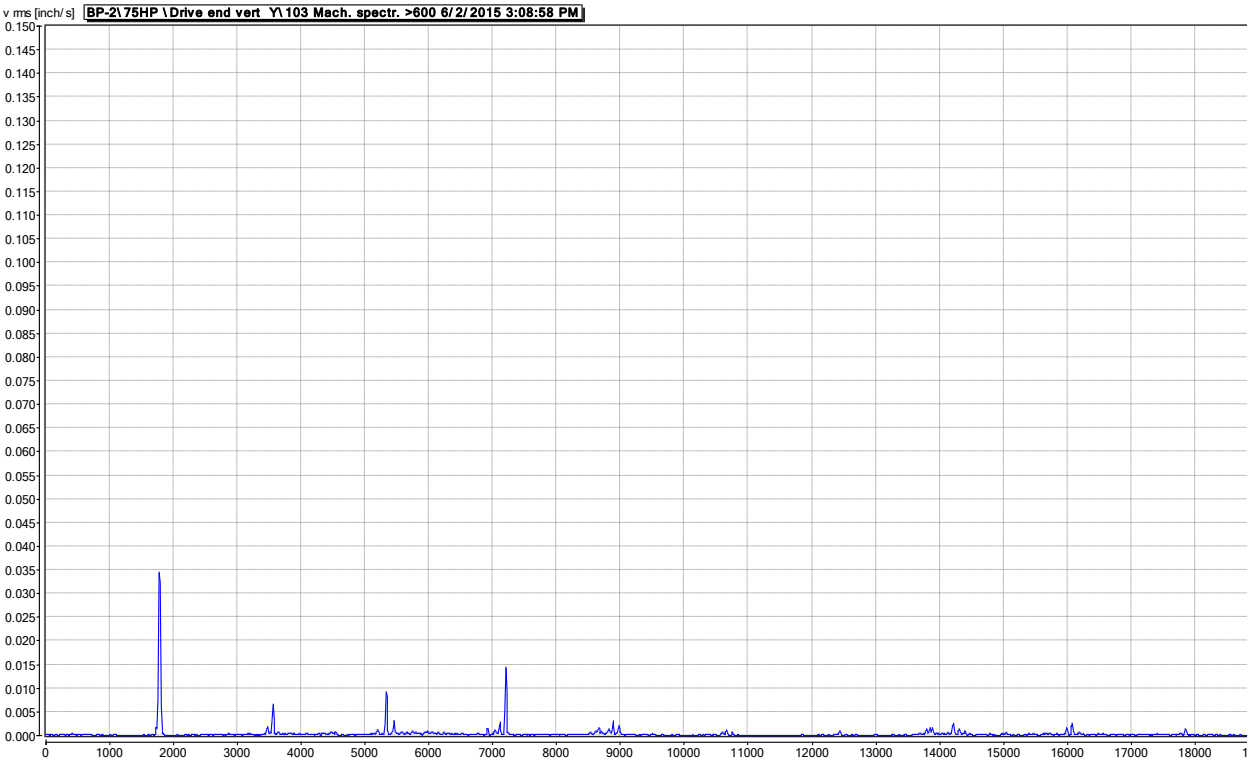


Figure 51: Motor DE-Y Filtered Vibration, highest peak is 0.034 in/sec at 1,778 cpm (1X run speed) with the remaining peaks below 0.015 in/sec

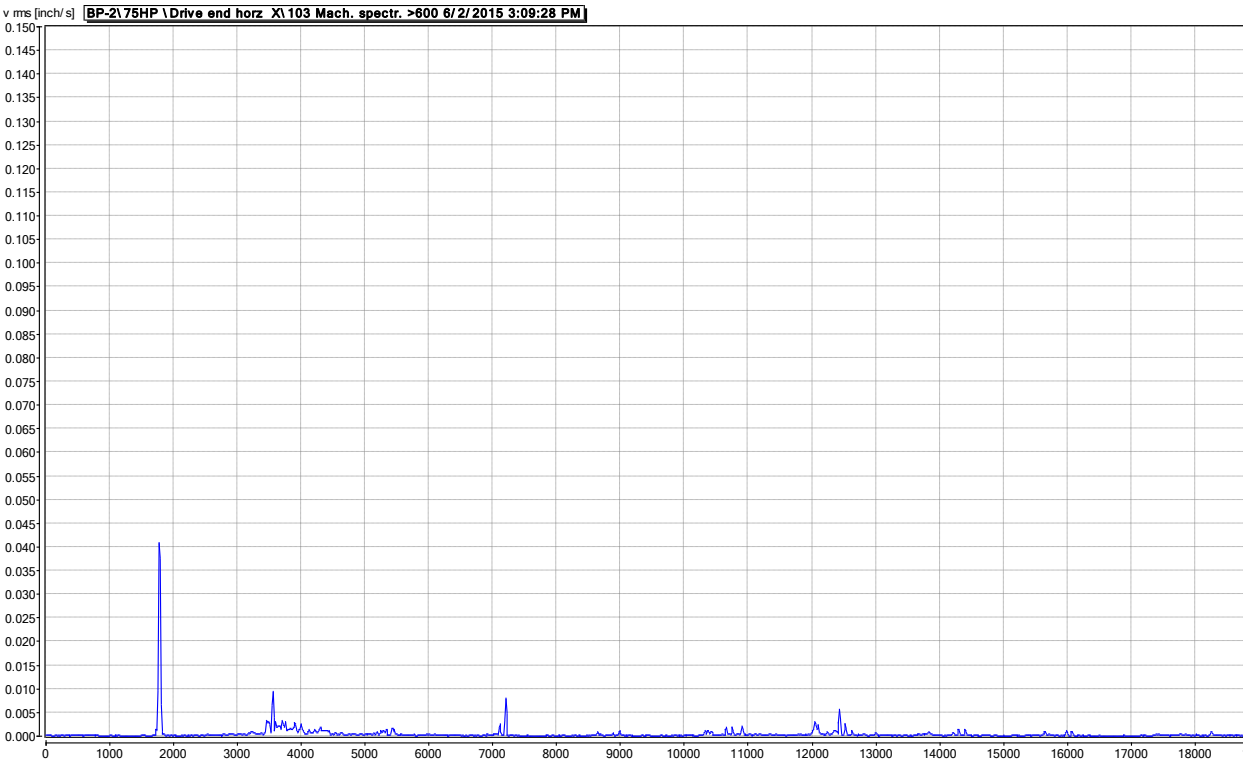


Figure 52: Motor DE-X Filtered Vibration, highest peak is 0.041 in/sec at 1,778 cpm (1X run speed) with the remaining peaks below 0.010 in/sec

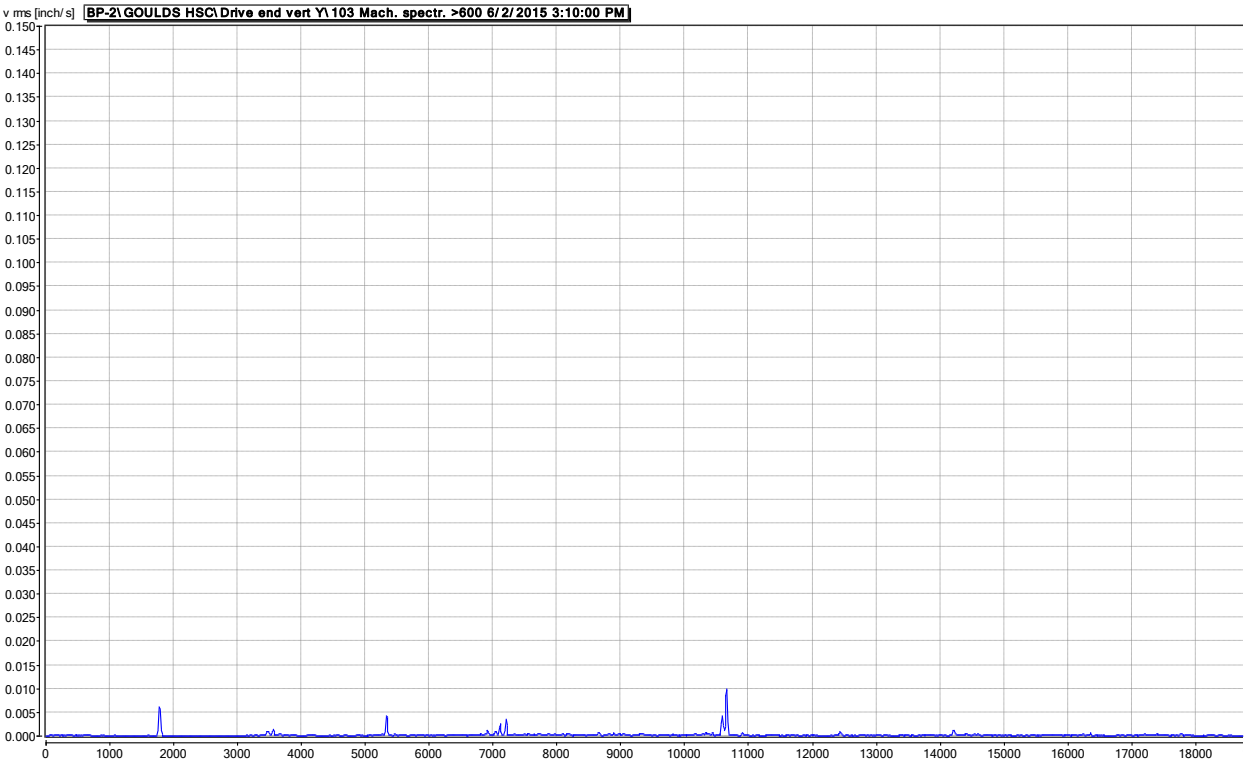


Figure 53: Pump DE-Y Filtered Vibration, all peaks are below 0.010 in/sec

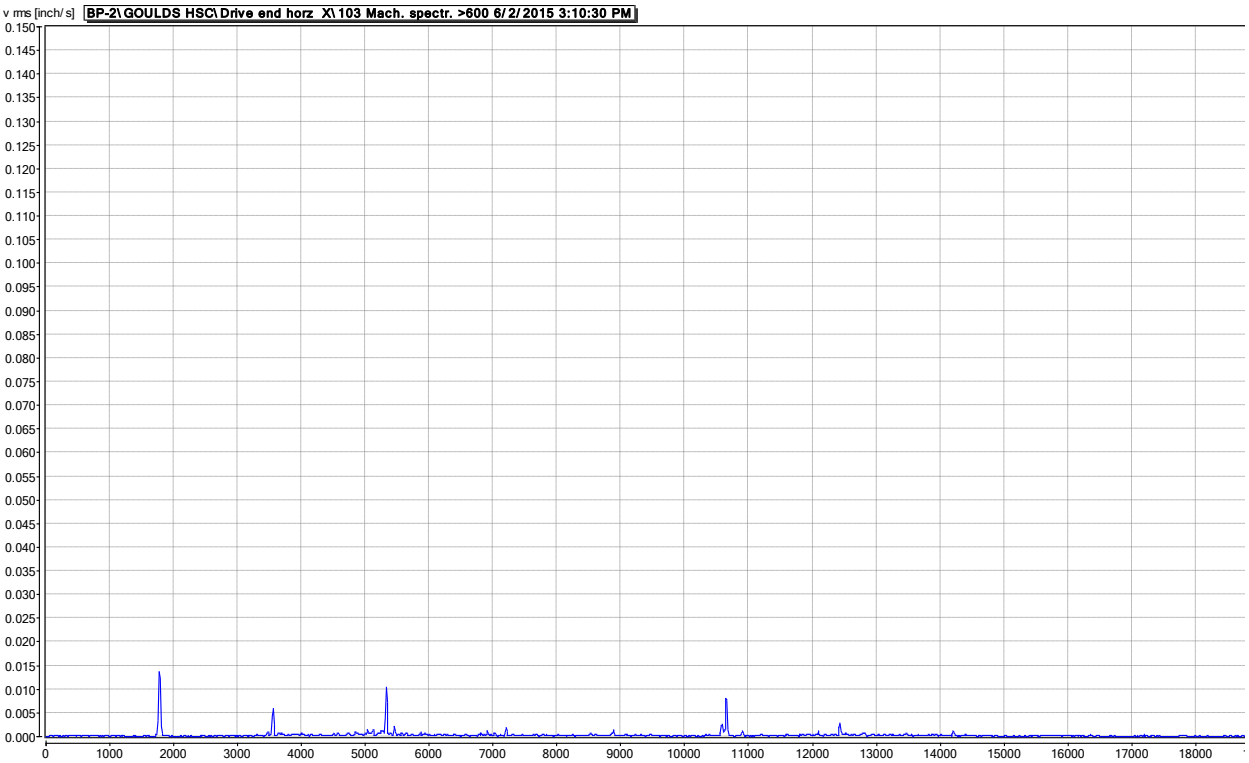


Figure 54: Pump DE-X Filtered Vibration, all peaks are below 0.010 in/sec

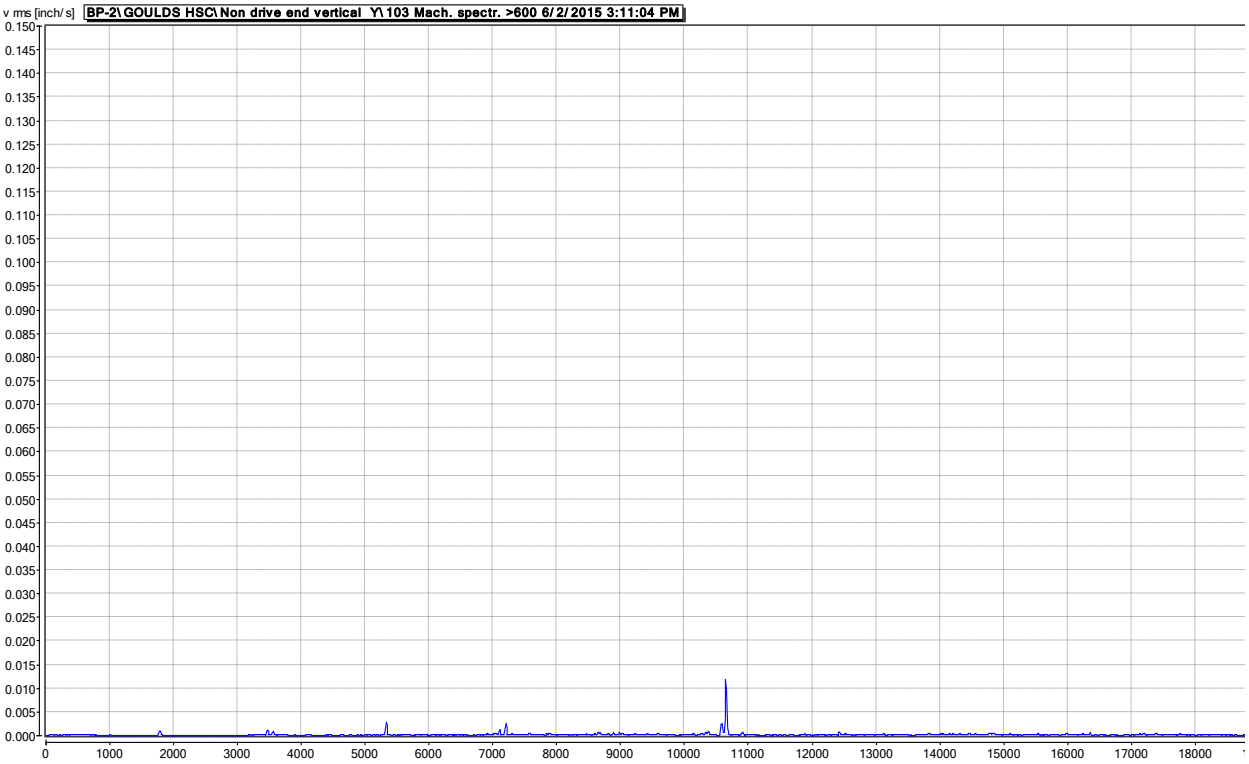


Figure 55: Pump ODE-Y Filtered Vibration, all peaks are below 0.015 in/sec

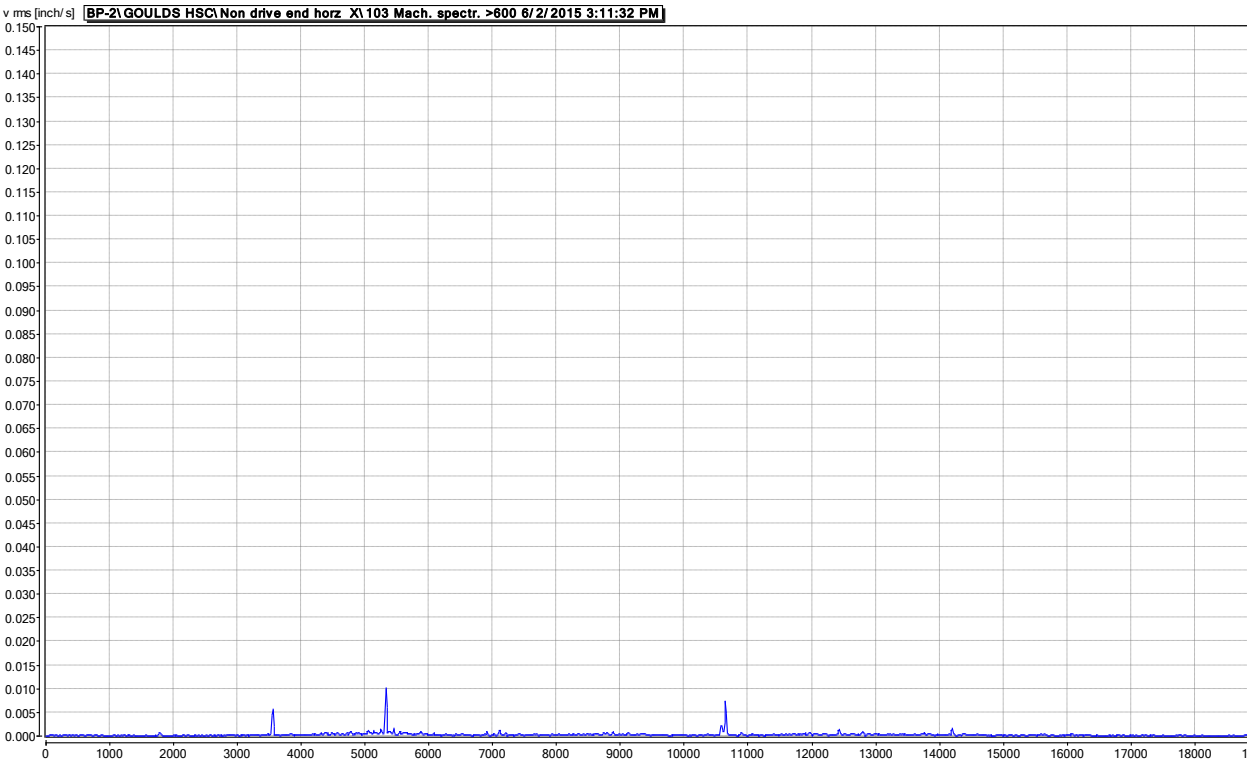


Figure 56: Pump ODE-X Filtered Vibration, all peaks are below 0.010 in/sec

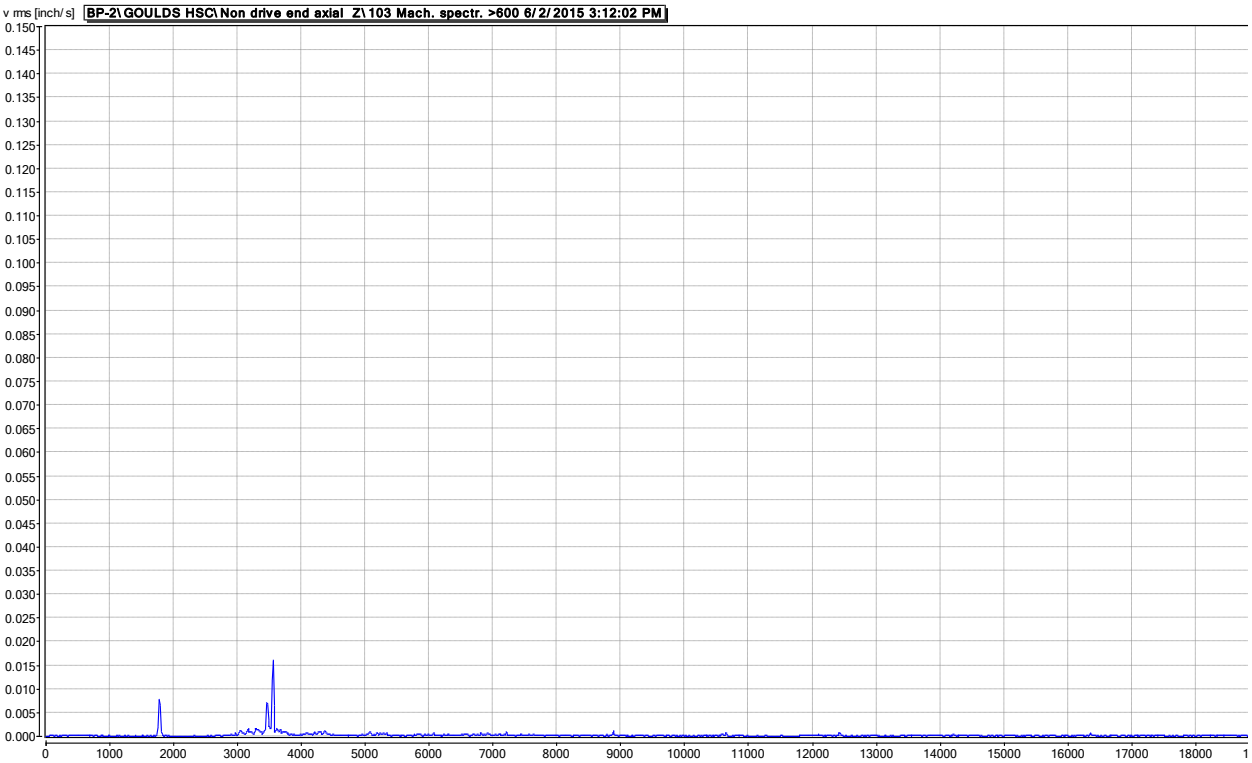


Figure 57: Pump ODE-Z Filtered Vibration, the highest peak is 0.016 in/sec at 3,551 cpm (2X run speed)

The motor and pump vibration are very low at all locations.

TEST DISCUSSIONS

HYDRAULIC OPERATION

- Discharge valve could not be placed on piping, no results

ELECTRICAL OPERATION

- No electrical data collected

MECHANICAL OPERATION

- Pump vibration is well below the Hydraulic Institute Standards with the highest vibration being 0.052 in/sec rms
- This pump is running very well

FIELD INSPECTION

TEST RESULTS

The alignment between the pump and motor shaft was measured. The vertical offset misalignment is 0.0005" and the angular misalignment is 0.0069". The horizontal offset misalignment is 0.0002" and the angular misalignment is 0.0224". The alignment needs to be corrected.

OTHER OBSERVATIONS

The eccentric reducer on the suction side of the pump is located too close to the pump, see Figure 47. This reducer should be positioned farther from the pump to ensure no cavitation or hydraulic issues.

BOOSTER PUMP #3

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The coupling on the discharge piping was to be used for the discharge gage. The discharge and suction valves were closed but the pressure could not be relieved. The plug in the coupling could not be pulled because the valves would not seal off the pressure.

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS			
Location		**Reading (in/sec rms)**	**Below HI Limits?**
MOTOR	ODE-X	**0.075**	Yes
	ODE-Y	**0.058**	Yes
	ODE-Z	**0.073**	Yes
	DE-X	**0.153**	Yes
	DE-Y	**0.089**	Yes
PUMP	DE-X	**0.025**	Yes
	DE-Y	**0.014**	Yes
	ODE-X	**0.022**	Yes
	ODE-Y	**0.017**	Yes
	ODE-Z	**0.028**	Yes

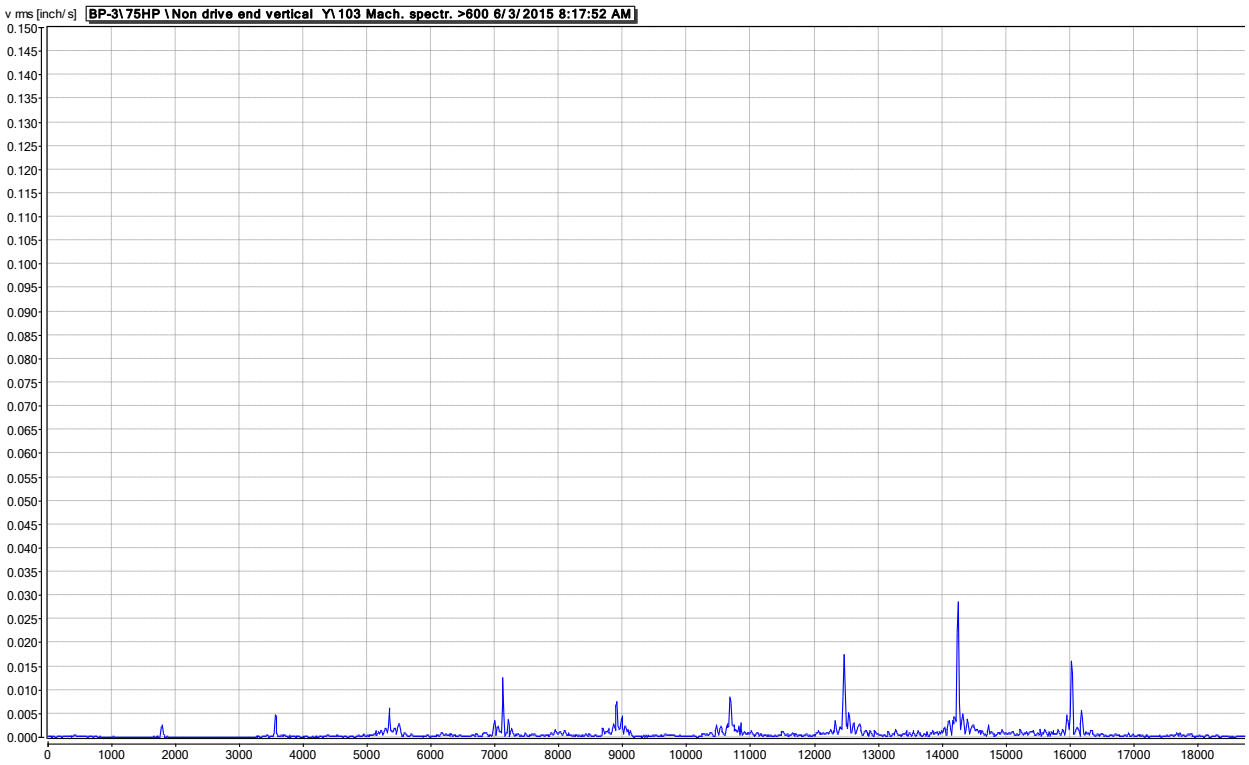


Figure 58: Motor ODE-Y Filtered Vibration, the highest peak is 0.029 in/sec at 14,246 cpm (8X run speed) with other peaks at 1X, 2X, 3X, 4X, 5X, 6X, 7X, and 9X

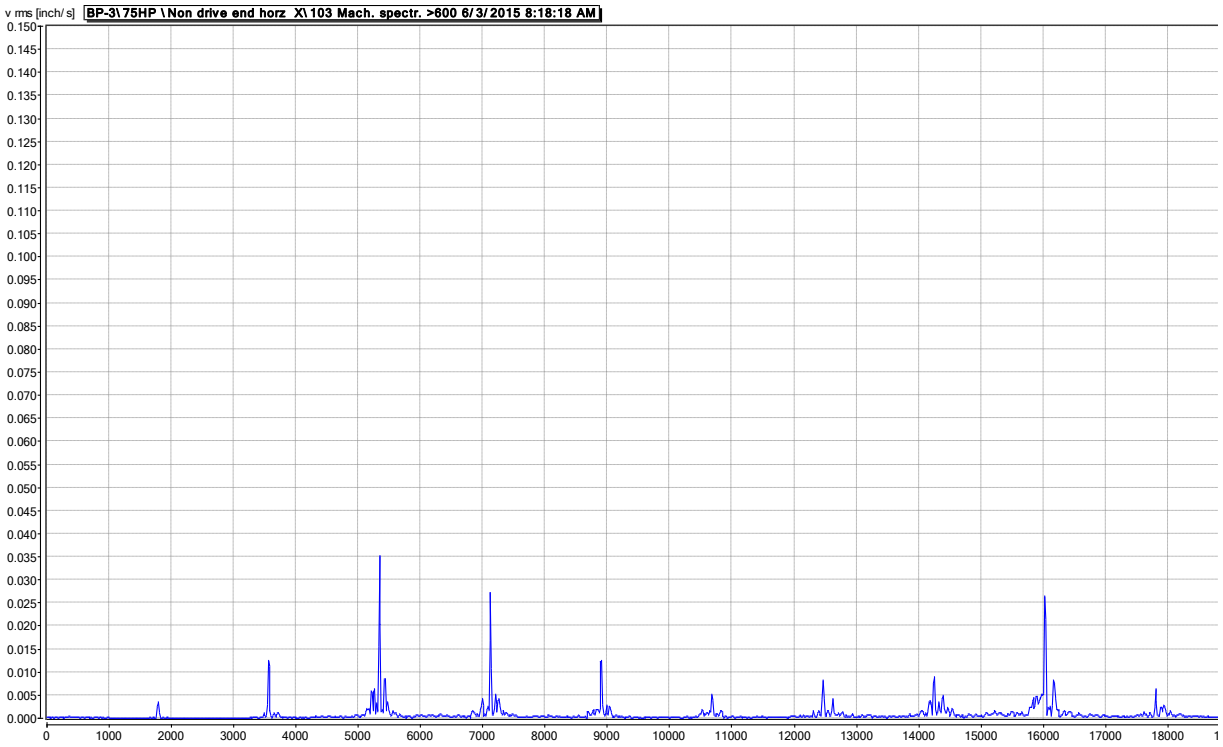


Figure 59: Motor ODE-X Filtered Vibration, the highest peak is 0.035 in/sec at 5,340 cpm (3X run speed) with other peaks at 1X, 2X, 4X, 5X, 6X, 7X, 8X, and 9X

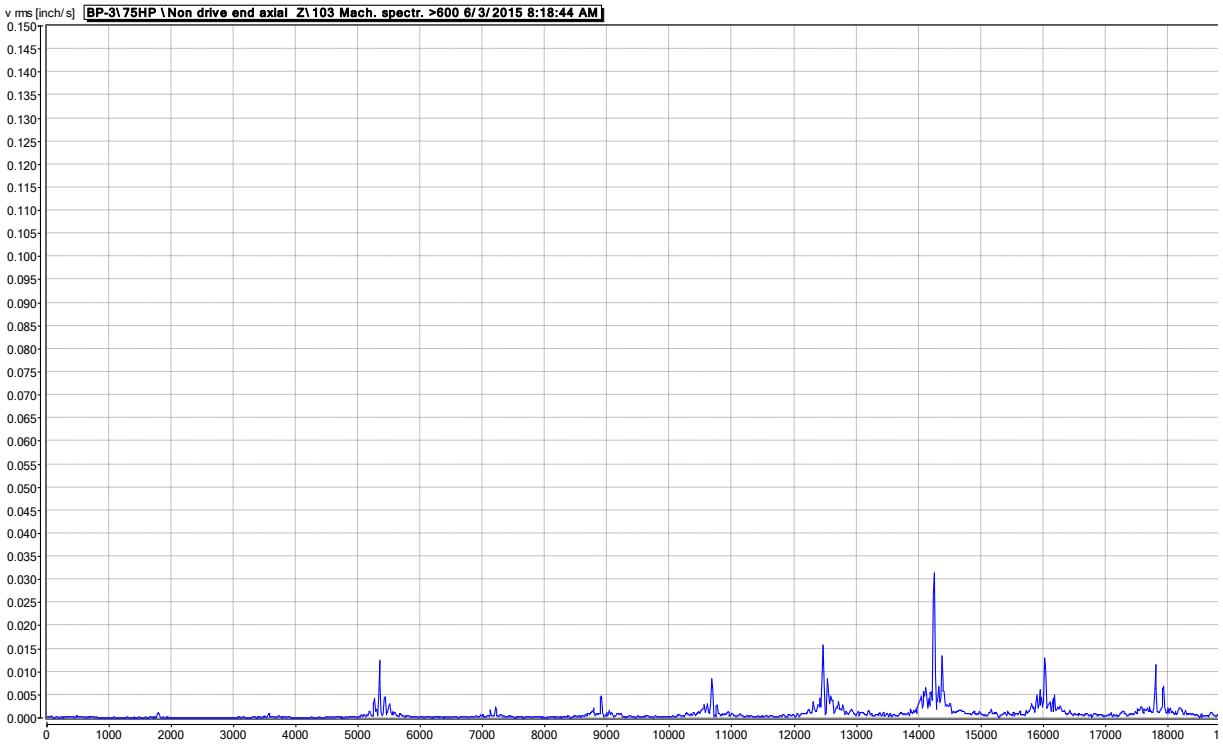


Figure 60: Motor ODE-Z Filtered Vibration, the highest peak is 0.032 in/sec at 14,242 cpm (8X run speed) with other peaks at 3X, 6X, 7X, 8X, 9X, 10X, 11X, and 12X

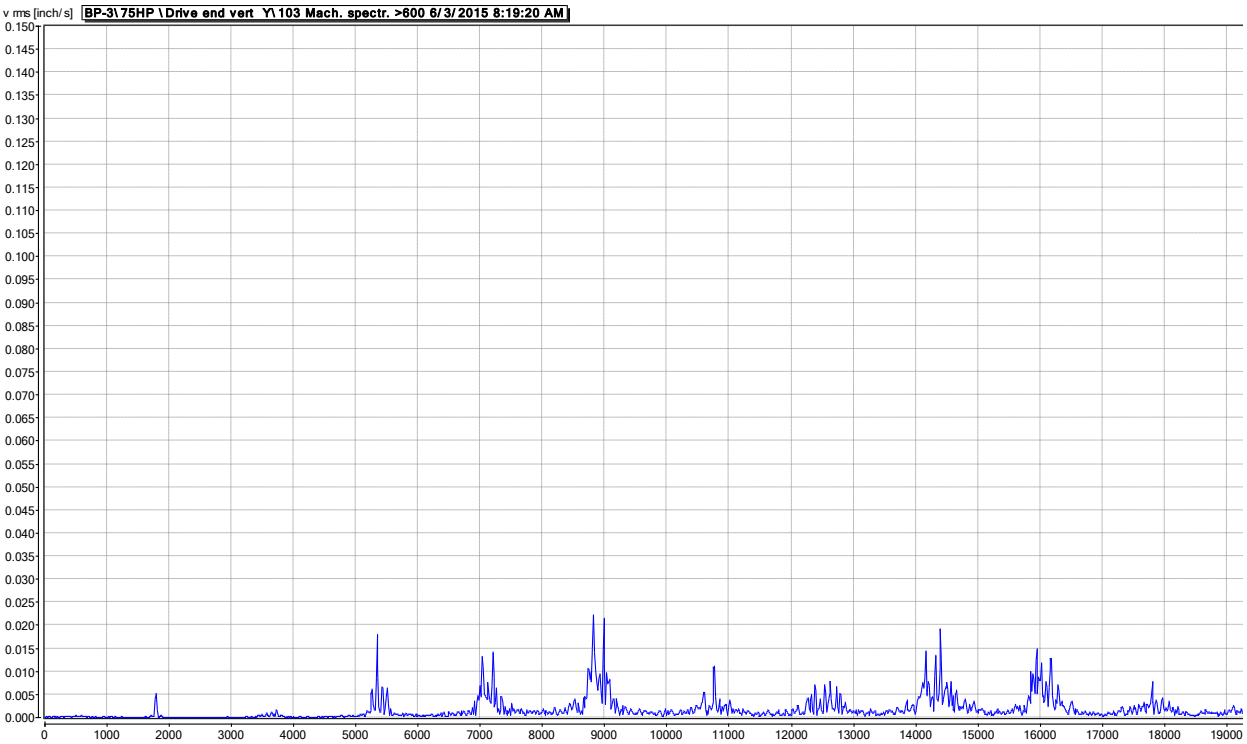


Figure 61: Motor DE-Y Filtered Vibration, highest peak is 0.022 in/sec at 8,816cpm (4.9X run speed) with other peaks at 1X, 3X, 4X, 6X, 7X, 8X, and 9X

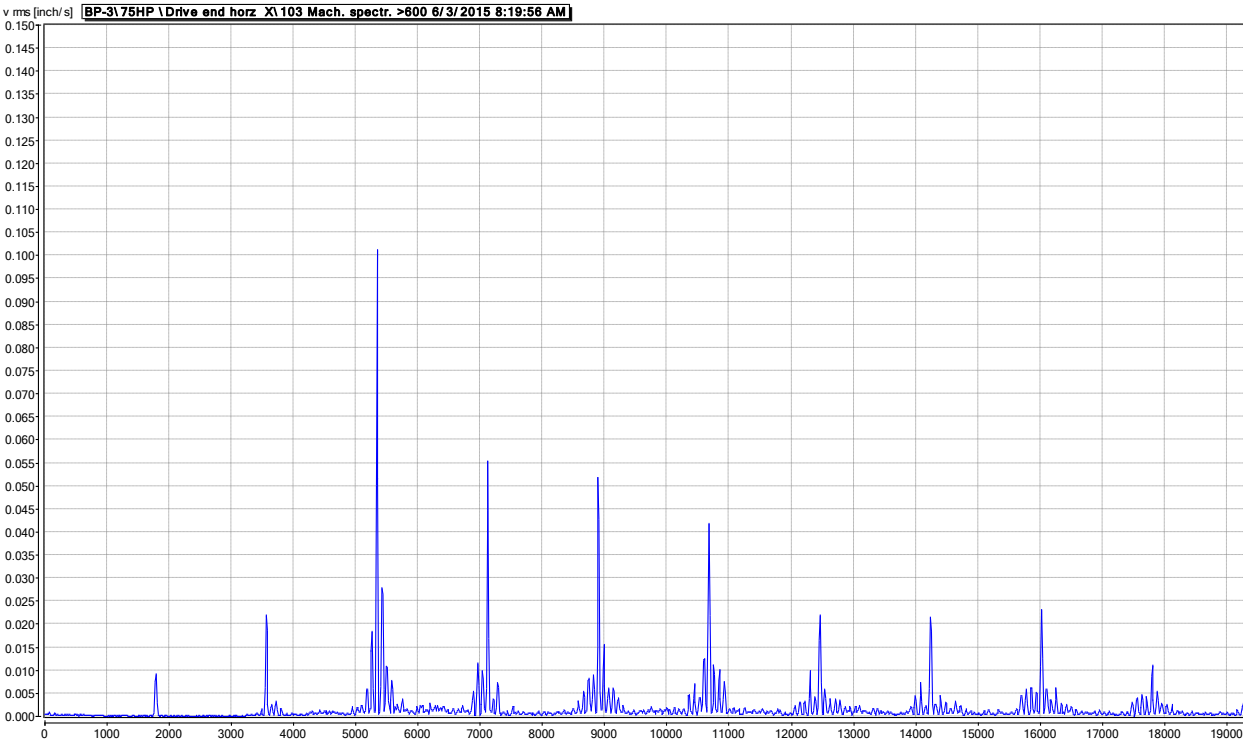


Figure 62: Motor DE-X Filtered Vibration, highest peak is 0.101 in/sec at 5,340 cpm (3X run speed) with other peaks at 1X, 2X, 4X, 5X, 6X, 7X, 8X, 9X, 10X, 11X, and 12X

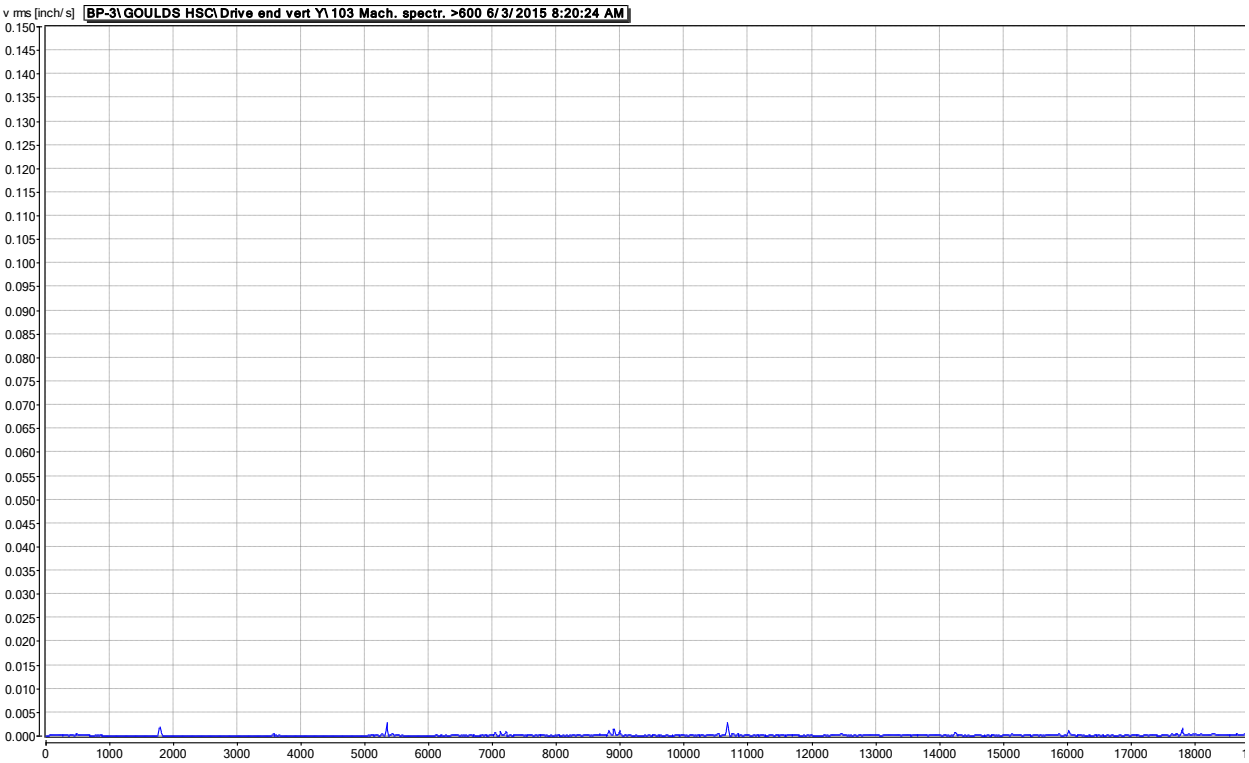


Figure 63: Pump DE-Y Filtered Vibration, all peaks are below 0.005 in/sec

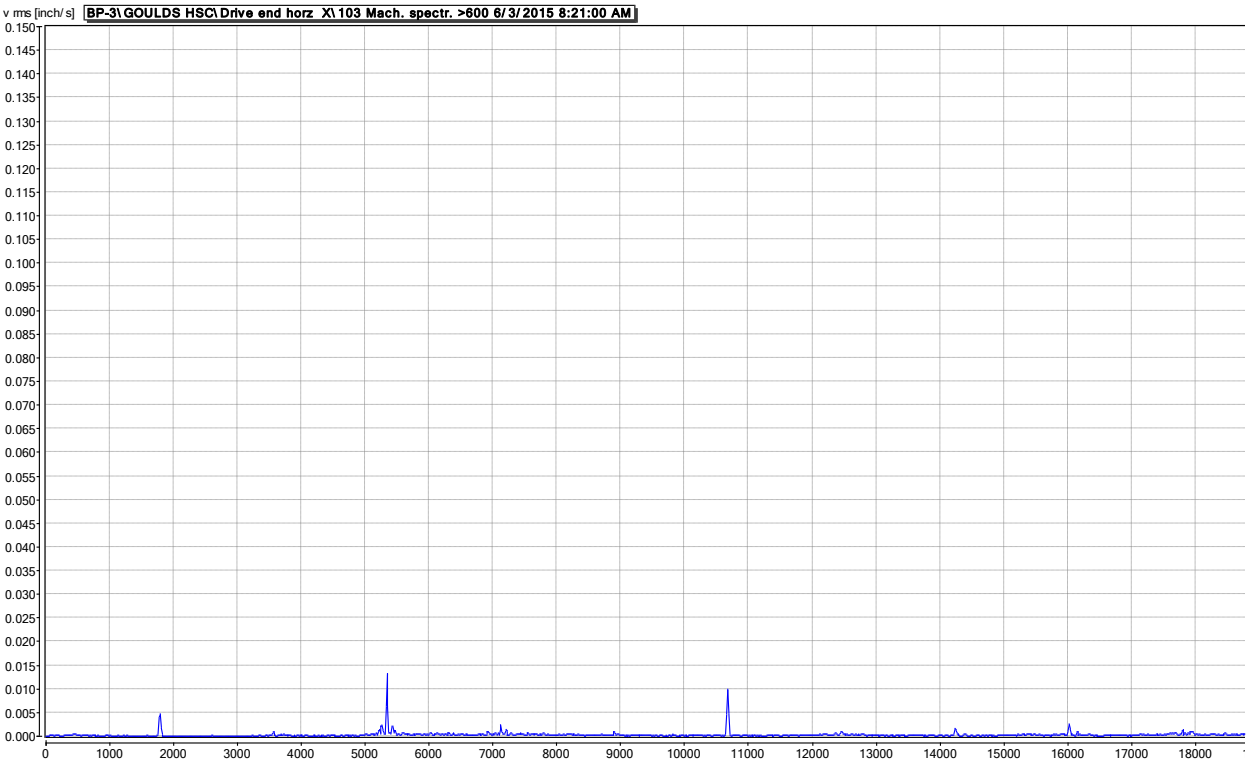


Figure 64: Pump DE-X Filtered Vibration, all peaks are below 0.015 in/sec

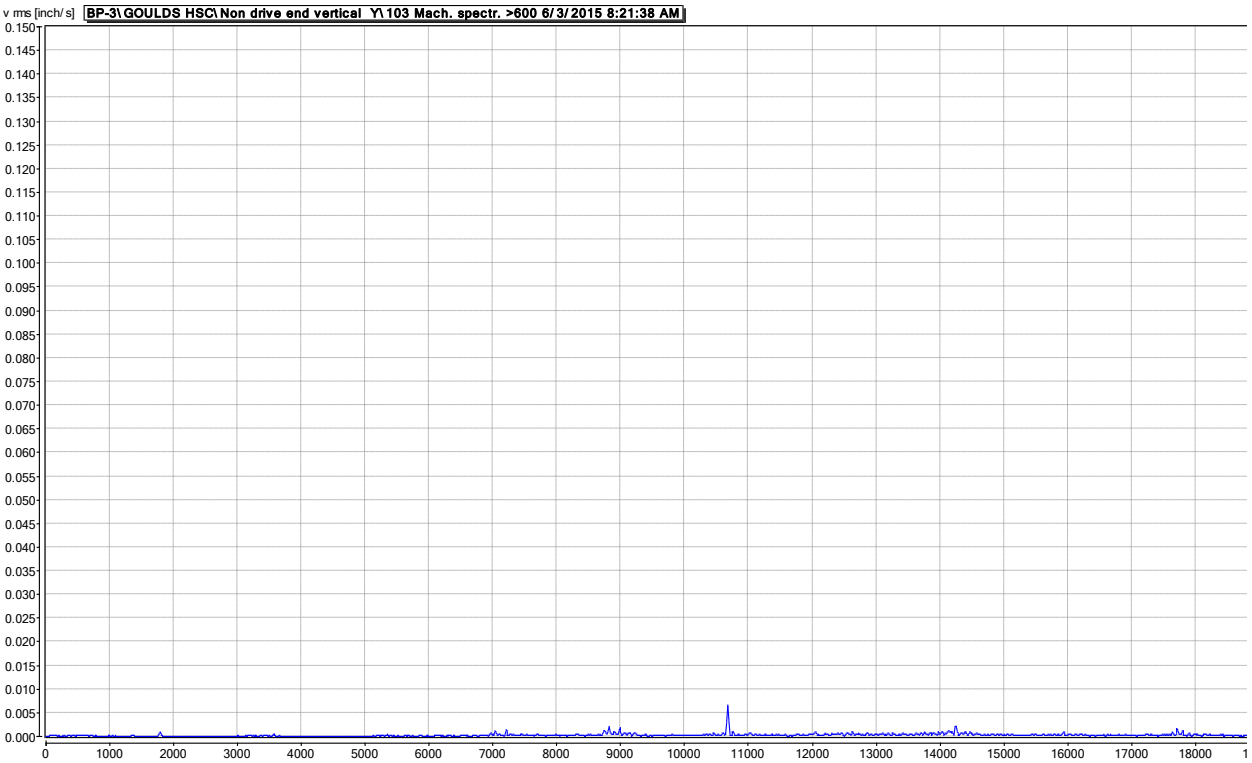


Figure 65: Pump ODE-Y Filtered Vibration, all peaks are below 0.010 in/sec

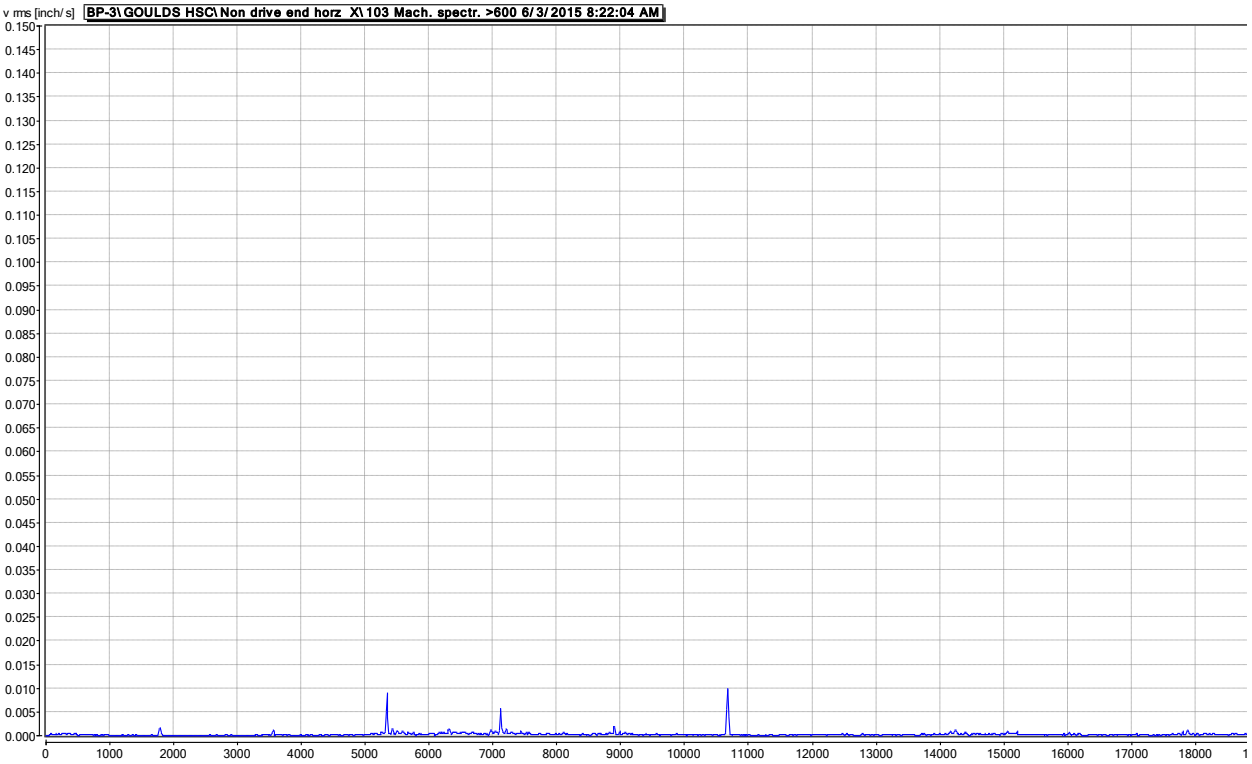


Figure 66: Pump ODE-X Filtered Vibration, all peaks are below 0.010 in/sec

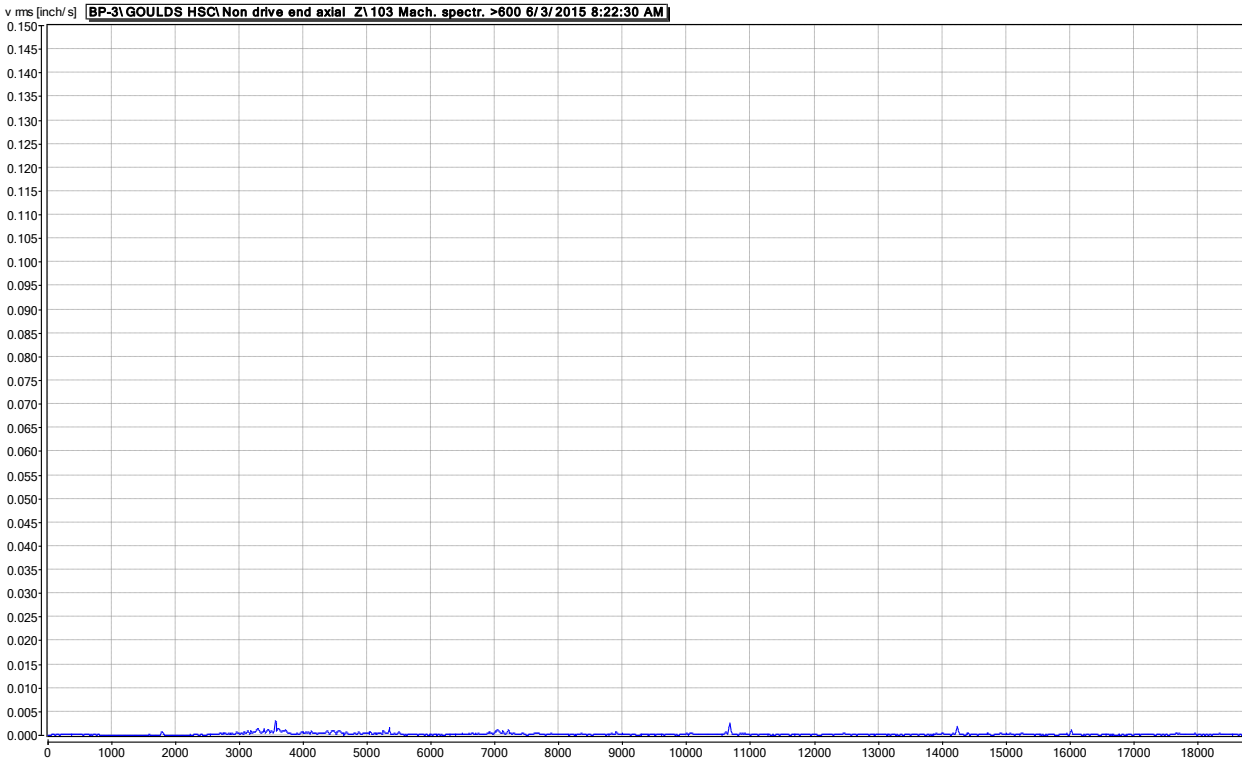


Figure 67: Pump ODE-Z Filtered Vibration, all peaks are below 0.005 in/sec

The motor vibration has peaks at 1X up to 12X consistently. This is an indication of looseness in the motor or bearings. The motor should be inspected soon.

The pump vibration is very low.

TEST DISCUSSIONS

HYDRAULIC OPERATION

- Discharge valve could not be placed on piping, no results

ELECTRICAL OPERATION

- No electrical data collected

MECHANICAL OPERATION

- Motor vibration is slightly above the HI limits with the highest vibration being 0.153 in/sec
- Pump vibration is well below the HI limits with the highest vibration being 0.028 in/sec rms
- This pump is still running very well

FIELD INSPECTION

TEST RESULTS

The alignment between the pump and motor shaft was measured. The vertical offset misalignment is 0.0001" and the angular misalignment is 0.0021". The horizontal offset misalignment is 0.0120" and the angular misalignment is 0.0473". The alignment needs to be corrected.

OTHER OBSERVATIONS

The eccentric reducer on the suction side of the pump is located too close to the pump, see Figure 47. This reducer should be positioned farther from the pump to ensure no cavitation or hydraulic issues.

BOOSTER PUMP #4

HYDRAULIC PERFORMANCE TESTING

TEST RESULTS

The coupling on the discharge piping was to be used for the discharge gage. The discharge and suction valves were closed but the pressure could not be relieved. The plug in the coupling could not be pulled because the valves would not seal off the pressure.

Below are the vibration readings recorded on this pump:

UNFILTERED VIBRATION READINGS			
Location		**Reading (in/sec rms)**	**Below HI Limits?**
MOTOR	ODE-X	**0.069**	Yes
	ODE-Y	**0.196**	No
	ODE-Z	**0.179**	No
	DE-X	**0.142**	Yes
	DE-Y	**0.098**	Yes
PUMP	DE-X	**0.139**	Yes
	DE-Y	**0.037**	Yes
	ODE-X	**0.052**	Yes
	ODE-Y	**0.030**	Yes
	ODE-Z	**0.080**	Yes

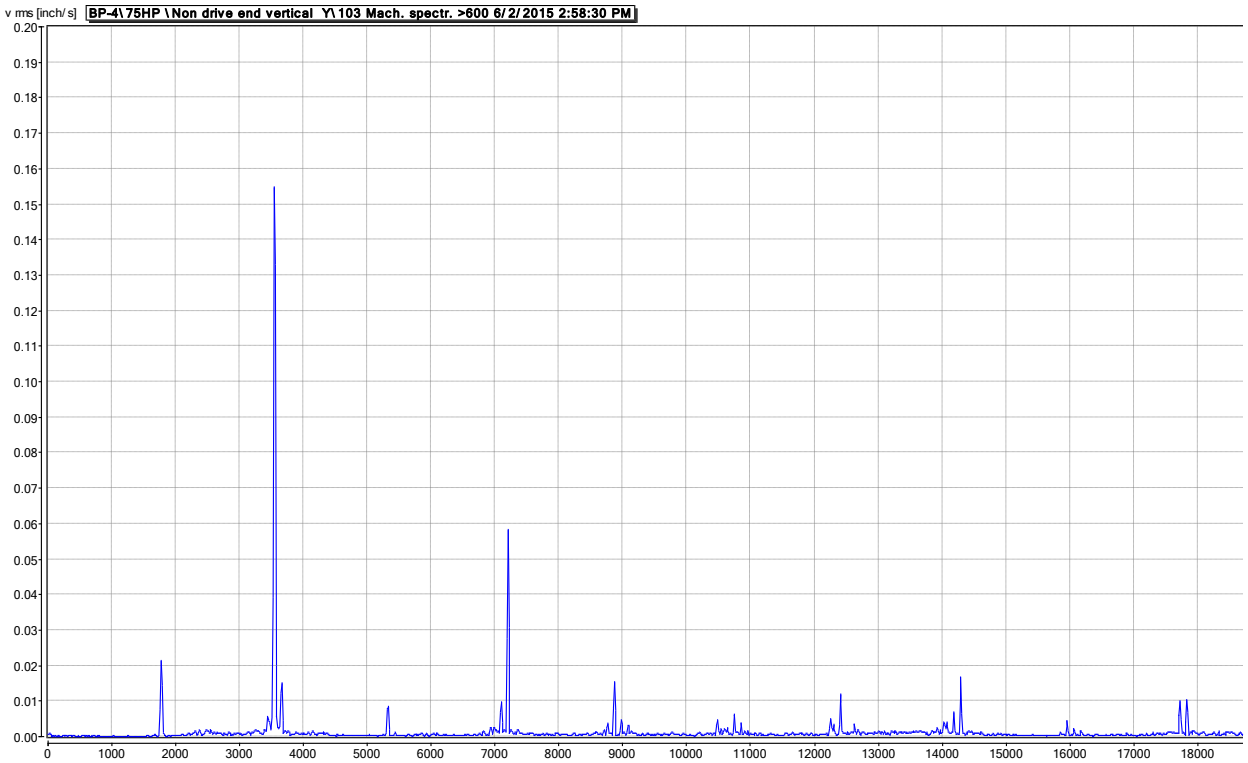


Figure 68: Motor ODE-Y Filtered Vibration, the highest peak is 0.155 in/sec at 3,548 cpm (2X run speed) with other peaks at 1X, 3X, 4X, 5X, 7X, and 8X

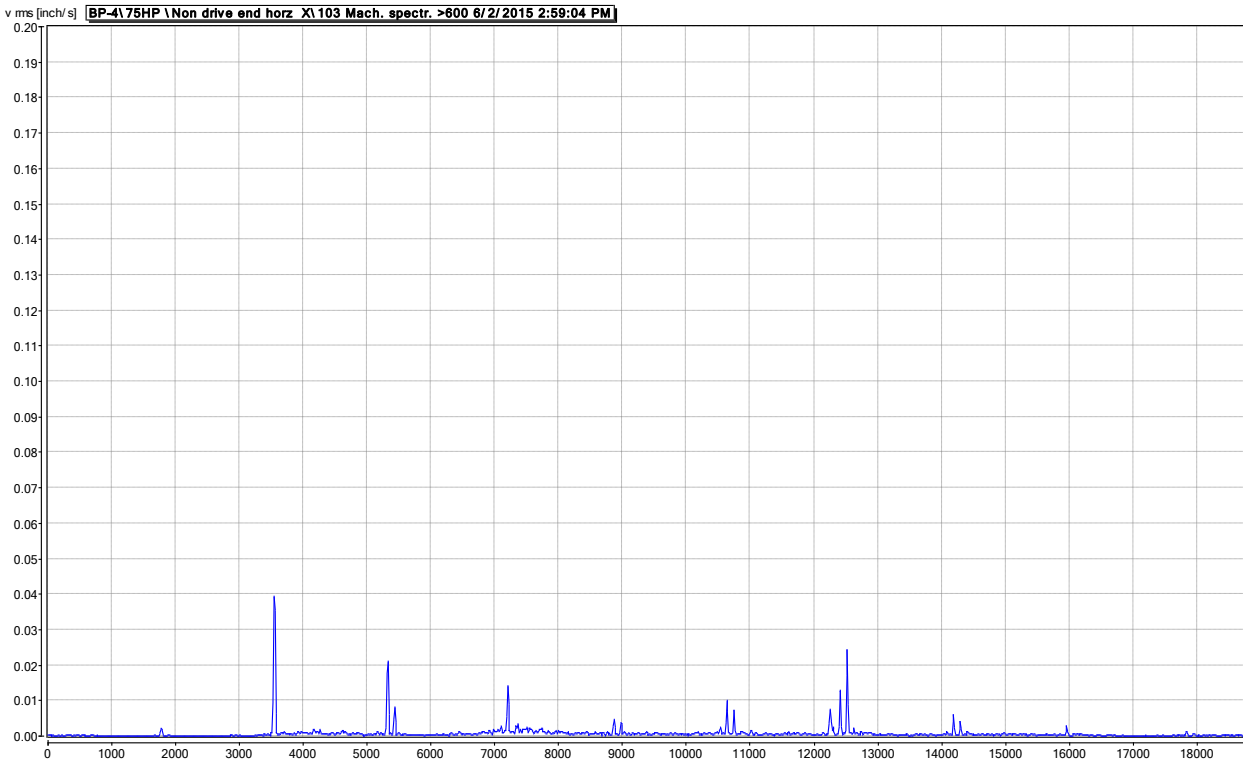


Figure 69: Motor ODE-X Filtered Vibration, the highest peak is 0.039 in/sec at 3,548 cpm (2X run speed) with other peaks at 3X, 4X, 6X, and 7X

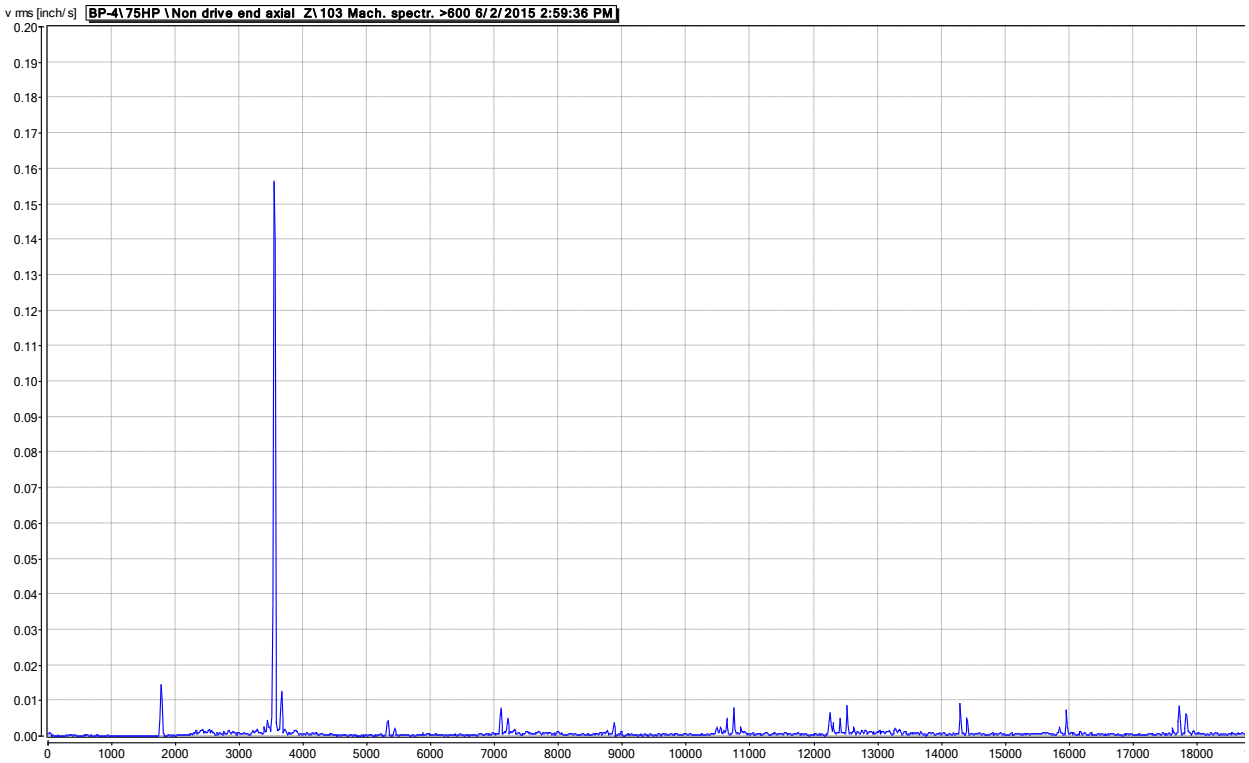


Figure 70: Motor ODE-Z Filtered Vibration, the highest peak is 0.157 in/sec at 3,548 cpm (2X run speed) with other peak at 1X

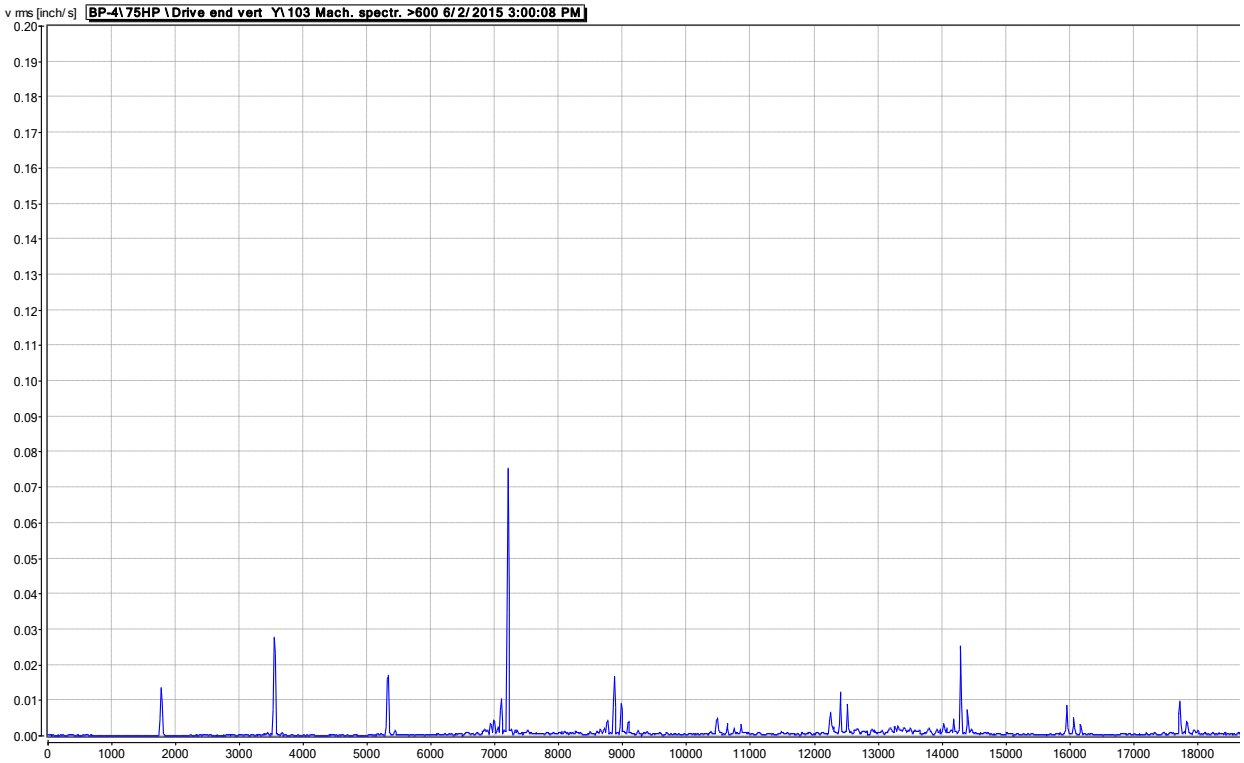


Figure 71: Motor DE-Y Filtered Vibration, highest peak is 0.075 in/sec at 7,200 cpm (4X run speed) with other peaks at 1X, 2X, 3X, 5X, 7X, and 8X

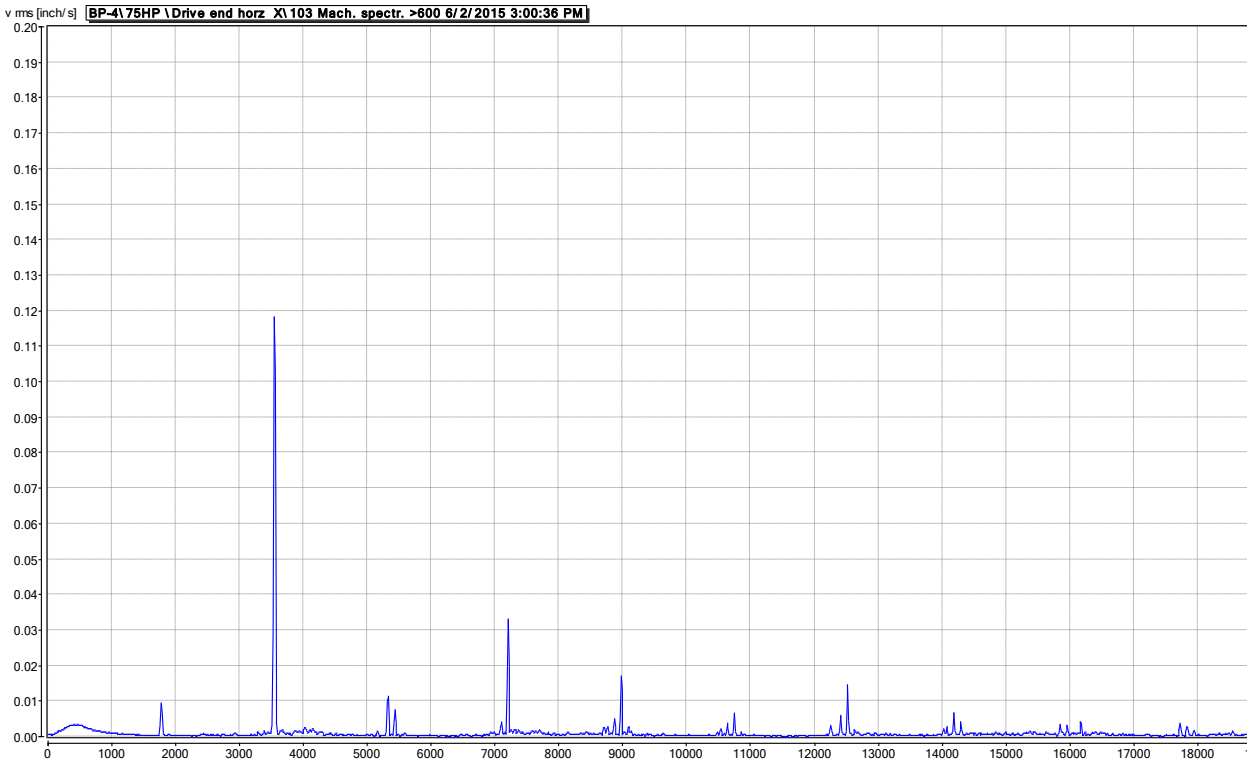


Figure 72: Motor DE-X Filtered Vibration, highest peak is 0.118 in/sec at 3,548 cpm (2X run speed) with other peaks at 1X, 3X, 4X, 5X, and 7X

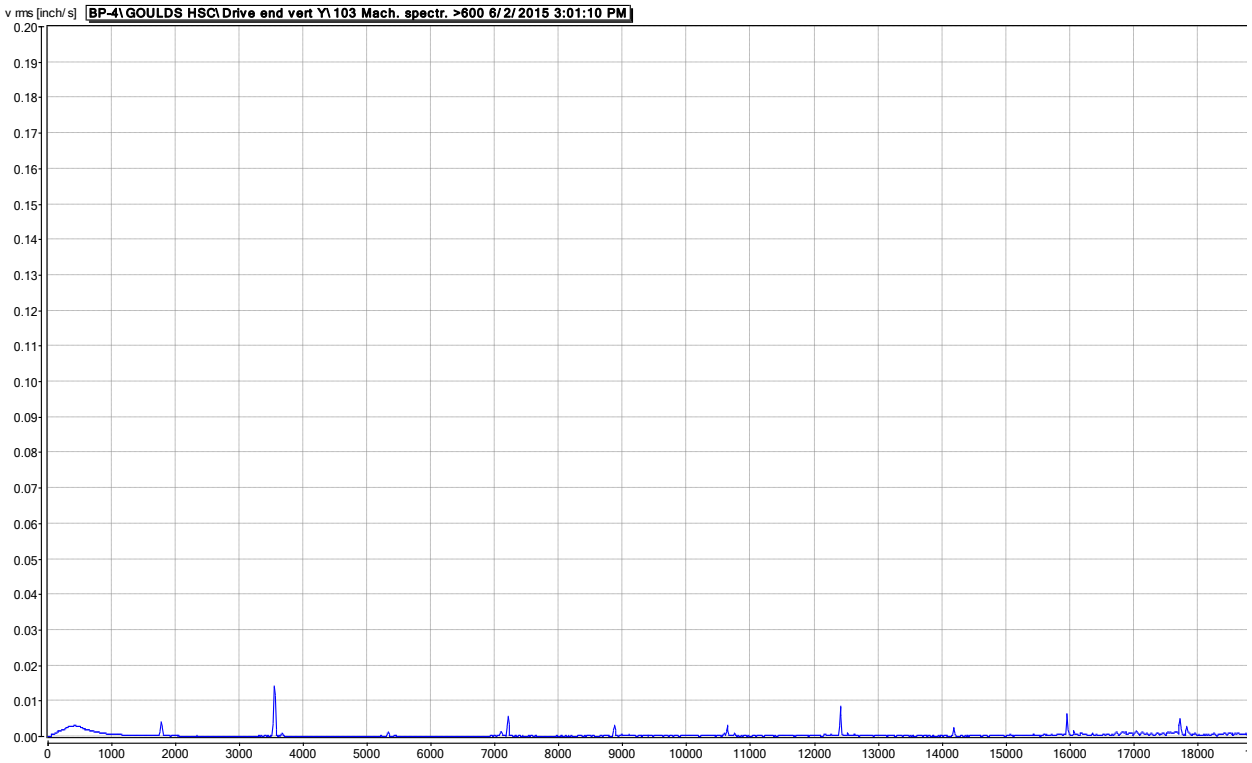


Figure 73: Pump DE-Y Filtered Vibration, all peaks are below 0.015 in/sec

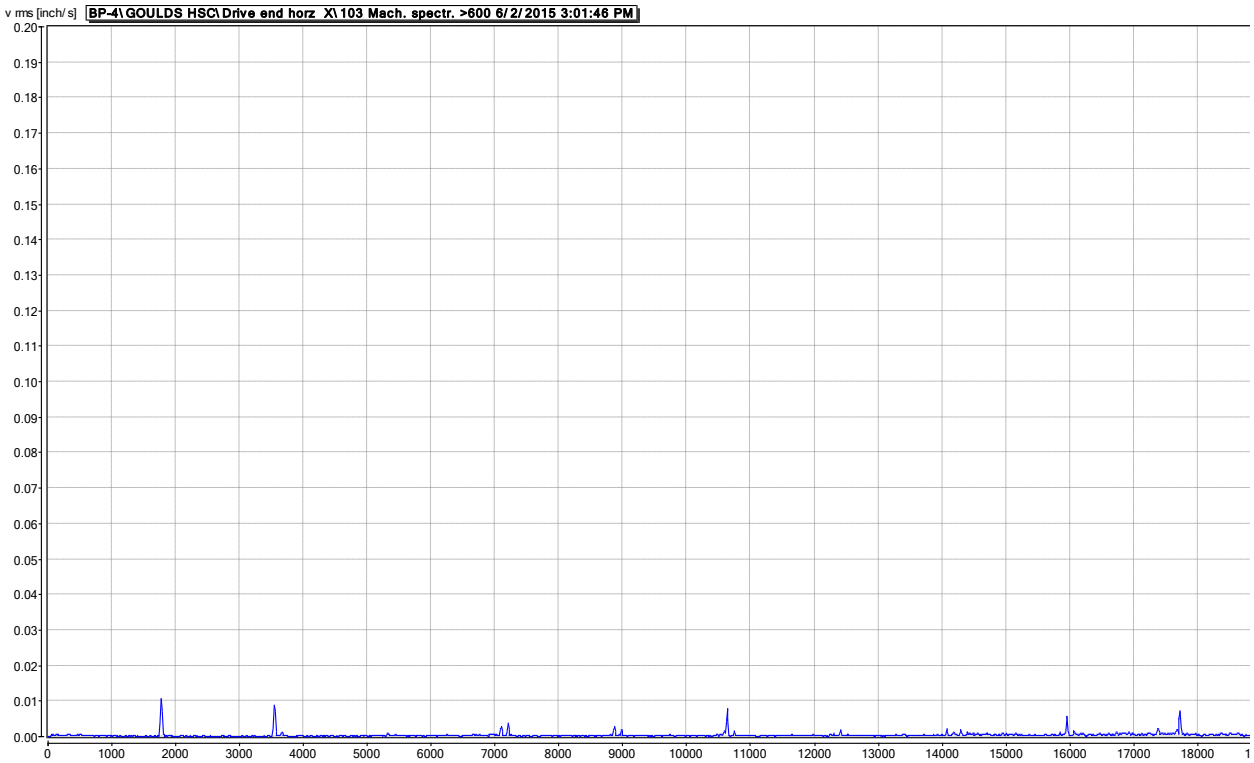


Figure 74: Pump DE-X Filtered Vibration, all peaks are below 0.015 in/sec

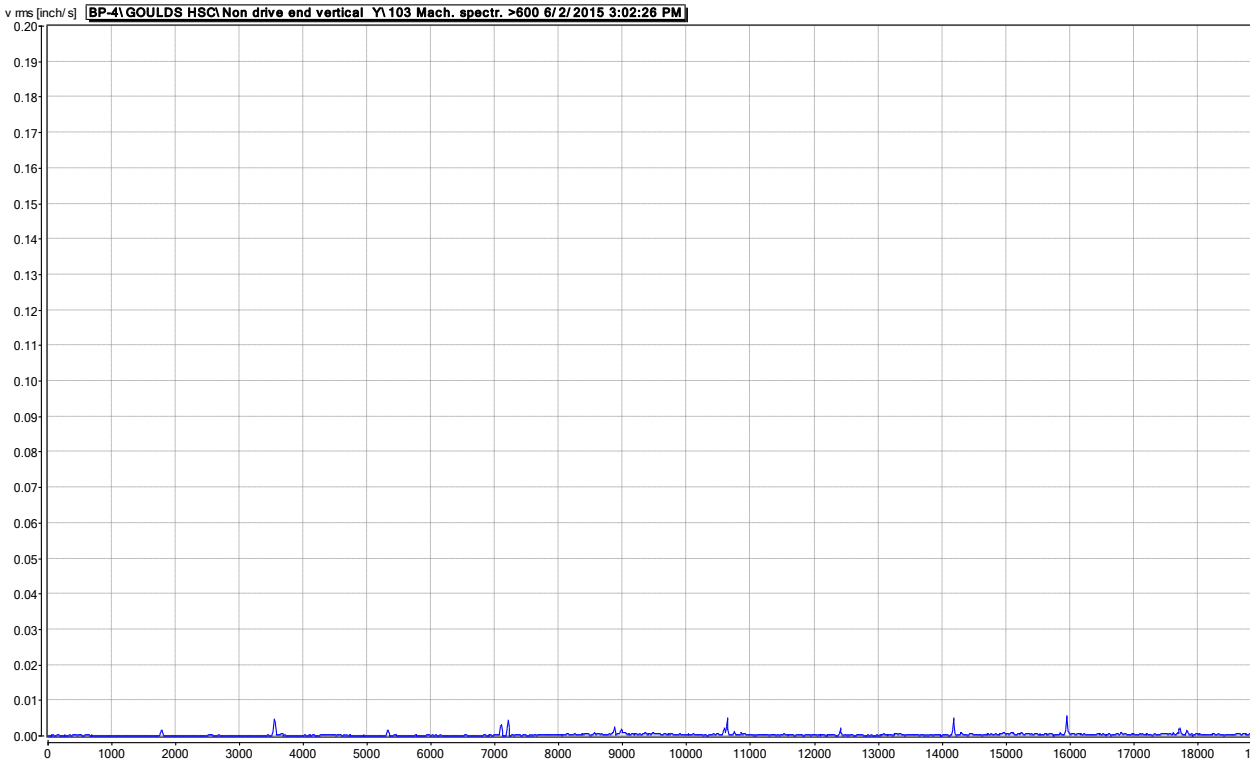


Figure 75: Pump ODE-Y Filtered Vibration, all peaks are below 0.010 in/sec

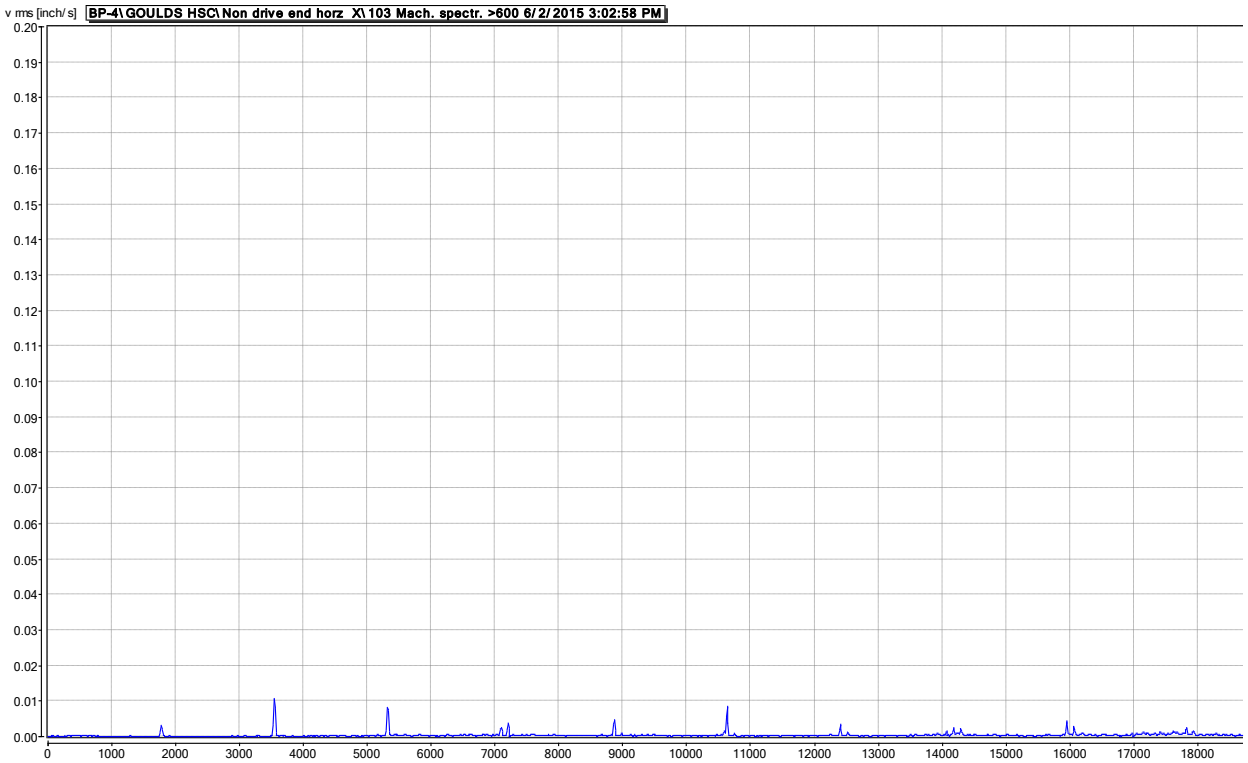


Figure 76: Pump ODE-X Filtered Vibration, all peaks are below 0.015 in/sec

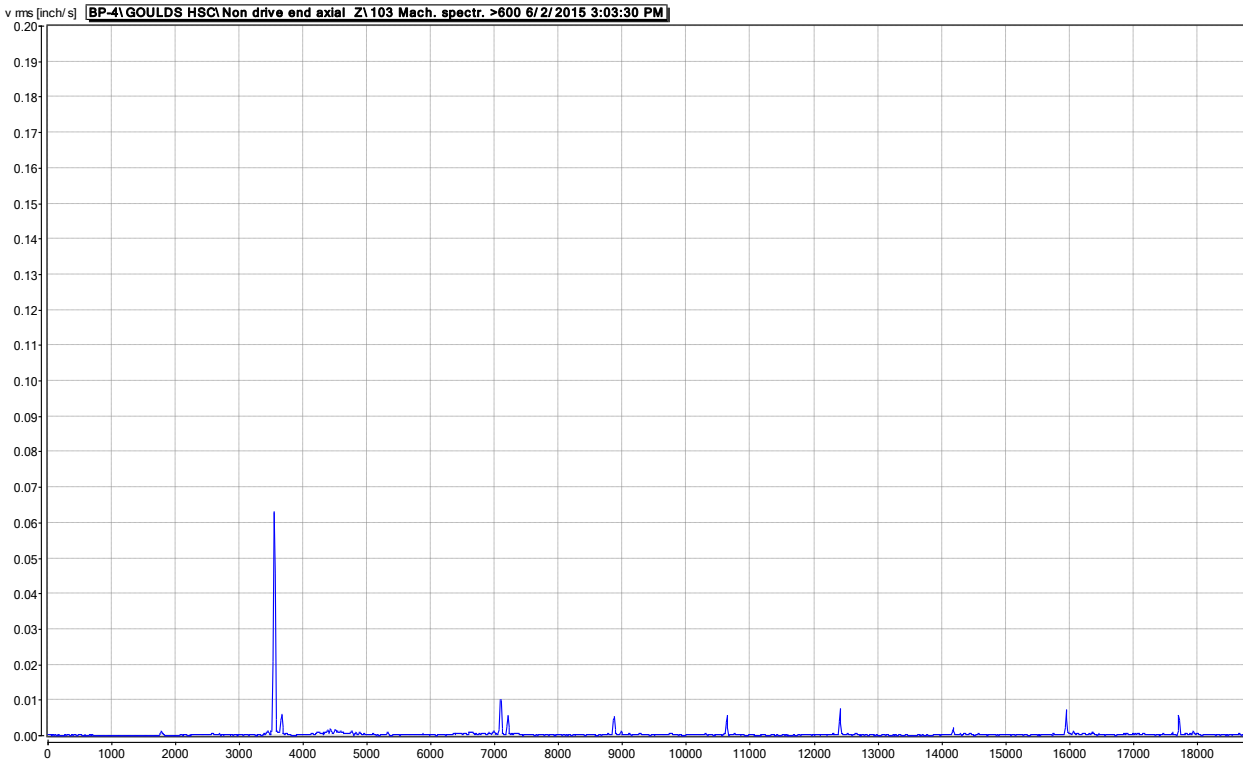


Figure 77: Pump ODE-Z Filtered Vibration, the highest peak is 0.063 in/sec at 3,548 cpm (2X run speed)

The motor vibration has peaks at 1X up to 7X consistently. This is an indication of looseness in the motor or bearings. The motor should be inspected soon.

The pump vibration is low and has a consistent vibration at 2X which is likely caused parallel and angular misalignment.

TEST DISCUSSIONS

HYDRAULIC OPERATION

- Discharge valve could not be placed on piping, no results

ELECTRICAL OPERATION

- No electrical data collected

MECHANICAL OPERATION

- Motor vibration is above the HI limits with the highest vibration being 0.196 in/sec
- Pump vibration is just below the HI limits with the highest vibration being 0.139 in/sec rms
- This pump is still running well but should be monitored for any increase in vibration

FIELD INSPECTION

TEST RESULTS

The alignment between the pump and motor shaft was measured. The vertical offset misalignment is 0.0077” and the angular misalignment is 0.0638”. The horizontal offset misalignment is 0.0037” and the angular misalignment is 0.0353”. The alignment needs to be corrected.

OTHER OBSERVATIONS

The eccentric reducer on the suction side of the pump is located too close to the pump, see Figure 47. This reducer should be positioned farther from the pump to ensure no cavitation or hydraulic issues.

REFERENCE DOCUMENTS

ITEM	DATE	DOCUMENT DESCRIPTION
APPENDIX A	6/2/2015	Old Booster PS, BP-1 Field Test Data
	6/2/2015	Old Booster PS, BP-2 Field Test Data
	6/1/2015	Old Booster PS, BP-3 Field Test Data
	6/1/2015	Old Booster PS, BP-4 Field Test Data
	6/2/2015	New Booster PS, BP-1 Field Test Data
	6/2/2015	New Booster PS, BP-2 Field Test Data
	6/3/2015	New Booster PS, BP-3 Field Test Data
	6/2/2015	New Booster PS, BP-4 Field Test Data
APPENDIX B	6/3/2015	New Booster PS, BP-1 Alignment Data
	6/3/2015	New Booster PS, BP-2 Alignment Data
	6/3/2015	New Booster PS, BP-3 Alignment Data
	6/3/2015	New Booster PS, BP-4 Alignment Data
APPENDIX C	N/A	Pump Catalog Curves
APPENDIX D	Various	Calibration Certificates

APPENDIX A

FIELD TESTING DATA

SMITH PUMP COMPANY, INC.

OLD BOOSTER PUMP STATION, BP-1

NAMEPLATE DATA

MOTOR:	USEM	**PUMP:**	LAYNE 12WMC
SERIAL NO.:	1216576	**SERIAL NO.:**	41376
RATED HP:	40 hp	**RATED FLOW:**	1,000 gpm
RATED SPEED:	1,785 rpm	**RATED HEAD:**	102' TDH
FLA:	49 A	**RATED SPEED:**	

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	1.4
DATE:	6/2/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	1.6
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	8.6
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	92.4%
STATION:	OLD PUMP STATION		

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START: 10:10 AM

TIME:	10:15 AM	10:30 AM				
RUN TIME (MIN):	5	20				
TARGE SPEED (RPM):	1,785	1,785	1,785	1,785	1,785	
FLOW METER (GPM):	1,136	1,115				
SUCTION PRESSURE (PSI):	8.5	8.3				
SUC. VELOCITY HEAD (FT):	0	0				
DISCH. PRESSURE (FT):	92	95				
DISCH. VELOCITY HEAD (FT):	0.61	0.59				
HEAD LOSS (FT)[1]:	0.00	0.00				
TDH (FT):	73	77				
SPEED (RPM):	1,788	1,787				
L1-L2 VOLTAGE (V):	484	480				
L2-L3 VOLTAGE (V):	488	484				
L3-L1 VOLTAGE (V):	482	479				
L1 CURRENT (AMPS):	31	31				
L2 CURRENT (AMPS):	34	34				
L3 CURRENT (AMPS):	31	31				
POWER FACTOR:	0.75	0.75				
INPUT POWER (HP):	30	30				
SHAFT POWER (HP):	28	28				
BOWL POWER (HP):	21	22				
CORRECTED FLOW (GPM):	1,134	1,114				
CORRECTED TDH (FT):	73	76				
CORRECTED INPUT PWR (HP):	28	28				
CORRECTED BOWL PWR (HP):	21	21				
PUMP EFFICIENCY (%)	74.9	76.9				
TEMPERATURE (°C)						
HOTTEST STATOR (RTD 1-9)						
UPPER BRG. (RTD 10)						
LOWER BRG. (RTD 11)						
VIBRATION (IN/SEC RMS)						
MT-0	0.918	0.885				
MT-90	0.359	0.357				
MT-VERTICAL	0.085	0.083				
MB-0	0.707	0.684				
MB-90	0.221	0.238				
OTHER:						

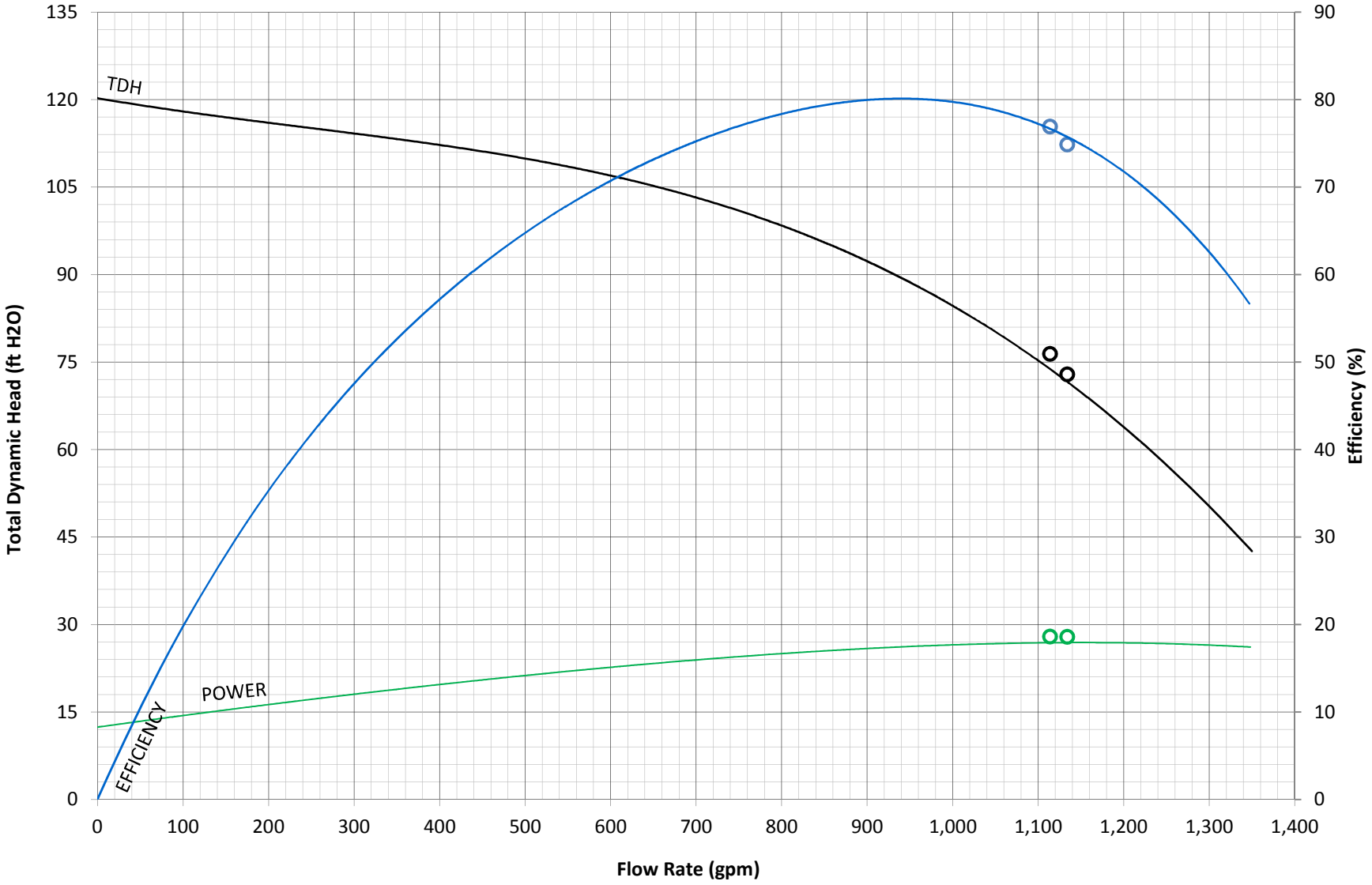
NOTES:

1 - PIPE PLANS NOT AVAILABLE FOR SUCTION SIDE OF PUMP, HEAD LOSS ESTIMATED

2 -

3 -

CITY OF HUNTSVILLE, OLD BOOSTER PUMP STATION
Booster Pump #1 Field Performance Test



SMITH PUMP COMPANY, INC.

OLD BOOSTER PUMP STATION, BP-2

NAMEPLATE DATA

MOTOR:	USEM	**PUMP:**	LAYNE 12WMC
SERIAL NO.:	1216577	**SERIAL NO.:**	41377
RATED HP:	40 hp	**RATED FLOW:**	1,000 gpm
RATED SPEED:	1,785 rpm	**RATED HEAD:**	102' TDH
FLA:	49 A	**RATED SPEED:**	

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	1.4
DATE:	6/2/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	1.6
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	14.7
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	92.4%
STATION:	OLD PUMP STATION		

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START: 9:15

TIME:	9:18 AM	9:34 AM				
RUN TIME (MIN):						
TARGE SPEED (RPM):	1,785	1,785	1,785	1,785	1,785	
FLOW METER (GPM):	1,131	1,137				
SUCTION PRESSURE (PSI):	8.4	8.4				
SUC. VELOCITY HEAD (FT):	0	0				
DISCH. PRESSURE (FT):	95	95				
DISCH. VELOCITY HEAD (FT):	0.07	0.07				
HEAD LOSS (FT):	0.00	0.00				
TDH (FT):	76	76				
SPEED (RPM):	1,782	1,787				
L1-L2 VOLTAGE (V):	486	486				
L2-L3 VOLTAGE (V):	489	490				
L3-L1 VOLTAGE (V):	485	485				
L1 CURRENT (AMPS):	30	30				
L2 CURRENT (AMPS):	33	33				
L3 CURRENT (AMPS):	30	30				
POWER FACTOR:	0.74	0.74				
INPUT POWER (HP):	30	29				
SHAFT POWER (HP):	27	27				
BOWL POWER (HP):	22	22				
CORRECTED FLOW (GPM):	1,133	1,136				
CORRECTED TDH (FT):	76	76				
CORRECTED INPUT PWR (HP):	27	27				
CORRECTED BOWL PWR (HP):	22	22				
PUMP EFFICIENCY (%)	79.6	80.5				
TEMPERATURE (°C)						
HOTTEST STATOR (RTD 1-9)						
UPPER BRG. (RTD 10)						
LOWER BRG. (RTD 11)						
VIBRATION (IN/SEC RMS)						
MT-0	0.281	0.297				
MT-90	0.070	0.068				
MT-VERTICAL	0.043	0.043				
MB-0	0.224	0.225				
MB-90	0.046	0.047				
OTHER:						

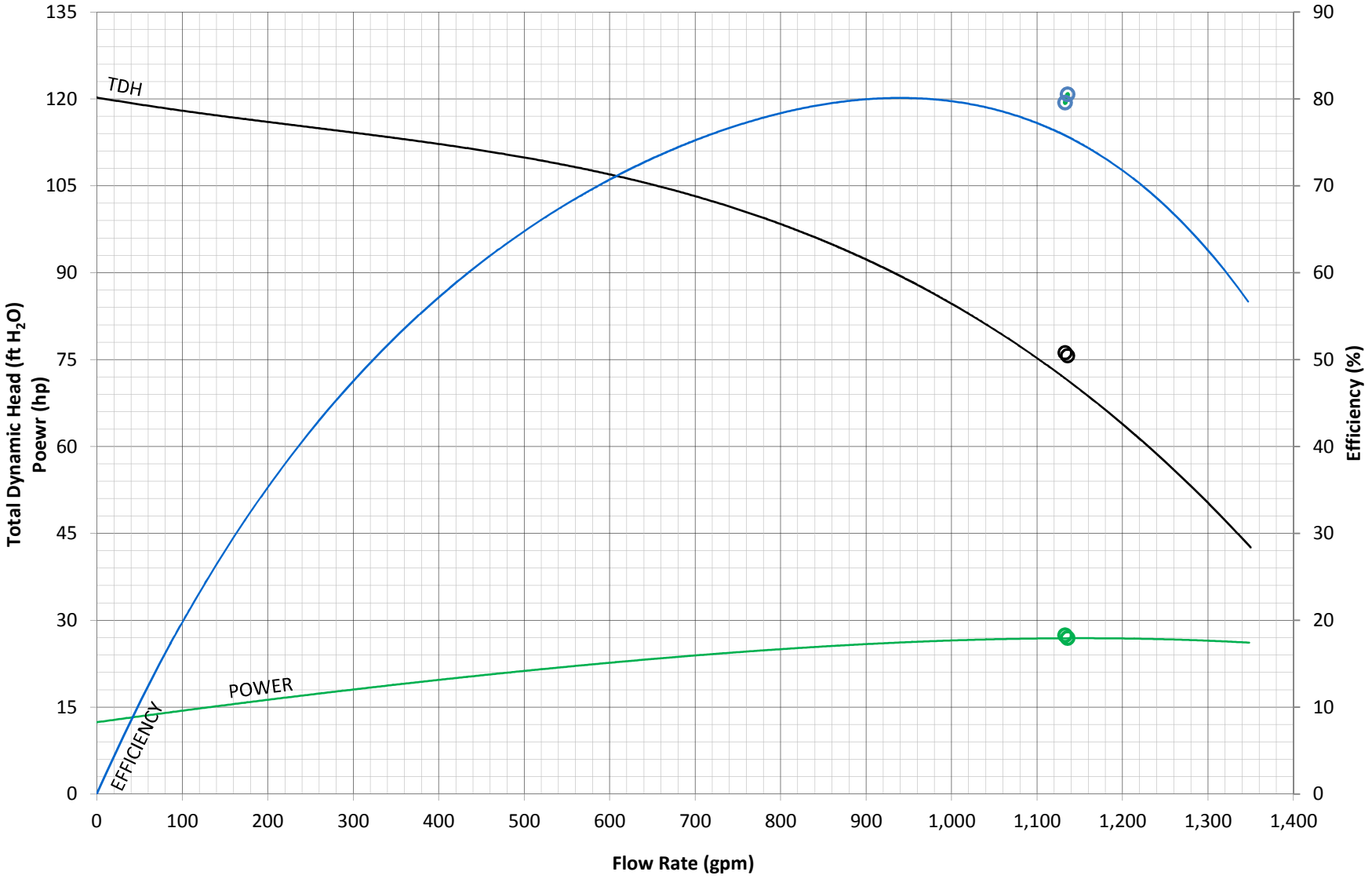
NOTES:

1 -

2 -

3 -

CITY OF HUNTSVILLE, OLD PUMP STATION
Booster Pump #2 Field Performance Test



SMITH PUMP COMPANY, INC.

OLD BOOSTER PUMP STATION, BP-3

NAMEPLATE DATA

MOTOR:	USEM	**PUMP:**	LAYNE 12THC
SERIAL NO.:	T06-391397-0001-GT-01	**SERIAL NO.:**	41378
RATED HP:	75 hp	**RATED FLOW:**	2,000 gpm
RATED SPEED:	1,785 rpm	**RATED HEAD:**	108' TDH
FLA:	90.7 A	**RATED SPEED:**	

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	1.4
DATE:	6/1/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	1.6
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	14.7
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	92.4%
STATION:	OLD PUMP STATION		

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

	START:	2:10 PM
TIME:	2:20 PM	2:35 PM
RUN TIME (MIN):	10	25
TARGE SPEED (RPM):	1,785	1,785
FLOW METER (GPM):	2,340	2,260
SUCTION PRESSURE (PSI):	9.3	9.7
SUC. VELOCITY HEAD (FT):	0	0
DISCH. PRESSURE (FT):	96	97
DISCH. VELOCITY HEAD (FT):	0.30	0.28
HEAD LOSS (FT):	0.00	0.00
TDH (FT):	75	75
SPEED (RPM):	1,790	1,791
L1-L2 VOLTAGE (V):	478	481
L2-L3 VOLTAGE (V):	476	486
L3-L1 VOLTAGE (V):	482	480
L1 CURRENT (AMPS):	72	72
L2 CURRENT (AMPS):	81	81
L3 CURRENT (AMPS):	74	75
POWER FACTOR:	0.67	0.67
INPUT POWER (HP):	64	64
SHAFT POWER (HP):	59	59
BOWL POWER (HP):	44	43
CORRECTED FLOW (GPM):	2,333	2,252
CORRECTED TDH (FT):	75	75
CORRECTED INPUT PWR (HP):	58	58
CORRECTED BOWL PWR (HP):	44	42
PUMP EFFICIENCY (%)	75.4	72.9
TEMPERATURE (°C)		
HOTTEST STATOR (RTD 1-9)		
UPPER BRG. (RTD 10)		
LOWER BRG. (RTD 11)		
VIBRATION (IN/SEC RMS)		
MT-0	0.181	0.189
MT-90	0.061	0.080
MT-VERTICAL	0.048	0.037
MB-0	0.084	0.129
MB-90	0.034	0.036
OTHER:		

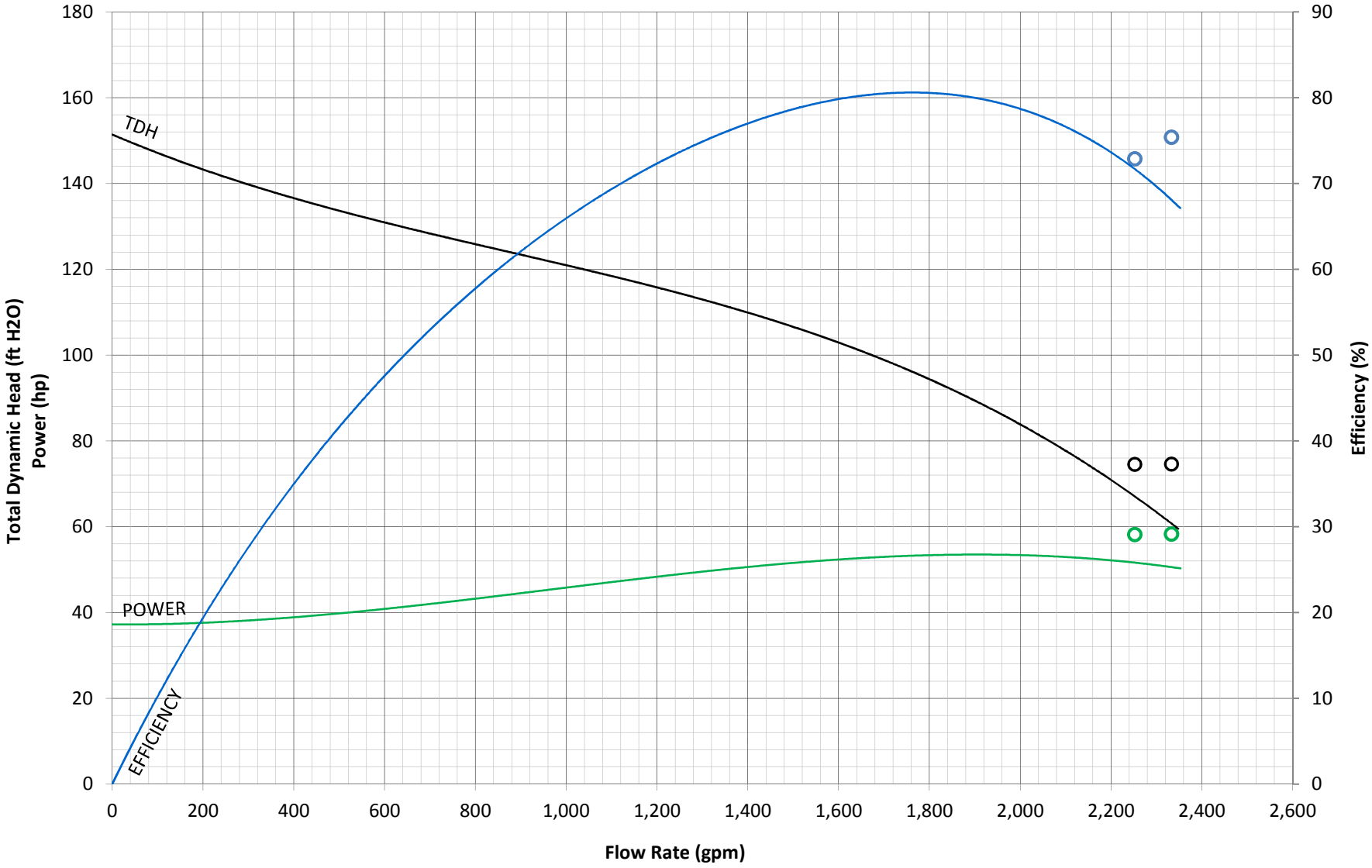
NOTES:

1 -

2 -

3 -

CITY OF HUNTSVILLE, OLD PUMP STATION
Booster Pump #3 Field Performance Test



SMITH PUMP COMPANY, INC.

OLD BOOSTER PUMP STATION, BP-4

NAMEPLATE DATA

MOTOR:	USEM	**PUMP:**	LAYNE 12THC
SERIAL NO.:	1216527	**SERIAL NO.:**	41379
RATED HP:	75 hp	**RATED FLOW:**	2,000 gpm
RATED SPEED:	1,785 rpm	**RATED HEAD:**	108' TDH
FLA:	90.7 A	**RATED SPEED:**	

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	1.4
DATE:	6/1/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	1.6
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	14.7
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	92.4%
STATION:	OLD PUMP STATION		

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

	START:	10:45 AM
TIME:	11:10 AM	11:55 AM
RUN TIME (MIN):	25	70
TARGE SPEED (RPM):	1,785	1,785
FLOW METER (GPM):	2,400	2,445
SUCTION PRESSURE (PSI):	10.0	9.8
SUC. VELOCITY HEAD (FT):	0	0
DISCH. PRESSURE (FT):	94	94
DISCH. VELOCITY HEAD (FT):	0.32	0.33
HEAD LOSS (FT):	0.00	0.00
TDH (FT):	71	72
SPEED (RPM):	1,785	1,788
L1-L2 VOLTAGE (V):	486	486
L2-L3 VOLTAGE (V):	482	480
L3-L1 VOLTAGE (V):	480	481
L1 CURRENT (AMPS):	62	62
L2 CURRENT (AMPS):	67	68
L3 CURRENT (AMPS):	62	61
POWER FACTOR:	0.87	0.87
INPUT POWER (HP):	64	64
SHAFT POWER (HP):	59	59
BOWL POWER (HP):	43	44
CORRECTED FLOW (GPM):	2,400	2,441
CORRECTED TDH (FT):	71	72
CORRECTED INPUT PWR (HP):	59	58
CORRECTED BOWL PWR (HP):	43	44
PUMP EFFICIENCY (%)	73.6	75.5
TEMPERATURE (°C)		
HOTTEST STATOR (RTD 1-9)		
UPPER BRG. (RTD 10)		
LOWER BRG. (RTD 11)		
VIBRATION (IN/SEC RMS)		
MT-0	0.371	0.383
MT-90	0.328	0.298
MT-VERTICAL	0.103	0.099
MB-0	0.246	0.255
MB-90	0.184	0.171
OTHER:		

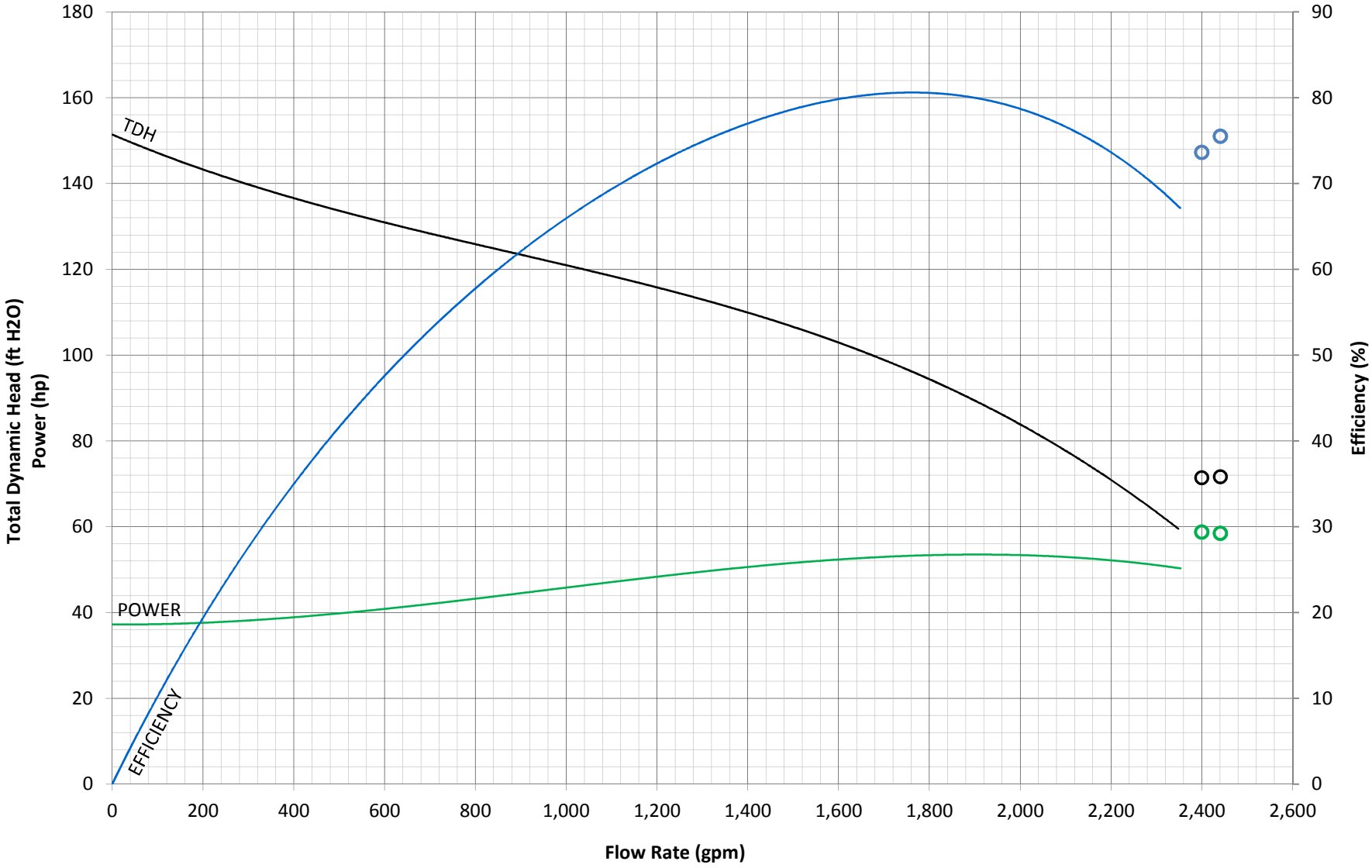
NOTES:

1 -

2 -

3 -

CITY OF HUNTSVILLE, OLD PUMP STATION
Booster Pump #4 Field Performance Test



SMITH PUMP COMPANY, INC.

NEW BOOSTER PUMP STATION, BP-1

NAMEPLATE DATA

MOTOR:	SIEMENS	**PUMP:**	GOULDS 3405, 6x8x12
SERIAL NO.:	51-380-561 LR68761-1	**SERIAL NO.:**	250B662
RATED HP:	50	**RATED FLOW:**	1,400
RATED SPEED:	1,770	**RATED HEAD:**	110
FLA:	58.5	**RATED SPEED:**	1,800

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	0.0
DATE:	6/2/2015	**PIPE I.D. AT SUC. GAGE (IN):**	12.6
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	1.7
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	10.6
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	93.0% (1)
STATION:	NEW PUMP STATION		

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START: 1:45 PM

	TIME:	2:00 PM	2:22 PM					
	RUN TIME (MIN):	15	37					
	TARGE SPEED (RPM):	1,750	1,750	1,750	1,750	1,750	1,750	
	FLOW METER (GPM):	1,800	1,840					
	SUCTION PRESSURE (PSI):	9.9	10.1					
	SUC. VELOCITY HEAD (FT):	0.33	0.34					
	DISCH. PRESSURE (FT):	92	91					
	DISCH. VELOCITY HEAD (FT):	0.67	0.70					
	HEAD LOSS (FT):	0.00	0.00					
	TDH (FT):	71	70					
	SPEED (RPM):	1,767	1,767					
	L1-L2 VOLTAGE (V):	481	481					
	L2-L3 VOLTAGE (V):	478	474					
	L3-L1 VOLTAGE (V):	475	488					
	L1 CURRENT (AMPS):	65	66					
	L2 CURRENT (AMPS):	65	65					
	L3 CURRENT (AMPS):	61	61					
	POWER FACTOR:	0.89	0.87					
	INPUT POWER (HP):	56	56					
	SHAFT POWER (HP):	52	52					
	BOWL POWER (HP):	32	32					
	CORRECTED FLOW (GPM):	1,783	1,822					
	CORRECTED TDH (FT):	70	68					
	CORRECTED INPUT PWR (HP):	51	51					
	CORRECTED BOWL PWR (HP):	31	31					
	PUMP EFFICIENCY (%)	62.1	62.2					
	TEMPERATURE (°C)							
	HOTTEST STATOR (RTD 1-9)							
	UPPER BRG. (RTD 10)							
	LOWER BRG. (RTD 11)							
	VIBRATION (IN/SEC RMS)							
MOTOR	**ODE-X**	0.044	0.037					
MOTOR	**ODE-Y**	0.055	0.066					
MOTOR	**ODE-Z**	0.067	0.057					
MOTOR	**DE-X**	0.076	0.072					
MOTOR	**DE-Y**	0.043	0.041					
PUMP	**DE-X**	0.034	0.038					
PUMP	**DE-Y**	0.026	0.028					
PUMP	**ODE-X**	0.021	0.020					
PUMP	**ODE-Y**	0.014	0.014					
PUMP	**ODE-Z**	0.031	0.030					
	OTHER:							

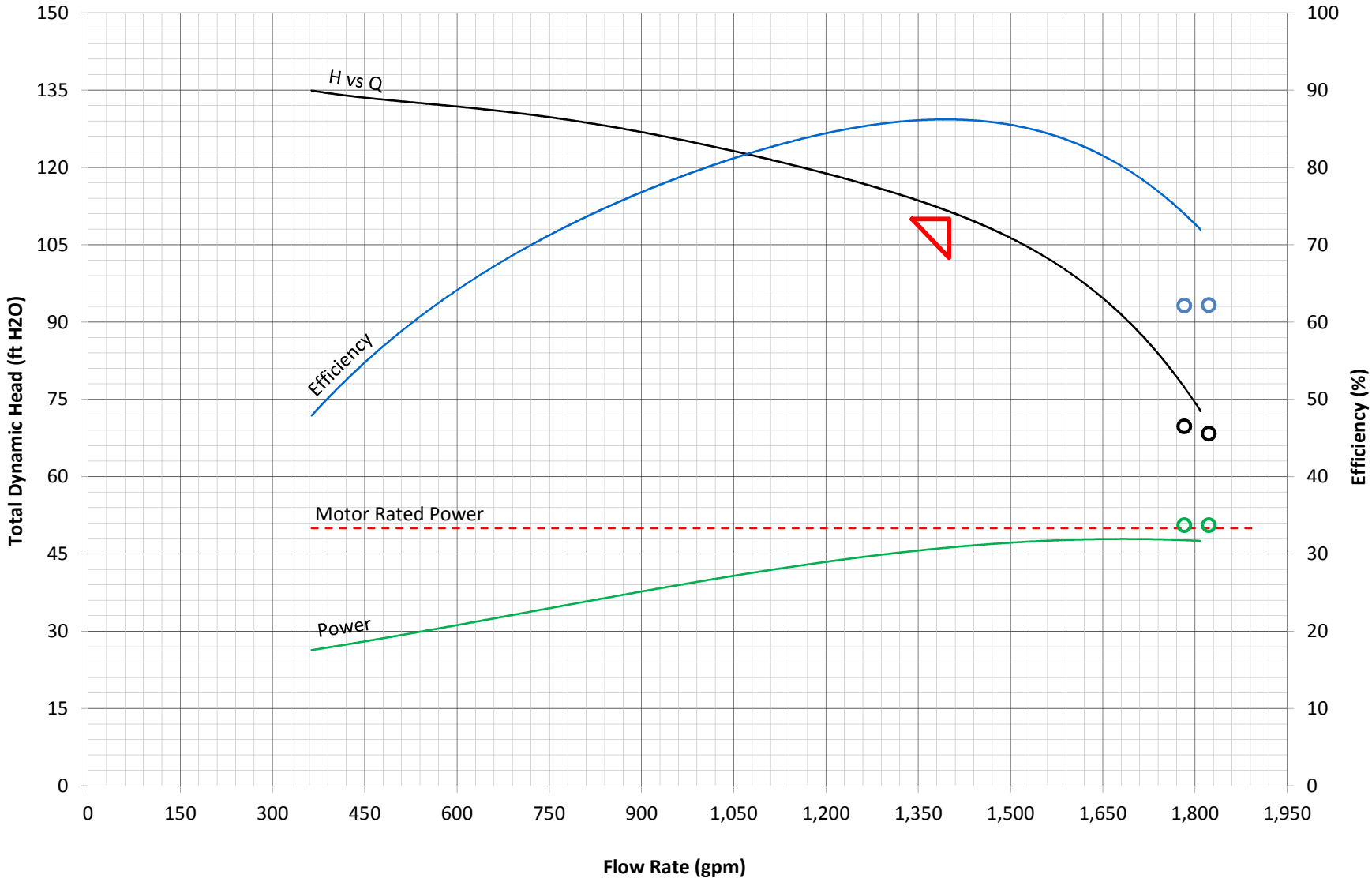
NOTES:

1 - MOTOR EFFICIENCY COULD NOT BE FOUND ON NAME TAG, EFFICIENCY IS ASSUMED

2 -

3 -

CITY OF HUNTSVILLE, NEW BOOSTER PUMP STATION
Booster Pump #1 Field Performance Test



SMITH PUMP COMPANY, INC.

NEW BOOSTER PUMP STATION, BP-2

NAMEPLATE DATA

MOTOR:	SIEMENS	**PUMP:**	GOULDS 3405, 6x8x12
SERIAL NO.:	F07TESP.36 1	**SERIAL NO.:**	250B662-1
RATED HP:	50	**RATED FLOW:**	1,400
RATED SPEED:	1,770	**RATED HEAD:**	110
FLA:	58	**RATED SPEED:**	1,800

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	0.0	
DATE:	6/2/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A	
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	N/A	(1)
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	N/A	(1)
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	93.0%	
STATION:	NEW PUMP STATION			

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START:

	TIME:						
	RUN TIME (MIN):						
	TARGE SPEED (RPM):	1,750	1,750	1,750	1,750	1,750	1,750
	FLOW METER (GPM):						
	SUCTION PRESSURE (PSI):						
	SUC. VELOCITY HEAD (FT):						
	DISCH. PRESSURE (FT):						
	DISCH. VELOCITY HEAD (FT):						
	HEAD LOSS (FT):						
	TDH (FT):						
	SPEED (RPM):						
	L1-L2 VOLTAGE (V):						
	L2-L3 VOLTAGE (V):						
	L3-L1 VOLTAGE (V):						
	L1 CURRENT (AMPS):						
	L2 CURRENT (AMPS):						
	L3 CURRENT (AMPS):						
	POWER FACTOR:						
	INPUT POWER (HP):						
	SHAFT POWER (HP):						
	BOWL POWER (HP):						
	CORRECTED FLOW (GPM):						
	CORRECTED TDH (FT):						
	CORRECTED INPUT PWR (HP):						
	CORRECTED BOWL PWR (HP):						
	PUMP EFFICIENCY (%)						
	TEMPERATURE (°C)						
	HOTTEST STATOR (RTD 1-9)						
	UPPER BRG. (RTD 10)						
	LOWER BRG. (RTD 11)						
	VIBRATION (IN/SEC RMS)						
MOTOR	**ODE-X**	0.025					
MOTOR	**ODE-Y**	0.025					
MOTOR	**ODE-Z**	0.022					
MOTOR	**DE-X**	0.052					
MOTOR	**DE-Y**	0.050					
PUMP	**DE-X**	0.029					
PUMP	**DE-Y**	0.019					
PUMP	**ODE-X**	0.021					
PUMP	**ODE-Y**	0.020					
PUMP	**ODE-Z**	0.027					
	OTHER:						

NOTES:

1 - DISCHARGE PIPING COULD NOT BE ISOLATED FROM DISCHARGE PRESSURE, THEREFORE NO GAGE COULD BE PLACED

2 -

3 -

SMITH PUMP COMPANY, INC.

NEW BOOSTER PUMP STATION, BP-3

NAMEPLATE DATA

MOTOR:	POWER TECH	**PUMP:**	GOULDS 3405, 6x8x12
SERIAL NO.:	SH10080001	**SERIAL NO.:**	250B662-4
RATED HP:	50	**RATED FLOW:**	1,400
RATED SPEED:	1,775	**RATED HEAD:**	110
FLA:	59.7	**RATED SPEED:**	1,800

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	0.0	
DATE:	6/3/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A	
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	N/A	(1)
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	N/A	(1)
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	91.7%	
STATION:	NEW PUMP STATION			

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START:

	TIME:						
	RUN TIME (MIN):						
	TARGE SPEED (RPM):	1,750	1,750	1,750	1,750	1,750	1,750
	FLOW METER (GPM):						
	SUCTION PRESSURE (PSI):						
	SUC. VELOCITY HEAD (FT):						
	DISCH. PRESSURE (FT):						
	DISCH. VELOCITY HEAD (FT):						
	HEAD LOSS (FT):						
	TDH (FT):						
	SPEED (RPM):						
	L1-L2 VOLTAGE (V):						
	L2-L3 VOLTAGE (V):						
	L3-L1 VOLTAGE (V):						
	L1 CURRENT (AMPS):						
	L2 CURRENT (AMPS):						
	L3 CURRENT (AMPS):						
	POWER FACTOR:						
	INPUT POWER (HP):						
	SHAFT POWER (HP):						
	BOWL POWER (HP):						
	CORRECTED FLOW (GPM):						
	CORRECTED TDH (FT):						
	CORRECTED INPUT PWR (HP):						
	CORRECTED BOWL PWR (HP):						
	PUMP EFFICIENCY (%)						
	TEMPERATURE (°C)						
	HOTTEST STATOR (RTD 1-9)						
	UPPER BRG. (RTD 10)						
	LOWER BRG. (RTD 11)						
	VIBRATION (IN/SEC RMS)						
MOTOR	**ODE-X**	0.075					
MOTOR	**ODE-Y**	0.058					
MOTOR	**ODE-Z**	0.073					
MOTOR	**DE-X**	0.153					
MOTOR	**DE-Y**	0.089					
PUMP	**DE-X**	0.025					
PUMP	**DE-Y**	0.014					
PUMP	**ODE-X**	0.022					
PUMP	**ODE-Y**	0.017					
PUMP	**ODE-Z**	0.028					
	OTHER:						

NOTES:

1 - DISCHARGE PIPING COULD NOT BE ISOLATED FROM DISCHARGE PRESSURE, THEREFORE NO GAGE COULD BE PLACED

2 -

3 -

SMITH PUMP COMPANY, INC.

NEW BOOSTER PUMP STATION, BP-4

NAMEPLATE DATA

MOTOR:	SIEMENS	**PUMP:**	GOULDS 3405, 6x8x12
SERIAL NO.:	51-380-861 LR68761-1	**SERIAL NO.:**	250B662-2
RATED HP:	50	**RATED FLOW:**	1,400
RATED SPEED:	1,770	**RATED HEAD:**	110
FLA:	58.5	**RATED SPEED:**	1,800

BY:	SHANE WALLACE	**SUC. GAGE TO CL OF DISCH. (FT):**	0.0	
DATE:	6/2/2015	**PIPE I.D. AT SUC. GAGE (IN):**	N/A	
PROJECT #:	172202	**DISCH. GAGE TO CL OF DISCH. (FT)**	N/A	(1)
ENGINEER:	FREESE & NICHOLS, INC.	**PIPE I.D. AT DISCH. GAGE (IN):**	N/A	(1)
CONTRACTOR:	N/A	**MOTOR EFFICIENCY (%):**	93.0%	(2)
STATION:	NEW PUMP STATION			

CALCULATIONS
CORRECTED VALUES
GIVEN VALUES

START:

	TIME:	
	RUN TIME (MIN):	
	TARGE SPEED (RPM):	1,750
	FLOW METER (GPM):	
	SUCTION PRESSURE (PSI):	
	SUC. VELOCITY HEAD (FT):	
	DISCH. PRESSURE (FT):	
	DISCH. VELOCITY HEAD (FT):	
	HEAD LOSS (FT):	
	TDH (FT):	
	SPEED (RPM):	
	L1-L2 VOLTAGE (V):	
	L2-L3 VOLTAGE (V):	
	L3-L1 VOLTAGE (V):	
	L1 CURRENT (AMPS):	
	L2 CURRENT (AMPS):	
	L3 CURRENT (AMPS):	
	POWER FACTOR:	
	INPUT POWER (HP):	
	SHAFT POWER (HP):	
	BOWL POWER (HP):	
	CORRECTED FLOW (GPM):	
	CORRECTED TDH (FT):	
	CORRECTED INPUT PWR (HP):	
	CORRECTED BOWL PWR (HP):	
	PUMP EFFICIENCY (%)	
	TEMPERATURE (°C)	
	HOTTEST STATOR (RTD 1-9)	
	UPPER BRG. (RTD 10)	
	LOWER BRG. (RTD 11)	
	VIBRATION (IN/SEC RMS)	
MOTOR	**ODE-X**	0.069
MOTOR	**ODE-Y**	0.196
MOTOR	**ODE-Z**	0.179
MOTOR	**DE-X**	0.142
MOTOR	**DE-Y**	0.098
PUMP	**DE-X**	0.139
PUMP	**DE-Y**	0.037
PUMP	**ODE-X**	0.052
PUMP	**ODE-Y**	0.030
PUMP	**ODE-Z**	0.080
	OTHER:	

NOTES:

1 - DISCHARGE PIPING COULD NOT BE ISOLATED FROM DISCHARGE PRESSURE, THEREFORE NO GAGE COULD BE PLACED

2 - MOTOR EFFICIENCY COULD NOT BE FOUND ON NAME TAG, EFFICIENCY IS ASSUMED

3 -

APPENDIX B

ALIGNMENT DATA

Smith Pump Co., Inc.

Department: Pump Shop

Mr. Larry Hernandez

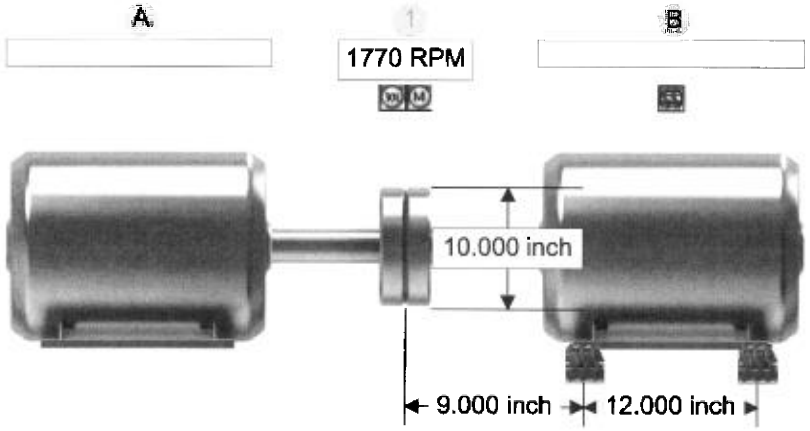
File information

Name:	Position-54
Company:	
Plant:	Freeze & Nichols
Area:	172202
Machine train:	Huntsville
Comment:	BP-1
Username:	
Note 1:	
Note 2:	
Note 3:	
Note 4:	
Note 5:	
Note 6:	
Note 7:	
Measured:	6/3/1999 8:33:00 AM

Description

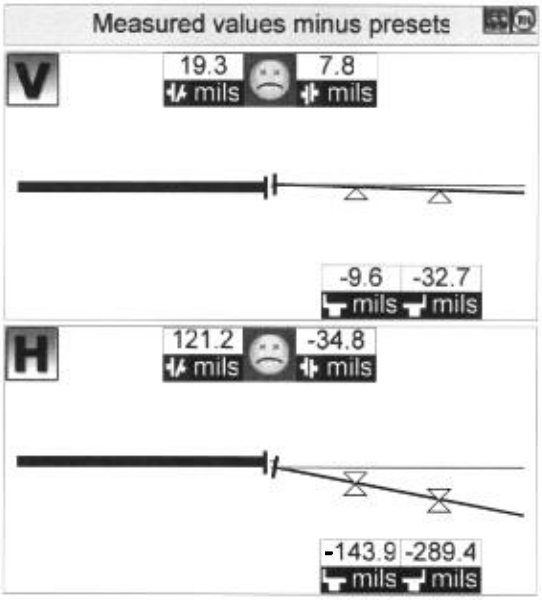
Component:	Type:	Mounting:
Machine A:	Standard	Static machine
Coupling 1:	Short flex	
Machine B:	Standard	4 Feet

Dimensions (graphical)



Dimensions	
Coupling 1:	
Coupling diameter	10.000 [inch]
Distance to the right machine	9.000 [inch]
RPM	1770 [RPM]
Machine A:	
Machine B:	
Length	12.000 [inch]

Result Graphic



Corrections	vertical	horizontal Units
Machine A:		
Stationary Machine		
Machine B:		
Foot 1	9.6	143.9 [mils]
Foot 2	32.7	289.4 [mils]

Coupling Results	vertical	horizontal Units
Coupling 1:		
Actual minus specification		
Gap	19.3	121.2 [mils]
Offset	7.8	-34.8 [mils]
Actual		

Gap	19.3	121.2 [mils]
Offset	2.8	-34.8 [mils]

Measurements

	Type	vertical	horizontal	SD Date / Time
Coupling 1:				
#	Sweep			--- 6/3/1999 8:33:...
	Distance laser - prism: 6.000 [inch]			
	Distance laser - coupling reference: 3.000 [inch]			
	Gap	19.3 mils	121.2 mils	
	Offset	2.8 mils	-34.8 mils	

Thermal growth

	vertical	horizontal	Units
Machine A:			
No thermal growth defined!			
Machine B:			
Left foot	5.0	0.0	[mils]
Right foot	5.0	0.0	[mils]

Smith Pump Co., Inc.

Department: Pump Shop

Mr. Larry Hernandez

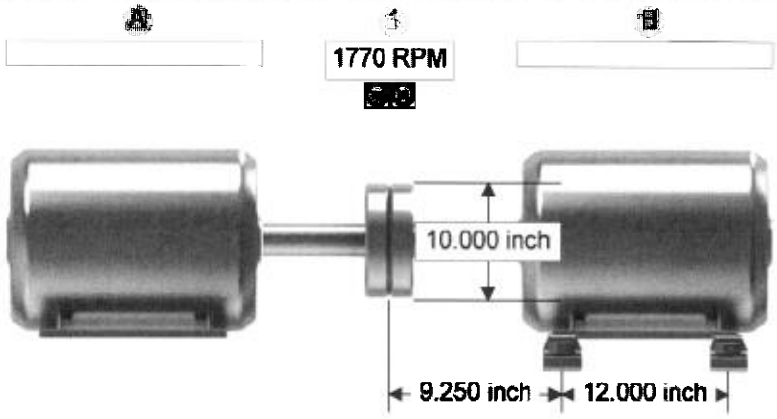
File information

Name:	Position-55
Company:	Freeze & Nichols
Plant:	172202
Area:	Huntsville
Machine train:	BP-2
Comment:	
Username:	
Note 1:	
Note 2:	
Note 3:	
Note 4:	
Note 5:	
Note 6:	
Note 7:	
Measured:	6/3/1999 8:54:00 AM

Description

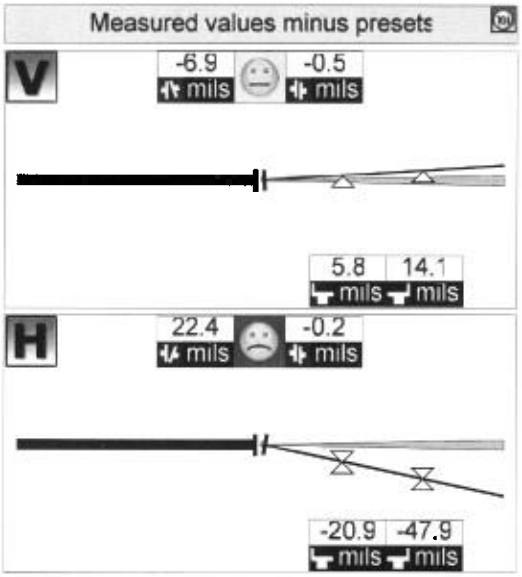
Component:	Type:	Mounting:
Machine A:	Standard	Static machine
Coupling 1:	Short flex	
Machine B:	Standard	4 Feet

Dimensions (graphical)



Dimensions	
Coupling 1:	
Coupling diameter	10.000 [inch]
Distance to the right machine	9.250 [inch]
RPM	1770 [RPM]
Machine A:	
Machine B:	
Length	12.000 [inch]

Result Graphic



Corrections	vertical	horizontal Units
Machine A:		
Stationary Machine		
Machine B:		
Foot 1	-5.8	20.9 [mils]
Foot 2	-14.1	47.9 [mils]

Coupling Results	vertical	horizontal Units
Coupling 1:		
Actual minus specification		
Gap	-6.9	22.4 [mils]
Offset	-0.5	-0.2 [mils]
Actual		

Gap	-6.9	22.4 [mils]
Offset	-0.5	-0.2 [mils]

Measurements

	Type	vertical	horizontal	SD Date / Time
Coupling 1:				
#	Sweep			--- 6/3/1999 8:54:...
	Distance laser - prism: 5.500 [inch]			
	Distance laser - coupling reference: 2.750 [inch]			
	Gap	-6.9 mils	22.4 mils	
	Offset	-0.5 mils	-0.2 mils	

Smith Pump Co., Inc.

Department: Pump Shop

Mr. Larry Hernandez

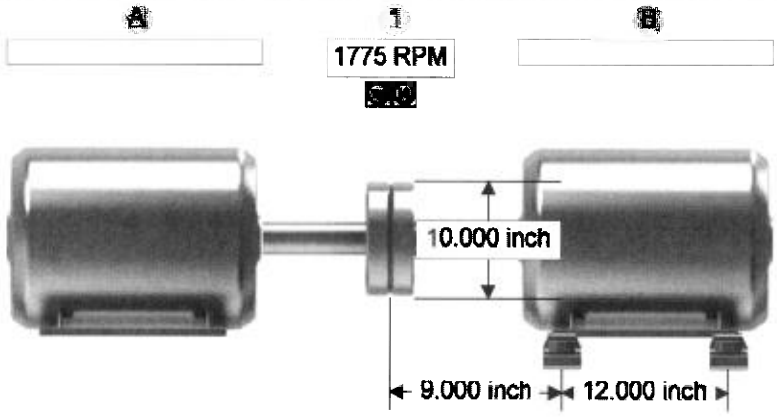
File information

Name:	Position-56
Company:	Freeze & Nichols
Plant:	172202
Area:	Huntsville
Machine train:	BP3
Comment:	
Username:	
Note 1:	
Note 2:	
Note 3:	
Note 4:	
Note 5:	
Note 6:	
Note 7:	
Measured:	6/3/1999 9:09:00 AM

Description

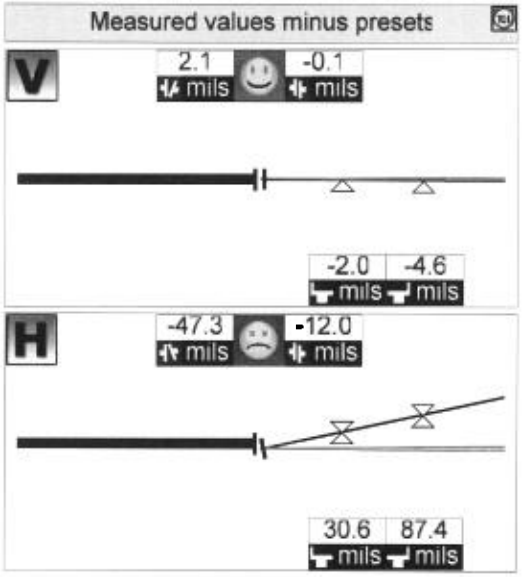
Component:	Type:	Mounting:
Machine A:	Standard	Static machine
Coupling 1:	Short flex	
Machine B:	Standard	4 Feet

Dimensions (graphical)



Dimensions	
Coupling 1:	
Coupling diameter	10.000 [inch]
Distance to the right machine	9.000 [inch]
RPM	1775 [RPM]
Machine A:	
Machine B:	
Length	12.000 [inch]

Result Graphic



Corrections	vertical	horizontal Units
Machine A:		
Stationary Machine		
Machine B:		
Foot 1	2.0	-30.6 [mils]
Foot 2	4.6	-87.4 [mils]

Coupling Results	vertical	horizontal Units
Coupling 1:		
Actual minus specification		
Gap	2.1	-47.3 [mils]
Offset	-0.1	-12.0 [mils]
Actual		

Gap	2.1	-47.3 [mils]
Offset	-0.1	-12.0 [mils]

Measurements

	Type	vertical	horizontal	SD Date / Time
Coupling 1:				
#	Sweep			--- 6/3/1999 9:09:...
	Distance laser - prism: 6.000 [inch]			
	Distance laser - coupling reference: 3.000 [inch]			
	Gap	2.1 mils	-47.3 mils	
	Offset	-0.1 mils	-12.0 mils	

Smith Pump Co., Inc.
Department: Pump Shop

Mr. Larry Hernandez

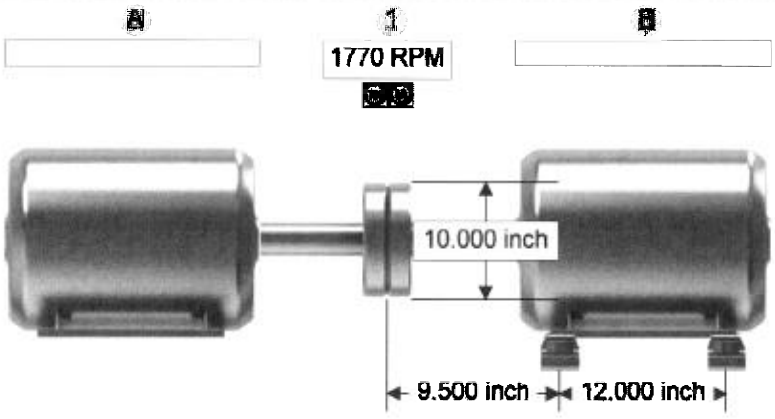
File information

Name:	Position-57
Company:	Freeze & Nichols
Plant:	172202
Area:	Huntsville
Machine train:	BP-4
Comment:	
Username:	
Note 1:	
Note 2:	
Note 3:	
Note 4:	
Note 5:	
Note 6:	
Note 7:	
Measured:	6/3/1999 9:19:00 AM

Description

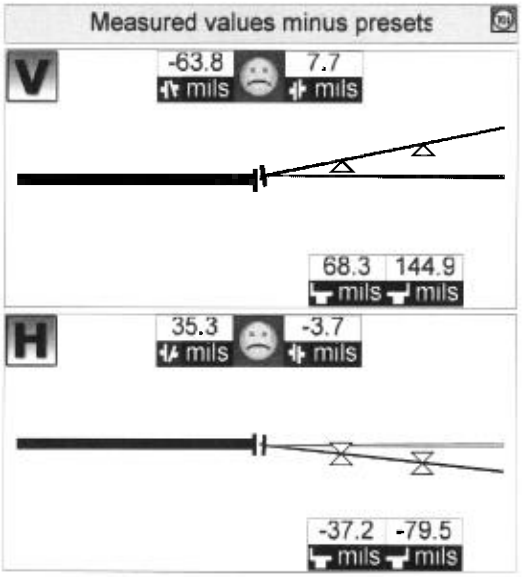
Component:	Type:	Mounting:
Machine A:	Standard	Static machine
Coupling 1:	Short flex	
Machine B:	Standard	4 Feet

Dimensions (graphical)



Dimensions	
Coupling 1:	
Coupling diameter	10.000 [inch]
Distance to the right machine	9.500 [inch]
RPM	1770 [RPM]
Machine A:	
Machine B:	
Length	12.000 [inch]

Result Graphic



Corrections	vertical	horizontal Units
Machine A:		
Stationary Machine		
Machine B:		
Foot 1	-68.3	37.2 [mils]
Foot 2	-144.9	79.5 [mils]

Coupling Results	vertical	horizontal Units
Coupling 1:		
Actual minus specification		
Gap	-63.8	35.3 [mils]
Offset	7.7	-3.7 [mils]
Actual		

Gap	-63.8	35.3 [mils]
Offset	7.7	-3.7 [mils]

Measurements

	Type	vertical	horizontal	SD Date / Time
Coupling 1:				
#	Sweep			--- 6/3/1999 9:19:...
	Distance laser - prism: 5.000 [inch]			
	Distance laser - coupling reference: 2.500 [inch]			
	Gap	-63.8 mils	35.3 mils	
	Offset	7.7 mils	-3.7 mils	

APPENDIX C

PUMP CATALOG CURVES

LAYNE & BOWLER, INC.
MEMPHIS, TENN.

DEEP WELL TURBINE PUMP PERFORMANCE CHART

DATE

THESE CURVES SHOW THE GENERAL SHAPE OF THE PUMP BOWL CHARACTERISTICS UNDER SHOP TESTS AT THE CONSTANT SPEED INDICATED. A TOLERANCE OF PLUS OR MINUS 2% MUST BE ALLOWED IN THE GUARANTEED CAPACITY, HEAD, AND EFFICIENCY AT THE RATED POINT WHEN PUMPING NON-GASEOUS WATER, FREE FROM DETRITUS, AT A TEMPERATURE NOT OVER 86° FAHR., AND WITH THE LOWEST IMPELLER SUBMERGED.

FOR

ADDRESS

TYPE OF PUMP FIG 12 EWMC R.P.M. 1750

SIZE OF PUMP 12 INS 2 STAGES 6WH5 IMPELLER —

FIELD PERFORMANCE

THE FIELD PERFORMANCE AS SHOWN BELOW, MAKES ALLOWANCE FOR ALL THE HYDRAULIC AND MECHANICAL LOSSES IN THE COLUMN AND SHAFT OF THE INSTALLATION ACCORDING TO THE STANDARDS OF THE HYDRAULIC INSTITUTE. THE FIELD PUMPING HEAD IS THE LIFT FROM THE WELL PLUS THE DISCHARGE HEAD MEASURED AT THE DISCHARGE CONNECTION AT THE SURFACE.

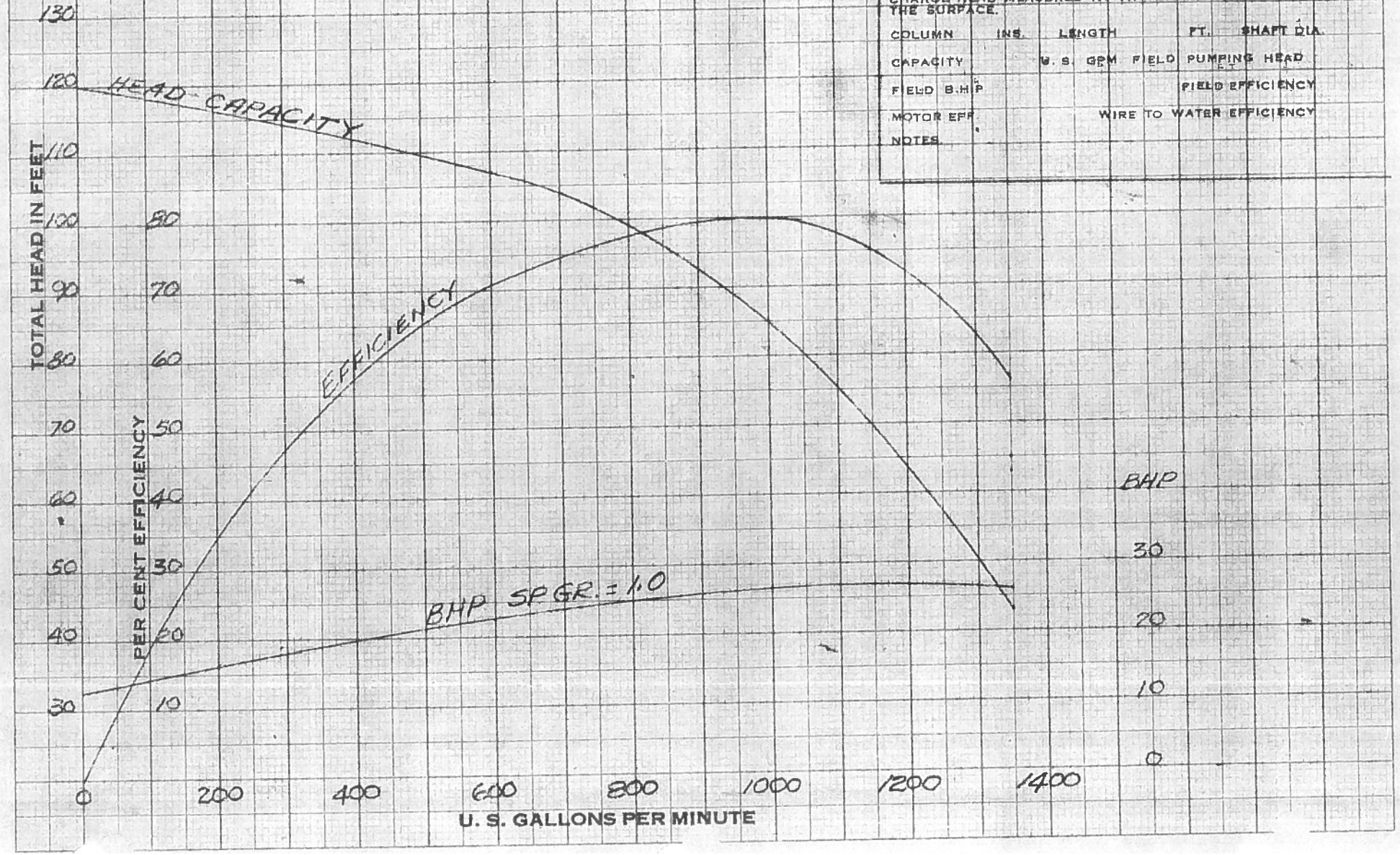
COLUMN INS. LENGTH FT. SHAFT DIA.

CAPACITY U. S. GPM FIELD PUMPING HEAD FT.

FIELD B.H.P FIELD EFFICIENCY

MOTOR EFF. WIRE TO WATER EFFICIENCY

NOTES



LAYNE & BOWLER, INC.
MEMPHIS, TENN.

DEEP WELL TURBINE PUMP PERFORMANCE CHART

CURVE SHEET NO. 11031
DATE

THESE CURVES SHOW THE GENERAL SHAPE OF THE PUMP BOWL CHARACTERISTICS UNDER SHOP TESTS AT THE CONSTANT SPEED INDICATED. A TOLERANCE OF PLUS OR MINUS 2% MUST BE ALLOWED IN THE GUARANTEED CAPACITY, HEAD, AND EFFICIENCY AT THE RATED POINT WHEN PUMPING NON-GASEOUS WATER, FREE FROM DETRITUS, AT A TEMPERATURE NOT OVER 86° FAHR., AND WITH THE LOWEST IMPELLER SUBMERGED.

PB 1834 B1

FOR

ADDRESS

TYPE OF PUMP PIG 12 THC R.P.M. 1770

SIZE OF PUMP 12 INS. 2 STAGES 6T7A IMPELLER —

FIELD PERFORMANCE

THE FIELD PERFORMANCE AS SHOWN BELOW, MAKES ALLOWANCE FOR ALL THE HYDRAULIC AND MECHANICAL LOSSES IN THE COLUMN AND SHAFT OF THE INSTALLATION ACCORDING TO THE STANDARDS OF THE HYDRAULIC INSTITUTE. THE FIELD PUMPING HEAD IS THE LIFT FROM THE WELL PLUS THE DISCHARGE HEAD MEASURED AT THE DISCHARGE CONNECTION AT THE SURFACE.

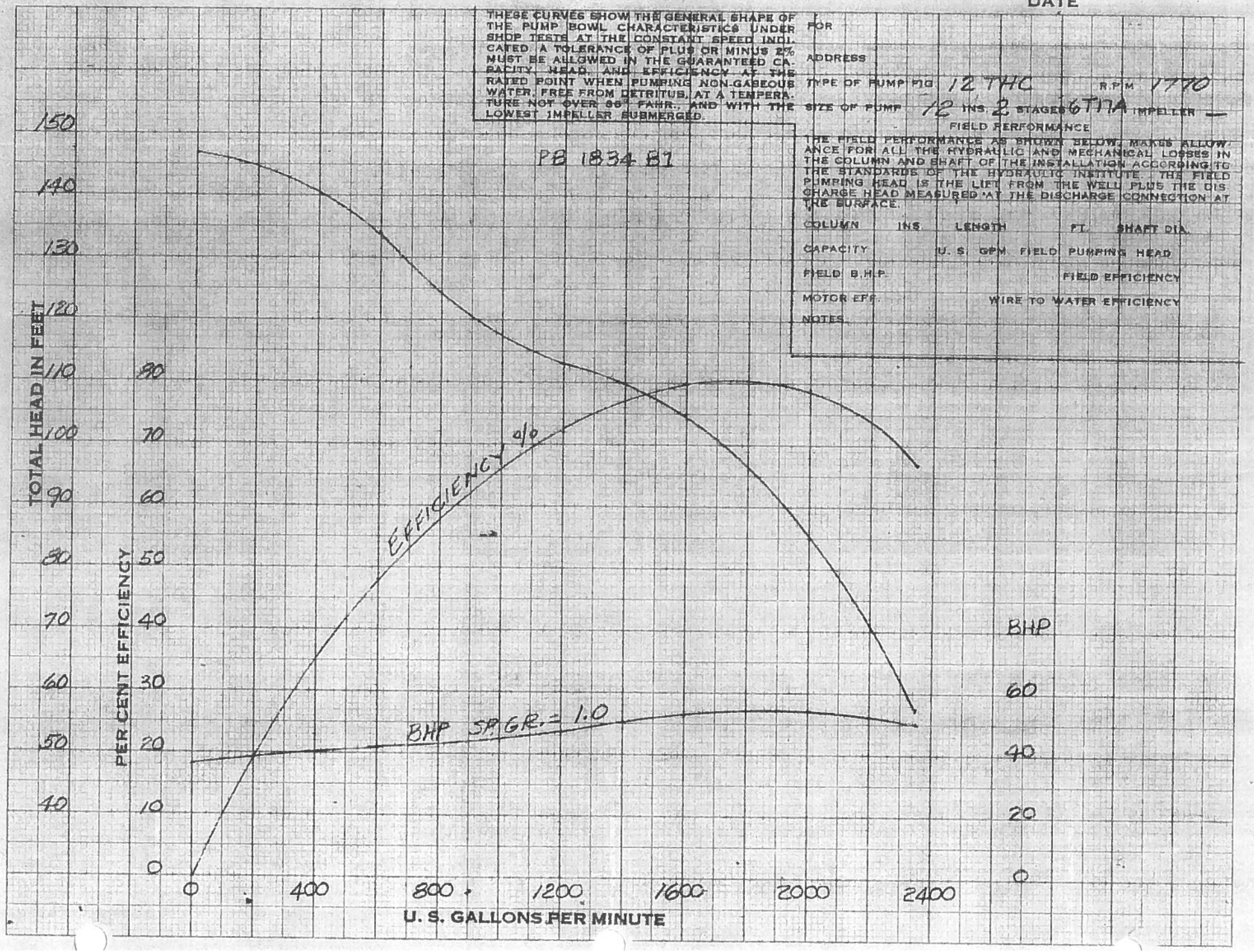
COLUMN INS. LENGTH FT. SHAFT DIA.

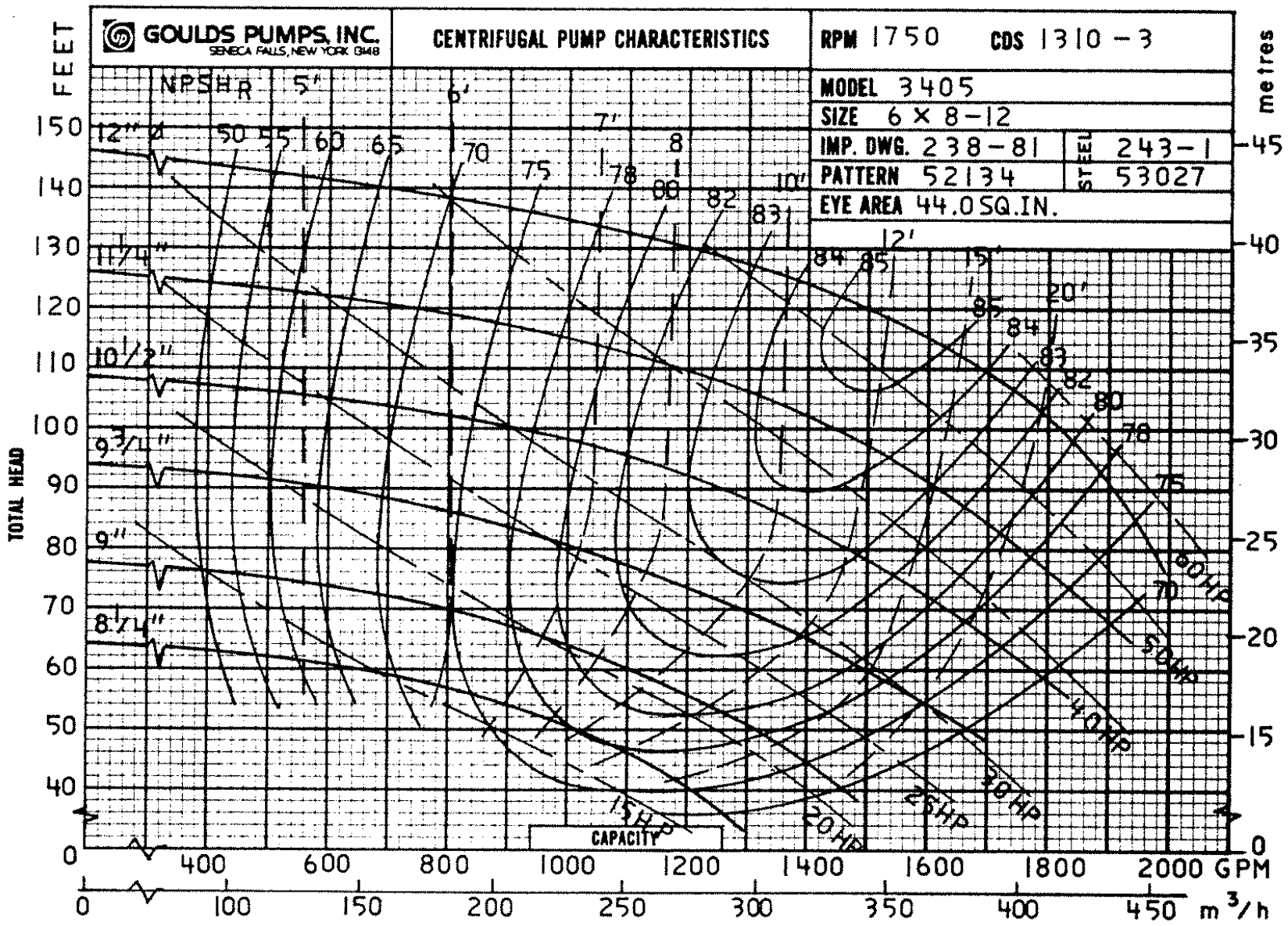
CAPACITY U. S. GPM. FIELD PUMPING HEAD

FIELD B.H.P. FIELD EFFICIENCY

MOTOR EFF. WIRE TO WATER EFFICIENCY

NOTES.




GOULDS PUMPS, INC.
SENECA FALLS, NEW YORK 13148
CENTRIFUGAL PUMP CHARACTERISTICS
RPM 1750 CDS 1310-3
MODEL 3405
SIZE 6 X 8-12
IMP. DWG. 238-81
PATTERN 52134
EYE AREA 44.0SQ.IN.
STEEL 243-1
STEEL 53027
TOTAL HEAD
FEET
metres
NPSHR
CAPACITY
GPM
m³/h

1750 R.P.M.

APPENDIX D

CALIBRATION CERTIFICATES

Equip. No. 1723

MICRO PRECISION CALIBRATION INC.

MPC CALIBRATION INC.
670 INTERNATIONAL PKWY DR, STE 100
RICHARDSON TX 75081
972-437-6700

Certificate of Calibration

Date: Apr 15, 2015 **Cert No. 222008122479748**

Customer:
SMITH PUMP COMPANY INC
301 M & B INDUSTRIAL
WACO TX 76712

		Work Order #:	TX-8005832
		Purchase Order #:	PU36823
MPC Control #:	CE0570	Serial Number:	02368
Asset ID:	CE0570	Department:	N/A
Gage Type:	LIQUID FLOWMETER	Performed By:	AMY BOLAM
Manufacturer:	GE PANAMETRICS	Received Condition:	IN TOLERANCE
Model Number:	PT878	Returned Condition:	IN TOLERANCE
Size:	N/A	Cal. Date:	April 15, 2015
Temp/RH:	72°F / 44 %	Cal. Interval:	12 MONTHS
		Cal. Due Date:	April 15, 2016

Calibration Notes:

Standards Used to Calibrate Equipment

I.D.	Description.	Model	Serial	Manufacturer	Cal. Due Date	Traceability #
CC6851	CALIBRATOR	5720A	6985201	FLUKE	Jul 1, 2015	222008122362473
CD6016	FUNCTION GENERATOR	3325A	2512A21513	HEWLETT PACKARD	Jan 18, 2016	222008122443493
CE9042	DECADE RESISTOR	DB62	1946002	ESI ELECTRONICS	Feb 6, 2016	222008122400368

Procedures Used in this Event

Procedure Name	Description
MPC-00089	Flow Meters Liquid and Gas

Calibrating Technician: Amy L Bolam

AMY BOLAM

QC Approval:

RICK HERNANDEZ

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA's Publication and NIST Technical Note 1297, 1994 Edition. Services rendered comply with ISO 17025:2005, ANSI/NCSL Z540-1, MPC Quality Manual, MPC CSD and with customer purchase order instructions.

Calibration cycles and resulting due dates were submitted/approved by the customer. Any number of factors may cause an instrument to drift out of tolerance before the next scheduled calibration. Recalibration cycles should be based on frequency of use, environmental conditions and customer's established systematic accuracy. The information on this report, pertains only to the instrument identified.

All standards are traceable to SI through the National Institute of Standards and Technology (NIST) and/or recognized national or international standards laboratories. Services rendered include proper manufacturer's service instruction and are warranted for no less than thirty (30) days. This report may not be reproduced in part or in a whole without the prior written approval of the issuing MPC lab.

Equip. No. 163665

TEXAS GAUGE & CONTROLS

7575 Dillon Street
Houston, TX 77061-2826
Phone: (713)-641-2282
Fax: (713)-641-3371
Toll Free: (800)-914-0009
www.TEXASGAUGE.com

CALIBRATION

Part Number ASHCROFT 30 PSI **Serial Number** TGC-7101

Pressure Range 0-30 PSI **Accuracy** +/- .25 **Full Scale**

Customer SMITH PUMP COMPANY, INC

PO Number: PU32376 **Order ID:** 73599

CALIBRATION CERTIFICATE
PRESSURE GAUGE

AS FOUND PRESSURE		INCREASING PRESSURE		DECREASING PRESSURE	
Increasing	/ Decreasing	Standard	/ Reading	Standard	/ Reading
0	29.98	0	0	30	29.98
7.62	15.02	7.6	7.62	15	15.02
15.02	7.6	15	15.02	7.6	7.6
30.02	0	30	30.02	0	0

Calibrated In Vertical **Position** **Temperature** 72

THIS IS TO CERTIFY THAT THIS GAUGE HAS BEEN INSPECTED AND TESTED AGAINST PRESSURE STANDARD #918933 (11/12/2014) TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, TRACEABILITY REFERENCE NIST Test #072-FP75-23 COMPENSATED TO LOCAL ACCELERATION DUE TO GRAVITY.

Special Conditions: READINGS IN PSI

CalibrationDate: 6/10/2014 **Inspector:**

TEXAS GAUGE & CONTROLS

7575 Dillon Street
Houston, TX 77061-2826
Phone: (713)-641-2282
Fax: (713)-641-3371
Toll Free: (800)-914-0009
www.TEXASGAUGE.com

CALIBRATION

Part Number ASHCROFT 30"HG **Serial Number** TGC-7101

Pressure Range 0-30"HG **Accuracy** +/- .25 **Full Scale**

Customer SMITH PUMP COMPANY, INC

PO Number: PU32376 **Order ID:** 73599

CALIBRATION CERTIFICATE
PRESSURE GAUGE

AS FOUND PRESSURE		INCREASING PRESSURE		DECREASING PRESSURE	
Increasing	Decreasing	Standard	Reading	Standard	Reading
0	29	0	0	29	29
10	20	10	10	20	20
20	10	20	20	10	10
29	0	29	29	0	0

Calibrated In Vertical **Position** **Temperature** 72

THIS IS TO CERTIFY THAT THIS GAUGE HAS BEEN INSPECTED AND TESTED AGAINST PRESSURE STANDARD #918933 (11/12/2014) TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, TRACEABILITY REFERENCE NIST Test #072-FP75-23 COMPENSATED TO LOCAL ACCELERATION DUE TO GRAVITY.

Special Conditions: READINGS IN "HG

CalibrationDate: 6/10/2014

Inspector:

Equip. No. 163665

TEXAS GAUGE & CONTROLS

7575 Dillon Street
Houston, TX 77061-2826
Phone: (713)-641-2282
Fax: (713)-641-3371
Toll Free: (800)-914-0009
www.TEXASGAUGE.com

CALIBRATION

Part Number ASHCROFT 460'FT H20 **Serial Number** 163665

Pressure Range 0-460'FT H20 **Accuracy** +/- .25 **Full Scale**

Customer SMITH PUMP COMPANY, INC

PO Number: PU32376 **Order ID:** 73599

CALIBRATION CERTIFICATE
PRESSURE GAUGE

AS FOUND PRESSURE		INCREASING PRESSURE		DECREASING PRESSURE	
Increasing	/ Decreasing	Standard	/ Reading	Standard	/ Reading
0	459.48	0	0	460	459.48
100.8	349.92	100	100.8	350	349.92
229.05	229.97	230	229.05	230	229.97
350.15	99.87	350	350.15	100	99.87
459.48	0	460	459.48	0	0

Calibrated In Vertical **Position** **Temperature** 72

THIS IS TO CERTIFY THAT THIS GAUGE HAS BEEN INSPECTED AND TESTED AGAINST PRESSURE STANDARD #918933 (11/12/2014) TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS, TRACEABILITY REFERENCE NIST Test #072-FP75-23 COMPENSATED TO LOCAL ACCELERATION DUE TO GRAVITY.

Special Conditions: READINGS ARE IN FT H20

CalibrationDate: 6/10/2014 **Inspector:**

The Meter Shop
4202 Director's Row #100
Houston Texas 77092

Certificate of Calibration

For Instrument: Extech 380976 Power Clampmeter
Serial Number: PM2000
Asset Number: 9147

CUSTOMER: Smith Pump Company
301 M&B Industrial
Waco TX 76712

The Meter Shop 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), or to NIST accepted intrinsic standards of measurement, or derived by the ratio type of self-calibration techniques. This calibration complies with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. and ISO 17025

CALIBRATION INFORMATION

Cal Date: 10 Oct 2014 | Temperature 23.0°C | Pass Y
Next Cal Due: 10 Oct 2015 | Humidity 43 % | Seals OK Y

Remarks: AS-FOUND : 120210916
Cal Procedure Manufactures Specifications. **Revision** $Revision: 1.4 $

STANDARDS USED FOR CALIBRATION

Asset Number	Description	Cal. Date	Due Date
5001	Fluke 5520A Calibrator	30 Jul 2014	29 Jul 2015

Signed:

Equip. No. 168553

CERTIFICATE of INSPECTION

Product: **VIBSCANNER/smartSCANNER Model# VIB 5.400**

P.O. No.: PU36844

Customer: SMITH PUMP COMPANY, INC.

This is to certify that the subject Data Collector was inspected at:

LUDECA

LUDECA INC.
1425 N.W. 88th Avenue
Miami, FL 33172

Phone No.: (305) 591-8935
Fax No.: (305) 591-1537

This inspection was conducted in accordance with the Ludeca's inspection procedure# LUDC1014-00. Ludeca's Inspection Certificate is in compliance of ANSI/NCSL Z540-1-1994. The calibration station utilizes a Model VC11 vibration calibrator. Vibration measurements were recorded at 159 Hz at a nominal temperature of 20°C. This certificate may not be reproduced, except in full, without the written approval of Ludeca, Inc. This certificate package consists of 1 pages.

Date of Inspection: **April 22, 2015** Valid Through: **April 22, 2017**

Instrument Serial No.: **03642**

HW - Status **3.01**

Inspector: **Regie Romo** Initials RR

Results

	As Found	Deviation	As Left	Deviation	Allowable
Velocity Sensitivity (Ref 10.27 mm/s)	10.34	0.68%	10.32	0.48%	±5%
Temperature Deviation °F, Ref/Test:	136.76/139	1.63%	134.26/135	0.55%	±3%

Q.A. INSPECTOR

LUDECA, INC.

VC11 is traceable by comparison calibration with a NIST certified primary standard thru PCB certificate #cal3-3459235878.429. Reference: Output for 175.3 gram mass = 10.27m/s^2 = 10.27mm/s @ 159.2 Hz.

VC11 Serial No.: 990999 **Certificate Dated:** 12-AUG-2014 **Due:** 12-AUG-2015

The Precision RTD Thermometer, Model 407907 is traceable to NIST ITS-90 through Certificate 110841/6606. Reference Temperature actual (≥100°F).

Precision RTD & Meter Serial No.: Z026266 **Certificate Dated:** 20-MAY-2014 **Due:** 20-MAY-2015

Printed: 4/23/2015 12:11 PM

SRVC-1823-01

CERTIFICATE of INSPECTION

Product: ALIGNEO TRANSDUCER MODEL# ALI 11.100

P.O. No.: PU30440

Customer: SMITH PUMP COMPANY, INC.

This is to certify that the subject Transducer was inspected at:

LUDECA

LUDECA INC.
1425 N.W. 88th Avenue
Miami, FL 33172

Phone No.: (305) 591-8935
Fax No.: (305) 591-1537

This inspection was conducted in accordance with Ludeca's inspection procedure# LUDC1012-02 dated, October 5, 2011. Ludeca's Inspection Certificate is in compliance of ANSI/NCSL Z540-1-1994. The calibration station utilizes a Master Set of gage blocks traceable to the *National Institute of Standards and Technology*. Measurements were recorded using the metric conversion of 1 inch = 25.4mm. This certificate may not be reproduced, except in full, without the written approval of Ludeca, Inc. This certificate package consists of 2 pages.

Date of Inspection:	**February 11, 2014**	Due: **February 11, 2016**
Transducer S/N:	**1207 1272**	
ALI 5.110 Prism S/N:	**1407 9959**	
Inspector:	**Damien Hamm**	Initials: D.H

Results

Total RMS error Laser Detector: **1.06%** Maximum allowable Error = 2%

Average Angular Deviation: **0.95°** Maximum allowable Deviation = 2°

Q. A. INSPECTOR

LUDECA, INC.

The Gage Block Set is a certified primary standard traceable to NIST through Certificate of Calibration #651429. The set is calibrated annually with a maximum uncertainty of 0.10 micrometers.

Gage Block Serial No.: SET 1	**Certificate Dated:** 15-NOV-2013	**Expires:** 15-NOV-2014
CaliChek-F® Serial No.: 4895855	**Certificate Dated:** 06-MAY-2013	**Expires:** 06-MAY-2015
CaliChek-T® Serial No.: 2898061	**Certificate Dated:** 24-APR-2013	**Expires:** 24-APR-2014

IN/OUT DATA SHEET

LUDECA, INC.	Item: ALI 11.100	
Customer: SMITH PUMP COMPANY, INC.	Serial Number: 1207 1272	
	Date Received: February 5, 2014	Date Completed: February 11, 2014
	Received via: UPS Shipped via: FEDEX	
Incoming Condition: Used		
Description of Fault: NIST calibration; no defects were found that affect accuracy or linearity. No adjustments were made and no parts were used.		

DEFECTIVE PARTS Name of parts/Subassembly	PART NUMBER	FAULT DESCRIPTION	WARRANTY

Repair: As found and as shipped readings are identical.

COMMENTS: The procedure and NIST Traceable standards used provide a measurement uncertainty that is at least equal to or better than four (4) times the specification of the unit under test. The procedures were performed at 68.5°F nominal, 46.4% humidity and in conformance with P. O. Number **PU30440**

Date: February 11, 2014

Q.A. INSPECTOR

Technician: Damien Hamm