WORLD-CLASS OUTSTANDING INTERNATIONAL

PROGRAM | EXHIBITION | NETWORKING

SEVERE CASING AND IMPELLER EROSION : ANALYSIS AND RESOLUTION

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ATM

Author Biographies

❖ Professional Experiences

2005 – Present : Flowserve Flow Solution Group

- Senior Technical Services - Saudi – Arabia
- Technical Services - Netherlands (responsible Africa French and English Speaking countries)
- EMA Central Engineering Group - Netherlands
- Technical Services Engineer - France

❖ Education

- Master of Science in Mechanical Engineering (Universite Orleans / Ecole Polytechnique de Montreal)
- Master's Degree Physics (Universite de Tours)

Agenda

- Introduction
  - Background information
  - Design data
- Failure Analysis
  - Erosion pattern location
  - Fluid analysis
  - Operating condition
  - Flow path identification
- New Design
  - Impeller backplate improvement
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- Conclusion

Introduction

Background Information

- Pumps have been in service for 3 years without showing any performance degradation
- After mechanical seal failure, pump brought to maintenance shop for overhaul
- After dismantling severe erosion patterns on the backside of the impeller and cover at wear ring location
- No erosion pattern on front side of the impeller

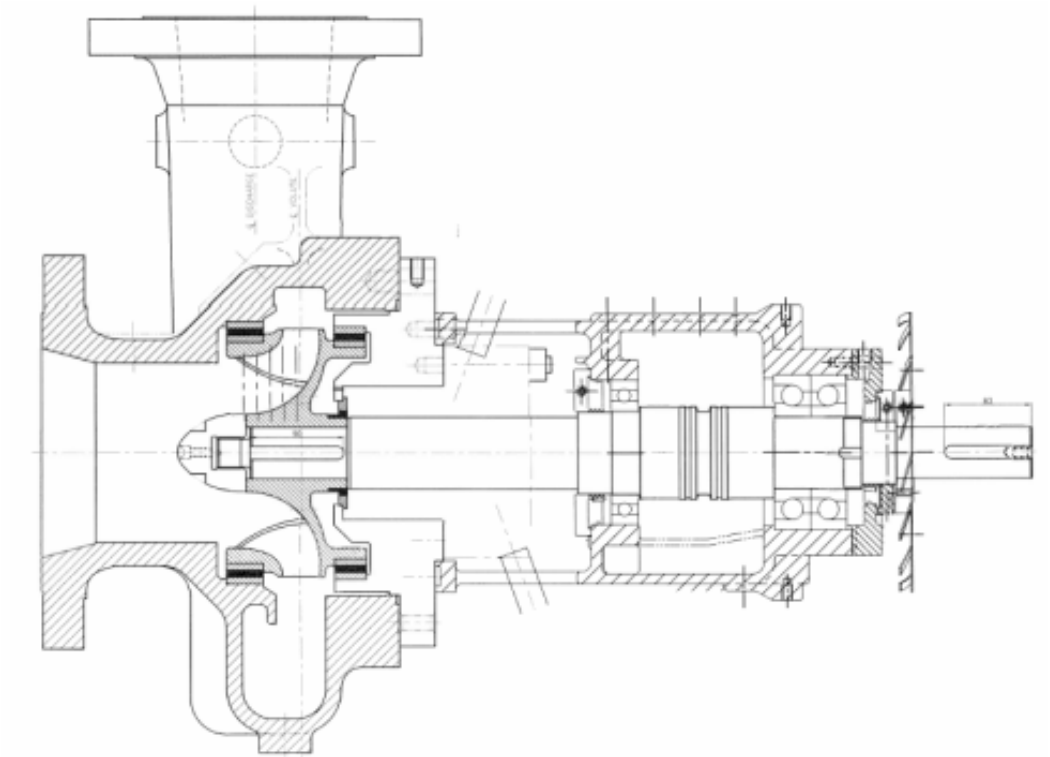
Introduction

Design Data

G204-A					
Service	Produced Water	Units	Rated Discharge Pressure	146.5	(Psig)
			Efficiency	72	(%)
Rated Capacity	2100	(Usgpm)	Temperature	115	(deg F)
Rated Head	211	(Ft)	Speed	3575	Rpm
Rated Suction Pressure	53.5	(Psig)	Capacity at BEP	2144	(Usgpm)

Introduction

Design Data

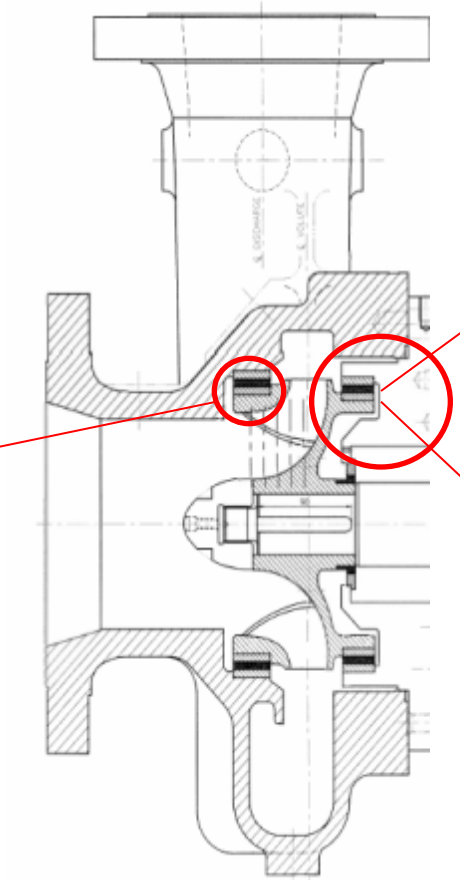


- Mechanical seal plan 32/62
- Flushing with external clean source, sea water in this particular case

Failure Analysis

Erosion Pattern Location

- No erosion damage on the front side
- Severe fish skin erosion
- Impeller back at wearing neck
- Cover inner side



Failure Analysis

Fluid Analysis

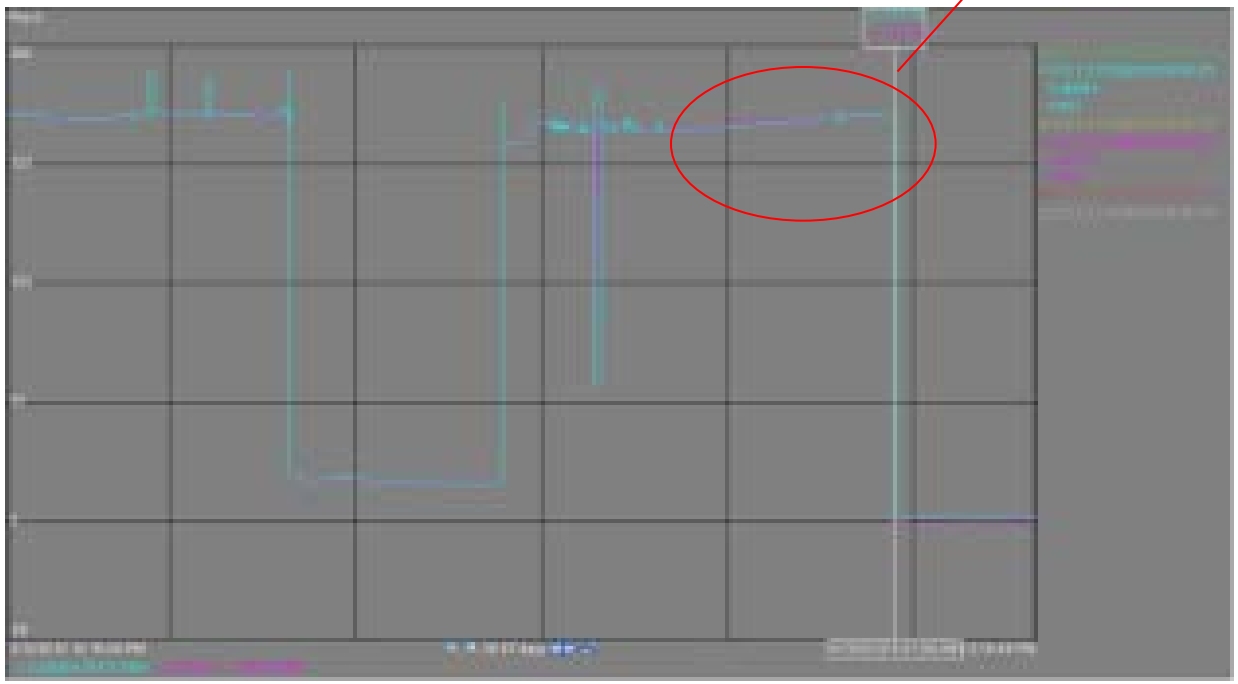
Sample Id	Sample Point	TSS Hydrocarbon mg/l	TSS Non-Hydrocarbon mg/l	Total TSS mg/l
Location 1	Water outlet from Train 3	54	36.4	90.4
Location 2	Water outlet from Train 4	81	24.7	105.7

- Pump datasheet indicate no TSS in the pumped medium
- Actual fluid analysis revealed at least 100 ppm
- Well sand particles and hard particles

Failure Analysis

Operating Condition

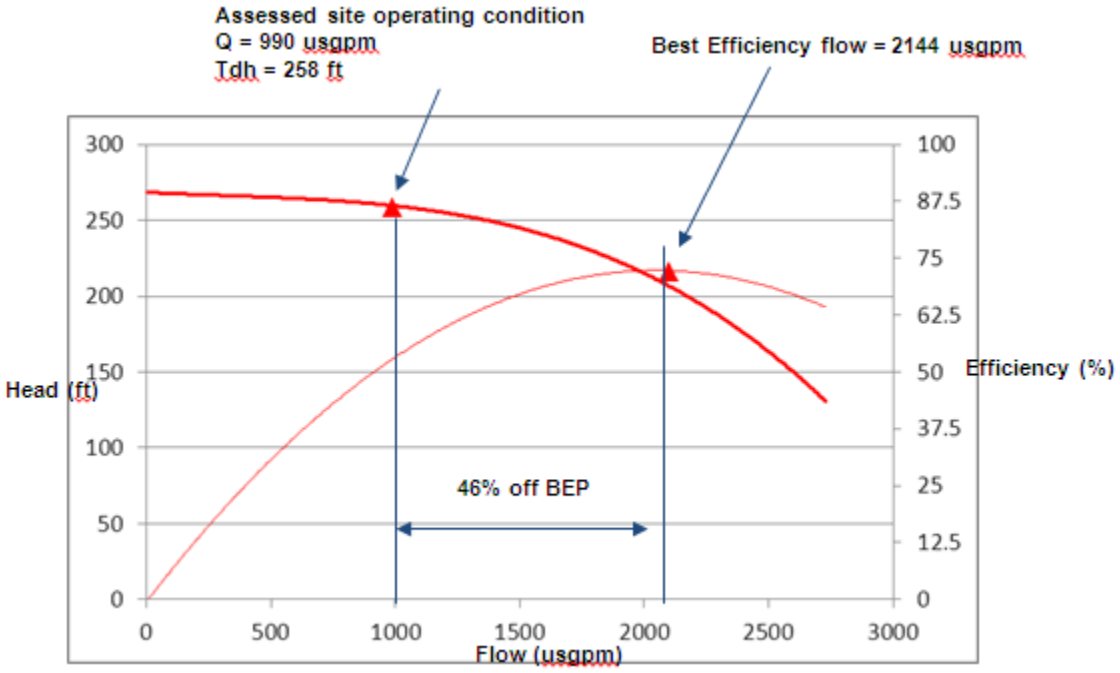
Main Discharge pressure around 170 psi g



- Tdh @ operating condition
- Total diff pressure = 114 Psi
- Total diff head = 258 ft

Failure Analysis

Operating Condition

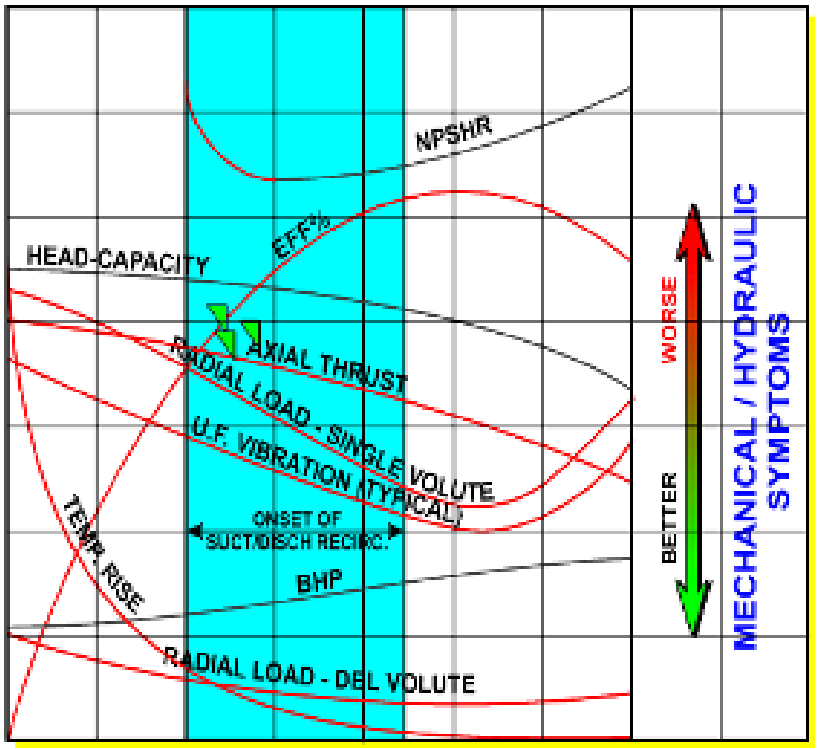


- If there is any discontinuity in the flow path it will accelerate wear at these locations

- Leakage flow on front and back shroud has higher impinging energy

Failure Analysis

Operating Condition

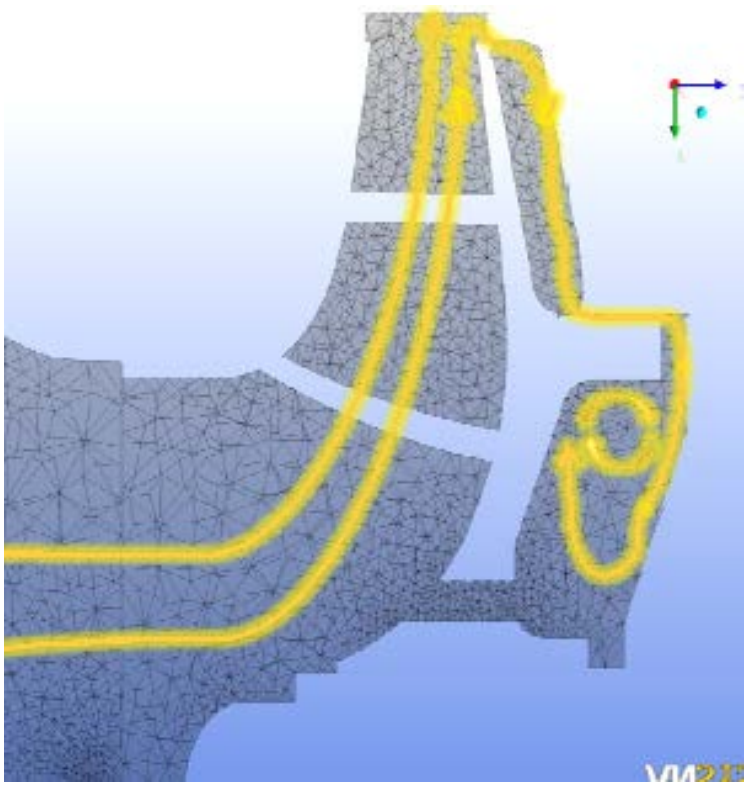


Operation far from BEP will result in:

- **Amplification of known hydraulic phenomenon**
- **Pump fluid will transfer more energy to wall surface**
- **High turbulence in narrow clearance area**

Failure Analysis

Flow Path Identification

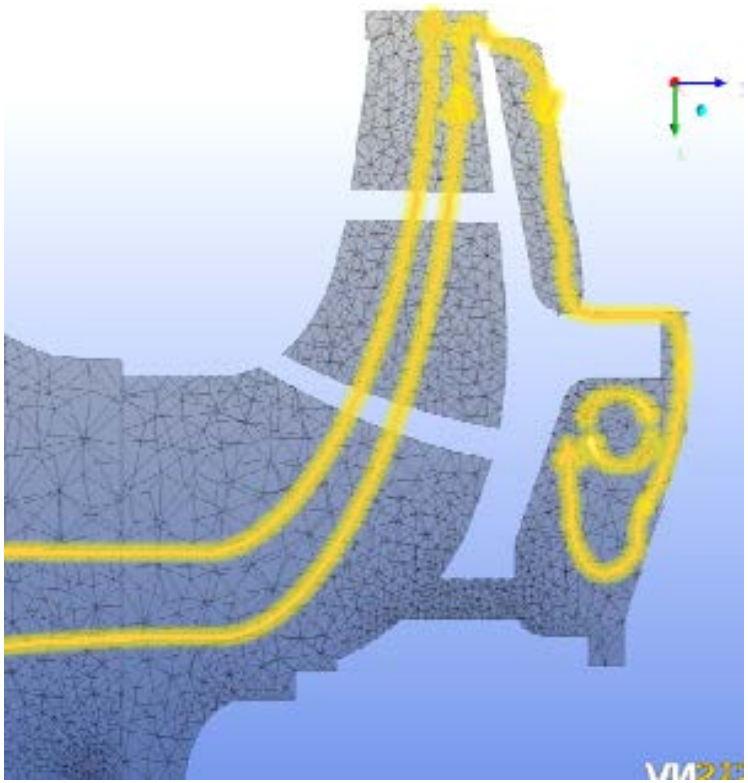


An analysis of the leakage flow path study done by Flowserve in a more severe abrasive service environment has demonstrated:

- Particle diameter plays an important role, only particles with smallest diameter enter the back shroud chamber
- A portion of the flow entering in the back shroud chamber is trapped, thus particles suspended are trapped in this chamber resulting in an accelerated erosion damage

Failure Analysis

Flow Path Identification



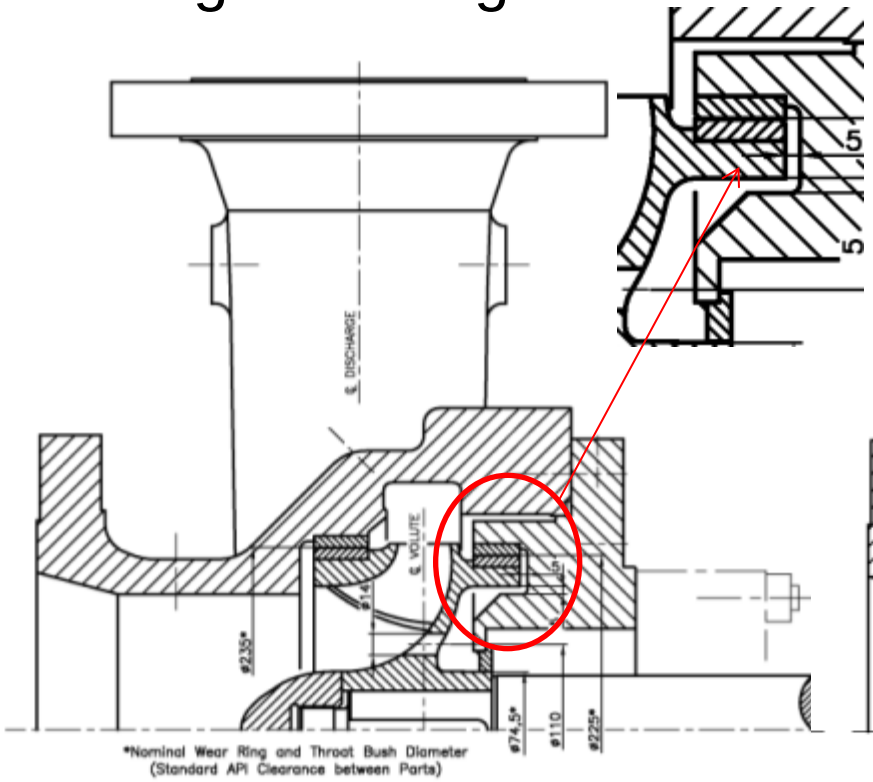
- Erosion damage is more severe when operating off BEP with a high impinging energy thus resulting in a more severe erosion rate

- Current design suggests a dead zone on the back side of the impeller and cover.
- Trapped particles will remain and won't be flushed.
- Therefore increased erosion rate

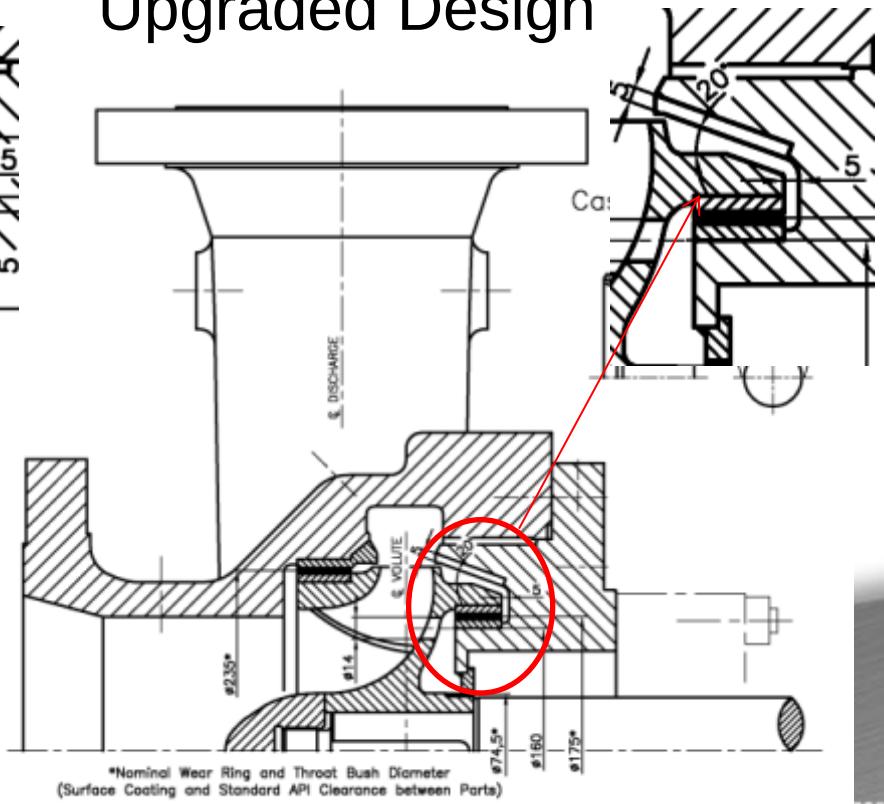
Upgraded Design

Improvement of the back side of the impeller

Original Design

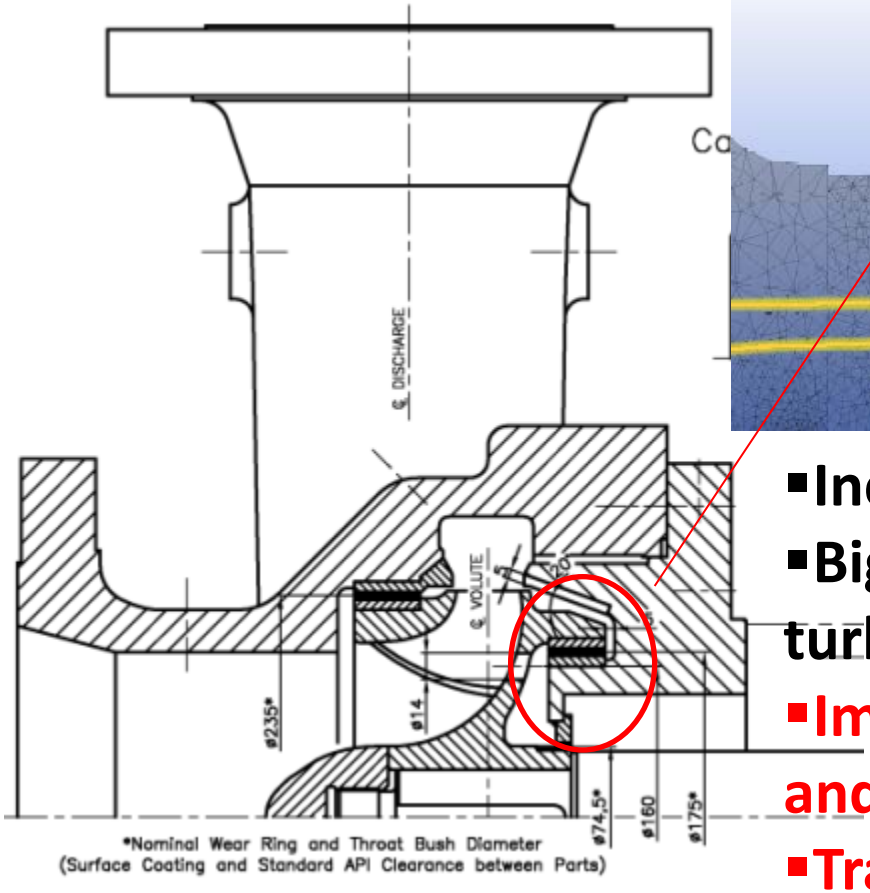


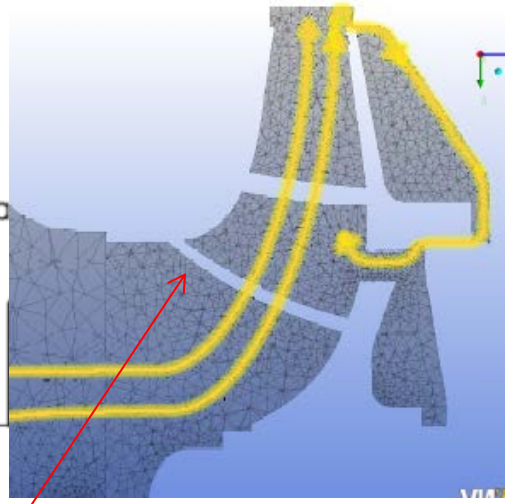
Upgraded Design



Upgraded Design

Improvement of the back side of the impeller





- **Increase of the back side area**
- **Bigger area = lower flow velocity , turbulence reduction**
- **Impeller balancing holes size increased and location changed**
- **Trapped particles will be centrifuged toward suction**

Upgraded Design

Axial Thrust Evaluation

- Back wearing OD change
- Axial Thrust evaluation
- Suitability of existing thrust bearings

- **Axial Thrust = Back Thrust – Front Thrust**

Axial Thrust (N)	
Existing design	1456
Upgraded design	8300

Still suitable for existing thrust bearings which can bear resulting thrust

Conclusion

Lesson Learned

- Original pump Design is a proven design with an extensive installed base
- Severe erosion found on this equipment after 3 years of operation has demonstrated the sensitivity of the design (impeller back shroud and cover) related to the pumped medium.
- These erosions patterns have not been observed in a clean liquid application, with no suspended solids.
- Erosion took place thanks to small particles size, where turbulence at the impeller back shroud and cover was extremely high resulting in a higher erosive action
- Hard solids particles are impinging in the rear close running clearances.

Conclusion

Improvement

- Design Enhancement has been implemented, main target was to reduce the turbulence level by increasing the back side of the impeller and cover area thus reducing local velocity and allowing hard particles to be flushed away.
- Pumps back to operation for a year

Financial Impact

- 12 Upgraded units
- Capex of 950 K dollars
- Expected life time 40 years