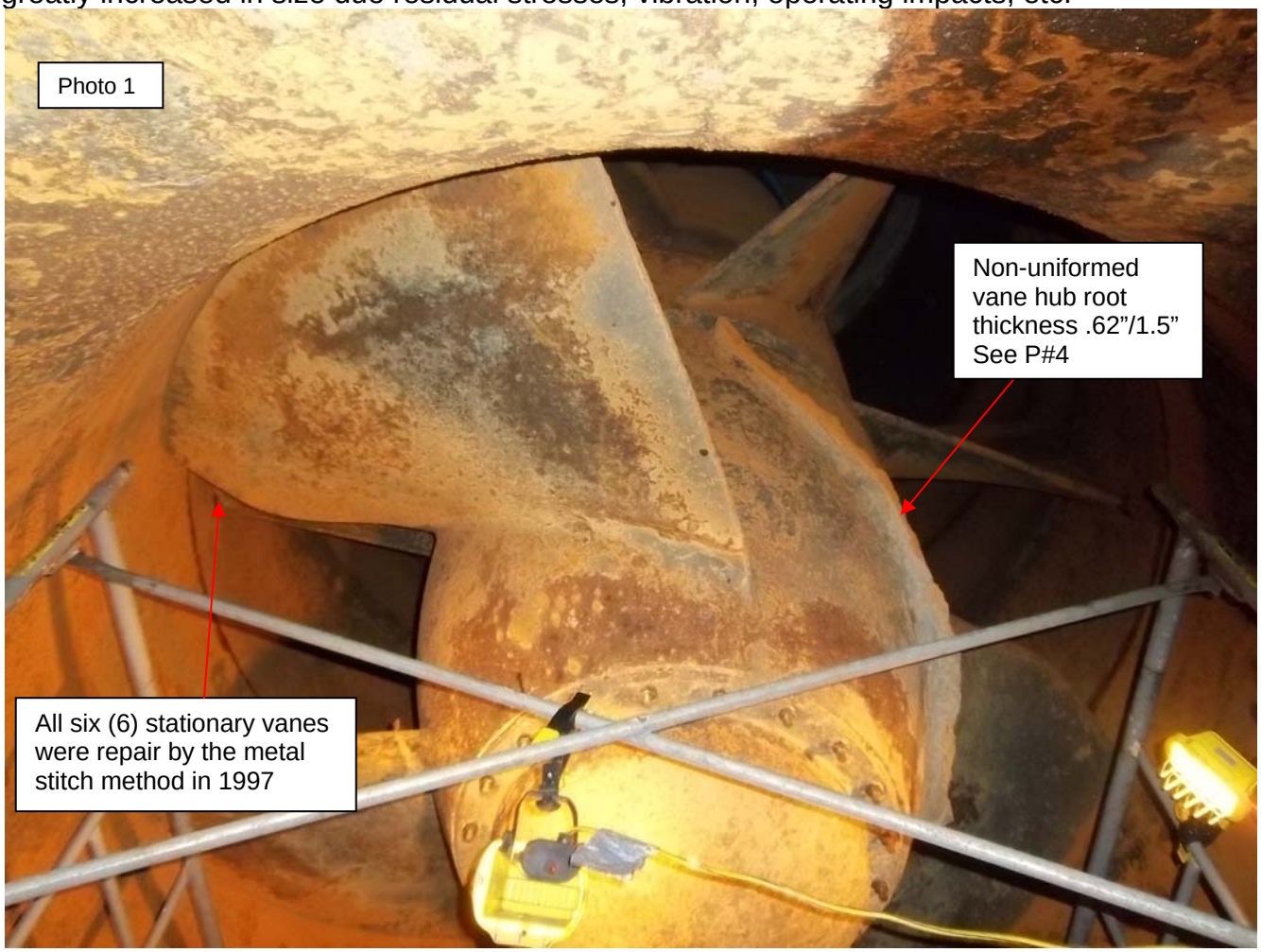
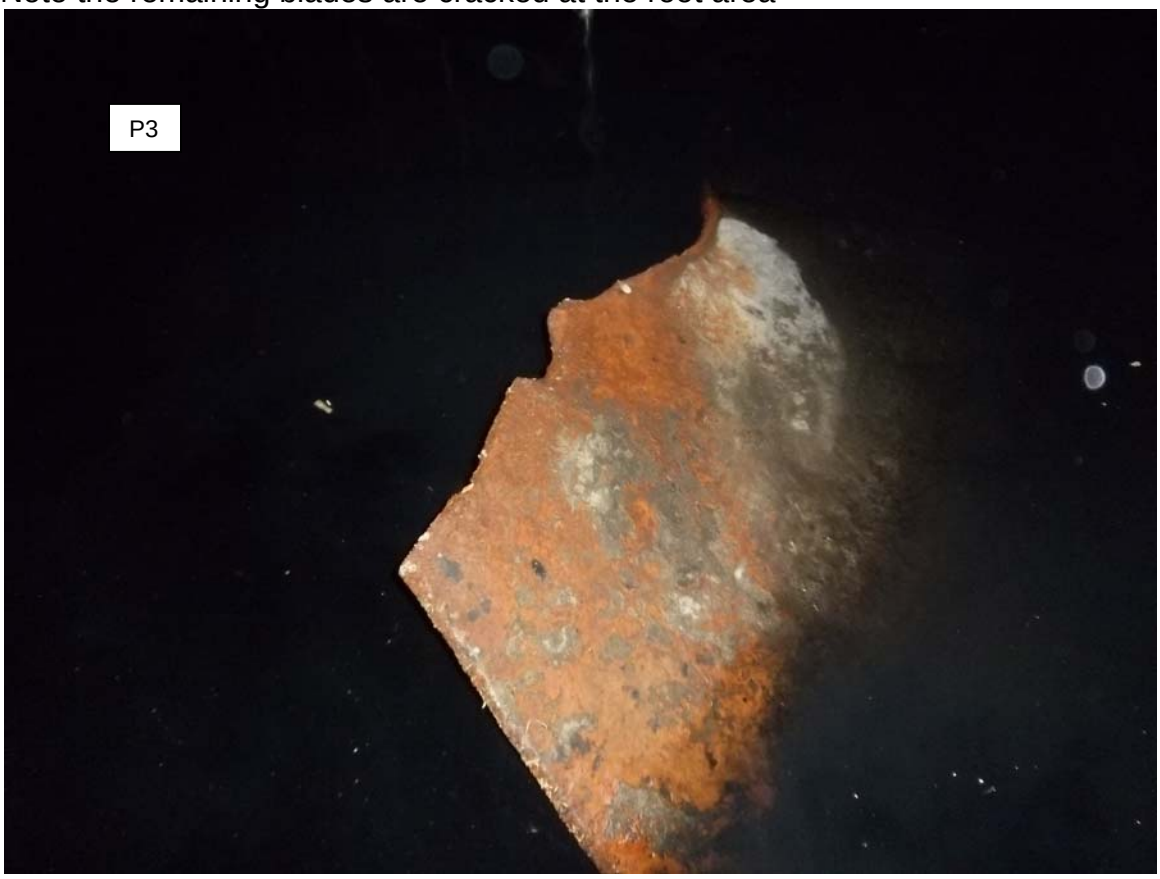
Unit No. 1 Worthington 119"Hi-Flo pump had been operating with a .025" shaft run-out at the upper bearing, this was due to… missing a propeller vane, the main component of the equipment. The 119" diameter impeller weighting 15,000 pounds fractured at one (1) of the four vanes, which completely sheared at the hub. Each vane is approximately 2' wide by 4' long and 1.5" thick, weighing over 600 pounds. The propeller material is a Ni-Resist cast iron, high nickel content (18-22%) which other than the mechanical damage is still in excellent condition after being submerged in brackish water for over forty (40) years.

The propeller vane cracking is attributed to the type of material (NiResist Type 1b) used back in the early 60's, which did not posses enough ductility (brittle), and had long graphite flakes. Over a long period of time in usage, the many small micro-cracks in the original casting structure have greatly increased in size due residual stresses, vibration, operating impacts, etc.



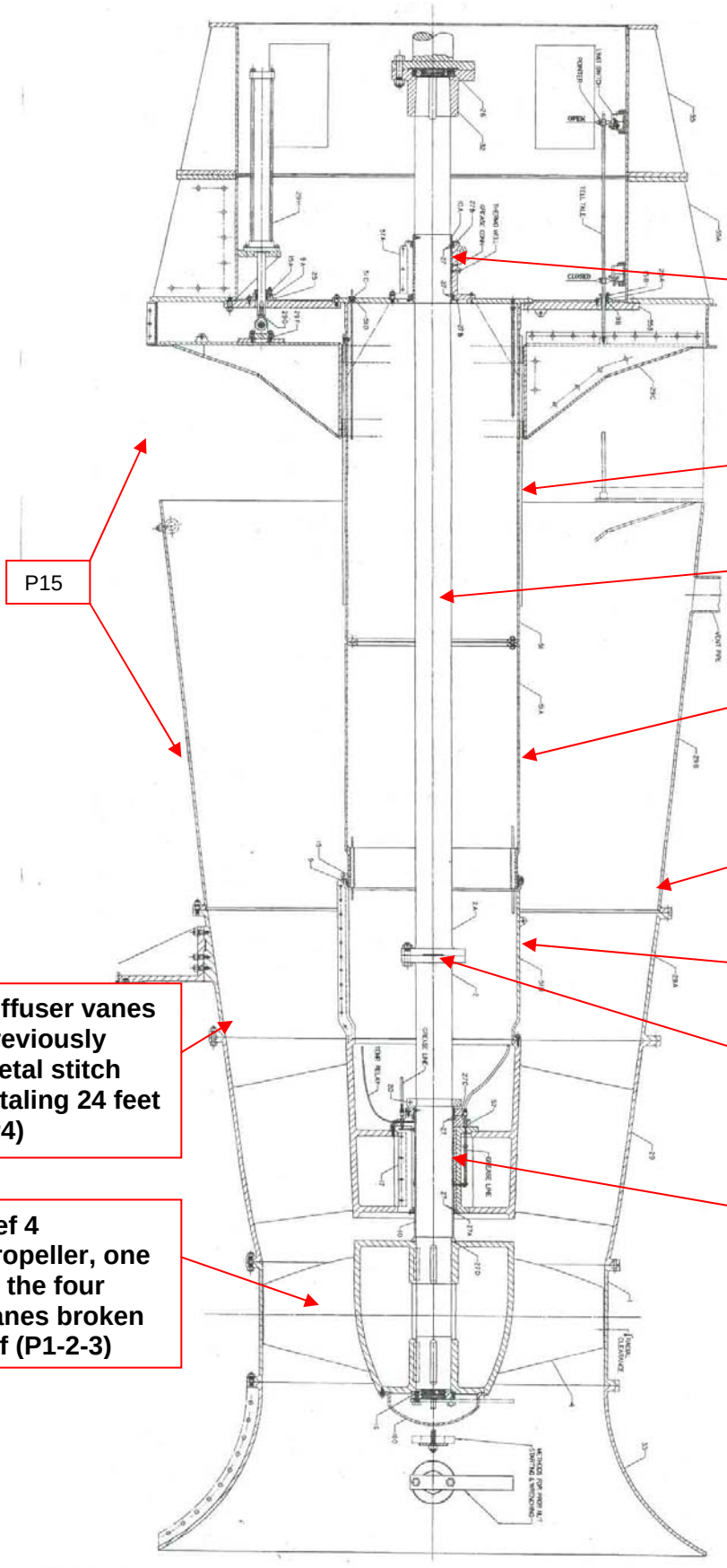
Attributing failure mode…to the original material problem, we believe there was a latent defect in the casting portion of the vanes. It is not known whether this was a problem with the original hand sketch type drawings from the early 1960's before CAD was developed and then transposed into the last propellers provide in 2001 and 2005. The leading vane hub root area varies from .62" to 1.75" thick, where-as the vanes have an overall thickness of 1 .5"/2.0". This a relatively thin area at high stress point, which probably had micro cracking when originally poured due to rapid cooling at this area.

Note the remaining blades are cracked at the root area



Broken blade found to the right of the suction intake area

Figure 8.0



Ref 10A Upper Sleeve, worn and scored
Ref 57A Upper Bearing, in fair condition, scored (P10)

Ref 51 Upper Column, in good condition (P13)

P15

Ref 2A Upper Shaft, in good condition (P7)

Ref 51A Lower Column, in poor condition with deep pitting (P12)

Ref 29 Lower Column, in fair condition with some deep pitting and hole (P15,16)

Ref 51B Split Covers, in good condition, (P14)

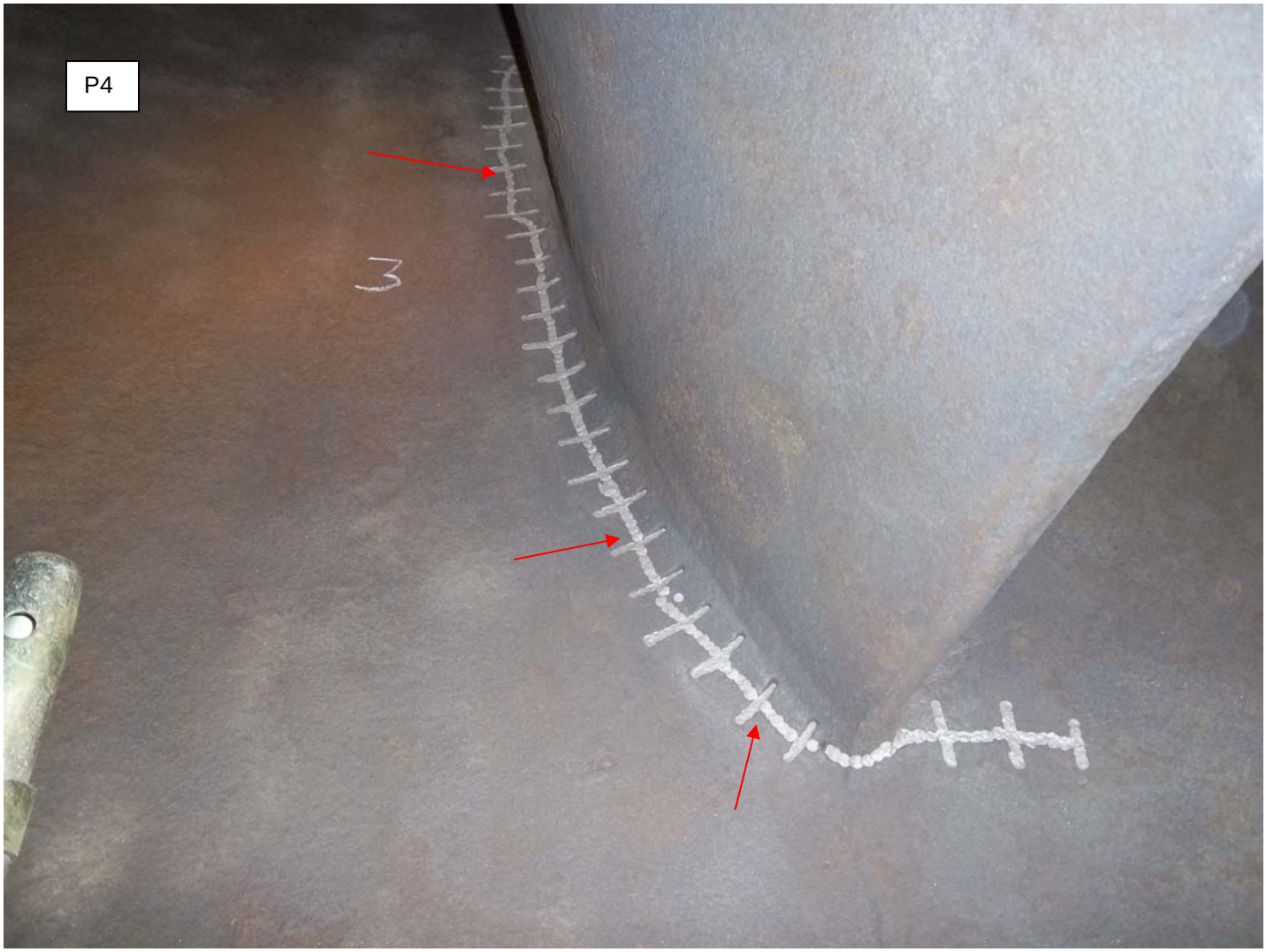
Diffuser vanes previously metal stitch totaling 24 feet (P4)

Lower coupling bolts galled and seized (P5)

Ref 4 Propeller, one of the four vanes broken off (P1-2-3)

Ref 57 Lower Bearing, old style to be upgraded (P 9)
Ref 17 Lower Bearing Bracket, cracked in several areas (P11)

Twenty-four feet of cracks to the stationary diffuser vanes…were repaired by the metal stitch method in 1997. The stationary diffuser guide blades for straightening the water flow from the impeller were crack on the backside. Each of the six (6) vanes had approximately 48 inches of linear indications at the hub root area outer perimeter, totaling 24 feet. These vanes also provide support for the lower bearing housing assembly and enclosing covers/columns. The fractures in the diffuser vanes are a typical occurrence on these units. Inspection revealed another 15 feet of various cracks, mapped on the **Diffuser Inspection Report**



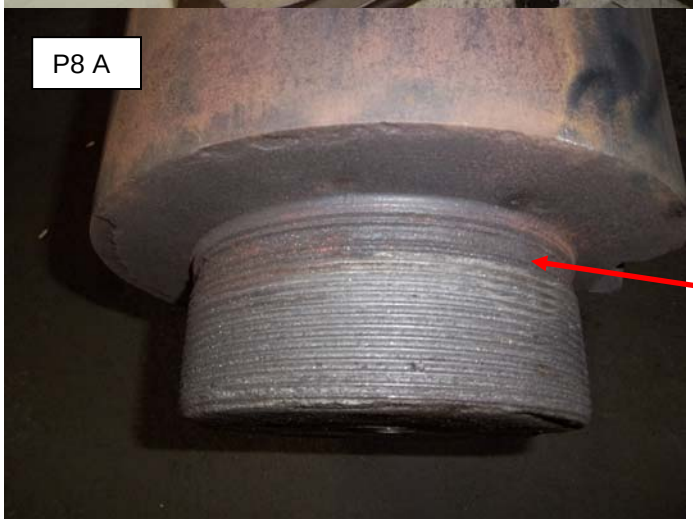
Previous metal stitching repair in excellent condition of a 48” crack, typical for each vane

7.3.2 Upper and Lower Shafting…have been completely cleaned to remove rust and scale for inspection. The upper shaft (30'L) cleaned to remove protective coating the entire length for NDT testing and inspecting. NDT by ultrasonic method and was accepted. ***(Ref Mistras Reports)*** Setup and checked for conformance to our drawing ***(AP-119-REF2A)*** TIR within .002/3".
(*Ref Figure 8.1*)
Note: During the disassembly several of the bolts had to be cut and most were galled to the nuts requiring heating and Hytorc Wrench for removal. Remnant of bolt lodged in the coupling hub.

Recommendations:

- Coat exposed areas with Cosmoline Rust Veto 342 rust protector.
- Furnish ten (10) new coupling body bolts with castle nuts
- Ream each bolt location and fit the new bolts and match mark

7.3.2 The lower shaft (12'L) was setup and checked for conformance to our drawing ***(AP-119-REF2)*** . TIR within .002". The propeller fit areas are eroded and undersized .010" **(*Ref Figure 8.2*)** The threads for the coupling nut are have been compromised from corrosion at the base area, but should be acceptable for the next cycle. NDT by ultrasonic testing was accepteptable ***(Ref Mistras Reports)***



Threaded section for the propeller nut are slightly eroded at the shoulder area, acceptable the next cycle of operation

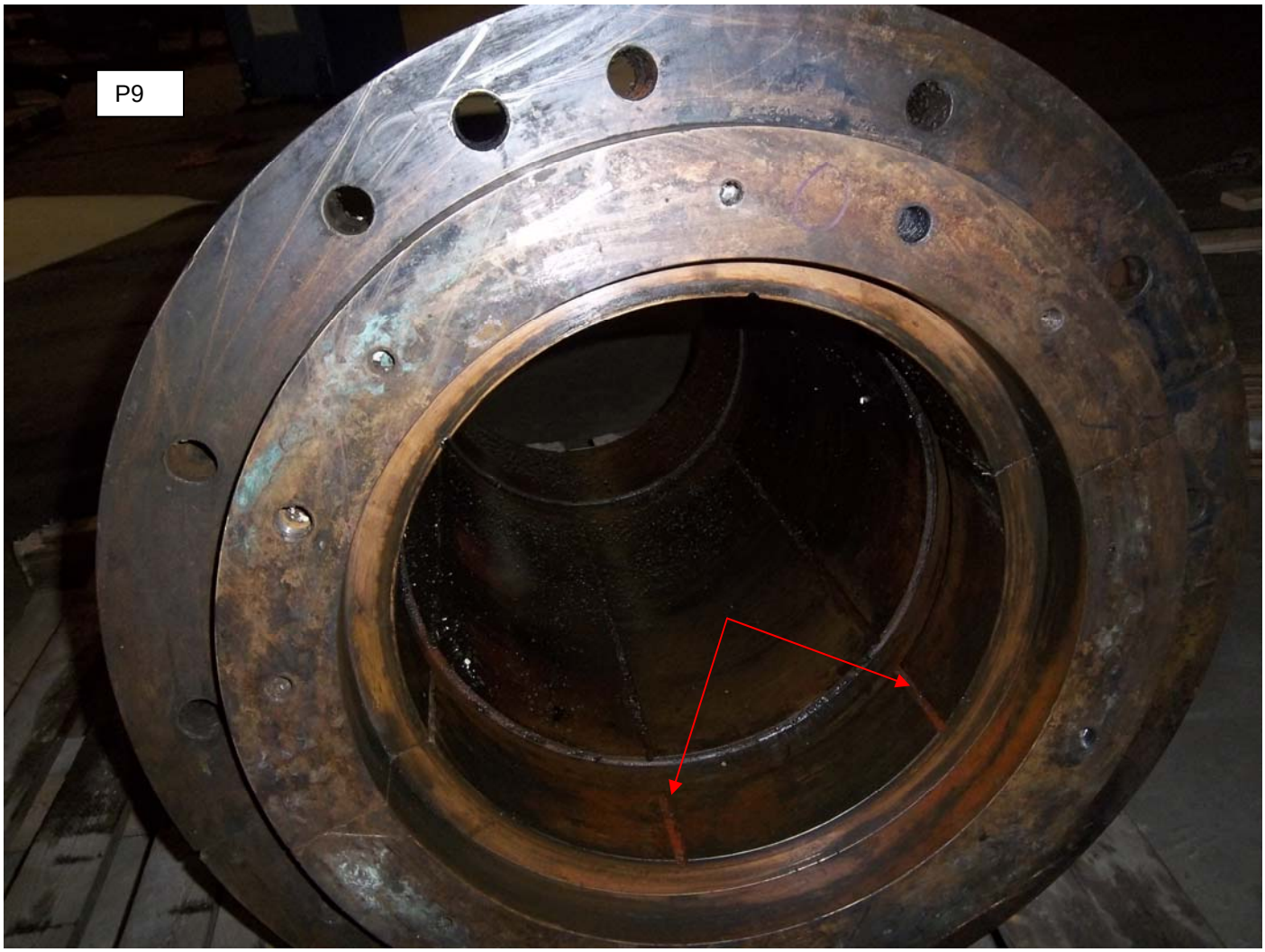
Recommendations:

- The propeller fit diameters be skim cut undersized by .030" and compensated in the new propeller bore to allow for .002"/.004" clearance
- Furnish and fit two new propeller keys

7.3.3 Upper/Lower Bearings and Sleeves…have been removed and cleaned for inspection. The lower bearing is the original design with limiting lubricating and is scored due to lack of lubrication along with the lower journal sleeve. The lower sleeve will be replaced under contract in Monel 400 material per our drawing ***(AP-119-REF10)***
Dimensional measurements recorded ***(Ref. Figure 8.4)***
Diametrical running clearance of the sleeve to the bushing .033"/.042" ***(Design .020"/.022")***

Recommendations:

- Contractually the lower bearing will be upgraded per our drawing ***(AP-REF119-57)*** which increase the lubrication grooves to ¾".



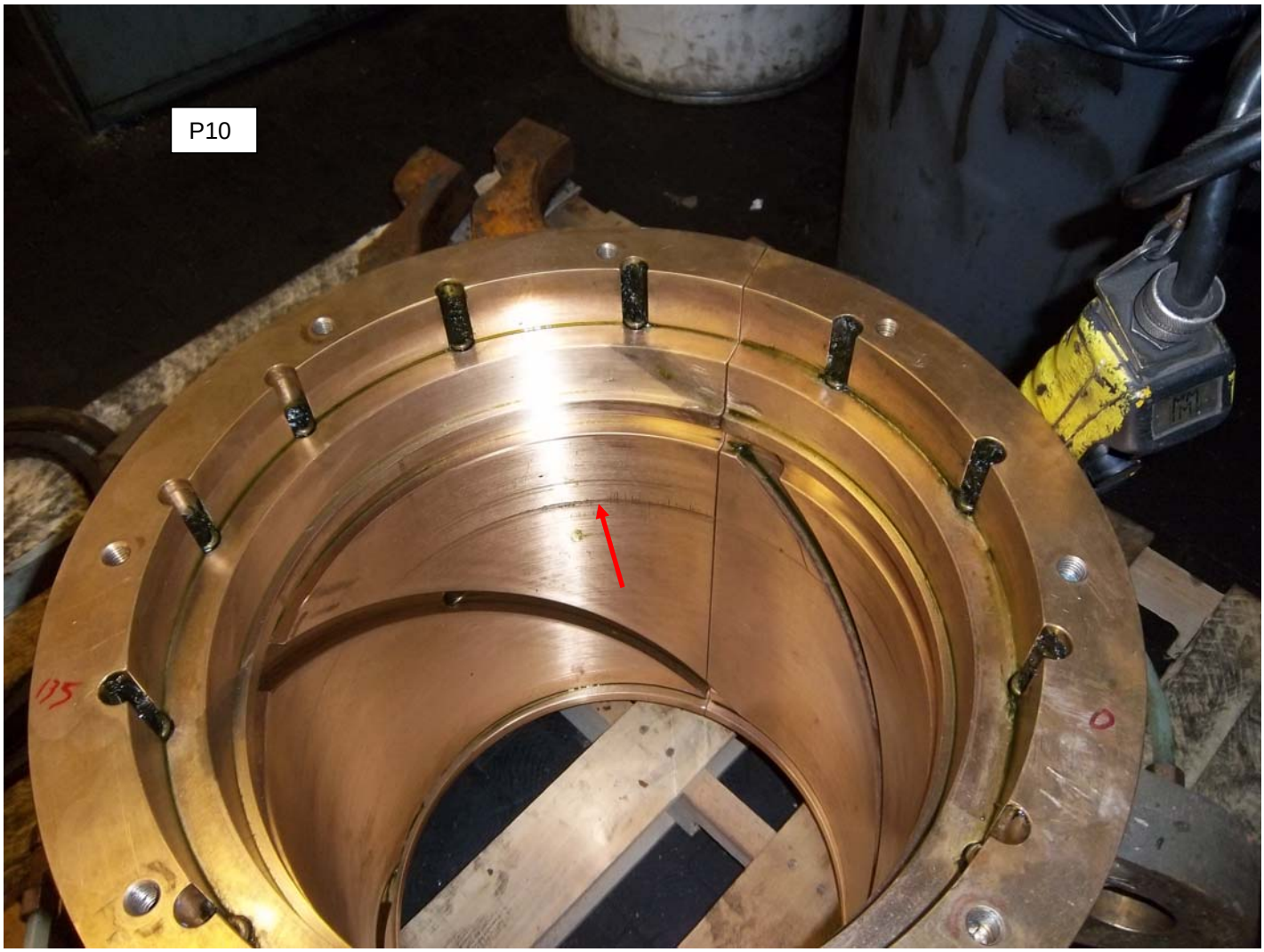
Original style lower bearing experience poor lubrication, which resulted in over heating
Note lack of lubrication on surface

7.3.3 Upper Bearing

The upper bearing is in fair condition with some scoring, and is of the new design, which incorporates the larger grease grooves and water cooling jacket, per our drawing ***(AP-119-57A)***
The upper journal sleeve is score and grooved at the seal areas and will be replaced as per the contract in 420SS per our drawing ***(AP-119-REF-10A)***
Dimensional measurements recorded ***(Ref. Figure 8.5)***
Diametrical running clearance of the sleeve to the bushing .027”/.033” ***(Design .020”/.022”)***

Recommendations:

- The upper bearing be re-machined, to remove score marks open the bore to 13.525” +.002”/-.000”
- Charge the cooling jacket with water and check for leaks
- Re-establish the clearance of .020”/.022” with the new journal sleeve.
- Replace the two (2) upper and the two (2) lower lip seals
- The upper shaft sleeve will be increased in diameter to 13.505” +.000”/-.002”



7.3.3 Lower Bearing Bracket… for mounting the lower bearing bushing and centralizing in the diffuser is in poor condition with spider cracks on both halves in the bottom area. Note previously metal stitched at other areas. Dimensional readings shown on ***(Figure 8.3)***

Recommendations:

- Furnish a new bearing bracket in Ductile Ni-Resist cast iron.
- All hardware for securing to the bearing frame be replaced in 316SS. .
- Replace the two (2) lip seals and the retainer plates with new 316SS hardware.

Note the hardware was carbon steel was severely corroded.

7.3.4 Inner columns and bearing covers in fair condition…after sandblasting the upper/lower shaft enclosing columns and split bearing chamber covers, all components were found in fair condition. The upper column is reusable as-is. The packing gland constructed of 300 series stainless and is in good condition. The split cover casting assembly is in good condition. The lower column expansion joint which seals between the split covers has some deteriorated and allowed water into the bearing chamber. The lower column has numerous deep (1/2") pits and should be replaced.

Recommendations:

- The split covers be cleaned and painted with One coat Rust Bond LT to 1-2 mils DFT, followed by two (2) coats of 890 LT 16- 20 mils DFT total.
- Furnish a new packing gland in 316L material as per our drawing ***(AP-119-REF-15)***
- Furnish a complete set of 316SS hardware.
- The lower column should be replaced completely new in carbon steel per our drawing ***(AP-119-REF-51A)*** Coating System as manufacture by Carboline Co. One coat Rust Bond LT to 1-2 mils DFT, followed by two (2) coats of 890 LT 16- 20 mils DFT total.

Lower Column typical of some deep pits

7.3.5 Inner columns and bearing covers continued

Upper column to be re-blasted for SSPC-SP 10 surface profile and painted with Carboline coatings systems. Contractually furnish and install two (2) Nitronic 60 guide keys for the backwater water closure

Upper Column good condition, cleaned and painted with Carboline System

Guide key location, carbon steel keys to be replaced with Nitronic material

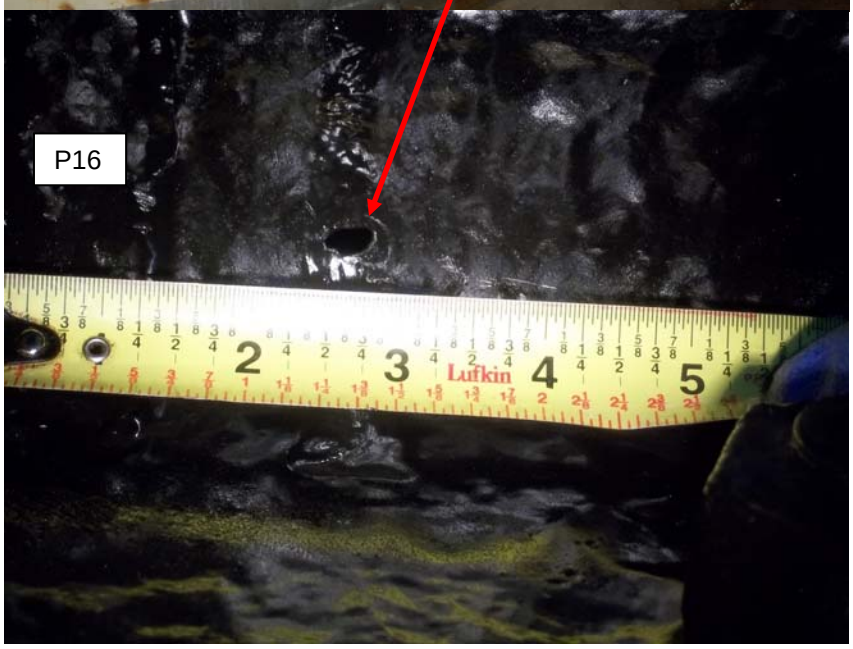
Lower split covers in good condition, cleaned and painted with Carboline System

7.3.7 Discharge cone and backwater closure…have been visually inspected prior to cleaning. Samples of the paint were removed from the inside and outside of the carbon steel cone along with a sample from the discharge closure for analysis of lead paint. The report from ***RI Analytical Report Pump 1 attached***, revealed sample #001 Outer Cone 500 PPM, sample #002 Cone Inner 1,700 PPM and sample #003 closure 4,600 PPM

Discharge Cone general condition good, no major erosion/corrosion issues.

General condition of the discharge cone is fair, the outer section shown at the base area where the paint has failed, is subject to high tide flooding of 2-3 inches.

This part of the cone will be coated with Belzona primer 6111 and then over coated with Belzona 5811



There are several deep pits including one area with a ½" hole Recommend the deep pits and hole be filled with Belzona 1121 Super Repair Metal, then over coat with 5811 Immersion Grade

Recommendations

- The components be cleaned by blasting in accordance USACE SECTION 02 82 33.13 20 for lead paint.
- All surfaces will have a SSPC-SP10 finish and primed with (***Belzona 6111)***, after which two (2) coats of (***Belzona 5811)*** Immersion Grade will be applied to both sides of the cone, within 3 days.
- The discharge closure will be painted with two (2) coats of (***Carboline 890 LT***)16- 20 mils DFT total.

7.3.7 The three (3) backwater closure cylinder...rams (6' L) are in good condition. The accumulator bladder was last replaced in 1997

Recommendations:

- Rebuild each cylinder with new packing ring assemblies.
- Replace the accumulator bladder and seal kit for 10 gal unit

7.3.8 The four (4) anti-rotation brake units…have been disassembled and inspected all cylinders are in good condition. The packing and seal rings have been leaking hydraulic fluid. The mounting plates for securing the brake pads are bent and caused uneven wear to the brake pads.

Recommendations:

- The brake mounting plates be straightened or replaced
- Skim cut the brake pads to be flat within .003”
- Replace with new cylinder packing in each brake

Two of the four brakes shown after being rebuilt with new seals and resurfaced brake pads

7.3.9 The Farval centralized lubrication… system provides #1NLGI grease to the upper and lower guide bearings. The upper bearing has one port in the middle and the lower bearing has two ports 180º at the top for lubricating the bearing. The unit has not been disassembled.


Recommendations

- Utilize the funds for inspection be applied to a new unit
- Furnish one (1) new Farval lube station, SS2200 Controller, 240/360 VAC -3 phase motor, 24# reservoir with low level switch, DR45 reversing valve, DM61 & DM62 grease valves- 3 outlets, Gauges and mounting base

7.3.10 The original Foxboro temperature gauges… for the upper and lower bearings are no longer functional temperature Indicators. Signals to be provided by RTD's installed on the lower and upper pump bearings. In addition to the Precision Digital gauges two Ashcroft gauges with control switches will be installed

Recommendations

- Upgrading with two (2) new Precision Digital M/N PD765-6R2-00 which will have two (2) sets of contact for Alarm setting 160˚F Shutdown 200˚F
- 1-Upper RTD-P/N S6FUAPX12511 6.0X-LR3R240P2S
- 1-Lower RTD-P/N S6FUAPX12511 6.0X-LR3R600P2S
- 2-¾-260S-U4.5 Monel
- 2-PDA-2501 Nema 4 Enclosures
- 2-Ashcroft 6” with capillary tube design and electrical integral alarm contacts

7.2.1 The 4,500HP electric drive motor

The electrical windings of the motor have been inspected and tested by (***Walco Electric Report)*** All winding test for resistance, megger and hypot passed. The motor was setup with portable heaters to continuously provide warm air to keep the windings dry while off the base plate.