Effect of Gas Seals on Pump Performance at Low Suction Pressure and Flow

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Objective

Understand the interaction between the gas required to lubricate the seal and the effect of the gas on pump performance.
Background

- NPSH test problem with a gas seal
- API end suction pump (1x2-9)
- Tested NPSH\(_r\) at the rating was 3.7m
- NPSH\(_a\) is 3.0m
- Customer required that the NPSH\(_r\) can not exceed 1.5m
- Quoted NPSH\(_r\) was 0.6m
- Pump normal flow 10% BEP & rated flow 15% BEP – these are system requirements
  - Pump designed to operate down to 10% BEP
Operating Conditions

- **Service:** C4700 Suction Condensate Injection
- **Liquid:** Hydrocarbon
- **Temp.:** 31º C
- **Vapor Pressure:** 18 kPa abs. (1.8 m abs.)
- **Specific Gravity:** 0.666
- **Viscosity:** 0.330 cp
- **Capacity:** 2.3 m³/hr Normal, 3.2 m³/hr Rated

- **Head:** 65 m
- **Speed:** 2930 rpm
- **NPSHr:** 0.6 m
- **NPSHa:** 3.0 m
- **Suction Pressure:** 40 kPa gauge (4.08 m gauge, 14.29 m abs.)
- **Min. Flow:** 2.11 m³/hr
- **Seal:** Non-Contacting Seals Back-to-Back, API Plan 74
Pump Performance Curve
Cross Sectional as Tested

All Flows

>50% BEP

<50% BEP

Balance Hole Location
Baseline Data

B.H. = Balance Hole
S.S. = Contacting Single Wet Seal w/ Plan 11
Effect of Varying Gas Pressure

Prod Test

Perf Curve

Prod Test w/o B.H. & Gas
Seal Set @ 0.5 Mpa

Prod Test w/o B.H. & Gas
Seal Set @ 0.85 Mpa

Prod Test w/o B.H. & Gas
Seal Set @ 1.0 Mpa

B.H. = Balance Hole
Cross Sectional - Bypass Line to Suction Vessel & Std. Throat Bushing

<50% BEP
Test with Bypass Line to Suction Vessel & Std. Throat Bushing

Flow (m³/hr)

NPSHr (m)

- Prod. Test
- Perf. Curve
- Prod. Test w/o B.H. & Gas Seal Set @ 0.5 Mpa w/ Bypass Line

B.H. = Balance Hole
Cross Sectional - Bypass Line to Suction Vessel & Close Clr. Bushing

<50% BEP
Test with Bypass Line to Suction Vessel & Close Clearance Throat Bushing

![Graph showing NPSHr vs Flow for different test conditions.]

- **Prod. Test**
- **Perf. Curve**
- **Prod. Test w/o B.H. & Gas Seal Set @ 0.85 Mpa w/ Bypass Line & Close**

B.H. = Balance Hole
Bypass line was clear to visually see size and quantity of gas bubbles
Installation
Conclusions & Recommendations

- Nitrogen gas caused the impeller to stall
  - Different than impeller cavitation due to insufficient NPSH
- Testing performed on only one pump type
  - Further testing needed to fully understand all of the effects
- Varying gas pressure
  - No significant impact
- Impeller without balance holes
  - Reduces amount of gas reaching impeller inlet
  - Increase in thrust loading
  - Increase seal chamber pressure
    - Requires increase in gas supply pressure
  - At low flow internal recirculation occurs
- Bypass line to suction vessel
  - Reduces amount of gas reaching impeller inlet
  - Larger the size of the line the better ($\geq 25$ mm)
  - Bringing the line back to vessel assures gas will dissipate prior to reaching impeller inlet
Conclusions & Recommendations

- Close clearance throat bushing
  - Assures gas enters bypass line
- All three were required for this application
- Didn’t achieve liquid seal tested value of 0.6m but reduced NPSH_r by 4x from initial test
- Being at 94% vacuum
  - Requires system to be 100% sealed
  - Harder to seal under vacuum than under pressure
  - As pressure is reduced size of bubbles increases
    - \(0.1\)mm @ atmosphere -> \(0.14\)mm @ 50% vacuum -> \(0.2\)mm @ 75% vacuum -> \(0.32\)mm @ 90% vacuum -> 1mm @ 100% vacuum
- Avoid gas seals
Questions?