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Mr. Chris Derrick
Reliability Engineer
Port Townsend Paper Corporation
100 Mill Road
Port Townsend, WA 98368

June 29, 2023

**#3 Boiler Feed Water Pump Bearing**

Dear Chris,
Part of PetroCard's lubrication program is to provide Port Townsend Paper Corp (PTPC) with engineering service. Outlined in this report is documented data outlining a proven method to extend the life of the feed water pump bearings.

**Background**
In the steam and power area, PTPC has three feed water pumps that provide the mill with water. These pumps are critical to the operation of the mill. The pumps are coupled with precision bearings. These bearings are lubricated with a very small oil reservoir between 4 and 8 gallons. There is no filtration on the system. Over the years the reservoirs have accumulated contamination, and the only way keep the oil somewhat clean is to change it during a down. Because of the small reservoir and the precision bearings, adding any filtration has not been possible.

**Contamination Study #3 Pump**
To understand the amount of contamination, we utilized PetroCard's oil analysis program and took representative samples from the reservoir. The analysis revealed a high level of contamination; 37,709 particles/ml greater than 4 microns with an ISO cleanliness code of 22/20/15.

**Evaluation of New Filtration System**
PetroCard's on-site engineer is recommending that PTPC run a test using a newly developed hand carry filtration system. This system, designed and developed by Fluidloop, uses a variable speed pump with flow rates of 0.25 to 1.0 gallons/minute. In addition, the filter has the following features –

1. Slow flow/low pressure
2. High dirt holding capacity
3. Both water and particle removal. See attached brochure.

The results proved out. The 4 micron and greater number dropped from the 37,709 particles to 650 particles with an ISO code of 17/15/11. See oil analysis dated June 15. This is an acceptable cleanliness level.

**Savings to PTPC**
Using the LET (Life Extension Table) we can calculate that the life of the bearings will be extended by 3 times. See attached LET and Reliability Solutions Table.

**Recommendations**
PetroCard recommends that PTPC purchase a Fluidloop system, and set-up of all the feedwater pumps for filtration.

Respectfully,

Duane DeNotta
Sales Engineer
PetroCard

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# OIL ANALYSIS REPORT

| | |
|---|---|
| WEAR | ABNORMAL |
| CONTAMINATION | ABNORMAL |
| FLUID CONDITION | ATTENTION |

Area
## STEAM AND POWER
Machine Id
## 269.0095 #3 BOILER FEED WATER PUMP
Component
## Bearing Lube
Fluid
## SHELL TURBO T ISO 68 (--- GAL)

## RECOMMENDATION

Resample at the next service interval to monitor. ( Customer Sample Comment: Pre-filter cart added )

## WEAR

In the absence of other significant wear metals, suspect copper due to sources other than wear (i.e. cooling core).

## CONTAMINATION

There is a high amount of particulates present in the oil. (PRE FILTER CART ADDED)

BEFORE Filtration

## FLUID CONDITION

Additive levels indicate the addition of a different brand, or type of oil. Confirm oil type. The AN level is acceptable for this fluid. The condition of the oil is suitable for further service.

| Test | UOM | Method | Limit/Min | Current | History1 | History2 |
|---|---|---|---|---|---|---|
| Sample Number | | Client Info | | PE0000808 | PE0000807 | |
| Sample Date | | Client Info | | 22 May 2023 | 22 May 2023 | |
| Machine Age | hrs | Client Info | | 0 | 0 | |
| Oil Age | hrs | Client Info | | 0 | 0 | |
| Filter Age | hrs | Client Info | | 0 | 0 | |
| Oil Changed | | Client Info | | N/A | N/A | |
| Filter Changed | | Client Info | | N/A | N/A | |
| Sample Status | | | | ABNORMAL | ATTENTION | |
| PQ | | ASTM D8184 | | 14 | 17 | |
| Iron | ppm | ASTM D5185m | >120 | 6 | 3 | |
| Chromium | ppm | ASTM D5185m | >5 | <1 | <1 | |
| Nickel | ppm | ASTM D5185m | >20 | <1 | 0 | |
| Titanium | ppm | ASTM D5185m | | 0 | 0 | |
| Silver | ppm | ASTM D5185m | | 0 | 0 | |
| Aluminum | ppm | ASTM D5185m | >4 | 0 | 0 | |
| Lead | ppm | ASTM D5185m | >30 | 10 | 3 | |
| Copper | ppm | ASTM D5185m | >17 | ▲ 137 | ▲ 66 | |
| Tin | ppm | ASTM D5185m | >10 | 0 | 0 | |
| Vanadium | ppm | ASTM D5185m | | 0 | 0 | |
| White Metal | scalar | *Visual | NONE | LIGHT | LIGHT | |
| Yellow Metal | scalar | *Visual | NONE | NONE | NONE | |
| Silicon | ppm | ASTM D5185m | >25 | 1 | 2 | |
| Potassium | ppm | ASTM D5185m | >20 | 1 | 1 | |
| Particles >4µm | | ASTM D7647 | >2500 | ▲ 37709 | 19854 | |
| Particles >6µm | | ASTM D7647 | >640 | ▲ 7974 | 3966 | |
| Particles >14µm | | ASTM D7647 | >160 | ▲ 310 | 17 | |
| Particles >21µm | | ASTM D7647 | >40 | ▲ 65 | 3 | |
| Particles >38µm | | ASTM D7647 | >10 | 3 | 0 | |
| Particles >71µm | | ASTM D7647 | >3 | 0 | 0 | |
| Oil Cleanliness | | ISO 4406 (c) | >18/16/14 | ▲ 22/20/15 | 18/16/11 | |
| Silt | scalar | *Visual | NONE | NONE | NONE | |
| Debris | scalar | *Visual | NONE | NONE | NONE | |
| Sand/Dirt | scalar | *Visual | NONE | NONE | NONE | |
| Appearance | scalar | *Visual | NORML | NORML | NORML | |
| Odor | scalar | *Visual | NORML | NORML | NORML | |
| Emulsified Water | scalar | *Visual | >0.2 | NEG | NEG | |
| Sodium | ppm | ASTM D5185m | | <1 | <1 | |
| Boron | ppm | ASTM D5185m | | 0 | 0 | |
| Barium | ppm | ASTM D5185m | | 0 | 0 | |
| Molybdenum | ppm | ASTM D5185m | | <1 | 0 | |
| Manganese | ppm | ASTM D5185m | | <1 | <1 | |
| Magnesium | ppm | ASTM D5185m | | <1 | <1 | |
| Calcium | ppm | ASTM D5185m | | 7 | 8 | |
| Phosphorus | ppm | ASTM D5185m | | ▲ 321 | ▲ 305 | |
| Zinc | ppm | ASTM D5185m | | ▲ 213 | ▲ 110 | |
| Sulfur | ppm | ASTM D5185m | | ▲ 1355 | ▲ 1250 | |
| Acid Number (AN) | mg KOH/g | ASTM D8045 | .05 | 0.45 | 0.53 | |
| Visc @ 40°C | cSt | ASTM D445 | 68 | 60.6 | 66.0 | |

PLANT

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# OIL ANALYSIS REPORT

| | |
|---|---|
| WEAR | NORMAL |
| CONTAMINATION | NORMAL |
| FLUID CONDITION | NORMAL |

Area
**STEAM AND POWER**
Machine Id
**269.0095 #3 BOILER FEED WATER PUMP**
Component
**Bearing Lube**
Fluid
**SHELL TURBO T ISO 68 (--- GAL)**

## RECOMMENDATION

Resample at the next service interval to monitor.

## WEAR

All component wear rates are normal.

## CONTAMINATION

There is no indication of any contamination in the oil. The amount and size of particulates present in the system are acceptable.

AFTER Filtration

## FLUID CONDITION

The AN level is acceptable for this fluid. The condition of the oil is acceptable for the time in service.

| Test | UOM | Method | Limit/An | Current | History1 | History2 |
|---|---|---|---|---|---|---|
| Sample Number | | Client Info | | PE0000892 | PE0000808 | PE0000807 |
| Sample Date | | Client Info | | 15 Jun 2023 | 22 May 2023 | 22 May 2023 |
| Machine Age | hrs | Client Info | | 0 | 0 | 0 |
| Oil Age | hrs | Client Info | | 0 | 0 | 0 |
| Filter Age | hrs | Client Info | | 0 | 0 | 0 |
| Oil Changed | | Client Info | | N/A | N/A | N/A |
| Filter Changed | | Client Info | | N/A | N/A | N/A |
| Sample Status | | | | NORMAL | ABNORMAL | ATTENTION |
| PQ | | ASTM D8184 | | 16 | 14 | 17 |
| Iron | ppm | ASTM D5185m | >120 | 4 | 6 | 3 |
| Chromium | ppm | ASTM D5185m | >5 | 0 | <1 | <1 |
| Nickel | ppm | ASTM D5185m | >20 | 0 | <1 | 0 |
| Titanium | ppm | ASTM D5185m | | 0 | 0 | 0 |
| Silver | ppm | ASTM D5185m | | 0 | 0 | 0 |
| Aluminum | ppm | ASTM D5185m | >4 | 0 | 0 | 0 |
| Lead | ppm | ASTM D5185m | >30 | 3 | 10 | 3 |
| Copper | ppm | ASTM D5185m | >17 | 62 | ▲ 137 | ▲ 66 |
| Tin | ppm | ASTM D5185m | >10 | 0 | 0 | 0 |
| Vanadium | ppm | ASTM D5185m | | <1 | 0 | 0 |
| White Metal | scalar | *Visual | NONE | NONE | LIGHT | LIGHT |
| Yellow Metal | scalar | *Visual | NONE | NONE | NONE | NONE |
| Silicon | ppm | ASTM D5185m | >25 | 2 | 1 | 2 |
| Potassium | ppm | ASTM D5185m | >20 | 0 | 1 | 1 |
| Particles >4µm | | ASTM D7647 | >2500 | 655 | ▲ 3709 | 1985 |
| Particles >6µm | | ASTM D7647 | >640 | 193 | ▲ 797.4 | 396 |
| Particles >14µm | | ASTM D7647 | >160 | 18 | ▲ 310 | 17 |
| Particles >21µm | | ASTM D7647 | >40 | 6 | ▲ 65 | 3 |
| Particles >38µm | | ASTM D7647 | >10 | 1 | 3 | 0 |
| Particles >71µm | | ASTM D7647 | >3 | 0 | 0 | 0 |
| Oil Cleanliness | | ISO 4406 (c) | >18/16/14 | 17/15/11 | ▲ 22/20/15 | 18/16/11 |
| Silt | scalar | *Visual | NONE | NONE | NONE | NONE |
| Debris | scalar | *Visual | NONE | NONE | NONE | NONE |
| Sand/Dirt | scalar | *Visual | NONE | NONE | NONE | NONE |
| Appearance | scalar | *Visual | NORML | NORML | NORML | NORML |
| Odor | scalar | *Visual | NORML | NORML | NORML | NORML |
| Emulsified Water | scalar | *Visual | >0.2 | NEG | NEG | NEG |
| Sodium | ppm | ASTM D5185m | | <1 | <1 | <1 |
| Boron | ppm | ASTM D5185m | | 0 | 0 | 0 |
| Barium | ppm | ASTM D5185m | | 0 | 0 | 0 |
| Molybdenum | ppm | ASTM D5185m | | 0 | <1 | 0 |
| Manganese | ppm | ASTM D5185m | | 0 | <1 | <1 |
| Magnesium | ppm | ASTM D5185m | | 0 | <1 | <1 |
| Calcium | ppm | ASTM D5185m | | 0 | 7 | 8 |
| Phosphorus | ppm | ASTM D5185m | | 286 | ▲ 321 | ▲ 305 |
| Zinc | ppm | ASTM D5185m | | 104 | ▲ 213 | ▲ 110 |
| Sulfur | ppm | ASTM D5185m | | 1052 | ▲ 1355 | ▲ 1250 |
| Acid Number (AN) | mg KOH/g | ASTM D8045 | 05 | 0.53 | 0.45 | 0.53 |
| Visc @ 40°C | cSt | ASTM D445 | 68 | 64.5 | 60.6 | 65.0 |

RELIABILITY SOLUTIONS
PROFITABLE RESULTS

| TypeISO Cleanliness Code | |
|---|---|
| ball bearings | 15/13/11 |
| roller bearings | 16/14/12 |
| journal bearings | 17/15/12 |
| industrial gearboxes | 17/15/12 |
| mobile gearboxes | 17/16/13 |
| diesel engines | 17/16/13 |
| steam turbine oils | 18/15/12 |
| paper machine oils | 19/16/13 |
| **Hydraulic systems less than 1,500 psi** | |
| servo valves | 16/14/12 |
| proportional valves | 17/15/12 |
| variable volume pump | 17/16/13 |
| cartridge valve | 18/16/14 |
| fixed piston pump | 18/16/14 |
| vane pump | 19/17/14 |
| pressure/flow control valve | 19/17/14 |
| solenoid valve | 19/17/14 |
| gear pump | 19/17/14 |
| **Hydraulic systems 1500 to 2500 psi** | |
| servo valves | 15/13/11 |
| proportional valves | 16/14/12 |
| variable volume pump | 17/15/12 |
| cartridge valve | 17/16/13 |
| fixed piston pump | 17/16/13 |
| vane pump | 18/16/14 |
| pressure/flow control valve | 18/16/14 |
| solenoid valve | 18/16/14 |
| gear pump | 18/16/14 |
| **Hydraulic systems greater than 2500 psi** | |
| servo valves | 14/12/10 |
| proportional valves | 15/13/11 |
| variable volume pump | 16/14/12 |
| cartridge valve | 17/15/12 |
| fixed piston pump | 17/15/12 |
| vane pump | 17/16/13 |
| pressure/flow control valve | 17/16/13 |
| solenoid valve | 18/16/14 |
| gear pump | 18/16/14 |

Remember, these ISO cleanliness targets are suggested base targets. Improvement should be made on desired reliability and cost performance. To achieve these standards care must be taken to see that accurate sample results are there.