Vertical Seawater Lift Pump
Reversible Performance Deterioration

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Abstract

Reversible performance deterioration of one of four parallel seawater vertical lift pumps has limited the pump’s ability for continuous operation. Given the pump’s flat performance characteristics curve, a systematic approach to field troubleshooting was required. Non-conventional inspections, inclusive of online video inspection, revealed performance deterioration caused by marine fouling. This case study will describe the troubleshooting steps, highlighting limitations of typical troubleshooting theories, and recovery through the use of an air lift pump.
Problem

- SW vertical lift pump (24 m) inside a concrete basin
- Limited continuous operation due to reduced flow
- Reversible on each re-start
- Problem with 1 out of 4 pumps
System Overview

Discharge Compartment

Electrochlorination System

BOG/GTG Cooling Systems

Potable Water

SW Vaporizer
SW Service
Hypochlorite
Data Analysis

- Evaluate system – define boundary
- What data was available?
  - Decrease in motor current
  - Overall SW header flow
  - Vibration Spectrum
Motor Current

• Motor current is the available performance measure
• Behavior limited to #2 pump
• SW header following same trend

Rate of performance degradation increase over time
Vibration Spectrum

- Normal operation:
  - Amplitude of 1X unchanged
  - Blade pass frequency stays constant.

- Lower performance:
  - Amplitude of 1X remains unchanged.
  - Blade pass frequency increases.

Amplitude Peaks:
- 0.937 @ 12.500
- 0.876 @ 61.875
- 0.794 @ 5.625
- 0.695 @ 62.500
- 0.613 @ 11.875
- 0.553 @ 6.250
- 0.408 @ 74.375
- 0.370 @ 5.000
- 0.346 @ 13.125
- 0.346 @ 8.125

Amplitude in mm/s rms, Frequency in Hz.
Data Analysis

• Limitations?
  – Pump curve
  – Historical performance
Pump Curve

- **Design:**
  - $H = 52.57$ m
  - $Q = 7,250$ m$^3$/h

- **Operating:**
  - $H = 53.8$ m
  - $Q = 6,600$ m$^3$/h

**Operational Changes:**
0.05 bar (0.7 psi) increase in either discharge pressure or DP across suction strainer
→ 5800 m$^3$/h (13% drop)

Performance calculation can not identify the problem
Historical Pump Performance

- Historic seasonality effect across all pumps
- Change in behaviour related on pump 2
- Basin strainer gets plugged, but no performance effect

Historical current drops in other pumps; Not as rapid

Rapid drops in current; faster rate than earlier years
Verification Plan

- Hypotheses table developed
  - Discharge Blockage
  - Internal Fouling
  - Suction Blockage
- Verifications based on probability and complexity

Diagram:
- Analyze Sequence of Events
- Brainstorm hypotheses
- Group hypotheses into common categories
- Develop verification plan
- Execute plan: First focus on “Low Complexity High Probability”
Underwater Basin Inspection (ROV)

Significant marine fouling

Clean strainer

Mechanical cleaning required to remove mussels

Mollusca/Mussels withstand forces
Non-Intrusive Inspections

- Partially stuck check valve
- Camera inspection inside pump
- No attached growth on pump internals
Non-Intrusive Inspections: Suction

Inspection Video
Suction Blockage Video Summary

Pre- Start Up

2 hours

5 hours

Shutdown

Post- Shutdown

5 hours to block strainer at >6000 m3/hr water flow...Why?
Basin Design

Jet flow through basin entrance

Flow distribution in basin affects rate of suction strainer blockage
Way forward

• Challenges:
  – Confined space
  – Where to discharge water and loose material?
  – How to separate water from debris?
  – High head (30 m) from basin floor – need for submersible pump
  – How to collect debris from around basin corners?

1.5 MW pump used for normal service!
Basin Cleaning – Air Lift Pump

- Min equipment
- No debris interaction
- Old technology
- 1.5 m³ loose debris recovered

Issue resolved on pump start up!
Conclusion

- Common problem for relatively simple equipment
- Recovery could become demanding
- Methodical approach to troubleshooting
- Non-conventional troubleshooting and recovery actions
- Continuous surveillance helps
Thanks!